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1 **GENERAL**

1.1 Scope of Work

The work to be included in these specifications will be as mentioned in the standard bidding documents.

1.2 Drawings

1.2.1 Tender Drawings

A number of Contract Drawings available at the date of Tender is included in the List of Drawings attached to these specifications. All work shall be performed in accordance (with the Drawings furnished together with the Contract) documents and any such additional Drawings as may be issued by the Engineer from time to time during the progress of the work. Additional Drawings, (if any), will be furnished to the Contractor in due time so as to enable the Contractor to perform the work shown thereon in its proper sequence and for any advance planning that may be necessary for the efficient performance of such work. The Engineer will decide in such instance whether additional Drawings are required for advance planning of the Works and determine the time required for the same.

All lines, elevations and measurements shown on the drawing are approximate and are intended to be used for tendering only. It shall be the Contractor's responsibility to verify and determine the exact lines, grades and elevations to the approval of the Engineer before commencing any section of the Works.

1.2.2 Shop Drawings

The Engineer shall have authority to order at any time and the Contractor agrees to provide at his own expense any number of shop drawings which, in the opinion of the Engineer, are necessary for the proper execution of a specified work. The Contractor shall not proceed with the above mentioned work unless these shop drawings are approved by the Engineer.
1.2.3 "As-Built" Drawings

All prints of the "Shop Drawings", where required, shall be corrected by the Contractor and submitted to the Engineer for approval as the Works proceed. Upon the completion of the Works, the Contractor shall prepare a complete set of "As Built" Drawings for the project as executed, presented on a computerized electronic form, and submit them to the Engineer for approval. When approved by the Engineer, the Contractor shall submit one computer diskette and six copies of all Drawings duly marked "As-Built". The final payment shall not be made except for the actual Works that have been completed in accordance with the Specifications and have been duly presented on the "As-Built" Drawings.

The Contractor shall not be entitled to any extra payment or extension of time for the correction, preparation and supplying of the mentioned drawings and transparencies.

1.3 Abbreviations of Standards

The following abbreviations covering the Standards used for the Works under the Contract shall have the significance set forth opposite each:

- **BS**  British Standards Specifications
- **CP**  Codes of Practice
- **ASTM** American Society for Testing and Materials
- **ACI** American Concrete Institute
- **ISO** International Organization for Specifications
- **IS**  Israeli Standards
- **AWWA** American Water Works Association
- **DS**  Danish Standards
- **DIN** Deutscher Normenausschuss

1.4 Standards

The Works have been designed to incorporate and utilize economically goods, materials and workmanship to various specifications which are detailed herein. Reference is commonly made to British Standards (BS), Codes of Practice (CP), Israeli Standards (IS) and to the American Society for Testing and Materials Standards (ASTM).

Different national or international standards (DIN or ISO etc...) that correspond to the specified Standards may be used provided that their requirements are not less stringent, and provided that the Contractor presents copies of such Standards translated into English. If any redesign of the Works is necessitated by the adoption of such alternatives, the costs incurred shall be borne by the Contractor. Those references shall in every case be deemed to include the latest edition or issue of such standards.
1.5 Units of Measurement and Abbreviations

All units of weights and measurements shall be based on the Metric System of Weights and Measurements except standard products which may be expressed in nominal units of the Imperial System.

The metric terms and symbols occurring in the Contract Documents are based on the "System International 'Unites" (SI System).

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<td>LM/RM</td>
<td>Linear Meter/Running Meter</td>
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<tr>
<td>Sq.m/M²</td>
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<tr>
<td>CM/M³</td>
<td>Cubic Meter</td>
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<tr>
<td>KG</td>
<td>Kilogram</td>
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<tr>
<td>TON</td>
<td>1000 Kilogram</td>
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<tr>
<td>MM</td>
<td>Millimeter</td>
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<tr>
<td>CM</td>
<td>Centimeter</td>
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<tr>
<td>M</td>
<td>Meter</td>
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<tr>
<td>LS</td>
<td>Lump Sum</td>
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1.6 Definitions

Wherever the words Defined in this section or pronouns used in their stead occur in the Contract Documents, they shall have the meaning herein given.

As Directed, as required, etc...

Wherever in the Contract Documents, or on the Drawing, the Works "as directed", "as described", "as ordered", "as requested", "as required", "as permitted", or words of like import are used, it shall be understood that the direction, description, order, request, requirements or permission of the Engineer is intended. Similarly, the words "approved", "acceptable", "satisfactory", and words of like import shall mean approved by, acceptable to, or satisfactory to the Engineer.

"APPROVED"

This word when applied by the Engineer to the Contractor's Drawings or documents shall mean that the Drawings or documents are satisfactory from the standpoint of interfacing with Contractor's furnished components of the installations, and/or that the Engineer have not observed any statement or feature that appears to deviate from the Specifications requirements. Except for the interfacing with the Contractor's furnished components, the Contractor shall retain the entire responsibility for complete conformance with all of the Specifications requirements.
1.7 Inconsistency in Contract Documents

The Contractor shall execute the Works according to the provisions of the Contract Documents. Any work indicated in one of the documents but omitted not stated in one or more of the other documents shall be treated as though it were included in all of them.

If any two documents of the Contract conflict as to the quantity of the work to be carried out, the discrepancy shall be brought to the notice of the Engineer, who shall instruct the Contractor which of the two conflicting documents to regard as correct.

If the Contractor should discover that any work has been omitted and/or not indicated entirely or partially from all the documents, but that such work is essential to the safety or proper functioning of the Works, he shall report the facts immediately to the Engineer. If the work is something which in the opinion of the Engineer could not have been foreseen by an experienced Contractor, the Engineer shall issue to the Contractor a variation order stipulating the details of the work to be done. Save as aforesaid in the above paragraph, no additional payment shall be made in respect of work carried out in connection with discrepancies between the various Contract Documents.

1.8 Errors in Computing Contract Documents

The Contractor shall be responsible for any error which he makes in computing any quantities of material and labor required or costs involved or through any lack of knowledge of the site of misunderstanding or any thing shown or implied on the Drawings or in the Specifications and/or the bills of Quantities.

The Contractor must refer any discrepancy in the Drawings or the Specifications to the Engineer before proceeding in any of the Works. The decision of the Engineer as to the interpretation of the discrepancy will be final.

Any item or items of work not specifically shown on the Drawings or referred to in the Specifications but which should be necessary for the proper construction of the Works in accordance with the best practice is implied and must be included for as incidental to the Contract price.

Any item which the Contractor has not inserted a price in the Bills of Quantities shall be deemed to be covered by other prices or rates therein.

1.9 Temporary Works and Reinstatement

Temporary staging shall be provided by the Contractor to enable the construction operations to be performed in the required sequence. The staging shall be properly designed and constructed for the loads which it will be required to support, and complete details of the arrangements proposed shall be submitted for approval.
Such approval, however, will not relieve the Contractor of his responsibility for the adequacy of the staging. The cost of such staging is to be included in the tendered rates and prices entered in the Bills of Quantities.

The Contractor shall provide and maintain all temporary roads and tracks necessary for movement of plant and materials and clear same away at completion and make good all Works damaged or disturbed.

The Contractor shall submit Drawings and full particulars of Temporary Works to the Engineer before commencing same.

The Engineer may require modifications to be made if he considers them to be insufficient and the Contractor shall give effect to such modifications but shall not be relieved of his responsibilities for the sufficiency thereof.

The Contractor shall provide and maintain weatherproof sheds for storage of materials pertinent to the Works both for his own use and for the use of the Employer and clear same away at the completion of the Works.

The Contractor shall divert as required, at his own cost and to the approval of the Engineer, all public utilities encountered during the progress of the Works, except those specially indicated on the Drawings as being included in the Contract.

Where diversions of services are not required in connection with the permanent Works, the Contractor shall uphold, maintain and keep the same in working order in existing locations.

The Contractor shall make good, at his own expense, all damage to telephone, telegraph and electric cables or wires, sewers, water or other pipes, except where the Public Authority or Private Party owning or responsible for the same elects to make good the damage. The cost incurred in so doing shall be paid by the Contractor to the Public Authority or Private Party on demand.

All injury to the surface of the land, to the beds of water-courses, projecting banks, etc..., where disturbed by the Works (other than where specifically ordered by the Engineer) shall be repaired by the Contractor or the Authorities concerned, at the Contractor's expense. All such making good shall be to the approval of the Engineer.

The requirements detailed above shall be provided and maintained at the expense of the Contractor.

The Employer shall not be liable for loss or injury to any Temporary Works.

1.10 Existing Facilities

The existing facilities must be kept in continuous operation throughout the construction period. No interruption will be permitted which adversely affects the degree of service provided. Provided permission is obtained from Employer and Engineer in advance, portions of the existing facilities may be taken out of service for short periods corresponding with periods of minimum service demands. Such permission will not relieve the Contractor of any of his responsibilities under the Contract.
1.11  Lines and Grades

The Contractor shall keep the Engineer informed, a reasonable time in advance, on the times and places at which he intends to do work, in order that lines may be established and necessary measurements for record and payment made with a minimum of inconveniences to the Engineer or delay to the Contract. The Contractor shall have no claim for damages or extension of time account of delays in the giving of lines and grades, making record measurements or destruction of such marks and the consequent necessity for replacement.

The Engineer will furnish the Contractor with such basic lines as he, the Engineer, deems necessary, but this shall not be constructed to mean all lines, elevations and measurements. It shall be the Contractor's responsibility before commencing any section of the Work to locate the permanent bench marks to be used. The Contractor shall refer all temporary bench marks thereto.

The Contractor shall be responsible for the stake-out survey for construction purposes and the replacement of monuments and property, markers disturbed by the work. The survey shall proceed in advance of the construction at a rate satisfactory to the Engineer. The Contractor shall keep the Engineer fully informed as to the progress of the stake-out survey.

The exact position of all work shall be established from control points which are given or modified by the Engineer. Any error, apparent discrepancy or omission in the date shown or required for accurately accomplishing the stakeout survey shall be referred to the Engineer who shall take whatever corrective measures be deemed necessary.

The Contractor shall be responsible for the accuracy of his work and shall maintain all reference points, stakes, etc..., throughout the life of the Contract. Damaged, destroyed or inaccessible reference points, bench marks or stakes shall be (replaced by the Contractor, existing or new control points) that will be or are destroyed during construction shall be reestablished and all reference ties recorded therefore shall be furnished to the Engineer. All stake-out survey work shall be referenced to the bench mark and valve centers given by the Engineer.

All computations necessary to establish the exact position of the work from control points shall be made and preserved by the Contractor. All computations, survey notes and other records necessary to accomplish the Work shall be neatly prepared and made available to the Engineer upon request or furnished upon Contract completion.

All instruments, equipment, stakes and other material necessary to perform the Work shall be provided by the Contractor.

All stakes used shall be of a type acceptable to the Engineer, clearly and permanently marked, so as to be legible at all time. It shall be the Contractor's responsibility to maintain these stakes in their proper position and location at all times. Any existing stakes or markers defining property lines and survey monuments which may be disturbed during construction shall be properly tied in to fixed reference points before being disturbed and accurately rest in their proper position upon completion of the Work.
The Engineer may check all or any portion of the stake-out survey work or notes made by the Contractor and any necessary correction to the Work shall be immediately made. Such checking by the Engineer shall not relieve the Contractor of any responsibilities for the accuracy or completeness of his work.

1.12 Survey Monuments

When any monument or property marker, whether of stone, concrete, wood or metal, or a mark on the pavement or sidewalk designating the lines of the streets or highway or of private property is in the line of any trench of other constructing work and may have to be removed, the Contractor shall notify the Engineer in writing at least 48 hours in advance of removal. Under no circumstances shall such monument or marker be removed or disturbed by the Contractor or by any of his sub-contractors, employees or agents, without a written order from the Engineer. The Contractor shall furnish all necessary labor and materials required in correctly resetting any monument or property marker disturbed. Should any monument or marker be destroyed through accident or neglect, the Contractor will be required, at his own expense, to correctly reestablish the monument or marker.

1.13 Subsurface Structures and All Utilities

Before beginning excavation operations, the Contractor shall contact the specified departments of the Municipality and utilities and notify them of his intention to begin excavation operations.

The contractor has to consider all the existing obstacles in his price.

The Drawings may show and specifications may discuss certain drainage or other structures or facilities believed to exist in the working area, the exact location of which may vary from the locations indicated. All drainage or other structures or facilities may not be shown. The Drawings do not show all sewage collection pipes, storm water collection conduits, underground electric conduits or aboveground telephone facilities, underground sanity facilities, all of which are known to exist in the area. There may be certain other facilities and utilities in the work not listed above or not shown on the Drawings, including all service connections that must remain in service.

It shall be the responsibility of the Contractor to determine the exact location of such pipeline, subsurface, structures and/or utilities ahead of his Work by exploratory excavation or other means and to take suitable precautions to prevent damage to them and to prevent interruption of the services which such facilities provide. If they are broken or damaged, they shall be restored by the Contractor or the appropriate utility at the Contractor's expense. Where pipelines, subsurface structures and/or utilities encountered in the Work coincide with the location of the Employers water pipes and the Engineer deems it advisable, the location of the water pipes may be changed to avoid the facilities. Where the Engineer does not deem it advisable to relocate the Employer's water pipes and where the pipeline, subsurface structures and/or utilities require relocation before the work can proceed, the Contractor shall notify the Engineer and the owner of said facilities of the location and circumstances and shall cease Work, if necessary, until the Contractor can establish satisfactory procedures to
properly move, remove or care for the facilities in conflict with the Employer's water pipes.

When electric cables, telephone cables, sewers drains, other pipelines, subsurface structures and/or utilities parallel and are in close proximity to the Work and they must be removed, relocated or altered in any way, the Work shall be in strict accordance with the requirements and specifications of the owner of said facilities.

In addition, the Contractor shall pay particular attention to poles, pole lines, overhead wires and all other facilities aboveground that may be in conflict with the work. The Contractor shall follow the same procedures outlined herein for underground facilities.

No claim for additional compensation will be allowed on account of any delay occasioned by the relocation of the Employer's water pipes or the relocation or removal of the pipe lines, subsurface structures and/or utilities above and below ground necessary for the construction of the Employer's water pipes. The entire cost of all pipelines, subsurface structures and/or utilities or other subsurface or aboveground facilities shall be included in the prices stipulated for the appropriate items of the Contract.

1.14 Safety of Adjoining Existing Buildings

The Contractor shall take all necessary precautions during the excavation for the Works particularity those excavations which are adjoining existing building and shall protect such buildings from damage or collapse by means of temporary or permanent shoring, strutting, sheet piling or underpinning or excavation in short length and/or other methods as he deems fit. Also, he shall properly support all foundations, trenches, walls, floors, etc..., affecting the safety of the adjoining existing buildings.

The contractor has to reconstruct any construction which will be affected by him during his works without any additional cost and this will be his own responsibility.

The Contractor shall alter, adopt and maintain all such Works described above for the whole period of the Contract and shall finally clear away and make good all damages done.

The construction and efficiency of the shoring, underpinning, strutting, etc..., for the purpose for which it is erected shall be the responsibility of the Contractor. Should any subsidence or any other damage occur due to the inefficiency of the shoring, underpinning, strutting, etc..., or any other support provided, the damage shall be made good by the Contractor at his own expense and responsibility.

The shoring strutting, piling, etc..., shall be executed in such a manner as to cause as little inconvenience as possible to adjoining owners or the public and the Contractor shall be responsible for negotiating with the adjoining owners the means to safeguard their property and for the use of any portion of their land for the purpose of executing the excavations and no claims submitted on this ground will be entertained.
The Contractor shall be held solely responsible for the safety of the adjoining existing buildings, the sufficiency of all temporary or permanent shoring, underpinning, strutting, piling, etc.

The Contractor shall keep the Engineer informed as to the manner in which he intends to proceed with the execution of the excavations and obtain his approval, such approval if given shall not absolve the Contractor of his responsibility under this clause.

The Contractor shall save harmless and indemnify the Employer in respect of all claims, demands, proceedings, damages, costs, charges and expense whatsoever arising out of or in relation to any such matters in so far as the Contractor is responsible under this clause.

1.15 Watching

The Contractor shall allow for all necessary watching for the security of the Works and the protection of the public, including shelter and fuel for any watchman as required.

1.16 Water for the Works

The Contractor shall provide all necessary water for the Works, with all temporary plumbing and storage, pay all charges, and alter, adapt and maintain temporary work as necessary and remove and make good at completion.

1.17 Electrical Power and Lighting for the Works

The Contractor shall provide all necessary artificial lighting and power for the execution and security of the Works and for protection, with all meters, temporary wiring and fittings, etc., pay all charges, and alter, adapt and maintain the temporary work as necessary and remove and make good at completion.

1.18 Medical Facilities

The Contractor shall arrange for medical attention to be available when necessary and shall provide dressing stations complete with all adequate first aid equipment within easy access of each Works area on the site.

The Contractor shall display in suitable places and names of his employees who are available from time to time to render first aid. The Contractor shall provide for the transport of serious cases to the nearest hospital.

1.19 Rejection of Materials and Works

a) The Director of works shall, during the progress of the works, have the power to order in writing:

b) the removal from the site of any materials which in the opinion of the Director of Works are not in accordance with the Contract Documents,
c) the substitution of proper and suitable materials, and

d) the removal and proper re-execution (not with standing any previous test thereof or interim payment therefor) of any work which in respect of materials or workmanship is not, in the opinion of the director of Works, in accordance with the Contract Documents.

All such orders shall be executed at the contractor’s expense.

a) Should the Contractor fail to carry out such order, after receipt of a notice issued in accordance with general condition, the operator shall be entitled to employ and pay to the other persons to carry out the order and all expenses consequent thereon or incidental thereto shall be borne by the Contractor and recoverable from him by the operator from the Security Deposit and/or from any sums to the Contractor without prejudice to any other rights which the operator may have in law or equity.

b) In no case shall the rejection of materials or work entitle the Contractor to an extension of the Contract time.

1.20 Periodic Reports

The Contractor must present to the Engineer’s Representative detailed reports and schedules in five copies, and shall prove to Engineer the correctness of the above mentioned reports without having the right to claim for any extra payment or compensation whatsoever in regard or in relation to such reports.

1.21 Photographs

The Contractor shall furnish, to the engineers representative sufficient Film for colour Prints, compatible with the Engineers Representative's camera to take the photographs. The employer may require up to 5 prints each of the photographs at a maximum size of 215 x 275 mm each. The contractor will pay for all developing of the photographs taken by the Engineers Representative. The Engineers Representative will furnish all cameras.

1.22 Site Progress Meetings

Site Progress meetings shall be held at regular intervals at least once every week in the presence of the Engineer for the purpose of coordinating the Contractors Works and to ensure that full compliance with the various Site meetings will be recorded, copies will be distributed to all persons concerned and full effect shall be given to all instructions contained herein.

Prior to such meetings the Contractor shall give to the Engineer's Representative details in, writing of that portion of the works he proposes to construct during the coming two weeks with details of the plant and methods he proposes to employ These proposals shall be discussed at the meeting and no work based on such proposal shall proceed without the approval of the Engineers Representative.
1.23  Customs and Local Dues

All state dues, tolls rates, duties, fees and charges in connection with the Works shall be deemed to be included by the Contractor in his Contract Unit Rates.

1.24  Materials, Goods and Workmanship

Materials delivered to the Site for the purpose of the Works, shall be accompanied by a "Certificate of Guarantee" signed by the authorized representative of the manufacturer, which will legally bind the manufacturer to the product delivered.

Such Certificate shall state that the materials specifications and test results are in compliance with the specified requirement of the pertinent designations of the most recent edition of ASTM or any other approved equivalent National Standard unless otherwise directed.

Falsification of such Certificates, Materials, Specifications or Test Results shall be just cause for the rejection of the materials.

Materials, goods and workmanship shall be of the best quality of their respective kind. The Contractor shall carry out everything necessary for the proper execution of the Works, whether or not shown on the Drawings or described in specifications.

Work for which provisional quantities are specified will be measured and dealt with in the manner stated in the conditions of Contract for provisional sums.

1.25  Specifics Manufacturer’s Products

Manufacturer's name or catalogue number, if shown in the specification or indicated on the Drawings, are given only for indicative purposes and for general reference only. It shall be understood that the actual material supplied shall meet the requirements of the specifications and, if necessary, the material specified under such manufacturer's name or catalogue indicated for reference, shall be modified under the direction of the Engineer.

Provided always that such modified material shall meet the requirements of the specified material together with the requirements of other materials specified for other trades in these specifications.

Any modification under such conditions shall not give the right to the Contractor to claim against any loss or extra cost incurred.

The contractor shall submit to the employer full set of catalog and manuals of the manufacturer (one original and two copies).
1.26 Alternative Materials

Should the Contractor wish to offer alternative items or materials to those specified, he shall supply details of such alternatives together with details of any reduction in the Contract price should the alternative be allowed to be substitute for the specified items of materials. All offered alternatives shall comply fully in all respects with the specifications of the particular items or materials. Acceptance or refusal or such alternatives will be entirely at the discretion of the Engineer.

If during the course of the Contract certain materials or items required for use in the Works should be unobtainable, despite the best effort of the Contractor, the Contractor may offer for the approval of the Engineer alternative materials or items, provided that they possess the minimum requirements of the originally specified material.

In the event of acceptance of any alternative materials or items, a suitable price reduction shall be made in respect of any decrease in value but no price addition shall be made in respect of increase in value.

In the event of refusal of any alternative materials or items the Contractor shall not be relieved of any of his obligations under the Contract and shall be solely liable for any delay or loss occasioned by his failure to provide the material or items as specified.

1.27 Imported Materials

The Contractor is required to produce documentary evidence that all imported materials or items have been ordered shortly after the site is handed over for the commencement of the Works. This means materials or items which have to be ordered from abroad. As soon as orders have been placed, copies of such orders shall be submitted to the Engineer. Consequently, no claim will be considered for extension of the Contract Period due to non-availability of materials.

1.28 Care of the Works

The Contractor shall keep all persons (including those employed by sub-contractors) under control and within the boundaries of the Site. He will be held responsible for the care of the existing premises and of the Works generally until their completion, including all work executed and materials, goods and plant (including those of sub-contractors and Suppliers) deposited on the Site; together with all risks arising from the weather, carelessness of work people, damage or loss by theft or any other cause; and he shall make good at his own expense, all such damage and loss.

1.29 Protection from Weather and floods

The Contractor shall keep the Works well drained until the Engineer certifies that the whole of the Works is substantially complete and shall ensure that so far as is practical, all work is carried out in the dry weather. Excavated areas shall be kept well drained and free from standing water.

The Contractor shall construct, operate and maintain all temporary dams, watercourses and other Works of all kinds including pumping and well point...
A dewatering plant that may be necessary to exclude water from the Works while construction is in progress. Such temporary Works and plant shall not be removed without the approval of the Engineer's Representative.

Notwithstanding any approval by the Engineer of the Contractor's arrangements for the exclusion of water, the Contractor shall be responsible for the sufficiency thereof and for keeping the Works safe at all times particularly during any floods and or making good at his own expense any damage to the Works including any that may be attributable to flood. Any loss of production of additional costs of any kind that may result from floods shall be at the Contractor's own risk.

1.30 Clearing Away

The Contractor shall take down and clear away all plant and temporary Works, including sheds, mess rooms, sanitary conveniences, offices, latrines, sign-boards, and other temporary Works, unless otherwise described, and made good.

The Contractor shall remove all existing rubbish and debris and surplus materials from the site as they accumulate and at completion; and clean all surfaces, including those of the effected portions of the existing premises, internally and externally, remove stains and touch up paint work and polished work, and leave the Works clean and to the satisfaction of the Engineer at completion.

1.31 Site Along Pipelines in Roads

The Contractor shall make all the necessary arrangements for any land required for working areas outside the right of way, including payment when necessary, and the Employer does not accept any liability in connection with such land. This includes land for temporary roads, detours and diversions.

Without prejudice to the generality of the Conditions of Contract, the Site along pipelines in roads unless the road is closed as hereafter provided, shall so far as possible be so limited that in all cases a free passage along such roads shall be maintained for vehicular traffic and pedestrians.

The Contractor shall provide access to all properties including garages fronting on such roads.

The Contractor shall assume and have full responsibility for the adequacy of safety provisions on all streets, roads, private ways and walks affected by his work.

1.32 Closing of Roads

The Contractor shall not close any road unless the Authority having charge of the road surfaces shall have previously given the appropriate notice or made the appropriate order and without the Contractor having first obtained the written consent of the Local Authority to close the same. In the event of such consent being refused, the Contractor shall have no claim for any additional payment. In the event of such consent being given, the Contractor shall provide, fix and maintain all warning signs and diversion notices as may be required by the said Authority and by the Engineer.
1. The Contractor shall provide, erect and maintain such traffic signs, lamps barriers and traffic control signals as may be necessitated by the construction of the Works in accordance with Highway Authority and Traffic Police requirements. The Contractor shall submit proposals for dealing with such situations to the Engineer and Traffic Police for consent. Compliance with this Clause shall not relieve the Contractor of any of his other obligations and liabilities under the Contract.

2. The Contractor shall, after consultation with any statutory or other authority concerned, submit to the Engineer for his approval a programme based on such consultation showing the scheme of traffic management he proposes for carrying out the Works before commencing any work which affects the use of the public highway and thereafter furnish such further details and information as necessitated by the Works or as the Engineer may require.

3. The Contractor shall not commence any work which affects the public highway until all traffic safety measures necessitated by the work are fully operational.

4. The flashing rate for flashing lamps shall be within the range 120-150 flashes per minute. The minimum luminous intensity of the lamps shall be 0.5 candela for steady lamps, 1.0 candela for ripple lamps at their peak, and 1.5 candela for flashing lamps at their peak.

5. The Contractor shall keep clean and legible at all times all traffic signs, lamps, barriers and traffic control signals and he shall position, re-position, cover or remove them as necessitated by the progress of the Works.

6. Where unsealed diversion roads are approved these must be maintained at frequencies to suit the traffic volume using them. A good running surface must be maintained and must at all times be free from ruts and potholes.

The Contractor shall, when required, supply in writing full information regarding the localities in which the materials are being obtained and in which the work is being prepared.

No permanent work shall be carried out without the consent in writing of the Engineer's Representative.

Full and complete notice, in writing, shall be given 24 hours in advance of the time of the operation in order to make such arrangements as deemed necessary for inspection.

1.33 Roads to Be Kept Clean

The Contractor shall take great care and all reasonable precautions to ensure that the roads and thoroughfares used by him either for the construction of the Works or for the transport of plant, labor and materials, are not dirtied as a result of such (construction or transport) and, in the event of their becoming thus dirtied in the opinion of the Engineer's Representative the Contractor shall take all necessary and immediate steps to clean them.
1.34 Road Crossing

Road crossing should be performed by digging the trench across the road and install the UPVC pipes inside a steel sleeve bigger in diameter. The crossing should be carried out with the coordination with the Municipality.

1.35 Tests for Watertightness of Structures

Inspection and testing of structures should be carried out as required in accordance with section 6 of CP 114, CP 115 : Part 2 : 1969 or section 9 of CP 110 : Part 1 : 1972 as appropriate. Testing for water tightness should be in accordance with the specifications.

Water retaining structures shall be capable of withstanding the following tests for water tightness with full care to protect the structure from damages by considering the right ways to fill the structure with water or by loading the earth pressure by carrying out the backfilling:

When ordered by the Engineer, the structures shall be filled with water by the Contractor at rates and to the depths ordered by the Engineer and kept filled for one week.

The water used need not be equal to normal drinking water but the source of the water shall be approved by the Engineer.

The structure when filled shall satisfy the test if at the end of one week no leakage is apparent.

Upon completion of the test the Contractor shall empty the structures and dispose satisfactorily of the contents. He shall clean the structures and any equipment therein of all deposits left by the testing water.

All pipelines shall be tested for water tightness in accordance with the specifications.

Roofs to potable water retaining structures should be watertight and should be tested on completion by either of the following methods:

A. flood the roof to a minimum depth of 25 mm of water for a period of 24 h;
B. use a hose or sprinkler system to obtain sheet flow over the whole rate of the roof for a period of not less than 6 h.

In either case the roof should be considered satisfactory if no leaks or damp patches show on the soft.

The tests referred to above, shall be performed at the Contractor's expense and shall be considered incidental to the Contractor.

1.36 Testing on Completion

The Engineer may before issuing the Certificate of Completion require any part of the Works to be tested for conformity with the Specifications and according to the manufacturer's instructions. Such tests shall be made at the Contractor's expense.
1.37 Inspection

Where the approval of the Engineer is required under these Specifications such approval shall not relieve the Contractor of his duties or responsibilities under the Contract.

If work to be done away from the constructing site is to be inspected on behalf of the Employer during its fabrication, manufacture, or testing, or before shipment, the Contractor shall give notice to the Engineer of the place and time where such fabrication, manufacture, testing, or shipping is to be done. Such notice shall be in writing and delivered to the Engineer in ample time so that the necessary arrangements for the inspection can be made.

In respect of all items of equipment and materials to be imported for incorporation in the permanent Works, the Contractor shall submit to the Engineer's Representative in the English language, inspection and test reports issued in the country of origin and certified by an independent inspector or inspection firm of international repute approved in advance by the Engineer. The reports shall certify that all such items are in full compliance with the Contract requirements and specifications and shall be accompanied by full details of sampling, inspection and test results. Each report shall be submitted prior to the shipment of the related items to the site.

No extension of time on account of delays due to inspection shall be granted as such times as is needed for inspection shall be considered to have been considered in the schedule of the Works.

Material and equipment procured with the country for incorporation in the permanent Works shall be inspected at the place of origin by competent and experienced specialized personnel appointed by the Contractor and approved by the Engineer. Inspection and test reports certifying that the related item is in full compliance with the Contract requirements and specifications shall be submitted prior to its incorporation in the Works.

The certification herein prescribed shall be submitted whether or not the engineer or his representative has exercised the right to witness tests or make inspections at the point of origin. The Engineer shall be entitled to apply the Condition of Contract in respect of items not so certified. Certification shall be furnished at the Contractor's expense. It shall not relieve the Contractor of the obligation to ensure that all material and workmanship incorporated in the Works shall be in full compliance with the Contract requirements and Specifications at the time of final handing over of the completed Works.

1.38 Protection of Finishes

The Contractor shall take every care to prevent damage to the Works from whatever cause and shall ensure that adequate protection is given to all Works from the activities of following trades and nominated sub-contractors. Vulnerable parts of the work particularly liable to damage, shall be protected as may be reasonable required by the Engineer's Representative.
1.39 Cooperation with Other Contractors

The Contractor shall note that other Works might be constructed in the Site of Works. He shall co-operate with the contractors of such Works in organizing their respective contracts so as to cause minimum of interference to each other and to the public. No claims resulting from such cooperation shall be entertained by the Employer except as stipulated in the Conditions of Contract.

1.40 Suppression of Noise and Pollution

The Contractor shall make every reasonable endeavor both by means of temporary Works and by the use of particular plant or silencing devices to ensure that the level of noise or pollution resulting from the execution of the Works does not constitute a nuisance.

The Contractor shall take all such precautions as may be necessary in the conduct of the work to avoid water pollution, air pollution, noise pollution harmful to health, spreading of plant diseases and pests or damage to natural resources or the environment, all as is consistent with good practice and as required by applicable laws, ordinances and regulations or lawful orders or authority having jurisdiction.

1.41 Protective Equipment and Clothing

The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for the operative and Site staff.

1.42 Cleaning Up

During its progress the work and adjacent areas affected thereby shall be kept cleaned up and all rubbish, surplus materials needed equipment shall be removed and all damage repaired so that the public and property owners will be inconvenienced as little as possible.

Where material or debris has washed or flowed into or been placed in existing watercourse, ditches, gutters, drains, pipes, structures, work done under this Contract, or elsewhere during the course of the Contractor's operations, such materials or debris shall be entirely removed and satisfactorily disposed of during the progress of the work, and the ditches, channels, drains, pipes, structures and work, etc..., shall, upon completion of the work, be left in a clean and neat condition.

On or before the completion of the work, the Contractor shall, unless otherwise especially directed or permitted in writing, tear down and remove all temporary buildings and structures built by him; shall remove all temporary Works, tools and machinery or other construction equipment furnished by him; shall remove, acceptably disinfect, and cover all organic matter and material containing organic matter and in, under and around privies, houses and other buildings used by him; shall remove all rubbish from any grounds which he has occupies and shall leave the roads and all parts of the premises and adjacent property affected by his operation in a neat and satisfactory condition.
The Contractor shall restore or replace, when and as directed, any public or private property damaged by his work, equipment, or employees, to a condition at least equal to that existing immediately prior to the beginning of operations. To this end the Contractor shall do as required all necessary highway or driveway, walk and landscaping work. Suitable materials, equipment and methods shall be used for such restoration.

The Contractor shall thoroughly clean all materials and equipment installed by him and his sub-contractors and on completion of the work shall deliver it undamaged and in fresh and new-appearing condition. All mechanical equipment shall be left fully charged with lubricant and ready for operation.

1.43 Permits, Licenses and Fees

The Contractor shall obtain and pay for all construction permits and licenses. Employer shall assist Contractor, when necessary, in obtaining such permits and licenses. Contractor shall pay all governmental charges and inspection fees necessary for the prosecution of the work. Contractor shall also pay all charges of utility service companies for connections to the work.

1.44 Methods of Measurement and Payment

1.44.1 Quantities

All estimated quantities stipulated in the Tender Form or other Contract Documents are approximate and are to be used only;

A. as a basis for estimating the probable cost of the work and
B. for the purpose of comparing the bids submitted for the work.

The actual amounts of work done under unit price items may differ from the estimated quantities. The basis of payment for work will be actual work done. Contractor agrees that he will make no claim for damages anticipated profits or otherwise on account of any differences between the amounts of work actually performed and the estimated amounts.

1.45 Advertising/Sign Board

The Contractor shall provide 4 boards with size of 2x3m at approved locations on the Site as agreed with the Engineer having suitable inscription including the name of the Contractor in accordance with details or directions given by the Engineer. No separate payment will be made for such advertising the cost of which is deemed to be included in the tendered rates and prices
1.46 Site Office for the Engineer’s Representative

1.46.1 General

The Contractor shall provide, maintain and keep clean, temporary site offices with all associated equipment and services for the exclusive use of the Engineer's Representative and his staff, from commencement of the Permanent Works until a Taking-Over Certificate is issued in respect of the Works.

The temporary site offices shall be either prefabricated portable unit/s or alternatively of some other form of weatherproof design and construction to the approval of the Engineer.

The offices shall have full partitions and room sizes shall be as shown in the attached Schedule of offices. All rooms shall have individual entrance doors.

Corridor and entrance areas shall be additional to the office sizes.

The offices shall be air-conditioned with the exception of the Toilet and Kitchen areas.

All rooms shall have glazed windows complete with fly screens.

Adequate fitted hardware, electrical switches, sockets, lighting, and plumbing fittings, sanitary ware and fittings and fixtures etc., shall be provided as necessary for the different areas.

The electrical installation shall provide for simultaneous use of all electrical appliances.

The Contractor may either arrange for a temporary power supply to the offices or alternatively provide and maintain adequate diesel generator sets. All electricity bills shall be paid by the Contractor.

The Contractor may either arrange for a temporary mains water supply or alternatively provide water tank supply. All water bills shall be paid by the Contractor.

One independent telephone line shall be provided for the offices as shown in the Schedule of Fittings and the Contractor shall pay all installation and rental charges and call charges within Palestine.

The Contractor shall submit any necessary drawings and calculations for the construction of the offices for the Engineer's approval before commencing construction and shall be responsible for ensuring that the offices are structurally sound. The Engineer may request alterations at this stage. The drawings shall be
approved in writing by the Engineer before installation/construction shall commence.

The offices shall be completed and all the equipment provided by the Commencement of the Permanent Works.

The Contractor shall provide all items listed in the attached Schedules.

Throughout the duration of the Contract, the Contractor shall ensure an uninterrupted supply of gas, water and electricity to the offices.

1.46.2 Specific Requirements

1. The Contractor shall be responsible for making all arrangements and payments in respects of any land required for the site.
2. The Contractor shall be responsible for the security of the office building and its contents at all times and shall employ watchmen for this purpose.
3. The Contractor shall supply the Consultant's staff with all safety clothing and equipment that shall be necessary for site working such as safety helmets, reflective waistcoats etc.
4. The contractor shall obtain the Engineer's approval for all furniture, and equipment proposed.
5. The Contractor shall retain on site for the exclusive use of the Engineer all codes and standards referred to in the Specification.
6. The office building and services shall be available, fully maintained, until the Taking-Over Certificate for the whole of the works has been issued.

The office building shall become the property of the Contractor after the completion of the Works.

The electrical supply shall be 220-250 volts, 50 Hz. Where the number of rooms required for the site office exceeds 4 No. (excluding toilet & kitchen) then a minimum of 1 No. Telephone line is required.

The office building shall be as new portable type cabins erected on suitable solid foundation.
SCHEDULE OF OFFICES

The office requirements on this contract are as follows:

<table>
<thead>
<tr>
<th>Room No.</th>
<th>Description</th>
<th>Size Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Project Manager</td>
<td>4m x 4m Yes</td>
</tr>
<tr>
<td>2.</td>
<td>Conference Room</td>
<td>6m x 4m Yes</td>
</tr>
<tr>
<td>3.</td>
<td>Toilet</td>
<td>2m x 2m Yes</td>
</tr>
<tr>
<td>4.</td>
<td>Kitchen</td>
<td>4m x 2m Yes</td>
</tr>
</tbody>
</table>

SCHEDULE OF FITTINGS

The fittings required under this contract for the site offices indicated in the schedule of offices, shall be to the Engineer's approval and are as follows:

Room No. and Quantity

<table>
<thead>
<tr>
<th>S/No.</th>
<th>Description of Item</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Executive desk with two locking drawers and chairs</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Desk with two locking drawers &amp; chair</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Conference table</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Desk with two locking drawers &amp; chair</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Chair plastic covered padded, steel frame</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Typist desk and chair</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Full size drawing board with stand, stool &amp; ‘T’ square</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Inclined plan table for drawings</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Six drawer plan chest</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Samples cupboard</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Four drawers steel filling cabinet</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>In/Out tray</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Four tier filling tray</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>Telephone hand set</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Waster paper basket</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>Portable dry powder fire extinguisher</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>Maximum-minimum thermometer</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>European W.C suit</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Wash hand basin, shelf, mirror &amp; towel rail</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Extractor fan</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>2 ring gas burner</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Refrigerator 6 cubic feet</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Water filter</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Sink unit</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Electric kettle</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Local telephone authority approved Fax machine with a separate telephone line</td>
<td>1</td>
</tr>
</tbody>
</table>
- Plane paper photocopier (A3/A4 format, reduction/enlargement facility, cassette feeds and sorting facility).

- Camera (Auto focus with 30-100 range lens and date imprint facility)
- Hire a car to the engineer representative (the Consultant’s Engineer) the car must be of not less than 2000 model-1600 cc engine capacity, automatic, air conditioning, with all the required and needed maintenance, petrol, insurance .. etc.. All these costs and fees must be paid by the contractor.

In addition to this telephone requirement the Contractor shall supply two mobile phones to the Consultant’s Engineers. These mobile phones will become the property of the Contractor at the completion of the Contract. The Contractor shall be responsible for all fees, costs and telephone charges incurred by the Project Manager for the duration of the Contract.

1.46.3 Payment

Payment will not be made for this item separately Preliminaries for the provision, erection, installation of the building and its services, including all charges for electricity, water local telephone etc. and all land charges in respect thereof and removal of the building and clearing area to the approval of the Project Manager after the completion of the project. Maintenance, including cleaning, servicing and charges for electricity, water and local Palestine telephone charges etc. shall be deemed included in the contract bid items.

1.46.4 Assistance to the Engineer

One) The Contractor shall provide and maintain for the use of the Engineer such surveying and engineering instruments as the Engineer may require for his duties (as mentioned). The Contractor shall provide the Engineer with all necessary assistance in checking the setting out of the
Works and interpreting any information used by the Contractor for this purpose including the sole use of a minimum of 3 chairmen.

Two) The Contractor shall provide the Engineer with all assistance, equipment and material required to document and record progress of the Works. The contractor must submit daily progress reports. Monthly progress reports including photographs as required by the Engineer shall be prepared in 5 copies size A4. The number of photographs will be as directed by the Engineer.

The contractor shall provide the engineer with complete set of contract documents and drawings as requested by the engineer.

Three) The Contractor shall provide all assistance, equipment and material required by the Engineer for all the measurement of the works for monthly valuation and for the final certificate payment.

Four) The Contractor shall be responsible for all follow up and co-ordination with all the service departments. (Electricity, Water, Drainage, Street Lighting, Telephone, Horticultural etc.). The contractor is responsible to pay all fees and insurance that may be required by the concerned parties to complete the works.

Five) The Contractor shall provide all unskilled labor and necessary tools as directed by the Engineer.

Six) If at any time before the commencement or during the progress of the work it appears to the Contractor that for the proper execution of a specified part of the Works, shop drawings are necessary, these drawings shall be established by the Contractor and submitted to the Engineer's Representative for approval. On the other hand, the Engineer's Representative shall have authority to order at any time and the Contractor agrees to provide any number of shop drawings which, in the opinion of the Engineer's Representative are necessary for the proper execution of a specified work. The Contractor shall not proceed with the above mentioned work until these shop drawings are approved by the Engineer's Representative. The Contractor shall not be entitled to any extra compensation or extension of time for the preparation of the above mentioned drawings.

These details shall be dimensioned in the metric system and shall describe accurately the method of fabrication, applied finish and sizes of all members and fixings and shall indicate methods of marking of components for site erection.

Seven) The Engineer shall furnish the Contractor transparencies of the original drawings to be corrected as the Works proceed. The Contractor shall correct where required, prepare and supply the Engineer's Representative the new transparencies marked "AS-BUILT" for his approval. When any correction of the As-built Drawings is finished and these are finally approved by the Engineer the Contractor shall submit 1 set on an approved positive film, 6 sets on paper and electronic copy of these drawings.

Such "As-built" drawings shall include but not be limited to the following information.
- Offsets from permanent references such as road edge, road centerline, kerb line, building line etc. at suitable intervals as directed by the Engineer, for all services.
- Level profiles for all sewerage, drainage, rising mains and pipelines.

Also the contractor shall submit geometric and construction data for the Engineers review and approval. On approval from the Engineer, the contractor shall submit 6-copies of such records along with the "As-built" drawings.
No final payment shall be made except for work that has been completed in accordance with the Specification and has been duly presented on the "As-Built" Drawings.
The Contractor shall not be entitled to any direct payment or extension of time for the preparation of the above mentioned drawings.

Eight) The Contractor shall at the commencement of works, provide the Engineer's Representative for his full and exclusive use enough number of concrete, asphalt, and room thermometers as required by the Engineer.

1.46.5 Payment

No direct payment will be made for assistance to the Engineer. All costs shall be considered included in the Contract bid items.

1.47 Surveying Equipment

1.47.1 Schedule of Equipment

The equipment required on site under this contract shall be to the Engineer's approval and is as follows:

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a.</td>
<td>Rolling Straight Edge when required</td>
<td>1</td>
</tr>
<tr>
<td>b.</td>
<td>Electronic total station (TC 1600 or equivalent with data recording facilities)</td>
<td>1</td>
</tr>
<tr>
<td>c.</td>
<td>Target reflectors with 2 km range</td>
<td>3</td>
</tr>
<tr>
<td>d.</td>
<td>Automatic level, tripod and staff (NAK 2 or equivalent)</td>
<td>1</td>
</tr>
<tr>
<td>e.</td>
<td>2m ranging poles</td>
<td>10</td>
</tr>
<tr>
<td>f.</td>
<td>30 meter steel tape</td>
<td>2</td>
</tr>
<tr>
<td>g.</td>
<td>30 meter fiber tape</td>
<td>2</td>
</tr>
<tr>
<td>h.</td>
<td>Manhole lifting keys for: heavy duty covers</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>medium duty cover</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>light duty cover</td>
<td>6</td>
</tr>
<tr>
<td>i.</td>
<td>Weatherproof, rubber-cased torches</td>
<td>6</td>
</tr>
</tbody>
</table>
j. Survey arrows, wooden pegs, nails etc. as required

k. Safety helmets as required

l. Marking chalk, paint as required

m. One copy of all standards referred to in the Specification

Fourteen. 5 m steel tape 4
Fifteen. Hammer 1 kg. 2
Sixteen. Hammer 3 kg. 2
Seventeen. Level books, field books, surveying
Eighteen. Umbrellas as required.
Nineteen. Silica gel bags as required.
Twenty. Universal straight edge 3 m with edge gauge. 1
Twenty-one. 3 m steel pocket tape graduated in mm. 2
Twenty-two. Aluminum spirit level 1 m long with 4 plumb and two level tubes. 1

1.47.2 Expendable Materials

The Contractor shall provide adequate supplies of expendable materials such as stationary, pencils, inks, drawing paper, pens, pegs, brushes, paint and other similar items as required by the Engineer's Representative.

1.47.3 Payment

Payment will not be made under this item separately and maintenance of the equipment, the supply of expendable materials and the attendance required shall be considered in the contract bid price.

1.48 Laboratory

1.48.1 General

For the duration of the contract, the Contractor shall carry out the required testing, unless otherwise specified herein.

Any testing which is required under the contract which cannot be carried out by the Contractor shall be carried out at the Contractor's expense at an independent laboratory which is approved by the Engineer. A copy of such testing shall be forwarded to the Engineer. 24 hours notice is required prior to site testing.

The Engineer shall be permitted to witness the testing carried out by the Contractor or an approved independent laboratory.

All sampling for tests shall be carried out by the Consultant's Inspectors and labelled as per relevant standard sampling requirements (as listed in section 1.26)
1.48.2 Payment

No payment shall be made to the Contractor for laboratory and testing related works.

1.49 Minimum Test Requirements & Standard Sampling Methods

1.49.1 Minimum Test Requirements

The following is the schedule of minimum requirements governing tests of materials which shall be carried out during the execution of the Works.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Frequency</th>
<th>Relevant Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water for concrete</td>
<td>1 test for each source and as directed by the Engineer thereafter.</td>
<td>BS 3148</td>
</tr>
<tr>
<td>Portland Cement</td>
<td>1 bag cement for quality testing shall be taken from each 1700 bags or fraction thereof for each source or manufacturer. The Engineer may in lieu of this accept a testing certificate.</td>
<td>BS 12- O.P.C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4027-S.R.C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 4550</td>
</tr>
<tr>
<td>Coarse Aggregate Concrete</td>
<td>One sample for quality testing shall be taken from each designated source. After approval one sample shall be taken for quality testing from each 1000 m³ when the material is in use. On each sample 2 sets of the required tests should be carried out except sieve analysis which shall be 3 in number.</td>
<td>BS 812</td>
</tr>
<tr>
<td>Materials</td>
<td>Frequency</td>
<td>Relevant Standard</td>
</tr>
<tr>
<td>----------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>-----------------------------</td>
</tr>
<tr>
<td>Fine Aggregate for concrete</td>
<td>As for Coarse above</td>
<td>BS 812</td>
</tr>
<tr>
<td>Bituminous Materials</td>
<td>One sample of each type of material shall be taken for each source or delivery from the manufacturers. Subsequent testing shall be as directed by the Engineer but not less than one sample for each 500 drums (55 gal) or equivalent.</td>
<td>As per relevant parts under BS 2000</td>
</tr>
<tr>
<td>Aggregates for Bituminous Mixtures</td>
<td>One sample for quality testing shall be taken from each designated source. After approval one sample shall be taken for quality testing from each 1000 m$^3$ when the material is in use.</td>
<td>ASTM 04.03, as specified in Section 1 of BS 812</td>
</tr>
<tr>
<td>Mineral Filler for Bituminous Mixtures</td>
<td>One sample for quality testing from each 50 tonnes or fraction thereof.</td>
<td>BS 812</td>
</tr>
<tr>
<td>Bituminous Mixtures</td>
<td>(i) One sample of each days production or each 200 tonnes laid ever is greater, shall be taken for quality testing. The sample should be taken from the paving machine after approximately half of any one load has been laid or from the plant.</td>
<td>BS 598 AASHTO T 168 ASTM D 979 or part thereof which-</td>
</tr>
<tr>
<td></td>
<td>(ii) One core sample for specific gravity testing shall be taken for each 300 lin.m of traffic lane or 2000 m$^2$ or parts thereof for each completed layer of pavement.</td>
<td>AASHTO T230/T166</td>
</tr>
</tbody>
</table>
A quality testing procedure (laboratory) for each subgrade material or embankment material shall be carried out for each 1500m³ of material as follows:

(i) Granular Gradation AASHTO T88

(ii) Atterberg Limits (Liquid and Plastic Limits), Linear shrinkage. AASHTO T89 T90, BS 1377

(iii) Compaction test Modified Proctor with compaction curve to obtain optimum moisture content and max. dry density. BS 1377 Part 4 or later revisions thereof.

(iv) C.B.R. at 95% of modified Proctor density. BS 1377 Part 4 or later revisions thereof

After laying and compaction a quality testing procedure on each 1000 m² or part thereof should be carried out as follows:

(v) Field density AASHTO T 191

(vi) Moisture content ASTM D 2216

As directed by the Engineer the following tests may also be carried out on the material as laid on site:

(vii) Field C.B.R. (with moisture content determined by weight from speedy method). ASTM D 4429
<table>
<thead>
<tr>
<th>Materials</th>
<th>Frequency</th>
<th>Relevant Standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-bases and Aggregate Roadbases</td>
<td>A quality testing procedure (laboratory) for each sub-base or granular</td>
<td>AASHTO T89</td>
</tr>
<tr>
<td></td>
<td>roadbase material shall be carried out for each source but not exceeding</td>
<td></td>
</tr>
<tr>
<td></td>
<td>1000 m³ of material as follows:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>For every completed layer, one field density shall be determined on each</td>
<td></td>
</tr>
<tr>
<td></td>
<td>500 square metres.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(ii) Liquid Limit</td>
<td>AASHTO T90</td>
</tr>
<tr>
<td></td>
<td>(iii) Plastic Limit</td>
<td>BS 1377</td>
</tr>
<tr>
<td></td>
<td>(iv) Linear Shrinkage</td>
<td>AASHTO T176</td>
</tr>
<tr>
<td></td>
<td>(v) Sand Equivalent</td>
<td>BS 1377 Part 4</td>
</tr>
<tr>
<td></td>
<td>(vi) Compaction Test</td>
<td>ASTM D1557</td>
</tr>
<tr>
<td></td>
<td>by Modified Proctor</td>
<td>(Modified using</td>
</tr>
<tr>
<td></td>
<td>method with compaction curve.</td>
<td>AASHTO T-180)</td>
</tr>
<tr>
<td></td>
<td>(vii) CBR at 100% of the modified Proctor density.</td>
<td>BS 1377 Part 4</td>
</tr>
<tr>
<td></td>
<td>After laying and compaction the following testing procedure shall be</td>
<td></td>
</tr>
<tr>
<td></td>
<td>followed for every 1000 m² of each layer:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(vii) Field density</td>
<td>AASHTO T191</td>
</tr>
<tr>
<td></td>
<td>(2 no.)</td>
<td>BS 1881</td>
</tr>
<tr>
<td>Concrete</td>
<td>One set of at least 10 cubes (or 8 cylinders) shall be obtained from</td>
<td></td>
</tr>
<tr>
<td></td>
<td>each 75 m³ or fraction thereof placed in each day or class of concrete.</td>
<td></td>
</tr>
<tr>
<td>Materials</td>
<td>Frequency</td>
<td>Relevant Standard</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>Slump tests and compaction factor tests shall be carried out at the site of the actual placing of concrete as directed by the Engineer.</td>
<td>BS 1881</td>
<td></td>
</tr>
<tr>
<td>Preparation of concrete specimens &amp; curing of specimens</td>
<td>ASTM C-192</td>
<td></td>
</tr>
<tr>
<td>Minimum cement content of hardened concrete as directed by the Engineer.</td>
<td>AASHTO T126</td>
<td></td>
</tr>
<tr>
<td>Precast Concrete</td>
<td>The flexural/transverse/strength and water absorption for each supplier of precast kerbs and Slabs (2 no. samples). Subsequently, on approval of a source or supplier 3 samples will be tested every 1000 lin.m. for kerbs and every 1000 m² for Slabs (tiles).</td>
<td>AASHTO T97</td>
</tr>
<tr>
<td></td>
<td></td>
<td>ASTM C78</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 7263:Part 1 1990</td>
</tr>
<tr>
<td>Reinforcing Steel</td>
<td>Reinforcement steel shall be supplied to site with a manufacturer's test certificate for each load. Where directed testing on any sample of reinforcement for the following types may be required:-</td>
<td>BS 4483</td>
</tr>
<tr>
<td></td>
<td>(i) Steel fabric reinforcement.</td>
<td>BS 4449</td>
</tr>
<tr>
<td></td>
<td>(ii)Mild Steel and high yield(hot rolled) bars.</td>
<td>BS 4482</td>
</tr>
<tr>
<td></td>
<td>(iii)Cold worked steel bars.</td>
<td>BS 6200:part 3 section 3.8</td>
</tr>
<tr>
<td></td>
<td>Chemical Analysis of Steel for carbon content as directed by the Engineer.</td>
<td>BS 6200:part 3 section 3.8</td>
</tr>
</tbody>
</table>
### 1.49.2 Standard Sampling Methods

The following is the schedule of standard sampling methods of materials which shall be carried out during the execution of the Works.

<table>
<thead>
<tr>
<th>Materials</th>
<th>Frequency</th>
<th>Standard Sampling Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water for concrete</td>
<td>1 test for each source and as directed by the Engineer thereafter.</td>
<td>BS 3148</td>
</tr>
<tr>
<td>Portland Cement</td>
<td>1 bag cement for quality testing shall be taken from each 1700 bags or fraction thereof for each source or manufacturer. The Engineer may in lieu of this accept a testing certificate.</td>
<td>BS 4550:Part 1</td>
</tr>
<tr>
<td>Coarse Aggregate</td>
<td>One sample for quality testing shall be taken from each designated source. After approval one sample shall be taken for quality testing from each 1000 m³ when the material is in use. On each sample 2 sets of the required tests should be carried out except sieve analysis which shall be 3 in number.</td>
<td>BS 812: Part 101 &amp; 102</td>
</tr>
<tr>
<td>Fine Aggregate for concrete</td>
<td>As for Coarse above</td>
<td>BS 812: Part 101 &amp; 102</td>
</tr>
<tr>
<td>Bituminous Materials</td>
<td>One sample of each type of material shall be taken for each source or delivery from the manufacturers. Subsequent testing shall be as directed by the Engineer but not less than one sample for each 500 drums (55gal) or equivalent</td>
<td>BS 3195: Part 3</td>
</tr>
<tr>
<td>Materials</td>
<td>Frequency</td>
<td>Standard Sampling Methods</td>
</tr>
<tr>
<td>-----------------------------------</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------------------------------------------</td>
</tr>
<tr>
<td>Aggregates For Bituminous Mixtures</td>
<td>One sample for quality testing shall be taken from each designated source. After approval one sample shall be taken for quality testing from each 1000 m³ when the material is in use.</td>
<td>ASTM 04.03, BS 812: Part 101 &amp; 102</td>
</tr>
<tr>
<td>Mineral Filler for Bituminous Mixtures</td>
<td>One sample for quality testing from each 50 tonnes or fraction thereof.</td>
<td>BS 812: Part 101&amp; 102</td>
</tr>
<tr>
<td>Bituminous Mixtures</td>
<td>(i) One sample of each days production or each 200 tonnes laid or part thereof whichever is greater, shall be taken for quality testing. The sample should be taken from the paving machine after approximately half of any one load has been laid or from the plant. (ii) One core sample for specific gravity testing shall be taken for each 300 lin.m of traffic lane or 2000 m² or parts thereof for each completed layer of pavement.</td>
<td>AASHTO T 168 BS 598</td>
</tr>
<tr>
<td>Subgrade and/or Embankment</td>
<td>A quality testing procedure (laboratory) for each sub-grade material or embankment material shall be carried out for each 1500m³ of material as follows:- (i)Granular Gradation (ii)Atterberg Limits (Liquid and Plastic Limits), Linear shrinkage.</td>
<td>AASHTO T87/T146 BS 1377</td>
</tr>
<tr>
<td>Materials</td>
<td>Frequency</td>
<td>Standard Sampling Methods</td>
</tr>
<tr>
<td>-------------------</td>
<td>-----------</td>
<td>----------------------------------------------------------------</td>
</tr>
<tr>
<td>(iii) Compaction test</td>
<td></td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td>(iii) Modified Proctor with compaction curve to obtain optimum moisture content and max. dry density.</td>
<td></td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td>(iv) C.B.R. at 95% of modified Proctor density.</td>
<td></td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td>After laying and compaction a quality testing procedure on each 1000 m² or part thereof should be carried out as follows:-</td>
<td></td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td>(v) Field density</td>
<td>AASHTO T 191</td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td>ASTM D 2216</td>
<td>(vi) Moisture content</td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>BS 1377: 1990 or latest revisions thereof.</td>
</tr>
<tr>
<td>(vii) Field C.B.R. with moisture content and dry unit weight from speedy method.</td>
<td>AASHTO T87/T146</td>
<td>ASTM D 4429 &amp; as directed by the Engineer</td>
</tr>
</tbody>
</table>

Sub-bases and Aggregate Roadbases.

A quality testing procedure (laboratory) for each sub-base or granular roadbase material shall be carried out for each source but not exceeding 1000 m³ of material as follows:

For every completed layer, one field density shall be determined on each 500 square metres.

(ii) Liquid Limit AASHTO T87/T146

(iii) Plastic Limit AASHTO T87/T146
<table>
<thead>
<tr>
<th>Materials</th>
<th>Frequency</th>
<th>Standard Sampling Methods</th>
</tr>
</thead>
<tbody>
<tr>
<td>(iv) Linear Shrinkage</td>
<td>BS 1377</td>
<td></td>
</tr>
<tr>
<td>(v) Sand Equivalent</td>
<td>AASHTO T176</td>
<td></td>
</tr>
<tr>
<td>(vi) Compaction Test by Modified Proctor method with compaction curve.</td>
<td>ASTM D1557, BS 1377</td>
<td></td>
</tr>
<tr>
<td>(vii) CBR at 100% of the modified Proctor density. After laying and compaction the following testing procedure shall be followed for every 1000 m² of each layer:-</td>
<td>ASTM D1883, BS 1377</td>
<td></td>
</tr>
<tr>
<td>(vii) Field density</td>
<td>AASHTO T191 (2 no.)</td>
<td></td>
</tr>
<tr>
<td>Concrete</td>
<td>One set of at least 6 cubes (or 4 cylinders) shall be obtained from each 75 m³ or fraction thereof placed in each day or class of concrete.</td>
<td>BS 1881:Part 120</td>
</tr>
<tr>
<td></td>
<td>One set of 4 cubes (or 4 cylinders) from each 75 m³ or fraction thereof placed in each day for Class S concrete for Water Absorption testing.</td>
<td>BS 1881: Part 122</td>
</tr>
<tr>
<td></td>
<td>Slump tests and compaction factor tests shall be carried out at the site of the actual placing of concrete as directed by the Engineer.</td>
<td>BS 1881, ASTM C-192, AASHTO T126</td>
</tr>
<tr>
<td></td>
<td>Preparation of concrete specimens &amp; curing of specimens</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Minimum cement content of hardened concrete as directed by the Engineer.</td>
<td>ASTM C1084:1991</td>
</tr>
<tr>
<td>Materials</td>
<td>Frequency</td>
<td>Standard Sampling Methods</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------</td>
<td>--------------------------</td>
</tr>
</tbody>
</table>
| Precast Concrete | The flexural/transverse/strength and water absorption for each supplier of precast kerbs and slabs (2 no. samples). Subsequently, on approval of a source or supplier 3 samples will be tested every 1000 lin.m. for kerbs and every 1000 m² for slabs (tiles). | AASHTO T97
| | | ASTM C78
| | | BS7263:Part 1
| | | 1990 |
| Reinforcing Steel | Reinforcement steel shall be supplied to site with a manufacturer's test certificate for each load. Where directed testing on any sample of reinforcement for the following types may be required:- | BS 4483
| | (i) Steel fabric reinforcement. | |
| | (ii) Mild Steel and high yield (hot rolled) bars. | BS 6200:Part 3 |
| | (iii) Cold worked steel bars. Chemical Analysis of Steel for carbon content as directed by the Engineer. | BS 4482
| | | BS 6200:Part 3
| | | section 3.8 |
1.49.3 Governing Standard and Other Materials

For all other materials where no governing standard is quoted in the Specification then a suitable national standard approved by the Engineer (BS, AASHTO or ANSI/ASTM) shall be used.

The most recent edition of any standard shall always be adopted unless otherwise stated in the specification or directed by the Engineer.

The equivalence between AASHTO and ANSI/ASTM will only be accepted when directed by the Engineer. The Engineer may opt for other national standards (BS, AASHTO, ANSI/ASTM) in place of those stated in the specifications.

1.49.4 Modified Tests

Should the Engineer's Representative deem it necessary to increase or reduce the number of the above mentioned tests, he shall issue his written instructions to the Contractor as and when required.

1.49.5 Source of Materials

The Contractor shall be responsible for obtaining the Approval of the local Authorities for the sources of materials and he shall have no right to claim for any compensation if he is to pay for the material in its source.

1.49.6 Testing Which the Contractor is Unable to Carry Out

Any testing which is required under the contract which cannot be carried out by the Contractor shall be carried out at the Contractor’s expense at an independent laboratory which is approved by the Engineer. A copy of such testing shall be forwarded to the Engineer for information.
2 EARTH WORK

2.1 Scope of Work
This section covers, excavation, leveling, trenching and backfilling work and shall include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property, backfilling, pipe embodiment, obstacles removal surfacing and grading and other related work.

No classification of excavated materials will be made. Trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition or condition thereof.

2.2 Site Investigation
The Contractor shall be deemed to have visited the site of Works and satisfied himself as to the nature of the ground and made himself conversant with the local conditions to be encountered during the execution of the Contract.

2.3 Materials

2.3.1 Backfill and Fill
Backfill and fill shall be a structurally sound material such as sand, Kurkar or approved native soil free of rocks, lumps, vegetables and other organic materials obtained from suitable excavated material and/or from approved borrow pits.

2.3.2 Water
Water shall be clean potable water free from injurious amounts of oil, acid or any other deleterious mineral and/or organic matter.

Watering shall consist of providing a water supply sufficient for the needs of the Works, the hauling and applying of all water required in the compacting of embankment, base, sub-base, and surfacing materials, special backfill and other fill and backfill material.

No payment will be made for water used in the Construction of embankment, subgrade, sub-base, and base, and the cost thereof shall be deemed to be included in the Contract unit prices of these items.

2.3.3 Concrete
Concrete used as fill for making up to correct level areas or over-excavation shall be, where required by the Engineer, of concrete \( (250 \text{ kg/cm}^2) \).

2.3.4 Sand Fill
Sand fill shall be clean coarse sand free from dirt or organic materials.

2.4 Site Preparation
Prior to commencing any excavation work, clearance from the concerned authorities must be obtained by the contractor, the Contractor shall establish a horizontal and vertical survey network, record existing ground elevations and stake the location of trenches to be excavated.

The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Engineer.

The Contractor shall obtain relevant excavation and road cutting permits as required to commencing work.

2.4.1 Existing Utilities

The Contractor shall ascertain the whereabouts of all existing utilities on the site both, above and below ground.

Such utilities shall be removed, sealed or rerouted in a manner prescribed by the authorities concerned at the Contractor's own expense. The Contractor shall also be held responsible for all damages entailed on any of the utilities adjacent to the site resulting from the Works.

All proposed or existing utilities, including buried pipes, sewers, ducts, culverts, cesspits, chambers and the like, in the vicinity of the work site, are to be determined by the Contractor and the location of them is to be shown on the drawing. However, the completeness and accuracy of this information is not guaranteed and no error or omission on the Drawings shall be done to relieve the Contractor from his responsibility for protecting such utilities at the Contractor's expense.

Prior to commencement of excavation, the Contractor shall establish the number and location of underground utilities and chambers in the immediate proximity of the work.

Where necessary, the Contractor shall use hand tools to excavate test pits prior to excavation to determine the exact locations of existing utilities. It shall be the responsibility of the Contractor to make such explorations sufficiently in advance of construction to enable the engineer to approve modifications, if any, to be made to the pipeline, structure or conflicting utility. The Contractor shall obtain the permission of the Engineer before commencing any test pits and shall fence, mark and protect them, as required by the Engineer. Test pits shall be refilled by hand as soon as practicable after the necessary information has been obtained. No Extra payment will be made for the excavation of test pits. Cutting of existing asphalt must be carried out by cutting saw.

As the excavation approaches sewers conduits, cables or other underground facilities, and with care the excavation shall be continued by means of hand tools. Where necessary, the Contractor shall provide temporary support for the existing utilities to prevent damage during his operations. Notwithstanding these provisions, if damage to existing utilities results from the Contractor's operations, such damage shall be repaired without delay by the Contractor or such repairs shall be borne by the Contractor.
If damage to existing utilities causes disruption to Contractor's schedule of work by delaying work in the area of such damage, the Contractor shall readjust time schedule, methods of working and resources so that critical dates in the schedule for the completion of the Contract are not affected.

2.4.2 Removal of Existing Structures and Other Obstructions
This work shall include, but not be limited to, the removal of existing structures and other obstructions interfering with the Works. The salvaging of any of these materials for the use for the Employer shall be as directed by the Engineer and unwanted materials shall be disposed off the Site in a satisfactory manner at the Contractor's expense.

No payment shall be made to the contractor for this item. All costs shall be considered in the contract bid items.

2.4.3 Cleaning and Grubbing
The Contractor shall perform the clearing and grubbing (if any), of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and off loaded, spread and leveled to approved dumps as directed by the Engineer.

2.5 Setting-Out
The Contractor shall stakeout the work as shown on the Drawings and secure the Engineer's approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out, the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval in accordance with the relevant Clause of the Conditions of Contract.

2.6 Excavation
The Contractor shall perform all excavation true to lines, widths and depths shown on the Drawings or to such further lines, depths or dimensions as may be directed by the Engineer or reach suitable bearing strata.

2.6.1 Keeping Excavations Free from Water
All excavations shall be kept clear of water by pumping or bailing or bay well point dewatering, but the latter system shall not be employed if any danger exists of withdrawing water from the foundations of the adjoining buildings and such water shall be discharged clear of the Works and the method adopted shall in no way contravene with the regulations of the Local Authorities.

The system or systems to be employed shall be approved by the Engineer. Such approval if given, shall not waive the Contractor's responsibilities and liabilities under the Contract.

Most of the work will be executed for running lines so no work will be commenced for any line before making sure that this line is dry by diverting the
flow to other lines using pumping, the cost of such pumping will be paid by the Contractor.

Particular attention shall be paid to the installation of sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel and public.

2.6.2 Storing of Suitable Excavated Material
During excavation, materials suitable for backfill and fill be stockpiled on the site at sufficient distance from the sides of the excavation to avoid over-loading and prevent cave-ins or mixing with the concrete during the construction of foundation.

2.6.3 Disposal of Unsuitable and Surplus Excavated Material
Upon the order of the Engineer, all unsuitable and surplus materials shall be immediately removed, loaded and transported off the site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

No measurement or direct payment will be made for the Disposal of Surplus Material.

2.7 Cutting Pavement and Surface Materials
The Contractor shall remove only as much of any existing pavement as is necessary for the prosecution of the work. The Engineer's Representative may require that the pavement be cut with pneumatic tools, without extra compensation to the Contractor, wherein the opinion of the Engineer's Representative it is necessary to prevent damage to the remaining road surface. Where pavement is removed in large pieces, it shall be disposed of before proceeding with the excavation.

From areas within which excavations are to be made, loam and topsoil shall be carefully removed and separately stored to be used again as directed; or if the Contractor prefers not to separate surface materials, he shall furnish, as directed, loam and topsoil at least equal in quantity and quality to that excavated.

2.8 Sheeting, Shoring and Bracing
Except where banks are cut back on a stable slope, excavation shall be sheeted, braced and shored as necessary to prevent caving or sliding. The Contractor shall furnish, put in place, and maintain such sheeting, bracing, etc..., as may be necessary to support the sides of the excavation and to prevent any movement of earth which could in any way diminish the width of the excavation to less than the necessary for proper construction, or could otherwise injure or delay the work, or endanger adjacent structures. If the Engineer's Representative is of the opinion that at any point sufficient proper supports have not been provided, he may order additional supports put in at the expense of the Contractor.

The Engineer may direct that sheeting and bracing be cut off at any specified elevation.

All sheeting and bracing not to be left in place shall be carefully removed in such manner as not to endanger the construction or other structures. All voids left or caused by the withdrawal of sheeting shall be backfilled immediately with
approved material and compacted by ramming with tools especially adapted to that purpose, by watering or by other means as may be directed.

The Contractor shall not be paid for any sheeting whether left in place or pulled.

2.9 Trench Excavation

2.9.1 General Requirements

Trench excavation work shall be performed in a safe and proper manner with appropriate precautions being taken to safeguard workmen and existing structures and utilities against all hazards.

All trench excavation shall be open cut from the surface unless authorized by the Engineer and shall be excavated so that pipes can be laid straight at uniform grade without dips or humps between terminal elevations indicated on the Drawings.

No more trench shall be opened in advance of pipe laying than is necessary to expedite the work. 150m shall be the maximum length of open trench on any line under construction.

No classification of excavated materials will be made. Excavation and trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the Contract work, regardless of the type, character, composition or condition thereof.

The pipe is to be laid in sand bedding, as indicated on the Drawings or directed by the Engineer the trench is to be excavated by labour to, or to just below, the designated subgrade, provided that the material remaining at the bottom of the trench is no more than slightly disturbed. The pipe is not to be laid directly on the trench bottom.

Whenever unstable soil which in the opinion of the Engineer, is incapable of properly supporting the pipe is encountered in the bottom of the trench, such soil shall be removed to the depth required and the trench backfilled to the proper grade with sand approved by the Engineer.

2.9.2 Mechanical Excavation

The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, buildings, culverts or other existing property, utilities or structures above or below ground. In all such locations hand excavation shall be used.

Mechanical equipment if used for trench excavation shall be of type approved by the Engineer. Equipment shall be so operated that the rough trench excavation bottom can be controlled, that uniform trench widths and vertical sidewalks are obtained at least from an elevation 20cm above the top of the installed pipe when accurately laid to specified alignment will be centered in the trench with adequate clearance between the pipe and sidewalks of the trench.
2.9.3 **Alignment and Minimum Cover**

The alignment of each pipeline shall be fixed and determined from offset stakes. Horizontal alignment of pipes and the maximum joint deflection used in connection therewith, shall be in conformity with requirements of the section covering installation of pipe.

Pipe grades or elevations are not definitely fixed by the Contract Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe of 120cm for main lines, 120cm for lateral and as directed by the Engineer for sub laterals, outlet pipes and house connections. Greater pipe cover depths may be necessary at certain locations, the locations and depths will be determined by the Engineer without extra payment. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finish ground or pavement surface elevation except where future surface elevations are indicated on the Drawings. Where there is no adequate minimum cover, concrete encasement will be used as hereinafter and as shown on the Drawings and as directed by the Engineer.

2.10 **Depth of Trench**

Where the trench is not shown on the Drawings, it shall be not less than 120cm in addition to the pipe diameter and bidding in all classes soil, whether is soft earth, rocky ground or solid rock, unless otherwise ordered by the Engineer.

The trench bottom shall be straight and even so as to provide a good support for the pipe on its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its coating.

The sand bedding under the pipe shall be not less than 15cm in the critical points and as shown on the Drawings and as directed by the Engineer.

The trench depth shall give the required minimum cover over the pipe as mentioned previously of these specifications.

2.11 **Width of Trench**

Pipe trenches shall be made as narrow as practicable and shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches firm and undisturbed until backfilling has been completed and consolidated.

2.12 **Excavation Concrete Valve Chambers**

Excavation for the concrete valve chambers shall be carried out to the dimensions, lines and grades shown on the Drawings or required by the Engineer.

Wherever the depth of the excavation or the nature of the soil makes it necessary to avoid caving in, the Contractor shall excavate the walls to a slope or brace and support the excavation.

Should nevertheless earth slides occur, the Contractor shall remove the material resulting therefrom, clean the excavation of all stones, clods and other loose
material and shall provide a clean excavation surface in which concrete can be cast according to the required dimensions and grades.

Should it appear that the bottom of the excavation does not provide a solid base for the casting of the concrete floor, the Contractor will be required to consolidate the bottom using hand tampers and increasing the moisture content, if required, until the required density is obtained, a/o placing concrete class (200 kg/cm²) as blinding, all as directed by the Engineer.

Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the over-excavation class (200 kg/cm²) or shall be filled with the concrete of which the structure is cast. In the case of over-excavation in the walls, whether caused by careless work or by the necessity to prevent slides by excavating to a slope or for any other reason, the Contractor shall remove all loose material from the excavation, cast the walls of the structure to the dimensions shown on the Drawings and fill the spaces between the structures and the sides of the excavation with compacted backfill in layers of 10cm thickness. The material of the backfill shall be moistened if necessary and compacted to the level of the adjacent natural soil.

2.13 Unauthorized Excavation

If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted, selected screened gravel or sand fill as directed by the engineer if the excavation was for a pipeline, or with (200 kg/cm²) concrete if the excavation was for a structure or a manhole.

2.14 Elimination of Unsuitable Material

If material unsuitable for foundation (in the opinion of the Engineer's Representative) is found at or below the grade to which excavation would normally be carried in accordance with the Drawings and/or structure, the Contractor shall remove such material to the required width and depth and replace it with compacted, selected screened gravel, sand fill or concrete as directed by the Engineer's Representative.

2.15 Disposal of Surplus Excavation Materials

All excavated materials shall from the site of work or disposed of by the Contractor except as directed or approved.

Surplus excavated materials suitable for backfill shall be used to backfill normal excavations in rock or to replace other materials unacceptable for use as backfill, or shall be deposited for other purposes in areas designated by the Engineer's Representative all as directed or approved and without additional compensation.

2.16 Bridging Trenches

The Contractor shall, at his own expense provide suitable and safe bridges and other crossings where required for the accommodation of travel and to provide access to private property during construction and shall remove said structures thereafter.

2.17 Backfilling
In general, and unless other material is indicated on the Drawings or specified, approved material used for backfilling trenches and excavations around structures shall be suitable material which was removed in the course of making the construction excavations.

Where a percentage of compaction for backfill is indicated or specified, it shall be percent of maximum density at optimum moisture as determined by method D of ASTM Standard Methods of Test for Moisture-Density Relations of Soils Using 10-lb hammer and 18 in Drop. Designation D1557-70. If the percentage of compaction is not indicated, it shall be understood to be 98%.

2.18 Filled and Backfill Under Structures

Unless otherwise indicated or specified, all fill and backfill under structures shall be compacted screened as specified and instructed by the engineer.

The fill and backfill materials shall be placed in layers not exceeding 15cm in thickness. Unless otherwise indicated or specified, each layer shall be compacted to 98% of maximum density at optimum moisture as determined by Method D of the above mentioned ASTM Standard Methods D1557-70.

2.19 The Engineered Fill Materials (Base Coarse)

2.19.1 Aggregate for Base Courses

1. Aggregate for use in base course construction shall be crushed stone. Aggregate may be washed, if directed, to remove excessive quantities of clay, salty clay or salts.

2. Crushed stone and crushed gravel shall consist of hard, durable and sound particles or fragments of stone, free from other deleterious substances not mentioned below, other requirements are gypsum, or Flaky particles. Other requirements:

   - Gypsum content (expressed as SO3) 2% max.
   - Clay Lumps and friable particles 8% max.
   - Elongated and Flaky particles for crushed rock (Determined in accordance with BS812 Part 1: 1975)
     - Granite & Basalt 40% max. each
     - Lime Stone 35% max. each
   - Maximum Dry density (g/cm3) 2.15 min.

Chert content (determined as percentage by weight insoluble in hydrochloric acid to be specified in special technical specification).

3. Methods used in production of crushed rock shall ensure that the finished product will be as uniform as participle. Crushing shall result in a product such that, for particles retained on 4.75 mm (No. 4) sieve at least 80% by weight shall have at least two factored faces.

4. Any material passing 4.75 mm (No. 4) sieve and product in crushing process shall be incorporated in the base material up to the gradation limits for the particular Class of aggregate involved.

5. Crushed aggregate for base course delivered to road site shall meet the requirements of Class A or Class B gradations as shown in (Table I) when tested in accordance with AASHTO T 27 after dry mixing and just before spreading and prior to compacting. The Class of aggregate to be used shall be
as shown on the drawings or otherwise as selected by the Engineer. The actual gradation shall, in all cases, be continuous and smooth within the specified limits for each Class. Gap graded aggregate will not be accepted. If gradation is tested after compaction a tolerance of 3% allowed in upper limit for percentage of material passing sieve 200.

Table I  Gradation of base Course Aggregate by Class

<table>
<thead>
<tr>
<th>Sieve Designation (square openings)</th>
<th>Class A</th>
<th>Class B</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm (2 in.)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>mm (1 - ½ in.)</td>
<td>75 - 100</td>
<td>55 - 85</td>
</tr>
<tr>
<td>mm (1 in.)</td>
<td>60 - 90</td>
<td>50 - 80</td>
</tr>
<tr>
<td>mm (3/4 in.)</td>
<td>45 - 80</td>
<td>-</td>
</tr>
<tr>
<td>mm (1/2 in.)</td>
<td>40 - 70</td>
<td>40 - 70</td>
</tr>
<tr>
<td>mm (3/8 in.)</td>
<td>30 - 65</td>
<td>30 - 60</td>
</tr>
<tr>
<td>mm (No. 40)</td>
<td>20 - 40</td>
<td>20 - 50</td>
</tr>
<tr>
<td>mm (No. 40)</td>
<td>8 - 20</td>
<td>10 - 30</td>
</tr>
<tr>
<td>mm (No. 200)</td>
<td>5 - 10</td>
<td>5 - 15</td>
</tr>
</tbody>
</table>

The material shall contain a minimum of 35% sand equivalent at any stage of construction.

6. The loss in weight shall not exceed 45% after 500 revolutions, when tested in accordance with AASHTO T 96 (Los Angeles Abrasion Test).

The ratio of wear loss = Abrasion after 100 Rev., should not be more than twenty percent of maximum allowed after 500 revolution.

7. The crushed aggregate base course material shall have a 4-day soaked CBR of not less than 80 when compacted at 100% modified proctor AASHTO (T 180-D) and tested in accordance with AASHTO T 193.

8. When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and loss by weight shall not exceed 12% in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

9. The portion of aggregate, including any blended material, passing the 0.425 mm (No. 4) mesh sieve shall have a liquid limit (L.L.) of not more than 25 and plasticity index (P.I) of not more than 6 and not less than 3 when tested in accordance with AASHTO T 90. In case of using cohesion less base course material the exposed surface shall exhibit intact and coherent surface to resist water erosion and fretting, the contractor at his own expense shall ensure such property any solution should not applied unless approved in writing by Engineer, such solution may include single bituminous surface treatment, bonding material and other necessary treatment all as directed and approved by the engineer. Provided that angularity test should be more than 8.
10. If additional fine material is required to correct the aggregate gradation, or for adjusting the L.L. or P.I. of the fraction passing the 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the aggregate material. Reworking of the material in situ to obtain the specified gradation will be permitted. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or natural material.

### 2.19.2 Measurement & Payment

The accepted quantity will be paid for at the Contract unit price complete in place including excavation and any back filling.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Engineered Fill Materials</td>
<td>Cubic Meter/as mentioned in B.O.Q</td>
</tr>
<tr>
<td>(Base Coarse)</td>
<td></td>
</tr>
</tbody>
</table>

### 2.20 Equipment

Equipment used to handle, place, spread, water, compact and finish sub-base shall conform with the Contractor’s approved Work Program.

#### 2.20.1 Construction of Trial Sections

1. Before commencement of Site sub-base construction, the Contractor may be required to lay and compact trial sections of varying thickness of sub-base. Each trial section shall be 2 lanes wide by 50 m long, at approved locations on or close to the Site. Each trial section shall be laid using the same materials, mix proportions, mixing, spreading and compaction equipment, and construction procedures, proposed for use in the Works.

2. The objectives of these trials shall be determine the adequacy of the Contractor’s equipment, the loose depth measurements that will result in the specified compacted layer depths, the field moisture content, and the relationship between the number of compaction passes and the resulting density of the sub-base material.

3. The Contractor shall not proceed with sub-base construction until the methods and procedures established in the trials have been approved.

### 2.21 Construction

#### 2.21.1 Stockpiling of Granular Material

1. Stock piling procedures shall conform with the relevant requirements of “Materials”
2. Methods used for stockpiling granular material and removing it from stockpiles shall not result in significant degradation or segregation nor the introduction of significant amount of foreign materials or extraneous matter.

3. Granular material adversely affected, in the opinion of Engineer, by stockpiling or handling procedures, shall not be incorporated in the Works regardless of previous approval of such material, until the deficiencies have been rectified in an acceptable manner.

2.21.2 Mixing and Spreading

1. All components of sub-base course material shall be mixed thoroughly and uniformly with water in situ. The amount of water added, as approved by the Engineer, shall be such that the material will be uniform and within the specified moisture content range at the compaction. Wetting of granular material in stockpiles or in trucks before or during delivery to the site will not be permitted. However, water shall be added to the material, if necessary, during placing and compaction of sub-base material.

2. The sub-base material shall be placed on the sub grade in a uniform layer or layers not exceeding 200mm thickness (after compaction). Where the required uncompacted thickness is greater than 250 mm but less than 500 mm, the material shall be placed in layers of 200mm thickness.

3. If approved, heavy duty vibrator compaction equipment is used, the maximum layer thickness may be increased up to 200 mm (after compaction) provided compaction tests with appropriate testing equipment indicate that the specified compaction standard will be attained and uniform throughout the thickness.

4. The sub-base material shall be placed to the required width using a self-propelled spreader or a motor grader equipped with blade extensions. Water shall be applied by approved spraying and thoroughly mixed with the sub-base material.

5. The material shall not be handled in such a way as to cause segregation. If the spreading equipment causes segregation in the material, or leaves ridges or other objectionable marks on the surface which cannot be readily eliminated or prevented by adjustment of the equipment, the use of such equipment shall forthwith be discontinued and it shall be replaced by a spreader or grader capable of spreading the material in a proper manner.

6. All segregated material shall be removed and replaced with well-graded material. “Skin” patching will not be permitted. Only minor surface manipulation and watering to achieve the required surface tolerances will be permitted during the compaction process.

7. Neither hauling nor placement of material will be permitted when, in the judgement of the Engineer, the weather or surface conditions are such that hauling operations will cause cutting or rutting of the sub grade or cause contamination of the sub-base material.

2.21.3 Compaction

1. The Contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surface. If the Contractor delays placing of succeeding layers of material to the extent that additional water is required to prevent ravelling or excessive drying, the application of such water shall be carried out as directed and at the Contractor’s expense.
The sub-base material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the centre, with each succeeding pass uniformly overlapping the previous pass.

Rolling shall continue until the entire thickness of each sub-base layer is thoroughly and uniformly compacted to 100% AASHTO T 180 (Method D) maximum density. Final rolling of the completed course shall be by means of an approved self-propelled roller. Rolling shall be accompanied by sufficient proper shape. When additional water is required, it shall be applied in an approved manner.

Any areas inaccessible to normal compaction equipment shall be compacted by use of portable mechanical tampers until the required standard of compaction is achieved.

Each layer shall be completely compacted and approved prior to delivery of materials for the subsequent layer.

Prior to placing a subsequent layer, the existing surface shall be made sufficiently moist as directed, to ensure proper bond between the layers.

The edges and edge slopes of the sub-base course shall be bladed or otherwise dressed to conform to the lines and dimensions shown on the Drawings and to present straight, neat lines and slopes as free of loose material as practicable.

Material which has dried out prior to final compaction, or which has dried and de compacted subsequent to final compaction, shall be watered and re compacted using approved equipment and procedures. If the Contractor is unable to return the material to its original or specified condition with respect to compaction, thickness and surface tolerance, the Contractor shall remove the material and reconstruct the sub-base course on a re-approved sub grade.

**2.21.4 Tolerances**

1. The fully compacted and completed sub-base course shall conform to the lines, grades and cross sections as shown on the Drawings.
2. The elevations of the finished sub-base course shall be checked by the Contractor in the presence of the engineer at maximum intervals of 10 m and at intermediate points as directed.
3. The tolerance on elevations of finished surface shall be plus 10 mm to minus 20 mm, minus tolerance shall be compensate by the proceeding layer.
4. When the finished surface is tested with a 3 m long straightedge, placed parallel to, or at right angles to the centreline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 10 mm.
5. All areas which exceed the specified tolerance shall be corrected by removing the defective sections of sub-base and reconstructing them or, if approved, by adding new material mixing and re compacting and finishing to the specified standard.

**2.22 Backfilling Against and Around Structures**

The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage as practicable after the structures are structurally adequate and other necessary work has been done, special leakage tests, if required, shall be made. Promptly after the
completion of such tests, the backfilling shall be started and then shall proceed until its completion. The best of the excavated materials shall be used in backfilling, within 50cm of the structure. Unequal soil pressure shall be avoided by depositing the material evenly around the structure.

The material shall be placed and compacted as specified below, insofar as applicable. Compaction shall be accomplished by water-jetting or puddling, if the nature of the material permits, otherwise by tamping.

Walls with fill on both sides shall have the fill constructed such that the difference in the top elevation of the fill on the two sides does not exceed 60cm at any time.

2.23 Backfilling Pipe Trenches

As soon as practicable after the pipes have been laid and the joints and fittings have acquired a suitable degree of hardness, if applicable, or the structures have been built and are structurally adequate to support the loads, including construction loads to which they will be subjected, the backfilling shall be started and there after it shall proceed until its completion. Under no circumstances shall water be permitted to rise in unbackfilled trenches after the pipe has been placed. The instruction of manufacturer of the pipe lines shall be followed and shall be agreed by the Engineer.

Trenches shall not be backfilled at pipe joints until after that section of the pipeline has successfully passed any specified tests required.

2.23.1 Materials

The nature of materials will govern both their acceptability for backfill and the methods best suited for their placement and compaction in the backfill. The materials and the methods shall both be subject to the approval and direction of the Engineer. Selected fill material around the pipe shall be clean coarse sand as specified. Selected fill material placed up to 30cm above the sand fill shall be well graded fill containing no stone or rock fragment larger than 10cm in greater dimension. Pieces of bituminous pavement shall be excluded from the backfill unless their use is expressly permitted, in which case they shall be broken up as directed.

2.23.2 Zone Around Pipe

The zone around the pipe shall be backfilled with sand to the limits indicated on the Drawings. Sand fill around pipe shall be thoroughly compacted by careful hand tamping in layers 15cm in depth up each side.

2.23.3 Remainder of Trench

The remainder of the trench above the zone around the pipe, shall be filled with selected fill as specified herein above and compacted by tamping as directed or approved in accordance with the nature of the material.

2.23.4 Tamping

The material shall be deposited and spread in uniform, parallel layers not exceeding 15cm thick before compaction. Before the next layer is placed, each layer shall be tamped as required so as to obtain a thoroughly compacted mass. The Contractor shall furnish and use an adequate number of power-driven
tampers, each weighing at least 10kg for this purpose. Care shall be taken that the material close to the bank, as well as in all other portions of the trench, is thoroughly compacted.

To ensure proper compaction by tamping, the material shall first be wet by sprinkling. However no compaction by tamping shall be done when the material is too wet either from rain or too great an application of water to be compacted properly; at such times the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compaction or such other precautions shall be taken as may be necessary to obtain proper compaction.

No superficial load shall be placed on the exposed surface of the trench unless the backfill is of noncohesive material is vibrated or is tamped in layers not exceeding 15cm in depth until the Engineer's Representative is satisfied that sufficient settlement has occurred to alleviate live or impact loads.

2.23.5 Miscellaneous Requirements

Whatever method of compacting backfill is used, care shall be taken that stones and lumps shall not become nested that all voids between stones shall be completely filled with fine material. The Contractor shall, as part of the work done under the items involving earth excavation and rock excavation as appropriate, furnish and place all other necessary backfill material.

All voids left by the removal of sheeting shall be completely backfilled with suitable materials, thoroughly compacted.

When required, excavated material which is acceptable to the Engineer for surfacing or pavement sub-base shall be placed at the top of the backfill to such depths as may be specified elsewhere or as directed. The surface shall be brought to the required grade and stones raked out and removed.

2.24 Embankment

2.24.1 Placement of Embankment

All embankment shall be constructed in reasonably close conformity to the lines, grades and cross sections established or shown on the Drawings.

Rocks, broken concrete or other solid materials shall not be placed in embankment areas where piling is to be placed or driven.

Embarkment of earth material shall be placed in horizontal layers not exceeding 20 centimeters in loose measurement and shall be compacted as specified, before the next layer is placed. Effective spreading equipment shall be used on each lift to obtain uniform thickness prior to compacting. As the compaction of each layer progresses, continuous leveling and manipulating will be required to ensure uniform density. The top layer of Embankment just prior to placing the sub base or base material should be compacted and shaped to the required tolerance specified for the subgrade preparation.
When the embankment material resulting from excavation consist predominantly of rock fragments of such size that material cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down to pieces, such material may be placed in the embankment in layer not exceeding in thickness the approximate average size of larger rocks. (Provided that the larger rocks dimensions do not exceed 25 cm). Each layer shall be leveled and smoothed with suitable leveling equipment and by distribution of spells and finer fragments or earth.

If required to lay through the embankment any duct for services (water, electricity etc. installations), the contractor shall take the necessary precautions to provide such duct and lay in good workmanlike manner as shown and/or directed to the satisfaction of the Engineer. Such duct shall be of asbestos cement pipe class "24 Kgs/cm²" or any other approved material to the diameter shown on the Drawings and/or as directed by the Engineer.

### 2.24.2 Compaction and Density Requirements

Embankment, constructed in layers of the depths specified herein, shall be compacted by means of rollers, hauling equipment, mechanical tamping and vibrating equipment or by other suitable means. Equipment shall be routed so as to distribute travel over the entire area of each layer of material insofar as is practicable and separate pieces of equipment shall not follow in the immediate tracks of preceding equipment.

At the time of Compaction, the moisture contents of the embankment material shall be such that the specified relative compaction will be obtained. If excess moisture is present, the material shall be manipulated so as to dry out and be recomputed to the proper compaction of the embankment before any retest will be carried out. Where the moisture content is below optimum by more than 2% when tested, water shall be added and the material remixed and compacted before any retest.

Where embankments 1.5 meter or less in height are to be constructed, the top 15 centimeters of the ground on which the embankment material is to be placed shall be compacted to a density of not less than 95 percent of the maximum density (BS 1337 Part 4) and minimum C.B.R. (BS 1377 Part 4) 15% at 95% maximum dry density unless otherwise stated on the drawings.

The upper 1.5 meter of the embankment material constructed as specified shall be compacted to 95 percent of the maximum density and below that depth the material shall be compacted to 90% of the maximum density. C.B.R. not less than 10% at 90% maximum density and 15% at 95% max. density.

Material placed in dikes shall be compacted to a density of not less than 90% of the maximum density   (BS 1377 Part 4).

All determination of density will be made in accordance with the latest BS 1377 Part 4.
When the embankment material is composed predominately of rock such that these compaction control procedures will not indicate the density achieved, the Engineer will determine the amount of compaction required and the adequacy of equipment used in obtaining the required compaction.

2.24.3 Gradation Requirements

The gradation requirements for the embankment of the road shall be according to AASHTO M57 grading requirements for materials for embankments and subgrade as approved by the Engineer.

The requirements of the embankment materials are:-

1. Coarse aggregate shall have a percentage of wear by Los Angeles Test (AASHTO T96) of not more than 50% (applicable only for gravelly materials on the fraction retained on 5 mm sieve.)

2. Fraction passing No. 200 sieve shall not be greater than two thirds of fraction passing No. 40, based on a sieve analysis conducted by AASHTO T88.

3. Fraction passing No. 40 sieve shall have liquid limit not greater than 35 percent and a plasticity index not greater than 10 percent.

2.24.4 Rockfill

Where Embankments to be compacted which are formed of material consisting predominantly of rock fragments of such size that the material cannot be placed in layers of the thickness prescribed without crushing, pulverizing or further breaking down the pieces resulting from normal excavation methods, such material may be placed in the embankment in layers not exceeding a thickness twice the average size of the larger rocks, except that no layer shall exceed six hundred (600) mm of loose measurement.

Material shall be carefully placed so that all large stones will be well distributed and the voids completely filled with smaller stones, earth, sand or gravel to form a solid embankment. Each layer shall be bladed or levelled with motor grader, bulldozer or similar equipment capable of shifting and forming the layer into a neat and orderly condition. No rocks larger than eighty (80) mm in any dimension shall be placed in the top one hundred and fifty (150) mm of the embankment unless otherwise noted on the Drawings. Conformance to these provisions and compaction in a manner and to a point of consolidation approved by the Engineer will be considered as fulfillment of the requirements for the type of compaction shown on the Drawings. Normally, compaction tests will not be performed in these areas but the Engineer reserves the right to test compaction in some other manner (Like plate bearing test), if he deems a test necessary to ensure consolidation. Each layer must be approved by the Engineer before the next layer is placed.
Embankments, which are formed of materials that contain rock but also contain sufficient compatible material other than rock or other hard material to make rolling feasible, shall be placed and compacted in the manner and to the point of consolidation approved by the Engineer. Moisture shall be added as directed by the Engineer. Compaction tests will be made wherever the Engineer determines they are feasible and necessary. Each layer must be approved by the Engineer before the next layer is placed.

2.24.5 Measurement and Payment

1st) Measurement

Embankment including rockfill will be measured in cubic meters by the average end area method. The volume paid for shall be to the lines and levels shown on the Drawings and calculated by the Engineer's Representative. Measurement of ducts shall be made in linear meter laid in place in respect of each diameter separately.

2nd) Payment

The accepted quantities of Embankment measured as provided above shall be paid for at the Contract unit price complete in place including placing, watering and compacting and the accepted quantities of ducts measured as above shall be paid for at the Contract unit price complete in place as specified including excavation, backfilling, compaction, etc.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Embankment</td>
<td>Cubic Meter/Sq. Meter/as mentioned in B.O.Q.</td>
</tr>
</tbody>
</table>

The diameter of ducts shall be as shown in the Bill of Quantities.

2.24.6 Relevant Tests and Standards

The following tests should be carried out unless otherwise directed by the Engineer at frequencies laid down in the specifications:

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain size Analysis of directed or as Soils (Sieve Analysis)</td>
<td>AASHTO T88</td>
<td>As</td>
</tr>
<tr>
<td></td>
<td>AASHTO M57</td>
<td></td>
</tr>
<tr>
<td>Relative Density</td>
<td>ASTM D4254</td>
<td>--</td>
</tr>
<tr>
<td>Atterberg Limits</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquid Limit 35%</td>
<td>AASHTO T89</td>
<td>Max.</td>
</tr>
<tr>
<td>Plasticity Index 10%</td>
<td>AASHTO T90</td>
<td>Max.</td>
</tr>
<tr>
<td>Linear Shrinkage Max.</td>
<td>BS1377 Part 4</td>
<td>Max.3%</td>
</tr>
</tbody>
</table>
2.25 Sub-Grade Preparation

2.25.1 Description

Subgrade preparation consists of compaction of the subgrade to the required density and finishing the surface of the subgrade to the required tolerance.

2.25.2 Construction

The finished subgrade immediately prior to placing subsequent sub-base or base material thereon shall be compacted to not less than 95 percent maximum density according to BS 1377: Part 4 or latest revision thereof. The material should have minimum C.B.R. (BS 1377: Part 4 or latest revision thereof) of 15% at 95% maximum dry density or as specified in the drawings. (The method shall be as directed by the Engineer but generally laboratory CBR tests shall be carried out at optimum moisture content and after 96 hours soaking and, if required, after 24 and 48 hours of soaking). The subgrade shall be smooth and uniform, and true to the required grade and cross-section. The surface of the grading plane at any point shall not vary more than 2 cm above or below the grade established for 3 locations maximum each 100 m. interval. Selected Material shall be added whenever and wherever needed.

Subgrade that does not conform to the above requirements shall be reshaped to conform to the specified tolerances, and recompacted at the Contractor's expense. Where the material fails to meet the required CBR as determined by Laboratory testing at 95% maximum dry density the subgrade shall be improved by replacement as detailed in the specification.

2.25.3 Measurement

Subgrade preparation will be measured by the square meter and the measurement will be made on the surface of the finished subgrade.

2.25.4 Payment
All accepted subgrade preparation as provided above will be paid for at the contract unit price.

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subgrade Preparation</td>
<td>Square Meter</td>
</tr>
</tbody>
</table>

### 2.25.5 Relevant Tests and Standards

Testing procedures as laid down in the specifications.

### 2.26 Granular Sub-Base

#### 2.26.1 Description

Granular sub-base shall consist of furnishing, spreading, and compacting sub-base in accordance with the details shown on drawings and these specifications.

#### 2.26.2 Materials

Granular sub-base material for Road sub-base shall consist of hard, durable natural/screened gravel or crushed stone, and shall be free from organic matter, clay balls or other deleterious substances. Granular Sub-base shall be well graded and lie within the grading envelope stated below. The material should have a minimum C.B.R. of 40% at 95% of maximum dry density and should comply with the specifications.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 in. (75 mm)</td>
<td>100</td>
</tr>
<tr>
<td>1 1/2 in. (38.1 mm)</td>
<td>85 - 100</td>
</tr>
<tr>
<td>3/8 in. (10 mm)</td>
<td>40 - 100</td>
</tr>
<tr>
<td>No. 4 (4.76 mm)</td>
<td>25 - 85</td>
</tr>
<tr>
<td>No. 30 (0.60 mm)</td>
<td>8 - 45</td>
</tr>
<tr>
<td>No. 200 (0.074 mm)</td>
<td>0 - 10</td>
</tr>
</tbody>
</table>

#### 2.26.3 Construction

Road sub-base material shall be delivered to the roadbed as uniform mixture and shall be spread in layers or windrows. Segregation shall be avoided and the sub-base shall be free from pockets of coarse or fine materials.

The road sub-base shall be spread by finisher and or grader or other approved mechanical methods to a thickness of not exceeding 200 mm in loose measurements, watered, shaped and compacted to the required grade and cross-section.
The compaction procedure and plant shall be to the satisfaction of the Engineer. At the time of compaction the moisture content of the laid material shall not vary by more than +/- 2% from the optimum moisture content.

The granular sub-base shall be compacted to not less than 95 percent of the maximum density determined in accordance with the latest BS 1377 Part 4. Particle size analysis of soils for sieve analysis of fine and coarse aggregate shall be carried out in accordance with AASHTO T27. The surface on completion of compaction be well closed, free from movement under compaction plant and free from ridges cracks or loose material. The finished surfaces of the road sub-base shall not vary at any point more than 10mm above or below the grade established by the Engineer. The road sub-base shall be maintained in a condition satisfactory to receive any subsequent base or surfacing material. sub-base which does not conform to the above requirements shall be reshaped or reworked, watered and thoroughly recomputed to conform to the specified requirements.

2.26.4 Measurement

Sub-base will be measured by the square meter unless otherwise specified.

2.26.5 Payment

The accepted quantities of Sub-base will be paid for at the Contract unit price, complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Granular Sub-base course</td>
<td>Sq. Meter</td>
</tr>
</tbody>
</table>

2.26.6 Relevant Test and Standards

The following test should be carried out unless otherwise directed by the engineer.

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>AASHTO T2</td>
<td>--</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>AASHTO T96</td>
<td>40% max.</td>
</tr>
<tr>
<td>Soundness (Sodium Sulphate Solution)</td>
<td>AASHTO T104</td>
<td>12% max.</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>AASHTO T89</td>
<td>30% max.</td>
</tr>
</tbody>
</table>
Plasticity Index  
AASHTO T90  
6% max.

Compaction test  
BS 1377  
(Modified Proctor)  
Part 4  
--

C.B.R. at 95% of modified Proctor density  
BS 1377  
(96 hr. soaked)  
Part 4  
40% min.

Field density  
AASHTO T191  
95% min.

Linear Shrinkage  
BS 1377  
3% max.

Sulphate Content (acid soluble)  
BS 1377  
0.5% max.

Chloride Content (water soluble)  
BS 812  
part 117  
1% max.

Sand Equivalent  
AASHTO T176  
25% min.

2.27 Aggregate Road Base

2.27.1 Description

Aggregate Road base shall consist of furnishing, spreading, and compacting aggregate base in accordance with the details shown on drawings and these specifications.

2.27.2 Materials

Aggregate material for Roadbase shall consist of hard, durable screened gravel or crushed stone, and shall be free from organic matter or other deleterious substances. Granular Roadbase aggregate shall be as directed by the Engineer who will choose from the following gradation or similar grading.

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>2 in. (50.8 mm)</td>
<td>-</td>
</tr>
<tr>
<td>1 1/2 in. (38.1 mm)</td>
<td>100</td>
</tr>
<tr>
<td>1 in. (25.4 mm)</td>
<td>75 - 100</td>
</tr>
<tr>
<td>3/4 in. (19.1 mm)</td>
<td>60 - 90</td>
</tr>
<tr>
<td>1/2 in. (12.7 mm)</td>
<td>45 - 80</td>
</tr>
<tr>
<td>3/8 in. (9.52 mm)</td>
<td>40 - 70</td>
</tr>
</tbody>
</table>
### 2.27.3 Construction

Aggregate for road base shall be delivered to the roadbed as uniform mixture and shall be spread in layers or windrows. Segregation shall be avoided and the base shall be free from pockets of coarse of fine materials.

The road base shall be spread by finisher and or grader or other approved mechanical methods, watered, shaped and compacted to the required grade and cross-section. The finished surface of the road base shall not vary at any point more than 1 cm. above or below the grade established by the Engineer.

The aggregate road base course shall be placed in horizontal layers not exceeding 200 mm in loose measurement.

**Aggregate Base:** The grading of test samples taken from the works is to be such that the % passing no.4 sieve size shall not vary by more than 7% from the sample originally submitted and approved.

The finished surfaces of the roadbase shall not vary at any point more than 1 cm. above or below the grade established by the Engineer. The aggregate base shall be compacted to not less than 100 percent of the maximum density determined in accordance with the latest BS 1377 Part 4. Particle size analysis of soils for sieve analysis of fine and coarse aggregate shall be carried out in accordance with AASHTO T88, T87. The roadbase shall be maintained in a condition satisfactory to receive any subsequent base or surfacing material. Aggregate roadbase which does not conform to the above requirements shall be reshaped or reworked, watered and thoroughly recompacted to conform to the specified requirements.

The compaction procedure and plant shall be proved by trials at the commencement of the works to the satisfaction of the Engineer. Compaction trials shall be carried out at varying moisture contents. The weights, types and number of passes of compaction plant shall also be varied to determine the optimum compaction effort.

Where directed by the Engineer a Sieve analysis shall be carried out on the material recovered from 5 consecutive field density tests. Where this sieve analysis shows an oversize material content of 10% or greater the area of construction will be removed and the source of the material rejected until further notice. Where considered necessary other areas of work which were carried out using material from the same source shall be tested in a similar manner.

### 2.27.4 Measurement

<table>
<thead>
<tr>
<th>No.</th>
<th>(mm)</th>
<th>x</th>
<th>y</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 4 (4.76 mm)</td>
<td>30 - 65</td>
<td>30 - 60</td>
<td>35 - 65</td>
</tr>
<tr>
<td>No. 10 (2.00 mm)</td>
<td>20 - 40</td>
<td>20 - 50</td>
<td>25 - 50</td>
</tr>
<tr>
<td>No. 40 (0.42 mm)</td>
<td>8 - 20</td>
<td>10 - 30</td>
<td>15 - 30</td>
</tr>
<tr>
<td>No. 200 (0.074 mm)</td>
<td>5 - 10</td>
<td>5 - 15</td>
<td>5 - 15</td>
</tr>
</tbody>
</table>
Aggregate Base will be measured by the square meter unless otherwise specified.

2.27.5 Payment

The accepted quantities of Aggregate Base will be paid for at the Contract unit price, complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate basecourse</td>
<td>Sq. Meter</td>
</tr>
</tbody>
</table>

2.27.6 Relevant Test & Standards

The following tests should be carried out unless otherwise directed by the Engineer at frequencies laid down in the specifications:-

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>AASHTO T2</td>
<td>--</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>AASHTO T96</td>
<td>40% max.</td>
</tr>
<tr>
<td>Soundness (Sodium Sulphate Solution)</td>
<td>AASHTO T104</td>
<td>12% max.</td>
</tr>
<tr>
<td>Sand Equivalent</td>
<td>AASHTO T176</td>
<td>40% min.</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>AASHTO T89</td>
<td>25% max.</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>AASHTO T90</td>
<td>6% max.</td>
</tr>
<tr>
<td>Test for organic materials</td>
<td>AASHTO T194</td>
<td>No organic materials permissible</td>
</tr>
<tr>
<td>Compaction test</td>
<td>BS 1377</td>
<td></td>
</tr>
<tr>
<td>(Modified Proctor)</td>
<td>Part 4</td>
<td></td>
</tr>
<tr>
<td>C.B.R. at 100% of modified Proctor density</td>
<td>BS 1377</td>
<td>80% min.</td>
</tr>
<tr>
<td>(96 hr. soaked)</td>
<td>Part 4</td>
<td></td>
</tr>
<tr>
<td>Field density</td>
<td>AASHTO T191</td>
<td>100% min.</td>
</tr>
<tr>
<td>Linear Shrinkage</td>
<td>BS 1377</td>
<td>3% max.</td>
</tr>
<tr>
<td>Sulphate Content</td>
<td>BS 1377</td>
<td>0.5% max.</td>
</tr>
<tr>
<td>Chloride Content</td>
<td>BS 812</td>
<td>1% max.</td>
</tr>
<tr>
<td></td>
<td>part 117</td>
<td></td>
</tr>
</tbody>
</table>

N.B. Nuclear Method for field density in accordance with AASHTO T238, ASTM D-2922 will be permitted.
2.28 Wit-Match Macadam Road Base

2.28.1 Description
Wet-Mix Macadam Roadbase shall consist of furnishing, spreading and compacting a granular roadbase in accordance with the details shown on the drawings and this Specifications.

2.28.2 Materials
Wet-Mix Macadam roadbase material shall consist of crushed rock or crushed wadi gravel material. It shall have at least one mechanically fractured face on 50% of the material retained on 5 mm sieve (Percentage of number of aggregates with at least one mechanically fractured face in total number of aggregates in the sample). The material shall be well graded and be within the grading limits shown below. It shall be practically free from all organic matter and any other deleterious substances (Maximum organic content permitted 0.1%).

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>% by weight passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>50 mm</td>
<td>100</td>
</tr>
<tr>
<td>37.5 mm</td>
<td>95 - 100</td>
</tr>
<tr>
<td>20 mm</td>
<td>60 - 80</td>
</tr>
<tr>
<td>10 mm</td>
<td>40 - 60</td>
</tr>
<tr>
<td>5 mm</td>
<td>25 - 40</td>
</tr>
<tr>
<td>0.600 mm</td>
<td>8 - 22</td>
</tr>
<tr>
<td>0.063 mm</td>
<td>0 - 8</td>
</tr>
</tbody>
</table>

The particle size distribution shall be determined in accordance with BS 1377 Part 2. The material shall be non-plastic. A minimum 10% fines value of 5 tonnes shall be required when tested in accordance with B.S. 812.

2.28.3 Construction
Aggregate for roadbase shall be delivered to the roadbase as uniform mixtures and shall be spread in layers. Segregation shall be avoided and the base shall be free from pockets of coarse or fine material.

Roadbase material shall be spread using a paving machine or a spreader box approved by the Engineer and operated with a mechanism which levels off the material to an even depth. Except where otherwise specified in individual clauses the material shall be spread in one layer so that after compaction the total thickness is as specified.

The finished surfaces of the roadbase shall not vary at any point more than 1 cm. above or below the grade established by the Engineer. The wet mix macadam base shall be compacted to not less than 100 percent of the maximum density determined in accordance with the latest BS 1377 Part 4. Particle size analysis of soils for sieve analysis of fine and coarse aggregate shall be carried out in accordance with AASHTO T88, T87 & T27. The
roadbase shall be maintained in a condition satisfactory to receive any subsequent base or surfacing material. Wet mix macadam roadbase which does not conform to the above requirements shall be reshaped or reworked, watered and thoroughly recompacted to conform to the specified requirements.

The compaction procedure and plant shall be proved by trials at the commencement of the works to the satisfaction of the Engineer. Compaction trials shall be carried out at varying moisture contents. The weights, types and number of passes of compaction plant shall also be varied to determine the optimum compaction effort. The material shall be compacted to a field density equal to or greater than the maximum dry density achieved by compaction test according to ASTM D1557. The moisture content of the laid material shall the optimum +/- 0.5 percent.

Where directed by the Engineer a Sieve analysis shall be carried out on the material recovered from 5 consecutive field density tests. Where this sieve analysis shows an oversize material content of 10% or greater the area of construction will be removed and the source of the material rejected until further notice. Where considered necessary other areas of work which were carried out using material from the same source shall be tested in a similar manner.

2.28.4 Measurement

Aggregate Base will be measured by the cubic meter unless otherwise specified.

2.28.5 Payment

The accepted quantities of Aggregate Base will be paid for at the Contract unit price, complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aggregate basecourse</td>
<td>cu.m</td>
</tr>
</tbody>
</table>
### 2.28.6 Relevant and Standards

The following tests should be carried out unless otherwise directed by the Engineer at frequencies laid down in the specifications:

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>AASHTO T2</td>
<td>--</td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>AASHTO T96</td>
<td>40% max.</td>
</tr>
<tr>
<td>Soundness (Sodium Sulphate Solution)</td>
<td>AASHTO T104</td>
<td>12% max.</td>
</tr>
<tr>
<td>Sand Equivalent</td>
<td>AASHTO T176</td>
<td>45% min.</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>AASHTO T89</td>
<td>25% max.</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>AASHTO T90</td>
<td>6% max.</td>
</tr>
<tr>
<td>Test for organic materials</td>
<td>AASHTO T194</td>
<td>No organic</td>
</tr>
<tr>
<td>Compaction test</td>
<td>BS 1377 Part 4</td>
<td>--</td>
</tr>
<tr>
<td>C.B.R. at 100% of modified Proctor density (96 hr. soaked)</td>
<td>BS 1377 Part 4</td>
<td>100% min.</td>
</tr>
<tr>
<td>Field density</td>
<td>AASHTO T191</td>
<td>100% min.</td>
</tr>
<tr>
<td>Linear Shrinkage</td>
<td>BS 1377</td>
<td>3% max.</td>
</tr>
<tr>
<td>Sulphate Content (acid soluble)</td>
<td>BS 1377 Part 3</td>
<td>0.5% max.</td>
</tr>
<tr>
<td>Chloride Content (water soluble)</td>
<td>BS 812 Part 117</td>
<td>1% max.</td>
</tr>
<tr>
<td>Elongation Index</td>
<td>BS 812 Part 105</td>
<td>35% max.</td>
</tr>
<tr>
<td>Flakiness Index</td>
<td>BS 812 Part 105</td>
<td>35% max.</td>
</tr>
<tr>
<td>Aggregates with minimum one face crushed</td>
<td></td>
<td>50% Min.</td>
</tr>
</tbody>
</table>

**N.B.** Nuclear Method for field density in accordance with AASHTO T238, ASTM D-2922 will be permitted.
2.29 Dikes of Guiding Dams

2.29.1 Description
Dikes shall consist of placing and compacting material to the sections, lines, and grades required to intercept the flow of surface water.

2.29.2 Construction
Guiding dams shall be constructed at the locations designated on the Drawings or as directed, in accordance with the details shown on the Drawings.

Fill material and compaction shall be as the embankment’s specifications.

2.29.3 Measurement
Dikes will be measured by the linear meter along the centerline of the dike.

2.29.4 Payment
The accepted quantities of Dikes will be paid for at the Contract unit price.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dikes or Guiding Dams</td>
<td>Linear Meter</td>
</tr>
</tbody>
</table>

2.30 Irish Crossing

2.30.1 Description
The wadi bed shall be excavated, to the required depth, leveled and compacted by a vibrating roller to not less than 95% of maximum density in accordance with AASHO designation. The gabions shall be placed in the upstream downstream direction. The voids of that portion of gabion under the road shall be filled with smaller stones to achieve maximum compaction. Open macadam courses, 10 cm. thick, shall then be placed and compacted as directed. The gradation of the Macadam aggregate will be determined on site by the Engineer's Representative. Following the macadam course, the reinforced concrete slab and other concrete shall be poured in situ or precast as shown on the Drawing and/or as directed by the Engineer. Upon the completion of work, all upstream and downstream trenches shall be filled and leveled to the satisfaction of the Engineer's Representative.

Construction of the Irish Crossing shall be in accordance with the details shown on the Drawings or as directed by the Engineer.

Reinforced concrete and plain concrete shall be 300kg/cm² in accordance with the Specifications but the cement used for the concrete shall be sulphate resistant cement.

The way of measurement and payment shall be to the way mentioned in the Bills of Quantities.
2.31 Gabions

2.31.1 Description

Gabions shall consist of furnishing and placing wire mesh boxes rectangular in shape filled with clean and uniform rocks larger than the mesh openings in accordance with the Drawings, and these specifications.

Gabions shall be of approved quality.

2.31.2 Materials

Wire mesh shall consist of galvanized steel fabricated in double twist woven hexagonal shape with the

<table>
<thead>
<tr>
<th>Wire Diameter</th>
<th>Mesh Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Boxes</td>
<td>3 mm</td>
</tr>
<tr>
<td>Mattresses</td>
<td>2 mm</td>
</tr>
<tr>
<td></td>
<td>8 cm x 10 cm</td>
</tr>
</tbody>
</table>

The rocks shall consist of clean solid rock non-friable and resistant to weathering and frost action meeting the following requirements:

- Specific gravity (bulk): ASTM C127-88, Min. 2.6 gms/cc
- Absorption: ASTM C127-88, Max. 3%
- Soundness by sodium sulphate: ASTM C88-90, Max 12%

The rock shall be larger in size than the larger mesh dimension. The rocks in the middle of the unit shall have a minimum size equal to the smaller mesh dimension.

2.31.3 Construction

Excavation required for the placement of gabions shall be made in accordance with the dimensions as shown on Drawings or as directed. Gabions shall be constructed in units to the dimensions indicated on the Drawings.

The sides, ends, and diaphragms of the gabions shall be lifted into a vertical position, and located together with binding wire to form the base.

The binding shall be carried out in a continuous lacing operation, the wire being passed through each mesh and around both selvedges which must be tight together with two round of turns after every second mesh.

Assembled gabions may be placed in position for filling singly, or wired together in groups suitable for man-handling. The baskets shall be securely wired together at all corners and edges in the same manner as described above. Where there are more than one course of gabions, the one in the upper course must be laced to those below. Gabions shall be slightly over-filled to allow for subsequent settlement.
2.31.4 Measurement

Box Gabions will be measured by the cubic metre and mattress gabions will be measured by the square metre in place.

2.31.5 Payment

The accepted quantity will be paid for at the Contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gabions, Boxes</td>
<td>Cubic Meter</td>
</tr>
<tr>
<td>Gabions, Mattresses</td>
<td>Square Meter</td>
</tr>
<tr>
<td>Excavation</td>
<td>Cubic Meter</td>
</tr>
<tr>
<td>Backfilling</td>
<td>Cubic Meter</td>
</tr>
</tbody>
</table>

2.32 Broken Stone Riprap

2.32.1 Description

This work shall consist of the protection works against scour for the bridge piers, bridge abutments, culverts, road embankments, guiding dams, channels and ditches where shown on the Drawings by loose stone riprap, grouted riprap, rock fill and rockfill with mat, furnished and constructed in accordance with these specifications at the locations and in conformity with the lines, grades and dimensions shown on the Drawings or as directed by the Engineer.

2.32.2 Materials

2.32.2.1 Stones

Stones for this work shall be hard, dense, durable, angular, field or quarry stones of such quality that they will not disintegrate on exposure to water or weathering. The minimum dimension of a single stone shall not be less than one third of the maximum dimension. Shale and stone with shale seams are not acceptable. Unless otherwise specified on the plans, the stones shall satisfy the following requirements.

1st) Loose Riprap Protection

- Maximum stone weight = 40 kg
- Fifty percent (50%) by weight = 8.0 kg.
- Twenty-five percent (25%) by weight = 2.0 kg.
- Minimum stone weight = 0.5 kg.
- Maximum stone dimension = 25 cm

2nd) Grouted Riprap Protection, Protection at Outlets of Culverts, Mat at Bridge Abutments and Mat in Rockfill Protection with Mat.
Maximum stone weight = 60 kg  
Fifty percent (50%) by weight = 15 kg  
Twenty-five percent (25%) by weight = 5.0 kg.  
Maximum stone dimension = 30 cm  
Minimum stone weight = 1.0 kg.

The rock material shall also meet the following quality requirements:

<table>
<thead>
<tr>
<th>Test</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Apparent specific gravity</td>
<td>2.7 g/cc min.</td>
</tr>
<tr>
<td>Absorption</td>
<td>1.5% max.</td>
</tr>
<tr>
<td>Abrasion loss after 1000 revolutions</td>
<td>45% max.</td>
</tr>
</tbody>
</table>

Tests for gradation and for quality requirements will be carried out by the Contractor at his own expense under the supervision of the Engineer, whenever the Contractor changes quarries or when rock layers within one quarry change. To aid the inspector's judgment, a sample of riprap of the specified gradation should be prepared by sorting, weighing and remixing in proper proportions. The sample shall weigh about 5 tons and shall be placed at the construction site.

3rd) **Gravel Layer**

The stones of the gravel layer shall be durable, angular field or quarry stones of approved quality, soundness and free of seams. The stone gradation shall be within the limit of Grading (1" to No.4) of the ASTM test sieve passing by weight complying in all respect with AASHO Designation T27-70.

2.32.2.2 **Grout**

Grout for grouted riprap shall consist of one part Portland cement and three parts of sand, thoroughly mixed with water to produce grout having a thick creamy consistency. The minimum amount of water should be used to prevent excess shrinkage of the grout after placement.

2.32.3 **Construction**

2.32.3.1 **Excavation**

Before commencing with the protection works, foundation trenches at the toe of the embankment slopes and other necessary excavations in the area to be protected with riprap or rock fill shall be excavated to the levels shown on the Drawings and/or as directed by the Engineer. If rock is encountered at a higher level than the excavation depth required, excavation shall stop at the surface of rock or as shown on the Drawings. All excavation for protection works shall be approved by the Engineer before the placing of riprap is begun.
Surplus excavated material resulting from protection works, shall be disposed off and levelled by the Contractor at his own responsibility and expense, outside the limits of the right-of-way unless otherwise directed by the Engineer.

2.32.3.2 Riprap

The stones shall be placed on the gravel layer or on the prepared surface or slope in a manner which will produce a reasonably well graded mass of stone with the minimum practicable voids. Stone protection shall be placed to its full thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of stone protection in layers or by dumping into chutes or by similar methods likely to cause segregation shall not be permitted and the entire mass of stones shall roughly conform to the gradation specified and shall be fairly compact. The thickness of the riprap layer shall at no place be less than seventy five percent (75%) the thickness indicated on the Drawings. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.

2.32.3.3 Gravel Layer

The gravel layer of 15 cm. depth or as shown on the Drawings shall be spread and leveled to the satisfaction of the Engineer.

2.32.3.4 Grouted Riprap

The stones shall be placed on the prepared slope on the gravel layer and shall be thoroughly moistened. The grout shall be delivered to the site by any means that will ensure uniformity and prevent segregation of the grout. If penetration of grout is to be obtained by gravity flow into the interstices, the grout should be spaded or rodded into the interstices to completely fill the voids in the stone blanket. If pressure grouting is used, care should be taken to avoid unseating the stones and grout should be spaded or rodded into the voids. Penetration of the grout should be to the depth specified. Stones should be brushed until 2 cm. or one fourth of the depth of the surface stone is exposed. Drain holes shall be provided as indicated on the Drawings.

Grout shall be placed only when the temperature meets the requirements for pouring concrete and shall be cured in a manner similar to that of concrete. After grouting is completed, no load should be placed on the grouted riprap until the grout has completed cured.

2.32.4 Measurement & Payment

This work will be measured by the cubic meter in accordance with the dimensions indicated on the Drawings, for works completed and accepted by the Engineer. The bid unit price per cubic meter for all types of protection and for rock fill shall constitute full compensation for furnishing and placing all materials, including labour, equipment, tools, and incidentals necessary to complete the work prescribed in this section, as well as all excavation works except excavation for structures which shall be paid for as provided in Section 6 of these specifications.
2.33 Excavation & Backfilling of Trenches all Service Lines Other Than Drainage, Sewerage & Water Supply

2.33.1 Excavation & Preparation of Tender Formation

The Contractor in carrying out excavation for cable/ducts shall, where required, erect and maintain an approved type of temporary fencing around any work and shall provide fenced access ways across the trenches.

1. The Contractor shall ensure that all excavation and timbering is carried out in a careful manner, that it is rendered secure and safe, and that all measures necessary are taken to prevent the removal or falling in of material beyond the trench dimensions detailed. The Contractor shall maintain all timbering until the completion of the work to the satisfaction of the Engineer and shall promptly remove any material which has caved into the excavation.

2. The Engineer may direct the Contractor to protect his excavation with timbering where, in his opinion, such timbering is necessary to ensure the safety of the workmen, adjoining structures and work generally. Any action taken by the Engineer in this regard will in no way relieve the Contractor of any responsibility or liability under the Contract.

3. A clear space shall be left between the edge of the excavation and the inner toes of the spoil banks, to the approval of the Engineer.

4. No back-throwing whatever shall be allowed and all materials shall be brought to the surface and formed in heaps clear of the excavation.

5. The material excavated in trenches shall, if unsuitable, be removed from site and shall be replaced with suitable material.

Unsuitable material shall include:

- Materials from swamps, marshes and bogs
- Materials susceptible to spontaneous combustion
- Stumps and perishable material
- Clays of liquid limit exceeding 40% and/or plasticity index exceeding 11%
- Excessively wet materials

All surplus and unsuitable excavated material shall be carted to the approved tip.

6. The bottom of the trench shall be accurately graded. Care shall be taken not to excavate below the depths indicated. Where rock is encountered, the rock shall be excavated to the required depth. Uneven surfaces of the bottom of trench shall be excavated 150mm deeper. Such depth in rock shall be backfilled with approved fill material and compacted as specified and/or as directed by the Engineer.

7. Whenever unsuitable soil, which in the opinion of the Engineer is to be removed, shall be removed to the depth required and the trench backfilled to the proper grade with approved fill material and compacted.
8. The width and depth of the trenches for electrical and telephone cables/ducts shall be as specified in the relative drawings or as ordered by the Engineer. Banks may be sloped or widened to facilitate placement of cables, but not the extent that will cause interference with other utilities and structures. No battering of trenches shall be allowed under existing carriageways, unless otherwise agreed by the Engineer.

2.33.2 Protection of Existing Services

1. Where new cable/ducts are to be laid alongside, over or under the existing, the Contractor shall take care to interfere as little as possible with the existing services and connections thereto and any damage shall be repaired by the Contractor to the approval of the appropriate Authority or by appropriate Authority at the cost of the Contractor.

2. The Contractor shall make all arrangements for protecting existing services and for temporarily diverting them to maintain the services without interruption.

3. Existing services, pipes, mains, ducts, etc., exposed in trenches for new work shall be protected in accordance with the requirements of the relevant Authority before trenches are refilled.

4. The Contractor shall lay cables, fittings, specials, etc., under hedges, fences, walls, etc., as necessary.

5. Where hedges are damaged or destroyed the whole shall be restored and reinstated with shrubs of the same kind as the hedge, planted in due season in an approved manner and fenced on each side with post and rail stock proof fences finished on top with one strand of galvanised barbed wire, or otherwise protected as required by the owners or occupiers and the Engineer.

6. Where fences or walls are damaged or destroyed the whole shall be restored and reinstated with like materials to the satisfaction of the owners or occupiers and the Engineer.

7. The Contractor shall ensure that no trees are damaged or permanently removed in carrying out the Contract except where directed due to the presence of permanent works.

2.33.3 Backfilling of Trenches

1. After the cables/ducts have been laid, the trench refilling shall commence with approved fill in compacted layers not exceeding 200 mm thick, each layer being well compacted by hand with iron rammers weighing not less than 5 kg, until the trench has been filled to a height of 300 mm above the top of the cable/duct.

2. The remainder of the trench shall then be refilled in compacted layers not exceeding 200 mm in thickness, each layer being well compacted with power rammers, vibrating plate compactors or other mechanical means of a type to be approved until the ground is thoroughly consolidated up to the required level for surface reinstatement. Each layer shall be compacted to 95% of its maximum dry density. Should the quantity of the excavated materials be not sufficient, due to unsuitability or otherwise, for the process of backfill and fill, the Contractor shall obtain the quantity.
required of such backfill and fill from approved borrow pits and transport same to the site of work at his own expense.

3. Trenches shall not be backfilled until all required tests are performed and until the Engineer has verified that the cables etc have been installed in accordance with the specifications and drawings.

4. Lumps and clods shall be broken up before use. Materials shall not be dropped from a height and where directed water shall be added to assist in adequate consolidation.

Where cover to cables/ducts is less than 400mm, or where ordered by the Engineer, protection in the form of concrete encasing shall be provided according to an approved drawing or as ordered by the Engineer.
3 **CONCRETE WORKS**

3.1 **Quality of Concrete**
Design mix to match the concrete specifications must be submitted by the contractor for the engineers approval.

The used concrete class for some element is (300 kg/cm²). (as mentioned in the drawings).

The used concrete class for other elements is (250 kg/cm²). (as mentioned in the drawings).

**Aggregate/Cement Ratio:** The term aggregate/cement ratio means the ratio by weight of aggregate to cement in the mix. For this purpose the aggregate is taken in a saturated surface-dry condition as for the water/cement ratio above.

**Fine/Total Aggregate Ratio:** The term fine-total aggregate ratio means the ratio by weight of the fine aggregate to the total aggregate in the mix expressed as a percentage. For this purpose the aggregate is also taken in a saturated surface dry condition as for the water/cement ratio above.

**Volume of Air Entrained:** The air content expressed as a percentage by volume of concrete, shall be determined by ASTM method C231 "Air Content of Freshly Mixed concrete by the Pressure Method". At least one test for each 120 cubic meters of concrete shall be made or as instructed by the engineer.

**Slump:** The slump of the freshly mixed concrete shall be determined in accordance with Part 2 of B.S. 1881 or ASTM C143. At least one morning and one afternoon test shall be made and whenever directed by the Engineer.

**Strength of Concrete:** Preliminary Test Cubes shall be taken from the trial mixes designed to select the job mix and shall be made and tested in accordance with Parts 6 and 8 of B.S. 1881. Works Test Cubes shall be those used for control during construction and shall be made and tested in accordance with parts 7 and 8 of B.S. 1881.

3.2 **Action to be Taken in the Event of Non-Compliance With the Testing Plan.**

When the average strength of four consecutive test cubes fails to meet the first requirement, the mix proportions of subsequent batches of concrete should be modified to increase the strength.

The action to be taken in respect of the concrete which is represented by the test cubes which fail to meet must be determined by the Engineer. This may range from qualified acceptance in less severe cases to rejection and removal in the most severe cases. In determining the action to be taken, the engineer should have due regard to the technical consequences of the kind and degree of non-compliance, and to the economic consequences of alternative remedial measures either to replace the sub-standard concrete or to ensure the integrity of any structure in which the concrete has been placed.
In estimating the quality of the sub-standard concrete and in determining the action to be taken, the engineer should establish the following, wherever possible.

1. The validity of the test results, and confirmation that specimen sampling and testing has been carried out in accordance with BS 1881.
2. The mix proportions actually used in the concrete under investigation. These may affect durability.
3. The actual section of the structure represented by the test (cube(s)).
4. The possible influence of any reduction in concrete quality on the strength and durability of this section of the structure.

The engineer has the right to carry out tests on the hardened concrete in the structure. These may include non-destructive methods or the taking of cored samples. The results of any such tests should not nullify the establishment of non-compliance with the testing plan provided that this is based on valid cube test results.

3.3 Air Content of Fresh Concrete.

The percentage air content determined from individual samples taken at the point of placing the concrete and representative of any given batch of concrete should be within ± 1.5 of the required value. The average percentage air content from any four consecutive determinations from separate batches should be within ± 1.0 of the required value.

It should be noted that the method of measuring air content described in BS 1881 is not necessarily applicable to concrete made with lightweight aggregate.

3.4 Additional Tests on Concrete for Special Purposes

Additional cubes may be required for various purposes. These should be made and tested in accordance with BS 1881 but the methods of sampling and the conditions under which the cubes are stored should be varied according to the purpose for which they are required. For determining the cube strength of concrete before transfer or of concrete in a member before striking formwork or removing cold weather protection, sampling should preferably be at the point of placing and the cubes should be stored as far as possible under the same conditions as the concrete in the members. The extra cubes should be identified at the time of making and should not be used for normal quality control or compliance procedures.

3.5 Method statement

3.5.1 Concrete method statement

   A. Supply: concrete will be supplied by an approved ready mix supplier.
   B. Mix. Concrete will be delivered according to the approved Mix design.
   C. Equipment:
      − Appropriate number of transit mixers will be used to grant delivery of concrete each (12-15) minutes including 3 minutes of fast mixing at site.
      − Concrete pump / crane and skip will be used if so instructed by the Engineer.
A minimum of 2 No. of vibrators and one standby will be available at the location of pours. Diameter of pocker will be decided accordingly to size of form work.

D. Crew & Tools: Casting crew will be supervised by foreman and will consist of 3 masons and 4 helpers. Using hand tools as required i.e. trowels, wheel barrow, buckets, hand shovels.

E. Approval of method and material for formwork is required.

F. Concrete will be casted in approved locations such as formwork, on compacted soil..etc.

G. Finishing : After completion of the pour the top surface will be finished in accordance with drawings and Specifications.

H. Curing : A day after poring the wet hessian wool for 7 consecutive days are required.

I. Removal of shutter as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Time For Removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Vertical sides of beams, columns and slabs</td>
<td></td>
</tr>
<tr>
<td>- Less than 1.2 m high</td>
<td>24 Hours</td>
</tr>
<tr>
<td>- More than 1.2 m high</td>
<td>48 Hours</td>
</tr>
<tr>
<td>2. Concrete walls</td>
<td>4 Days</td>
</tr>
<tr>
<td>3. Beams and main slabs removal of props in summer</td>
<td>14 Days</td>
</tr>
<tr>
<td>4. Beams and main slabs removal of props in winter</td>
<td>18 Days</td>
</tr>
</tbody>
</table>

J. Remedial works: Any remedial works (after shutter removal) must be inspected and approved by the Engineer.

K. Notification for checking “ready for concrete” areas should be at least 24 hours in advance.

L. Placing of concrete:
   - Should not take place in the open during storms or heavy rains.
   - Adequate lighting should be provided at night or in dark interiors after the approval of the engineer.

3.6 Quality assurance & Quality control.

A. Cubes for testing shall be made, cured, stored, transferred and tested to BS 1881 (calibration of cube testing machine to be verified at 3 monthly maximum intervals.

B. Slump test must be taken for all transit mixers as per Specifications.

C. Only approved concrete or plastic spacers should be used.
D. Construction / contraction / expansion joints shall be formed and located as shown on the drawings or advised by the Engineer and filled / sealed with approved materials.
E. Partially set concrete shall not be incorporated in the works.

3.7 Steel Reinforcement Method Statement
A. All reinforcement in the steel yard will be covered by plastic sheets, and placed above bare soil level in a well drained area. The stock piling will be made in separate stock divided per diameter of steel.
B. All bar cutting and bending schedules must be approved by the Engineer.
C. Steel rod reinforcement shall be cut, bent, and fixed to BS 8110 Part (1) cold cutting to be used.
D. Overlapping length is to be 40 X diameter bar.
E. Anchorage shall be 40 X dia. of steel.
F. Bar cutting machine will cut up to 22 mm bar diameter.
G. Bar bending machine will bend up to 22 mm bar diameter.

3.8 Quality assurance & Quality control
A. Yield stress test for proposed steel, or any other test requested by the Engineer.
B. Binding wire must be approved by the Engineer.
C. Reinforcement shall be grit blasted before use to remove rust (if required).

Minimum thickness of concrete covers shall be stated in the drawings or according to schedule under the specifications of the Concrete Works- Particular Specifications. Concrete or plastic spacers as agreed by the Engineer are required to assure covers are maintained.

3.9 Concrete Works Specifications

3.9.1 Description
Structural concrete shall consist of furnishing all materials and constructing structures of the forms, shapes and dimensions shown on the plans or as directed, using Portland cement concrete, in accordance with the details shown on the Drawings and these specifications.

Portland cement concrete shall consist of a mixture Portland cement, fine aggregate, coarse aggregate, water and additives when required. The mixture shall be proportioned, mixed, placed and cured in accordance with these specifications for the class of concrete specified.

3.9.2 Materials
These specifications give methods of specifying, producing and assessing concrete for compliance which will in general ensure that strength, durability and impermeability will be adequate for liquid-retaining structures. CP 110: part 1 : 1972.

3.9.2.1 General Requirements
The classes of concrete and the minimum required compressive strength shall be as shown:

<table>
<thead>
<tr>
<th>Concrete Class</th>
<th>Comp. Strength @ 28 day for Cylinder</th>
<th>15x15x15 cm cube</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 300</td>
<td>300kg/cm² ( 4260 psi )</td>
<td>345kg/cm² ( 4900 psi )</td>
</tr>
<tr>
<td>B 250</td>
<td>250kg/cm² ( 3550 psi )</td>
<td>287kg/cm² ( 4075 psi )</td>
</tr>
<tr>
<td>B 200</td>
<td>200kg/cm² ( 2850 psi )</td>
<td>230kg/cm² ( 3270 psi )</td>
</tr>
<tr>
<td>B 150</td>
<td>150kg/cm² ( 2130 psi )</td>
<td>180kg/cm² ( 2555 psi )</td>
</tr>
</tbody>
</table>

3.9.2.2 Fine Aggregate for Concrete and Mortar
Fine aggregate for concrete shall consist of natural sand having hard and durable particles, or of other inert materials with similar characteristics. It shall not contain harmful materials such as clay lumps, tree roots, shale, iron pyrites, coal mica, organic matter or any deleterious matter which may attack the reinforcement in such a form or in sufficient quantity to affect adversely the strength or durability of the concrete. If necessary, the aggregate shall be washed and sieved to remove the deleterious substances.

The fine aggregate shall comply in all respects with following requirements:

3.9.2.2.1 Gradation

<table>
<thead>
<tr>
<th>Sieve No.</th>
<th>3/8&quot;</th>
<th>#4</th>
<th>#16</th>
<th>#50</th>
<th>#100</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Passing by weight</td>
<td>100</td>
<td>95 - 100</td>
<td>45 - 80</td>
<td>10 - 30</td>
<td>2 - 10</td>
</tr>
</tbody>
</table>

The Engineer may approve on request the use of other gradations provide that there is satisfactory data on the properties of concrete made with them.

3.9.2.2.2 Absorption 6% max.

3.9.2.2.3 Fineness Modulus
(F.M) 2.3.3.1 and ± 0.2 tolerance from the approved sample

3.9.2.2.4 Sand Equivalent (S.E.)
70 (min) for concrete Classes B250 and B300
65 (min) for concrete Classes B200 and B150 (AASHTO-T176)

3.9.2.2.5 Soundness Test
A. to be 12 max. When tested by sodium sulphate
B. and 18 max. When tested by magnesium sulphate (AASHTO-T104)
3.9.2.2.6 Clay Lumps and Particles
0.5 % max. (AASHTO-T112)

3.9.2.2.7 Passing #200 sieve 5% max.

3.9.2.2.8 Organic impurities
Not darker than standard color (AASHTO-T121-81)

3.9.2.2.9 Coarse aggregate for Concrete
Coarse aggregate for concrete shall consist of natural gravel, crushed gravel, or crushed stone free from coating of clay or other deleterious substances. It shall not contain harmful materials such as iron pyrites, coal, mica, laminated materials, tree roots, shale or any materials which may attack the reinforcement in such a form or in sufficient quantity to affect adversely the strength and durability of the concrete. If necessary, coarse aggregate shall be washed to remove deleterious substances.

The aggregate shall comply in all respects with the requirements of B.S. 882, AASHTO specifications, or other equivalent ASTM standards, if required by the Engineer. The aggregate shall also fulfill the following requirements.
The Engineer may approve on request the use of other gradations provided that there is satisfactory data on the properties of concrete made with them. The preferred normal maximum sizes of coarse aggregate are 40 mm and 20 mm. The maximum size of coarse aggregate should in no case be greater than one-quarter of the minimum thickness of the member.

### Absorption
4% max.

### Abrasion
35% max. For concrete Classes B250 and B300.
40% max. For concrete Classes B200 and B150. (AASHTO-T96)

### Soundness Test
- to be 12 max. When tested by sodium sulphate.
- and 18 max. When tested by magnesium sulphate. (AASHTO-T104)

### Clay Lumps and Friable particles:
1% max. (AASHTO-T112-81)

### Chlorides (cl)
(by weight of cement) 0.35% max.

### Sulphate (S03)
(by weight of cement) 2.5% max.

### Passing #200
1% max.

### Flakiness and Elongation Index
25% max. For each (BS-812)

### Ratio of Water loss
100/500 22% max.

### Samples of Aggregates
Samples of both fine and coarse aggregates are to be submitted to the Engineer for testing at least one week before commencing deliveries. No deliveries in bulk are to commenced until such samples are approved by the Engineer as complying with the specifications.

### Water
Water for washing aggregate and for mixing of concrete shall be potable, fresh, clean and substantially free from oil, acids, alkali, sewage, deleterious mineral or organic matter. It shall not contain chlorides such as sodium chloride in excess of 1000 ppm.
nor sulphates such as sodium sulphate in excess of 600 ppm. It shall not contain any impurities in amount sufficient to cause a change in the time of setting of Portland cement of more than 25 percent, not a reduction in the compressive strength of mortar of more than 5 percent compared to results obtained with distilled water.

Water for curing concrete shall not have a PH lower than 5 nor contain impurities in sufficient amount to cause discoloration of the concrete. Sources of water shall be maintained at such depth and the water shall be withdrawn in such a manner as to exclude silt, mud, grass and other foreign matter.

3.9.6 Water/Cement Ratio

The quantity of water to be added to the cement and aggregates during mixing shall be just sufficient to produce a workable mix to enable it to be well compacted and worked into corners of formwork and around reinforcement.

All mixes shall be designed in respect of the proportioning of water so that the Slump Test when conducted according to (AASHTO T-119 or B.S 1991, 1952) shall not be greater than 3 cm for concrete which is to be vibrated and 7 cm for concrete which will not be vibrated. Measurement of water on the site shall take into account moisture present in the aggregate, and Slump Tests shall be taken sufficiently and frequently to ensure that variations in the moisture content of the aggregate are fully taken into account in determining the amount of water to be added.

3.9.7 Trial Mixes

Following the Engineer's approval of the materials for each class of concrete, the Contractor shall prepare a trial mix of each grade of concrete in the presence of the Engineer. Each trial mix shall comprise not less than 1/3 of a cubic meter of concrete and shall be mixed in an approved type of concrete mixer similar to that which the Contractor proposes to employ on the works. The quantities of all ingredients of each trial mix, including water, shall be carefully determined by weight according to the mix design.

Each trial mix shall show no tendency to segregate when handled and compacted by the methods by which the Contractor proposes to handle and compact the grade of concrete in the works and it shall be capable of adequate compaction by such methods.

3.9.8 Cement

Use Portland cement type 1 (AASHTO M85-080 / BS 12). The cement shall be of approved manufacture and shall be delivered in bags with seals unbroken, or delivered in bulk, and it shall be delivered in approved containers. Test certificates from the manufacturers or suppliers shall be submitted for each consignment and shall indicate the results of the tests for compressive strength, setting time, soundness and fineness. Cements shall be stored on the site in such a way to keep it away from water at all times.

The cement used should be either:

A. Portland cement complying with the requirements specified in BS 12, or
B. Portland blastfurance cement complying with the requirements specified in BS 146, or
C. Sulfate-resisting Portland cement complying with the requirements specified in BS 4027, or
D. Low heat Portland cement complying without the requirements specified in BS 1370, or
E. Low heat Portland blastfurance cement complying with the requirements specified in BS 4246, or
F. Super sulfated cement complying with the requirements specified in BS 4248.
G. If super sulfated cement is used, reference should be made to 6.3.5 of CP110:Part 1:1972.

3.9.9 Cement content.
The cement content of any batch of concrete should be not less than the specified minimum value minus 5% of that value, nor more than the specified maximum value plus 5% of that value. The observation of batching in relation to the indicated batch weights is one way of ensuring this.
As an alternative the cement content may be determined from samples representative of any batch of concrete provided that a suitable testing regime (including errors due to sampling) is used to measure the cement content of fresh concrete to an accuracy of ±5% of the actual value with a confidence of 95%.
The minimum cement content which will be provided in the concrete must be acceptable for durability and impermeability for liquid-retaining structures and will be 360 kg/m³ and must not be more than 400 kg/m³.

3.9.10 Admixtures
Air entraining agents, plasticisers, waterproofing agents, retarders, and other similar admixtures shall be of approved proprietary brands and shall be used in accordance with the manufacturer's recommendations. Samples of proposed admixture shall, if required, be submitted to an approved testing authority by the Contractor in order to ascertain its suitability for use in the works.
The cost such admixtures shall be included in the cost of concrete and no extra payment shall be made if they are used. The proportions of cement, fine aggregate and coarse aggregate and water shall be determined by the Contractor before concreting commences and submitted together with such test results as may be required to the Engineer for approval and the Contractor shall not commence concreting before such approval is given nor shall be alter or vary in any way the proportions of mix unless he submits new test results and mix proportions to the Engineer for approval.
The approval by the Engineer of such mix designs does not in any way absolve the Contractor of any of the requirements of the specification.
If naturally occurring sand gravel mixtures are to be used with or without the addition of single sized aggregates, the Contractor shall satisfy himself that the natural variations in the source of such material do not prejudice the strength of the concrete or the requirements of maximum aggregate size and for this purpose the Engineer may require tests of concrete made from materials selected from various parts of the source and may require such screening of pre. treatment of the mixture as is in his option necessary to ensure compliance with the specification.
Calcium chloride or admixtures containing chlorides should not be used. Other admixtures and constituents may only be used with the approval of the engineer.

3.9.11 Measurement of Ingredients

The aggregates for the concrete shall be measured by weight, but measurement by volume may be allowed in special circumstances with the prior approval of the Engineer.

When the aggregate are to be measured by weight, the weight-batching machines shall be of a type approved by the Engineer. They shall be kept clean and in good condition and adjustment. At intervals as the Engineer may require, the Contractor shall check the accuracy of each weight-batching machine.

When the aggregates are to be measured by volume, the proportions of fine and coarse aggregate shall be measured in well constructed gauge boxes, of dimensions approved by the Engineer, to guarantee that whole multiples of such gauge boxes will ensure the use of one or more whole bags or containers of cement and the capacity of the concrete mixer shall be such as to ensure that no splitting of cement bags or containers is required. Gauge boxes shall be properly filled and struck-off level addition of fine aggregates to allow for bulking due to moisture content being made as required.

An efficient water measuring device shall be fitted to each concrete mixer. Any cement container shall be such as to contain an accurately weight amount of cement.

3.9.12 Mixing Concrete

The concrete shall be mixed in a power driver machine of the batch type, no hand mixing being allowed. The mixer shall be large enough to admit the use of one cement bag or container or whole multiples of bags or containers at a time. The mixing shall continue until there is a thorough distribution of the materials and the mass is uniform in consistency and color. The period of mixing judged from the time that all the ingredients, including water, are in the mixing drum shall be ordered by the Engineer, but shall not be less than 2 minutes or 20 reevaluations of the drum, which ever is longer should there be for any reason for stoppage of greater than 30 minutes, the drum or other containers after mixer shall be thoroughly washed before mixing is resumed. On completion of the mixing, the concrete shall discharged into clean boards or into clean barrows, etc. The method of discharge from the mixer shall be such as to cause no segregation whether partial or otherwise of the concrete materials.

3.9.13 Re-mixing

Concrete which has commenced to set shall not be remixed either with or without additional water and in no case shall such concrete be used in the works.

3.9.14 Concrete Testing - Preliminary

The following method of testing shall apply to standard concrete cubes or cylinders. After the materials have been approved and at least 10 days before any concrete is placed the Contractor shall make preliminary sets of test cylinders or cubes. Each set of test cylinders or cubes shall be comprised of cylinders or cubes made from a single sample of concrete taken from the point of final discharge of the wet concrete.
Each cylinder or cube shall be made under the Engineer’s supervision. Cylinders or cubes shall be tested as follows. Three cylinders or shall be tested 7 days after the date of manufacture and three cylinder or cubes 28 days after the date of manufacture. Preliminary test cylinders or cubes shall be made and tested for all grades of concrete and for all proposed variations of quality quantity or origin of the aggregates and cement.

Should either the test crushed at 7 days or that crushed at 28 days fall below the specified requirements, the Contractor shall, on the Engineer’s instructions, alter the mix design and/or the source of aggregates, cement or water, and/or the method of mixing including alteration or the type mixer. The compressive strength of the concrete cube or cylinder at 7 days shall be equal to two thirds (2/3) of the required compressive strength at 28 days.

3.9.15 Concrete Testing - Works

Prior to commencing the work the Contractor, shall make available on site the following minimum approved equipment kept in good condition at all times:
Six 15 cm cube moulds.
Slump cones.
Set of B.S. sieves or equivalent.
Balance.
Thermometer.
Plastic Cylinder.
Other accessories as required.

All testing shall be done in the presence of the Engineer or his authorized representative either on Site or in an approved testing laboratory as directed.
In case of the concrete compression strength is less than the required specified strength, non destructive tests will be carried out to verify these results according to CP110.
(Test at 7 days must not be less than 2/3 the required strength at 28 days)

3.9.16 Testing plan:

Each cube shall be made from a single sample taken from a randomly selected batch of concrete. The samples should, where practicable, be taken at the point of discharge from the delivery vehicle.
Compliance with the specified characteristic strength may be assumed if
A. the average strength determined from any group of four consecutive test cubes exceeds the specified characteristic strength by not less than 0.5 times the current margin, and
B. each individual test result is greater than 85% of the specified characteristic strength.
The current margin should be taken to be 70% of the specified characteristic strength for concrete of grade 15 N/mm² for concrete of grade 20 or above, unless a smaller margin has been established to the satisfaction of the Engineer.

If only one cube result fails to meet the second requirement then that result may be considered to represent only the particular batch of concrete from which that cube was taken provided the average strength of the group satisfies the first requirement.
3.9.17 Concrete Testing - Workability

The Contractor shall make slump and/or compacting factor tests at such frequency as the Engineer considers necessary to ensure that the workability and consistency is maintained in accordance with the specified mix or accepted mix design and the trial mix. But, in any case workability tests shall be made at least once every two hours during which concrete is being mixed.

**Slump:** The workability of concrete should be within the limits specified in specifications.

<table>
<thead>
<tr>
<th>Compacting factor</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>+ 0.03, where the required value is 0.90 or more;</td>
<td>+ 0.04, where the required value is less than 0.90 but more than 0.80;</td>
</tr>
<tr>
<td>+ 0.05, where the required value is 0.80 or less.</td>
<td></td>
</tr>
<tr>
<td>VB</td>
<td>+ 3 seconds or + one fifth of the required value, whichever is the greater.</td>
</tr>
</tbody>
</table>

3.9.18 Frequency of Testing

During the mixing and casting of concrete the frequency of testing control purposes shall be as indicated below or as directed by the Engineer. No direct payment will be made for testing. The price of this work shall be included in the bid prices of concrete.

3.9.19 Transporting Concrete

Concrete shall be taken from the place of mixing to the place of deposition by methods which will prevent the segregation or loss of the ingredients and which are sufficiently rapid to ensure that the concrete does not commence to set before it is compacted in position. The concrete shall be deposited as near as possible to its final position in the Work and shall not allowed to flow into position.

Deposition of the concrete through chutes shall not be permitted and neither shall the concrete be dropped from a height exceeding five feet. Pumping concrete through delivery pipes may be permitted, but only with the prior approval of the Engineer.

<table>
<thead>
<tr>
<th>Type of Test</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grading, fine and coarse aggregate</td>
<td>Once for each source</td>
</tr>
<tr>
<td>Concrete Cylinder or Cube Test</td>
<td>1 set for 30 m³ of concrete or for each working day</td>
</tr>
<tr>
<td>Slump Test</td>
<td>Once every two hours from each mixer</td>
</tr>
<tr>
<td>Mix Design</td>
<td>Once for each source of aggregate or every combination of sources</td>
</tr>
</tbody>
</table>
3.9.20 **General Requirements For Placing Concrete**

No concrete shall be placed in a foundation until the extent of excavation and the character of bearing materials have been approved and no concrete shall be placed in any structure until the placement of reinforcing steel and the adequacy of the forms and false work have been approved.

The concrete shall be placed in its final position as soon as possible after it has been mixed and in any case before the initial set has taken place. The Contractor shall ensure that concrete which has already been placed in position and commenced to set is not disturbed by the placing or compaction of further concrete nearby.

All concrete shall be carefully worked around and between reinforcement and all other embedded fittings without such reinforcement or fittings being disturbed.

Concrete is to be worked well up against whatever surface it joins.

3.9.21 **Tamping For Compacting Concrete**

All concrete shall be thoroughly compacted to the maximum with approved rammers without any segregation in its final position before it commences to set. Care shall be taken to ensure that the use of spade type remmers does not cause segregation of the aggregates and water. Initial compaction of slabs shall be with approved remmers and compaction by a screed board shall be limited to that required for the final shape and finish. During the placing and compaction of reinforced concrete, a competent steel setter shall be in attendance to adjust and correct if necessary the position of the reinforcement.

Concrete shall not be tamped as the primary means of compacting without the Engineer's approval. Vibrating shall be the primary means of compacting.

3.9.22 **Vibrating For Compacting Concrete**

Concrete shall be compacted by vibrating with approved vibrators. The vibrator shall not be attached to any reinforcement or embedded fitting and where vibrators of the immersion type are used, care shall be taken to ensure that they do not come into contact with the reinforcement or embedded fittings. Freshly placed concrete shall not be vibrated in a manner likely to cause damage to concrete in other parts of the Works which has already taken its initial set. Concrete shall not be vibrated in such a manner and to such an extent as to cause segregation of the constituent materials. If shutter type vibrators are used, they shall be augmented by immersion type vibrators if the thickness of the concrete member is more than 15 cm (6-in).

3.9.23 **Curing of Concrete**

All concrete shall be protected from the harmful effects of freezing, sunshine, drying winds, rain, flowing water, or other adverse elements for at least 7 days after placing. The concrete shall be protected from drying-out by being sprayed with fresh clean water and covered with hessian, clean sand or other approved materials which shall be kept wet.

Membrane curing of concrete with an approved liquid be used as an alternative to curing with water except that membrane curing liquid shall not be applied to surfaces
of concrete from which the shuttering has been struck, until the concrete has been inspected and approved by the Engineer.

Concrete curing compound shall be of an approved type which shall be readily distinguishable upon the concrete surface for at least four hours after application. The color, if any, shall become inconspicuous within seven days after application.

The Contractor shall ensure that all concrete is adequately protected against inclement weather until properly set and shall if necessary provide additional protection to that specified above.

3.9.24 Intervals During Concreting

The timetable for the depositing of concrete between construction joint should be arranged that no face of concrete shall be left for more than 20 minutes before fresh concrete is deposited against it. Pause for meals, servicing of machines, changes of shift, etc. And the distribution of carefully coordinated to ensure that the above mentioned interval shall not be exceeded.

3.9.25 Construction Joint

Contractor wishes to make additional construction joints he shall obtain the prior approval of the Engineer, which approval may include the provision and placing of additional reinforcement at the Contractor's expense.

Constructions joints shall be formed by inserting temporary vertical stopping-off boards to form a tongue and groove joint with the concrete placed subsequently except if separately detailed on the drawings.

Unless otherwise shown on the drawings, construction joints shall be located as near as possible to the position of minimum shear and tensile stress in the concrete.

3.9.26 Jointing Fresh to Set Concrete

At a construction joint, the face of the previously placed concrete shall be cleaned of any skin or latency or loose materials by brushing with a wire brush or other approved method and washing with clean water. Insecurely held aggregate shall be removed. Excess water shall be remove and the surface while still wet shall be covered with 1:2 cement mortar which must be vigorously stippled into the surface by means of a suitable stiff brush. With the depositing of the fresh concrete following closely.

3.9.27 Expansion Joints

Expansion joints shall be provided at positions shown on the drawings, or as directed by the Engineer, and shall be form according to the instructions and dimension shown on the drawings.
3.9.28 **Inspection of Concrete**

The Contractor shall not proceed with the surface finish or making good concrete surface until he has received the Engineer's permission to do so and he shall apply cement slurry or mortar or any other coating to the concrete surfaces from which the shuttering has been struck until the concrete has been inspected and approved by the Engineer.

3.9.29 **Faulty Concrete Work**

The Contractor shall on the written instruction of the Engineer remove and reconstruct any such portion of the work which in the opinion of the Engineer is unsatisfactory as regards quality of concrete, incorrect dimension of the cast portion, honeycombing or other such cause as shall cause the construction to be less than the standard required and which in the opinion of the Engineer may prejudicially affect the strength or durability of the construction.

3.9.30 **Repairs to Concrete**

The method of repairing and replacing defective concrete which the Contractor proposes to adopt shall be submitted to the Engineer for prior approval and the repair shall be made in such a manner as he directs or approves.

3.9.31 **Supervision of Concrete Work**

Throughout the progress of the concrete work, the Contractor shall employ and provide such supervision as is necessary to ensure:

- The day-to-day control of the quality of the concrete.
- The mixing, transporting, placing, compacting, curing and protection of the concrete.
- The conducting of all testing as specified herein and any further testing which the Engineer may require.
- The conducting of investigations as the Engineer may require.
- The preparation of reports and keeping or report as the Engineer may require.

3.9.32 **Finishing of Concrete**

All exposed concrete surfaces not requiring shuttering shall be trawled to a smooth dense surface with the minimum of cement and fine particles being brought to the surface and shall be free from irregularities (steel trawled mechanical machine is recommended to be used to finish the concrete floors and slabs).

Shuttered surface of concrete which will always be in contact with the ground may be cast against sawed timber. All other exposed shuttered surfaces including precast concrete shall be cast against steel, plywood or planed timber form work and shall be carefully rubbed down with carborundum to remove all imperfections and irregularities. Surfaces which are honeycombed, porous or irregular and which in the opinion of the Engineer do not comply with the specifications, shall be cut out and replaced with sound concrete as directed by the Engineer. The cost of all normal surface finishes and repairs shall be deemed to be included in the bid price of the concrete.
3.10 Reinforcement

Steel reinforcement should comply with the requirements in section 7 of CP 110: part 1: 1972 or in CP 114 or ACI code 318 M / 318 RM and shall generally be one of the following types:

A. Deformed, plain and clean billet steel bars for concrete reinforcement according to ACI building code 318M/318RM complying with (ASTM A615M-93) grade 400 (Fy = 4200 kg/cm²).

B. Certified Mill test reports are required according to this code.

C. Deformed steel bars will be used for all diameters except 6mm steel bars will be plain steel.

D. All tests required for this item will be controlled by (ASTM A615M-93).

E. The number of tests will be decided by the engineer.

3.11 Minimum Cover

3.11.1 Reinforcement Position for water tank

Main bars in external faces of columns and beams 30 mm
Main bars in internal faces of columns and beams 30 mm
Main bars in floor slabs and soffits of roof slabs 30 mm
Main bars in top of roof slabs 30 mm
Outermost bars in internal faces of walls 40 mm
Outermost bars in externals faces of wall 40 mm
Bars in top of ground slabs 50 mm
Bars near faces in contact with soil 50 mm

3.11.2 Reinforcement position for other elements

Main bars in external faces of columns and beams 25 mm
Main bars in internal faces of columns and beams 25 mm
Main bars in floor slabs and soffits of roof slabs 25 mm
Main bars in top of roof slabs 25 mm
Outermost bars in internal faces of walls 25 mm
Outermost bars in externals faces of wall 25 mm
Bars in top of ground slabs 25 mm
Bars near faces in contact with soil 50 mm

The placing of all reinforcement will be checked by the Engineer and in no case is concrete to be poured around any steel that has not been passed by him. The Contractor is to ensure that no steel is displaced from its position during the placement of concrete and until the concrete has set.

3.12 Form work

The concrete form work must be prepared by using steel molds or 18mm thick marine plywood. Water tight ties (threaded bolts) used to secure and align the form work should not pass completely through any part of the structure which is liquids retaining unless effective precautions can be taken to ensure water tightness after their removal. The ends of any embedded ties should have cover equal to that required for the
reinforcement. The gap lefts from the end of the tie to the face of the concrete should be effectively sealed by approved water tight material. Any steel left in the structure should be adequately protected against corrosion. Workshop drawings for concrete elements form works and method of concreting must be submitted by the contractor for the engineer’s approval before the starting of the works.

3.13 Pneumatically applied mortar

3.13.1 General.
This clause deals with mortar applied pneumatically through a suitable nozzle and used, for example, as cover to external pre-stressing steel.

3.13.2 Materials and proportions of mix.
The grading of fine aggregates for pneumatic mortar, which to some extent dependent on the type of mixer and digester to be used, should confirm in general to the grading of fine aggregate given in zones 1 or 2 of table 8 of BS 882 : 1965. The proportions for pneumatic mortar should be such that the cement content does not extend that of the mix represented by 50 kg cement/0.07 m³ sand nor fall below that of the mix represented by 50 kg cement : 0.11 m³ sand.

A suitable mix for the final cover coat is 50 kg cement : 4.5 kg hydrated lime : 0.1 m³ sand and passing no. 7 mesh sieve (2.36 mm normal aperture six as specified in appendix C to BS 410 : 1969).

3.13.3 Mixing and placing.
The aggregate and cement should be mixed in an approved mechanical mixer and delivered from an approved mechanical desgister. The mixture should be applied by an experienced operator using an approved nozzle. The velocity of the material leaving the nozzle should be uniform and the amount of water injected into the mixture adjusted so as to ensure minimum rebound of the sand.

3.13.4 Curing.
Immediately after the pneumatic mortar has been placed it should be protected against premature drying by shading gram strong sunshine and shielding from the wind. As soon as it has hardened huts sufficiently to avoid damage it should be thoroughly wetted and thereafter kept wet continuously for at least 7 days, adequate protection, e.g. by shading and shielding, being given against fluctuations in temperature.

3.14 Joints and Jointing Materials
All joints must be considered as specified in the General Specifications and Drawings.

3.14.1 Classification
Jointing materials may be as follows:
A. joint fillers
B. water stops
C. joint sealing compounds (including primers where required).

3.14.2 General.
The jointing materials should be capable of accommodating reacted movement without permanent distortion or extrusion, and they should not be displaced by fluid pressure. The materials should remain effective over the whole range of temperature and humidities considered. For example, they should not slump unduly in hot weather neither should they become brittle when cold. The materials should be insoluble and durable and not change unduly by evaporation of solvent or plasticizers, nor, in exposed portions, should they be altered by exposure to light. Depending on the application, they may need to be non-toxic and tasteless, or resistant to chemical or biological attack. Ease of handling and of application or installation is important and their use should not prevent the proper compaction of the concrete next to the joint.

3.14.3 Joint fillers.

Joint fillers are compressible sheet or strip materials fixed to the face of the first-placed concrete and against which the second-placed concrete is cast. They are used in expansion joints to provide the initial separation between the faces of the joint without obstructing subsequent closing of the joint. The material should be of sufficient thickness to maintain the initial gap between the concrete faces when under pressure from the newly placed concrete. Since the percentage expansion or contraction of the filler is inversely proportionally to initial width of the joint, there is an advantage in a wide joint.

The usefulness of a joint filler would be considerably increased if the material remained in contact with both faces of the joint throughout subsequent joint movements.

This would require an plastic material with either some initial compression or else tenacious adhesion to the faces of the joint. The requirements are important when the joint filler is used as a support for joint sealing compound since failure to fill the joint completely may allow the seal to be forced through the joint. The requirements are less stringent when the filler, used in conjunction with a water bar, may be required only to provide the gap between the joint faces.

Absorbent joint filler should not be used as they may lead to the risk of hydrostatic pressure and make it difficult to ensure continuous adhesion by the sealant. There is also the risk that certain types of filler can deteriorate. It is preferable to use non-rotting cork-based joint fillers rather than fibrous joint filler which can absorb moisture.

3.14.4 Water Stops.

Water stops are generally performed strips of durable impermeable material which are wholly or partially embedded in the concrete during consideration so as to span across the joint and provide a permanent water tightness movements and for preserving water tightness. It is important to ensure that proper compaction of the concrete against the water stop is practicable. The water stop should be sufficiently wide to ensure the water tightness, and it not be allowed the water stop moving during concreting; in wall joint, water stops of the fully embedded type should be placed centrally in the thickness of the concrete and the wings or end bulbs should be supported by some form of tying to adjacent reinforcement. The distance of the water stop from the nearest exposed concrete face should be not less than half the width of the water stop. The full concrete cover to all reinforcement should be maintained. Centrally-placed water stops should not generally be used in a flat horizontal position such as in a floor slab joint. If this is unavoidable care should be taken to ensure full
compaction of concrete under the water stop. With slabs, the 'under-slab' partially embedded type is preferable.

The design of the structure should generally provide for the continuity of the water stops system across all joints particular between floor and wall systems. The correct procedure for making the running joints on site using heat fused butt joint for PVC, vulcanized or pocketed sleeve joints for rubber and braised or welded lap joints for copper or steel must be adopted. Intersections and special junctions such as arise between rubber and PVC should be prefabricated it sealing compounds. Joint sealing compounds are impermeable ductile materials which are to provide a watertight seal by adhesion to the throughout the range of joint movement, which a have been in common use for this purpose usable teen based on bitumen or coal-tar pitch without filler such as limestone or state dust, asbestos rubber. They are usually applied after construction in the hot state (rubber bitumen compound using to type A1 a specified in BS 2499 : 1973 ) or gunning into position. Primmer is often assist adhesion and some local drying of the surface e.g. by gas torch may be advisable. The difficulties experienced with this class of material are going permanent adhesion to the concrete during of the joint whilst of the same time ensuring materials does not slump or is not extruded from joint.

The sealing compound is usually applied in the surface of the concrete along the. The actual minimum width will depended on the known characteristics of the material. In floor joints of the expansion type the sealant is supported by the joint filler. The sealing of floor joints is generally quite successful since retention of the material is assisted by gravity and in many sealing can be delayed until just before the reservoir is put service so that the amount of joint opining subsequently to be accommodated is quite small. The chase should not be too narrow or too deep to hinder complete filling. Here again, a wider joint demands a smaller percentage distortion in the material.

Vertical joints in wall should be primed where necessary and them sealed on the water face with a bituminous putty or other approved sealant. A suitably shaped chase should previously have bed formed. Cold-applied two-component sealing compounds based on polysulphide rubber complying with BS 4254 may be used in vertical joints in walls and generally in expansion joints because of their non-slumping properties and greater extensibility. Most sealants should be applied in conditions of complete dryness and cleanliness.

3.15 Precast Concrete Kerbs, Edgings & Quadrants

Precast concrete kerbs and edgings shall be hydraulically pressed and they and precast concrete quadrants shall comply with the requirements of BS 7263 Part 1 and to the dimensions and shapes shown on the drawings and/or as directed by the Engineer. They shall be concrete (250 kg/cm²) with approved cement as indicated in the specification. They shall be uniform in color free from cracks, flows or other defects with well defined arises.

The kerbstones shall be 1000 mm long or as directed by the Engineer's Representative. Samples of kerbstones proposed to be used shall be submitted to the Engineer for his approval prior to order or manufacture. Kerbstones shall not be used before they have been inspected and approved by the Engineer. They shall be fully cured when delivered to site (28 days min.)
Kerbstones shall be laid on concrete (200 kg/cm²) bedded on 1:3 sand cement mortar as specified and/or as directed by the Engineer. All kerbstones shall be well bedded and settled in place true to line and level with a suitable wooden mould. Before kerbstones shall be approved it should be ensured that their top surfaces are in a uniform plane and their front faces are in correct alignment. Any kerbstones not satisfying these requirements or having cracked or broken arises or faces shall be removed and replaced or reset as instructed by the Engineer.

Joints between kerbstones shall be not less than 3 mm nor greater than 5 mm in width and shall be uniform from top to bottom. Joints shall be left open.

Where precast kerbs of straight section are laid to form radii, joints should be filled with non-shrinkage mortar, and expansion joints (using flexel or similar joint filler) shall be provided at 3 m centers. For radii of 10 m or less quadrants shall be used. Kerbs of a reduced size shall only be used for this condition where approved by the Engineer.

Tolerance in top level of kerbstones and horizontal alignment shall be +/- 3 mm.

All kerbstones, where instructed by the Engineer shall be painted alternately Black, White and Red. The paint shall be an approved concrete paint (thermoplastic) in two applied coats and as instructed by the engineer.

Tolerance in the top levels of kerbs is +/- 3 mm.

Transverse strength and Water Absorption shall be in accordance with B.S. 340.

3.16 Measurement and Payment

The prices inserted in the Bills of Quantities for concrete and payment thereof shall be based on net finished specified dimensions of the work and shall include the cost of all testing, mix design, trial mixes, construction and subsequent removal to tip of trial panels, mixing, transporting, placing compacting, curing, surface finishing, protection, construction and expansion joints, repairs to concrete, supervision, formwork and all labor and materials and tests.

The concrete kerbstone laid as shown on the drawings or as ordered on site by the Engineer including edging will be paid for at the bid unit rate per linear meter measured in place including excavation, backfilling with the concrete base and backing and painting complete with joints as specified and/or as directed by the Engineer.

The steel reinforcement is considered as included in the concrete unit price.

Payment for Paving Concrete : Payment in Sq.m
Payment for Kerbing Concrete : Payment in Lin.m
Payment for Structural Concrete : Payment in Cu.m
3.17 Culverts

3.17.1 Description

This work shall consist of furnishing all materials, installation and construction of reinforced concrete box culverts including headwalls, apron and wing walls, all in conformity to the lines, grades and dimensions shown on the Drawings and/or as directed.

3.17.2 Materials

Plain concrete for blinding under the bottom slab or box culverts and apron shall be concrete (200 kg/cm²) as specified in the drawings.

All reinforced concrete shall be concrete (350 kg/cm²) as shown in the drawings.

All reinforcing steel shall be deformed reinforcing steel except the reinforcing steel for pipes, which shall be mild steel and approved by the engineer.

The structural concrete and reinforcing steel used in this work shall be as described in the specifications.

3.17.3 Construction

3.17.3.1 Camber

The invert grade of culvert shall be cambered by an amount sufficient to prevent the development of a sag or back slope in the flow line as the foundation soil settles under the weight of the embankment. The amount of camber shall be determined by the Engineer, based upon consideration of the flow line gradient, the height of fill, the compressive characteristics of the supporting soil stratum to ledge rock. In no case shall the camber be sufficient to produce an adverse grade after settlement has occurred.

3.17.3.2 Jointing

The mixture shall be one part Portland Cement and two parts sand by volume. The quantity of water in the mixture shall be sufficient to produce a stiff, workable mortar but shall in no case exceed twenty one (21) litres of water per bag of cement. The sand shall conform to AASHO M 45-42 and the cement shall conform to AASHO M 85-70.

The pipe ends shall be thoroughly cleaned and wetted with water before the joint is made. Stiff mortar shall then be placed in the lower half of the groove of the pipe section already laid. Next, mortar shall be applied to the upper half of the tongue of the pipe section being laid. Then the tongue end of this pipe shall be inserted in the groove end of the pipe already laid, the joint pulled up tight, taking care to see that the inner surfaces of the abutting pipe sections are flush and even.

3.17.3.3 Backfilling
Backfilling material in a trench and up to the elevation of the top of the pipe shall be selected fine compactable soil material. It shall be compacted at near optimum moisture content, in layers not exceeding 20 cm in compacted thickness, by pneumatic tampers, or other means approved by the Engineer. Care shall be exercised to thoroughly compact the backfill under the haunches of the pipe and to ensure that the backfill soil is in intimate contact with the sides of the pipe. The backfill shall be brought up evenly on both sides of the pipe for its full length.

3.17.4 Measurement & Payment

Ordinary Portland cement reinforced concrete box culverts wing walls and apron as shown on the Drawings or as ordered on site and as staked out by the Engineer in the field will be paid for at the bid price per linear meter as reinforced concrete (350 kg/cm²) and at the bid price entered in the Bills of Quantities. Such payment shall be full and complete compensation to the Contractor for everything furnished and done to provide the box culverts and headwalls in place, including excavation, sheeting, shoring, draining water, backfilling, formwork,.etc.

Blinding 10 cm thick under box culverts shall be poured below the bottom slab over a prepared bed as directed. The bed shall be prepared compacted dry to 100% of maximum dry density by selected material shall be added. Payment of this work shall be considered to be included in the other items.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reinforced Concrete Box Culvert (Dimensions)</td>
<td>M3</td>
</tr>
</tbody>
</table>
4 MASONRY WORKS

A. Quality of mix for block work and mortar to match the general masonry specifications.

B. Dimensions of used blocks:
   - 40x20x20 cm for walling.
   - 40x20x15 cm for walling.
   - 40x20x10 cm for walling.
   - 40x25x17 cm for roofing.

C. Curing for masonry works must be carried out for seven days.

D. Block work compression strength test after 28 days = 40 kg/cm².

E. The maximum height allowed to be built at one time is one meter (5 rows of blocks).

F. The execution of this works must be carried out according to the drawings, specifications and engineer's instructions.

4.1 Manufacture

4.1.1 Generally

Generally the blocks used shall be of local manufacture made with concrete in approved vibrated pressure machines. The fine aggregate to be used for blocks shall be clean and sharp approved sand. It shall be chemically and structurally stable and shall comply with the Table of Gradings given hereunder. The cement, coarse aggregate and water to be used for blocks shall comply with the requirements given for Concrete Works, and the methods of measuring and mixing the material shall be the same. The following Mixing Table shall be strictly adhered to in all cases. Water/cement ratio shall be strictly governed to produce a mix of nil-slump.

4.1.2 Mixing Table

Normal Mix (all by volume)
1 part Cement, 2 parts Fine Aggregate and 5 parts Coarse Aggregate.

4.1.3 Table Of Grading

(a) Fine aggregate

<table>
<thead>
<tr>
<th>BS 410 Sieve No.</th>
<th>Approximate size : mm</th>
<th>Percentage (by weight) Passing BS sieve</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>10.00</td>
<td>100</td>
</tr>
<tr>
<td>-</td>
<td>5.00</td>
<td>90-100</td>
</tr>
<tr>
<td>7</td>
<td>2.36</td>
<td>75-100</td>
</tr>
<tr>
<td>14</td>
<td>1.18</td>
<td>55-90</td>
</tr>
<tr>
<td>25</td>
<td>0.60</td>
<td>35-59</td>
</tr>
<tr>
<td>52</td>
<td>0.30</td>
<td>8-30</td>
</tr>
<tr>
<td>100</td>
<td>0.15</td>
<td>0-10</td>
</tr>
</tbody>
</table>

(b) Coarse aggregate 10mm single size aggregate.
3.1.4 The blocks shall be hard, sound, square and clean with sharp well defined arrises and shall, unless previously approved by the Engineer, be a work size of see the above mentioned dimensions with properly formed half blocks for bonding.

3.1.5 Hollow blocks, where required, shall be similar quality and overall size to solid blocks, and shall be of local manufacture made with concrete as described above in approved vibrated pressure machines. The design of the cavities and webs shall be submitted to the Engineer for approval before manufacture. The thickness of the membranes or solid portions of hollow blocks shall be not less than (40mm) each and the combined thickness of the solid portion shall exceed one third of the total thickness in either horizontal direction. (Light weight lime - blocks can be used according to drawings, bills of quantities and Engineer’s approval).

3.1.6 Arises shall be sharp and true; blocks which have damaged arises are not to be used in the works and shall be discarded at the expense of the Contractor.

3.1.7 Immediately after molding the blocks shall be placed on clean, level, non-absorbent pallets. Blocks shall not be removed from the pallets until inspected and approved by the Engineer. Blocks shall be cured by being kept thoroughly wet by means of water sprinklers or other approved means for a period determined by the Engineer but in all cases for not less than three days. Blocks must not be left on earth or sand during the curing process. Blocks shall be stacked in honeycomb fashion. Solid stacking will not be permitted.

3.1.8 The average crushing strength of solid or hollow blocks shall be not less than 40kg/cm² of gross area (average of 12 blocks).

4.2 Mortars

3.2.1 The sand to be used for mortar shall be clean and sharp. It shall be chemically and structurally stable and shall comply with the Table of Gradings below. The lime to be used for mortar shall be hydrated lime complying with BS 890.

3.2.2 Where colored mortars are required these shall be obtained either by the use of colored cement or by addition of pigments complying with BS 1014.

3.2.3 The cement and water to be used for mortar shall comply with the requirements given under Concrete Works Section, and the methods of measuring and mixing shall be the same. The following Mixing Table shall be strictly adhered to in all cases.

3.2.4 Mixing Table

<table>
<thead>
<tr>
<th>Nominal Mix</th>
<th>Cement Kilos</th>
<th>Sand M³</th>
<th>Lime (Dry Hydrate) Kilos</th>
</tr>
</thead>
<tbody>
<tr>
<td>1:4</td>
<td>360</td>
<td>1.00</td>
<td>as approved by the Engineer</td>
</tr>
</tbody>
</table>
3.2.5 Table of Grading

<table>
<thead>
<tr>
<th>BS410 Sieve No.</th>
<th>Approximate Size : mm</th>
<th>Sand passing Through Sieve : Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>3</td>
<td>95-100</td>
</tr>
<tr>
<td>7</td>
<td>2.4</td>
<td>80-100</td>
</tr>
<tr>
<td>14</td>
<td>1.2</td>
<td>60-100</td>
</tr>
<tr>
<td>25</td>
<td>0.6</td>
<td>30-100</td>
</tr>
<tr>
<td>52</td>
<td>0.3</td>
<td>5-65</td>
</tr>
<tr>
<td>100</td>
<td>0.15</td>
<td>0-15</td>
</tr>
</tbody>
</table>

Note: the above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

3.2.6 The mortar generally shall be cement and sand (1:4) mix.

3.2.7 Where plasticiser is added to the mortar the following mixes shall be used:
   (a) Building mortar - cement and sand (1:6) and
   (b) Mortar for pointing - cement and sand (1:3)
   The plasticiser shall be used strictly in accordance with the manufacturer’s instructions.

3.2.8 All mortar shall be used before the initial set has begun. Mortar shall not be remixed after the initial set has taken place. The full description given under Plaster Work Section, shall apply also to the measuring, mixing etc. of mortar for block work.

4.3 Construction

A. All block work shall be set out and built to the dimensions shown on the Drawings.
B. Walls shall be carried up regularly without leaving any part more than one meter lower than another unless the permission of the Engineer is first obtained. Work which is left at different levels shall be racked back. In the case of cavity walls, both thicknesses shall not be carried up more than about 400mm.
C. The courses of block work shall be properly leveled. The perpendicular points shall be properly lined and quoins, jambs and other angles plumbed as the work proceeds.
D. All walls shall be thoroughly bonded in accordance with the best constructional practice and as directed by the Engineer. Broken blocks shall not be used except where required for bond (if approved by the Engineer).
E. All concrete blocks shall be soaked with water before being used and the tops of walls left off shall be wetted before work is resumed. The faces of walls shall be kept clean and free from mortar droppings and splashes.
F. All blocks shall be properly spread with mortar before being laid and all joints shall be thoroughly flushed up solid through the full thickness of the wall at each course as the work proceeds.

G. For block walls the gauge shall be 5 courses to 1000mm.

H. Walls to be left unplastered shall have a fair face consisting of selected blocks pointed with a neat weathered or flush joint as the work proceeds using the same mortar mix as for jointing.

I. Walls to be plastered shall have the horizontal joints raked out to a depth of 15 mm to form a key.

J. Block work shall be bonded to concrete columns and the like with 200x60x0.6 mm non ferrous metal ties cast in concrete and subsequently bent down, ragged and built into every course of block work. Gunning ties to concrete will not be permitted (other ways of bond must be approved by the Engineer).

K. Cavity walls shall be built to the dimensions shown on the drawings and the two thicknesses shall be bonded together with wall ties spaced one meter apart horizontally and approximately 400 mm apart vertically and staggered. Extra ties shall be provided at reveals, quoins and openings.

L. The ties shall be of the butterfly twist type of No. 10 SWG mild steel wire, zinc coated and similar to those described in BS 1243. The length of the ties shall be approximately 80 mm less than the total thickness of the wall. The cavity shall be kept clean by lifting screeds or other means approved by the Engineer and shall be left clean at completion.

M. Allowance shall be made for leaving, temporarily, open courses immediately under all structural members built into the walls. These open courses shall be left in suitable positions to permit the structural members to take up their full deflection. The open courses shall be made good and pointed up after the structural members have been fully loaded and before the completion of the works.

4.4 Measurement and Payment

The prices inserted in the Bills of Quantities for the masonry works and payment thereof shall be based on net finished specified dimensions of the work and shall include the cost of all testing, mix design, trial mixes, construction and transporting, placing compacting, curing, surface finishing, protection, construction and expansion joints and all labors and materials and tests.

Payment for Masonry Works : Payment in Sq.m
5 PAVIOUR (INCLUDING MARBLE AND TERRAZZO WORKER)

5.1 Materials
Portland cement, fine aggregate and water shall be as previously specified. The color pigments shall be of an approved manufacture, lime-proof and non-fading and complying with British Standard No. 1014: 1942. The marble chippings shall be of an approved quality in irregular pieces varying for .047 inch to 3/8 inch in size due to the effect required. The pieces should preferably be roughly cubical in shape and flaky shaped pieces shall not be used. The granite chippings shall be of an approved quality graded from 1/2 inch down with not more than 5 per cent fine material passing a No. 100 sieve. Marble and granite aggregates shall comply generally with Table of Gradings. In connection with marble aggregates the percentages are approximate only. The actual gradings should be selected to produce the surface effects required.

<table>
<thead>
<tr>
<th>TABLE OF GRADINGS -</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZES</td>
</tr>
<tr>
<td>B.S. Sieve No.</td>
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</tbody>
</table>

Note: The above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned.

5.2 Mixing
Materials for in-situ pavings and locally manufactured tiles shall be measured separately in approved gauge boxes on a clean, dry, level surface. Materials shall be mixed either by hand or machine as previously specified.

5.3 Proportions
The following Mixing Table shall be strictly adhered to in all cases. Variations will be permitted only when demanded by the Particular Specification for individual Works or prior written consent of the Engineer.

<table>
<thead>
<tr>
<th>MIXING TABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Mix</td>
</tr>
<tr>
<td>1:1</td>
</tr>
<tr>
<td>1:2</td>
</tr>
<tr>
<td>1:2 ½</td>
</tr>
<tr>
<td>1:3</td>
</tr>
<tr>
<td>1:4</td>
</tr>
<tr>
<td>1:5</td>
</tr>
</tbody>
</table>

5.4 Granolithic Paving
These shall consist of a (1:2 1/2) mix—one part Portland cement to two and half parts of granite aggregate mixed with sufficient water to give a suitable plasticity for laying. Generally the pavings shall be laid immediately following the concrete sub-base. If these pavings are laid on a matured concrete sub-base the concrete shall first be well cleaned, wetted and brushed with a Portland cement grant.

To produce a wearing surface the Granolithic mixture shall be tamped in with a wood and trowelled twice with a steel trowel to produce a smooth finish.

The paving shall be laid in alternate bays not exceeding 9 square Meters in area and the bays shall be separated by expansion strips of brass or other approved material. Granolithic pavings shall be cured by covering them with hessian wet for seven days.

5.5 Cement and sand pavings

These shall consist of a (1:3) mix—one part of Portland cement to three parts of sand mixed with sufficient water to give a suitable plasticity for laying. Generally the pavings shall be laid immediately following the concrete sub-base. If laid on a matured concrete sub-base the same precautions should be taken as described for Granolithic paving above. The paving shall be laid in bays as described above for Granolithic paving. Cement and sand paving intended as a wearing surface shall be trowelled twice with a steel trowel to produce a smooth finish. In addition two coats of sodium silicate solution shall be brushed on. Cement-sand paving shall be cured as described above for Granolithic paving.

5.6 Cement and Sand Tiles

These shall be formed with a (1:2) mix of white or colored cement, or in white cement with a color pigment added, and sand applied as a facing not less than 7 1/2 mm. thick to a Portland cement and sand (1:5) mix backing. The tiles shall be cast in heavy metal moulds under pressure to the proportions and sizes shown in the following Table.

<table>
<thead>
<tr>
<th>GRADING OF GRANITE AND MARBLE CHIPPINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sizes</td>
</tr>
<tr>
<td>B.S. Sieve No.</td>
</tr>
<tr>
<td>------</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>-</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>52</td>
</tr>
<tr>
<td>100</td>
</tr>
</tbody>
</table>

It is essential that closer grading limits be selected for the Marble Chippings if a consistent and uniform surface texture is desired.

Colored cement and sand skirtings to match tiles, 10 cm or 20 cm with chamfered top edges shall be produced in the same way as the tiles using the same mixes. All cement and sand tiles shall be cured by totally immersing them, after the initial set has taken place, in a tank of clean water for at least 24 hours. Cement and sand tiles shall be laid and bedded direct on to a concrete sub-floor on a cement and sand 1:4 mix screed.
This screed shall be 2 1/2 cm. thick in the case of 2 1/2 cm. tiles and 3 cm. thick in the case of 2 cm. tiles. The total thickness of cement and sand screed and tiles shall not exceed 5 cm. All tiles shall be laid with square joints. All cement and sand tiles shall be cured by totally immersing them after the initial set has taken place in a tank of clean water for at least 24 hours. All tiling shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match the tiling. Any surplus grout shall be cleaned off the face of tiling and surrounding surfaces immediately and all tiling shall be carefully cleaned off.

5.7 Terrazzo Tiles

These shall be formed with a (1:2 1/2) mix of white or colored cement or white cement with a color pigment added and granular marble chippings applied as a facing not less than 5 mm thick to a Portland cement and sand (1:5) mix. The tiles shall be cast in heavy metal moulds under pressure to the proportions and sizes shown in the following table.

<table>
<thead>
<tr>
<th>TERRAZZO TILE DIMENSIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Size</strong></td>
</tr>
<tr>
<td>20 x 20</td>
</tr>
<tr>
<td>25 x 25</td>
</tr>
<tr>
<td>30 x 30</td>
</tr>
<tr>
<td>40 x 40</td>
</tr>
</tbody>
</table>

Tiles shall be cured as for cement and sand tiles and then ground, filled and polished before distribution to Site. Grinding shall be done wet by means of a No. 80 carborundum stone. Filling shall be carried out with neat cement grout of the same color as the facing mix and this shall be worked into the surface with a wooden shaper to fill all voids and air holes. Surplus grout shall be removed with a dry cloth. After a minimum period of 24 hours polishing shall be carried out wet by means of a No. 140 carborundum stone. Terrazzo skirtings 7 cm or 10 cm or 20 cm high with chamfered top edge, shall be produced in the same way as for tiles using the same mixes. Terrazzo tiles shall be laid and bedded direct on to a concrete sub-floor on a cement and sand (1:4) mix screed. This screed shall be 2 1/2 cm thick in the case of 2 1/2 tiles and 3 cm thick in the case of 2 cm tiles. The total thickness of the cement and sand screed and tiles shall not exceed 5 cm. All tiles be laid with square joints. All tilling shall be grouted up on completion, care being taken to fill all joints completely. The grout shall consist of neat cement of a color to match the tiling. Any surplus surfaces immediately and all tiling shall be carefully cleaned off. All terrazzo surfaces shall be polished on completion. Large areas such as floors shall be wet polished by means of approved machines using No. 140 carborundum wheel. Any surface too small for convenient machine polishing may be polished by hand using a No. 140 carborundum stone and water. Care must be taken during any polishing operation not to damage any angles or arises. Terrazzo covering to items such as sills, treads and risers to steps, skirtings etc., shall generally be applied in accordance with the foregoing specification except that the thickness of the facing shall be at least 10 mm. thick.
5.8 Marble Pavings

Marble paving should be from the best quality and shall generally be 2 cm. thick the size, type and pattern that be as stated in the Particular Specification and/or shown on the Drawings. The marble slabs shall be fixed solid on a bed of cement and sand (1:4) mix 3 cm. thick tight joints grouted in lime putty. A protective slurry of putty at least 3 mm thick shall be applied to the marble pavings and subsequently cleaned off. Treads to stairs shall be 2 cm. thick fixed solid on a bed of cement and sand (1:4) mix 3 cm. thick Risers to stairs shall be 2 cm thick fixed solid on a backing of cement and sand (1:4) mix 3 cm. thick. Window sills shall be 4 cm. thick bedded below on plaster slabs. Skirtings shall be 2 cm. thick in lengths of about 1.5 Meters, fixed solid on a backing of cement and sand (1:4) mix 2 cm. thick. Joints in skirtings shall be arranged to coincide with joints in adjacent pavings. Rounded arises, nosing and mouldings shall be adequately protected by means of timber casings or lime putty ceilings. Treads, risers, skirtings and windows sills shall be grouted and protected in a manner similar to pavings. The exposed faces and edges of all marble shall be polished smooth and be free from scratches or other defects.

5.9 Marble Linings

Marble linings to walls, columns and the like shall generally be 2 cm. thick and the size, type and pattern shall be as stated in the Particular Specification and/or as shown on the Drawings. The marble slabs shall be cut square and true and shall be uniform in shape and thickness. Patterns and mouldings shall be accurately formed in accordance with the Drawings. The marble slabs shall be fixed with copper cramps and books and plaster rabs leaving an air space of 12 mm. behind the slabs to prevent transfer of soluble salts from the backing materials. The cramps shall be 2 1/2 cm. x 5 mm. x 10 mm. girth one end and turned down and grouted into mortise in marble and the other end built into wall set 45 cm. apart in each bed. Mortises shall be accurately and carefully cut and all joints shall be thoroughly grouted. Exposed edges and mouldings shall be protected by means of timber casings or lime putty coatings. The exposed edges and faces of all marble shall be polished smooth and shall be free from scratches or other defects.

5.10 Tiles (Side Walks Type) :-

Tiles shall be formed as following :-

- Top layer (wearing) :- Portland cement, quarts, bazelt gravel and coloring agent (10 mm min).
- Down layer – Cement, crushed sand and gravel.
- Tiles shall be cured by totally immersing them after initial set has taken place in a tank of clean water for at least 24 hours.
- Tiles shall be grouted upon completion, care being taken to fill all jointing completely, the grout shall consist of neat cement of a color to match the Tiling.
- Dimensions of tiles : 30 x 30 x 3.2 cm
- 2.0 cm Expansion joint Filled with performed Bituminous Filler and sealed with cold-applied joint-sealer is to be installed/10.0 cm.
- A well compacted layer of approved selected material (Kurkar) is to be spread as a bedding layer prior to subsequent tiling.
5.11 Concrete Block Surfacing

5.11.1 Form of Construction

Concrete block surfacing shall consist of precast concrete blocks on a sand laying course laid on a 100 mm or 150 mm sub-base and/or base as shown on the drawings and/or as instructed by the Engineer laid on subgrade. In general blocks should conform to the requirements of the Specification for Precast Concrete Paving Blocks as per B.S.6717.

5.11.2 Subgrade

The subgrade shall be prepared in accordance with the earthworks specification.

5.11.3 Base

The base shall be 100 mm or 150 mm thick and shall be laid in accordance with Aggregate Road Base specification. The material used in any instance shall be as shown on the drawings.

Due allowance shall be made in the final levels of the base for the compaction of the laying course above, which occurs when the paving blocks are being vibrated. The amount of compaction of the laying course shall be determined by site trials prior to commencement of the actual surfacing.

5.11.4 Laying Course

The laying course shall consist of washed sand with a particle size of 0-5 mm containing not more than 3% silt plus clay by weight. The sand shall be obtained from a single source, allowed to drain before use and shall be covered with suitable sheeting to minimize moisture changes.

↑ Permissible sulphate and chloride contents shall not exceed 0.3% and 0.5% respectively, (expressed as a % by weight).

↑ The laying course shall be laid to a compacted depth of 50 mm. During laying the sand shall be uniform in moisture content and shall be carefully screeded to form a smooth compacted surface to receive the paving blocks.

↑ The profile of the laying course before compaction shall be similar to that of the finished surface. The maximum deviation from the design levels shall be +/- 5 mm.

↑ The edge restraints to the paved area shall be laid in advance of the laying course.

5.11.5 Surface Course

The surface course shall consist of precast concrete blocks generally 60 mm thick, of approved size, shape,pattern and colours and manufactured on a approved machine.
5.11.6 Cement

The Cement to be used in the manufacture of the paving blocks shall, unless stated otherwise, be approved portland Cement from approved manufacturers and shall comply with the requirements of B.S.4027 "Approved Portland Cement". If ordinary Portland Cement is used, it shall comply with the requirements of BS 12 "Ordinary Portland Blastfurnace Cement".

The cement content (for ordinary Portland Cement) of the compacted concrete shall be not less than 400 kg/m³.

5.11.7 Admixtures

Admixtures will be only be permitted to be used in the concrete with the express permission of the Engineer.

When admixtures are used in the manufacture of the blocks very strict control is to be maintained to ensure that the correct quantity of admixture is used at all times. The equipment to be used for dispensing and the method of incorporating the admixture in the concrete shall be subject to the approval of the Engineer.

5.11.8 Aggregate Generally

Aggregate shall consist of naturally occurring materials, crushed or uncrushed, complying with B.S. 882, "Aggregates from natural sources for Concrete and shall be obtained from sites to be approved by the Engineer.

Aggregate shall be in all cases free from earth, clay, loam, soft clayey, shaley or decomposed stone, hollow shells organic matter and other impurities and shall be of a hard and dense description.

5.11.9 Aggregate Testing

Sampling and testing in accordance with BS 812 or other approved methods shall, when directed by the Engineer, be carried out to confirm the suitability of the aggregates.

Where applicable, the following specific test criteria shall apply unless stated otherwise:-

- Flakiness index BS 812 Part 105 Max. 20%
- Elongation index BS 812 Part 105 Max. 35%
- Water absorption BS 812 Part 2 Max. 2%
- Aggregate crushing value BS 812 Part 110 Max. 20%
- Magnesium Sulphate Soundness Max. 16%
- Loss (test: ASTM C88-76, 5 cycle)

5.11.10 Aggregate Reactivity Porential

Aggregates shall not contain any materials that are deleteriously reactive with the alkalis in the cement, or any alkalis which may be additionally present in the aggregates and mixing water, in amounts sufficient to cause excessive localised or general expansion of the concrete.
When directed by the Engineer, tests in accordance with ASTM C289 shall be carried out to determine the aggregate alkali reactivity. Should these tests show that any rock constituent is in any way reactive, the aggregate containing it shall not be permitted to be used unless the Mortar Bar tests demonstrate conclusively that its effect is innocuous when combined with other rock constituents in the proportions to be used in the Concrete mixes.

Mortar Bar tests shall be conducted in accordance with ASTM C227.

5.11.11 Dust

The amount of material passing a B.S.75 micron sieve in the combined aggregates when tested in accordance with B.S. 812 (wet sieving method) shall not exceed the following limits:

- Fine aggregate: 3% by weight
- Coarse aggregate: 1% by weight

5.11.12 Fine Aggregate

The sand for concrete shall be capable of passing through a 5 mm B.S. test sieve and it shall be so graded that when mixed with the coarse aggregate and cement it shall produce a concrete of the maximum density. Crushed Sand may be added to natural sand in order to achieve the required grading. Crushed sand alone may only be used with the approval of the Engineer.

The use of beach sand or other natural sand shall be permitted as a fine aggregate in concrete to improve mix grading, workability and density of the concrete provided that the salt content is maintained within the limits specified and where approved by the Engineer.

The fine aggregate shall not contain more than 25% by weight of soluble calcium carbonate in either the fraction retained on or the fraction passing a 600 micron B.S. Sieve.

The use of fine aggregate which, in the opinion of the Engineer, contains appreciable amounts of flaky or elongated particles shall not be allowed.

5.11.13 Coarse Aggregate

The term coarse aggregate means an aggregate retained on a 4.75 mm B.S. sieve with a nominal maximum size of 10 mm. The grading of the coarse aggregate shall be within the limits prescribed in BS 812, table 1 and shall be such that when combined with sand and cement it shall produce a concrete of maximum density.

The manufacturer shall take all necessary steps to prevent the segregation of coarse aggregate into separate sizes after it has been graded.
5.11.14 Water

For mixing concrete, water shall be fresh and free from all sediment and dissolved or suspended matter which may be harmful to the manufacture of concrete as specified and shall be tested in accordance with BS 3148. Specifically pH value shall be in the range of 7-9, total dissolved solids shall not exceed 2000 mg/l and alkali carbonates and bicarbonates shall not exceed 1000 mg/l.

5.11.15 Chloride Content

The levels of equivalent acid soluble chlorides (BS 812, 6068) as NaCl (Cl x 1.65 = NaCl) should generally not exceed the following:-

(a) Coarse aggregate - 0.02% by weight
(b) Fine aggregate - 0.06% by weight
(c) Fresh water - 600 mg/l

The total chloride content (as NaCl) of any mix, including that present in the cement, shall not exceed 0.3% by weight of cement in the mix, or 0.2% if sulphate-resisting Portland Cement is used.

5.11.16 Sulphates Content

The levels of acid-soluble sulphates, (as SO3) should generally not exceed the following (BS 812,6068) :-

(a) Coarse aggregate - 0.3% by weight
(b) Fine aggregate - 0.3% by weight
(c) Fresh water - 500 mg/l

The total sulphate content as SO3 of any mix, including that present in the cement, shall not exceed 3.7% by weight of cement in the mix.

5.11.17 Concrete Mix

The required average compressive strength of the blocks shall be not less than 49N/mm² in a wet condition. No individual blocks shall have a strength of less than 40N/mm². These values shall be required at the date of testing. However generally they should be considered as 28 day strengths.

Adequate measures shall be taken to ensure that the concrete paving blocks are properly cured in a manner that is to the satisfaction of the Engineer.

5.11.18 Sampling Blocks

Two blocks shall be drawn from each group of 1000 blocks for sampling giving 10 blocks for every designated 5000 block section or part thereof in a consignment. All samples shall be clearly marked at the time of sampling in such a way that the designated section or part thereof and the consignment represented by the sample, are clearly defined.
These blocks shall be tested for dimensional accuracy, compressive strength and water absorption.

Should any of the 10 test blocks not comply with the tests for dimensional accuracy it shall be left to the discretion of the Engineer whether the whole consignment from which these blocks are selected shall be deemed not to comply with the Specification.

5.11.19 Compressive Strength

The average compressive strength of the block on delivery when sampled and tested in the manner described below shall not be less than 49 N/mm² in wet condition. No individual block strength shall fall below 40 N/mm² in wet condition. Thickness and chamfer correction factor for compressive strength expressing the value to the nearest 1 N/mm² shall be as shown.

<table>
<thead>
<tr>
<th>Block thickness (mm)</th>
<th>Correction factors</th>
<th>Plain block</th>
<th>Chamfered block</th>
</tr>
</thead>
<tbody>
<tr>
<td>60 or 65</td>
<td>1.00</td>
<td>1.06</td>
<td></td>
</tr>
<tr>
<td>80</td>
<td>1.12</td>
<td>1.18</td>
<td></td>
</tr>
<tr>
<td>100</td>
<td>1.18</td>
<td>1.24</td>
<td></td>
</tr>
</tbody>
</table>

Test for Compressive Strength

The sample specimens shall be tested in a wet condition after being stored for at least 24 hours in water maintained at a temperature of 20°C +/- 5°C. Before the specimens are sub-merged in water, the necessary area shall be determined as follows:

(i) Where possible, the plan area or the wearing surface area shall be calculated by multiplying the length by the width.

(ii) Alternatively the plan area or the wearing area shall be calculated by cutting out shapes of cardboard and weighing it to the nearest 0.05 g.

\[
A_s = \frac{20000 \times m_s}{m}
\]

Where \( A_s \) = Area of block (mm²)

\( m_s \) = Mass of cardboard shape matching test block (g) the block shall be placed wearing surface uppermost on the cardboard.

\( m \) = Mass of 200 x 100 mm cardboard rectangle (g) cut from the same cardboard.

In case of chamfer or radius, the width of chamfer or radius shall be measured and marked on the cardboard shape. This shape shall then be cut out accurately and weighed for the above calculation of the wearing surface area.

Plywood, nominally 4 mm thick, shall be used as packing between the upper and lower faces of the specimen and the machine platens, and these boards shall be larger than the specimen by a margin of at least 5 mm at all points. Fresh packing shall be used for each specimen tested.

The load be applied without shock and increased continuously at a rate of approximately 15 N/mm² per minute until no greater load can be sustained. The maximum load applied to the specimen shall be recorded. The strength shall be expressed to the nearest 0.1 N/mm².
**Wear Resistance**: Rate of wear resistance should not be more than 3mm on average for 3 samples of each batch. However, each sample should not have wear resistance over 4mm.

### 5.11.20 Test for Dimensional Accuracy

Standard rectangular blocks shall be manufactured with a nominal length of 200 mm and a nominal width of 100 mm. Alternative sizes and shapes shall have a ratio of length to width on plan of not less than 1 1/2 or greater than 2 1/2. The width shall not be less than 80 mm or greater than 115 mm. The minimum normal thickness for paving blocks of any size shall be 60 mm. The preferred nominal thickness shall be 60, 80 and 100 mm.

All arises shall be clean, plane and of uniform dimension. Wearing surface area shall be not less than 70% of the plan area.

<table>
<thead>
<tr>
<th>Tolerances</th>
<th>Length</th>
<th>+/- 2 mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width</td>
<td>+/- 2 mm</td>
<td></td>
</tr>
<tr>
<td>Thickness</td>
<td>+/- 2 mm</td>
<td></td>
</tr>
</tbody>
</table>

### 5.11.21 Water Absorption

Concrete paving blocks shall be tested as the Engineer may direct for water absorption. This test shall be based upon that specified in BS 1881 and the maximum acceptable limits for water absorption shall be:

- 2% absorbed after 10 mins
- 5% absorbed after 24 hours

The Engineer may also require tests for Drying Shrinkage and Moisture Movement for which purpose a specimen cut from a typical concrete paving block would be used and the methods of testing would be based upon those specified in BS 7263 Part 1:1990 (Appendix B) and BS 1881 Part 122 but agreed with Engineer.

Based upon the results of tests specified above, the Engineer may vary the acceptable limits for water absorption to achieve the minimum absorption with the aggregate approved for use in the paving blocks.

### 5.11.22 Colour

The colours of the concrete paving blocks shall be as instructed by the Engineer and shall be maintained at a uniformity that is acceptable to the Engineer. Pigments shall comply with BS1014.

### 5.11.23 Laying the Blocks

Laying of the paving blocks shall commence at right angles to the main pavement axis starting at one end of the area. The paving blocks shall be laid in a herringbone pattern unless otherwise shown on the drawings or instructed by the Engineer at 45° to the main pavement axis.
The paving blocks shall be laid on the sand laying course in such a manner as not to disturb the blocks already laid. Each block shall be placed firmly against its neighbour so that they fit closely together. The joints between blocks shall not exceed 3 mm.
5.11.24  **Edge Details**

Where blocks do not fit at the edge restraints or other obstructions such as manholes or upstands the gaps shall be filled using cut blocks. Blocks shall preferably be cut using a mechanical block splitter but may be cut by hand using a club hammer and bolster chisel after having scored the cutting line on all faces of the block.

Dimensional accuracy, uniformity of joints gaps, alignment and squareness shall be checked after laying the first three rows of blocks and thereafter at regular intervals. If joints begin to open, the blocks shall be knocked together using a hide mallet.

5.11.25  **Compaction by Vibration**

After each 20 sq.m., or such area that has been agreed with the Engineer, has been laid the blocks shall be compacted to the required levels using a plate vibrator.

The plate vibrator shall have a plate area of 0.2 to 0.3 sq.m and have a compaction force of 9-16 KN. Two passes of the plate vibrator shall be made in each direction, i.e. at 90° to each other.

5.11.26  **Filling Joints**

Fine dry sand with a particle size of 0-3 mm and which shall then be brushed over the paving, filling the joints, and a further pass of the plate vibrator made in each direction.

The plate vibrator shall not pass closer than 1 m to a temporarily unrestrained edge during laying.

No paving shall be left uncompacted overnight except for the 1 m strip at the temporarily unrestrained edge.

5.11.27  **Laying Tolerance**

On completion, the finished surface level shall be within 5 mm of the design level and the maximum deviation within the compacted surface, measured by a 3 m straight edge, shall not exceed 5 mm. The level of any two adjacent blocks shall not differ by more than 2 mm. Any areas of paving which do not comply with these tolerances shall be removed, the sand laying course adjusted and the paving blocks re-laid to the correct levels.
5.12 Tiles Testing

All paving shall be protected from damage during subsequent operations and shall be well washed and thoroughly cleaned before handing over.

The tiles must be tested according to the international standards and as follow: -

**Water Absorption:** Absorption should not be more than 8% by weight for each sample.

**Transverse Strength:** It should not be less than 3 N/mm² for each sample.

**Wear Resistance:** Rate of wear resistance should not be more than 2mm on average for 3 samples of each batch. However each sample should not have wear resistance over 2.5mm.

5.13 Tiles and Cladding

All the tiling & cladding works will be executed according to the drawings and engineers instructions and will be tested to control the quality of the materials as mentioned in the general specifications.

A. Terrazzo tiles (local production):
   - Terrazzo (marble chips) floor tiles size 25x25x2.5cm.
   - Terrazzo (marble chips) skirting 1x7cm.

B. Marble Works:
   - Local marble (Yatta) 3cm thick will be used for doors entrances WCs, and main entrances.
   - Local marble (Yatta) copings 3cm thick will be used for staircases and roof parapets.
   - Perlato marble 30x60x3cm tiles will be used for flooring.
   - Colored marble (preganza 2.0cm thick with sizes as requested by the engineer).
   - Windows sills will be local marble 3 cm thick (from Yatta ).

C. The kitchen cabinets:
   - Local marble (3cm thick from Yatta) will be used for dividers, shelves, floor and back of the kitchen cabinets and the work top will be from Tiger Eye marble from Italy, the cupboard leaves will be of 12mm thick ordinary plywood covered with colored Formica 1mm thick.

D. West Bank stone:
   - West Bank stone of 5.0cm thick from Jamaen-First Choice will be used as shown in the drawings and the engineer’s instructions.

5.14 Concrete Block Paving (Interlocking Tiles)

5.14.1 Form of Constructions
Concrete block surfacing shall consist of precast concrete blocks on a lying course 50mm thick sand on sub-base on subgrade.
5.14.2 Test Standards
Unless stated otherwise, testing of subgrade, sub-base materials and workmanship shall be carried out in accordance with BS 812 and BS 1377, laboratory Maximum Day Density tests shall be in accordance with Test 13 of BS 1377 and liquid limit shall be determined in accordance with test 2A or 2B of BS 1377, In-situ C.B.R testing shall be in accordance with test 15 BS 1377.

5.14.3 Subgrade
Subgrade shall consist of approved granular material compacted to 95% of the laboratory maximum dry density, the C.B.R value shall not be less than 15% (in case of supplying imported fill material).

5.14.4 Sub-Base Materials
Sub-base shall consist of approved granular material compacted to 95% of the laboratory maximum dry density, the C.B.R value shall not be less than 40%.

5.14.5 Base Materials
Base material shall be crushed rock or similar hard material or naturally occurring gravel which is clean and free from organic matter, clay balls and other deleterious materials. The materials shall comply with the following grading:

<table>
<thead>
<tr>
<th>Sieve Size (mm)</th>
<th>Percentage by Weight Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 100</td>
<td>100</td>
</tr>
<tr>
<td>37.5 85-100</td>
<td>85-100</td>
</tr>
<tr>
<td>10 40-70</td>
<td>40-70</td>
</tr>
<tr>
<td>5 25-45</td>
<td>25-45</td>
</tr>
<tr>
<td>0.600 8-22</td>
<td>8-22</td>
</tr>
<tr>
<td>0.075 0-10</td>
<td>0-10</td>
</tr>
</tbody>
</table>

The total acid-soluble sulphate content (as S03) (BS 812 Test 118) shall not exceed 2% by weight, the total acid-soluble chloride content (as NaC1) (BS 812: Test 117) shall not exceed 3.3% by weight.
The laboratory C.B.R value shall be a minimum of 80% at 100% of the laboratory maximum dry density after soaking for 96 hours.

Material for Base shall have physical Properties which do not exceed the following test value:

- Liquid Limit: 25%
- Linear Shrinking: 3%
- Plasticity Index: 6%
- Stone Size: 50mm
- Aggregate Crushing Value: 25%
- Water Absorption: 2%
- Flakiness Index: 35%
- Elongation Index: 35%
MgSO₄ Soundness
(5 Cycles) (ASTM C 88) 15%

The sand equivalent shall not be less than 45 when tested in accordance with ASTM D24419.

5.15.6 Laying Compaction of and Testing Sub-Base
Sub-base material shall be spread evenly and compacted in layer not exceeding 200mm compacted thickness to obtain a well-bound surface finish, loose or segregated areas shall be made good by addition of lines or by removal and replacement of the material as directed.

Compaction shall be carried out by approved plant operating on the material at an approved moisture content until a dry density of not less than 95% of the laboratory maximum dry density is achieved. One density test shall be carried per 250m².

The sub-base and base shall be laid to the level shown on the Drawings the rate of one set of tests for each 500m². The set contains of 3 sand cones tests.

The edge restraints to the paved area shall be installed before the laying course.

The sand shall be laid at a uniform moisture content and carefully screened to form a smooth compacted surface.

The profile of the laying course before compaction shall be similar to that of the finished surface, the maximum deviation from the design levels shall be ±5mm. The laying course shall be placed to a level which takes into account the compaction which occurs during vibration of the blocks; the amount if this compaction shall be determined by trials prior to commencement of surfacing.

5.15.7 Surface Course
The surface course shall consist of approved precast concrete blocks complying with BS 6717: part 1. The concrete constituent shall comply with the requirement of the concrete specification given elsewhere. Additional requirements are contained in the following specification.

5.15.8 Fine Aggregate
Fine aggregate shall not contain more than 25% by weight of soluble calcium carbonate in either the fraction retained on or the fraction passing a 600 micron BS sieve.

5.15.9 Coarse Aggregate
Coarse aggregate shall be material retained on a 4.75mm BS sieve, the nominal maximum size shall be 10mm, the grading shall comply with BS 882, table 4 so that when mixed with sand and cement a high density concrete is produced.

5.15.10 Sampling and Testing
Sampling and testing of blocks shall be carried out in accordance with BS 6717. Sampled blocks shall be subjected to all the tests covered by appendices A and B of BS 6717.
If any of the 20 test block do not comply with the requirements for dimensional accuracy the whole consignment may be rejected.

5.15.11 Test for Compressive Strength
Testing of blocks for compressive strength shall be carried out in accordance with appendix B of BS 6717 except that blocks shall be soaked for 24 hours in fresh water at 20 degrees centigrade immediately prior to testing. Fresh plywood packing shall be used for each specimen tested.
The compressive strength after 28 days must not be less than 450.0kg/cm².

5.15.12 Water Absorption
Blocks shall be tested for water absorption, the test shall be based on that specified in BS 1881: Part 122 and the maximum acceptable limits for water absorption
2.5% absorbed after 10 minutes.
5.0% absorbed after 24 hours.

The acceptable limits for water absorption may be required to be varied to achieve the minimum absorption compatible with the aggregate approved for use in the paving blocks.

5.15.13 Color
The color of blocks shall be uniform and as detailed on the drawings or as directed by the engineer. Samples of each different color shall be submitted for approval.

5.15.14 Block Laying
Block laying shall commence at angles to the main pavement axis starting at one end of the area.
Interlocking blocks shall be laid in a herringbone pattern at 45 degree to the main pavement axis or other pattern as approved or directed. Rectangular blocks shall be laid in patterns as directed using different colors if directed.

Blocks shall be laid on the sand laying course so that blocks already laid are not distributed, blocks shall be placed to fit closely together, the width of joints shall not exceed 3mm.

Dimensional accuracy, uniformity of joint gaps, alignment and squares shall be checked after laying the first three rows of blocks and thereafter at regular intervals.

If joint begin to open, the block shall be knocked together using a hide mallet.

5.15.15 Edge Details
Special edge blocks shall be used on all adages of interlocking block paving which are parallel to or perpendicular to the main pavement axis.

Where the shape of or dimensions of paved areas preclude the use of special or standard blocks on all edges, cut blocks shall be used, blocks shall be cut to suit, using a mechanical block splatter, in-situ concrete shall not be used to make up to edge restraints.
5.15.16  Compaction by Vibration
Blocks shall be compacted to the required levels using a plate vibrator as each area of 20 m² is laid.
The plate vibrator shall have a plate area of 0.2 to 0.3 m² and compaction force of 9 to 16kn. Two passes of the plate vibrator shall be made in two directions at 90 degrees to each other.

5.15.17  Filling Joints
Joints shall be filled by brushing in line dry sand with a particle size of 0 to 2mm and maximum sulphate content (as S03) of 0.4% by weight a further pass of the plate vibrator shall be made in each direction.

Weed killer have to be mixed with residual qualities with the sand used for sealing the joints.

The vibrator shall not be used within 1m of an unrestrained edge. Paving shall not otherwise be left uncompleted overnight.

5.15.18  Laying Tolerance
The finished surface level shall be within 5mm of the design level and the maximum deviation within the compacted surface, measured by a 3m straight edge shall not exceed 5mm. The level of any two adjacent blocks shall not differ by more than 2mm.

5.15.19  Payment
The accepted quantity will be paid for at the Contract unit price complete in place including excavation and any back filling, mortar, ..etc.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paviour</td>
<td>Square Meter</td>
</tr>
</tbody>
</table>
6 ROOFER AND CORROSION PROTECTION MATERIAL

6.1 General

6.1.1 Corrugated Steel Roofs

All corrugated galvanized steel sheeting (whether fixed to wood or steel framing) shall be of 22 or 24 gauge fixed with minimum of 15 cm. end laps and with side laps as specified in the Particular Specification. When ordered to have a one corrugation side lap, the sheets shall have a cover of not less than 6 cm. and all lapped sides shall be arranged to face away from the prevailing wind. When ordered to have a one and half corrugations side lap the sheets shall be arranged alternatively with a cover of not less than 9 cm, one sheet being fixed with the lapped sides turned upwards away from the bearer and the other (cover) sheet with the lapped sides turned downwards. Sheets shall be secured to wooden purlins at centers not exceeding 30 cm. by galvanized drive screws 75 mm. long with galvanized diamond shaped washers and lead sealing washers. All holes for bolts, drive screws etc., shall be punched from the underside of the sheets and shall be on the crown of the corrugations. Galvanized steel ridge capping shall be supplied and fixed to wood or steel purlins as described above. Hook bolts, drive screws and washers shall generally comply with British Standard No. 1494.

6.1.2 Asbestos Cement Roofing

Asbestos cement corrugated roofing shall be manufactured of fiberised asbestos and Portland cement complying with the equality requirements of British Standard No. 690 : 1963 and shall be obtained from an approved manufacturer. The sheeting be 6 mm. minimum thickness and shall be complete with all the necessary accessories including ridge cappings etc. Fixing shall be as described for corrugated steel except that holes shall be drilled and NOT punched.

6.1.3 Flat Roofs

The provisions, concretor, shall apply to the construction of solid reinforced concrete slab roofs and to hollow slab roofs. Finishing to these roofs will generally consist of a combination of the following materials. The actual finish will be specifically shown on the Drawings or in the Particular specification. Lightweight concrete screeds for obtaining falls or as an insulation layer shall be of an approved type of foamed concrete. The materials shall be measured, applied and cured in accordance with the manufacturer's instructions and to the satisfaction of the Engineer. Mixing shall take place in mechanical mixers of approved design. In all cases the finished screed shall have the properties described in the Particular Specification or shown on the Drawings regarding the density, permeability and insulating value. Vermiculite screeds for obtaining falls or as an insulating layer shall consist of vermiculite aggregate and cement mixed and applied in accordance with the details given below. The vermiculite aggregate shall be an exfoliated micaceous mineral aggregate incombustible and chemically inert, obtained from an approved manufacturer and graded in accordance with the following table.
The vermiculite shall be delivered on the manufacturer's sealed and branded containers with shall be clearly marked to shown the crude of vermiculite contained therein. The vermiculite shall be sealed in a covered store raised off the ground and the bags stacked not more than 3 M high. Gauge boxes shall be used for the measurement of vermiculite and following mixing table shall be strictly observed.

<table>
<thead>
<tr>
<th>Grade DETAILS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade</td>
</tr>
<tr>
<td>Number</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
</tbody>
</table>

The grade of vermiculite to be used for each portion of the Works shall be as described in the Particular Specification. Mixing may be carried out by hand or by approved machine in accordance with the following procedures:

By Hand: The measured quantity of vermiculite shall be poured out onto a clean dry level surface and the water added. Mixing shall be carried out until the water has been distributed amongst the vermiculite. The cement shall be added and further mixing shall take place until all materials are uniformly distributed.

By Machine: The machine shall be an approved counter-current rotation paddle type mixer operating at the speed recommended by the manufacturer. The water shall be placed in the mixer followed by the vermiculite and mixing shall be carried out until the water has been distributed amongst the vermiculite. The cement shall then be added and further mixing shall take place until all materials are uniformly distributed.

It is extremely important to ensure that the mixing period is kept as short as possible in order to prevent compression of the vermiculite. For this reason ordinary concrete mixer of the revolving drum type are unsuitable and shall not be used. If an approved mixing machine is not available then the mixing shall be carried out by hand.

It is also important that the water content be kept to the minimum possible to allow for the proper hydration of the cement. Sloppy mixes shall not be used. An even consistency free from lumps and excess water is required. As a site test for consistency, a handful of the mix when firmly gripped should just release water.

Placing of the vermiculite mix shall take place immediately after mixing. The vermiculite screed shall be laid in alternate bays not exceeding 16.00 square Meters in area to a minimum depth of 5 cms. The vermiculite mix shall be carefully spread by means of a rake to a depth 12 1/2 % greater than the finished thickness required and shall then be lightly trowelled down to its finished thickness. The mix shall not be tamped, vibrated or compressed with heavy implements.

The vermiculite screed shall be crude by covering with damp hessian for a period of seven days and during this time the screed shall not be subjected to traffic of any kind. After curing the vermiculite screed shall be protected by a layer of cement and sand (1:4) mix. This topping shall be well trowelled in to ensure proper adhesion with the vermiculite screed and screed and shall have a minimum finished thickness above the vermiculite screed of 1 cm. The topping shall be cured with damp hessian for a
period of seven days as described above for screeds. Alternatively the cement and cement topping may with the approval of the Engineer, be applied immediately after trowelling the vermiculite screed. If roofing is to be laid on the topping the surface shall be finished flat and true with a steel trowel. Vermiculite screeds and cement and sand topping layer shall not be laid during rain. After laying they shall be protected by approved means from the effects of rain, excessive heat, etc. The screeds and topping shall be allowed to dry out thoroughly before subsequent roofing operations be carried out. To facilitate drying the Contractor may insert 1/2 inch diameter temporary ventilating tubes obliquely through the topping. Concrete screeds for obtaining falls shall be (1:3:6) mix as previously described. Cement screeds shall be (1:6) mix as shown in the Mixing Table below. Both types shall be finished flat and true with a steel where felt roofing is to be fixed on the screeds. The thickness of screeds will be defined on the Drawings or in the Particular Specification:

<table>
<thead>
<tr>
<th>MIXING TABLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal</td>
</tr>
<tr>
<td>1:6</td>
</tr>
</tbody>
</table>

Wood wool, slabs where used for insulation shall be an approved type of wood wool insulation, fire resistant and vermin proof complying with British Standard No. 1105 (Normal quality). The thickness shall be a minimum of 5 cms. and the slabs shall be held dry with loose butt joints. Terrazzo or cement sand tiles shall be manufactured and laid as described under PAVIOR. Tiled tile skirtings shall consist of triangular fillet of concrete (1:3:6) mix or cement and sand (1:6) mix or vermiculite and cement (8:1) mix with a row of 20 cms. x 20 cm. X 2 cms. terrazzo or cement and sand tiles bedded on in cement and sand (1:4) mix to form a skirting to match the tiling. The top edge of this tile skirting shall be let into the wall and the joint carefully pointed. Expansion joints in vermiculite, concrete or cement and sand screeds and toppings shall be formed every 4 Meters in both directions and shall be continuous throughout the depth of screed or screed and topping. Expansion joints in tilling shall be formed every 4 Meters in both directions and shall be continuous throughout the depth of tiling and screed. The expansion joints shall generally be formed of 1 cm. thick fibber board impregnated with bitumen, accurately cut, with butt joints and fixed vertically and straight. The top 1 cm. of the joint shall be filled with a mixture of bitumen and sand (1:7) mix. Alternatively the top 1cm. shall be filled with "Secomastic" ('K'-gun grade) or other equal and approved joint sealing compound. Care shall be taken to prevent staining of the adjacent surfaces when pouring the bitumen. Expansion joints shall continue into the titled tile skirtings and fillets. Felt roofing, below tiling, shall be according to manufacture or two-ply, tropical grade, fibber-based bituminous roofing felt weighing not less than 1.8 kg/sq.M. (40 lbs/12 sq.yd.) and shall comply generally with British Standard No. 747 (Class 1 Type 1 c.) The felt shall be thoroughly bonded to the roof or screed and between layers. Care shall be taken to ensure that all surfaces upon which felt is to be laid are dry, smooth and clean. The bonding shall be means of bitumen (60/70) penetration) applied hot as a continuous coating to an average thickness of not less than 1.5 mm. and not more than 2.0 mm. so as to give a complete coat over the whole area at the rate of not less than 1.5 kg/sq. M. and not more than 2.0 kg/sq. M. for each bonding coat. The felt shall be laid with 15 cm. side and end laps which shall be staggered. The felt shall be carried up the walls etc., over fillets to form a skirting continuous with the roof covering. The skirting shall be bonded to the fillets and walls and shall be not less than 15 cm. in vertical height. The felt shall be dressed and bonded into rain-
water outlets and under flashings. Where roof finishings are required to be of a bitumen and sand mix this shall be composed of a mix to the following proportions (by weight):

- Bitumen 60/70 penetration 13%
- Filler (Passing 200 sieve) 11%
- Sand 76%

Mixing shall be carried out in an approved machine until all materials are thoroughly mixed. The mixing temperature shall be between 325 F (163 C to 191 C) and mix shall be applied at temperature sufficient to maintain the workability of the mix. The covering shall be laid in one coat to give a consolidated thickness of 2 cm. after rolling with a light hand roller. 15 cm. x 15 cm. angle fillets shall be laid at edges of roofs against parapets etc., properly bonded the roof covering and with top edges turned into joints of walls. The covering shall also be dressed into rain-water outlets and under flashings.

6.1.4 Generally

All roof finishes shall be carefully worked or fitted around pipes or openings. On completion all roofs are to be felt sound and watertight and in a neat and clean condition before handing over.

TECHNICAL SPECIFICATIONS FOR STANDARD ROOF FINISHES

STANDARD SPECIFICATIONS FOR ROOF FINISHES:

1. The work of roof finishes shall consist of the following:
   - Hot bitumen primer coat to concrete roof slab.
   - Thermal insulation.
   - Sheathing membrane.
   - Sand/Cement screed.
   - Roof waterproofing and U/V protection
   - Concrete tiles.

2. Contractors Obligations:
   The Contractor shall provide all the materials, labor and equipment etc., for this work and shall carry out and complete the entire work of roof finishes as per specifications detailed below:
   The Contractor shall submit to the Department a five years guarantee in the form of an Insurance Policy for the roof finishes from any of the approved local Insurance Companies prior to initial takeover of the project by the Department. A specimen copy of the Insurance Policy shall be submitted before starting work on site for the approval of the Department.
   The insurance policy must cover the cost of labor, plant and materials for replacement and repair of the roof finishes, water-proofing and insulation in the event of its failure or leakage during the course of five years from the date of initial handing over of the projects.
6.2 PART I

6.3 Specifications

6.4 Insulation

6.4.1 Polystyrene Rigid Foam Boards

Contractor shall lay a layer of 5 Cm. thick rigid polystyrene boards fully bonded to primed surface of the screed or directly on the concrete slabs as specified here under. Bonding shall be done either by hot bitumen or any other approved bonding agent recommended by manufacturer. Above polystyrene rigid boards shall comply with the following:

**Thickness : 5 Cms.**

- Thermal conductivity at 10% mean temperature : \( K = 0.028 \, \text{W/m deg. C} \)
- Density : 32.35 Kg/m³
- Water absorption : 0.1% volume
- Capillary : None
- Compressive strength at 5% Compression : \( = 0.245 \, \text{M/N/M2} \)

There shall be no air between screed or concrete slab and polystyrene board.

2. Polyurethane Foam:

3 Cm. thick (minimum) polyurethane foam sprayed in 3 layers each 1 Cm. thick over cement/sand screed laid to fall (1%) over the primed surface of the concrete roof slab. It shall consists of the following:

- 1 part 'Plyol' and 1 part 'Isocyanate' mixed as recommended by the manufacturer and approved by the Engineer.
- Mixing Proportions : 1/1
- Density : 60 Kg/m³
- Tensile strength : 5.0 daN/cm²
- Compressive strength : 3.5 daN/Cm²
- Water absorption : 59 gr/M²/24 hours
- Thermal conductivity : 0.021 W/C

3. Rigid Mineral Wool Slab:

Rigid mineral wool slabs shall be bonded to the primed surface of concrete slab. The rigid mineral wool slabs shall comply with the following:

**Thickness:**

- 8 Cms. thick faced with aluminum foil on one side.
- Non combustibles and water repellent.

**Density:**

- 120 Kg/M³

Thermal conductivity coefficient 'K' value at 10 C shall not be more than 0.031 w/m deg. C. It shall be fully bonded to concrete roof slab with hot bitumen or the approved/recommended bonding agent.
There shall be no air between the concrete slab or screed and mineral wool slab. Fiberglass roving strips shall be provided at the edges, corners, parapets and along the mineral wool slab horizontal joints.

6.5 Sand/Cement Screed:

(A base for waterproofing treatment or thermal insulation)

3.2.1 Minimum 3 Cm. thick sand/cement screed layer - 1 part cement to 4 parts clear sand shall be laid to fall 1% or as specified on the drawings, over the concrete roof slab or the roof thermal insulation depending on the types of roof finishes specified hereunder. Maximum thickness of the screed shall be 10 cm.
  - Screed will be used to create the proper slopes for rain water as shown on the drawings.

3.2.2 Sand used for the screed shall be clean natural and, free of all salts and other impurities, graded passing through a 4.76 mm. British Standard sieve with a good proportion of larger particles.

3.2.3 Cement shall be Portland cement complying to B.S. 12: 1978 for ordinary and rapid hardening Portland cement.

6.6 Waterproofing:

6.6.1 Two coats of Elastomeric Acrylic Paint

Diathon or similar approved waterproofing and ultraviolet rays protection shall be applied over the polyurethane foam. First coat shall be gray color with fiber glass mesh reinforcement bonded to the insulation surface. The second top coat shall be white color applied perpendicular to the first coat. Total thickness of the coat shall be 609 dry microns (excluding fiberglass mesh). The above waterproofing only used when polyurethane foam insulation is used over the screed for non-traffic able roofs.

6.6.2 Cold applied Waterproofing Membrane for non-Traffic Able Roofs:

2 coats of 2 component Elastomeric self adhesive membrane over primed, screeded surfaces with aluminum paint on top for U/V protection.

Component Elastomeric self adhesive membrane shall consist of a mix of 9 volumes 'premix' - polymerizable black liquid and one volume of 'Activator' - straw colored liquid - laid to an average thickness of 1.5 mm. Top coat shall be sprayed with a layer of clean sand when it is still green, as a key for the U/V protection, which shall be done by two coats of aluminum reflective paint.

Rubberized bitumen/polyurethane membrane shall consist of standard rolls of self adhesive and self-sealing 1.5 mm. thick rubber-bitumen compound with solar shield a luminous to exposed top surface - all to be laid on primed screeded surface with necessary end laps and side laps as recommended by the manufacturers.

6.6.3 Traffic able Roofs:

2 components Elastomeric membrane shall have average thickness of 1.5 mm. and shall be mix consisting of 9 volumes 'Premix' - polymerizable black liquid and one volume of 'Activator' - a straw colored liquid laid over primed roof surface.
Rubberized bitumen/polythene shall consist of standard rolls of self-adhesive and self-sealing bitumen/polythene waterproofing membrane to factory controlled thickness of 1.5 mm. confirming to B.S. Code of Practice 102.

Self adhesive membrane 4kg/m² with angle fillet will be used as water proofing layer (polypet or approved equivalent).

6.7 Priming of Concrete Roof Slab Surfaces:
3.4.1 Top surfaces of roof slab shall be primed and given two coats of Oxidized bitumen 115/15 at the rate 2 kg./m² brush applied to cover all the surfaces - up stands, sleeves of ducts, pipes etc., that are required to covered with roof finishes mentioned above.

6.8 Sheathing Membrane:
3.5.1 Polythene 'Visqueen' 500 Grade or similar membrane laid with necessary side laps (10 Cm.) and end laps as required (Min. 15 Cm.)

6.9 Concrete Passing Slabs:
3.6.1 Pre-cast paving slabs shall be hydraulically pressed, square edges sizes 60 x 60 5 Cm. thick made from Portland cement and aggregates-all to comply B.S. 368:1971.

6.10 Mastic Sealant:
3.7.1 Mastic used for the joints shall be cold poured - 2 part polysulphide based sealants confirming to B.S. 4254:1967.

6.10.1 PART II

6.11 Type of Roof finishes based on the above Specifications:-

6.12 Roof finishes Type A: (Non-Trafficable Roofs)

Step (1) : Priming of roof slab/surfaces as described in 3.4.1
Step (2) : Sand/cement screed (See 3.2)
Step (3) : Polyurethane foam as detailed on 3.1.2
Step (4) : U/V protective coating/waterproofing as described in 3.3.1

6.13 Roof Finishes Type B: (Non-Trafficable Roofs)

Step (1) : Priming of roof slab/surfaces as described in 3.4.1
Step (2) : Polystyrene rigid insulation slabs (boards) laid over primed surfaces of roof slab as specified in 3.1.1.
Step (3) : Sheathing membrane as described in 3.5.1
Step (4) : Sand/cement screed as specified in 3.2
Step (5) : Waterproofing as specified in 3.3.2

6.14 Roof Finishes Type C: (Non-Trafficable Roofs)

Step (1) : Priming of the roof slab surfaces and described in 3.4.1
Step (2) : Rigid mineral wool insulation slabs as specified in 3.1 (c)
Step (3) : Sheathing membrane as described in 3.5.1
Step (4) : Sand/Cement screed as specified in 3.3.2
6.15 Roof Finishes Type D: (Trafficable Roofs)

Step (1) : Priming of the roof slab surfaces as specified in 3.4.1
Step (2) : Thermal insulation as specified in 3.1.1
Step (3) : Sheathing membrane as described in 3.5
Step (4) : Sand/Cement screed as specified in 3.2
Step (5) : Roof waterproofing as specified in 3.3.3
Step (6) : Sand/cement mortar (1:6) bed min. 2.5 Cm. thick
Step (7) : 5 Cm. thick 60 x 60 Cm. concrete roof paving slabs as specified in 3.6.1

Surfaces of these concrete slabs shall be suitably coated/treated with approved waterproofing compound to render them watertight.

5. Contractor must use the type of finishes as specified on the drawings for the particular project or any other type of roof finishes specified above and approved by the Department Architect. Work of the roof finishes shall be carried to the complete satisfaction of the department Engineer. The roof shall be tested for water tightness by flooding the same with 5 Cm. deep sheet of water for 72 hours prior to initial take-over of the building.

6. Contractor must use the appropriate type of detail for horizontal and vertical joints as shown on the drawings. Up stands for expansion joints on the roof shall be properly covered with the waterproofing membrane over the plastered vertical and horizontal surfaces. Points shall be properly sealed with approved mastic sealants and protected from damage by providing pressed aluminum sheet cover as indicated in details on the drawings.
7.1 Materials

7.1.1 Corrosive Environments

Corrosion protection systems and surface coatings shall in all cases be suitable for exposure to their contact environmental conditions which may include any or all of the following:

1) The climatic conditions prevailing in the project area with particular emphasis on temperature variations, high surface temperatures and high humidities.
2) Septic sewage with a pH value of unity.
3) Sulphuric acid solution in sewage slimes in concentrations up to 15% by weight.
4) Hydrogen sulphide and other gases emanating from sewage, septic sewage and sewage sludges.
5) Saline groundwater with high sulphide contents both below the water table and in soil zones above the water table where capillary action and the presence of oxygen may cause extremely severe conditions.
6) Wind blown chlorides.
7) Wind blown abrasive sands.

7.1.2 Paint

Protective and decorative paint systems including primers and undercoats shall be obtained ready mixed for use. All containers of paints and other coating systems shall show date of manufacture, shelf life and pot life where applicable.

The contractor shall only be allowed to use paints which are delivered to the site in sealed cans or drums bearing the name of the manufacturer and properly labeled.

Tints and shades of final coats shall be advised by the Engineer or his Representative.

7.1.3 Impervious Tanking Membrane

Membrane used for tanking to concrete structures shall be impervious, self-adhesive and covered with a release agent.
Rubber bitumen/PVC membrane shall have a minimum bitumen thickness of 1.5 mm and PVC thickness of 0.3 mm.
7.1.4 PVC Sheet Lining Materials

PVC sheet materials to be used for lining concrete structures and pipelines internally shall be manufactured from polyvinyl chloride, plasticisers and pigments to make permanently flexible sheets.

The colour of the sheet shall be approved on site.

The PVC sheet shall have a minimum thickness of 1.5 mm and shall be formed by extrusion to have on one side locking keys or ribs of either T or diamond section at centers not greater than 75 mm. It shall be capable of forming a continuous 100% effective seal with the use of welding strips or other approved method and shall be supplied with all materials and tools for making the joints.

The tensile strength of the material shall be not less than 17000 kN/m².

All weld strips, patches and other sheets used in the permanent fixing of the ribbed sheet shall be of a material having the same composition as the ribbed sheet.

7.1.5 Bituminous Emulsion

Bituminous emulsion shall be to the approved standard and shall not contain less than 53% of bitumen.

7.1.6 Water Proof Paper

Water proof building paper shall be to the approved standard. For road works.

7.1.7 Protective Materials for Wrapping Pipeline Components

The protective materials for wrapping pipeline components shall comprise a rust inhibiting compound for the bolts, a mastic or comparable filler which will not harden for moulding over the assembly, and a water proof tape for wrapping.

7.1.8 Approved Paint Supplies

The following paint systems have been successfully used in sewage environments in the middle east. Reference to these systems in no way precludes the use of similar or superior systems by other suppliers.

Supplier / System :-

Colebrand Limited) Epoxy Prefabrication Primer: CXL 100
Colebrand House) Epoxy Resin Solvent Free Coating: CXL 115
20 Warwick Street) High Build Epoxy Airless Spray Coatings
Regent Street) CXL 141 for temperate climates) applications
London WIR 6BE) CXL 140 for hot climates applications
England)

Corroless International Limited)
Berk House)
Basings View) Corroless T
7.2 Installation

7.2.1 Protection to Surface of Concrete Structures

Concrete structures shall be protected both internally and externally where indicated on the drawings and by the methods detailed.

All protection systems shall be applied strictly in accordance with the manufacturer's instructions, two copies of which shall be included with the Contractor's application for the approval of the material, and when approved will be deemed to be part of this specification unless stated otherwise.

The permissible rate of permeation of all protection systems shall not exceed 0.0027 perm inches (ASTM, 1 perm inch = 1 gramme of water per hour per square foot (0.0929 m²) per mil (0.0254 mm) of thickness for a 1 inch (25.4 mm) difference in Hg vapour pressure on each side of a membrane.

Coatings shall not be applied at expansion, contraction or construction joints which incorporate a sealant.

The minimum of all coatings and linings shall be 0.5 mm.

1) External Buried Surfaces

The external surfaces of concrete substructures shall be protected or "tanked" by one of the following methods which will be indicated on the drawings.

(a) An impervious bituminous sheet membrane. The selfadhesive lap joints shall not be less than 150 mm wide.

Where the membrane is laid on blinding concrete, the surface shall be free from sharp edges and projections. The membrane shall be protected from damage during the fixing of steel reinforcement and the pouring of concrete. Where the tanking is applied to vertical surfaces the surface shall first be painted with one coat of bitumen primer.

(b) A brush applied bituminous emulsion. The surface shall first be wire brushed and all dust and loose scale removed. Three coats of bituminous rubber emulsion paint shall then be applied. the second coat shall not be the same colour as either the 1st or 3rd.

Both methods of protection shall totally enclose the substructure within a waterproof membrane to the limits shown on the drawing.

During the backfilling operation around all tanked structures the waterproof membrane shall be protected from damage by the use of fibreboard, or other approved material.

2) Internal and External Exposed Surfaces

Where exposed surfaces of concrete structures are not protected by reinforced plastic liners one of the following systems will be indicated on the drawings required.
(a) An epoxy resin, acrylic, polyester or latest paint system. The surface shall first be wire brushed and all dust and loose scale removed. An epoxy resin or other primer/sealer (for concrete and allied substrates) shall then be applied followed by coats of high build epoxy airless spray or other coatings to give a minimum thickness of 300 microns. The approved paint system must have adequate flexibility to suit the thermal movements of the concrete without cracking whilst maintaining an effective bond.

(b) A PVC sheet lining which shall be fixed such that the keys or ribs are cast into the concrete surface. The lining shall be capable of taking up the same profile as the concrete substrate as indicated on the drawings.

Site operatives for employment on this work shall be certified by the manufacturer as trained to a satisfactory standard in fixing and welding techniques.

After completion of either of the linings or systems as described in sub-clauses (a) and (b) above they shall be offered for inspection and testing. Two sets of testing equipment e.g. feeler probes and spark testing shall be provided and be maintained and available at all times for the sole use of the Engineer's Representatives.

Only linings or systems completely free from pinholes will be accepted.

7.2.2 Protective Coating to Metalwork

Protective coating and surface preparation shall be to the approved standard and conform with the "Schedule of Protection Systems" given below, but only epoxy systems as detailed in Shop Coatings Schedules 1 & 4 shall be used.

Coatings shall only be applied when:

1. The surface to be coated is completely dry.
2. The air temperature is above 4°C.
3. The humidity is less than 85%.

Manufactured items shall have all surface protection applied at the place of manufacture or in Palestine under controlled application conditions approved by the Engineer.

All coats of paint or other coating systems shall be purchased from one manufacturer and applied strictly in accordance with the manufacturer's instructions.

All machined, polished or bright surface whether internal or external shall be protected against corrosion and damage.

Where like metals are jointed at the works priming shall be applied prior to joining.

The mating surfaces of structural steelwork shall be sealed with litharge and glycerin during erection.

Where dissimilar metals are mated including bolts, nuts and washers, the mating surface shall be insulated the one from the other to provide protection against galvanic action.

On delivery of items to site, any defect in the protective coatings shall be made good.
### SCHEDULE OF SURFACE PREPARATIONS

<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a)</td>
<td>Degreasing</td>
</tr>
<tr>
<td>(b)</td>
<td>Blast Cleaning</td>
</tr>
<tr>
<td>(c)</td>
<td>Fettling</td>
</tr>
<tr>
<td>(d)</td>
<td>Site cleaning</td>
</tr>
<tr>
<td>(e)</td>
<td>Wire wool or Wire cloth</td>
</tr>
<tr>
<td>(f)</td>
<td>Polish and/or anodise</td>
</tr>
</tbody>
</table>

### SCHEDULE OF PROTECTIVE COATINGS

<table>
<thead>
<tr>
<th>System</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>Zinc metallisation or zinc spray to the approved standard.</td>
</tr>
<tr>
<td>P2</td>
<td>Sealer primer to follow hot dip galvanising.</td>
</tr>
<tr>
<td>P3</td>
<td>Zinc chromate etching primer to follow zinc spray.</td>
</tr>
<tr>
<td>P4</td>
<td>Micaceous Iron Oxide Paint containing not less than 80% and not more than 5% antisettling agent.</td>
</tr>
<tr>
<td>P5</td>
<td>Alkyd Resin base undercoat.</td>
</tr>
<tr>
<td>P6</td>
<td>Alkyd Resin base gloss finish paint.</td>
</tr>
<tr>
<td>P7</td>
<td>Zinc Chromate primer.</td>
</tr>
<tr>
<td>P8</td>
<td>Epoxy or Polyester prefabrication primer.</td>
</tr>
<tr>
<td>P9</td>
<td>Epoxy or Polyester resin solvent free coating.</td>
</tr>
<tr>
<td>P10</td>
<td>High build Epoxy or Polyester airless spray coating.</td>
</tr>
<tr>
<td>P11</td>
<td>Approved nylon, PVC or other synthetic dip or spray applied coating.</td>
</tr>
<tr>
<td>P12</td>
<td>Hand wrapping with hydrocarbon paste, mastic and tape.</td>
</tr>
</tbody>
</table>
Notes:

(1) For manufactured items all cutting and drilling shall be completed before application of any of the surface treatment specified.

(2) Epoxy/polyester paint systems shall achieve a minimum dry film thickness (dft) of 300 microns. The number of coatings to achieve this thickness may vary according to method and time of application.

(3) Epoxy/polyester coatings must be applied by airless spray or electrostatic charging of particles and stoving.

(4) Freedom from pinholes shall be established by use of a spark tester.

7.2.3 Payment

The accepted quantity will be paid for at the Contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protective Painting</td>
<td>Square Meter</td>
</tr>
<tr>
<td>Roofing</td>
<td>Square Meter</td>
</tr>
</tbody>
</table>
8 CARPENTRY AND JOINERY

8.1 Timber
All softwood for carpentry and joinery work shall be well seasoned, sound, bright, free from shakes, large, loose or dead knots, waney edges, warp, incipient decay, stained sapwood or other defects and shall be to approval of the Engineer. Timber for carpentry work shall be carefully swan square and shall hold the full dimensions shown on the drawings. The hardwood for joinery work shall be best quality teak, well seasoned, close grained and free from all defects. The Contractor shall allow for all necessary cutting timber to size and shape, for preparation of surfaces, for all fixings for properly jointing and putting together including framing, glue notching, sinking, scribing, meters, ends, short lengths and any other sundry items of a like nature and for priming all concealed surfaces of joinery. Aluminum primer shall be applied to the backs of all door frames. All sizes shown on drawings are finished sizes unless otherwise stated. Timber for joinery work shall be finished with the exact sizes shown on the drawings with pencil round exposed arises and no joinery shall be built in until inspected and approved by the Engineer. The whole of the hardwood joinery shall be rubbed down to a smooth surface and left clean and ready to receive an oiled finish.

8.2 Moisture content of Timber
The softwood generally shall have a moisture content limit of 12%. The hardwood shall have a moisture content limit of 10% and shall have been kiln dried. The whole of the timber for joinery work shall be properly stacked and protected from rain and ground moisture.

8.3 Plywood
The plywood shall be external quality resin bonded equal to B.S. 1455. The minimum thickness shall be 4 mm. Plywood face veneers shall comply with B.S. 1455, Grade 1. Plywood adhesives shall comply with B.S. 1203, Grade 1. Plywood shall be obtained from an approved source to the correct thickness specified. The Contractor will not be permitted to make up the required thickness by gluing together sheets of thinner plywood.

8.4 Block board
Block board shall be external quality resin bonded equal to B.S. 3444.

8.5 Face Veneers
Face Veneers shall be hard durable and capable of being finished easily to smooth surface. That shall be free from knots, worm and beetles holes, splits, glue stains, filling or inlaying of any kind, of defects. Face veneers shall be applied to one or more sides as described in the Particular Specification or shown on the Drawings. Timber for face veneers shall be as described in the Particular.

8.6 Asbestos Insulating Board
Asbestos insulating board shall comply with B.S. 3536.

8.7 Fixings and Jointing
Softwood in carpentry work shall be put together with steel nails except where described as framed when it shall be properly joined and held together with glue and steel screws. Fixings shall be stout steel nails and screws.

8.8 Doors
Joinery works shall be carefully put together and properly jointed in accordance with best practice, all joints shall be glued and screwed or doweled. Any screws appearing on face work shall have the heads let in and be pellated unless otherwise described. Softwood fixings shall be about steel screws. Hardwood joinery shall be put together and fixed brass cups and screws. Cups for fixing hardwood joinery shall be cast brass cups with milled edges and shall be neatly let in to finish flush with the face of the work.

8.9 Windows and Sashes
Windows and fanlight sashes shall be framed to the size shown on the drawings. Sashes hung folding shall have meeting beads screwed on. Glazing bars if required shall be of twice rebated section.

8.10 Hatches and Shutters
Hatches, shutters and similar items of joinery shall be framed to the sizes shown on the drawings.

8.11 Fly screens
Fly screens to doors shall be framed and braced with tails styles and braces and filled in with approved copper or galvanized steel fine wire mesh of 0.70 mm. beaded on.

8.12 Frames
Frames to doors, windows and fly screens shall be provided and built in to the sizes shown on the drawings. Frames shall be securely tied to walls by means of steel or similar metal cramps, galvanized or dipped in bitumen as follows:
Door frames : Three cramps to each side.
Window frames : Two or more cramps to each side according to size.
Doors, windows, etc. shall be carefully and accurately fitted to the frames to give a uniform clearance of not more than 3 mm. all round.

8.13 Architrave's, Door Stops, etc.
Architrave's, door stops, etc. shall be as shown on the drawings and all properly mitered at intersections. Glazed beads where required shall be wrought splayed and rounded and shall be neatly mitered and fixed with small brads or lost-head nails.

8.14 Fittings
In connection with fittings such as wardrobes, cupboards counters, etc., the doors, frames, drawers, rans and framing etc., shall be properly and accurately framed together as shown on the drawings.
8.15  **Shelving**
Wrought shelving shall be constructed and fitted as shown on the drawings supported with bearers on farming or

8.16  **Scribing**
All joinery such as architraves, beads, etc. required to fit against the contour of irregular surface shall be accurately scribed to ensure a close butt connection.

8.17  **Finish**
All joinery which is to be polished, varnished or painted shall be finished smoothed and clean by rubbing down with the fine sandpaper.

8.18  **Protect joinery from damage**
All joinery shall be protected from damage during the course of the Works and on completion shall be to the engineer's entire satisfaction. Before handing over, the Contractor shall ensure that all doors, drawers, etc. work easily and shall make all necessary adjustments including those needs during the maintenance period.

8.19  **Measurement & Payment**
The accepted quantity will be paid for at the Contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carpentry &amp; Joinery</td>
<td>L.S/No.</td>
</tr>
</tbody>
</table>
9 IRONMONGERY

9.1 Generally
The Contractor shall provide and fix the ironmongery required by the Particular Specification or shown on the Drawings complete including all necessary screws, bolts, plugs and other fixings. The use of nails for fixing ironmongery will not be permitted. The Contractor shall hand over all work in a finished state and to the satisfaction of the Engineer.
All ironmongery shall be of first quality and shall be obtained from an approved manufacturer.
The Contractor will be required to submit for approval samples of all items of ironmongery he proposes to use.
All doors shall be provided with a rubber door stop plugged and screwed to the floor and all opening sashes of windows shall be provided with friction stays. The size, materials, finishes, type and quality of ironmongery shall be as described in the Particular Specification or shown on the drawings.

9.2 Finish
The finish of the various items of ironmongery shall be as described in the Particular Specification or shown on the drawings.

9.3 Fitting and Testing
All screws used for fixing ironmongery shall be of the correct type, materials, finish, size and shape to the satisfaction of the Engineer.
The hinges on which doors, windows, fly screen doors, etc. are hung shall be carefully housed or let in to the door, window, fly screen door, etc. and to the frames.
All fittings shall be removed before commencing and painting operations and shall be re fixed in place after all painting works are completed and approved by the Engineer.
All ironmongery shall be carefully wrapped and protected until completion of the work and any items or parts which are damaged or defaced shall be replaced at the Contractor's expense before handing over.
On completion all locks, catches and similar items of ironmongery shall be properly cleaned tested and oiled and all keys be clearly labeled with metal tags approximately 5 cm x 2 cm securely fixed to the keys and handed to the Engineer on approved wooden board.

9.4 Measurement & Payment
The accepted quantity will be paid for at the Contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ironmongery</td>
<td>L.S/No.</td>
</tr>
</tbody>
</table>
10 METAL AND ALUMINUM WORKS

10.1 Generally
All materials shall be free from scale, rust damage or defects.
All welding, brazing or hot forging shall be carried out by approved processes.
All metalwork shall be approved by the Engineer before starting painting works.

10.2 Windows and Doors
The following specifications relating to metal windows shall cover also metal casement doors and, where applicable, partitions. Generally metal windows shall be supplied complete with frames, fixing lugs and glazing clips or beads. Composite windows shall be supplied complete with the necessary transoms and mullions. Generally the windows will be required to open inward.
Mild steel windows shall be manufactured in accordance with B.S. 990 with regard to materials and workmanship. The windows shall be formed of hot rolled mild steel sections, electrically welded, and rustproof by either hot or cold galvanizing, metallizing or sheradizing process as required. The rust-proofing shall be sufficient to withstand the 72 hour salt-spray test as provided for in B.S. 1391. Opening sashes shall be fitted with steel hinges having brass pins. Pivoting sashes shall be fitted with bronze centres. Side hung or vertically pivoting sashes shall be fitted with sliding stays and handle fasteners with two point noses as shown on the Drawings or as specified in the Particular Specification. Top hung or horizontally pivoting sashes shall be fitted with brass peg stays. Button hung sashes shall be fitted with brass lever catches and, according to size, one or two steel side arms each. Aluminum windows shall be manufactured of extruded sections of Aluminum alloy, flash welded. Fittings shall be of aluminum alloy in accordance with B.S. 1331. Fly screens shall fitted to all opening leaves of windows, consisting of aspirated metal sub-frame filled in with fly wire as previously described. The fly screens shall be adequately secured with suitable slips, set screws or turn buckles and shall be removable for maintenance purposes. Fly screen doors shall consist of similar sections to the metal casement doors and shall be fitted with removable panels of fly wire in a manner similar to that described for window fly screens.

10.3 Aluminum Curtain Walling
The type and dimensions of the aluminum alloy curtain walling shall be as described in the Particular Specification or shown on the Drawings. The curtain walling shall consist of mullions, transoms and head and sill members, to the module shown on the Drawings, fitted together with spigot and socket joint set in non-hardening mastic. The curtain walling shall be of adequate strength to resist the wind pressures, panel loadings etc., as shown on the Drawings or in the Particular Specification and shall be securely anchored to the building by means or bolts, channels, etc.; to the approval of the Engineer. Adequate provision shall be made to accommodate thermal movement and suitable weathering devices shall be incorporated. The curtain walling shall be supplied in either standard or anodized finish. In the latter case the units shall be protected by a plastic covering applied by the manufacturer and stripped off when installation is completed.
10.4 Sundries

Wrought steel balustrades shall be provided to staircases and balconies as shown on the Drawings. Burglar bars and safety bars shall be provided to windows where shown on the Drawings. Cramps for fixing wood door and window frames shall be 20 cm long x 3 cm x 3 mm section and shall have one end bent and twice drilled for screwing to frame and other end fishtailed for building into walling. Cramps shall be galvanized or dipped in bitumen before fixing Mild steel ladders where required shall be as shown on the Drawings. Metal roller shutters shall be provided to sized shown on the Drawings. Each roller shutter shall be constructed of heavy-gauge metal slats and shall be complete, including channel iron guides, roller box, spindle and counter balance springs and with staple welded to door, hasp set in concrete floor and padlock. The roller shutter shall be as stipulated in the Particular Specification.

The required Aluminum sections are Colored powder coated sections and will be used from Mifromal/Kalil or approved equivalent with 6mm thick clear glass.

All accessories will be aluminum accessories.

10.5 Measurement & Payment

The accepted quantity will be paid for at the Contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal &amp; Aluminum</td>
<td>L.S/No.</td>
</tr>
</tbody>
</table>
11 **METAL & PLASTIC WORKS**

11.1 **Structural Steelworks**

Structural steelworks shall be provided and fixed complete with all plates, cleats, bolts, etc. cut to lengths and sizes and drilled as shown on the drawings. The quality of the steel works generally shall be in accordance with B.S. 15 (Mild Steel for General Structural Purposes). Steel tubes shall be seamless tubes in accordance with B.S. 1387 or B.S. 1775. All bolts and nuts shall be to International Standard. Black bolts shall be in accordance with B.S. 916. Bolts shall be of sufficient length to show at least on full thread beyond the nut after tightening. Washers, where used, shall be to B.S. 3410 with a tolerance of 1 1/2 mm. (1/16 inch) on the diameter of the hole. The design and detailing of connections and workmanship shall be in accordance with the drawings and B.S. 49 (The use of Structural Steel in Building). When bolting to diminishing sections tapered washers shall be used. Riveting shall be carried out in accordance with B.S. 449 and B.S. 275 using rivets with snap heads and points and of sufficient length. Surfaces in contact with members to be riveted shall have all burrs removed to ensure perfect contact. Riveting shall be carried out carefully so as to avoid distortion of the riveted members. Welding shall be carried out in accordance with B.S. 1856 or B.S. 938 using electrodes as specified in B.S. 639 or B.S. 1719. Welders shall be suitably qualified and experienced and, if so required by the Engineer, shall produce evidence of their capability of executing the test welds specified in B.S. 2645 Part 1. All steelworks fabricated outside the site shall be painted one coat of red lead primer before delivery to the site.

11.2 **Metal and Plastic Materials**

11.2.1 **Aluminum Alloy**

Aluminum alloys shall be selected as having properties appropriate to the duty of the unit, the method of fabrication and the environmental conditions.

In general alloys of the following ISO designations shall be used:

<table>
<thead>
<tr>
<th>For Castings</th>
<th>For Wrought Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Si7 Mg</td>
<td>A1 Mg 4.5 Mn</td>
</tr>
</tbody>
</table>

or

<table>
<thead>
<tr>
<th>For Castings</th>
<th>For Wrought Items</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1 Si12</td>
<td>A1 Sil Mg Mn</td>
</tr>
</tbody>
</table>

Alternative alloys may be proposed by the Contractor if the manufacturer considers its properties more appropriate to the application or the environmental or physical conditions.

11.2.2 **Steel**

Steelwork shall be to the appropriate standard and where specified or detailed shall be hot dipped galvanized at the place of manufacture.
11.2.3 Stainless Steel

Stainless steel shall have the following composition with mechanical properties to the appropriate approved standard.

**Percentage Chemical Composition**

<table>
<thead>
<tr>
<th>Element</th>
<th>Welded</th>
<th>Cold</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% minimum</td>
<td>% maximum</td>
</tr>
<tr>
<td>Carbon</td>
<td></td>
<td>0.03</td>
</tr>
<tr>
<td>Silicon</td>
<td>0.20</td>
<td>1.00</td>
</tr>
<tr>
<td>Manganese</td>
<td>0.50</td>
<td>2.00</td>
</tr>
<tr>
<td>Nickel</td>
<td>11.00</td>
<td>14.00</td>
</tr>
<tr>
<td>Chromium</td>
<td>16.50</td>
<td>18.50</td>
</tr>
<tr>
<td>Molybdenum</td>
<td>2.25</td>
<td>3.00</td>
</tr>
<tr>
<td>Sulphur</td>
<td>-</td>
<td>0.03</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>-</td>
<td>0.045</td>
</tr>
</tbody>
</table>

Alternative, higher grade, stainless steel may be proposed by the Contractor if the manufacturer considers its properties more appropriate to the environmental or physical conditions.

11.2.4 Reinforced Thermosetting Plastics

Reinforced plastic shall be as follows unless otherwise agreed in writing by the Engineer.

(1) **Manufacturing Standards**

The specification for design, materials, construction, inspection, and testing of plant manufactured from reinforced plastics shall conform to the appropriate sections of the approved standard.

(2) **Resins**

(One) Isophthalic, Terephthalic, Bisphenol and Vinyl Ester resins may be specified and they shall comply with the approved standard. The resins used shall have a minimum strain to failure of cured cast resin of 2%.

(Two) (b) Pigments or fire retardant resins (or fillers) shall only be used when specified or ordered in writing.

(Three) Additives shall not be included in the resins unless they are required for viscosity control.

(Four) Due attention must be paid to preclude the possibility of air inhibition occurring on the laminate surfaces. The inclusion of paraffin wax etc., must be in accordance with resin suppliers recommendations.

(Five) Where protection against Ultra Violet light degradation is required, a translucent UV inhibitor should be included in the outer layers of the laminate.
(3) **Curing**

Curing systems shall be in accordance with the Resin Manufacturer's recommendations. The manufacturer of the laminate shall demonstrate that the laminate has been adequately cured prior to its acceptance at the laminator's works.

(4) **Reinforcement**

(One) 'E' type glass chopped strand mat reinforcement shall be to the approved standard and shall be to a maximum unit weight of 600 gm/m².

(Two) 'E' type glass woven roving fabrics shall be to the approved standard and shall be to a maximum unit weight of 800 gm/m².

(Three) 'C' type glass veil (or synthetic fabric veil where agreed to its use by the Engineer), shall be used to reinforce all surface sealing resin layers on laminates.

(Four) Use of 'ECR' Corrosion Resistant glass will be permitted.

(5) **Structural Design**

(One) The laminate shall be designed to withstand all the loadings normally carried by the laminates.

(Two) Under the worst combination of loading conditions, a maximum strain of 0.2% shall be permitted in the laminate.

(Three) A minimum laminate thickness of 6 mm shall be maintained for all GRP laminates including the facings over or under stiffener sections.

(Four) Stiffener sections may be used to increase the rigidity of a structure. the minimum glass reinforcement content shall be 1.2 kg/m² in these areas.

Stiffener sections may be manufactured from the following materials.

- Polyurethane Foam
- Marine Plywood - or
- Other material agreed in writing

Stiffener sections shall not be made from steel or metal sections unless written consent has been previously obtained. Where stiffening sections are employed they shall not be construed as adding to the strength of the section to which they are added.

(6) **Moulds**

Moulds shall be of adequate rigidity to retain dimensional stability and permit a high level of laminate consolidation. The mould surfaces shall be of a quality which will ensure the maintenance of surface finish throughout the full extent of the Contract.

(7) **Fabrication Methods**

Manufacture shall be by approved mechanical methods wherever possible. Items produced by hand lay-up processes will only be permitted if a suitable mechanically manufactured product is not available. If deposition of resin by gun is used, this must be carried out by airless spray technique.
(One) Unreinforced gel coats shall have a maximum thickness of 0.5 mm. Unreinforced flow (top) coats shall be fully brushed out to remove resin rich areas. The flow coat shall not exceed 0.3 mm in thickness.

(Two) Surface veil or synthetic fabric reinforced layers shall consist of approximately 90% resin by weight. The thickness of this reinforced layer shall not exceed 0.5 mm.

(Three) Chopped strand mat layers shall have a resin content of between 65% and 75% by weight.

(Four) Woven roving glass fabric layers shall have a resin content of between 40% and 60% by weight.

(Five) Where edges of laminates are cut or exposed these shall be sealed with a continuous layer of fully cured resin.

(Six) Bisphenol or vinyl ester protective layers to isophthalic/terephthalic laminates, shall be applied with a 'C' type glass veil (or synthetic fabric veil) reinforcement after hardening of the substrata. When this has sufficiently cured to prevent movement, a continuous flow (top) coat of bisphenol or vinyl ester resin shall be applied and fully cured. In such cases it is anticipated that an appropriate paraffin wax additive will be required to prevent air inhibition of the surface.

(8) **Samples**

(One) A sample measuring 1 metre square and typical of each different laminate proposed shall be submitted for approval together with a detailed descriptive specification at least 4 weeks prior to the commencement of manufacture.

(Two) Production samples measuring 300 mm square and typical of each different section of laminate shall be submitted to the Engineer's duly authorised Inspecting Engineer throughout the period of manufacture for the purpose of testing.

(Three) Samples of liquid and cast resin together with reinforcements and surfacing veils (or fabrics) required to manufacture the samples indicated in (b) above shall also be made available to the Engineer.

Failure to provide any of the samples designated in (a), (b) and (c) above shall be construed as representing a delay in completion of the Contract under the terms and conditions contained therein.

(9) **Tolerances for Moulded GRP**

Tolerances in thickness shall be in accordance with the following table:-

<table>
<thead>
<tr>
<th>Nominal Thickness mm</th>
<th>Moulding from open mould. mm</th>
<th>Moulding from closed mould mm</th>
<th>Matched metal mouldings mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to but not including 1.5</td>
<td>± 0.50</td>
<td>± 0.20</td>
<td>± 0.18</td>
</tr>
<tr>
<td>1.5 to but not</td>
<td>± 0.75</td>
<td>± 0.30</td>
<td>± 0.20</td>
</tr>
</tbody>
</table>
(10) Quality Control and Testing

The following tests for inspection and quality control shall be carried out :-

(One) (1) The laminate shall be fully cured and shall show full resistance to a commercial acetone sensitivity test.

(Two) The laminate shall give Barcol Hardness of at least 90% of the resin manufacturer's recommendations. The measurement of hardness by means of a Barcol Impressor shall be carried out in accordance with the approved standard.

(Three) Resin burn off tests shall be performed on cut-outs for manways, etc., where no such cut-out exists the Engineer reserves the right to have 50 mm diameter cut-outs for checks to be made on local glass reinforcement content. The tests shall be conducted in accordance with the approved standard and the result shall define glass content.

(Four) The following strengths of the laminate shall be determined in accordance with the approved standard.

(1) Ultimate tensile unit strength

(2) Flexible strength

(3) Lap shear strength

(4) * Shear strength of bond between thermoplastic linings and laminate.

(5) * Peel strength of bond between thermoplastic linings and laminate.

* Results shall be at least 95% of the minimum values specified by the laminate manufacturer.

(d) Where a laminate has been designed to take bolts in the make up of the structure tests for bolt bearing strength shall be performed. Bolt bearing strength tests shall be performed in accordance with the approved standard.

(e) Where a laminate is to be used in conjunction with electrical control equipment all or part of the following additional tests may be called up which shall be carried out in accordance with the approved standard.

(1) Electrical strength of sheet parallel to the plane of the sheet.
(2) Electrical strength of sheet normal to the plane of the sheet.

(3) Electrical strength of casting laminating resin system.

(4) Insulation resistance of laminated sheet using IEC taper pins.

(f) Additional tests may be called up at the discretion of the Engineer.

(g) (1) Test Certificates shall be obtained from the resin supplier for the following:-

Heat distortion temperature of resin and unreinforced resin extension to failure.

(2) Test Certificates shall be obtained from the glass reinforcement manufacturer for all the different grades and types of glass employed in the fabrication of the laminate.

(h) All the tests referenced in (a) to (f) above shall be witnessed unless waived in writing by the Engineer.

(11) **Trial Erection**

A sufficient proportion of the fabricated sections of the structure must be trial assembled to demonstrate the correctness of fit of the various sections.

**11.2.5 Metal and Plastic Prefabricated Items**

**11.2.5.1 Valves and Panstocks General**

Unless otherwise specified all valves and penstocks shall be anti-clockwise opening and the maximum effort required, applied at the circumference of the hand wheel to operate the valves against the maximum unbalanced head shall not exceed 220 N.

All hand wheels shall have the words "to open" and "to close" in Arabic and English with arrows indicating the direction of rotation cast on and shall be coated in plastic, nylon or other approved materials in order to withstand the ambient conditions.

Unless otherwise specified or agreed the screwed portion of spindles and extension spindles shall be of stainless steel.

Rising spindles to be installed in open air shall be protected with suitable metal or plastic cover.

Extension spindles, where required, shall be connected to the screwed spindle with a suitable muff coupling. Universal joints shall be provided at cranks.

The nuts shall be of gunmetal or synthetic material and mating surfaces of gates and bodies shall be of gunmetal, copper alloy or synthetic material. Nylon or other thermoplastic materials liable to attack shall not be used where Hydrogen Sulphide is likely to be present.

Where "Operation by Tee Key" is specified the valve or penstock shall be supplied with a suitable yoke with a squared cap of standard size to receive the tee key.
The keys shall be supplied at the rate of one key per two valves or two penstocks unless the valve or penstock is to be installed in an isolated location in which case one key shall be supplied for each fitting location.

All valve waterways are to be coated internally with a solvent free epoxy or polyester lining of 100% solid content to be applied at the place of manufacture.

Valves and penstocks shall be capable of withstanding corrosion in the ambient conditions and any parts manufactured from a material which is not itself resistant must be protected.

All valves and penstocks will normally be witness tested at works.

Before delivery to site all working surfaces shall be thoroughly cleaned, and, if metal, protected by grease.

Packing must be sufficient to ensure complete protection of the fitting during transit and storage.

Valves under 300 mm diameter together with all hand wheels and other easily detachable items on both valves and penstocks are to be packed in timber packing cases and properly bound with steel packing bands.

All valves of 300 mm and over are to be protected with wood or plywood discs or flanges together with straw rope and hessian wrapping.

11.2.5.2 Gate Valves for Water Supply

Unless higher pressure ratings are required for the pipeline, gate valves shall have a nominal pressure designation of 10 bars which shall be marked on the valve body. Unless detailed to the contrary to suit existing pipework, flanges shall have a pressure designation of 10 bars and shall be drilled accordingly. The face to face lengths of the valves shall be in accordance with ISO 5752 Series 3. Valves with lengths to Series 14 may be used with suitable make up pieces to achieve the Series 3 lengths.

Valves stem seals shall be of the stuffing box and gland form. Valves shall not be fitted with resilient seals.

Indicators, hand wheels, caps for key operation, extension spindles, capstan headstocks and locking devices shall be provided as specified or shown on the drawings.

Valves shall be 'open end' tested.

Valves for which witnessed tests at works are required are so specified.

11.2.5.3 Gate Valves for Sewage and Related Fluids

Unless higher pressure ratings are required for the pipeline, gate valves shall have a nominal pressure designation of 10 bars which shall be marked on the valve body. Unless detailed to the contrary to suit existing pipework, flanges shall have a nominal pressure designation of 10 bars and shall be drilled accordingly. The face to face lengths of the valves shall be in with ISO 5752 Series 3. Valves with lengths to Series 14 may be used with suitable make up pieces to achieve the Series 3 lengths.
Valves shall normally be metal seated with valve bodies of iron and the seatings copper alloy faced. The gates shall be of wedge pattern, copper alloy faced with inside screw non-rising stems of forged bronze. They shall have a packed gland stuffing box seal.

Where resilient seal gate valves are detailed the valve bodies shall be of iron. The gates shall be of iron and wedge pattern with nitrile rubber covering and with inside screw non-rising stems of stainless steel or forged bronze. They shall have a seal of nitrile rubber O rings.

Where actuator operated, valves larger than 300 mm shall have copper alloy faced guides and slippers. When 300 mm dia and smaller actuator operated valves are installed other than in a vertical position they shall have machined guides and gates.

Valves shall normally be provided with drain plugs.

11.2.5.4 Air valves

Air valves for pumped pressure pipelines will be the special high pressure 'Dual' large orifice type with a maximum working pressure of 100 meters head and a body test pressure of 200 meters head. For other duties, such as distribution mains single, small orifice type valves may be used.

11.2.5.5 Pressure Reducing Valves

Pressure reducing valves shall be flanged with cast iron bodies and shall be supplied complete with inlet and outlet pressure gauges and adjustable regulating weights. The maximum sustained inlet pressure shall be determined from the closed valve pressure of the installed pumps.

11.2.5.6 Inlet Float Valves

Inlet float valves shall be of the streamlined needle type complete with stilling and control basins and 38 mm dia. syphon. The sizes of the valves for each installation are shown on the drawings.

11.2.5.7 Metal Flap Valves

Flaps and frames shall be of close grained cast iron. Mating surfaces of flaps and frames shall be of non-ferrous metal (excluding aluminum) machined to ensure a watertight fit in the closed position.

Hinge pins shall be of phosphor bronze; all flaps shall be double hung.

All cast iron surfaces shall be cleaned by grit or shot blasting to be free from grease, then coated as specified for the environment. Hinge pins and mating surfaces shall be smeared with grease.
11.2.5.8 Plastic Faced Flap Valves

Flap valves shall be faced in an approved synthetic material so as to be corrosion-free in the ambient conditions. The flap shall be weighted to assist closing and shall be suitably braced and reinforced.

Hinge pins shall be of stainless steel and all flaps shall be double hung and seated off the vertical.

Mating surfaces shall be accurately moulded or machined to ensure a watertight fit in the closed position.

11.2.5.9 Metal Penstocks

Penstocks, gates, frames, support tubes brackets and pillars shall be of close grained cast iron. Mating surfaces of gates and frames shall be of non-ferrous metal (excluding aluminum) accurately machined to ensure a 'watertight' fit in the closed position within the permissible leakage rates as specified.

Adjustable wedges with non-ferrous faces shall be fitted to all off-seating penstocks and seating penstocks having a waterway area exceeding 0.3 m².

Operation shall be by means of rising or non-rising phosphor bronze or stainless steel screwed spindles, as detailed, working in gun metal nuts for clockwise closing.

All working surfaces shall be cleaned and protected with grease, other surfaces shall be cleaned by grit or shot blasting and coated as specified for the environment.

11.2.5.10 Plastic Faced Penstocks

Penstock frames, spindles, support tubes and brackets shall be manufactured from either stainless steel or protected mild steel.

Penstocks gates shall be faced in an approved synthetic or other material capable of withstanding corrosion from the anticipated conditions. They shall be reinforced and designed to withstand deflections capable of damaging bonds or seals between the component elements of the gate when subjected to the maximum head specified.

Mating surfaces of gates and frames shall be of synthetic or other material and shall be accurately machined or molded to ensure a watertight fit when in the closed position.

Adjustable wedges of corrosion resistant material shall be fitted to all off-seating penstocks and seating penstocks which have a waterway area exceeding 0.3 m².

Operation shall be by means of rising or non-rising stainless steel spindles as specified working in gunmetal nuts.
11.2.5.11  Reinforced Plastic Liners for Pumping Stations and Manholes

Reinforced plastic liners for Pumping Stations and Manholes shall be manufactured to the dimensions given on the drawings, within the following tolerances:

1. The work size, which is defined as the internal diameter as specified by the manufacturer, shall be declared and shall not differ from the normal diameter by more than ± 1%.
2. A manufacturing tolerance on the work size of 10 mm will be allowed provided that a tight fit is achieved between the liner and the slab liner.
3. Liners shall be supplied in lengths to suit requirements with a resin-rich finish to internal surfaces.
4. Minimum thickness shall be 6.5 mm for sewerage work and 5 mm where approved for drainage work.
5. The out of squareness shall not be greater than 10 mm.
6. The deviation from straightness of the bore of the liner shall not exceed 20 mm.

Although the liners are not designed to be structural, they shall have a sufficient stiffness to withstand:

1. Buckling or distortion in transit or storage.
2. A hydrostatic head of 8 metres without distortion damage, leakage or permeation.

The manufacturer shall provide shop drawings of the proposed roof and reducing slab liners prior to manufacture for approval.

The manufacturer shall stipulate the maximum deflection of the slab liner permitted without causing surface cracking to the gel coat. The Contractor must take care not to exceed this limit, and any surface cracking that occurs will be repaired.

11.2.5.12  Access Covers and Frames

All access covers and frames, with the exception of those for sewerage manholes, shall be sand tight with seatings designed to be nonrocking unless detailed otherwise.

The Contractor shall obtain from the supplier/manufacturer a guarantee that replacement component parts will be available for a minimum period of 10 years from the issue date of the Completion Certificate.

Double triangular covers must be loosely coupled by stainless steel bolts with nuts provided with an approved method to render the nuts incapable of both undue tightening or loosening.

Holes provided in non-ventilating covers for lifting keys shall be appropriately shaped pockets which shall not penetrate through and there shall be no projections above cover level.

Undersides of covers and frames shall be protected with an approved epoxy coating system appropriate to the Palestine environment. The coating system may be applied at the place of manufacture or in-situ under controlled application conditions approved by the Engineer. All covers and frames shall be delivered to
site with a transit protective packaging or wrapping. Any damage occurring to the approved coating system shall be made good prior to installation.

Covers for sewerage shall also be provided in with a reinforced plastic sealing plate in accordance of specifications. The design of cover, frame and sealing plate shall be such that no load can be transferred from the cover to the sealing plate.

Access covers shall be as follows:

1. **Sewerage**
   - Manhole covers shall be 600 mm x 600 mm square clear opening double triangular heavy duty, embossed with the word 'Sewerage' in Arabic and English.
   - Inspection chamber covers shall be single seal 600 mm x 600 mm square clear opening heavy or medium duty, embossed with the word 'Sewerage' in Arabic and English.

2. **Storm/Land drainage**
   Manhole covers shall be non-ventilated, 600 mm diameter clear opening circular heavy duty, embossed with the word 'Storm' in Arabic and English.

3. **Irrigation**
   Chamber covers shall be non-ventilated, 600 mm diameter clear opening circular heavy duty, embossed with the 'Irrigation' in Arabic and English.

4. **Pumping Stations and Associated Chambers**
   They shall be rectangular 600 mm x 750 mm or 600 mm x 900 mm or multiple of these sizes, as detailed on the drawings with the concrete infill, and shall be heavy duty.

   Where ventilated covers are detailed the total area of ventilation shall not be less than 5 % of the minimum clear opening area and the covers shall be provided with suitable protective sand traps which shall seat in the access cover frame.

### 11.2.5.13 Reinforced Plastic Sealing Plates to Access Covers

Reinforced plastic sealing plates to access covers shall be designed to provide a push-fit, gas-tight seal with the cover frame. The sealing plate shall be in the form of a plug with a flange to prevent the plate passing into the manhole. The seal shall be achieved by means of an approved integral synthetic rubber gasket mechanically looked into the periphery of the plate. The gasket shall be suitable for the service temperature range 0°C to 60°C and possess good weathering and ozone resistance. Any lubricant used on the seal shall be silicone based. The underside of the plate shall have a resin-rich finish and there shall be no exposed fibbers. Cut and/or drilled faces shall be sealed with resin.

The plate shall have a minimum thickness of 5mm and be capable of withstanding a static load of 150 kg applied centrally over a 150 cm square surface area with a deflection, measured at the center of the plate, not exceeding 25 mm.

A minimum of two number reinforced plastic lifting handles shall be provided per plate. They shall be of the same materials as the plate and securely laminated to the plate or fixed by stainless steel blind rivets.
The complete seal plate shall be resistant to 10% sulphuric acid at 50°C for 100 days.

11.2.5.14 Underground Hydrants and Covers

Underground Hydrants shall be of the screw-down pattern.

11.2.5.15 Ladders and Safety Hoops

Ladders and safety hoops shall be either mild steel, aluminum or reinforced plastic, as detailed.

Unless a higher grade of protection is specified all mild steel ladders shall be hot dipped galvanized after fabrication. For all mild steel ladders the stringers shall be 65 mm by 12 mm and spaced 375 mm apart. The rungs shall be 25 mm dia. reduced to 20 mm dia. at the ends and riveted over. They shall be spaced at 225 mm centers. The ladders shall be provided with welded-on fixing brackets or the ends of the stringers shall be turned over to form fixings. The fixings shall be drilled for 16 mm diameter bolts.

Mild steel safety hoops shall be of circular pattern fabricated from 50 mm by 10 mm flats. Fixing shall be by 12 mm dia. countersunk screws with washers and nuts, the screws being inserted from the inside of the ladder stringers.

Aluminum and reinforced plastic ladders shall be dimensionally similar to mild steel ladders for rung widths and spacing. The treads of rungs shall be roughened.

11.2.5.16 Road Gully Gratings

Road gully gratings shall be manufactured from ductile iron and be of the raised kerb type complete with sand seal, road retaining bar and a removable GRP debris grating. The weir depth shall be a minimum of 165 mm and the frame and cover are to be protected with an approved bitumen epoxy coating system appropriate at the place of manufacture. The clear opening size shall permit removal of the GRP grit bucket.

All covers and frames shall be delivered to site with a transit protective coating. Any transit damage to the approved coating system shall be made good prior to installation.

The Contractor shall obtain from the supplier/manufacturer a guarantee that replacement component parts will be available for minimum period of 10 years from issue date of the completion certificate.

11.2.5.17 Open Mesh and Chequer Plate Flooring

Open mesh and chequer plate flooring shall be of mild steel, aluminum or reinforced plastic as detailed.

Unless higher loadings are called for floorings shall be designed to take pedestrian loading based on a central point load of 100 kg under which the deflection shall not exceed span/200 for metal flooring and span/100 for reinforced plastic flooring. Reinforced plastic flooring shall have a non slip tread surface.
Unless a higher grade of protection is detailed all mild steel flooring shall be hot-dipped galvanised after fabrication.

11.2.5.18 **Galvanized Steel Gaurdrailing**

Tabular handrails and standards shall be of 10 gauge thickness 32 mm nominal internal diameter steel tube. Solid handrails shall be 25 mm diameter and solid standards 32 mm diameter. The balls on the standards shall be of adequate size to accommodate the rails which shall be fixed by grub screws for tubular rails and by welding for solid rails or by similar approved fixings.

Heights of rails, overall dimensions and details of the bases for the standards, fixing bolts and any other special requirements relating to the gaurdrailing are shown on the drawings.

All components shall be galvanized or zinc coated after fabrication.

11.2.5.19 **Aluminum Gaurdrailing**

Unless otherwise specified or ordered, aluminum gaurdrailing shall be constructed with tubular rails fixed to double ball pattern solid forged standards. Both rails and standards shall have a minimum outside diameter of 38 mm.

The rails and standards shall be of aluminum alloy. The standards shall be fitted with base plates approximately 150 mm x 65 mm x 16 mm thick.

11.2.5.20 **Safety Chains and Fittings**

Safety chains to gaurdrailing shall be supplied by the gaurdrailing manufacturer to the dimensions shown on the drawings.

Safety chains or ropes shall be fitted in manholes across the entries to all sewers exceeding 700 mm diameter and shall be manufactured of polypropylene rope or other material capable of withstanding continuous exposure to the severe corrosive conditions occurring in sewers or drains carrying septic sewage and groundwater.

All safety chains shall be capable of withstanding an impact loading equivalent to 1950 Nm/sec. Fittings shall be of stainless steel.

11.2.5.21 **Nuts, Screws, Washers and Bolts**

Nuts, screws, washers and bolts shall be of such material to resist environmental corrosion and electrolytic action with mating metals.

Unless an alternative is specially approved, stainless steel items shall be supplied for all dismanteable items.

Zinc coated items 10 mm diameter and larger shall have the nuts cut oversize and shall be spun galvanized (or equivalent). Smaller zinc coated items shall be electroplated.

Black hexagonal bolts, screws and nuts shall be to a grade with a tensile strength of 400 N/mm².
Bright (high tensile) items to a grade with a tensile strength of 800 N/mm² may be used instead of black items.

The items shall have coarse metric threads.

Bolting for pipes and fittings shall comply with the approved standard. Spheroidal graphite iron bolts for use with ductile iron pipes and fittings shall have a tensile strength of 500 N/mm².

At least two washers shall be provided with each nut and bolt set.

### 11.2.5.22 Fixing Bolts etc. and Building-in Material

Fixing bolts, nuts and washers shall be of stainless steel. The bolts may be rag bolts to the approved standard, expansion bolts, or resin bonded bolts.

When the bolts etc. are used for fixing aluminum items they shall be insulated from the aluminum by a non-metallic sleeve and under washer.

The building-in material for use with rag bolts, shall be a proprietary epoxy non-shrink grout or a proprietary non-shrink mortar or caulking compound.

### 11.2.5.23 Step Irons

Step irons shall be either of galvanized malleable cast iron to an approved standard or of stainless steel.

Stainless steel step irons shall be fabricated from 25 mm diameter solid bar twice bent to form a 'U' shaped rung width, 375 mm with two legs 350 mm long, the ends of the bar shall be ragged and built 175 mm into the concrete wall. The tread of the rung shall be stamped or otherwise roughened.

### 11.2.5.24 Traveling Cranes, Jibs, Runway Beams

Traveling cranes, jibs, runway beams and similar structures where not mentioned in detail shall be designed in accordance with the approved standard. Unless otherwise detailed they shall be classified as hand or light power operated items.

The appliance shall bear a permanent inscription on each side readily legible from ground level stating the safe working load. The inscription shall read:

"SAFE WORKING LOAD X TONNES"

4 No. copies of the Testing Certificate shall be supplied.

Cranes shall be controlled from the level specified. Hand operated motions shall be controlled by endless chains and power operated motions by hold-on push buttons mounted in a compact unbreakable pendant. Pendants shall operate at low voltage and shall not be supported by the control cable.

Hoist units may be wire, rope or chain units. Chain units shall be fitted with a chain box to hold the excess chain when the hook is at its maximum height. A non-overhoisting device shall be fitted to all electric hoists.
All electric drive motors shall be fitted with electromagnet brakes to prevent over travel on release of the control button.

Electric cranes shall be supplied complete with all necessary electric feed cables suitable for connecting to a junction box fitted adjacent to the crane beam. Cables feeding the hoist unit and down shop cable shall be flexible cables suspended from carriers sliding on taut wires.

Protective coatings shall be applied as specified for the environment.

11.2.5.25  Hand Blocks

Hand blocks shall be provided with lifting and operating chains of the dimensions detailed and shall be clearly inscribed on the block. Each block shall be works tested to 150% of the working load and a confirmatory manufacturer's test certificate shall be provided.

11.2.5.26  Chain Link Fencing

Chain link fencing and fence posts shall be to the general details of the approved standard.

11.2.5.27  Plastic Weir Plates

Plastic weir plates shall be fabricated from a composite plastic or reinforced plastic laminate of minimum thickness 10 mm.

Bolt spacings shall not exceed 600 mm on circular weirs and 500 mm on straight weirs.

11.2.5.28  Fabric Filter Membrane

Fabric filter membrane shall be manufactured from bonded woven or non-woven continuous filament synthetic fibbers biologically resistant and resistant to all naturally occurring soil acid and alkalis.

The fabric shall be of a grade strong enough to resist damage during placement and backfilling operations, permeable and suitable to prevent the ingress of fine sand particles.

11.2.5.29  Stainless Steel Clamping Systems

Stainless steel band for fixing UPVC saddles to AC pipes shall comply with the requirements of specifications and be resistant to environmental corrosion and electrolytic action. Standard band 19 mm wide shall be utilized with the edges of the band rounded for ease of handling.

Clamping shall be by 'standard' buckles. Buckles shall be manufactured from the same material as the standard band and have the same corrosion resistance.
11.2.6 Installation of Metal and Plastic Items

11.2.6.1 Installation of Access Covers

Access cover frames shall be bedded on cement mortar, which shall be launched over the base and sides. Where concrete/brickwork is shown on the drawings this shall be adjusted to allow for the frames to be set to the required levels and inclinations.

The mating surfaces of covers and frames shall be cleaned and given a coating of vegetable based, high melting point, grease after all construction activity has ceased.

The sets of lifting keys shall be handed over to the Engineer's Representative.

11.2.6.2 Fixing Metalwork and Machinery

Where expansion and resin bonded fixing bolts are to be used the Contractor shall prepare the fixing bolt holes as detailed by the bolt manufacturer.

The holes for other fixing bolts may be dimensioned and detailed on the drawings or elsewhere in which case the Contractor shall prepare them by boxing or drilling. If they are not so dimensioned and detailed the Contractor shall form them by methods which shall be agreed in advance by the Engineer's Representative.

Where a group of holes has to be formed for a number of bolts for fixing one item, the formers shall be securely fixed together before the concrete is poured around them. The boxes shall be suitably protected to avoid extraneous matter falling into them.

The Contractor shall agree in advance with the Engineer's Representative on the methods to be adopted for building bolts into prepared holes. The methods shall take account of the materials being used and the equipment or machinery that is to be fixed. The timings and sequence of the work shall be determined by the Contractor or if he, or a nominated Sub-Contractor, provides the item to be fixed. Where the item to be fixed is provided under a separate contract the Contractor shall carry out the work only when instructed by the Engineer's Representative.

Unless otherwise specified, all items to be fixed shall initially be set on adequate packers and the bolts shall then be located in their correct positions. The building-in shall then be carried out in the manner specified by the bolt manufacturer (for expansion bolts) or by the supplier of the building-in material. The bolts shall not be brought into use until they are effectively anchored in building-in material has achieved adequate strength. The bolts and nuts shall be tightened by the party responsible for erection of the item and, when agreed with the Engineer's Representative, the Contractor shall fill the voids below or behind the item with a dry mix 1:3 cement/sand mortar or an approved proprietary material. This shall be done so as to form a solid and effective bedding the extent of which will be detailed in the documents or agreed with the Engineer's Representative. Any shrinkage in the bedding shall be dealt with by packing, caulking grouting and/or tightening the fixings, appropriate. The Contractor shall not tighten any bolts associated with items which are fixed or erected by nominated Sub-Contractors or other Contractors.
11.2.6.3  Reinforced Plastic Liners for Concrete Protection

The construction methods employed shall be so as to ensure that a completely water and gastight seal is made preventing any exposure of the concrete surround to the corrosive liquids and gases present.

In particular:-

1)  The rebates formed in the concrete base slab and benching in which the liner is positioned shall be tightly packed with a suitable sealant in accordance with the recommendations of the liner manufacturer and to the approval of the Engineer.

2)  Any holes required in the liner for pipework shall be carefully cut to the outside diameter of the pipes. A 25 mm x 25 mm rebate shall be formed in the concrete around the pipe and this shall be sealed with an approved mastic sealant appropriate to the environment.

3)  The liner and slab liner shall be bonded together with Glass Reinforced Plastic. The joint shall be completely watertight and strong enough to increase the rigidity of the liner so as to prevent undue distortion during handling on site.

Reinforced plastic liners shall be handled in the same manner as reinforced plastic pipes. In addition, extra care shall be taken to avoid damage to the liners which are not designed to carry loads.

The manufacturer shall visit the site to demonstrate to the Contractor in the presence of the Engineer's Representative the methods of handling and lifting, including formation of the joints between the chamber liner.

The Contractor is reminded that these liners are not designed to withstand pressure exerted by the concrete during construction.

11.2.6.4  Cutting and Sealing of Reinforced Plastic

Where the Contractor is required for any reason to cut reinforced plastic (GRP), he shall seal the exposed ends with an approved resin before incorporating the cut reinforced plastic in the work. No cut reinforced plastic shall be used until the resin has cured.

The resin shall be as recommended by the manufacturer of the reinforced plastic item and shall be pigmented so that the areas where it has been applied are easily identifiable.

It shall be delivered to site in sealed containers bearing the name of the manufacturer and properly labelled as to its contents and shelf life.

11.2.6.5  Installation of Penstocks

Metal or plastic faced penstocks shall be installed in accordance with the manufacturer's recommendations and the requirements of specifications. Care shall be taken to prevent distortion of the gate frame at the time of installation.

Permissible rates of leakage under the specified working head shall be as follows :-

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'On-seating' installation : 5 liters per meter of slide perimeter per hour 'Off-
seating installation : 30 liters per meter of slide perimeter per hour.

The slide perimeter shall be measured as the total length of contact faces between
the gate and the frame in the closed position.

11.2.6.6 Installation of Stainless Steel Clamping Systems

The band shall be fed through the bridge of the buckle and then between the ears
before passing the band around the objects to be clamped and again through the
buckle. The end of the band shall be anchored by folding back under the buckle
and any slack shall then be taken up.

The band shall be tightened by means of a purpose made clamping to until there is
no appreciable movement of the band.

The band shall be folded back over the buckle by moving the tool in an arc to its
full extent. To avoid an increase in tension in the band and ensure that it does not
fall due to overloading the camp tool shall be slackened as necessary during this
maneuver. The band shall then be severed using the cutter blade incorporated in
the clamping tool to leave a short stub.

Following removal of the tool the stub shall be pressed down between the ears and
the clamping operation completed by gently hammering down the ears over the
stub.

Two number bands shall be installed per saddle connection.

For flexible pipe materials a rubber protection strip shall be inserted between the
pipe barrel and the steel band.

11.3 Measurement & Payment

The accepted quantity will be paid for at the Contract unit price complete in place
including excavation and any back filling.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal &amp; Plastic Works</td>
<td>L.S/No./R.M/ as mentioned in B.O.Q.</td>
</tr>
</tbody>
</table>
12 PLUMPING AND SANITARY WARE

12.1 Generally
The Contractor shall provide all materials, labour, plant and equipment to execute, complete and maintain the Works. The Contractor shall carry out the test required under the supervision of the Engineer, and shall make good and replace any defective work. The Contractor shall be responsible for protection of all plumbing from any damage whether due to concurrent work of other trades or otherwise and he shall clean up on completion and leave all works in perfect working order and to the satisfaction of the Engineer.

12.2 External Plumbing

12.2.1 Gutters
Rainwater Pipes and Fittings Gutters, Rainwater Pipes and Fittings shall be as described in the Particular Specification or shown on the drawings and shall comply with the following:
   a) Asbestos cement to B.S. 569.
   b) Cast iron to B.S. 460 and B.S. 1205.
   c) Aluminum to B.S. 2997.
   d) Approved enameled iron pipe.
   e) Unplasticised P.V.C. pipes to B.S. 3506.

12.2.2 Flashings
Flashings shall be one of the following:
   a) Cold-rolled annealed copper sheet 0.5 mm. thick.
   b) Lead sheet 1.2 mm thick.
   c) Aluminum sheet 0.8 mm thick.

12.2.3 Jointing
Asbestos cement gutters shall be jointed with a cold caulking compound and rust-proof steel gutter bolts. Asbestos cement pipes shall be telescoped i.e. the socket end against the direction of flow, and left unjointed.
Cast iron gutters shall be jointed with red and white lead putty and rust-proof gutter bolts. Cast iron rainwater pipes shall be jointed with red and white lead putty when used externally or with tarred yarn gasket and molten lead when used internally.
Aluminum gutters and pipes shall be jointed by a double welted seam without the use of solder.
Enameled iron pipes shall be jointed with tarred gasket and red lead.
Unplasticised P.V.C. pipes shall be jointed with approved solvent cement or as directed by the Engineer. The jointing surfaces shall be thoroughly cleaned and dried before cement is applied.

12.2.4 Fixing
All gutters, pipes, leads, offsets, shoes, etc. shall be fixed as shown on the Drawings or described in the Particular Specification. All gutters shall be fixed complete with all necessary angles, square and obtuse, right and left hand, external and internal. All necessary stop ends, stop end outlets, socket and spigot drops, double socket clips, tees and nozzle pieces, double end nozzle pieces, double socket clips, etc.; shall be provided and fixed. A copper wire balloon grating shall be provided and fixed in each
gutter outlet. Gutter brackets are to be of stout metal of the same relative heavy make as the gutters, except that galvanized steel shall be used for asbestos cement. The brackets shall be of the screw-on-to-fascia type whenever possible, and shall strictly correspond with the gutters in pattern and mould. At least one bracket shall be provided for each gutter length and shall be painted when required before fixing. Rainwater pipes and fittings shall be fixed to the wall by approved holder bats or other means plugged and screwed to the wall. Where required, the pipes and fittings shall first be fixed then removed to allow for painting or rough-cast fishes to be applied and they shall then be refitted and jointed. Care shall be taken that the bottom pipe length in each vertical stack of asbestos cement pipes is of soil quality.

12.3 Pipes and Fittings

Pipes and fittings for conveying water for both hot and cold services and waste shall be as described in the Particular Specification or shown on the Drawings and shall comply with following:

12.3.1 Underground Services

Solid drawn copper tubes complying with B.S. 1386 with capillary or compression fittings of copper alloy complying with B.S. 864.

Galvanized seamless steel tubes complying with B.S. 1387 - Heavy Tubes, with galvanized malleable cast iron fittings complying with B.S. 143.

2) Internal Services etc.

Solid drawn copper tubes complying with B.S. 659 Table 1, Water and Gas quality, with capillary or compression fittings of copper alloy complying with B.S. 864.

Galvanized seamless screwed and socketed steel tubes complying with B.S.1387, Heavy Tubes, with galvanized malleable cast iron fittings complying with B.S. 143.

Lead pipes complying with B.S. 602 and B.S. 1085.

Unplasticised P.V.C. pipes complying with B.S. 3505 with compression fittings of brass and gunmetal as required.

Fixing brackets and clips shall be generally in accordance with B.S. 1494. The maximum opening there of shall be as set out in table below:
12.4 Jointing

Joints between pipes fittings and shall be carried out as detailed in Table 11.1 below:

<table>
<thead>
<tr>
<th>TABLE 11.1</th>
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</thead>
<tbody>
<tr>
<td><strong>TABLE OF JOINTS</strong></td>
</tr>
<tr>
<td>Copper to similar Pipes</td>
</tr>
<tr>
<td>Copper to steel</td>
</tr>
<tr>
<td>Copper or steel to cast iron</td>
</tr>
<tr>
<td>Cast iron to stoneware</td>
</tr>
<tr>
<td>Copper or steel to stoneware</td>
</tr>
<tr>
<td>Cast iron to asbestos</td>
</tr>
<tr>
<td>Copper or steel to asbestos</td>
</tr>
<tr>
<td>Steel to steel</td>
</tr>
<tr>
<td>Lead to lead</td>
</tr>
<tr>
<td>Lead to other pipes</td>
</tr>
<tr>
<td>Unplasticised P.V.C. pipes</td>
</tr>
</tbody>
</table>

All cuts shall be made square to the pipe axis by approved means and all burrs shall be removed. The use of pipe cutting appliances which diminish the bore of the pipe shall not be permitted. Joints between different metallic materials shall be made with suitable insulators to prevent electrolytic action. The Contractor shall perform all necessary jointing in services and wastes etc., assemble, fix and connect up to all sanitary fittings, tanks, heaters and drains. Joints between metal pipes which depend on putty or cement will not be permitted. This applies particularly in the jointing of the traps of sinks, baths, lavatory basins etc., to the waste pipes. Such joints shall be by means of suitable screwed unions in the case of wrought iron or steel, by compression fittings in the case of copper, by caulked run lead joints in the case of cast iron and by wiped soldered joints in the case of lead. In all cases provision shall be arranged for cleaning the traps in the event of blockage. Wastes of sinks, lavatory basins etc., shall be set into the appliances with white lead and secured with screw fittings. The use of flexible connectors between services and sanitary fittings will not be permitted. Such connections shall generally be formed of pip similar to the service or of lead pipe provided that all bendings is carefully carried out with no diminution of the water way.

12.5 Brass work

Taps and stop valves shall comply with B.S. 1010 and shall be marked with the manufacturer's name or trade mark and the nominal size. Gate valves shall comply with B.S. 1952. Gate valves for hot water systems shall be bronze parallel slide valves. Valves shall be marked with manufacturer's name or trade mark, the nominal size and the class number. Mixing valves shall comply with B.S. 1415 and shall be marked with the manufacturer's name and trade mark and the nominal size. Traps and wastes shall comply with B.S. 1184. Where systems are provided with antisyphonage, traps occurring in ranges of fittings shall have 40 mm (1 1/2 in.) deep seals. Where no antisyphonage is provided, such traps shall have 80 mm (3 inches) deep seals. Flushing cisterns and flush pipes shall comply with B.S. 1125. Ball valves shall
comply with B.S. 1212 and be marked with the manufacturer's name or trade mark. Floats shall comply with B.S. 2456 and shall be marked with the manufacturer's name or trade mark. Manufacturer's certificate testifying that the flushing cisterns comply with B.S. 1125 must be submitted to the Engineer.

12.6 Storage Tanks

PVC Water storage tanks shall be provided to the sizes and in the positions shown in the Drawings or as required by the Particular Specification, complete with all the required connections. Overflow, distribution and filler pipes shall be connected to the sides of tanks and washout pipes shall be connected to the bases of tanks. Overflow pipes shall be one fly wire caps. Overflow pipes shall be fitted 3 to 4 cm lower than filler pipes. Supports for water storage tanks shall be constructed of steel props or of concrete as indicated in the drawings and according to the manufacturers instructions and the engineers approval.

12.7 Sanitary Fittings

All sanitary fittings shall be of an approved quality obtained from an approved manufacturer. Sanitary fittings and their connections, services, wastes, etc., shall be located as shown on the Drawings and shall be designed and installed to the satisfaction of the Engineer. Unless otherwise required by the Particular Specification or shown on the Drawings, the quality and sizes of the fittings shall be according to B.S. Standards as follows:

Sinks shall be either white glazed fire clay complying with B.S. 1206 or stainless steel complying with B.S. 1244 fitted with two 1/2 inch diameter chromium plated bib cocks, combined overflow and 1 1/2 inch diameter trapped waste, plug and chain. Sinks shall be fixed on pair of cantilever brackets built into wall or no frame and supports of 1.0 inch diameter galvanized steel pipe or on block work piers as detailed on the drawings, or directed by the Engineer.

Lavatory basin shall be white enameled glazed fire clay complying with B.S. 1188 size 58 x 44 cm. (22 x 16 in) chromium plated pillar valves, combined overflow and 1 1/4 inch diameter trapped waste, plug and chain. Lavatory basins shall be fixed on pair of cantilever brackets built into walls.

Baths shall be white porcelain enameled cast iron complying with B.S. 1189, with rectangular tops and side and end panels where required, fitted with two 3/4 in. diameter chromium plated pillar valves, 1 1/4 in. overflow and 1 1/2 in. diameter trapped waste, plug and chain. Where baths are fitted with a shower this shall be of either the overhead type or the telephone type. In all cases the shower hose and exposed piping shall be chromium plated and the connections to such showers shall be through a chromium plated mixing valve. The baths and showers shall be fixed as detailed on the Drawings or directed by the Engineer.

Asiatic Water Close Suites shall be sea-water resistant and shall comprise white glazed fire clay squatting slab, pan, 'S' or 'P' trap with 3 1/2 inch bore outlet, two gallon capacity high or low level white enameled cast iron or white glazed fire clay or plastic flushing cistern fixed to walls with cantilever brackets or concealed fixing, 1 1/4 in. (high level) or 1 1/2 in (low level) diameter flush pipes, non-corroding valves siphon, 1/2 inch low-pressure ball value and union, 3/4 in overflow and union, and either flushing handle or pull and chain. A flush valve may be installed instead of the flushing arrangement described above if required.

European Water Closet Suites shall comprise white glazed fire clay pan complying with B.S. 1213, weighing approximately 20 kg. and having 'S' or 'P' trap with 3 1/2 in
bore outlet, two-gallon capacity high or low level white enameled cast iron or white glazed flushing cistern fixed to walls with cantilever brackets or concealed fixing 1 1/4 in (high level) or 1/2 in (low level) diameter flush pipe, non-corroding valves siphon, 1/2 in low-pressure ball valve and union, 3/4 in overflow and union either flushing handle or pull and chain, and with double flap solid section plastic ring seat complying with B.S. 1254.

Urinals shall be either fitted bowl type urinals of white glazed fire clay, or shall type urinals of white glazed fire clay. The bowl type shall be supported on steel brackets cut and pinned to wall and shall have chromium plated flat grating and outlet. The stall type shall comprise back slabs, division, returned ends, floor treads, channel with returned ends and chromium plated removable domical grating and outlet. Flushing cisterns of sufficient capacity shall be connected through flush pipes and sparge pipes of copper, chromium plated where required.

Where required sea water resisting flushing shall be used.

12.8 Sundries

Where required by the Particular Specification the following fittings shall be provided:

- Adjacent to European Water closet a porcelain chromium plated or white enameled toilet paper holder.
- Adjacent to Asiatic water closet a suitable water draw off point.
- To wall adjacent to lavatory basin a chromium plated or white enameled towel rail with end brackets.
- Adjacent to bath a recessed porcelain soap tray.

12.9 Electric Hot Water Heaters

These shall be of the pressure type with an expansion pipe and together with their connections, services, etc., shall be in accordance with the Particular Specification or as shown on the Drawings and shall be designed and installed to the satisfaction of GEDCO.

12.10 Pipes

The pipes shall be unplasticised polyvinyl chloride (U.P.V.C.) pipes, as shown on Drawings or as detailed. Pipes shall be laid in position by means of a leveling instrument. Supporting wedges will not be permitted. Where necessary, cutting of pipes shall be carried out.

Special attention is directed with regard of turning down the cut ends to the correct outside diameters.

12.11 Manholes

Manholes of the Gravity Sewers shall be Pre-cast reinforced concrete circular manholes, in compliance with Local standards, specification and standard drawings. Depth of manhole, diameters and directions of pipes shall be according to the Drawings or as directed by the Engineer.

The tops of manhole covers shall be flush with the surface of the road or sidewalk through which the sewers pass. In open areas, the manholes shall project 0.3m above ground level and shall be determined by the Engineer. However, manholes located in the drive way should be of the same riding service level.

Manholes covers shall include a frame and be made of cast iron, of diameter and weight as specified. Precast concrete covers could be used if specified.
Pipes shall be connected to manholes by means of manhole connector sleeves, which will be supplied by the Contractor. Payment for pre-cast manholes shall be made by unit. The unit rate shall include for the cost of excavation and compacted backfill, blinding layer supply and fixing of manhole connector sleeves, cast iron steps, ladders, covers and frames, benching of floor, connection of all pipes, and all labour and materials necessary to complete the manhole according to starting work or at any time during construction, the manufacturer supplying the manholes, if requested by the Engineer shall furnish certified reports that the manholes, to be used are in compliance with specifications.

12.12 Pipe laying Tolerances
All pipes and manholes shall be laid and constructed according to the lines and slopes shown on the Drawing, or as instructed by the Engineer within the following tolerances:
  a) Maximum permissible variation in alignment and location- 1cm.
  b) Maximum permissible variation in invert levels – 0.5cm.

12.13 Manhole Steps
Cast iron manhole steps (step irons) shall be in accordance with B.S. 1247 or equivalent internationally acceptable standard. Supply and installation of manholes steps shall be deemed to be included in the unit rates for the manholes.

12.14 Connection to an Existing System

12.14.1 Scope
This Clause includes the requirement for carrying out the following works:
  1) Connection of a sewer to an existing manhole.
  2) Construction of a manhole on an existing pipe.

12.14.2 Safety Regulations
Special safety precautions must be taken when connections are made to or any other work is undertaken in existing sewers. The above mentioned requirements shall in no way be construed as relieving the Contractor from full and complete responsibility for the safety of his workmen and any other person who may suffer accident of injury due to the works carried out by the Contractor.

12.15 Builder's Work
Normally pipes will be fixed on the surface of walls and the Contractor shall perform all cutting and pinning for holder-bats or plugging and screwing for pipe clips. Where pipes are required to be concealed in the walls etc. the Contractor shall perform all cutting and subsequent making good. Pipes passing through walls or floors shall be sleeved.
All builders works are the contractor's responsibility and must be done in accordance with the engineer's instructions.

12.16 Testing
When the installation has been completed to the satisfaction of the Engineer it shall be tested in the following manner:
The entire system shall be slowly filled with water, allowing any trapped air to escape. When all outlets are closed the system shall be checked for water tightness. Each outlet shall then be checked for rate of flow and correct operation.

12.17 Cleaning
The Contractor shall carefully clean out all cold water and hot water tanks, service pipes, sanitary fittings throughout, traps and wastes. The Contractor shall also make good all flushing valves, check regulating valves, check taps including re-washing as necessary and leave all works in perfectly clean and working condition.

12.18 Recommendations

12.18.1 Water Distribution Networks

All the materials used in the main water distribution lines are galvanized steel pipes. All the internal cold water pipes will be galvanized steel pipes schedule 40. Hot water pipes will be steel pipes schedule 40.

12.18.2 Water Heaters
Enamed series or approved equivalent water heaters are recommended 80 liters capacity. The boiler, made with thick steel, is tested at 16 atm and provided with safety valves. Its Protection with exclusive glasslining and the magnesium anode. This boiler due to existence of a large plane flange which makes inspections extremely easy. The insulation consists of a thickness of 2.5cm of expanded polyurethane, thus reducing heat dispersion to minimum values.
12.18.3 Kitchen Sinks
Is manufactured from a single piece of high grade 18/10 stainless steel, as a result of this process no welding is necessary, and a much stronger produced. Sink with one bowel or two bowels will be considered as shown in the drawing & as mentioned in B.O.Q.

12.18.4 Water Mixer
The recommended type is chrome type fixed to the wall (HAMAT-Eris).

12.18.5 Hand Wash Basin
The recommended type is Colored Porcelain wash basin without pedestal (Bracket type-Italian Made).

12.18.6 WC Closet
The recommended type is Colored Porcelain WC closet with plastic cistern.

12.18.7 Water Tanks
Water tank used is PVC local made / Rotoplace or approved equivalent with lockable cover.
The tanks capacities will be as mentioned in the bills of quantities and as shown in the drawings.
The installation of the water tank must be carried out according to the manufacturer’s instructions i.e. (Tank foundations, Mechanical float valve, fittings, vent pipe, overflow, drain, connections, tank foundation and the required accessories).

12.19 General
This section consists of furnishing all plant, equipment, appliances and materials and in performing all operations necessary in the construction of manholes in accordance with the Specifications, Drawings and Engineer’s instructions and subject to the terms of the conditions of Contract.

12.20 Material

12.20.1 Concrete
Concrete to be used in the construction of manholes and valve chambers shall be concrete which have a compressive strength of 300 kg/cm$^2$ after 28 days and its minimum cement content per 1 m$^3$ of ready concrete is 350 kg.

All concrete aggregates, cement and water shall be sampled and tested as frequently as deemed necessary by the Engineer. All test samples shall be supplied by the Contractor at his own expense. Samples shall be obtained in accordance with the latest editions of the American Society for Testing and Material (ASTM), American Concrete Institute (ACI) code or any equally approved Standard.

The Contractor shall inform the Engineer at least 24 hours in advance of the times and places at which he intends to place concrete.
Prior to pouring concrete in any structure, the Contractor shall secure a written order to commence from the Engineer.

12.20.2 Reinforcement

Reinforcement to be used is deformed steel bars conform to the requirements of the standard specifications for deformed Billet-steel Bars of grade 50 with minimum yield strength of $3500$ kg/cm$^2$ for concrete reinforcement of ASTM Designation (A-615) or equivalent.

All reinforcement shall be placed strictly in accordance with the Drawings and as instructed in writing by the Engineer. Nothing shall be allowed to interfere with the required disposition of the reinforcement are placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part shall be in actual contact with the bars, around which they are intended to fit.

12.20.3 Cast Iron/Ductile Iron Items

Materials and allowable loads in cast iron frames and covers shall comply with British Standard 497 and as specified hereinafter. Cast iron boxes and hoods shall be designed to resist a traffic load equivalent to a concentrated load specified hereinafter. All cast iron items shall be factory dipped in coal tar as specified in British Standard 497.

12.21 Cleaning

All manholes and valve chambers specified under this section shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter of any kind and shall be free of any such accumulations at the time of final inspection.

All Ductile Iron items shall comply with B.S. EN 124.

12.22 Construction of Manholes and Valve Chambers

All manholes and chambers shall have reinforced-concrete bases. Chamber bases for valves may be precast or cast in place at the chamber bases for valves may be precast or cast in place at the Contractor's option and as approved by the Engineer. For precast reinforced-concrete manhole bases, opening for pipes shall be cast in the base at the required location during its manufacture. Field cut openings will not be permitted. The top of precast or cast in place bases shall be suitable shaped by means of accurate steel bellring forms to receive precast wall sections (if used).

Manhole walls (rings) and cover slabs shall be either precast or cast in places reinforced-concrete. In precast construction rubber o-rings are to be placed in all joints except for the joint between the cast in place roof slab and the top wall ring. In below the manhole cover slab shall have removable plus or minus 30cm high concrete ring.

The cast iron frames and covers for manholes shall be brought to grade by a maximum of three courses of concrete blocks and a reinforced concrete frame into
which the cast iron frame is embedded. 250-kg/cm² concrete is cast around the concrete blocks for rigidity. Manhole frames shall be set with the tops conforming accurately to the grade of the pavement or finished ground surface or as indicated on the Drawings as directed. The cast iron manhole frames and covers shall be as indicated on the Drawings and hereinafter specified.

The inverts shall conform accurately to the bottom of the adjoining valves, all as indicated on the Drawings and approved by the Engineer.

External and internal formwork for all manholes shall be in accordance with the requirements of these Specifications. The use of the sides of the excavations instead of external formwork is not allowed. Internal surfaces of all manholes shall be smooth finished by the use of steel forms, plywood or timber with one face treated to a smooth surface and coated with two coats of coal tar epoxy compound. The internal surfaces of the manholes will be plastered with cement mortar using 1:1.5 mix and 1.0cm thickness.

Manholes shall be completely constructed as the Works progress and as each one is reached by the pipe work. Manhole frames and covers shall be placed immediately after the completion of the manhole. If not defined elsewhere, the depth shall be taken as the difference between the top of the manhole and the base of the manhole.

12.23 Formwork of Valve Chambers

The Contractor shall be responsible for the design and stability of the formwork. The Contractor shall submit a full program of work indicating the various phases for the erection and removal of forms and the manner in which he intends to execute.

12.23.1 Material

All forms shall be of plywood or wrought lumber, unless otherwise specified or directed by the Engineer and shall be built mortar tight and of sufficient rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations. Forms shall be constructed and maintained so as to prevent wrapping and the opening of joints due to the shrinkage of the lumber.

The forms shall be substantial and unyielding and shall be so designed that the finished concrete will conform to the proper dimensions and contours. The Contractor shall take into consideration the effect of vibration on the formwork and shall be responsible for any damage or default resulting thereof.

12.23.2 Workmanship

Forms should be inspected by the Engineer prior to installation of reinforcement.

The number and spacing of the form struts and braces shall be such that the forms will be braced rigidly and uniformly lock joints between form sections shall be free from play or movement. The shape, strength, rigidity, watertightness and surface smoothness or reused forms shall be maintained at all times. Any warped or bulged lumber must be re-sized before being re-used. Forms which are unsatisfactory in any respect shall not be re-used.
Metal ties or anchorages within the forms shall be so constructed as to permit removal to a depth of at least 40mm from the face without injury to the concrete. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 10mm from the face of the concrete with chisels or nippers; for green concrete, nippers are necessary.

All fittings for metal ties shall be of such design that the cavities produced upon their removal are the smallest possible. The cavities shall be filled with cement mortar and the surface left sound, smooth, even and uniform in color.

All forms shall be treated with oil and saturated with water immediately before placing the concrete. For members with exposed faces, the forms shall be treated with an approved oil to prevent the adherence of concrete.

Any material which will adhere to or discolor the concrete shall not be used.

The Contractor shall provide means for accurately measuring the settlement of the forms during placement of the concrete and shall made all necessary corrections as directed by the Engineer.

**12.23.3 Removal of Formwork**

To facilitate satisfactory progress with the specified curing and enable earliest practicable repair or surface imperfections, form shall be struck as soon as the concrete has hardened sufficiently to prevent damage by careful form removal. Forms shall not be struck until the strength of the concrete is such that form removal will not result in perceptible cracking, breaking of surfaces or other damage to the concrete and that the concrete can sustain the load to be borne at the time of striking.

Forms shall be struck with care so as to avoid injury to the concrete and any concrete so damaged shall be repaired.

No formwork shall be struck until the Engineer's approval has been obtained, but as a guide to the Contractor and subject to the foregoing requirements the following minimum striking times, from the completion of concrete, placing may be assumed:

- For the sides of valve chambers 3 days.
- Striking of roof forms shall start from the centre and proceed in concentric circles towards the wall.
- As soon as the forms have been struck, the work of finishing and repair of concrete may commence.

**12.24 Frames and Covers**

The Contractor shall furnish all Cast Iron/Ductile Iron frames and covers conforming to the details shown on the Drawings, or as hereinbefore specified. As described in the General Specifications, the Contractor shall submit for approval detailed shop and working Drawings of all castings before fabrication. The castings shall be of good quality, strong, tough, even-grained cast iron, smooth, free from scale, lumps, blisters, sandholes and defects of every nature which would render them unfit for the service for which they are intended.

All castings shall be thoroughly cleaned and subject to a careful hammer inspection.
Two types of cast iron manholes covers will be used (25 tons and 8 tons bearing capacities), the type of manhole cover to be used for each manhole will be determined on Site according to traffic load as directed by the Engineer.

The covers shall have a rubber ring installed at the inner surface of the cover and frame seating to ensure non-rocking under traffic and the covers shall be vented by four 25mm holes as indicated on the Drawings.

Before being shipped from the foundry, castings shall be given one coat of coal-tar pitch varnish, applied in a satisfactory manner so as to made a smooth coating, tenacious and not brittle or with any tendency to scale off. The Contractor should consult with the Engineer for the words to be written on the covers.

12.25 Precast Elements

Precast elements shall be either of concrete or mortar as shown on the Drawings and as specified hereinafter.

12.25.1 Materials

12.25.1.1 Precast Concrete Elements

Precast concrete elements shall be of plain or reinforced concrete dimensions, thickness and reinforcement rods and bars shown on the Drawings and stated in the Bill of Quantities.

12.25.1.2 Precast Mortar Elements

Moist tamped mortar precast elements shall be of a mixture of ordinary or tinted cement and sand (fine aggregate) approximately in the proportions of one part cement to two and one-half parts of sand. The sand shall be specially selected for colour and grading. The sand shall be screened through 1/8” inch square meshes and all oversize particles shall be discarded. Only sufficient water shall be used in mixing to permit the immediate removal of the member from the mould. The pattern, dimensions and thickness shall be as shown on the Drawings and/or as directed in writing by the Engineer.

12.25.1.3 Mortar

Mortar for joining the precast elements shall be composed of one part of portland cement and three parts of clean sand unless otherwise specified. The cement and sand shall conform to the requirements of ordinary portland cement and aggregate for mortar specified herebefore.

12.25.2 Fabrication

Precast concrete or mortar elements shall be cast in mortartight metal lined timber moulds and shall be mechanically vibrated when cast. The Precast elements shall be removed from the moulds as soon as practicable and shall be dept damp for a period of at least 10 days. Any elements that shows checking or soft corners or surfaces shall be rejected. The method of storage and handling shall be such as to preserve true and even edges and corners, any precast element which becomes chipped, marred or cracked before or during the process of placing shall be rejected, sampling of precast elements shall be submitted to the Engineer for approval, prior to fabrication, at the Contractor's own expense.
12.25.3  Workmanship

All precast concrete or mortar elements shall be well cleaned and thoroughly wetted with clean water before placing in their positions shown on the Drawings. The precast elements shall be bedded and jointed in cement and sand mortar (1:3) mix and the joints raked out on both faces to receive plaster or pointing as indicated on the Drawings and/or stated in the Bill of Quantities to the satisfaction of the Engineer.

12.25.4  Payment

The prices inserted in the Bills of Quantities for plumping works and payment thereof shall be based on net finished specified dimensions of the work and shall include the cost of all testing, construction, transporting, placing compacting, curing, surface finishing, protection, cast iron/ductile iron covers, steps and all labor and materials and tests.

Payment for plumping Works:  Payment in Units/Running Meter/L.S.
Payment for chambers:  Payment in Units/L.S

12.26  Septic Tanks and Soakaways

12.26.1  Scope

This item shall consist of the design, provision and construction of septic tanks and soakaways, including connections to buildings.

12.26.2  General

Septic tanks and soakaways shall be designed and constructed in compliance with the following requirements. Plans showing the design, dimensions and proposed location of each septic tank and soakaway to be constructed must be submitted to the Engineer prior to the commencement of work on such septic tanks and soakaways and to allow sufficient time for the adequate checking of the plans. The approval in writing of the Engineer, together with such building Approvals, Permits, etc. as may be required from any statutory Authority must be obtained by the Contractor before commencement of work.

12.26.3  Design and Construction Requirements

1- Any septic tank for the reception of foul water from buildings shall be sited.

- As not to render liable to pollution of any spring, or other source of water, which is used or likely to be used for drinking or domestic purpose.

- That there is ready means of access for cleaning it and removing its contents without carrying them through any building where people reside or are employed.
Not to be such proximity to any building to which any person resides or is employed, or to which the public has access or is liable to become a source of nuisance or danger to health.

2- Storm water shall not be connected to septic tanks but to soakaways if no other solution is possible.
3- Trade waste and effluent from hospitals requires special treatment and shall not be connected direct to septic tanks.
4- Water from kitchens, bathrooms and WCs can be connected direct to septic tanks.
5- The maximum Nos. of people to be connected to one septic tank is 300.
6- Any septic tank shall be of adequate size having in no case a capacity of less than 3.0 m³.
7- A septic tank volume of at least 300 l/capita must be provided.
8- Any septic tank shall be of suitable water depth, which is for:

- Tank volumes of less than 4 m³ 1.2 m - 1.9 m. In such case at least 2 chambers are required, having a 2:1 volume proportion.

- Tank volumes of more than 4 m³ 1.5 m - 3.0 m, in such case at least 3 chambers are required having a 2:1:1 volume proportion.

- If 4 chambers shall be built, the volume proportion shall be 3:1:1:1

9- When separate line are existing or planned, effluent from baths and washing machines can be connected to the second chambers.
10- Any septic tank shall be:-

- So constructed as to be impervious to both, liquid from the inside and subsoil water from the outside.

- Properly covered so as to be impervious to surface water and rain water from outside and smell from inside.

- Fitted with heavy-duty manhole covers for the purposes of inspection, emptying and cleaning.

- Adequately ventilated.

11- The separation walls of septic tanks must be provided with holes or slits below water level.
12- Effluent from septic tanks and storm water drains can be connected to the same soakaway.
13- Ground plate and parts of the soakaways wall shall be permeable.
14- The permeable area must be at least 1 m²/ capita for sewage, or 1 m²/300 l for storm water.
15- The ground water table must be at least 1.5 m below foundation of the soakaway.
16- Any soakaway shall:

- be filled with gravel.
- have a sand layer of at least 15 cm on top of the gravel be surrounded by a 30 cm gravel layer/wall
be fitted with heavy duty covers.

12.27 Measurement & Payment

The accepted quantity will be paid for at the Contract unit price complete in place including excavation and any back filling.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plumping &amp; Sanitary Ware</td>
<td>L.S/No./ as mentioned in B.O.Q</td>
</tr>
</tbody>
</table>
13 **PLASTER WORK AND OTHER FLOOR WALL AND CEILING FINISHES**

13.1 **Materials**

The cement and water used for plastering shall comply with BS specifications. The sand for plastering shall be clean, fine sand and shall be chemically and structurally stable. The sand shall be sieved and graded in accordance with the Table of Gradings given below:

<table>
<thead>
<tr>
<th>TABLE OF GRADINGS-PERCENTAGE PASSING FOR PLASTERING</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sizes</strong></td>
</tr>
<tr>
<td>B.S. Sieve No.</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>14</td>
</tr>
<tr>
<td>25</td>
</tr>
<tr>
<td>52</td>
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<tr>
<td>100</td>
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</tbody>
</table>

*Note:* The above figures represent the limits of percentages (by weight) passing sieves of the sizes mentioned. The gypsum plaster shall be of the hemi-hydrate type with a controlled setting time as Type 6 Clause B of British Standard No. 1191: 1955. The resultant plaster shall be chemically inert when set, be capable of being trowelled to a smooth surface and shall be highly resistant to cracking and crazing. Imported lime shall be of the hydrate type complying with Class B of British Standard No. 890.

*Note:* Cebex 112 or approved equivalent must be added to the mortar which will be used for Plastering, Rendering, Tiling & Screeds to control air entertainment mortars and to allow plasticising of the mortar mix and easier finishing (According to the Manufacturers Instructions).

13.2 **Mixing**

The mixing shall be done mechanically and the proportions shall be in accordance with Mixing Table given below:

<table>
<thead>
<tr>
<th>Mixing Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nominal Mix</strong></td>
</tr>
<tr>
<td>1:4 cement</td>
</tr>
<tr>
<td>1:1 cement</td>
</tr>
<tr>
<td>1:5 cement with 20% imported lime</td>
</tr>
<tr>
<td>1:4 Imported lime with 10% cement</td>
</tr>
</tbody>
</table>
With regard to the lime mortars gauged with cement, the addition, just before use, of the cement to small quantities of the lime/sand mix shall preferably take place in a mechanical mixing shall continue for such time as will ensure uniform distribution of materials and uniform color and consistency. It is important to note that the quantity of water used shall be carefully controlled. Gypsum plaster shall be mixed in a clean pail or other approved vessel. The required amount of water shall be placed in the pail and the plaster added gradually and allowed to soak for 5 minutes. It shall then be stirred to a uniform consistency free from lumps and no more material shall be mixed than can be used in half an hour.

13.3 Workmanship
All plastering shall be executed in a neat workman like manner. All faces except circular work shall be true and flat and angles shall be straight and level or plumb. Plastering shall be neatly made good up to metal or wood frames and skirting and around pipes or fittings. Angles shall be rounded to 5 mm. radius. Surfaces of undercoats shall be well scratched to provide a key for finishing coats. Screed marks or making good on under-coats shall not show through the finishing coats. Surfaces described as trawled smooth shall be finished with a steel or celluloid trowel to a smooth flat surface free from trowel marks. Surfaces described as floated shall be finished with a wood or felt float to a flat surface free from trowel marks. All tools, implements, vessels and surfaces shall at all times be kept scrupulously clean and strict precautions shall be taken to prevent the plaster or other materials from being contaminated by pieces of partially set material which would tend to retard or accelerated the setting time.

13.4 Preparation
All surfaces to be plastered shall be clean and free from dust, loose mortar and all traces of salts. Where cement plaster is to be applied to surfaces shall first be dashed with a mixture of Portland cement and (1:1) mix to form a key. All surfaces shall be thoroughly sprayed with water and all free water allowed to disappear before plaster is applied. Before plastering is commenced all junctions between differing materials shall be reinforced. This shall apply where walls join columns, where brick walls join block walls and similar situations where cracks are likely to develop and as directed by the Engineer. The reinforcement shall consist of a strip of galvanized wire mesh (10 to 15 mm. hexagonal mesh) 15 Cms. wide which shall be plugged, nailed or stapled as required at intervals of not exceeding 50 cms. at both edges.

13.5 Curing
Plaster shall be cured after the application of each full coat by seven days.

13.6 Application
After preparation of the surfaces, the undercoat shall be applied to the required thickness between screeds laid, ruled and plumbed as necessary. When nearly set the surface of the undercoat shall be scratched. The undercoat shall be allowed to set hard and shall be curd. Where plastering is applied in one coat or where roughcast is to be applied the scratching should be omitted. The finishing coat shall be applied to the required thickness by means of a laying-on trowel and finished to give the required surface. The sprayed finish shall be applied with an approved machine to give a finish of even texture and thickness. The sprayed finish shall be applied in four separate coat allowing time for drying between coats. Application in one continuous operation to build up a thick layer will not be permitted. the total finished thickness of the four sprayed coats shall be not less than 3 mm. The sprayed finish shall not be applied until all repairs and making good to the undercoat are completed. Rain-water pipes, fittings and the like shall first be fitted, then removed during the spraying process and
refitted and jointed afterwards. Any plaster which adheres to other pipes, doors, windows and the like shall be carefully removed before it has set. Curing shall take place after the application of the fourth coat. Plaster should not be allowed to more than 2cm thick. Incase it is more wire mish should be used and plaster will be applied in multiple layers.

13.7 Wall Tiling
The tiles for wall tiling shall be true to shape, flat and free from flaws, cracks and crazing and keyed on the reverse side and shall be of a manufacture approved by the Engineer. The tiles shall be specially selected 6 inch x 6 inch x 1/4 inch thick (about 15 Cms x 15Cms x 6.4 mm.) white or colored glazed on face complying with the requirements or British Standard No. 1281. The external angles and side and top edges of glazed wall tiling shall be formed with rounded edge tiles. At intersections returned rounded edge tiles shall be used. Alternatively where so required by the Particular Specification, the external angles and side and top edges shall be formed with angle beads. Joints shall match the general tiling and at intersections special fittings shall be used. The screed for wall tiling shall be cement and sand (1:4) mix 10 mm. thick and the materials, methods of mixing, preparing and applying the screed shall be similar to those described for undercoat. The surface shall be scratched in an approved manner when nearly set to form a key. The surface of the screed shall be well wetted before the tiling is applied. All tiles shall be immersed in clean water for 6 hours or until saturated and all surplus water drained off before bedding. Tiles shall be bedded in cement and sand (1:4) mix 6 mm. thick to a true vertical face with continuous horizontal and vertical joints and pointed in the neat white or colored cement and any surplus which adheres to the face of the tile shall be wiped off with a damp cloth before it sets hard. The joints shall be either close, tight joints or open joints not exceeding 2 mm. wide as required by the Particular Specification. Where tiling abuts against wood or metal frames or other tiling at angles and around pipes etc., it shall be carefully cut and fitted to form a close neat joint. Open irregular joints filled with cement and sand or plaster will not be permitted.

13.8 Glass Mosaic:
The mosaic shall be first class Italian glass mosaic obtained from an approved manufacterer of the colors shown on the Drawings or in the Particular Specification. The individual tiles shall be approximately 20 mm. x 20 mm. x 5 mm. thick with an average weight of 10 Kilograms per square Meter. The face of each tile shall be flat and true with opposite edges parallel. The rear edges shall be chamfered. The tiles shall be formed of a homogeneous vitreous paste having a high silica content and the finished tiles shall be opaque and uniform in color throughout their thickness. With the exception of red or yellow tiles, which may be glossy, the face of the tiles should present a malt surface. The mosaic shall be fixed with soluble adhesive to a strong fixing paper in sheets 30 Cms. x 30 Cms. The sheets shall be packed in stout cardboard cartons wrapped in waterproof bituminous paper. The cartons shall be contained in a strong wooden case for shipment. To facilitate handling the wooden case shall contain not more than about 3 square Meters. They key coat shall consist of cement and sand (1:5) mix which should be applied four or five days before the mosaic. Application to walls etc., shall generally commence from the bottom working upwards by means of throwing the mix vigorously against the surface with a casting trowel and pressing it firmly into joints etc., to ensure adhesion. The surface should be finished plumb and straight and shall be well scratched to form a key. All
irregularities of the wall surface shall be well leveled off and the minimum thickness at any point shall be 5 mm. The base coat shall consist of cement and sand (1:5) mix with a proportion of imported hydrated lime of up to 20% by volume added to delay setting. Vertical screeds shall be fixed at edges of surfaces and intermediately as required to permit accurate application of the base coat and shall consist of timber strips 5 mm. to 8 mm. thick x 20 mm. wide. The strips shall be coated with mortar as described for base coat, firmly set to the wall and shall be carefully plumbed on face and edge. The key coat shall be well wetted and the base coat shall be applied and carefully leveled between the screeds to give a smooth flat surface which shall be kept moist until the mosaic is fixed. The screeds shall be removed and the base coat leveled up. The bedding coat shall consist of neat white cement and water mixed as previously described for gypsum plaster. The bedding coat shall be applied immediately before the mosaic is fixed to a thickness of 1 mm. Horizontal and vertical reference lines shall be drawn on the bedding coat to ensure accurate fixing of the mosaic. The mosaic sheets shall have their backs coated with a layer of bedding coat mortar which shall be well trawled in over the whole sheet so that all spaces between tiles are completely filled. The prepared sheets of mosaic shall then be fixed true to level and plumb commencing from the bottom working upwards. Each sheet shall be patted with a steel float especially along the joints between sheets. Any dropped tiles shall be replaced. The surfaces shall be hammered lightly over a tapered wood block especially where the fixing paper has a dry appearance indicating insufficient penetration of bedding mortar. It is essential that the finished surface be flat and true and that the top edge be leveled. The entire surface shall then be sprayed three or four times with water to soften glue on the fixing paper. In cases where the mosaic is exposed to sun or wind the spraying shall be substituted by brushing with a coat of grout similar to the base coat mortar. When the fixing paper is thoroughly wet, it shall be carefully peeled off keeping the hand close to the surface to prevent dislodging the tiles. The Contractor shall then carry out any adjustments to tiles which are necessary to render the joints between sheets undetectable. The surface of the mosaic shall then be sprayed with water and all traces of glue and excess mortar shall be washed off. The surface shall be wiped dry with clean wood shavings. The joints shall then be grouted up using bedding mortar applied by means of a small trowel to ensure that all joints are completely filled for their full depth. Surplus mortar shall be wiped off with wood shavings. The special edge tiles ("owls beaks") shall then be applied, leveled and grouted. The entire surface shall then be grouted once more and cleaned off with wood shavings. After two to six days at the discretion of the Engineer the surface shall be washed with a 25% solution of hydrochloric acid applied by brush. The surface shall then be sprayed several times with clean water and dried off with clean white rags.

13.9 Clay Tiles

Clay roof tiles (Tognona-Italy) will be installed as shown in the drawings & the engineer instructions.
13.10 Tiles

All the tiling works will be executed according to the drawings and engineers instructions and will be tested to control the quality of the materials as mentioned in the general specifications.

E. Ceramic wall tiles:
   – Ceramic wall tiles size 300x200x6mm will be used up to the door level (made in Italy).
   – Non slipping ceramic floor tiles size 300x300x8mm made in Italy will be used for kitchen and WCs and as shown on drawings and the engineer instructions.

13.11 Measurement & Payment

The accepted quantity will be paid for at the Contract unit price complete in place including excavation and any back filling.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastering Works</td>
<td>Square Meter</td>
</tr>
<tr>
<td>Tiling Works</td>
<td>Square Meter</td>
</tr>
</tbody>
</table>
14 GLAZING

14.1 Materials

Clear glass shall be flat-drawn clear sheet glass complying with British Standard No. 952 Section 1, ref.: 4.a. (1) "Ordinary Glazing Quality" of the substances shown below:

<table>
<thead>
<tr>
<th>Nominal Substance</th>
<th>Limits of Thickness</th>
<th>Possible Variation in Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ounces</td>
<td>Millimeters</td>
<td>Per foot super</td>
</tr>
<tr>
<td>24</td>
<td>2.75 to 3.05</td>
<td>MIN.</td>
</tr>
<tr>
<td>26</td>
<td>3.10 to 3.50</td>
<td>oz.</td>
</tr>
<tr>
<td>32</td>
<td>3.90 to 4.30</td>
<td>22.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>26.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>31.75</td>
</tr>
</tbody>
</table>

14.2 Plate Glass

Plate glass shall be cast, rolled or drawn glass ground and polished on both surfaces complying with British Standard No. 952 Section 1, ref.: 6.a (i) "Glazing for Glazing Quality" of the substances shown below:

<table>
<thead>
<tr>
<th>Nominal Substance</th>
<th>Limits of Thickness</th>
<th>Possible Variation in Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Inches - Millimeters</td>
<td>Per foot super</td>
</tr>
<tr>
<td></td>
<td></td>
<td>MIN. lb. oz.</td>
</tr>
<tr>
<td>3/16</td>
<td>10/64 to 14/64</td>
<td>3.97 to 5.56</td>
</tr>
<tr>
<td>1/4</td>
<td>14/64 to 20/64</td>
<td>5.56 to 7.94</td>
</tr>
<tr>
<td>3/8</td>
<td>23/64 to 27/64</td>
<td>9.13 to 10.72</td>
</tr>
<tr>
<td>1/2</td>
<td>30/64 to 34/64</td>
<td>11.91 to 13.49</td>
</tr>
</tbody>
</table>

14.3 Obscured Glass

Obscured glass shall be figured rolled glass complying with British Standard No. 952 Section 2, ref.: 12.b. of "Arctic" or similar type and of the substances shown below:

<table>
<thead>
<tr>
<th>Nominal Substance Approximate</th>
<th>Approximate Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ins.</td>
<td>mm.</td>
</tr>
<tr>
<td>1/8</td>
<td>3</td>
</tr>
<tr>
<td>3/16</td>
<td>5</td>
</tr>
<tr>
<td>1/4</td>
<td>6</td>
</tr>
</tbody>
</table>
14.4 Wired Glass
Wired glass shall polished wire glass having both surfaces ground and polished and with hexagonal or square wire mesh inserted during rolling complying with British Standard No. 952 Section 4, ref.: 20.b. of the substance shown below:

<table>
<thead>
<tr>
<th>Nominal Substance Inches</th>
<th>Limits of Thickness Inches</th>
<th>Possible Variation in Weight Per foot super Per Meter supper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN. lb. oz.</td>
<td>MAX. lb. oz.</td>
</tr>
<tr>
<td>1/4</td>
<td>5.56 to 7.14</td>
<td>2 12</td>
</tr>
</tbody>
</table>

14.5 Heat-absorbing Glass
Heat-absorbing glass shall be polished plate glass substantially opaque to infrared radiation's complying with British Standard No. 952 Section 4, ref.: 24 of the substances shown below:

<table>
<thead>
<tr>
<th>Nominal Inches</th>
<th>Limits of Thickness Inches</th>
<th>Possible Variation in Weight Per foot super Per Meter supper</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MIN. lb. oz.</td>
<td>MAX. lb. oz.</td>
</tr>
<tr>
<td>3/16</td>
<td>3.97 to 5.56</td>
<td>2 0</td>
</tr>
<tr>
<td>1/4</td>
<td>5.56 to 7.15</td>
<td>2 13</td>
</tr>
</tbody>
</table>

14.6 Armourplate Glass
Armourplate glass shall be toughened safety glass made of heat treated polished plate complying with British Standard No. 952 Section 4, ref.: 29.b. of 1/4 in., 3/8 in., or 1/2 in. substance as previously given.

14.7 Mirror Glass
Mirror glass shall be Silvering Quality polished plate glass silvered on one side, cooper-backed, varnished and painted complying with British Standard No. 952 ref.: 6.a. (iii) and 27 and of the substances previously given. Edges of mirrors shall be bevelled.

14.8 Putty
Putty for glazing to wood shall be tropical grade glazing quality. Putty for glazing to metal shall be tropical grade metallic glazing quality.

14.9 Glazing Beads
Wood glazing beads shall be of teak, splayed and rounded to the sizes shown on the Drawings and neatly mitered and braided. Metal beads shall be supplied with metal windows and doors and these shall be sprung or screwed on according to design.
WORKMANSHIP

14.10 Glazing to Wood without Beads
The rebates shall be previously treated with one coat of priming paint and the bedding putty inserted. The glass shall be embedded in the putty and secured by sprigs. The front putty shall be inserted to form a triangular miter filling from the edge of the rebate to 2 mm. back from the sight line. The bedding putty shall be trimmed off level with the sight line to form a neat back putty. When the putty has hardened sufficiently the painting shall be carried out and care shall be taken to seal the joint between putty and glass by painting up to the sight line.

14.11 Glazing to Wood - with Beads
The rebates shall be previously treated with one coat of priming paint and the bedding putty inserted. The glass shall be embedded in the putty and secured by the beads. The bedding putty shall be trimmed off level with the slight line to form a neat back putty and the painting shall be carried out.

14.12 Glazing to Metal - without Beads
The rebates shall be previously treated either by rust proofing or priming as described elsewhere and the bedding putty inserted. The glass shall be embedded in the putty and secured by pegs or clips inserted in holes in the rebates. The front putty shall be inserted to form a triangular mitered filling from the edge of the rebate to 2 mm. back from the sight line. The bedding putty shall be trimmed off level with the sight line to form a neat back putty. When the putty has hardened sufficiently the painting shall be carried out and care shall be taken to seal the joint between putty and glass by painting up to the sight line.

14.13 Glazing to Metal - with Beads
The rebates shall be previously treated either by rust proofing or priming as described elsewhere and the bedding putty inserted. The glass shall be embedded in the putty and secured by the beads. The bedding putty shall be trimmed off level with the sight line to form a neat back putty and painting shall be carried out.

14.14 Glazing Without Putty
Where specimen, wash leather, ribbon velvet, flannel, felt, asbestos or similar materials shall be used in place of putty for internal glazing in conjunction with beads. The materials should be fitted so that it covers all parts of the glass which will be covered by the rebate and bead.

14.15 Mirrors
Mirrors shall be fixed to walls with rubber sleeves and chromium plated dome-headed screwed into prepared plugs let into walls.

14.16 Cleaning etc.
The Contractor shall replace all cracked or broken glass and clean all glazing both sides and all mirrors before handing over.
14.17 **Measurement & Payment**

The accepted quantity will be paid for at the Contract unit price complete in place including excavation and any back filling.

Payment will be made under:

<table>
<thead>
<tr>
<th>Payment Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glazing Works</td>
<td>Square Meter</td>
</tr>
</tbody>
</table>
15 **PAINTING AND DECORATION**

15.1 **Generally**

Every possible precaution shall be taken to keep down dust before and during painting processes. No paint shall be applied to surfaces structurally or superficially damp and all surfaces must be ascertained to be free from condensation, efflorescence, etc., before the application of each coat. Primed or undercoated wood work and metal work should not be left in an exposed or unsuitable situation for an undue period before completing the painting process. No exterior or exposed painting shall be carried out under adverse weather conditions, such as rain, extreme humidity, dust storms, etc. Metal fittings such as ironmongery etc., not required to be painted shall first be fitted and then removed before the preparatory processes are commenced. When all painting is completed the fittings shall be cleaned and re fixed in position. The Contractor will be required to repaint at his own expense any work on which the paint is found to be incorrectly applied. The Contractor shall be responsible for protecting from damage the paint work and all other work during and after painting operations including the provision of all necessary dust heats, covers, etc. Brushes, pails, kettles etc. used in carrying out the work shall be clean and free from foreign matter. They shall be thoroughly cleaned before being used for different types or classes of material.

15.2 **Materials**

The decorating materials shall be obtained from approved manufacturers and shall be supplied in the manufacturers' sealed and branded containers. All materials must be thoroughly stirred before use. Details of mixing and application shall be in accordance with the specifications of the manufacturers concerned and to the approval of the Engineer. The mixing of paints etc., of different brands before or during application will not be permitted. No dilution of painting materials shall be allowed except strictly as detailed by the manufacturers and as approved by the Engineer. Mordant solution shall be equal in quality to "Lithoform" manufactured by I.C.I. Ltd. Rust inhibitors shall be equal in quality to "James" brand Calcium Plumbate Primer manufactured by Foster, Blackett and James Ltd. or as described elsewhere herein. Fillers shall be "Polyfilla", "Alabastine" or other equal and approved. Thinners shall be approved turpentine or white spirit. Priming paints shall be:

**For wood work:** Leadless gray priming paint in accordance with British Standard No. 2522. Alternatively wood work of hard, non-absorbent timber, resinous timber of prominent grain shall be primed with one coat of aluminum sealer equal to "A 519-3648" manufactured by I.C.I. Ltd.

**For steel work:** Red oxide priming paint in accordance with British Standard No. 2524.

For **galvanized**, zinc or aluminum alloy surface: gray zinc chromate priming paint equal to "A 500-388" manufactured by I.C.I. Ltd.

**For plaster**, concrete and brickwork, ceiling boards etc.: Algalia resisting priming paint equal in quality to "A 500-368" manufactured by I.C.I. Ltd. Knotting shall be in accordance with British Standard No. 1336. Stopping shall be hard stopping composed of paste white lead, gold size whiting. Undercoating shall be:

Zinc oxide based undercoating paint.

White lead based undercoating paint in accordance with British Standard No. 2525. Colors shall approximate to the finishing paint.
Synthetic alkyd based undercoating equal to "Dulux" undercoating paint manufactured by I.C.I. Ltd. Finishing paints shall be:
Zinc oxide based oil paint in accordance with British Standard Nos. 277 and 278.
White lead based oil gloss finishing paint in accordance with British Standards Nos. 2526 and 2527.
Synthetic alkyd based finishing paint equal to "Dulux" finishing paint manufactured by I.C.I. Ltd.
Petrifying liquid shall be used undiluted as supplied by the manufacturer. A small quantity of water paint of the finishing color may be mixed with the petrifying liquid. Water paint shall be an approved brand of washable oil-bound water paint complying with British Standard No. 1053 Type A. Thinning shall be done with petrifying liquid or fresh water only. Emulsion paint shall be of the Polyvinyl Acetate (P.V.A.) type obtained from an approved manufacturer. The precise specification shall comply with the manufacturer's normal practice. In all cases thinning shall be done with thinners supplied by the manufacturer or fresh water only. Stain for wood work shall be an approved brand of oil stain complying with British Standard No. 1215. Varnish for wood work shall be an approved brand of exterior oil varnish complying with British Standard No. 257, No. 2 Pale.

PREPARATION PROCESS

15.3 Internal Plaster, Fair faced Concrete And Block work
Surfaces shall be allowed to dry out completely and cracks shall be cut out and made good with suitable hard plaster or cement/sand mix as appropriate, such repaired portions shall be allowed to dry out. No painting shall be carried out on plastering less than five weeks old. Efflorescence shall be completely removed by rubbing down with dry coarse cloths followed by wiping down with damp cloths and allowed to dry. All surfaces shall be rubbed down with fine glass paper and brushed free of dust before applying any form of decoration. Surfaces which are to receive water paint shall be treated with one coat of petrifying liquid applied by brush and allowed to dry for at least twenty four hours before the application of water paint. A period of twenty four hours, or longer if necessary, shall be allowed between subsequent coats. Fair faced concrete and/or cement and sand plastered surfaces which are to receive oil paint shall be given one thin coat of oil putty and allowed to dry for at least two days. The surfaces shall then be rubbed down with fine glass paper and given a second thin coat of oil putty when completely set shall be rubbed down again with fine glass paper before applying the priming coat of oil paint. All surfaces which are to receive oil paint shall be treated with one coat of alkali resisting priming applied by brush and allowed to completely harden.

15.4 Ceiling Boards etc.
Soft Boards. Where used externally or under humid conditions will receive one coat of priming paint and one coat of undercoat on back, face and edges. Soft Boards. Where used internally will receive one coat of priming paint and one coat of emulsion paint on back, face and edges. Hardboard. Composite panels will be treated in the same way as soft boards under humid conditions. Acoustic. Will be treated on the face in the same way as plaster, Boards but the paint may be applied by spray; the backs and edges should not be treated. Asbestos. If surfaces are to receive oil paint later one coat of priming paint should be applied. If surfaces are to receive water paint or emulsion paint no priming paint will be necessary.
15.5 Steelworks including Windows, Louvers, etc. Internally and Externally.

If delivered galvanized, the surfaces shall be cleaned to remove grease and dirt before priming. Where rusting has occurred through damage to the galvanizing, such rust shall be removed by wire brushing back to clean metal and the galvanizing made good with a rust inhibiting agent. The surface shall then be treated with one coat of mordant solution and one coat of zinc chromate priming paint. If delivered primed, the surfaces shall be examined to ascertain that the priming paint is hard, firmly adhering and in good condition. If not satisfactory, the priming paint shall be removed and the surfaces cleaned to removed rust, and re-primed. If the condition shall be cleaned to remove grease and dirt, minor damage to the priming paint being made with red oxide priming paint after removal of rust. If delivered un-primed and not galvanized, the surfaces shall be cleaned to remove grease and dirt, and wire brushed and scraped to remove all rust and scale before applying a red oxide priming paint. Priming paint shall be brushed well into the surface and shall be allowed to dry and harden thoroughly before the application of subsequent coats. Items of steelworks such as frames to roller shutters, covers to expansion joints, etc., which are to be built into walls first be primed.

15.6 Exposed Service Pipes

Copper, aluminum and brass pipe work shall have the surfaces slightly abraded with glass paper and white spirit or similar solvent and wiped clean. No priming paint will be necessary, the surfaces being finished in two coats of glass paint. Steel pipes will be treated as for steelworks with the exception that galvanized pipes are to be treated with a zinc chromate priming paint. Coated soil pipes shall be wiped clean and treated with two coats of knotting followed by priming paint as described above.

15.7 Woodwork Required to be Painted

Surfaces shall be cleaned to remove grease and dirt. The surface of teak shall be cleaned with white spirit to remove free oil. The preparation process shall then be: Knot. All knots shall be treated with shellac knotting. Prime. One coat of primer shall be thoroughly applied by brush to all surfaces and when dry a further coat to be applied to end-grain surfaces. Stop. When priming paint is hard, all cracks, holes open joints etc. shall be made good with hard stopping and all open grain surfaces filled smooth with linseed oil putty or an approved filler and rubbed down with fine glass paper. No joinery shall be primed until it has been approved by the Engineer. Priming shall be carried out on the Site and not in the factory. Items of carpentry work which are to be built into walls etc. shall be first treated by twice coating with creosote or other approved preservative.

15.8 Woodwork Required To Be Stained And Varnished.

Surfaces shall be cleaned to remove grease and dirt. The wood shall then be stopped, filled and rubbed down. In the case of teak free oil shall be removed by cleaning with white spirit.
FINISHING PROGRESS

15.9 Internal Plaster
Where emulsion paint is specified two coats shall be applied by brush in addition to any priming paint. Where water paint is specified two coats shall be applied by brush in addition to the petrifying liquid. The water paint shall be thinned to the consistency of thick cream. Where oil paint is specified this shall be two or three coat work as detailed in the Particular Specification, applied by roller or brush, but not by spray, to produce hard gloss, oil gloss, eggshell or flat finish as required. The finishing coat of paint to walls and ceilings shall be applied after the completion testing of the electrical installation. Any paint splashes on electrical fittings shall be carefully cleaned off.

15.10 Ceiling Boards Etc.
Both acoustic and plain ceiling boards will be treated as for plaster, but the paint may be applied by spray. Water paint or emulsion paint shall be applied by brush to the specification of the manufacturers. Where a ceiling board is likely to be exposed to extreme humidity, i.e. kitchen and external corridors and covered ways, an oil paint shall be used on the face after fixing.

15.11 Unplastered Concrete or Block work
As for plastered surfaces. Externally a cement type paint may be used, and shall be applied keeping a constantly wet edge, in strict accordance with the manufacturer's instructions.

15.12 Steelworks And Exposed Service Pipes
Internally, apply one coat gloss paint over two undercoats. Non-ferrous pipes shall be finished in two coats of gloss. Externally, apply two coats gloss paint over one undercoat.

15.13 Woodwork Required to be Painted As for Steelworks.

15.14 Woodwork Required to be Stained and Varnished
The woodwork, internally and externally, shall be stained as directed on Site, rubbed down, brushed off and treated with two coats of varnish. If the varnish is found to be tacky after two or three days it shall be washed off with turpentine and re-executed from a new supply of varnish at the Contractor's own expense.

15.15 External Rendering
Painting of external rendering will be avoided, the colors generally being obtained in the rendering. A tallow lime wash shall be used where necessary.

Note: All precautions should be done to avoid any damages to already executed works during painting process.

15.16 Granulate Works
1st) The ratio mixing of the granulate materials is as follows: -
- Cement: 1
- Sand: 2
Aggregate: 4

- The used aggregate is (No. 2.5) which must comply with B.S. 812.
- The white aggregate is Israeli product (I).
- The red aggregate is Egyptian product (E).
- The block aggregate is Israeli product-caravel (C).

2nd) The mixes of aggregate to have different colors are as follows: -
1- White Mix:
   I: 5
   E: 1
2- Red Mix:
   Completely Egyptian Aggregate.
3- Black Mix:
   I: 4
   E: 2
   C: 1
4- Aluminum Strip 20mm thick x 2.5cm wide will be used.

15.17 Measurement and Payment:

The prices inserted in the Bills of Quantities for Granulate works and payment thereof shall be based on net finished specified dimensions of the work and shall include the cost of all testing, mix design, trial mixes, construction, aluminum strips, mixing, transporting, placing compacting, curing, surface finishing, protection, construction and expansion joints, and all labor and materials and tests.

Payment for Granulate Works: Payment in Sq.m

15.18 Painting works:

All painting materials should be from Approved products (ICI, Crown or Tamber).

A. White emulsion paint with primer will be used for ceilings.
B. Oil paint will be used for walls painting.
C. Oil paint will be used for timber doors and steel works.
D. Primer paint will be used for painting of steel works.
E. Hot bitumen 60/70 will be used to paint the concrete elements under the finishing floor level.
F. Two coats of hot Bitumen 60/70 must be painted by brush in two perpendicular layers and to be applied for all concrete sections and block works up to the plinth level as shown in the drawing and according to the Engineer's instructions.

15.19 Polycarbonate Works:

The contractor has to achieve the following specifications.
The contractor has to supply and install the polycarbonate shells according to the manufacturer instructions.

15.19.1 Forming
Forming Paltough sheets should always be done when the formed zone is at a temperature above the “Glass Transition Temperature” (T.G.) which is approximately 150°C. Any failure to do so will result in high internal stresses that might greatly decrease impact resistance and increase chemical sensitivity. Unlike other plastics, these internal stresses cannot be seen by the naked eye and can only be detected with the use of a light polarizer. Annealing can solve this problem in certain cases, however, the problems encountered in annealing make it complicated and inefficient.

15.19.2 Thermoforming:
When thermoforming is done, it is always recommended to pre-dry the sheet. A predried sheet can be safely heated up to 180° - 190°C. At this temperature, the sheet will lend itself to deep-drawing and tight curve forming.

15.19.3 Pre-drying conditions:
Paltough and Palsun sheets should be pre-dried at 120°C. Palsun Mirror and Reflective sheets should be pre-dried at 110° - 115°C. The duration of pre-drying is dependent upon the amount of humidity absorbed by the sheet and by its thickness. Therefore, the best method to determine the pre-drying time is as follows:

- Cut 2-3 small pieces from a sheet in the sample batch.
- Place these pieces in an oven at the pre-drying temperature (110° - 120°C).
- At predetermined intervals of 2-3 hours, take out a piece and heat it to the forming temperature (170° - 180°C).
- Check for the appearance of bubbles in the piece. If no bubbles appear after 10 minutes, the sheet is dry. If bubbles do appear, additional pre-drying is necessary.
- After determining the pre-drying time, proceed to pre-dry the production items.

15.19.4 Thermoforming with P.E. Masking:
Paltough sheets must masked by a P.E. foil that is designed to tolerate thermoforming. However, if lengthy pre-drying is necessary, the P.E. may leave marks on the surface which might be unacceptable in circumstances where high optical quality is required. In these cases, it is necessary to remove the masking foil before pre-drying.

1. Vacuum Forming
Is to accomplish with a pre-dried sheet on any good vacuum machine. It is preferable to use automatic machines that grip the sheet from all sides during the entire process. This is especially important when working with thin sheets of 1-2.0 mm. Such sheets might exhibit shrinkage of up to 5% and must be attached firmly to a frame. Vacuum forming without pre-drying should be done very carefully. Sheet temperature should not exceed 160°C. Uneven heating, resulting in local heating above 160°-165°C, will cause bubbles to appear in the overheated area.
2. Pressure forming
Is a process like vacuum forming. This method is possible without pre-drying, since the draw ratio is not high and the shape is very simple (spherical or near-spherical).

3. Drape Forming
Can be done without pre-drying, but the P.E. masking foil must be removed because it requires long heating times at high temperatures. If the sheet is not pre-dried, only accurately controlled air circulation ovens should be used in order to prevent local overheating. It is necessary to examine the sheet and its shrinkage, since, in this method, the sheet is not attached to a frame that prevents shrinkage.

4. Hot line Bending
Can be done without pre-drying, but this also requires accurate control of the temperature. Initially, overheating will be detected at the edges of the bending line where the sheets heat more rapidly. Extreme care should be taken not to force the bend at a temperature below 155°C. Failure to do so will induce internal stress that will cause the sheet to lose most of its impact resistance. It is highly recommended to experiment with small pieces, checking them for impact resistance by hitting the bend line with a heavy hammer while the piece is lying on the floor or work table, with the bend line up. Breakage of the piece indicates that the bending temperature was too low. When bending sheets of more than 3mm thickness, only tow-sided bending machines will produce satisfactory results. Hot line bending can be performed with the P.E. masking foil on the sheet, except when working with a thickness of 6mm or more. In such cases, heating time and temperature on the surface of the sheet will be too high, causing the P.E. to melt locally. It is possible to remove the P.E. along the bend line before forming, thereby eliminating melting of the P.E., while protecting most of the sheet surface for convenient handling after forming.

15.19.5 Thermoforming Palsun Mirror and Reflective P.C.:
All methods mentioned for forming Paltough and Palsun sheets are applicable, with some exceptions and limitations. Pre-drying should be conducted at 110°C-115°C. Care should be taken to allow for longer periods of time than for pre-drying regular P.C. Drawing will lower the reflectivity of the sheet, relative to the draw ratio. Better optical quality is achieved when the laminated surface is on the outside of the object. However, if the object is for outdoor use, the U.V.-protected side (the un laminated side) should face outward. Hot line bending and infrared heating will require longer heating times because of the reflectivity of the sheet. The forming and drawing ratio are limited, since at a certain depth the laminated layer will start to tear.

15.19.6 Fabricating
1. Cutting:
Paltough sheets are easily cut with wood-cutting saws. Avoid using high-speed equipment made for cutting steel, since the friction tends to melt the P.C. Guillotine shear cutting is possible, but not recommended for thicknesses of more than 5-6mm, as the cut edge will usually be rough and distorted. Laser cutting with industrial I.R. laser machines is possible. The cut usually looks burnt and internal stress may result due to high local temperature. When laser cutting, it is recommended to anneal the part at 130°C for 1-2 hours. Water jet cutting with a properly tuned machine can give good results.

2. Machining:
P.C. is easy to machine. Special care should be taken to preneve overheating and melting due to high friction. If high turning speeds are used to achieve good surface quality, it may be necessary to stop the machine periodically to allow the part to cool. Sharp tools are essential in preventing friction heating.

3. Cutting Mirror and Reflective P.C.:
These products should always be cut with the laminated side of the sheet facing up. Cutting with this surface down will result in delamination of the reflective layer as a result of the up-and-down motion.

15.19.7 Bonding
At Paltough, we have tested several systems that we recommend for different bonding applications.
For small works in which high impact resistance is not essential, it is convenient to use hot-melt adhesive guns. The best hot-melt is the Polyamid-based type, though others such as E.V.A. are also effective.
For semi-structural, high-impact, outdoor weather resistance uses (bonding sheet edges in skylight domes to the frame or to another sheet, building aquariums, sealing car window frames, etc.), we recommend “Dow Corning’s” Q3-7098 silicone adhesive. this adhesive requires no primer besides degreasing with isopropyl alcohol if the sheet surface is not clean. The adhesion to P.C. is excellent and application with a 300cc tube dispenser is convenient. It bonds P.C. to metals, glass and other plastics, including P.C. itself. The only drawback is that the adhesive is not available in transparent colors, but only in opaque white, grey or black.
For superior bonding strength, impact and tear resistance as well as high transparency, “Engineering Chemical’s” Polyurethene HE 17017 and HE1908 are recommended. These are tow component type systems that are more difficult to work with than single component adhesives. These should be used only where the highest mechanical and optical properties are required, such as ballistic glazing in which P.C. and glass are bonded together.
For bonding flat sheet part such as mirrors or small shelves to flat surfaces such as walls, doors, ceramic tiles etc., we recommend “3M’s” double-sided stick tape 4930. This is an acrylic foam adhesive that offers excellent adhesion of P.C. to flat surfaces. There are many other adhesives that are compatible with P.C., but extreme caution should be used to avoid use of any that are solvent-based. Solvent-based adhesives can and do cause serious failures in critical places. Furthermore, it should be noted that some adhesive tapes of the pressure-sensitive type contain solvents or solvent traces which may cause stress cracking only months after application.
Our laboratory offers a testing service for those clients who wish to check if an adhesive is compatible with Paltough products.
15.19.8 Cleaning and Finishing

For cleaning and degreasing before painting or bonding, use isopropyl alcohol (IPA). Apply with a soft cotton cloth or cotton wool. If the IPA contains water and water droplets appear after the IPA has evaporated, finish by wiping with a dry cloth. This method may also be used if any marks remain from the P.E. masking foil. For cleaning, dusting or polishing glazings, we recommend the use of Palbrite. This is a special polish for Paltough P.C. which contains special designed waxes and solvents. Palbrite cleans sheets without scratching, while leaving a waxy, glossy, protective layer that is anti-static and dust-repelling. The lubricating effect on the sheet’s surface also serves as an abrasion resistor. The ideal maintenance procedure is to clean and polish the sheet once very 1-2 weeks with Palbrite. It is possible to clean with soap and water, but this may result in residue build-up that will eventually require further cleaning. If this method is chosen, use only mild detergents. Glass cleaning agents that contain ammonia should be avoided as they will damage the P.C.

15.19.9 Painting

It is possible to paint Paltough sheets with a variety of painting agents. Two component paints such as polyurethane or epoxy-based paints are usually compatible. We suggest that solvent-based paints be avoided, as most solvents and thinners may damage P.C. If, however, very rapid drying is possible and all residues of the thinner evaporate immediately, it is possible to use standard printing or silk screen equipment and paints. Most paint suppliers have standard paints which are compatible with P.C. In case of doubt, a compatibility test of a specific paint with Paltough can be performed in our laboratory.

15.19.10 Chemical Resistance

Polycarbonate is soluble in a number of technical solvents. Ideal solvents include: methylene-chloride, ethylene-chloride, chloroform trichloroethane, tetrachloroethane, m-cresol and pyridine. Relatively poor solvents for Polycarbonate include: dioxane, tetrahydor furan, cyclohexanone and dimethylformamide. Examples of swelling agents are: benzene, chlorobenzene, tetralin, acetone, ethyl acetate, acetoneitrile and carbon tetrachloride. P.C. is resistant to: mineral acids (even in high concentrations) many organic acids, oxidizing and reducing agents, neutral and acid salt solutions, many greases, waxes and oils, saturated, aliphatic and cycloalitalic hydrocarbons and alcohols, with the exception of methyl alcohol. P.C.’s resistance to water may be described as good, up to a temperature of approximately 60°C. At higher temperatures, gradual chemical decomposition occurs, the extent and speed of which depend on time and temperature. P.C. is, therefore, not ideally suited for prolonged contact with hot water. Its behavior following repeated, brief contact with hot water is more favorable. For example, tableware was washed over 1000 times in dishwashing machines and no adverse change in the plastic materials could be detected. P.C. is chemically degraded by aqueous or alcoholic alkaline solutions, ammonia gas and its solutions and amines. P.C.’s resistance to chemicals and various other products it summarized in the following table. The test results were obtained using moldings that were low in stresses. The samples were immersed in the respective media for six months at 20°C without any mechanical load. Resistance of P.C. depends not only on the nature of
the chemical to which it is exposed, but also on the concentration, the temperature
during the period of contact, the length of this period and the stress conditions within
the molding. When contact is brief, P.C. may, therefore, show adequate resistance to
a number of chemicals to which it is not resistant under the test conditions described
above. It is recommended that a separate test be conducted in situations where the
service conditions differ from the above test conditions.
In selecting the test media, the most important ones were chosen from all fields. In
many cases it will be possible, on the basis of this information, to draw conclusions as
to the behavior of chemically similar media not tested here. In case of doubt, a
compatibility test of specific materials with Paltough P.C. can performed in the
Paltough Laboratory.

15.20 Measurement and Payment
The prices inserted in the Bills of Quantities for the polycarbonate works and
payment thereof shall be based on net finished specified dimensions of the work
and shall include the cost of all testing, construction and transporting and all
labors and materials and tests.

Payment for Polycarbonate Works: Payment in Sq.m
16 ROADWAY LIGHTING

16.1 General

One) All Control cabinets, cables, lighting masts including holding down bolts with nuts and washers, brackets, luminaries, flood lights, lamps, service cut-outs and appurtenances will be supplied, delivered, installed tested and commissioned by the contractor, or as itemized in the Bill of Quantities.

Two) The Contractor shall supply and install all cabling and warning tapes required for the roadway lighting starting from the proposed feeder pillars to the end of the lighting circuit. The local Electricity Authorities shall supply and install the supply cables to the Feeder pillars.

Three) The Local Electricity Authority shall install any new sub-stations required for the system.

Four) The Contractor shall be responsible for the civil works of the roadway lighting system (except as otherwise specified) the layout for which is shown on the drawings. This work may include road sign illumination and under-bridge lighting.

Five) The works include also the provision and installation of duct crossings for service cables. The installation of ducts to the required diameter shall be according to the clauses of these Specifications.

Six) The position, type of ducts and constructional details are shown on the Drawings but final location will be determined on the basis of the approved shop drawings by the Engineer.

Seven) The Contractor shall liaise with the Municipality Street Lighting Section Engineer and co-ordinate his activities where appropriate, with the Electricity and Water Authorities.

Eight) The base/foundation connection to be adequately grouted. No site welding will be permitted. Galvanized steel holding down bolts shall be conforming to BS 4360 Grade 50C. The Contractor shall supply a precision made steel template to ensure correct horizontal and vertical holding down bolt alignment with 2 nuts below and on top of mast base-plate.

Nine) All stainless steel components shall be of Grade AISI 316.

Ten) Materials and equipment shall be suitable for use under the prevailing conditions of a harsh marine environment.

Eleven) In calculating the rating of electrical cables, switch-gear and all items of equipment, the necessary derating factors shall be determined and applied to ensure that the equipment will operate satisfactorily and meet its design criteria.

Twelve) The electrical supply system shall be 380/220 volts, 3-phase, 4 wire, 50 Hz and supplies shall be made available at appropriate locations by Electricity Authorities.

Thirteen) Layouts of conduits to be detailed by the consultant. The contractor shall confirm the detail and submit to the Engineer for approval before commencing construction of any structure.

16.2 Reference Standards

- The installation shall comply with:
 Relevant British Standards and Codes of Practice, or equivalent as approved by the Engineer.
 Standards and Recommendations issued by the International Electro-Technical Committee.
 IEE Regulations and guide and the general requirements of the local supply authority.
 Chartered Institution of Building Services Guide Book (IES) for external lighting.
 CEI
 VDE
 International Commission of Illumination (CIE) recommendations on lighting.
 All Standards and Codes referred to shall be the latest issue at the time of invitation to Tender.

One) MAIN POWER SUPPLY

The Contractor shall contact the supply authority at an early stage of the Contract to make all the necessary arrangements for the power supply.
The supply for the lighting masts will be from new and/or from existing feeder pillars located as shown on the Drawings. Power supply to new feeder pillars shall be from new, or existing DEWA sub stations as shown on the drawings.
The supply will be 3 phase and neutral 380/220V, 50 Hz.

Two) Check of equipment supplied by Others

The Contractor shall ensure that all equipment supplied by others forming part of his installation shall be new and in accordance with the standards required. Any defect must be reported in writing within seven days of receipt of the equipment in order to allow changes to be made or replacements instructed by the Engineer.
The following are the general conditions under which the cable shall operate:
Electrical energy is generated as three phase alternating current at a frequency of 50 ± 5%.
The working voltage on any of the systems does not normally exceed fluctuations ±10% above the nominal voltage.
The material covered by this specification shall be suitable for operation during the varying atmospheric and climatic outdoor conditions in Palestine.

Three) Distribution Cables

All cables accessories and materials shall be of the best quality and most suitable for local climatic conditions and shall be such that the cable shall withstand without damage, any conditions arising from short circuits, switching operations and sudden variations of load and voltage as may be met under normal working conditions. The cable shall be suitable to be buried directly in saline soil. The Contractor shall submit for approval a sample cut-piece of each type of cable and one metre length of any cable size with the required embossment or with non erasable print. The materials are to be accompanied by
manufacturers installation instructions. This specification provides for manufacturing, testing of four core power stranded copper conductor XLPE/SWA/MDPE cable, rated service voltage 600/1000 volts.

Four) Conductors

− The conductors shall be stranded plain annealed copper in accordance with IEC Publication 228: Conductors of Insulated Cables or BS 6360:1981.
− The conductors shall comply with the test requirements mentioned at Clause 9 of BS 6360:1981 and test certificates from independent authorities/ labs. shall be submitted.

Five) Insulation

− The insulation shall be XLPE (GP8) complying with table 16 of BS 5467:1989 and BS 6899 in addition to IEC Publication: 502:1983 Table III.
− Test Certificates from independent approved bodies/ authorities to be submitted prior to delivery to site.
− The insulation thickness shall comply with BS 5467:1989 Clause 6, Table 16.
− Core insulation colors shall be Red-Yellow-Blue-Black.
− The insulation shall meet the Test Requirements mentioned in the following standards:-
  − Section three of IEC Publication 502:1983.
  − Clause 20 of BS 5467:1989 relating to compatibility.
  − BS 6234:1987
  − Clause 5, Table 5 of BS 5467:1989 relating to insulation.

Six) Bedding

− The inner sheath shall be black extruded PVC bedding complying with the requirements of BS 5467:1989 and BS 6746:1984 for type 9 compound or IEC Publication: 502:1983.

Seven) Fillers and Binders

− Non hygroscopic synthetic fillers to be applied ithbedding in accordance with BS 5467:1989 Clause 8 and IEC Publication: 502:1983 to form a compact acicular cable.
− The fillers and binders shall comply with the compatibility test given in Clause 20.1 of BS 5467:1989.

Eight) Wire Armour

− The armour shall consist of a single layer galvanized steel round wires of appropriate size mentioned in Table 16 of BS 5467:1989, and IEC Publication 502:1983. The armour wires must cover the entire periphery of the inner sheath as per BS 5467:1989.
Eight) Armour Tests

- Samples of galvanized steel armour wires shall be tested for mechanical strength and electrical resistance in accordance with BS 5467:1989, and BS 1442:1969, respectively.
- Testing requirements for zinc coatings on steel wire and for quality requirements shall comply with BS 443:1982. Test Certificates from independent approved authorities/laboratories shall be submitted prior to delivery to site.

Nine) Oversheath

- The oversheath shall be MDPE (Medium Density Polyethylene) type TS2 complying with BS 6234:1987.

Eleven) Testing of Cables

- Tests on the complete cable shall be carried out according to the schedules given in Table 5 under Clause 15 of BS 5467:1989. Test Certificates from independent approved authorities/laboratories shall be submitted prior to delivery to site.

Twelve) Earth Cable

- This specification provides for manufacturing and testing of single core stranded copper conductor PVC cable (non-armoured). The cable, in general, shall comply with BS 6004:1984.

Thirteen) Conductors

- The conductors shall be stranded plain annealed copper in accordance with IEC Publication 228: Conductors of Insulation Cables or BS 6360:1981.
- The conductor shall comply with the test requirements mentioned at Clause 9 of BS 6360:1981 and test certificates from independent authorities/ laboratories shall be submitted.

Fourteen) Insulation

- PVC insulation complying with the requirements of BS 6746:1984 for type 9 compound Radial thickness of insulation and outer diameter according to table 1 of BS 6004:1990.
- Compliance to the requirements shall be checked with the appropriate tests listed in table 8 of BS 6004:1990. Test Certificates from independent approved bodies/laboratories shall be submitted prior to delivery to site.
- Insulation Colour: Yellow-green.
Fifteen) Sealing & Drumming of Cables

- Before dispatch, the manufacturer shall cap the ends of all cables so as to form a seal to prevent the ingress of water during transportation and installation.
- All cables shall be delivered to site with the manufacturer's seals, labels or other proof of origin intact. The labels and seals shall be retained for inspection by the Engineer.
- Each drum length of cable shall be allotted a distinctive and separate reference number. This number shall appear on the Test Sheets covering the respective length of cable and shall also be clearly marked on the cable drum. All cables shall be capped on the drum to prevent the ingress of water.

16.3 Cable Installation

1- General

One) The arrangements of cables and all methods of installation shall be subject to approval by the Engineer.

Two) Cables shall be installed in one length from terminal point to terminal point. The radius of each bend or change in direction of the route of any cable shall not be less than the IEE Regulations, the relevant BS specifications, or the cable manufacturer's recommendations, whichever is the greater.

Three) Multi-core cables carrying alternating current for three phase working shall be laid strictly in accordance with the IEE Regulations.

Four) The Contractor shall lay in the trench along with the power cable a single core copper earthing cable of not less than 16 sq.mm diameter for 4x16, 4x25 and 4x35 sq.mm dia, 25 sq.mm for 4x50 sq.mm dia and 35 sq.mm for 4x70 sq.mm dia power cables respectively. The earthing cable shall run all the way from the feeder pillar to the last column on each circuit. Looping of the earthing cable shall be made inside each column.

2- Cables Laid Directly in the Ground

One) The Contractor shall excavate trenches along approved cable routes to the minimum depths shown on the detailed drawings.

Two) All loose rock, stones and other sharp materials shall be removed from the trench.

Three) The Contractor shall supply washed sieved sand and cable warning tapes. He shall supply and lay these materials along the trench route as specified in the drawings.

Four) The Contractor shall lay, level and compact clean sand in the bottom of the trench to a depth of 75 mm before laying the cables. After laying the cables he shall then cover them with a further 75 mm of clean sand, level and compact. The backfilling of the trench, including the laying of PVC warning tape, shall then be completed in accordance with the specifications.
Five) The Contractor shall leave for future use in cable trench loops of one meter cable at the entry and exit duct of each foundation.

3- Cables Laid in Ducts

One) Where cables cross under roads and paved areas they shall be drawn into ducts provided complete with temporary tapering wooden plugs of suitable diameter to prevent the ingress of soil into the ducts.

Two) The removal of temporary plugs, rodding and cleaning of the ducts shall be carried out by the Contractor. The ducts shall be sealed with suitable sealing material after the cables have been drawn through.

4- Cables in Concrete Trenches:

One) Cables in concrete trenches shall be installed in a support system comprising moulded reinforced nylon hooks and clamps attached into a heavy gauge galvanised steel channel fixed to the walls by stainless steel Grade AISI 316 cast-in ragbolts or by stainless steel grade AISI 316 threaded studs grouted into percussion-drilled holes with polyester resin anchor grout.

5- Cables Fixed to Steel Work or Concrete Walls:

One) XLPE insulated cables installed on steel work shall be held in moulded reinforced nylon hooks and clamps which shall be spaced so as to avoid sagging of cables. In no instance shall the spacing of the cleats exceed 750 mm.

Two) All cleats and runs of cables shall be arranged in the nearest and least obtrusive manner.

Three) All steel work required for supporting cable cleats, shall be galvanized and painted as specified for Miscellaneous Metal work.

6- Cables in Saddles:

One) Where MICC/PVC cables are required to be fixed in saddles, PVC sheathed copper fixing saddles shall be used. Saddles shall be fixed with stainless steel grade AISI 316 the PVC saddle sheath which would allow galvanic action between the saddle and its fixing.

Two) Runs shall be neat and free from kinks, care being taken in the routing to avoid risk of damage to or interference with other equipment.

7- Cable Support Spacing:

Spacing of cable supports shall be as laid down for the relevant size and type of the cable in IEE Regulations and the relevant BS specification.
8- **Termination of Cables**

One) All jointing materials shall conform to the relevant requirements of the British Standard/IEC Standard and the Contractor shall state the types of compounds he proposes to use.

Two) All cables shall be color-coded in accordance with the IEE Regulations. In the final sub-circuits, cores shall be identified by the colors red, yellow or blue as appropriate. Tapes and sleeves will not be permitted.

Three) The Contractor shall allow for at least 300 mm of the cable to be cut off immediately before the termination is made. This requirement shall apply to all cable ends.

Four) All cable ends are to be sealed against the ingress of water, deleterious matter, etc..

9. **Earthing System**

One) Contractor shall install an earthing system to the last column/mast of every circuit including all feeder pillars as shown on the Drawings. The earth installation shall in general be in accordance with British Code of Practice CP 1013, and in accordance with the requirement of Electricity Authority Regulations and guide.

Where the requirements of the Electricity Authority Regulations and guide differ from those of the IEE Regulations, the former shall prevail.

Two) Electrodes shall consist of 16 mm minimum diameter hard drawn copper rod driven vertically to a minimum depth of 3.0 m. Rods shall be complete with hardened steel tip and driving cap. Rods shall be capable of being extended in lengths, as necessary, by the provision of permanent screw mechanisms.

Three) A PVC coated earth continuity conductor of 75 mm2 cross-section copper cable shall be inserted between the earthing stud in the pillar or lighting column and the earth electrode. The connection of the copper tape cable to the earth electrode shall be made by means of a suitable conductor clamp. After final acceptance tests, the connection shall be wrapped in petrolatum impregnated tape.

Four) The earthing conductors shall have a minimum current carrying capacity in accordance with CP 1013.

Five) Each electrode shall be driven to a depth such that it penetrates the summer water table by minimum of 2 metres.

Six) Earth electrode distance should not exceed 5 metres out of centre of foundation of last column, and at an agreed location adjacent to the feeder pillar.

10. **Earth Electrode Terminations**

One) Every connection of an earthing leads to an earth electrode shall be made in a pit measuring approximately 300 mm x 300 mm x 300 mm. The connection
shall be soundly made by use of hard soldered joints, or clamps. All earth electrodes and earthing leads shall be of copper.

Two) The contractor shall ensure that throughout the installation all metallic parts of all equipment, other than current-carrying conductors, are bonded to form a continuous path by way of connecting the armouring (or earth conductors) of the local authority's cables at feeder pillars, sub stations, etc.

Three) After installation, the pit shall be filled with sand and a removable cover placed on pit.

11. Testing After Installation

After cable laying and installation of earthing systems the Contractor will perform the following tests:-

1st) CONTINUITY OF CONDUCTORS:

− A test shall be made to verify the continuity of each conductor, including the earth continuity conductor of each circuit.

2nd) INSULATION RESISTANCE TEST:

− This test will be applied to each section of cables and will comprise of:-
  − Phase to phase insulation resistance.
  − Phase to neutral insulation resistance.
  − Phase to earth insulation resistance.
  − Neutral to earth insulation resistance.

  • The resultant insulation resistance for any of the above measurements shall not be less than 8 to 10 mega ohm per meter cable length and measured with 1000 volt.
  • For these tests, a voltage not less than 2.5 times the normal voltage of the supply shall be applied for the measurement of insulation resistance.

3rd) Earth Resistance Test:

− To be performed with specific calibrated earth resistance meter. The resistance of any point in the earth continuity system of the installation to the main earth electrode shall not exceed 1 ohm, and the resistance to earth at this termination shall not exceed 0.5 ohm.
− Inspection certificates, completed by the Contractor shall be generally in accordance with IEE regulations.
− Brand type and calibration report of test equipment used for testing the electrical installation by the Contractor shall be subject to the approval of the Engineer.
− These calibration reports are to be submitted to the Municipality Street Lighting Section along with the test results prior to the commencement of the maintenance period.
− Owing to the highly corrosive nature of the sub-soil at certain locations the Electricity Authority shall be consulted regarding the metal to be used for the earth termination.
12. Concrete Foundations for Masts

One) Concrete for the foundations shall be Class 30 in accordance with these Specifications.
Two) The cement content shall be increased by 10% if any part of the foundation is below the water table.
Three) The Contractor shall provide the Engineer with shop drawings with supporting design calculations for approval prior to construction of the foundations.
Four) A sample foundation is to be approved by the Engineer and Municipality Roads Lighting Section before commencement of the work and the same standard is to be maintained throughout the contract.
Five) Denso tape shall be placed on the exposed section of the threaded part of the holding down bolts before casting the foundations. After concreting the bolts shall be thoroughly cleaned, greased and checked with a template to ensure accurate placement.

13. Existing Street Lighting Facility

Street lighting services which fall within the site of the works which are damaged by the Contractor shall be repaired/rectified by the Contractor within 24 hours. The Contractor shall be responsible for obtaining road closure permission where applicable and to provide necessary material and manpower.

SPECIFICATIONS FOR CONVENTIONAL (1-16 METERS) ROADS LIGHTING POLES (COLUMNS) & BRACKETS

1st) General

The road lighting poles are intended to hold one or more lanterns, and consist of one or more parts: a post, possibly an extension piece and, if required a bracket. The road lighting poles, in general, shall comply with the requirements of BS 5649: Part 1 to 8.

2nd) Specific

- Pole up to a height of 14 meters shall be of one solid piece other than the bracket. Poles of 16 meters height shall be made of not more than two sections.
- The light poles shall be suitable for supporting a lantern array as shown on the drawing.
- The pole shaft shall have an octagonal cross section, continuously tapered and longitudinally welded. The welding of the steel lighting pole shall be metal-arc welding complying with BS 5135. No circumferential weld shall be accepted.
- All pole shafts shall be provided with substantial rigid flange plate, thickness as per drawing, with an opening for cable entry.
- The plate shall be welded with the shaft with 2 Butt welds from inside and outside. The weld shall be metal-arc welding complying with BS 5135.
- The pole shaft shall be fabricated from a high strength structural steel complying with the requirements of BS 1840.
- The steel used for the fabrication of the shaft shall be of material conforming to BS 4360, 'weldable structural steels', Grade 50 C, ageing resistant and suitable
for hot dip galvanizing. Alternatively, steel conforming to or better than Euronorm 25-72 grade FC 360B shall be used in accordance with BS: 5649: Part 3:1978.

− The flange plate shall be fabricated from mild steel conforming to BS 4360, Grade 43 C.

− The brackets shall be fabricated from steel conforming to BS 4360, Grade 43 C.

− The anchor bolts, shall be fabricated from steel conforming to BS 4360, Grade 50C Euronorm 25-72 grade FC 360B as per BS 5649: Part 3:1978. Each anchor bolt to be provided with 2 Nos. nuts & 2 Nos. washers.

− Poles, Flange plates/base plates, doors, Brackets, Anchor Bolts, nuts and washers shall be protected against corrosion from inside and outside in compliance with the requirements of BS 729:1971 (The minimum average zinc coating weight on one side should not be less than 714 g/sq.meter) and clause 4.2, 4.3, and 4.4 respectively of BS 5649: Part 4:1978 or EN 40: Part 4.

− Poles with bracket(s) and lantern(s) shall be able to withstand a wind-speed of 160 km/hr. including gust factor. The maximum stress for a wind-speed of 160 km/hr. shall not exceed 50% of the minimum strength of the material. The design loads shall meet the requirement of BS 5649:Part 6: 1982.

− The maximum horizontal and vertical deflection at the top of a pole, shall not exceed the value given in Clause 6.5 of BS 5649: Part 7:1985.

− The maximum allowable tolerances for the pole, bracket(s), base plate/flange plate and anchor bolts shall comply with BS 5649:Part 2:1978 and EN40:Part 2.

− The relevant thickness and dimensions of poles, brackets, doors, base plate/flange plate and anchor bolts shall be as shown on the drawing.

− The poles and vertical parts of the arm bracket(s) shall be constructed, so that the exterior surfaces of the poles shall be free from protuberances, dents, cracks or other imperfections. Appropriate wrapping and packing is to be done before shipping to maintain this quality and to preserve the finish during shipping and storing. Anchor bolts shall be packed in wooden boxes.

− The lighting pole to be adequately reinforced and strengthened at the location of the inspection compartment opening to compensate for loss in section of the post at this point

− The poles shall have a base compartment with a vandal resistant, dust and waterproof door for housing the service cut-out. The door opening shall be of adequate dimension as shown on the drawing for easy access and maintenance.

− A galvanized corrosion resistant steel clamp for fixing a wooden board for mounting the service cut-out shall be welded inside the base compartment. The wooden board must be provided in the compartment. It shall be easily removed and refixed to steel clamp provided. The wooden board shall be not less than 20mm thickness seasoned Marine Ply and be of the same size as the compartment door and shall be non-hygroscopic and rot resistant.

− The base compartments and cable ways shall comply with the requirements BS:5649:Part 5:1982

− A 30mm long threaded stud of corrosion resistant steel carrying 2 nuts and 2 washers to be provided for earth connection. The stud to be located in an easy accessible place near the inspection cover inside the lighting column (stud diameter to be of M8 size) in compliance with Clause 5 of BS 5649:Part 5:1982 or EN5:Part 5.
The door shall be flush & secured by a positive action lock which forces the door out when opening. All loose parts of the locking device shall be so arranged that they are held captive on the door when it is in the open position. All the moving parts of the locking device shall be stainless steel of Class 316 material. An approved neoprene sealing gasket shall be affixed to the door opening to ensure a water-proof and dust proof enclosure to IP 53. There shall be a stainless steel chain (6mm), class 316-material strength, between the pole and the door to ensure the door cannot be lost if incorrectly secured.

The structural design of the poles (columns) shall be tested in accordance with BS 5649:Part 8:1982. Test certificates from independent approved authorities/laboratories shall be submitted along with the tender.

3rd) Miscellaneous Requirements:

- Offered material shall be supplied exactly as indicated on specifications and drawings.
- Shipment will be allowed only after the approval of the free sample given by the contractor.
- Erected poles shall be clean, free from dust, debris and damages.
- A test certificate from an independent laboratory shall be submitted confirming the galvanization coating weight and component composition, as specified elsewhere.

4th) Design Information:

The contractor shall submit for approval the following design calculations and data prior to the fabrication of any part of the light poles or brackets.

- Shop drawings showing general dimensions of all components of the pole including mounting bracket(s) for single and multiple luminaries array.
- Detailed scaled shop drawings of both pole and luminaries mounting brackets.
- Shop drawings giving the details of the fixing and locking system between the pole and the luminaries mounting bracket.
- The total maximum load moments for each section under maximum stresses.
- Computation of stresses in the base plate and anchor bolts, under maximum wind-load with maximum number of luminaries in place. Consider the weight and the windage area of each luminaries to be 12.5 kg and 0.15 sq. meter respectively.
- Maximum deflection at the top of the pole, under conditions and wind velocities mentioned earlier.
- Contractor may submit any new treatment method for extra protection against corrosion of the base plate area and up to the height of 300mm.
- Detail calculations of the necessary strength for anchor bolts to be used should be submitted for different heights of pole.
- Means of assembling two section poles (e.g. 16m poles) shall be indicated in detail.
- Impact resistance calculations at a height of one meter above the base plate of the column.
- Maximum tolerable impact calculations to shear the plate from the pole from an impact point one meter above the flange plate.
- Materials specification for each parts of the column.
Contractor shall provide along with the samples, table showing all data and all test results mentioned under above and indicate deviations from contract specifications, if any.
14. Street Lighting Luminaries & Flood Lights

1st) General

- The luminaries and flood lights shall be designed to receive one high pressure sodium and/or mercury lamp, with internal control gear necessary for the operation of the lamp. Luminaries shall operate on 220 Volts AC, +/-10% at 50 Hz +/- 5%.
- The street lighting luminaries and flood lights shall follow the provisions of the latest versions of the following standards:

1. BS 4533
2. BS 4533 : Part 102 Section 102.3: 1990
3. BS 1615
4. BS 1470
5. BS EN 60922:1991
6. BS EN 60923:1991
7. BS 6500:1990
8. IEC 598 Part 1 and 2
9. BS 4533: Part 103: Section 103.1:1988
10. BS 5489 Part 1, 2 & 3:1992
11. BS 5225: Part 1
12. BS 5101 (Part 1) and (Part 2)
13. BS 6193:1990
14. BS 3772:1990
15. BS 2011 (Part 1.1:1989 and Part 2.1 all)

2nd) Construction

The luminaries and flood lights shall accommodate lamps with cap base E 40 size, as complete with the following assembly.

- Injected molded silicon aluminum alloy casting body in two compartments as per Clause A2, section 1.4, BS 4533 Part 1.
- Super purity one piece aluminum reflector of grade S1 of BS 1470 with an anodic coating of not less than grade AA10 of BS 1615.
- Strong very high thermally resistant and mechanically transparent protector. The protective bowl or diffusor shall be made of toughened glass.
- Neoprene gaskets/or high quality felt gaskets silicon.
- Stainless steel hinges, mounting clips and fastening bolts, Grade AISI 316.
- Movable porcelain lamp holder with position markings and anti - vibration fixation device.
- Complete control gear (as per BS 4782 : 1971) mounted on easy removable equipment mounting board.
- Two adjustable cable entries.
- A teblock for the connection of incoming supply cables shall be provided in luminaries incorporating auxiliaries and shall be situated as close as possible to the point of entry of the supply cable and shall accessible.
- A means of clamping the electrical supply cables shall be provided in the lantern where necessary to relieve the termination of strain. The cable clamp arrangement shall not damage the insulation of the cable.
3rd) Mechanical Requirements:

- Luminary shall be with separate compartments for the optical system and for the control gear.
- The tightness of the optical compartment shall be IP65, according to the I.E.C. 598-1 standard (International Electro-technical Commission). This tightness degree shall be achieved by the use of neoprene gaskets or silicon gasket. The design of the luminary shall be such that the sealing gasket will never be exposed to sunlight or to the luminous flux emitted by the lamp.
- The tightness of the control gear compartment shall be IP54 or better, according to the I.E.C 598-1 standard.
- The opening of the control gear compartment shall allow a complete and easy visual check of all electrical parts and shall be suitable for easy access and easy maintenance.
- The mechanical strength of the body its accessories and the protector of the luminary shall be sufficient to withstand without any damage the drop test as per BS 2011 Part 1.1:1989 & Part 2.1 Ea.
- The luminary shall be able to withstand without any damage a wind speed of 160 km/h including gust factor.
- Special precautions shall be given to the choice of materials which shall be able to resist without any damage or aging or alteration in its structural or physical properties, the severe Gulf climatic conditions, as indicated under the specifications, in addition, to the heat emitted by the lamp.
- Fixing shall be of an effective locking means using stainless steel bolts.
- The weight of the luminary including protector cover and control gear shall not exceed 15 kg.
- The luminary in general shall comply with the requirements mentioned at BS 2011.
- All fixings which carry the weight of the lantern and internal accessories shall be provided with suitable locking devices to prevent the dislodgment of any part of the lantern by vibration either in service or in maintenance. Compliance shall be checked as per BS 2011 Part 1.1:1989, and Part 2.1 Ea. to Ef.

4th) Electrical Requirements

- Provision for one lamp for each lantern shall be made. The electrical accessories such as ballasts, ignitors and capacitors shall be prewired and preassembled on metallic supports that are fixed into the control gear compartment.
- Special care shall be taken to allow easy maintenance and quick replacement of the accessories. They shall be bolted (and not riveted) on the removable supports. The supports shall be laid
down in the compartment and in no case shall be suspended by bolts, for security reasons and maintenance facilities.

− All electrical accessories shall be able to withstand, in continuous operation and without any damage, the temperature existing inside the control compartment, in an ambient temperature of 50 degree C. Cable connections to the lamp holder within the lantern shall be of the heat resistant type with silicon or glass fiber or other approved insulation. The arrangement shall comply with BS 4533.

− The cable feed terminals and the earth screw shall be fixed inside the control gear compartment. A cable holder shall be mounted near the terminals. An isolating conduit shall be fitted to protect the incoming feeder cable. The arrangement in general shall comply with BS 4533.

− A separate set of control gear shall be provided for the lamp comprising one choke associated with one capacitor, one ignitor and starter (instant type) if any. The control gear should be encapsulated in an approved enclosure conforming to IP 54 tightness. Terminals of all ballasts, capacitors, ignitors (if any) and starters shall be shrouded. The ballast shall be designed to operate the lamp and control it continuously in ambient temperatures ranging from 0 degree C. to 80 degree C.

− The ignitors shall be solid state fully electronic, non-timed, multiple-pulse, super-imposed, pulse type which shall not require the use of tapped ballasts nor be dependent on external capacitors. The ignitor shall not produce a high voltage pulse across the ballast windings, and shall have screwed terminals. The ignitor shall be fully encapsulated impervious to the ingress of moisture, and shall have a temperature rating not less than 90 degree C.

− The choke shall be of reactor, non-tapped and tropicalised of Class H Insulation and Vacuum impregnated with an unsaturated polyester resin of not less than thermal class H (180 degree C. in accordance with IEC 85:1984). The capacity of the choke should be such as to keep the illumination of the lamp within the design limit. The capacitor shall be of the diphenyl impregnated type and shall be in a leak proof metal container fitted with an internal discharge resistor. The permitted operating temperature of the capacitor shall be marked on its case and shall be 85 Deg. C.

− The capacitors shall have value sufficient to raise the power factor of the complete system to 0.85 or better. Each lamp shall operate using only one choke and one capacitor. Any combination of two or more capacitors to have the equivalent value of capacitance will not be accepted. Chokes & capacitors shall comply with the latest BS EN 60922:1991 & BS EN 60923:1991.

− The control gear shall be supplied by the lantern manufacturer and shall be incorporated in a separate compartment in a way that heat emitted by lamp is not conducted or transferred to the gear
components. It shall also be distinctly marked with the month and year of manufacture, in addition, to the standard marking.

- The lantern shall have a screw type lamp holder. The lead at the higher potential above earth shall be connected to the center contact.

- The operating temperature and thermal endurance characteristics shall conform to Clause 17, Section 2.7, Part 2 of BS 4533.
5th) Photometrical Requirements:

- The lamp fitting shall be adjustable to allow the luminous flux distribution to be adapted to the geometrical installation conditions.
- The adjusting device of the lamp shall be sufficiently sturdy, and designed in a way it cannot be disturbed, during its normal life time (vibrations) or during maintenance operations (lamp replacement).
- This device shall have permanent markings so that the lamp position recommended by the manufacturer can be easily realized.
- The photometrical classification of the luminaries, according CIE Nr. 34 publication shall incorporate the following characteristics, depending on the lamp position adjustment:
  - Longitudinal flux control: Throw - intermediate or long
  - Transverse flux control: Spread - Narrow or average
  - Glare control: SLI - Greater than 3

6th) Photometrical Performance Requirement:

- Computer calculation relating to illuminance and luminance results detailed hereinafter shall be submitted. The overall luminance uniformity ratio (UO) & longitudinal luminance uniformity ratio (UI) which will be achieved on roadway, values of glare control mark (G), threshold increment (TI) and specific Lantern Index (SLI) wherever applicable shall be in accordance with the specifications.
- For the luminance calculation, the road surface to be considered is the R4 type with QO = 0.08 according to CIE Standards.
- The calculations shall be performed in accordance with CIE Nr. 30 and shall be based on the data given in the drawings. These computer calculations shall achieve the results mentioned in the drawings.
- These results are to be achieved taking into consideration a total ma factor of 0.8 (dust depreciation factor x lamp lumen depreciation factor).
- If possible to have more spacing the computer calculations shall determine the maximum spacing of poles to be adopted to achieve the above results.

7th) Documents to be submitted with the offer:

The manufacturer shall supply following technical documentation and information for each type of luminaries for the approval of the Engineer. The approval of the Engineer does not absolve the Contractor of the contractual obligations regarding the performance and compliance to the specification requirements.

- Catalogue sheet of the luminary
- Detailed construction drawing of the luminary Polar diagram of luminous intensity in road way vertical plane and transverse vertical plane.
− Utilization factor curve for actual inclination of luminary.
− Isolux diagram for actual inclination of luminary.
− Intensity table, in the C-gamma co-ordinates recommended by CIE Nr.27 Publication.
− Computer calculation printout showing the illumination and luminance levels. Longitudinal Uniformity Ratio (UI), overall uniformity Ratio (UO), specific lantern index (SLI), glare control mark (G) and threshold increment (TI).
− Tightness test certificate conforming to IP65 protection degree for the optical compartment of the luminaries and the IP 54 protection degree for the control gear compartment. This test certificate shall be issued by an independent official laboratory.
− Shock test certificate confirming the resistance of the body to an impact energy as per Clause 4.4 Section 1.4 of BS 4533, Part 1. This test certificate shall be issued by an independent official laboratory.
− Wind resistance certificate confirming that no damage will occur to the luminary at winds up to 160 km/hr. for a short period. This certificate shall be issued by an independent official laboratory.
− Total weight of the luminary (with lamp and control gear)
− Power factor of one complete luminary (under normal working conditions)
− Total electric consumption of the luminary, including control gear losses.
− Rated lumen output of the lamp under nominal conditions
− Depreciation curve of the luminous flux with burning hours
− Luminous flux variation with the main voltage
− Make and type of ballast and capacitors separately with their electrical characteristics, eg. Impedance, power factor, Temperature rise (t), max. temperature (tw) and power losses.
− The contractor shall submit with his tender full details of areas using the same type of luminaries in the Middle East and Gulf Area.
− A computer program according to CIE standard on 5 1/4" size floppy disc fully IBM compatible should be supplied and the matrix program for the offered luminary.
− The contractor shall submit for the Engineer's approval dimensional drawings of the control gear arrangements showing the exact positions of chokes and capacitors within the lantern.

8th) Materials to be submitted with the offer:
− The contractor shall submit along with the offer 5 sets of luminaries of each type to equip 5 mast for examination and photometrical test on site.
− The materials to be accompanied by manufacturer's assembling and erection instruction.
− The contractor shall carry out site testing after installation work is completed for photometric performance in accordance with the contract specification requirements. All the test shall be carried out in the presence of the Engineer. The luminance measuring device shall be provided by the Engineer.
− The final acceptance of any submitted offer shall be strictly depending on the photometric and electrical performance test on site.
17 LOW VOLTAGE FLEXIBLE POWER CABLES FOR
CONVENTIONAL LIGHTING COLUMNS AND LUMINARIES

17.1 General

The following specifications are for manufacturing, and testing of circular, flexible, copper conductor, confirming to harmonized code H05 VV-F, 300/500 Volts grade, PVC insulated, sheathed cable rated for 70 deg. C. as per BS 6500 Table 16, which is to be used inside the lighting columns between luminaries and service Cut-out.

17.2 Conductors

- The conductors shall be stranded plain/tinned annealed copper in accordance with BS 6360:1981 class 5 flexible conductor.
- The conductor shall comply with the test requirements mentioned in BS 6500: 1990 and test certificates from independent authorities/labs. shall be submitted.

17.3 Insulation

- The insulation shall be PVC insulation Type TI2 complying with BS 6500: 1990 suitable for 70 deg. C.
- Test Certificates from independent approved bodies/authorities to be submitted with the offer as evidence.
- The insulation thickness shall comply with BS 6500:1990 Table 16.
- Core insulation colors of each core shall be as per Table 16 of BS 6500: 1990.
- The insulation shall meet the Test Requirements mentioned in BS 6500.

17.4 Sheath

1st) Type:

The sheath shall be PVC type TM2 complying with the latest edition of BS 6500.

2nd) Thickness:

Thickness of sheath should comply with Table 16 of BS 6500: 1990.

3rd) Testing:

Tests on the complete cable shall be carried out according to BS 6500: 1990. Test Certificates from independent approved authorities/laboratories shall be submitted with the offer as evidence.

4th) Cable Identification:

Cable identification shall be according to BS 6500:1990.
17.5 Specification for Mid-Hinged Mast

1st) MID-HINGED MAST:

- All masts and brackets shall be designed to meet the wind loading requirements of British Standard CP3 chapter V, Part 2-1972, and ILE Technical Report No. 7. The design must consider wind velocities of 160 kph including a gust factor of 1.3.
- The steel used for the construction of the mast and bracket shall have a tensile strength of no less than 4450 kg/sq.cm. to B.S. 4360 and all welding shall be in accordance with B.S. 5135.
- All Manufacturer's certificates shall be supplied with respect to the steel used in the mast.
- The mast shaft shall have an octagonal cross-section continuously tapered and longitudinally welded. No circumferential weld shall be acceptable, except at the mid-hinged point.
- The high mast shall be designed to accommodate a set of four luminaries and associated brackets for achieving the luminance level requirement as specified elsewhere.
- A door opening shall be provided in the base of the mast of adequate dimensions to permit clear access to equipments namely Control Gears, and Cutouts complete with a close fitting weather-proof door having a heavy duty lock. The door seam tightness shall conform to IP 54 standard. The opening shall be adequately reinforced to maintain the strength of the mast.
- The base flange shall be free of laminations and the welded connection to the mast shall fully develop the strength of the section. The base plate shall be manufactured as per the loading requirement or as specified elsewhere.
- Inside each mast there shall be a galvanized steel earthing bolt with a diameter of M8.
- The entire mast and bracket shall be hot-dip galvanized internally and externally in accordance with B.S. 729, 1971.
- All component parts or fasteners shall also receive the same hot-dip galvanized treatment, threaded components centrifugal spun to remove local excess of zinc.
- Galvanizing shall be performed in such a manner as will provide a minimum coating weight of 714 gr/sq.m. of surface (minimum 100 microns DFT).
- Coating weight shall be determined by a suitable magnetic or electronic measuring device. However, in cases of dispute, the Engineer may direct that a stripping test in accordance with B.S. 729 be carried out.
- The contractor shall depute a Technician at site to demonstrate the assembly (P).
- The mast shall be hinged approximately midway above the base so that it may be raised/lowered by means of externally operated rope and counter weight. The rope shall be portable and to be easily detachable for use with other hmast.
Employer. Materials or workmanship which are not in accordance with the Specification shall be replaced by the contractor at his own cost and risk.

- The mast shall be of a suitable dimensions to accommodate the control gear and cutout in the bottom compartment.
- The spindle of mid-hinged mast shall be stainless steel grade AISI 316.
- All bolts, nuts, locking screws and door chain shall be stainless steel Grade AISI 316.
- Copper braid for electrical conductivity to be provided between fixed and movable sections.
- The mast shall have a special arrangement in order to impose no stress or pulling force upon the mast internal cabling.
- At mid-hinged point there shall be arrangements to prevent ingress of water, moisture and dust (Minimum IP54).
- Stainless steel rod of grade AISI 316 shall be provided for slip joint adjustment.
- The cables support plate at mid-hinged point shall be provided to secure the lantern wire to eliminate any stress on power cables.
- Provision of securing the movable part with the fixed part in lowered position shall be made by using hooks and rope.
- All calculations showing the maximum forces encountered in the mast while lowering or raising the mast to be submitted.
- All calculations showing the maximum forces on the foundation and the mast holding down bolts/while lowering or raising the mast to be submitted.
- All calculations showing the forces encountered by the wind loading to be submitted.
- All calculations showing the max top flexation under given wind load and the forces occurring on the holding down bolts to be submitted.
- All calculations showing the maximum forces and pressure encountered by the mast raising and lowering equipment during operation to be submitted.
- Details of the power supply cable tension release facility in the top of the mast to be submitted.

2nd) LUMINAIRES SPECIFICATION:

The luminaries of the mid-hinged high mast shall be as per specified elsewhere.

17.6 Low Voltage Flexible Power Cable for Mid-Hinged High Masts

1st) General

- Low Voltage cable shall be used inside the high mast between the luminaries and service cut-out. The following specifications are for manufacturing and testing of 3 core x 4 sq. mm flexible, copper conductor, 450/750 Volts grade, rubber insulated, sheathed cable rated for 85 deg. C. as per the below mentioned standards:

  IEC 245 Part 4
  VDE 0282 BS 6007: 1983
The maximum and the minimum overall diameter of the cable shall be 16 mm and 13 mm respectively.
2nd) **Conductors**

− The conductors shall be stranded plain/tinned annealed copper in accordance with IEC publication 228: Conductors of Insulation Cables or BS 6360:1981 or VDE 0295 Clause 5.

− The conductor shall comply with the test requirements mentioned in BS 6007: 1983 and test certificates from independent authorities/labs. shall be submitted.

3rd) **Insulation**

− The insulation shall be rubber insulation complying with BS 6007: 1983 suitable for 85 deg. C.

− Test Certificates from independent approved bodies/authorities to be submitted with the offer as evidence.

− The insulation thickness shall comply with BS 6007:1983 Clause 11.3, table 12 and the applications mentioned in the same standard or as per VDE 0281/4.85 and IEC 245.

− Core insulation colours of each core shall be as per Clause 6 of BS 6007: 1983 or to VDE 0293.

− The insulation shall meet the Test Requirements mentioned in the following standards:-

  BS 6007: 1983

  IEC 245 Part 4

  VDE: 0282

4th) **Fillers & Binders**

Non hygroscopic synthetic fillers to be applied integrally with the bedding in accordance with BS 6007: 1983 Clause 7 to form a compact and circular cable.

5th) **Oversheath**

− **Type:** The oversheath shall be rubber type EM2 complying with the latest edition of BS 6007: 1983.

− **Thickness:** Thickness of oversheath should comply with Clause 9.3 of BS 6007:1983.

− **Testing:** Tests on the complete cable shall be carried out according to the schedules given under Clause 12, 13 and 14 of BS 6007: 1983. Test Certificates from independent approved authorities/laboratories shall be submitted with the offer as evidence.

6th) **Cable Identification**

Cable identification shall be according to BS 6007:1983.
17.7 Raising/Lowering Crown High Mast

17.7.1 Lighting Requirements

− The general lighting requirements shall be as set out on the drawings.
− The numbers, locations, types and aiming angles of luminaries and high masts shown on the drawings are indicative only. The final design shall be determined by the contractor from the manufacturer’s photometric data. The calculations shall be submitted to the Engineer in the form of drawings of the roadway system, overprinted with pole/mast positions, showing illuminant levels, and overall illuminant uniformity.
− For the luminance calculation, the road surface to be considered is the R4 type with $Q_0 = 0.08$ according to CIE standards.
− The calculations shall be performed in accordance with CIE Publication No.30 regarding the grid of calculated points and of observer positions. Computer calculations shall demonstrate the achievement of the following minimum lighting criteria.

Average illuminant level : greater than 50 lux

Overall uniformity ratio

$U_o = \frac{L_{\text{min}}}{L_{\text{av}}}$ : not less than 0.5

− These results shall be achieved taking into consideration a total maintenance factor (dust depreciation factor x lamp lumen depreciation factor) of 0.80.

17.7.2 Flood Lighting Masts

1st) General

Lighting mast height shall be as shown on the drawings or specified elsewhere. Mast shall be equipped with a mobile crown arrangement.

Structure and Construction:

− The mast shall not be more than 3 and 4 sections, other than the luminaries carriage for 30 and 40 meters high masts respectively.
− The mast shall be suitable for supporting the array of lanterns.
− The column shaft shall have a polygonal cross-section, continuously tapered and longitudinally welded. The welding of the steel column shall be metal-arc welding complying to the provision of BS 5135. No circumferential weld shall be accepted.
− The shaft shall be manufactured and fabricated from a high strength structural mild steel plate, single thickness without laminations complying with the requirements of BS 1840, cut and folded to form a polygonal section.
− The shaft shall be delivered in separate sections to be assembled on site by slip-on joint system.
− The steel used for the fabrication of the shaft shall be of material complying to BS 4360, weldable structural steel, grade 50C, aging resistant and suitable for hot dip galvanizing.
− All mast shafts shall be provided with substantial rigid flange plate, with an opening for cable entry.
− The plate shall be welded to the shaft with 2 Butt welds-to one from inside and the other from outside. The weld shall be metal-arc welding complying with the requirements of BS 5135.
− The luminaries carriageway and the anchor bolts shall be fabricated from steel confirming to BS 4360, grade 50C. Anchor bolt to be provided with 3 Nos. nuts & 2 Nos. washers.
− Mast with luminaries carriage and mobile ring and lantern shall be able to withstand a wind-speed of 160 km/hr. including gust factor. The design loads shall meet the requirement of BS 5649: Part 6:1982.
− The Mast and vertical parts of the arm brackets shall be constructed straight. The exterior surfaces of the mast shall be free from protuberances, dents, cracks or other imperfections.
− The lighting mast the adequately reinforced and strengthened at the location of the inspection compartment opening to compensate for loss in section of the mast at this point.
− The masts shall have a base compartment with a vandal resistant, dust and water-proofer.
− The door opening shall be provided in the base of the mast and it be of adequate dimension to allow clear and easy access to the equipments mounted therein. The door shall be fitted with a heavy duty lock. All the moving parts of the locking device shall be stainless steel Grade AISI 316. An approved reference sealing gasket shall be affixed to the door opening to ensure a water proof and dust proof enclosure to IP 53. The base plate shall be free from laminations and shall be fully welded to the mast base.
− The structural design of the masts shall be tested in accordance with BS 5649: Part 8:1982. Test certificates from independent approved bodies shall be submitted for approval by the Engineer.
− Assembly of masts shall be in accordance with the manufacturer's instructions.

2nd) Hot Dip Galvanizing

− The poles, flange plates, base plate, doors, luminaries carriage, anchor bolts, nuts and washers shall be protected against corrosion from inside and outside.
− The operation shall consist of dipping the steel parts into a zinc bath at a temperature of 450 deg. C. after completion of the treated comprising of degreasing, pickling, rinsing, fluxing and drying separately. The galvanizing shall be made in accordance with the requirements of BS 729:1971 (The minimum average zinc coating weight on one side shall not be less than 715 g/m2).
− Masts shall be finished and painted as specified elsewhere.

3rd) Lowering and raising devices
The lowering raising device with latching mechanism allows for load to be removed from hoisting unit when luminaries ring is latched in.

The lowering and raising system shall consists of, but not limited to:

- Driving Head
- Mobile Ring
- Hoisting Unit

- Driving Head:

  The driving head shall be made of hot dip galvanized steel (refer to Clause B above) and shall be fixed to the top of the plate by a flange secured to the most top by at least 6 bolts.

  The driving head shall be pre-assembled and tested in the factory prior to shipment and supplied complete with 3 stainless steel ropes (Grade AISI 316) and associated double-pulley assemblies and electrical power cable. Each steel rope and power cable shall have their own separate arm, housing the pulleys made of stainless steel, grade AISI 316 mounted on self lubricating ball bearings and seamless axles.

  The housing cable, 3 units, shall be made of stainless steel grade AISI 316. Each cable shall have a safety factor of not less than 5 times the safe working load of winch. The hoisting cables shall be of three connectors allowing regulations from ground.

  Three latching sleeves assuming correct positioning, entering and locking of the mobile part of the crown when raised and locked in final position shall be provided.

  The locking system shall take up vibration free all horizontal and vertical loads of the mobile part of the crown even when exposed under the most severe climatic conditions.

  The top of the driving head shall be covered with a canopy made of 3 mm thickness aluminum sheet.

  The latching and unlatching operations shall be regulated by two limit switches located at the base of the mast, easily reachable through the inspection door.

  The mobile part is fastened in raised position to the fixed part of the head gear by means of 3 positive latching system protected against corrosion, and the suspension cables shall be tension free. Both latching system and the suspension cables to be approved by the Engineer.

  All bolts, nuts and washers of the pole shall be made of stainless steel grade AISI 316.

  The electrical power cable shall be round, extra flexible, 500/750 Volt grade, with EPR insulation and HOFR outer sheath rated for 85 deg. C.

  They shall be capable of withstanding the mechanical stresses produced by the anchoring and pulley system and shall be suitably rated to carry the maximum electrical loading. Outer sheath shall be suitable for exposure to strong sunlight and a marine environment, and shall be colored black.

  Arrangements shall be provided to ensure that the power cables and stainless steel wire ropes are separated before passing over their respective pulleys, and
close-fitting guides shall protect the pulleys to prevent ropes and cables leaving the pulley grooves.

- **Mobile Ring:**

  The mobile ring shall be fabricated and coated against corrosion according to the pole specification. It shall be complete with lanterns and brackets to suit lighting design requirements consisting of flood lights and control gear boxes. During lowering and raising operations the mobile ring shall smoothly and without any sideward movement/rotation slide along the shaft with 3 groups of plastic rollers at 120 degrees. All bolts, nuts and washers of mobile ring shall be made of stainless steel grade AISI 316.

- **Hoisting Unit:**

  Suitable numbers of drum winches, with base flanges for mounting on holding down bolts shall be fitted in the bottom of mast for operation by hand and power-tool, for raising and lowering the mobile ring. The winch shall be fitted with a friction winch clutch, ratchet and pawl, and the handle. Spindle-plate shall have a safety pin-locking device. Winches shall be totally enclosed to exclude dust and blown sand from gears and oil baths. The mobile ring shall be raised and lowered by means of remote control push button panel box 10M away. The control box shall conform to IP 55 heavy duty anticorrosion, protected against U.V. of sunlight, and shall have proper locking arrangements. Winch power tools shall be portable multi-speed, reversible units incorporating a torque limiting device. They shall be supplied with a flexible supply cable and a remote control switch to allow winches to be operated from a distance of 10 meters. A supporting system shall be provided to securely locate power tools during operation. Power tools shall be rated to raise the crown from ground to mast top in not more than 15 minutes.

  One spare winch power tool set shall be handed over to the Engineer on completion of the contract.

**4th) Electrical Equipment**

- The driving head shall be designed to accommodate a round power cable. Plugs and sockets shall comply with IEC304-1, and IEC 309-2.

- Internal control panels within mast bases shall incorporate a main circuit breaker for isolation of main power, and outgoing MCBs for the rising multi-core cables. They shall have the facility for terminating incoming power cables and shall be fitted with weatherproof plug and socket arrangement to allow connection of the rising multi-core cables. Control panels shall be complete with
a 16A, 220V weatherproof socket and ELCB of appropriate rating to supply the winch power tool. Control panels shall receive protective treatment as specified and shall be sealed to IP 54 of BS 5490.

- On the mobile ring a weather proof (IP 65 grade of protection) distribution box made of 3 mm. thick aluminum sheet, housing the terminal clamps and a powered socket with cable for flood lights, ground test shall be provided. The protective treatment of the distribution box shall be as specified elsewhere for other panels.
- All cable glands shall be made of brass conforming to BS 6121.
- The contractor shall supply and install 2.5 mm<sup>2</sup>, 3 core butyl rubber insulated and sheathed flexible cords to be pulled through flexible conduits for the connections between terminal boxes, control-gear boxes and individual flood light fittings.
- An earthing terminal shall be provided within the mast base, located so that easy access for connection/disconnection of the copper earthing tapes can be achieved.

5th) Warning Labels

To avoid wrong operations the supplier shall put inside the inspection door cover warning in Arabic and English l.

6th) Miscellaneous Requirements

- Offered material shall be supplied exactly as indicated on specifications and drawings.
- Shipment will be allowed only after the approval of the Engineer.
- On completion of inst, exposed nuts and bolt heads of holding down bolts shall be caped with grease UPVC caps.

7th) Design Information

The contractor shall submit for approval the following, design parameters, calculations and data prior to the fabrication of any part of the masts or brackets.

- General dimensions of all components of the mast include mounting mobile ring and multiple luminaries array.
- Detailed scaled drawings of both mast and luminaries mounting brackets.
- Details of the fixing and locking system between the mast and the luminaries mounting bracket.
- The total maximum load moments for each section under maximum stresses.
- Computation of stresses in the base plate and anchor bolts under maximum wind-load with maximum number of luminaries in place.
- Maximum deflection at the top of the mast, under conditions and wind velocity mentioned earlier.
- Supplier may submit any new treatment method for extra protection against corrosion of the base plate area and up to the height of 300 mm.
- Detail calculations of the necessary strength for anchor bolts to be used.
- Means of assembling of mast's sections shall be indicated in details.
- Impact resistance calculations at a height of one meter above the base plate of the column.
- Maximum tolerable impact calculations to shear the plate from the mast and from an impact point one meter above the flange plate.
- Materials specification for each parts of the column.

8th) Test Certificate

The contractor to provide with each mast a detailed test certificate.
- for mast shaft materials and accessories;
- for the electrical power supply system;
- for the hoist system;
- for galvanization coating weight and component composition; and
- for anchor bolts, nuts and washers for both material and galvanization.

9th) Important Note

The contractor shall provide the Engineer with a written guarantee that the hoisting and latching systems used in the mast shall work maintenance free for a period of at least 20 years from date of commissioning.

The Engineer reserves the right to reclaim from contractor any cost involved for repair or replacement of any item related to the hoisting and latching system used during the twenty years period.

17.7.3 Flood Light Luminaries Specification

1. The flood lights shall be of 1 x 1000 Watt high pressure sodium lamp, with control gear housed in a separately mounted 3 mm aluminum powder coated weather-proof box on the frame, necessary for the operation of the lamp. Luminaries shall operate on 220 Volts AC, +/-10% at 50 Hz +/-5%. The flood lights shall be as per the requirements of specifications.

2. Complete control gear (as per BS 4782:1971) mounted on easy removable equipment mounting board housed in a separately mounted weather-proof box on the frame. Each set of control gear shall be separately fused at the mast head with 20 amp MCB. The control gear boxes shall be made of 3mm thick aluminum sheet and shall receive epoxy powder coating on both inside and outside surfaces. The box door shall have polyamide type hinges and two Alen key type locking devices made of stainless steel grade AISI 316.
3. An approved locking device shall be provided with luminaries to allow this to be locked in its set position.

17.8 Aviation Light

Aviation lights to be provided and installed to the top of each high mast of higher than 30 meters. The aviation light is to be in accordance with the Civil Aviation requirements and shall be permanently powered.

The lights are to be fixed to the mobile ring and positioned so luminaries can be easily replaced.
17.9 Lighting Beneath Over-Bridges

1st) General

- Area flood lighting shall be provided under the flyovers. Flood lights shall be positioned as designed by the contractor to the requirements of Specification and to the Engineer's approval.

2nd) Flood Light Luminaries

- Flood lighting luminaries shall be of the high pressure sodium type as per the flood lighting specification mentioned elsewhere and with internally housed control-gear with appropriate lens and reflector. Each luminaries shall house appropriate Lamp wattage associated control gear and power factor correction capacitor to achieve the luminance level required beneath flyovers.
- Control of under-bridge flood lights shall be from the nearest road lighting control panel. Cabling to luminaries shall be concealed in ducts and conduits cast into structures, with suitable junction boxes at changes of direction.

17.10 Gantry Signs Illumination

1st) Luminaries and Conduits

- Lighting luminaries for the illumination of gantry signs shall be high pressure mercury and comply with the requirements of the relevant Clauses of BS 4533: Section 102.3 and 103.1. Other requirements will comply with the specification for Flood Lighting described elsewhere, and internally housed control-gear. Each luminaries shall house a 1 x 400 watt high pressure mercury lamp.
- Wiring to lighting luminaries shall be by means of PVC Cables in a GI pipe. GI Pipe shall be securely fixed to structural steel work by distance saddles and a flexible conduit from GI pipe to luminaries.
- Final connections to lighting luminaries shall be carried out by short lengths of EPR insulated, butyl-sheathed flexible cable. The interface between the PVC cable system and the flexible cable shall be a weather-proof 3-pin socket outlet and plug.

2nd) Control of Gantry Sign Luminaries

- Gantry sign luminaries shall be controlled by road lighting control panel. The control box for each gantry shall be mounted on the steel structure and shall be complete with all electrical accessories required. Main power supply shall be taken from the nearest feeder pillar by XLPE/SWA/MDPE cabling as specified elsewhere.
3rd) **Gantry Sign Lighting Requirements**

- The gantry sign lighting shall be as per CIE No. 35 (TC-4.6) 1978, and shall have a maintained average luminance of 180 candelas per square meter (for white letters) and the ratio of the maximum luminance of one color in a specified area to the minimum luminance in the same area shall not exceed:

  2.5 for the inner zone of each area with a definite color;
  5 for the outer zone of each area with a color; and
  8 over the total area of the sign face.

Whereas the inner area shall be that area bounded by a similar rectangle of length and height equal to 70% of the overall length and height of the rectangular area located symmetrically within the sign.

- The maintained average luminance value are to be based upon the total of lantern dirt depreciation factor and a lamp lumen depreciation factor of 0.65.

### 17.11 Lamps

The lamps required shall comply with the following:

**Table 10.11.1**  
**Street Lighting Lamps**

<table>
<thead>
<tr>
<th>Type</th>
<th>Power into Lamp (Watt)</th>
<th>Total Luminous Flux (lm)</th>
<th>Lamp Base</th>
<th>Life Time (Min. Values)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pressure Mercury Vapour</td>
<td>125</td>
<td>6,400</td>
<td>E27</td>
<td>16,000</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>15,500</td>
<td>E40</td>
<td>16,000</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>23,000</td>
<td>E40</td>
<td>16,000</td>
</tr>
<tr>
<td>High Pressure Sodium</td>
<td>70</td>
<td>7,000</td>
<td>E27</td>
<td>24,000</td>
</tr>
<tr>
<td></td>
<td>150</td>
<td>16,000</td>
<td>E40</td>
<td>24,000</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>27,000</td>
<td>E40</td>
<td>24,000</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>48,000</td>
<td>E40</td>
<td>24,000</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>130,000</td>
<td>E40</td>
<td>24,000</td>
</tr>
<tr>
<td>Rapid Start HG TLD Tube Light</td>
<td>58</td>
<td>5,200</td>
<td>G13</td>
<td>12,000</td>
</tr>
</tbody>
</table>

**Remarks:**

1. The high pressure mercury vapor lamps shall be milky white color.
2. The high pressure sodium lamps shall be clean tubular type and golden color.
3. The tube light specified above shall be white/33 color. 5 feet long and 26 mm diameter.
4. Lamp thread: Tin copper or chrome plated copper.
5. Operating Voltage: 220 Volts +/- 10% at 50 Hz +/- 5%.
6. At half life, the maintained luminous flux shall not be less than 75% of the initial luminous flux.
7. The high pressure mercury vapor lamp shall conform to BS 3677:1982.
8. The high pressure sodium vapor lamp shall conform to BS 6193:1988.
9. Failure rate shall not exceed 3% in the first 100 burning hours.
10. Test certificates from approved independent laboratories shall be submitted along with the tender documents.

17.12 Specification for Street Lighting Services Cutout

1st) Application
- The street lighting service cutout are required to be installed at the base of columns (poles) for protecting the luminaries fixed at the top of the columns against short circuits.

2nd) Rating
- The service cutout shall be rated at 380V/220V, 50 Hz operation, at 50 deg. C amb. temp. and 95% relative humidity.

3rd) Standard
- The street lighting service cutout shall conform to the provisions of BS: 5486 (Part I) - 1977 or IEC 439.

4th) Construction
- The typical arrangement of a street lighting services cutout along-with dimensions and materials of construction are shown in the drawings.
- The street lighting service cutout shall consist of:

  - Housing with cover
  - Fuse carriers of required numbers
  - 4 Terminal Blocks, R, Y, B, N
  - 2 Brass cable glands with shrouds, for sizes mentioned in the BOQ
  - 1 Knock-out for Brass cable glands, 3 c X 10 sq.mm
  - 4 Nylon cable glands with shrouds of best quality, 3c X 4 sq.mm
  - 1 N-terminal, 6-way 10 sq.mm
  - 1 E-terminal, 6-way 10 sq.mm
- Fuse Holder shall be DIN rail mounted fully insulated and capable to accept cylindrical H.R.C. fuses of suitable rating with fuse dimensions of 10 x 38 mm.
- Terminal Assembly:

  4 cable terminals (3 phase and 1 neutral) shall be fixed to a high quality phenolic fibre board, or glass fibre reinforced insulator. The dielectric strength of the insulator shall not be less than 2 kV/mm.
  The flexural strength of the insulator shall be not less than 1000 kg/cm² the insulator material to be in according to DIN 7735 type 2081 or similar approved.
  Each cable terminal assembly shall be capable of accepting 2 Nos. sector shaped copper cables of not less than 35 mm² each.
  Each incoming and outgoing terminal shall be bolted to an electrolytically tinned H.C.H.D. copper bar of 40 x 5 mm cross section.
  Each cable terminal shall have the provision to connect and to tap off a lugged 4 mm² phase colored wire of not less than 10 cm. long.
  The tap of wire shall be bolted on to the main terminal by using a M5 x 15 mm slit head screw with spring washer.
  1 No. lugged tap of wire in phase color to be provided and fitted on each terminal.
  All terminal parts to be made from materials which are not subject to develop corrosion when used in combination with each other.
  A high quality flexible phase insulating barrier shall be provided between all terminals as well as on both sides of the end terminals. The phase barrier shall protrude sufficiently on all sides of the terminal to ensure electrically safety.
  Brass cable glands shall conform to B.S. 6346/1969 and shall be type BW, complete with lock nut. They shall be mounted together with a 1 mm thick tinned copper plate, linking them together. The copper plate shall be bonded to an external earth stud and to the earth bar.
  Neutral and earth bars shall be of nickel plated brass, accepting 10 mm² cable sizes. The earth bar shall be solidly bounded to the metal housing.

5th) Housing

- The housing consists of a base plate, holding all components and glands, and a removable cover. The material shall be Electro galvanized sheet steel, polyester powder coated to a film thickness of min. 100 microns, against corrosion under Middle East climatic conditions. The plate shall be 3 mm thick and the cover 1.25 mm thick. Protection class shall be IP 44. The base plate shall have 2 Nos. rear fixing holes of 7 mm diameter.
- The cover fixing screws shall be captive. The overall dimensions are shown in the drawing.

6th) Testing

- The cutout shall be tested as per the provisions of BS: 5486 Part 1: 1986 and IEC 439-1: 1985 Clause 8, and routine test certificates shall be submitted for Engineer's approval.
7th) Materials to be submitted with the offer

- Each contractor shall submit with his offer three numbers of each type of cutout required for, and fully assembled. The materials to be accompanied by manufacturers operating instructions.
17.13 Feeder Pillar Specification

1st) General

- This section contains a description and the specifications for the lighting control panels as indicated on the drawings, described in the Bill of Quantity and as specified herein:
- The panel shall consist of a single compartment cabinet with one door opening. All panels shall be constructed fully suitable for permanent outdoor installation for the control of roadway lighting. (Each control panel shall have two single phase 40 amp MCB complying with BS 3871: Part 1: 1984 and connected to the outgoing side of KWH meter suitable to supply power to a traffic control panel.)
- The cabinets (Feeder Pillars) shall be constructed in a way to ensure easy installation of a direct 3 phase KWH direct reading meter. All cabling for connecting the meters shall be installed by the contractor (KWH meters will be supplied by Electricity Authority and installed by the contractor).
- The cabinets (Feeder Pillars) with a capacity of 210 amp and above shall be delivered with a 3 phase, CT operated KWH meter, the meter shall be fused and installed in the cabinet ready for operation.
- The meter and CT must be approved and calibrated by the Electricity Authority prior to installation. All calibration cost to be borne by the contractor. A signed test report from Electricity Authority for each meter to be submitted to the Engineer. Each complete feeder pillar must be accompanied by a copy of meter test certificate. The copy to be placed inside the cabinet in the drawing pocket. Each feeder pillar must be furnished with a single line "As-Built" wiring diagram.

2nd) Equipment Housing

- Housing shall be to standards equivalent to BS EN60529:1991.
- The enclosure shall be fabricated from high grade aluminum sheet with thickness not less than 3mm. The sheet aluminum enclosure shall be coated with a thermosetting powder of an epoxy resin base modified by polyester resins. The enclosure shall be provided with a smooth finish and excellent protection against corrosion for 10 years maintenance free outdoor use. It should also have excellent chemical protection properties against acid, salt, water and solvents. All other sheet metal should be hot dip galvanized in accordance with BS 729: 1986.
- The panel enclosure shall be made suitable to withstand the dynamic stresses in the event of a short-circuit. The doors shall be Neoprene gasket to provide protection against the ingress of moisture and dust to degree IP55 of IEC 529. The gasket shall be adequate to maintain this protection at 60 degree C. ambient.
- The enclosure shall have 4 louvers (ears) for diagonal ventilation. Prevention of the ingress of dust through louvers shall be provided to maintain the degree of protection of IP55 of IEC 529. The color of the enclosure must be beige (RAL 7032).
- A pre-fabricated sloped canopy of suitable dimensions to protect the cabinet from water and direct vertical sunlight shall be provided. The material shall comply with the requirements mentioned at Para 19/20.2.1 above.
- An air gap not less than 1.5 cm shall be present between the canopy and the cabinet.
- The compartment doors shall have robust weather-proof hinges of polyamide type with suitable and substantial lockable latchdevice. A metal pocket for the schematic diagram and the "As-Built" diagram shall be provided in the enclosure door. The diagram shall not be stuck to the enclosure. The enclosure door shall have two locks of flush non-rusting type with separate keys (two numbers) to each panel. All keys shall have the same profile and design to match all doors. Non-rusting materials shall mean stainless steel Grade AISI 316 or gun metal.
- An ultra violet resist a reinforced window with a suitable dimension (approximately 10 cm x 10 cm) is to be supplied on the panel door opposite to the proposed location of the KWH meter.
- The door shall be designed in a manner that opening of 180 degree can be attaine. An anodized aluminum label, preferably dual color, bearing "Palestine" Municipality" in both Arabic and English, 50 mm size in first row, and "Street Lighting Panel" in 25mm size for the second row shall be attached to the door in a proper location and firmly attached with rivets. All hinges are to be gun metal or stainless steel.
- The enclosure shall be provided with a door switch-operated internal illumination lamp circuit complete with self-contained control gear fluorescent tube suitably protected from accidental damage and located in the top side of the panel.
- The panel shall have full size neutral and earth bar completely bonded to the main shell and connected to the door by a braided copper wire. Provision shall be made in the enclosure to terminate the earth busbar with the earth electrode outside the panel. The earth bar is to be tin plated copper.
- Four numbers of openings in the bottom plate anchoring the feeder pillar to the concrete foundation shall be provided. Dimension, location and size of anchor bolts to be used is to be specified. A 3mm Bakelite plate has to be included, separating the aluminum bottom from the concrete base. The controller housing panel shall allow building up equipment complying with IEC 439 and BS 5486 Part 1:1990.
- The equipment mounting panel shall be hot dip galvanized steel sheet not less than 3mm thick epoxy coated, or 5mm Pertinax and shall be easily installed and removed from the front of the cabinet in assembled form. All devices and equipment shall be accessible from the front of the panel. All hinges and locks are to be easily removable/replaceable.
- The panel shall be provided with a removable gland plate of maximum 1 mm thickness near the bottom to fix compression type brass glands along with earth tag. All incoming and outgoing cables shall enter and leave the cabinet at the bottom.
- Cable gland entry holes are to be factory punched and are to be the knockout type or sealed with appropriate rubber cover. The number of cable entry holes shall not be less than six and shall be according to the cable size and the unused relative dimensions are to be specified by the Engineer.
- The feeder pillar dimensions shall be within the range specified herein:
Height: 1000 mm (without canopy) : Dimensions +/- 10mm
Width: 750 mm
Depth: 250 mm
and consist of the following: (over leaf)
3rd) Contactor/AC.3

- A contactor shall be provided to control simultaneously all outgoing circuits.
- The remote control contactor shall be of the single coil actuated, electrically operated, suitable to carry not less than the rated current of the main circuit breaker at 60 degree C. ambient and shall be obtained without the use of latches or semi-permanent magnets.
- The contactor shall comply with BS 5424: Part 1:1977 and shall be for AC 3 class duty. Rated insulation voltage for 660 V AC. The contactor shall have minimum making and breaking capacity in accordance with utilization category AC 3 of IEC 158-I and shall be suitable for minimum class II intermittent duty. Ambient operation temperature shall be in the range of -10 degree C. to 90 degree C.
- The contactor components must be suitable for continuous duty and for repetitive load switching. The contactor selected shall be such that all current carrying and live parts shall be properly shielded and it shall not be possible to come into accidental contact with them. All contact assemblies shall be dust protected, and an arrangement for easy removal of the coil shall be provided (preferably slide in type). The coils of all contactors shall be suitable for operation at a voltage of 220 +/- 10 to 15% and frequency of 50 Hz. operation. The pick up of the coil shall be from 0.85 to 1.1 of the voltage. The operation of the contactor shall be by means of a photocell.

4th) Circuit Breaker (Incoming MCCB)

- There shall be one moulded case circuit breaker for the incoming feeder to each control panel. It must be rated for three phases, 380V A.C., 50 Hz. to IEC 157-I and BS EN60947-2:1992 specifications as indicated on the drawings.
- Moulded case circuit breakers shall be suitable to accommodate auxiliaries and under-voltage release. They shall be of the thermal magnetic type with a short circuit capacity withstand of not less than 50 KA at 380V, and shall be suitable for 60 degree C. ambient temperature operation with the prevailing enclosure condition. Pad locking facility for the MCCB shall be provided. The exposed incoming terminals shall be provided with a suitable insulated cover up to the equipment mounting plate in order to allow no access to the live incoming terminals. There shall be minimum clearance of 300 mm between the incoming ganded cable and input terminals of the MCCB.
- Bus bars shall be provided throughout the main power circuit. All bus bars are to be tin plated copper and colour sleeved according to phase.
- The capacity of the Terminal sockets for MCCB shall be 185 sq.mm stranded Cu/Al cables through suitable terminal tin plated copper bars.

5th) Wiring and Cabling

- All secondary internal wiring within the control cabinet shall be with heat resisting, 1000V hard grade PVC/XLPE Insulated copper cables, colour coded or sleeved for easy phase identification suitable for the circuit rating, arranged neatly and firmly attached. All the wiring leads shall be so arranged to allow current reading with a clip-on ammeter on each phase of main incoming and all outgoing circuits. All wiring shall be housed in wiring trunking forming an integral part of the enclosure whenever possible.
- Busbars shall be of the same amperage ratings at 60 degree C. ambient at enclosure condition as the main circuit breaker and shall be made of tinned copper flats and round bars complying with BS 159. They shall be colour sleeved for easy phase identification and adequately supported to withstand dynamic stresses in the event of short circuit. Exposed busbars shall be insulated and screened to prevent accidental contact in live conditions. An earth or ground bar not less than 40 mm x 4 mm shall be solidly bolted with stainless steel bolts of grade AISI 316 to the main body of the control cabinet.

- Sufficient vacant area (25 cms x 30 cms minimum) shall be left for future installation of a KWH meter. Wooden back board shall be provided for the installation of a KWH Meter.

- All wire terminals into connectors shall have wire ends or straight lugs. All the wires selected should have the amperage rating at 60 degree ambient and sufficient allowance for enclosure derating.

- The suppliers’ attention is drawn to the fact that:

  All incoming cable feeders to the panel shall be armoured, solid aluminium conductors, 4 core, XLPE insulated and PVC over-sheathed;
  All outgoing cable feeders from the panel shall be armoured, stranded copper conductors, 4 Core, XLPE insulated and PVC over-sheathed. The out-going terminals shall be suitable for 2 cables of 70 mm², 50 mm², 35 mm² and 25 mm²; therefore, all the connectors must be suitable to receive these types of cable.

- All output cables shall be connected through rugged terminals. All terminals shall be designed for sector shaped stranded copper conductors. All incoming and outgoing cables are to enter from the bottom of the enclosure and hence all the connections must be done at the bottom and not at the sides.

- All cables and wires must be color coded as per the following detail.

  Blue, Red and Yellow for phases
  Black for neutral
  Green/Yellow for the earth wherever required.

6th) Fuse and Fuse Base

- There shall be a LV HRC system consisting of fuse boxes, fuse cartridge and accessories complying with BS 88.

- The fuse base shall be suitable for cylindrical type fuses of size 22 x 58 mm and the base shall be of modular construction suitable for Din Rail mounting. The bases are to be made of thermo setting, self extinguishing material rated for 100A. Metal parts, contacts and springs are to be zinc plated and passivated for protection against corrosion. All modular fuse carriers with shielded terminals shall be similar to Legend 21471 single pole or equivalent.

- Cylindrical cartridge type fuse links suitable for the bases are to be used. They shall conform to IEC 269-2 and BS 1361 (1986) or DIN 43620 and shall withstand a rupture capacity of 100 KA. Fuses shall be of a low internal loss and low internal temperature rise. All fuses are to be protected by insulating shield or similar.
- Each feeder pillar must have one number 4 Amps single phase HRC fuse with base for the cabinet internal lamp circuit.
- Each feeder pillar shall have one number single phase 20 Amps ELCB and appropriate corrosion resistant switched socket outlet (3 pin square British type with box pattress) as per BS 1363 (1984) appropriately located and neatly and tightly fitted inside the enclosure.

7th) Cable Glands

- All cable glands shall be brass compression type cable glands complying to BS 6121 with earth tags and lock buds for XLPE/SWE/PVC/MDPE cables 4 core. All cable glands to be supplied with matching cable sleeves.
- Cable lands shall be weatherproof, with inner and outer seals suitable for steel wire armored cables. The contractor shall drill for the installation of the glands where necessary.
- Glands shall be fitted with PVC shrouds filled with waterproof plastic compound and made fast to the cable with PVC tape.
- Glands shall be fitted with earthing rings to allow connection of protective conductors. The contractor shall carry out all work involved in terminating the cables, supplying weatherproof plastic compound, PVC shrouds, tape, etc., all subject to the approval of the Engineer.

8th) Control System

The switching of the lighting luminaries shall be through an automatic control arrangement comprising of a photocell and selector switch.

- Photo Electric Switch

The cabinet shall be equipped with a photo electric switch of the following specification:

The photo-electric control switch or cell for the control cabinet shall operate from a supply voltage of 220 Volts and be rated for a load of 100 Watts. They shall be adjustable for turning on and turning off within a range of 5-2000 lux. It shall be suitable for operation within 0 degree C. to +60 degree C. temperature range. It shall have a fail-safe feature so that the lighting remains energized in the event of component failure. The photo-electric control switch shall be housed and mounted inside the control cabinet. An on-off auto switch of 5 amp rating shall be provided and properly labeled for controlling and by-passing the photo-electric cell. A resistor type surge protection shall be provided in parallel to the photocell switch. Photocell to be fitted inside the cabinet behind a factory made transparent ultra violet resistant window of size 10 cm x 10 cm. The photo electric cell shall be fully electronically operated type.

- Selector Switch

A selector switch for performing the following functions shall be provided in the cabinet.
1. **Power Supply Distribution Panels-Panels-Documents and Information to be Submitted**
   a. The Contractor shall submit the relevant design calculations, drawings and data for approval prior to the fabrication of any panels, which is to include but shall not be limited to the following:-
   b. General dimensions of the panel anchor bolts, opening locations and gland plate openings.
   c. Detailed scale drawing for the fixed components in the panel including important maintenance and operating instructions of the manufacturer.
   d. General description of the material, manufacturing, fabrication, coating and treatment of feeder pillar panel.
   e. Door hinges, locks and flaps drawings (including materials).
   f. Internal cabinet ventilation (circulation and air flow design).
   g. Detailed general arrangement drawing.
   h. Single line diagram
   i. Chart showing yearly on/off times according to the latitude of Palestine indicated above.

9th) **Testing**

- The cabinets and internal main circuitry shall be manufactured and tested in accordance to the testing specifications of BS 5486 Part 1: 1990 and IEC 439-1: 1985 clause 8
- The contractor shall submit ASTA or KEMA tests certificates for routine and type test from independent approved laboratories/bodies to show the compliance of his product.

10th) **General**

- The contractor shall submit three samples of each type of feeder pillar panel complete with all auxiliaries and ready for installation for Engineer's approval.
- However, the approval of Engineer does not absolve the contractor of the contractual obligations as to the performance compliance to the specification requirements.
- All components, catalogues, manufacturers ratings, cable glands calculations and detailed drawings are to be attached with the sample submittals.
- The contractor shall submit to Palestine Municipality ASTA and/or KEMA test certificates for Feeder Pillars along with the samples.

17.14 **Meteorological and Ambient Conditions Prevailing in Palestine**

Under certain combinations of the above climatic conditions considerable condensation may take place.
Particular attention should be paid to the prevailing corrosion conditions. A considerable amount of salt is contained in the atmosphere which together with the extremely high ambient humidity, can produce severe corrosion problems.

Distribution of rainfall is irregular, and the precipitation amounts are normally of no significance, but attention should be paid to the fact that sudden heavy rainfalls in a very short period of time can occur.

The prevailing wind directions are from the North and West. Strong winds are common with maximum velocities exceeding 160 km/hr. and sand-storms and dust-storms occur in the summer months.

### 17.15 Lighting Requirement

**TABLE No. 1**

<table>
<thead>
<tr>
<th>Luminaries type</th>
<th>1000 W</th>
<th>400W</th>
<th>250W</th>
<th>250W</th>
<th>150W</th>
<th>125W</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of luminaries per hole</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Installation height (m)</td>
<td>25</td>
<td>14</td>
<td>10</td>
<td>8</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>Spacing of poles (m)</td>
<td>110</td>
<td>50</td>
<td>45</td>
<td>30</td>
<td>45</td>
<td>25</td>
</tr>
<tr>
<td>Width of the road (m)</td>
<td>15</td>
<td>11</td>
<td>7.3</td>
<td>7.3</td>
<td>7.3</td>
<td>7.3</td>
</tr>
<tr>
<td>Number of lanes</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Set back from kerbline (m)</td>
<td>-</td>
<td>-</td>
<td>3.45</td>
<td>3.45</td>
<td>3.45</td>
<td>1.0</td>
</tr>
<tr>
<td>Center median width (m)</td>
<td>10</td>
<td>6</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
### TABLE No. 2

<table>
<thead>
<tr>
<th></th>
<th>1000 W HPSV</th>
<th>400 W HPSV</th>
<th>250 W HPSV</th>
<th>250 WHPM V</th>
<th>150 W HPSV</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average luminance level $L_{av}$</td>
<td>3.0</td>
<td>2.0</td>
<td>1.5</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Overall uniformity ratio $U_o$, higher than</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Longitudinal uniformity ratio $U_l$, higher than</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
</tr>
<tr>
<td>Glare control mark : $G$</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>Threshold increment $T_l$</td>
<td>10%</td>
<td>10%</td>
<td>15%</td>
<td>20%</td>
<td>15%</td>
</tr>
</tbody>
</table>

### 17.16 PAYMENT

The prices inserted in the Bills of Quantities for electrical works and payment thereof shall be based on net finished specified dimensions of the work and shall include the cost of all testing, materials, transporting, placing compacting and all labor and materials and tests.

Payment for Electrical Works: Payment in Units/Running Meter/Lump Sum
18 ROADWAY WORKS

The specifications of earth works, which were mentioned previously in these specifications, are applied.

18.1 Use of Bituminous Material for Surfacing

18.1.1 Description

Bituminous Materials for Surfacing shall consist of the requirements for bituminous materials that may be designated for use in surfacing or for other uses under other sections of these specifications.

18.1.2 Materials

Bituminous material shall conform to the requirements of the specifications for the type and grade specified for each application.

When the type or grade specified indicates a choice between two or more types or grades, the selection will be made by the Engineer and the type or grade furnished shall conform to the requirements of the specifications for the type or grade selected.

18.1.3 Construction

18.1.3.1 Traffic Control

In the construction or application of a bituminous prime coat, bituminous tack coat, seal coat or bituminous surface treatment, the roadway surface shall not be used by the Contractor, his agents, or others until it has been definitely established to the satisfaction of the Engineer that it will not be damaged or marred under the action of traffic. No traffic of any description shall be allowed on any bituminous application until the bituminous material has been rolled, if required. The Contractor shall erect and maintain approved barricades, signs and other traffic control devices and shall use every possible means to protect the work and to exclude traffic from the roadway surface for as long a time as may be required. Traffic shall be handled in the manner most convenient to the travelling public. When traffic is handled on a one-way basis, the Contractor shall provide such watchmen, flagmen and pilot trucks as deemed necessary to ensure adequate protection for the roadway surface.

Traffic may be detoured around the work, provided that detours are constructed and maintained in a satisfactory manner and properly signed. When it is necessary to provide for traffic across a bituminous treated surface, the crossing shall be blotted with material, as directed, before the crossing is opened to traffic.
18.1.3.2 Application of Bituminous Material

1st) Distributor Trucks

Distributor trucks shall be of the pressure type with insulated tanks. The use of gravity distributors will not be permitted.

The use of any equipment which, in the opinion of the Engineer, fails to provide a satisfactory application of bituminous material will not permitted.

The distributor trucks shall be designed and equipped with the necessary accessories and instruments to provide for the uniform application of bituminous material on various widths of surface at readily determined and controlled rates. The maximum allowable variation from any specified rate of application shall not exceed ten percent.

Distributors and booster tanks shall be so maintained at all times that no dripping of bituminous material will occur from any part of the equipment.

The minimum equipment for an approved distributor truck shall be as follows:

A positive displacement-type bitumen pump powered so that uniform distribution of the bituminous material at the rate specified will be obtained. The pump shall be powered either by a separate unit independent of the truck power unit or the pump shall be powered by a hydostatic motor operated by a power take off mounted on the truck transmission. No by-passing of the material to the tank during distribution operations will be permitted. The speed of the pump shall be controlled either by the driver or by the boatman. A metering device shall be provided to furnish accurate information as to the amount of material being pumped in order to ensure accurate control of the spread.

A heating device, as an integral part of the truck, which will heat the material to, and maintain it, at the required temperature. The device shall be of a low pressure type with separate low pressure blower and high pressure spray nozzle to provide fast and adequate heating before and during the spreading operations.

A pump or other device for circulating and agitating the bituminous material during the heating process.

Devices and charts to provide for accurate and rapid predetermination and control of the amount of bituminous material being applied, including a tachometer of the auxiliary wheel type, reading speed in meter’s per minute, and a suitable instrument for recording, in meter the total distance traveled.

A dial indicator, mounted in full view of the boatman, that will show accurately the quantity of bituminous material in the tank.

An accurate thermometer, mounted on the tank and capable of being read from the ground, that will show the temperature of the bituminous material in the tank.
A full circulating swinging spray bar capable of spraying various widths of from 15 centimeters to 4 meters. When extensions are used, they shall also be of the full circulating type. The spray bar shall have a minimum lateral movement to each side of 15 centimeters and shall have adjustments to permit the surface to be treated from various heights.

A hand hose and nozzle attachment to be used for spotting skipped areas and areas inaccessible to the distributor.

A pressure gauge, pump tachometer or other approved devices for controlling the amount of bituminous material being pumped through the spray bar.

Dual pneumatic tires. Dual axis will not be permitted unless they are equipped with dual tires.

Spray bar nozzle valve which are operated by levers so that all valves may be quickly opened or closed in one operation by the bootman at the rear of the distributor.

An adequate platform for the bootman to stand on.

2nd) Heating and Application Requirements.

Bituminous materials shall be heated by a retort or steam coils in such a manner that steam will not be introduced directly into the bituminous material.

The various types or grades of bituminous materials shall be mixed with materials or applied at temperatures within the limits given and at no time shall the Contractor increase the temperature of the bituminous material above the higher limit specified.

The spray bars on the distributor trucks shall be controlled by a bootman riding at the rear of the distributor where the operation of all sprays is in full view. Spreading by means of cab-controlled valves will not be permitted, except in the application of bituminous material to a windrow.

In order to obtain uniform distribution, the distribution shall be promptly started or stopped at the junction of two applications.

The distribution shall be promptly cut off prior to the decrease in uniform flow caused by the distributor tank becoming empty, when there is a decrease in uniform flow due to any reason whatever, or when the forward movement of the distributor slows down or stops.

In the event that any spots are missed in the application or any areas develop that do not have a uniform spread or penetration, such areas shall be remedied without unnecessary delay as directed.

Care shall be taken to prevent the spraying or splattering of bituminous material on adjacent (curb) trees and shrubbery or any other object outside of the area designated for spraying.
Unused bituminous material shall not be disposed of within the right-of-way, lines, unless permitted.

18.1.4 Measurement

Bituminous Materials for Surfacing will be measured by the square meter of net area applied.

Measurement for payment will be made only of the quantity of bituminous materials used in accordance with these specifications.

18.1.5 Payment

The accepted quantities of Bituminous Materials for surfacing, measured as provided above, will be paid for at the contract unit price, complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt Cement</td>
<td>m²</td>
</tr>
<tr>
<td>Liquid Asphalt</td>
<td>m²</td>
</tr>
<tr>
<td>Emulsified Asphalt</td>
<td>m²</td>
</tr>
</tbody>
</table>

18.2 Bituminous Prime Coat

18.2.1 Description

Bituminous Prime Coat shall consist of furnishing bituminous material and applying this bituminous material to a prepared base course, in accordance with these specifications.

18.2.2 Materials

Bituminous material shall conform to the requirements of the specifications for the type and grade specified. Prime Coat shall be medium curing liquid asphalt grade MC-70 or MC-30 as directed by the Engineer.
18.2.3 Construction

18.2.3.1 Preparation of Surface

The surface on which the bituminous prime coat is to be placed shall be uniformly smooth and firm and reasonably true to grades and cross sections as shown on the Drawings, and shall be so maintained throughout the period of placing the prime coat. In no event shall a prime coat be placed on a soft, uneven base. Any holes, depressions of irregularities shall be repaired by the removal of all loose and unsuitable material and replacement by suitable material, which shall be compacted to produce a dense surface conforming to the adjacent area. Uniformity of surface texture is of the utmost importance.

When required, the surface on which the prime coat is to be placed shall be lightly bladed and rolled immediately prior to the application of bituminous material.

18.2.3.2 Heating of Bituminous Material

The use of any method of agitation or heating that introduces free steam or moisture into the bituminous material is prohibited. Materials heated to temperatures above twenty-eight (28) degrees centigrade higher than the maximum application temperature specified in table Bituminous Binder and Wearing Course shall be considered as overheated and shall be rejected until the material can be resampled and retested. The reacceptance or final rejection will be made by the Engineer on the same requirements under which the material was originally tested.

18.2.3.3 Temperature of Bituminous Material at Time of Application

Bituminous materials shall be applied at temperatures within the range shown in Table.

18.2.3.4 Application of Bituminous Material

Bituminous material shall be applied only when the surface is clean and either damp or dry, when the atmospheric temperature is above (15) fifteen degree centigrade and when the weather is not foggy or rainy.

Atmospheric and roadway surface conditions should be such as will permit satisfactory penetration and adhesion of the prime coat. Prime coat shall not be overlaid with other surfacing less than 36 hours after application unless so instructed by the Engineer.

The approximate quantity of bituminous material to be used will vary in rates from 0.7 kg. to 1.0 kg. per square metre. However, the exact amount used will be determined by the Engineer at the time of application. The bituminous material shall be uniformly applied to the prepared surface at the rate so designated and in one application.
Traffic control and the application of bituminous material shall conform to the requirements of the specifications.

18.2.3.5 Blotting

If deemed necessary by the Engineer after the bituminous material has been applied for forty-eight (48) hours under favorable conditions and the prime coat has not dried sufficiently that it will not be damaged by traffic, a light application of aggregate shall be applied. The blotter material shall be a clean fine sand, chat sand, or other material as approved by the Engineer.

Blotting material shall be applied sparingly on only the areas that have not dried. Blotting of the prime coat shall be done only when directed by the Engineer. Normally, additional time shall be allowed for drying of the prime coat when in the opinion of the Engineer this procedure does not seriously delay subsequent operations.

When so directed the surface of the completed prime coat shall be rolled with a pneumatic tired roller.

18.2.3.6 Maintenance of Surface

Traffic shall be kept off the bituminous material until it has penetrated the base or subgrade and cured sufficiently.

The integrity of the prime coat shall be maintained at all times until the next course is placed or until final acceptance. In the event of traffic causing holes and breaks in the surface, such holes or breaks shall be satisfactorily repaired by the Contractor.

18.2.4 Payment

The accepted quantities of bituminous material for Bituminous Prime Coat will be measured and paid for as specified under the specifications/bills of quantities for the bituminous material used including furnishing, applying and removing blotter material.

No measurements or direct payment will be made for rolling.

18.3 Bituminous Tack Coat

18.3.1 Description

Bituminous Tack Coat shall consist of furnishing bituminous material and applying this bituminous material to a bituminous primed surface, to the surface between layers of bituminous mixed materials or to an existing bituminous surface, in accordance with these specifications.
18.3.2 Materials

Bituminous material shall conform to the requirements of the specifications for the type and grade specified. Tack coat shall be anionic emulsified asphalt grade SS1 or cationic emulsified asphalt SS1h or as directed by the Engineer.

18.3.3 Construction

The surface on which the bituminous tack coat is to be placed shall be dry and free from loose material. If the surface is not so, it shall be cleaned immediately in advance of applying the bituminous material, in a satisfactory manner.

The approximate quantity of bituminous material to be used will vary in rates from 0.3 to 0.5 kg. per square meter. However, the exact amount used will be determined by the Engineer at the time of application. The bituminous material shall be uniformly applied to the surface being tacked at the rate so designed and in one application.

Traffic control and the application of bituminous material shall conform to the requirements of the previous mentioned items.

Bituminous material shall be applied only so far in advance of the placement of the bituminous mixed materials as is necessary to obtain the proper conditions of tackiness. In no event shall more bituminous material be applied on one day than will be covered by bituminous mixed material during that same day.

18.3.4 Payment

The accepted quantities of bituminous material for Bituminous Tack Coat will be measured and paid for as specified in specifications/bills of quantities for the bituminous material used (sq/meter).

18.4 Seal Coat

18.4.1 Description

Seal coat shall consist of furnishing all materials and applying a bituminous Seal Coat, to a surface, in accordance with the requirements of these specifications.

Seal Coat shall consist of an application or applications of a bituminous material followed by an application of aggregate as cover material in accordance with the requirements of these specifications.
18.4.2 Materials

18.4.2.1 Bituminous Material

Bituminous material shall conform to the requirements of the specifications for the type and grade specified.

Bituminous material used in the construction of Seal Coat on shoulders shall be as follows:

Medium Curing Liquid Asphalt for Seal Coat
- Grade MC-70.
Rapid Curing Liquid Asphalt for Seal Coat
- Grade RC-250.

18.4.2.2 Cover Material

Aggregate for seal coat cover material shall consist of clean sand, gravel, crushed stone or crushed gravel. All aggregate shall consist of clean, tough durable particles free from lumps of chalk, or clay and shall not contain calcareous or clay coatings, organic matter or foreign substances. Cover aggregate shall conform to the following grading and other requirements. The aggregate shall have a maximum flakiness index of 25 when tested in accordance with BS 812.

<table>
<thead>
<tr>
<th>Sieve Size Gradation</th>
<th>Percentage Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>3/4 in. (19.1 mm)</td>
<td>100</td>
</tr>
<tr>
<td>1/2 in. (12.7 mm)</td>
<td>90-100</td>
</tr>
<tr>
<td>3/8 in. (9.52 mm)</td>
<td>50-80</td>
</tr>
<tr>
<td>1/4 in. (6.35 mm)</td>
<td>10-45</td>
</tr>
<tr>
<td>No. 4 (4.76 mm)</td>
<td>0-15</td>
</tr>
<tr>
<td>No. 8 (2.38 mm)</td>
<td>0-15</td>
</tr>
<tr>
<td>No. 200 (0.074mm)</td>
<td>0-2</td>
</tr>
</tbody>
</table>

Los Angeles Abrasion (AASHO T-96)
(After 500 revolutions) 40%

Maximum
Soundness Test - Coarse or Fine aggregate (Sodium Sulphate Solution - AASHTO T-104) 10%
Maximum
The rate of application of chip seal and bituminous material for the various types of cover aggregate shall be within the ranges specified in the following table. However, the exact rates will be determined at the time of application.

<table>
<thead>
<tr>
<th>Type of Gradation</th>
<th>Rate of Application</th>
<th>Kg/Square Meter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Chip Seal</td>
<td>Bituminous Material</td>
</tr>
<tr>
<td>A</td>
<td>13 to 15</td>
<td>0.90 to 1.20</td>
</tr>
<tr>
<td>B</td>
<td>11 to 13.5</td>
<td>0.70 to 1.20</td>
</tr>
<tr>
<td>C</td>
<td>6.5 to 8.5</td>
<td>0.70 to 1.20</td>
</tr>
<tr>
<td>A First Application</td>
<td>3 to 15</td>
<td>0.70 to 1.20</td>
</tr>
<tr>
<td>C Second Application</td>
<td>6.5 to 8.5</td>
<td>0.70 to 0.90</td>
</tr>
</tbody>
</table>

18.5 Construction

18.5.1 General Requirements

The surface to be seal coated shall be thoroughly cleaned prior to applying the bituminous material or slurry. The Contractor shall inspect the surface to be sealed and shall satisfy himself as to the extend of the cleaning work required and the type of equipment that will be necessary to clean the surface. Self-propelled rotary power brooms along with hand brooms if necessary shall be used immediately in advance of applying the bituminous material.

When Seal Coat is to be applied to an untreated material, a prime coat consisting of liquid asphalt of specified type shall be applied to the material in place at a rate of from 1.2 to 1.5 kg per square meter. The exact rate will be determined at the time of application.

When ordered, pilot trucks, with drivers and flagmen as necessary, shall be provided to direct, control and escort traffic through the area being sealed.

Traffic control and the application of bituminous material shall conform to the requirements the specifications.

18.5.2 Application of Bituminous Materials

Bituminous material shall be applied only when the temperature of the surface on which the bituminous material is to be applied is at least 29 degree C (85 degree F).

The material shall be uniformly applied at the rate so designated, in one application, to the surface being sealed.

The distributor used for the application of bituminous material and the care of the bituminous surface shall conform to the requirements for such equipment and care as specified under the specifications.
Transverse joints shall be made by means of any method, approved by the Engineer prior to the start of the work, that will ensure a proper joint with the preceding work at intersections and at junctions with all pavement and structures.

18.5.3  Spreading Cover Material

Cover material shall be immediately and uniformly spread over the freshly applied bituminous material by means of a self-propelled continuous feed chip spreader or an approved spreader. Any oversize texture is of the utmost material picked up during stockpiling or loading operations shall be eliminated before entering the spreader hopper. Supplemental spreading and smoothing shall be done by hand methods where necessary.

18.5.4  Rolling Cover Material

Following the spreading of cover material, the surface shall be promptly rolled with a self-propelled pneumatic tired roller, or a hand roller where seal coat is required on embankment slopes, where the slope is 3/1 three horizontal to one vertical. At least two rollers shall be used, however, if expressly permitted on projects where there is a small amount of seal coat work to be done, only one roller will be required.

18.5.5  Traffic On Seal Coat

Except for times when it is necessary for hauling equipment and/or pilot trucks to travel on the newly applied seal coat, traffic of all types shall be kept off the seal coat until it has had time to set properly. The speed of all hauling equipment and pilot trucks shall not exceed 25 kilometers per hour. The minimum traffic free period shall be not less than three hours. Seal coat operations shall be so scheduled that, if possible, the normal flow of traffic will be resumed before sunset.

18.5.6  Removing Loose Cover Material

All loose cover material shall be removed from the paved surface by brooming, in not less than 24 hours not more than 72 hours after application. The Engineer will consider all conditions and determine the best time for the removal of the cover material. The cover material shall be removed at this time by means of a rotary power broom. The broom shall be in good condition and of a design suitable for the work. The pressure of the broom against the pavement shall be adjusted so that particles which are stuck to the asphalt will not be dislodged.

18.5.7  Measurement

Seal coat will be measured by the square meter.
18.5.8 Payment

The accepted quantities of seal will be paid for at the contract price for Seal Coat including cover aggregate and bituminous material complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seal Coat</td>
<td>- One Application</td>
</tr>
<tr>
<td>Seal Coat</td>
<td>- Two Applications</td>
</tr>
</tbody>
</table>

18.6 Dense Bituminous Macadam

18.6.1 General

Dense Bitumen Macadam shall be manufactured generally in accordance with BS 4987: 1988 and in accordance with any amendments thereto or as superseded in this specification.
18.6.2 Bitumen Materials

Unless otherwise specified or directed by the Engineer, bituminous material shall be of Grade 60/70 penetration, and shall conform to the requirements of the specification.

18.6.3 Aggregate Materials

Aggregate shall consist of coarse and fine aggregates and filler, if such is required to obtain the grading for the combined aggregate, shall be free from decomposed material, clay, organic matter and other deleterious substances. Coarse and fine aggregates shall consist of clean crushed rock or crushed gravel. The source of aggregate is considered to be the crushing site from which it is produced.

18.6.3.1 Coarse Aggregate

The aggregate shall have at least one mechanically fractured face on 100% of the number of particles retained on the 6.3 mm sieve. In addition, for wearing course, the percentage of fully crushed particles shall exceed 70% of the total number of particles retained on the 3.35 mm sieve (percentage in number of fully crushed aggregates in total number of aggregates in the sample).

18.6.3.2 Fine Aggregate

The fine aggregate shall be produced from the same crushing process as the coarse in that it shall be the result of a crushing process which provides coarse aggregate complying with the basecourse requirements. Uncrushed screened material will not be permitted. Crushed sand shall be produced by crushing clean coarse aggregate and shall not be thin, flaky or elongated.

18.6.3.3Filler

If additional material passing the 0.075 mm BS sieve is required for compliance with the grading limits it shall consist of crushed rock. Crushed rock shall be taken to refer to any materials which can be used as source to produce coarse aggregate suitable for basecourse. Where approved by the Engineer, Portland Cement, hydrated lime or other suitable approved material may be used. In all cases at least 75% of the added material shall pass the 0.075 mm BS sieve.

The fine aggregate may be produced with the coarse aggregate from the same source in such that the processing of the natural deposit yields a combined aggregate that meets the requirements of the specification.
### Minimum Test Requirements for Aggregates

<table>
<thead>
<tr>
<th>Test Requirement</th>
<th>Specification/Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Crushing Value</strong></td>
<td>Max. Aggregate Crushing Value</td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td>23% (BS 812)</td>
</tr>
<tr>
<td><strong>Flakiness Index of Aggregate</strong></td>
<td>30% Max. (BS 812)</td>
</tr>
<tr>
<td>(Individual Stockpile)</td>
<td>Basecourse</td>
</tr>
<tr>
<td><strong>Los Angeles Abrasion</strong></td>
<td>35% Max. (AASHTO T-96)</td>
</tr>
<tr>
<td>(Individual Stockpile)</td>
<td>Wearing Course</td>
</tr>
<tr>
<td><strong>Soundness - Sodium Sulphate</strong></td>
<td>12% Max. (AASHTO T-104)</td>
</tr>
<tr>
<td>(Individual Stockpile)</td>
<td>Wearing course</td>
</tr>
<tr>
<td><strong>Elongation Index</strong></td>
<td>25% Max. (BS 812)</td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td>Basecourse &amp; Roadbase.</td>
</tr>
<tr>
<td><strong>Sand Equivalent</strong></td>
<td>45% Min. (AASHTO T-176)</td>
</tr>
<tr>
<td><strong>Unit Weight</strong></td>
<td>Min. 1120 Kg/m3 (AASHTO T19)</td>
</tr>
<tr>
<td><strong>Water Absorption</strong></td>
<td>2 Percent Max. (BS 812)</td>
</tr>
</tbody>
</table>

Each source of aggregate or constituent of the proposed mix shall be tested and reported separately. Test shall be applied to samples or fraction of samples as recommended or detailed in the relevant British Standard (BS 812) or AASHTO.

#### 18.6.4 Aggregate Combination

Aggregates shall be combined to give a smooth grading conforming to Table for DBM roadbase/basecourse and Table for wearing course.

The grading of the aggregate combination shall be uniform within the limits shown. Any rejection or addition of any size or sizes of particles to obtain a satisfactory uniformity shall be the full and complete responsibility of the Contractor. Fines or filler will only be added where the natural crushed material is short of such sizes and the addition is required to bring the combined aggregate within the specified limits.
Table for DBM

Aggregate Grading for Roadbase/Basecourse and Wearing Courses above 50 mm thick

<table>
<thead>
<tr>
<th>B.S. Test Sieve (mm)</th>
<th>Aggregate Percentage by mass passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>28</td>
<td>100</td>
</tr>
<tr>
<td>20</td>
<td>80 - 100</td>
</tr>
<tr>
<td>14</td>
<td>64 - 86</td>
</tr>
<tr>
<td>10</td>
<td>52 - 75</td>
</tr>
<tr>
<td>6.3</td>
<td>39 - 60</td>
</tr>
<tr>
<td>3.35</td>
<td>29 - 47</td>
</tr>
<tr>
<td>1.18</td>
<td>20 - 36</td>
</tr>
<tr>
<td>0.300</td>
<td>7 - 20</td>
</tr>
<tr>
<td>0.075</td>
<td>2 - 6</td>
</tr>
</tbody>
</table>

Table for wearing course

Aggregate Grading for Wearing Courses 50 mm Thick & less

<table>
<thead>
<tr>
<th>B.S. Test Sieve (mm)</th>
<th>Aggregate Percentage by mass passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>100</td>
</tr>
<tr>
<td>14</td>
<td>80 - 100</td>
</tr>
<tr>
<td>10</td>
<td>66 - 90</td>
</tr>
<tr>
<td>6.3</td>
<td>56 - 78</td>
</tr>
<tr>
<td>3.35</td>
<td>42 - 58</td>
</tr>
<tr>
<td>1.18</td>
<td>26 - 43</td>
</tr>
<tr>
<td>0.6</td>
<td>16 - 30</td>
</tr>
<tr>
<td>0.075</td>
<td>3 - 6</td>
</tr>
</tbody>
</table>

18.6.5 Dense Bituminous Macadam Design Mix.

On approval of all constituents (aggregates, bitumen, etc.) the Contractor shall allow 30 days for the preparation of a design mix. This design mix will be prepared by the Contractor for use, approved by the Engineer after an independent testing laboratory carry out necessary tests to check this mix design properties using the Marshall Method as laid out in the Asphalt Institute Publication MS2.

These trial mixes shall combine the mineral aggregates and asphalt in such proportions as to produce a mixture conforming to the following composition limits by weight of the total mix (including tolerances):

- 60/70 pen bitumen
  - (i) Roadbase/basecourse: 4.0 +/- 0.5%
  - (ii) Wearing Course: 4.5 +/- 0.5%
When tested according the Marshall Method, the bituminous mixture shall conform to the following requirements (ASTM D1559-65 or latest revision thereof)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stability (kgs)</td>
<td>900 min. for Roadbase/Basecourse.</td>
</tr>
<tr>
<td></td>
<td>900 min. for Wearing Course</td>
</tr>
<tr>
<td>Stiffness</td>
<td>min 450 kg/mm</td>
</tr>
<tr>
<td>Flow (Millimeters)</td>
<td>2 - 4</td>
</tr>
<tr>
<td>Voids in total mix (%)</td>
<td>4 - 9</td>
</tr>
<tr>
<td>Voids filled with asphalt (%)</td>
<td>50 - 65</td>
</tr>
<tr>
<td>Voids in Mineral Aggregates</td>
<td></td>
</tr>
<tr>
<td>Wearing Course</td>
<td>Min. 14.5%</td>
</tr>
<tr>
<td>Base Course</td>
<td>Min. 13.5%</td>
</tr>
<tr>
<td>Number of Blows per face</td>
<td>- 75</td>
</tr>
</tbody>
</table>

The voids in the total mix shall be calculated using the effective specific gravity of aggregates determined with the use of AASHTO T-209, the voids in the Mineral Aggregate (VMA) shall be calculated using the Bulk Specific Gravity both in accordance with the methods set out in Appendix C to this Specification. The voids Filled with Bitumen shall be calculated as the VMA less VIM as percentage of VMA.

The optimum bitumen content should initially be achieved by averaging the optimum value obtained for stability, density, median of voids in total mix and median of voids filled with bitumen. Where an accepted value cannot be obtained from this method the Engineer may choose to reject the materials or accept some alternative bitumen content which is felt offers acceptable results. The mix formula will take into consideration the absorption of asphalt into the aggregates. Thus, for calculations for voids, the adjusted bulk specific gravity of the Marshall specimens, adjusted for the portion of asphalt lost by absorption, shall be used.

The intention in the choice of the parameters for the mix design is to produce a stable stiff mix. To this the stability/flow ratio shall be maximized within the other given constraints.

Generally the optimum bitumen content should be chosen to produce a stiff mix resistant to permanent deformation at likely ambient working temperatures and the Marshall Method approach should be used for guideline purposes only.

Loss of Marshall Stability by submerging specimens in water at 600 C for 24 hours as compared to stability after submersion - 25 % Max.

in water at 600 C for 20 mins (frequency of testing as mentioned in the specifications).

Prior to final approval, a mix containing bitumen at the upper percentage limit (including the allowable positive tolerance) shall be compacted to refusal(500 blows), and the resulting voids in mix value shall not be less than 2% (a higher figure may be required by the Engineer if he considers this necessary).
The gradation of the combined aggregate, including the mineral filler shall be within the limits specified here. The Engineer may vary the specified limits where he deems it necessary, on the basis of the Marshall tests, to obtain optimum stability and life of the completed mix.

### 18.6.6 Job Mix Formula

Upon determination of the optimum design mix which shall be called the "Job mix formula" and subsequent approval by the Engineer, the Contractor shall adjust his plant to proportion the individual aggregates, mineral filler and asphalt to produce a final mix that, when compared to the job mix formula, shall be within the following limits:

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greater than or equal to 6.3 mm</td>
<td>+/- 4</td>
</tr>
<tr>
<td>3.35 mm - 1.18 mm</td>
<td>+/- 3</td>
</tr>
<tr>
<td>1.18 mm - 0.600 mm</td>
<td>+/- 3</td>
</tr>
<tr>
<td>0.600 - 0.075</td>
<td>+/- 2.0</td>
</tr>
<tr>
<td>Less than 0.075</td>
<td>+/- 1.5</td>
</tr>
<tr>
<td>Bitumen Content</td>
<td>+/- 0.3%</td>
</tr>
<tr>
<td>Voids in total mix</td>
<td>+/- 1%</td>
</tr>
<tr>
<td>Temperature of mix when leaving plant</td>
<td>+/- 10 Degree C</td>
</tr>
</tbody>
</table>

The Engineer will test the mix frequently and, if necessary direct the Contractor to readjust the plant to maintain conformity to the job-mix formula. If, during production, the grading of the aggregates alters, the mix shall be redesigned and the plant readjusted as outlined above. It should be noted that although the above variation in Bitumen content shall be permitted from an approved job-mix this variation shall not take the bitumen content out of the outside limit controls stated in this clause and consideration should be given to this point when fixing a bitumen content for the job-mix formula.

However where approved by the Engineer it may be acceptable that the outside limits on tolerances of grading may be outside original design envelope should it be considered the suitability of the mix shall not be affected.

The intent of these specifications is to have the Contractor supply a combined aggregate to pugmill of the asphalt plant that meets the grading requirements as herein specified.

The Contractor shall supply the various components of the final aggregate and deliver these to a set of cold feeders. It shall be heated and following the heating and drying it shall be delivered to a set of screens to be separated into sizes as specified prior to delivery to the pugmill where it is mixed with the specified
liquid bitumen. The addition of mineral filler may or may not be necessary but the grading requirements of the total aggregate must be met irrespective of the manner in which the Contractor chooses to produce the specified aggregate. A Viscosity vs Temperature relationship for the job mix shall be carried out to determine mixing and compacting temperature.

Samples for testing of the day to day working should be taken from the material after laying by the paver machine but before any compaction or directly from the manufacturing plant as directed by the Engineer in accordance with AASHTO T168. Samples of the compacted material should be taken in accordance with AASHTO-T230 Method B.

Field densities, to be taken the day following laying where practical, shall be carried out in accordance with AASHTO-T166(Method A or B) or ASTM D 2726/1188.

All field density testing, including retesting, shall be carried out within 7 days of material laying. Tests after such period shall not be accepted as providing evidence of compaction complying with this Specification. Re-compaction by means of steel rollers will not be permitted. Extraction of bitumen should be carried out in accordance with AASHTO - T164 and T30.

The assistance of the Engineer in the preparation of the job mix formula no way relieves the Contractor of the responsibility of producing a bituminous mixture meeting the requirements of the Specifications.

18.6.7 The Asphalt Mixing Plant Requirements

The plant shall be so designed and operated to produce mixtures within the specified job-mix tolerances.

All plants used for preparation of bituminous macadam consist of the following basic components:

One) A cold feed system, either a single reciprocating feeder or a multiple feeder.
Two) A conveyer or elevator to move the cold aggregate into the drier.
Three) A rotary drier.
Four) A dust collector with a means for returning the collected mineral dust back into the hot stone elevator, if so required.
Five) A hot stone elevator.
Six) A set of screens to make the separation of the aggregate to the sizes as required by the specifications.
Seven) A set of hot stone bins for the storage of the various components of the aggregate prior to proportioning.
Eight) An approved proportioning system, either by volume or by weight.
Nine) Adequate and approved scales or volumetric devices for the control of the proportioning.
Ten) An approved mixer pugmill.
Eleven) A discharge hopper for loading trucks.
 Twelve) Adequate and approved asphalt and fuel storage tanks.
Tanks for the storage of bitumen shall be equipped with heating coils under effective and positive control for the heating of the material to the temperature requirements as instructed. Heating shall be accomplished by an approved means but in no case shall open flame be allowed to contact the heating tank. A circulating system for the continuous circulation between the storage tank and the mixer shall function during the entire operational period. All pipe lines, tanks and units carrying hot bitumen shall be insulated or jacketed. The bitumen storage tank shall have a capacity for at least one day's full operation.

The plant shall have an accurate and positive mechanical means of feeding the cold aggregate into the drier at a uniform rate. When the aggregates must be blended at the cold elevator to meet the requirements of the job mix tolerances, a mechanical interlocked feeder of two or more bins shall be provided.

The drier shall be of an approved type and shall be capable of drying and heating the aggregate to the temperature requirements of the specification for paving mixtures the capacity of the drier shall be sufficient to meet the full capacity of the plant mixer and shall provide the heated aggregate at a uniform temperature.

Plant screens shall be capable of screening all aggregate to the sizes required for proportioning, and the screening capacity shall be greater than the mixer capacity. The screening efficiency shall not be less than 80% of laboratory.

The asphalt plant shall have storage bins under the screens for the storage of hot aggregate of sufficient size to provide continuous operation of the plant. The bins shall have sufficient compartments to store each size of aggregate as required by the specifications. Each compartment shall be equipped with an overflow chute and with a "telltale" device to indicate the position of the aggregate in the bins at the lower quarter points.

A satisfactory means shall be provided either by weighing or by volume or by metering, to obtain the proper amount of asphalt in the mix. The accuracy shall be to one percent of the amount required; if the metering system is used there shall be a means to check the delivery by weight. Suitable means shall be provided for maintaining the specified temperature of the asphalt in the pipelines, meters, weight buckets, spray bars, tanks and other containers.

An approved armored thermometer shall be fixed in the asphalt feed line. An armored (thermometer) or an electric pyrometer or other approved device shall be installed in the boot of the discharge chute from the drier to continuously record the temperature of the heated aggregate.

The plant shall be equipped with a positive means to govern the time of mixing and to keep it constant.

The plant shall be equipped with a mechanical dust collector which shall be so designed to return the collected material back to the aggregate prior to mixing.

The plant shall be equipped with ladders and stairs when necessary and all open gears or exposed moving parts shall be guarded.
The Contractor shall calibrate his plant at least at monthly intervals and whenever directed by the Engineer.

18.6.8 Pollution Control

All temporary asphalt mixing plants must be provided with an effective filter system to prevent the escape of dust, smoke and any other pollutant to the atmosphere. Before operation of such plant begins, written approval of the Health Authority must be obtained.

18.6.9 Special Requirements for Batch Plants

18.6.9.1 Weight Box or Hopper

The equipment shall include a means of accurately weighing each bin size of aggregate in a weight box or hopper, suspended on scales, ample in size to hold a full batch without hand raking or running over. The weight box or hopper shall be supported on fulcrums and knife edges to constructed that they will not be easily thrown out of line or adjustment. Gates on both bins and hopper shall be so constructed as to prevent leakage when they are closed.

18.6.9.2 Asphalt Bucket

If an asphalt bucket is used for weighing the asphalt, it shall have a capacity of twenty (20) percent of the weight of the aggregate required for one batch. It shall be steam jacketed or equipped with properly insulated electric heating units and shall be suspended on dial scales or beam scales equipped with a tell-tale so that the tare weight of the bitumen bucket will be shown for each weighing and the net weight of the asphaltic binder measured accurately to within one (1) percent above or below the required weight. The bucket shall be so arranged that it will deliver the heated asphalt in a thin uniform sheet or in multiple streams the full width of the mixer, except in the case of a rotary mixer where the asphalt binder is sprayed.

18.6.9.3 Mixer Unit for Batch Method

The plant shall include a batch mixer of an approved twin pugmill type, rotary drum type, or any other type that has proved itself capable, of producing a uniform mixture within the limits specified herein. It shall have a batch capacity of not less than five hundred kilograms. If of the pugmill type the clearance of the blades from all fixed and moving parts shall be not more than 2 cm. The mixer shall be so constructed as to prevent leakage of the contents until the batch is discharged. The mixer shall have a time lock to control the operation of a complete mixing cycle by locking the weight box gate after the charging of the mixer, until the closing of the mixer gate at the completion of the cycle, it shall lock the asphalt bucket throughout the dry and wet mixing periods. The dry mixing time is defined as the interval of time between the opening of the weight box gate and the application of the asphaltic binder, the wet mixing period is the
interval between the application of the asphaltic binder and the opening of the mixer gate. The control of the mixing time shall be flexible, and capable of being set at intervals of not more than five (5) seconds through cycles up to three (3) minutes. A mechanical batch of box counter shall be installed as part of the timing device and shall be so designed as to register only on the actuation of the asphalt bucket release and to preclude the register of any material through the operation of pulling bins.

18.6.10 Special Requirements for Continuous Mixing Plants

18.6.10.1 Gradation Control Unit

The plant shall include a means of accurately proportioning the aggregate from each bin, after the heated aggregate has been screened and stored in the hot stone bins, either by weighing or by volumetric measurement. When proportioning is by volume, the unit shall include a feeder mounted under the compartment bins. Each bin shall be equipped with an accurately controlled and adjustable gate to form an orifice for volumetrically measuring the material drawing from each respective bin compartment. The orifice shall be rectangular, of dimensions approximately 20 cm x 23 cm, with one dimension adjustable by positive mechanical means with a lock.

Indicators shall be provided on each gate to show the gate opening in inches or meters. Mineral filler, if used, shall be proportioned by a separate arrangement directly to the mixer.

18.6.10.2 Calibration

The plant shall include a means of calibration of the gate opening by means of weight test samples. The materials fed out of the bins through the individual orifices shall be by-passed to a suitable test box, each compartment material confined on a separate box section. The plant shall be equipped to handle conveniently such test samples weighing up to four hundred kilos (400) and to weigh them on accurate scales.

18.6.10.3 Synchronization of Aggregate and Bitumen Feed

A satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bitumen from the meter or other proportioning source. This control shall be accomplished by interlocking mechanical means or any approved positive method.

18.6.10.4 Mix Unit of the Continuous Method

The plant shall include a continuous mixer of an approved twin pugmill type, or any other type which has proved itself capable of producing a uniform mixture within the job mix tolerances set by the specifications. The pugmill paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix as may be necessary if so directed. The mixer shall carry the manufacturer's plate giving the net volumetric capacity of the mixer at the several
heights inscribed on a permanent gauge of aggregate per minute, at normal plant operating speed.

**18.6.10.5  Mixing Time**

Unless therewise required, the determination of the mixing time shall be by weight method under the following formula and the weights shall be determined by tests according to:

\[
\text{Mixing Time} = \frac{\text{Pugmill dead load capacity in kilos}}{\text{Seconds}} \times \frac{\text{Pugmill output in kilos per second}}{}
\]

**18.6.11  Preparation of Mineral Aggregate**

Prior to being mixed the heated combined aggregate shall be put through a set of screens for the purpose of dividing the aggregate into two or more sizes delivering such sizes to appropriate hot stone storage bins. The screens shall be so arranged that any particles of size greater than the top specified size shall be reject. If only two bins separation is available the separation shall be done on the No. 4 screen size. If more than two bins are available the Contractor will so split the aggregate in the sizes that give the maximum control over the gradation of the combined aggregate. Components shall have a plasticity index of zero.

The stockpiles shall be maintained in a clean fashion such that no deleterious materials may contaminate the aggregates. To this end aggregates should be stored on concrete slabs and separations between bins should be sufficient to prevent cross mixing.

Each aggregate ingredient shall be heated and dried at such temperature that the temperature as recorded in the hot fines bin after screening shall not exceed 163 degrees C. If the aggregates contain sufficient moisture to cause foaming in the mixture or if their temperature is in excess of 163 degree C they shall be removed from the bins and returned to their respective stockpiles.

Immediately after heating, the aggregate or aggregates shall be screened into at least three (3) sizes and conveyed into separate bins ready for batching and mixing with bituminous material. When the aggregates furnished are of such size and grading that separating into three (3) bins is impractical, the number of required separations may be reduced to two (2) with the approval of the Engineer.

The efficiency of the screening operations shall be sufficient to produce, at plant operating capacity, gradations in each of the sizes of heated and dried aggregates which are reasonably uniform and result in the production of a mixture complying with the limits specified for the aggregate.

**18.6.12  Preparation & Composition of the D.B.M. Mixture**

Each size of aggregate, the bitumen binder, and the filler, if used as a separate constituent, shall be measured separately accurately to the proportions in which
they are to be mixed. When the mixture is prepared in a twin pugmill mixer the volume of the aggregate shall not be so great as to extend above the tips of the mixer blades when these blades are in a vertical position. After the aggregate, including the filler, has been charged into the mixer, the asphaltic binder shall be introduced and mixing continued until all the particles of the mineral aggregate are coated uniformly.

The initial mixing time will be designated by the Engineer. Mixing time may be increased by the Engineer if additional time is necessary to obtain a homogeneous mixture and satisfactory coating.

One batch plant's timing shall begin at the start of the asphalt introduction into the pugmill.

The length of mixing time for continuous plants will be determined by the following formula or other approved methods.

Mixing time in seconds = Pugmill dead load capacity in kilos / Pugmill output in kilos second

The temperature of the asphalt except for temporary fluctuations shall not be lower than fourteen (14) degrees C below the temperature of the aggregate at the time the two (2) materials enter the mixer or pugmill.

The constituents of the total mixtures shall be combined in such proportion as directed based on the job mix formula.

The finished bituminous macadam shall be tested in place by such standard ASTM or AASHTO tests as deemed necessary to establish the quality of the finished product. Samples shall be taken as considered necessary for checking the asphalt content in the mixtures by means of the standard extraction test to ensure that the specified gradation has been provided.

18.6.13 Use of the Bitumen

The bitumen shall be tested from time to time to ensure that it is maintained at a uniform consistency. The Engineer's Representative may test other physical properties of the bitumen to check on the quality of the material delivered and to ensure that it meets the required specification. For D.B.M. as herein specified the bitumen shall be 60/70 penetration paving grade unless otherwise specified in the special provisions of the contract. It shall be heated within a temperature range of 135 degrees C to 163 degrees C at the time of mixing. All material reheated more than 28 degrees C above the maximum shown shall be considered overheated and shall be rejected until the material can be resampled and tested. The reacceptance or rejection will be made on the same requirements as established for the original material. The exact temperature of mixing shall be determined from an approved viscosity temp. relationship. The storing temperature of bitumen shall not exceed 1200C.
The mixing temperature shall be determined from Viscosity vs temperature relationship as required by ASTM D-1559.

18.6.14 Asphalt Plant Inspection

The Engineer's Representative or his authorized representative shall have access at all times to the Contractor's asphalt plant. The Contractor shall provide ladders or stairs for easy access for the inspectors to obtain samples or to check on working parts of the plant or to inspect the screens or the screening arrangement.

18.6.15 Hauling the D.B.M. Mixture

The hot plant mixed D.B.M. shall be delivered to the haulage trucks at the temperature set by the Engineer's Representative. Each truck shall be equipped with a suitable box. The truck box shall contain no dirt or other foreign materials and loaded trucks shall proceed immediately to the Site of the paving operation and shall discharge the load without delay. Any loads which are not satisfactory for any reason whatsoever including loss of heat shall be rejected. Where payment of the D.B.M. is by the ton each truck shall be weighted and a valid weight certificate shall accompany the load for delivery at the paver. Trucks transporting D.B.M. shall be covered.

18.6.16 Placing and Finishing

18.6.16.1 General Requirements

The base or subgrade upon which the D.B.M. is to be placed shall be prepared and maintained smooth firm and in reasonably close conformity to the lines grades and dimensions established or shown on the Drawings.

If necessary to obtain the required base or sub-grade surface conditions and if ordered a base material or D.B.M. shall be spread and compacted as directed to fill and level low areas and high areas shall be removed by cutting and levelling.

In advance of the placement of a D.B.M. course and the course is being placed on a primed or paved surface the surface to be paved shall be swept clean of loose dirt and other objectionable material using power brooms along with hand brooms and other means as necessary.

No Bituminous Material shall be laid if the atmospheric temperature is below 15°C or the weather is rainy or foggy or moisture is apparent on the laying surface.

A light coat of bituminous material shall be applied as directed to edges or vertical surfaces against which D.B.M. is to be placed is at least 18°C (65°F).
The temperature of the D.B.M. just prior to the dumping of the material from the hauling vehicle shall be at least 120\(^\circ\)C (240\(^\circ\)F) but not exceed 163\(^\circ\)C (325\(^\circ\)F).

When Bituminous Prime Coat is specified prior to the placement of D.B.M. the bituminous prime coat shall be applied in accordance with the requirements of the specifications. No D.B.M. shall be placed until the prime coat has penetrated the base or subgrade and has cured sufficiently.

When a bituminous tack coat is specified prior to placement of any course of D.B.M. the bituminous tack coat or coats shall be applied in accordance with the requirements of the specifications. Tack coat may not be required where the delay between course laying is less than 48 hours and when the surface is fresh and clean at the discretion of the Engineer.

18.6.16.2 Loading Material Into the paving Machine

The mixed material shall be dumped from the hauling vehicles directly into the paving machine.

When dumping directly into the paving machine from trucks, care shall be taken to avoid jarring the machine or moving it out of alignment. Trucks shall be securely attached to the paving machine while dumping.

18.6.16.3 Placing and Finishing by Means of a Propelled Paving machine

The bituminous mixture shall be spread and finished true to crown and grade by an automatically controlled bituminous paver. Bituminous mixtures may be spread and finished by hand methods only where machine methods are impractical as determined by the Engineer.

The automatically controlled paver shall spread the bituminous mixture without tearing the surface and shall strike a finish that is smooth true to cross section uniform in density and texture and free from hollows transverse corrugations and other irregularities.

The paver shall be operated at a speed which will give the best results for the type of paver being used and which co-ordinates satisfactorily with the rate of delivery of the mixture to the paver so as to provide a uniform rate of placement without intermittent operation of the paver.

All mixed material shall be delivered to the paver in time to permit completion of spreading finishing and compaction of the mixture during daylight hours.

All bituminous mixtures shall be delivered to the paver at a temperature between 120\(^\circ\)C - 163\(^\circ\)C. Mixtures delivered to the paver at lower temperatures shall be discarded.

The longitudinal joints in successive layers shall be offset not less than fifteen (15) centimeters nor more than thirty (30) centimeters. The width of surface or top course placements shall conform to traffic lane edges as shown on the plans.
The leading half of half-roadway paving shall not get ahead of the pavement by more than one (1) average full-day of paving and in no case shall the leading half be more than one-half (1/2) kilometer ahead of the trailing half without the written permission of the Engineer. If the Contractor fails to comply with this requirement the Engineer may suspend paving on the leading half until such time as the Contractor shall pave the trailing half to a point approximately even with the leading half.

Unless otherwise directed by the Engineer, where successive layers are to be placed, the surface of the existing layer shall be swept clean with a power broom, or by other means as approved by the Engineer and a tack coat applied.

Bituminous mixtures, except on leveling courses, shall be spread in a placement thickness so that after rolling the nominal thickness of the compacted bituminous material will not exceed eight (8) centimeters. Where practical, top layers should not exceed five (5) centimeters.

The maximum thickness for layers may be increased slightly when such increase is more adaptable to total pavement thickness and when in the opinion of the Engineer it is not detrimental to placement and rolling conditions.

18.6.16.4 Preliminary Survey Reference String Line.

The Contractor will make the survey required for the reference grade. When the survey is approved by the Engineer, the Contractor shall erect and maintain an approved reference string line and operate the paver to conform to the string line for the initial layer and/or any other layers as directed. Elevation control points stakes for the first layer of wearing course shall be set at a maximum spacing of twenty (20) metres. For subsequent layers, control points shall be set at ten (10) metres maximum spacing. The Contractor shall furnish and maintain and approved mobile string line for all layers not laid with the erected string line, and operate the paver to conform to that string line. The string line shall be erected parallel to the reference grade and the bituminous mixture shall be spread at a constant elevation above, below or at the string line elevation as directed.

The use of the automatically controlled bituminous paver to provide both longitudinal and transverse control shall include the furnishing and maintaining of a string line, whether it be erected or mobile, by the Contractor. The longitudinal and transverse controls shall operate independent of each other to the extent that the surface of the bituminous mixture will conform to the string line and will be uniform in cross section or crown.

The Contractor shall establish the centerline points and shall maintain the location of the points until the completion of the surfacing or as directed. When directed by the Engineer the Contractor shall erect a string line to be used as a guide for the finishing machine in order to maintain a uniform edge alignment. If any other method is proposed by the Contractor, it shall be approved by the Engineer.

18.6.16.5 Machine Spreading
The Contractor will make a survey study of the centerline profile and crown of the existing surface or base and determine or calculate a Reference and approval fill values at each profile point necessary to erect the Reference String Line.

On the initial traffic lane paving operation, the asphaltic mixture shall be spread with the bituminous paver to a grade line constant to the Reference String Line.

Hot asphaltic mixtures shall be placed only when the atmospheric temperature is four (4) degrees C or above, and when the weather is not foggy or rainy and when the existing surface is free from moisture.

18.6.16.6 Joints

When a surface course is placed over a leveling course or when a finishing course is placed over a surface course longitudinal joints shall be staggered with relation to the longitudinal joints of the underlying course.

Longitudinal joints of the final course, whether surface or finishing course, shall be located at the center of a lane or at the joints between two adjacent lanes.

Before a surface course is placed in contact with a cold transverse construction joint, the cold material shall be trimmed to a vertical face by cutting the material back for its full depth and exposing a fresh face. After placement and finishing of the new material the material on both sides of the joint shall be dense and the joint shall be well sealed. The surface in the area of the joint shall conform to the requirements hereinafter specified for surface tolerances when tested with the straightedge placed across the joint.

18.6.16.7 Compaction of Mixtures

After spreading and strike-off and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted. Rolling will not be prolonged till cracks appear.

Rollers shall be of the steel wheel and or pneumatic type and shall be in good condition, capable of reversing without backlash and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate will not be permitted. A minimum of three (3) rollers two (2) steel-wheel and one (1) pneumatic tyre type, shall be used with each spreading operation.

Initial or breakdown rolling shall be done by means of either a tandem power steel roller or a three (3) wheel power steel roller. Rolling shall begin as soon as the mixture will bear the roller without undue displacement. Rolling shall be longitudinally, beginning at the low side of the spread of material and proceeding toward the high side overlapping on successive trips by at least one-half (1/2) the width of the rear wheels. Alternate trips of the roller shall be of slightly different lengths.
The motion of the roller shall at all times be slow enough to avoid displacement of the mixture. To prevent adhesion of the mixture to the rollers, the wheels of the rollers shall be kept properly moistened with water, but an excess of water will not be permitted.

The initial or breakdown rolling shall be followed by rolling with a pneumatic tired roller. Final compaction and finish rolling shall be done by means of a tandem power steel roller unless otherwise designated. When the specified density is not obtained changes in the size and/or number of rollers shall be made as corrective measures to satisfy the density requirement.

Rollers shall be operated by competent and experienced roller men and shall be kept in operation continuously if necessary so that all parts of the pavement will receive substantially equal compaction at the time desired. The Engineer will order the mixing plant to cease operation at any time proper rolling is not being performed.

Rolling subsequent to that on the day of laying shall be by smooth pneumatic tyred rollers (PTR) only.

The road density requirements shall be equal to or greater than ninety seven (97) percent of the Marshall density of each day's production for basecourse/roadbase and ninety eight (98) percent for wearing course.

Any mixture that becomes loose, broken, mixed with foreign material, or which is in any way defective in finish or density, or which does not comply in all other respects with the requirements of the specifications shall be removed, replaced with suitable material and finished in accordance with the specifications.

18.6.16.8  Contact Surface

Contact surfaces of kerbing gutters, manholes, and similar structures shall be painted with a thin uniform coating of asphaltic material approved by the Engineer.

The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be seven (7) millimetres above the edge of such structures.
18.6.16.9 Trial Area

After the approval of any one job mix formula the Contractor shall demonstrate the compaction methods he propose to use. For this purpose a trial area of minimum length 100 m and minimum width one traffic lane shall be laid using only compaction plant that is available one each paver. The number of passes of each unit of plant shall be recorded. A full testing procedure will then be carried out to determine the compaction achieved and the consistency of the material with the job mix formula.

No further D.B.M. work will be permitted until the compaction methods are shown to be acceptable.

From the number of passes required and speed of compaction plant the maximum output of D.B.M. shall be determined and this shall not be exceeded unless additional compaction plant is brought to site.

18.6.16.10 Trafficking of Asphalt Surface

When asphalt is laid during the summer months (May to October) and where the roads are heavily trafficked, the surface should not be trafficked until a period of 7 days has elapsed. The Contractor should consider this restriction while programming his works.

18.6.17 Density Requirements

The density of the mixture as placed and compacted on the road shall be determined from samples cut from the compacted courses on the road at locations specified by the Engineer. Samples shall be obtained in sets of two (2) cut from the same location on the road. The frequency of testing shall be as stated in this Specification or a minimum of one (1) set per day for shorter runs and such additional tests to determine limits of areas deficient in density, or for recheck. The density of these samples will be referred to as "Road Density".

Core testing shall be carried out by the Contractor. The equipment shall be capable of cutting the mixture without shattering the edges of the specimen or otherwise disturbing the density of the specimen. Samples shall be ten (10) centimetres in diameter (nominal).

The Contractor shall take samples only in the presence of the Engineer's Representative. Where necessary additional core samples may be taken to confirm thickness of layers.

The Contractor shall when necessary furnish and apply cold water ice or other cooling substance to the surface of the pavement to prevent the samples from shattering or disintegrating. The Contractor shall cut all samples and fill and compact all test holes at his own expense.

Should the asphaltic material fail to achieve the specified density, at the discretion of the Engineer re-rolling may be allowed subject to the following conditions:
1. The Densification to be achieved shall be 1% or less.
2. Only PTR's weighing not more than 18 tonnes to be used.
3. Re-rolling to take place within 72 hours from the time of the initial rolling of the asphalt.
4. Re-rolling to take place at the time of the day when the natural asphalt temperature is at its maximum.
5. Re-rolling to be applied for a maximum of two hours.
6. Re-rolling to be carried out in the presence of the Resident Engineer.
7. The section of the works in question to be cored for density determination within 24 hours after the completion of the re-rolling.
8. If after re-testing the density achieved is 0.5% or less below the specified density, the asphaltic layer will be accepted in the works subject to a 20% reduction to the billed rates. If on the other hand the density achieved is greater than 0.5% below the specified density the asphaltic material shall be removed and new material laid to the specification at the Contractor's cost.

18.6.18 Pavement Uniformity and Thickness of Cores

The total depth of asphaltic courses and surface courses shall be measured in two (2) separate operations for each type of material. Thickness determinations shall be made at a minimum of four (4) locations per lane per kilometer, at locations designated by the Engineer.

The first two cores in the binder course shall be taken when all layers but one (1) are laid. The second two cores in the binder course shall be taken through the last layer adjacent to the location where the first cores were taken. The first two cores in the surface courses shall be taken through the last layer adjacent to the locations where the first surface course were taken. Where binder courses or surface courses are laid in a single layer only two (2) cores shall be taken for each type of material.

The finished pavement shall be of uniform thickness and texture and the thickness shall not vary more than 3 mm. from that specified.

The surface tolerance of any paving course shall be such so as not exceed 6 mm. when tested by means of a 4 meter straight edge longitudinally and 3 mm. when tested transversely.

Any layer with deviations exceeding the foregoing limits shall be corrected or removed and replaced by the Contractor at his own expense.

18.6.19 Measurement

D.B.M. will be measured by square meters for the theoretical area paved.
18.6.20 Payment

No payment will be made for extra width or for extra thickness.
Payment will be made under:
Pay Item Pay Unit
D.B.M. Square Meter

18.6.21 Relevant Tests and Standards

The following tests should be carried out unless otherwise directed by the Engineer at frequencies laid down in the specifications :-

**AGGREGATES**

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limits</th>
</tr>
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<tbody>
<tr>
<td>Sampling</td>
<td>B.S. 812/AASHTO T2</td>
<td></td>
</tr>
<tr>
<td>Aggregate Crushing Value</td>
<td>B.S. 812 Part 110</td>
<td>Max. 23%</td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate Flakiness/</td>
<td>B.S. 812 Part 105</td>
<td>Max. 30/25</td>
</tr>
<tr>
<td>Elongation Index</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Los Angeles Abrasion</td>
<td>AASHTO T96</td>
<td>Max. 35</td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td>To specified limits</td>
<td></td>
</tr>
<tr>
<td>Grading Analysis</td>
<td>AASHTO T-27 &amp; T-11</td>
<td>As shown in</td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td>Tables.</td>
<td>specified limits</td>
</tr>
<tr>
<td>Soundness using Sodium Sulphate</td>
<td>AASHTO T104</td>
<td>Max. 12</td>
</tr>
<tr>
<td>(Individual stockpile)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Density</td>
<td>AASHTO T19</td>
<td>Min. 1120 Kg/m³</td>
</tr>
<tr>
<td>Sand Equivalent</td>
<td>AASHTO T176</td>
<td>Min. 45</td>
</tr>
<tr>
<td>Water Absorption</td>
<td>ASTM C127</td>
<td>Max. 2%</td>
</tr>
<tr>
<td>Mix Design</td>
<td>Asphalt Institute-MS</td>
<td></td>
</tr>
</tbody>
</table>

2
### Mineral Filler:

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>B.S. 812</td>
<td>-</td>
</tr>
<tr>
<td>Grading Analysis</td>
<td>AASHTO T37</td>
<td>As AASHTO M17</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>AASHTO T90</td>
<td>Max. 4</td>
</tr>
</tbody>
</table>

### BITUMEN MIXTURES

<table>
<thead>
<tr>
<th>Test</th>
<th>Standard</th>
<th>Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sampling</td>
<td>AASHTO T168</td>
<td>--</td>
</tr>
<tr>
<td>Bitumen Content</td>
<td>AASHTO T164</td>
<td>As specified</td>
</tr>
<tr>
<td>Density</td>
<td>AASHTO T166</td>
<td>As specified for any course</td>
</tr>
<tr>
<td>Marshall Criteria</td>
<td>ASTM D1559</td>
<td>As specified</td>
</tr>
</tbody>
</table>

Loss of Marshall Stability by submerging specimens in water for 60°C for 24 hours as compared to stability after submersion in water at 60°C for 20 minutes.

Mechanical analysis of Extracted Aggregates To confirm application of design mix on site AASHTO T30.

---

#### 18.7 Bituminous Materials - Quality

#### 18.7.1 General Requirements

Bituminous materials shall conform, when tested in accordance with the tests hereunder enumerated, to the following requirements, as applicable, for the types and grades designated and used. Certificates conforming to these requirements shall be submitted by the Contractor.
18.7.2 Sampling of Bituminous Material

It shall be the responsibility of the Contractor to provide convenient facilities for obtaining accurate samples of bituminous materials from transports, distributor trucks, and from storage tanks by means of an approved sampling device.

18.7.3 Bituminous Material Requirements

18.7.3.1 Penetration Grade Bitumen

Penetration Grade Bitumen shall conform to the requirements of specified table.

18.7.3.2 Liquid Asphalt

One) Slow curing liquid asphalt.
    Slow curing liquid asphalt shall conform to the requirements of specified table.
Two) Medium Curing Liquid Asphalt.
    Medium Curing Liquid Asphalt shall conform to the requirements of specified table.
Three) Rapid Curing Liquid Asphalt.
    Rapid curing liquid asphalt shall conform to the requirements of specified table.

18.7.3.3 Emulsified Asphalt

Emulsified asphalt (Anionic Type) shall conform to the requirements of specified table.

Emulsified asphalt (Cationic Type) shall conform to the requirements of specified table.

Emulsified asphalt Grade RS-1, SS-1 and SS-1h shall be diluted with water to give an asphalt content of not less than 26 percent.

If grade RS-1 is used, it shall be diluted by the manufacturer. If either Grade SS-1 or SS-1h is used, it may be diluted in the field.

18.7.4 Application

Application requirements for bituminous materials shall be in accordance with specified table.
18.8 Pavement Marking

18.8.1 Description

Pavement marking shall consist of supplying road marking paint for marking of the pavement as outlined herein. It shall include the marking of the centerline the shoulder strip or edge, the barrier lines, the cross walks and any other markings required on the pavement for the control and direction of the traffic.

18.8.2 General Description

The material used shall conform in most respects to the B.S. Specification for Road Marking Materials (Super imposed type) BS 3262, 1989, including amendments. Where there is no conformance, the deviations shall be clearly given (as in this specification) in reference to the relevant tables and paragraphs of BS 3262.

The material shall be thermoplastic sprayable or hand applied and shall consist of light colored aggregate, pigment and extender, bound together with hard wearing resins, plasticised with oil as necessary.

The grading of the various ingredients shall be such that the final product, when in a molten state, can be sprayed on the road surface at approximately 1.5 mm. thickness.

18.8.3 Aggregate

The aggregate shall consist of white silica sand, crushed calcite, calcined flint or quartz, or other approved aggregate, and the colour shall comply with the requirements laid down in BS 3262 i.e. the luminance factor compared with magnesium carbonate shall be not less than 50.

18.8.4 Reflectorization

Ballotini, complying BS.6088, incorporated in the mixture shall be in accordance with BS 3262 i.e. all shall pass a No. 10 BS sieve (1.68 mm); not more than 10 percent shall pass a No. 36 B.S. sieve (0.42 mm); and not less than 80 percent shall be transparent glass, reasonably, spherical, and free from flaws.

The ballotini sprayed on to the surface of the line shall conform to the same limits of colours and roundness, but may be smaller; not more than 10 percent shall pass a No. 72 BS sieve (0.21 mm).

18.8.5 Pigment and Extender

The pigment shall be titanium dioxide (in accordance with Paragraph 6 a (i) of B.S. 3262 and shall be not less than 10 percent by weight of the mix.

The extender shall be whiting (in accordance with Paragraph 6 b of BS 3262). The total content of pigment and extender shall be 18-22 percent (in accordance with Paragraph 6c of BS 3262).
18.8.6  **Binder**

The binder shall not contain more than 5 percent of resin or other acidic material. It shall consist mainly of hydrocarbon resins plasticised with mineral oil.

18.8.6.1  **Binder**

The resins used shall be of a color at least as pale as Grade WG resin. It shall have an acid value not greater than 2, and must pass the heat stability test described in 26.6.3 below.

18.8.6.2  **Resins**

The oil used as plasticiser shall be a mineral oil with color and viscosity as defined in Paragraph 7a (ii) of B.S. 3262 i.e. at least as pale as grade 4 on the P.R.S. Shellac and Varnish "A" Disc, and 1/2 to 3 1/2 poises at 25°C viscosity. In addition, when heated for 16 hours at 150°C it shall not darken excessively.

18.8.6.3  **Oil**

The softening point of the binder shall be used only as a guide to quality control, and the behaviour of the thermoplastic shall be judged from the performance tests described below.

18.8.6.4  **Softening**

The viscosity of the melted binder at the spraying temperature must be such as to produce a thermoplastic mix of the required spraying properties.

18.8.7  **The Composition of the Mixture**

The composition of the laid materials as found on analysis shall comply with the requirements of Table 1 of BS 3262 reproduced below:

<table>
<thead>
<tr>
<th>Table 1. Proportions of constituents of marking material (see note)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constituent (s)</td>
</tr>
<tr>
<td>---------------------------------------------------------------</td>
</tr>
<tr>
<td>Binder (resin and oil)</td>
</tr>
<tr>
<td>Solid Glass beads *</td>
</tr>
<tr>
<td>Aggregate together with pigment, extender and solid glass beads</td>
</tr>
<tr>
<td>* Where specified.</td>
</tr>
</tbody>
</table>

Note: Black material is to be non-reflectorised and binder is to be 19.3% by mass of the total
The intension of this standard is that a minimum of 20% glass beads complying with BS 6088 should be incorporated in the mix at the time of manufacture.

B: Grading of Combined Aggregate

Pigment and Extender and where specified solid glass beads in the marking material

<table>
<thead>
<tr>
<th>Passing B.S. Sieve</th>
<th>Percentage by We</th>
</tr>
</thead>
<tbody>
<tr>
<td>Minimum</td>
<td>Maximum</td>
</tr>
<tr>
<td>2.80 mm</td>
<td>100</td>
</tr>
<tr>
<td>600 micron</td>
<td>65</td>
</tr>
<tr>
<td></td>
<td>95</td>
</tr>
</tbody>
</table>

18.8.8 Mixing

The temperature limits imposed by B.S. 3262 for materials based on resin shall not apply. Temperatures up to 220°C may be used; at these temperatures the material shall not discolor in the time required for its use.

18.8.9 Containers

These shall conform to the following requirements of Paragraph 10 of B.S. 3262.

18.8.9.1 Materials

One) Containers shall be made of a material which does not contaminate the contents, and will protect the contents from contamination.

Two) Not less than 25 kg or more than 100 kg.

Three) Each container shall be clearly marked with the manufacturer's name, batch number, and date of manufacture.

As stated in these specifications, the binder shall be hydrocarbon resins, and shall not contain more than 5 percent of resin.

18.8.10 Application

Application shall be by mobile sprayer, either hand-propelled or self-propelled.

The road surface shall be dry, and free of loose detritus, mud, or other extraneous matter. Where old paint or thermoplastic material are present, the manufacturers shall be consulted as to whether the surface is suitable.

A tack coat should not be necessary when the plastic is applied to carriageways. Where it is considered necessary to use a tack coat, this shall be a rubberised type recommended by the manufacturers of the plastic.
In addition to the ballotini included in the mix, and additional quantity of glass beads shall be sprayed on to the hot Sprayplastic line at the time of application. For quality and limits of grading see Reflectorization. The rate of application shall be at the rate of about 0.5 kg/m².

The material shall be laid in intermittent lines or continuous lines of 1.5 mm thick using an approved pressure spray unit as directed by the Engineer. The finished lines shall be free from "raggedness" on sides and ends and be in true plane with the general alignment of the carriageway.

The upper surface of the lines shall be level, uniform and free from streaks.

18.8.11 Weight Per Gallon

The composition shall possess and approximate specific gravity of 2.0

18.8.12 Flash Point

The compound shall have an open flash point exceeding 230°C.

18.8.13 Performance Tests on the Material

These tests shall be performed as per B.S.3262.

18.8.13.1 Abrasion Resistance

The thermoplastic must possess excellent wear-resistant properties. The may be measured by taking a 3 mm thickness on a monel-panel and subjecting it to wet (water lubricated) abrasion in a Taber instrument using H.22 Calibrade wheels(B.S.3262, appendix K). The loss in weight after 200 revolutions shall not exceed 0.5 gm.

18.8.13.2 High Temperature Softening

The material, when tested by the approved method, shall show little or no indentation at 80°C.

In order to confirm that material possesses adequate thermoplastic properties over the required climatic temperature for good levelling, a sample shall be applied to a small piece of well dried hard-board (say 12 cm x 6 cm) for a coating thickness of 3 mm in a 10 cm. wide stripe across the board. When thoroughly cold this is laid flat in a thermostatically controlled oven maintained at the highest temperature the road surface (white) is normally expected to reach. A 100 gm weight (diameter 24 mm) is placed on its level surface, preferably on a disc of thin paper, 25 mm. diameter. After standing for one hour the weight should not have penetrated the surface of the material any more than with a slight impression.
18.8.13.3 Whiteness

The mean luminous factor of the mixed material shall not be less than 75. White lines shall remain free from discoloration by normal traffic.

18.8.14 Traffic Control & Protection of the Work

The Contractor shall control the traffic in such a manner as to protect the freshly marked surface from damage. The traffic control shall be so arranged as to give minimum interference to the travelling public. Signs, barricades, flagmen and control devices shall be supplied by the Contractor and a system of spaced warning flags or blocks shall be used to protect the fresh markings until it has dried if so required. Any lines, strips or markings which become blurred or smeared by the traffic shall be corrected by the Contractor at his own expense.

18.8.15 Measurement

Pavement marking will be measured by the linear meter for centerline, edge line and parking delineation and square meter for all other markings. Markings measured by Linear meter will not include gaps in intermittent markings.

18.8.16 Payment

The agreed quantity of Pavement Marking measured as provided above will be paid for at the contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pavement Marking</td>
<td></td>
</tr>
<tr>
<td>Continuous and intermittent road marking lines in thermoplastic material. (Different widths measured separately)</td>
<td>Linear metre</td>
</tr>
<tr>
<td>Pavement Marking (Miscellaneous)</td>
<td>Square meter</td>
</tr>
</tbody>
</table>

The Miscellaneous marking will include arrows, chevrons, hatching and all other markings not measured here as linear meter.
18.9 Road Signs

18.9.1 Description

Road Signs shall consist of supplying and erecting road signs as shown on the drawings and the Road Signs list in accordance with these Specifications.

18.9.2 Scope

Road Signs shall be supplied and installed in place as shown on the drawings and list of Road Signs and in accordance with the Drawings and Specifications.

18.9.3 Signs Base Material

The standard road signs shall be of 3 mm. or 5 mm. T6 Alloy Aluminum sheets. This plate shall be non-porous, smooth, flat, rigid, weather proof and shall not rust or deteriorate. It shall be so cut that there are no sharp edges and that the corners are rounded off to a radius of 30 mm. Any trade mark or other printing shall be carefully removed with lacquer thinner.

18.9.4 Sign Face and Back Face

The sign faces for different messages shall be made with wide angle reflective sheeting which shall be processed on to the aluminum plate. The base of the sign face shall be normally of white blue or yellow wide angle reflective sheeting or as described in the foregoing paragraphs, but the particular sign message shall, however, be in black non-reflective film.

Prior to application of reflective film, the signs shall be cleaned and shall be waxfree. They shall be greased by vapour or by alkaline immersion and etched by scrubbing with abrasive cleanser, such as medium fine steel wool. They shall be rinsed thoroughly and dried with hot air before applying any reflective material.

The sheeting shall be cut by any standard method by a band saw or a power guillotine. The cutting tool shall be clean and sharp. The sheeting shall be cut from face side and held securely during cutting to avoid shattering and edge chipping.

The sheeting after application to the sign base shall not come off the edges nor shall it peel off nor warp. The surface shall be smooth, flat and free from any bubbles, pimples, edge chipping or edge shattering. It shall be washable and weatherproof.

The sheeting of different colors reflective or non-reflective shall have a life of 5 years after application to the face of the sign.

This life of 5 years shall be the outdoor at-site life during which period it shall not fade in color or its reflectivity nor shall it deteriorate in any way.
The backface of the aluminium sign plate shall be provided with gray opaque non-reflective film so that the life of the two faces remains the same, i.e. about 5 years.

The colors shall be in accordance with the colors used on international road signs. They have to be approved by the Engineer's Representative.

18.9.5 Erection of Road Signs

All signs shall be mounted approximately at right angles to the direction of, and facing, the traffic they are intended to serve.

To get maximum effectiveness from reflecting sheeting, the sign must be properly located and should be faced slightly towards the road, according to this procedure:

If the center of the sign is 30 m or less from the centerline of the highway the sign should be faced toward a point 160 m down the road. If more than 30 m the sign should be faced 250 m down.

To avoid specular glare the sign face should be tilted back two or three degrees (about 1 cm. per 26 cm. of sign height)

Details about the mounting and the footing of the different type of signs are shown on the drawings. Mild steel posts shall be treated with one of the following treatments as approved by the Engineer.

1. Shot blasted, one coat primer (min. thickness 50 microns), one coat micaceous iron oxide (min. thickness 50 microns), one coat undercoat, and one coat finish of alkyd based oil paint (min. total thickness of both coats 100 microns).

2. Shot blasted, rustproof with hot wire zinc spray and under coat and finish coat as (1).

3. Shot blasted, hot wire zinc spray rustproofing and wet applied PVC spray giving a minimum plastic coating of 0.125 mm. The finish colour should be grey.

For both (1) and (2) the finish coat should be black and white hoops as directed by the Engineer.

All bolts and other fittings should be non-ferrous or hot dipped galvanized. Connecting surfaces of different metals should be separated by neoprene washers.
18.9.6 **Lettering**

Sign lettering shall be in the English language in clear, open capital letters and in the Arabic language as shall be directed by the Engineer.

To improve legibility a relatively wide spacing between letters should be used. The space between letters should be 1 or 2 widths of the letter stroke, depending on whether the sides of the adjacent letters are vertical or round.

The space between lines of copy should be approximately equal to the height of upper case letters used in that line of copy. Space between lines of copy should be approximately 3/4 of the average height of the upper case letters in adjacent lines of copy.

Spacing to top and bottom borders should be approximately equal to average letter height of adjacent line of copy. Spacing to side borders from ends of longest line of copy should be approximately equal to height of upper case letters in that line. Longest line should be "Visually Centered" on sign to account for slanted or open-sided letters on either end.

A brilliant reflective border makes the sign more conspicuous. Border width should be approximately 1/3 to 3/4 the stroke width of the largest letters of the sign.

18.9.7 **Guarantee By Contractor**

All road signs shall be guaranteed by the Contractor against any defect in material and workmanship for a period of five years from the date of completion of the Works under the Contract. If any defect should arise due to material or workmanship shall be rectified by the Contractor at his own expense.

If such defect is rectified by other than the Contractor in accordance with the Employer's instructions, the expense of such rectification shall be deducted from any monies due on Contract or any other Contract as the Employer may decide.

18.9.8 **Measurement**

Road Signs will be measured per unit for each Sign.

18.9.9 **Payment**

The accepted quantities of Road Signs will be paid for at the Contract unit price complete in place.

Payment will be made under:

<table>
<thead>
<tr>
<th>Pay Item</th>
<th>Pay Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road Signs</td>
<td>No.</td>
</tr>
</tbody>
</table>

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19 PIPELINES AND PIPES WORKS

19.1 Pipe and Pipeline Material

19.1.1 Granular Material for Pipe Bedding

Granular material for pipe bedding shall be free-draining, hard, clean, chemically stable gravel, crushed stone or crushed slag, graded in accordance with the following table:

19.1.2 Percentage by Weight Passing Sieve

<table>
<thead>
<tr>
<th>Test Sieve mm</th>
<th>For Pipes of Diameter 400 mm and below</th>
<th>For Pipes of Diameter 600 mm &amp; above</th>
</tr>
</thead>
<tbody>
<tr>
<td>63</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>37.5</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>20</td>
<td>85 - 100</td>
<td>-</td>
</tr>
<tr>
<td>14</td>
<td>-</td>
<td>100</td>
</tr>
<tr>
<td>10</td>
<td>0 - 50</td>
<td>0 - 50</td>
</tr>
<tr>
<td>5</td>
<td>0 - 10</td>
<td>0 - 25</td>
</tr>
<tr>
<td>2.36</td>
<td>-</td>
<td>0 - 5</td>
</tr>
</tbody>
</table>

Note: For pipes 400 mm to 600 mm diameter, either grading is acceptable.

The material shall have a Compaction Fraction value not exceeding 0.2 when determined in accordance with the following test:

A representative sample of about 40 kg shall be heaped onto a clean surface and quartered to obtain approximately 10 kg. The moisture content of the sample should not differ materially from that of the main body of material, at the time of use in the trench.

A 150 mm internal diameter open ended cylinder 250 mm high, shall be placed on a firm flat surface and loosely filled, without tamping, from the 10 kg sample. Any surplus material shall be struck off level with the top of the cylinder. The area around the filled cylinder shall be cleared of all surplus material and the cylinder then lifted clear of its contents and placed alongside the material.

Approximately one quarter of the material shall then be replaced into the cylinder and compacted by tamping vigorously with a 40 mm diameter metal rammer weighing about 1 kg until no further compaction can be obtained. This operation shall then be repeated for each of the remaining quarters, tamping the final surface as level as possible.

The distance from the top of the cylinder to the surface of final layer shall then be measured and this value, divided by the height of the cylinder, shall be taken as the Compaction Fraction.

Pipe bedding material to concrete pipes shall not contain more than 0.3 per cent sulphate, expressed as sulphur trioxide.

For uPVC pipes only rounded aggregates will be permitted but for all other pipe materials crushed aggregates may also be used.

19.1.3 Pipe Classifications and Pressure Ratings
For structural purposes pipes shall be classified into three groups:

**Group A:** Rigid pipes which do not depend on lateral support from the bedding and trench sides for structural strength.

Pipe materials include: -

Concrete
Clayware
Asbestos Cement
Pitch Fibre
Grey Iron

**Group B:** Flexible pipes which depend on lateral support from the bedding and trench sides for structural strength and to prevent distortion.

Pipe materials include: -

RP (Reinforced Thermosetting Plastic Pipes)
uPVC (unplasticised Polyvinyl Chloride)
HDPE (High Density Polyethylene)
PP (Polypropylene)

**Group C:** Pipes which have some flexibility but which have sufficient strength to support some loadings without assistance from the ground.

Pipe materials include: -

Steel
Ductile Iron

Pressure pipes shall be supplied to the following rated pressure classifications: -

Asbestos Cement 12 bar
RP 12 bar
uPVC 12 bar (12 bar rated pipes used to allow for temperature derating).

### 19.1.4 Joint Requirements and Limitations

Unless pipes are detailed with rigid joints or are specified differently all pipelines shall be jointed with approved mechanical, flexible joints with elastomeric joint rings. The whole joint assembly shall be compatible with the pipe construction and with the specified performance of the completed pipeline.

**Flexible joints**

May comprise either an integrally formed socket (bell) and spigot assembly with single sealing ring, or a separate sleeve coupling and double spigot assembly with two sealing rings.

The completed joint shall be capable of accepting the following ranges of deformation when subjected to internal pressure without losing its seal at the specified test pressure, without direct contact between spigot and socket/coupling and without inducing stresses or strains in the pipe material beyond the safe working limits.
<table>
<thead>
<tr>
<th>Pipe Diameter</th>
<th>Minimum Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angular deflection:</td>
<td></td>
</tr>
<tr>
<td>up to and including 200 mm</td>
<td>30</td>
</tr>
<tr>
<td>(all materials)</td>
<td></td>
</tr>
<tr>
<td>Over 200 and not over 500 mm</td>
<td>1.75</td>
</tr>
<tr>
<td>Over 500 and not over 1350 mm</td>
<td>1</td>
</tr>
<tr>
<td>Over 1350 mm</td>
<td>0.5</td>
</tr>
</tbody>
</table>

Straight draw: Not less than 10 mm or the following proportions of the length of the longest pipe/unit at any joint:

1% for polyethylene pipes
0.5% for polypropylene, polybutylene or ABS pipes.
0.3% for RP and uPVC pipes
0.1% for steel, ductile iron, asbestos cement

Shear:

Pipe materials which are listed in structural groups A and C shall be loaded to 20 N/mm of pipe diameter. Pipe materials which are listed in structural group B shall be subjected to 5% elliptical deflection of the spigot end forming part of the joint.

If the approved standard for a pipe material does not include a shear test for the jointing system, this test shall be carried out in accordance with test procedure of another appropriate pipe material standard.

Elastomeric joint sealing rings shall be manufactured from ethylene propylene rubber (EPM, EPDM) and shall have a hardness measured in International Rubber Hardness Degrees (IRHD) compatible with the pipe material.

19.1.5 Concrete Pipes

The materials, manufacture, physical requirements, dimensional variations, workmanship and finish for the manufacture of pipes shall meet the requirements of BS 5911.

In all cases the Engineer shall approve the sources of materials for pipe manufacture and shall supervise the necessary tests on representative samples to ascertain their compliance with the Specifications prior to importation of the pipes to the site of works. All tests shall be performed by or under the supervision of the Engineer and at the Contractor's expense.

The Contractor shall be solely responsible for securing all pipes and fittings required for the Contract regarding quantity, type and quality from any source
unless otherwise specified and the Employer shall not guarantee the availability of such materials on the local market.

All cement used for the manufacturing of concrete pipes shall be of a fresh and approved quality Portland approved cement Type I, complying with the requirements of ASTM C150.

Reinforced and unreinforced concrete pipes shall be of sound manufacture.

Unreinforced concrete pipes shall generally conform to BS 5911 spigot and socket type except in respect of internal diameter, minimum crushing strength and internal dimensional tolerances.

The crushing test loads in kN/linear metre of effective length when tested in accordance with BS 5911 shall be not less than given in Table below.

**Crushing Strength of Unreinforced Pipes**

<table>
<thead>
<tr>
<th>Nominal Internal Diameter of Pipe (mm)</th>
<th>Load (kN/linear metre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>250</td>
<td>35</td>
</tr>
<tr>
<td>300</td>
<td>39</td>
</tr>
<tr>
<td>350</td>
<td>44</td>
</tr>
<tr>
<td>400</td>
<td>48</td>
</tr>
<tr>
<td>450</td>
<td>52</td>
</tr>
<tr>
<td>500</td>
<td>55</td>
</tr>
</tbody>
</table>

Reinforced concrete pipes shall generally conform to BS 5911 except in respect of internal diameters, minimum crushing strength and internal dimensional tolerances. Unless otherwise agreed with the Engineer pipes up to and including 1400 mm internal diameter shall be of the spigot and socket type and pipes with internal diameters in excess of 1400 mm shall be of the joint type.

The crushing test loads in kN/linear metre of effective length when tested in accordance with BS 5911 shall be not less than given in Table below.
Crushing Test Loads of Reinforced Concrete Pipes

<table>
<thead>
<tr>
<th>Nominal Internal Diameter of Pipe (mm)</th>
<th>Load (kN/linear metre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>600</td>
<td>105</td>
</tr>
<tr>
<td>700</td>
<td>105</td>
</tr>
<tr>
<td>800</td>
<td>140</td>
</tr>
<tr>
<td>900</td>
<td>155</td>
</tr>
<tr>
<td>1000</td>
<td>175</td>
</tr>
<tr>
<td>1200</td>
<td>210</td>
</tr>
<tr>
<td>1400</td>
<td>225</td>
</tr>
<tr>
<td>1600</td>
<td>270</td>
</tr>
<tr>
<td>1800</td>
<td>310</td>
</tr>
<tr>
<td>2000</td>
<td>350</td>
</tr>
</tbody>
</table>

In the event that the minimum crushing test requirements are not satisfactory and upon the approval of the Engineer and at his discretion, the pipes shall then be protected by encasing them in (250 kg/cm²) concrete in accordance to Concrete Work of these Specifications and the engineer's instructions. The thickness of concrete encasement shall be sufficient to obtain the same minimum crushing strength requirements but shall not be less than 150 mm. No additional payment shall be made in lieu of this work other than that for the pipes at the rates indicated in the Bill of Quantities. The Contractor shall not be entitled to claim for an extension of time with respect to this work.

All pipes and fittings shall be marked indelibly after manufacture. The markings shall include:

(a) Name of Manufacturer.

(b) Date of manufacture and serial number.

(c) Nominal diameter.

Nominal diameters shall refer to internal diameters of pipes.

The tolerances of the nominal diameter of pipes shall be ±5 mm for 250 to 500 mm nominal diameter, ±10 mm for 600 to 1000 mm nominal diameter and ±15 mm for 1200 to 2000 mm nominal diameter.

The tolerance on the length of an individual pipe shall be ±20 mm. The checking of dimensions and tolerances shall be done with special gauges approved by the Engineer, to be supplied by and at the expense of the Contractor.

All pipes manufactured in accordance with BS 5911 shall be tested and certified in accordance with the requirements of BS 5911. All rejected pipes shall be promptly stamped "Rejected" in a conspicuous location on the pipe.
19.1.6  **UPVC Pipes and Fittings**

UPVC pipes and fittings shall be manufactured and tested to the relevant approved standard for their pressure or gravity duty.

UPVC pipes for gravity pipelines shall have a standard dimension ratio, $D:t$ (diameter to thickness), of between 35 and 42.5.

Any pipes exhibiting cracks, notches or deep scratches or other damage will be condemned and shall not be incorporated into the permanent work under any circumstances.

19.1.7  **Reinforced Thermosetting Plastic Pipes and Fittings**

Pipe manufacturers must be Members of, or affiliated to, a quality control or certification authority relevant to the pipes or fittings proposed for incorporation in the Works.

GRP units will be manufactured using materials to the approved standard. The laminate construction will include a resin rich inner layer of minimum thickness 1.50 mm and a resin rich outer layer of minimum thickness 1.00 mm.

The incorporation of silica sand onto the outer layer will be permitted.

Silica sand aggregate fillers shall be graded and between the sizes 0.50 mm and 3.00 mm.

The resin shall be cured to reach a hardness not less than 90% of the resin manufacturer's recommended hardness using a prescribed test.

A manufacturer's tolerance of $\pm$ 2.00% shall be allowed on the nominal diameter of the pipe. The pipes shall be supplied in standard lengths of 3, 6 or 12 metres with a tolerance of $\pm$ 25.00 mm. The deviation from straightness of the bore of the pipe shall not exceed 0.30% of the effective length or 15.00 mm whichever is smaller and shall apply when measured on site. Up to 10% of the pipes will be allowed in random lengths.

The ellipticity of any pipe when measured resting freely on the ground shall not be more than 2% of the mean diameter at any point. No pipe known to have undergone a deflection greater than 10% shall be incorporated into the works.

Calculations shall be provided to show that the proposed form of pipe manufacture will give the specified physical properties.

The stiffness of the pipe is defined as $EI/D^3$

Where $E =$ bending modulus of pipe wall circumferentially (in N/m²).

$I =$ moment of inertia of pipe wall per unit length (in m⁴/m)

$D =$ nominal diameter in metres
Pipes shall have an initial stiffness of not less than 2,500 N/m². They shall have a resistance to longitudinal tensile force per unit of circumstance as under:

<table>
<thead>
<tr>
<th>Diameter</th>
<th>Resistance (N/mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>up to 700 mm</td>
<td>100</td>
</tr>
<tr>
<td>700 mm to 1,000 mm</td>
<td>120</td>
</tr>
<tr>
<td>1,000 mm to 1,600 mm</td>
<td>160</td>
</tr>
<tr>
<td>1,600 mm to 2,400 mm</td>
<td>250</td>
</tr>
<tr>
<td>2,400 mm to 4,000 mm</td>
<td>300</td>
</tr>
</tbody>
</table>

When subjected to a parallel plate loading test no evidence of crazing or cracking shall be evident with a deflection of 10% and no structural failure with a deflection of 20%.

Evidence from the manufacturer shall be provided of the satisfactory completion of the "strain corrosion test" on a sample of pipe representative of those to be supplied together with an assurance that such tests are continuing. The appearance of blisters, delamination, wicking or any other structural degradation of the test sample will constitute failure of the test notwithstanding the wording of the standard test procedure.

The jointing system shall be an approved bell and spigot or coupling system. Where the system involves separate reinforced plastic couplings of sockets formed by a lay-up process subsequent to pipe production, the resins used shall be clear and non-pigmented to permit visual examination within the laminate.

Where GRP laminate is cut, exposed ends shall be sealed with a suitable resin and the whole approved prior to incorporation into the works. Where such cutting and sealing takes place at site the resins used and the methods of storage, mixing, application and curing shall be strictly to the manufacturer's recommendation. Before any such work takes place the manufacturer's representative shall visit the site to demonstrate and give clear procedural advice to the Contractor in the presence of the Engineer's Representative.

1) A scratch of greater depth than 0.30 mm.
2) Cracks of any type on the inside of the pipe.
3) Cracks on the outside, longer than 200 mm
4) Circumferentially or 6 mm longitudinally.
5) Delaminations.
6) Damaged ends including bubbles, cracks, voids,
7) Exposed reinforcement or extraneous matter.
8) Internal protruding fibres.
9) More than 25% of the external area with protrusions of any sort.
10) Air voids and blisters exceeding 5 mm diameter or 1 mm in depth, greater in area than 0.50% of internal or 1.00% of external surfaces.
11) Pitting to more than 5% of the internal or 10% of the external surface area and individual pits more than 1 mm diameter or 0.5 mm in depth.
12) Wrinkles over than 3% of the surface area and individual wrinkles more than 2 mm deep.

19.1.8 Cast Iron Pipes and Fittings

Cast iron pipes and fittings for sewers, rising mains, drains or other purposes may be grey iron or ductile iron, to the approved standard unless either material is specifically detailed on the drawings.

Unless a "higher" pressure rating is necessary for the pipe duty cast iron pipes shall be rated for 10 bar working pressure.

Unless detailed to the contrary to suit existing pipework, flanges for cast iron pipes shall be rated for 10 bar working pressure and drilled accordingly.

19.1.9 Clay Pipes and Fittings

Clay pipes and fittings shall be normal pipes of standard strength unless extra strength or chemically resistant pipes are specifically called for on the drawings or in the Bills of Quantities.

Pipes may be glazed or unglazed.

19.1.10 Pipes for Land Drains

Pipes for land-drains shall be uPVC pipes for gravity duty complying with the requirements of this Specification. The pipes shall be perforated with holes or slots to a configuration subject to approval by the Engineer's Representative. The minimum cross-sectional area of the perforations, at the inside surface of the pipe barrel, shall be 2700 mm² per meter run of pipe.

19.1.11 Stone for Land Drains

Stone for land drains shall be nominal single size 20 mm and/or nominal single size 63 mm in accordance with the following table and placed as shown on the drawings. The stone shall also comply with the requirements the specifications.

<table>
<thead>
<tr>
<th>Percent by Weight Passing</th>
<th>Test Sieve</th>
<th>Nominal size of single size stone</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm</td>
<td>63 mm</td>
<td>20 mm</td>
</tr>
<tr>
<td>75</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>63</td>
<td>85 - 100</td>
<td>-</td>
</tr>
<tr>
<td>37.5</td>
<td>0 - 30</td>
<td>100</td>
</tr>
<tr>
<td>20</td>
<td>0 - 5</td>
<td>85 - 100</td>
</tr>
<tr>
<td>14</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>10</td>
<td>-</td>
<td>0 - 25</td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>0 - 5</td>
</tr>
<tr>
<td>2.36</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
19.1.12 Pipeline Construction

19.1.12.1 Storage and Handling of Pipes

Method Statements must be approved for the transportation, handling and storage of pipes before any pipes are delivered to site.

All pipes shall be handled and stored in compliance with the manufacturer's recommendations subject to the following limitations:

At every point of loading or unloading, all pipes or castings must be handled by approved lifting tackle. Unloading by rolling down planks or any other form of inclined ramp will not be allowed.

Pliable straps, slings or rope shall be used to lift pipes, and steel cables or chains will not be used without written permission.

Nesting of pipes for transportation will be permitted provided method statements demonstrate that effective precautions will be taken to protect inner surfaces from damage.

All coated pipes shall be thoroughly inspected on arrival at site for detection of any damage to the coatings which shall be made good in an approved manner.

**Reinforced Thermosetting Resin Pipes**

When pipes are transported or stacked they shall be supported on cradles conforming to the shape of the pipe at not more than 5 metre centres. Pipes must on no account be stacked directly on the ground but if individual pipes are placed on the ground prior to laying care shall be taken to remove all rocks and any potentially damaging debris.

**Thermoplastic Pipes**

Care shall be taken to prevent distortion of the pipes during transportation, handling and storage. They shall be stacked either on bearing timbers on a level surface staked to prevent movement, or in suitable racks. Not more than two layers shall rest on the bottom layer, and for spigot and socket pipes, sockets shall be at alternate ends so that no pressure comes on a socket. Bearing timbers shall be spaced at not more than 1 metre and shall be wide enough to prevent denting of the pipe wall. Sharp edges (e.g. of metal) shall be avoided. Similar care shall be taken with pipes in transit.

All thermoplastic pipes shall be shaded from direct sunlight during handling, storage and laying.

The Contractor shall ensure that thermoplastic pipes do not come into contact with bituminous or other hydrocarbon based materials.
19.1.12.2 Trench Widths for Pipeline

Nominal trench widths for single pipelines shall be defined as the diameter plus 500 mm.

Nominal trench widths for two or more pipes in the same trench (laid in parallel with similar invert levels) shall be defined as the sum of the internal diameters plus 450 mm between the pipes, plus 450 mm.

Any excavation from the bottom of the trench to 300 mm above the level of the crown of the pipe which exceeds the nominal widths defined above shall be filled with concrete or the specified bedding materials as directed on site.

Except where wide trenches are required to suit ground conditions as defined below, method statements may propose trench widths narrower than the nominal widths defined but they must be sufficiently wide for safe working and to allow the pipes to be correctly laid and jointed and the bedding and surround compacted.

Pipelines in Wide Trenches

Wide trenches shall be constructed to not less than the defined widths for those categories of Group B flexible pipelines in granular defined below.

Prior to commencing trench excavation in an area an assessment of the Modulus of Deformation (E’s) shall be made of the soils likely to be encountered at springing level of the pipes. In noncohesive soils, approved static cone penetrometer tests shall be carried out. In cohesive soils other approved methods shall be used to determine E’s. Tests shall be carried out at intervals to be determined on site which in variable ground conditions may be to every pipe length.

If the value of E’s determined from the results of such tests is greater than 2.5 MN/m2 then trench width is not critical. If less than 2.5 MN/m2 then trench widths shall be constructed to the widths defined in the following table unless alternative means of increasing the passive resistance of the trench sides are detailed or are proposed in method statements where economic or environmental restrictions make wide trenches undesirable.

<table>
<thead>
<tr>
<th>Non-Cohesive Soils</th>
<th>Wide Trench Widths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Static Cone Penetrometer Test Kg/cm²</td>
<td>Modulus of Deformation E's (MN/m²)</td>
</tr>
<tr>
<td>8.5 - 7.7</td>
<td>2.50 - 2.25</td>
</tr>
<tr>
<td>7.7 - 6.1</td>
<td>2.25 - 1.80</td>
</tr>
<tr>
<td>6.1 - 3.1</td>
<td>1.80 - 0.90</td>
</tr>
<tr>
<td>3.1</td>
<td>0.90</td>
</tr>
</tbody>
</table>
19.1.12.3 Pipelaying

Pipes shall be laid and jointed in accordance with all relevant recommendations of the manufacturer. Any variations between the manufacturer's recommendations and this specification shall be highlighted in the Contractor's Method Statements and a ruling will be given with the approval.

Pipes shall be checked for soundness and be thoroughly cleaned out immediately prior to laying.

The setting of the pipeline to the required levels and alignment shall be carried out by approved procedure such as boning between sight rails. Large diameter pipes, 1000 mm diameter or greater, shall be individually set to level and line by instrument.

For pipelines laid in trenches and headings the permissible tolerances in line and level unless otherwise specified shall be ± 3 mm in level and ± 12 mm from centerline between manholes or access points. Also where a gravity pipeline or sewer is shown as a straight line between manholes it will not be accepted as having passed the final test unless a light can be sighted through the length concerned.

For pipeline jointing systems incorporating flexible jointing rings pipes shall be laid with a gap between the end of the spigot and the base of the socket, or between spigots. This gap shall be not less than 6 mm or greater than one third of the straight draw test dimension specified for the pipe joint and it shall be achieved by approved means, such as marking the outside of the pipe or using removable metal or hardwood feelers.

Where flexibly jointed pipes are laid to curves the horizontal displacement at any joint as laid shall not exceed three quarters of the maximum allowed by the manufacturer.

Pressure pipelines shall be secured at all changes in direction by concrete anchor blocks.

For pipelines laid in headings the individual pipes shall not exceed 1.50 m in length and the headings shall be driven complete from shaft before pipelaying is commenced.

After laying a length of pipeline but before preliminary testing is carried out, the pipeline shall be checked for level and gradient on top of the pipes. If a pipe is not at the correct level it shall be unjointed and removed, the bed shall be adjusted and the pipe shall be relaid and rechecked for line and level.

After the joint has been made and the preliminary testing completed the annular gap at a socket or collar outside the flexible jointing ring shall be closed with fine grained clayey soil to prevent the entry of granular material.
19.1.12.4 Pipelines Bedded on Trench Bottom

Where pipes are to be bedded directly on the trench bottom the formation shall be trimmed to provide even bedding of the pipeline and to be free of extraneous matter that may damage the pipe or its coating.

Joint holes at each pipe joint shall be scooped away in the trench bottom to enable the joint to be made.

19.1.12.5 Pipelines in Concrete Grades and Surrounds

Where pipes are to be laid with a concrete cradle or surround they shall be supported initially above the trench bottom on concrete setting blocks. The blocks shall either be laid accurately to level and covered with damp-proof sheeting beneath the pipe barrel or shall be provided with two hardwood wedges each to an approved pattern to enable the pipe level to be adjusted.

The blocks and wedges shall be of sufficient size and strength to prevent settlement of the pipes during laying and at least two concrete blocks shall be provided for each pipe.

The concrete shall be poured on one side of the pipe until it can be worked under the pipe along its full length to ensure that no voids develop. The concrete shall then be brought up equally on both sides of the pipe until the required level is reached.

Approved measures appropriate to the pipe material shall be provided to prevent flotation or other movement during placement or curing of the concrete.

Concrete cradles to pipes of all diameters and surrounds to pipes of one metre diameter or less shall be poured in a single lift. Concrete surrounds to pipes over one meter diameter shall normally be poured in two lifts, with a horizontal joint not more than 100 mm below the crown of the pipe. Concrete shall be prevented from entering pipe joints.

Concrete cradles and surrounds shall be interrupted over their full cross sectional area at each pipe joint, by shaped expansion joint filler. The thickness of filler shall be 18 mm for pipe diameter less than 450, 36 mm for pipe diameter 450 to 1200 and 54 mm for pipe diameters greater than 1200.

In spigot and socket pipelines the joints in the bed shall be at the face of each socket, and in all flexible joints the concrete shall be prevented from entering the pipe joint.
19.1.12.6 Pipelines on Granular Beds

Where granular beddings to pipelines are detailed the minimum thickness of bedding material beneath the pipe shall be:

150 mm (minimum 100 mm under sockets) for pipes not exceeding 300 mm internal diameter except when bedded on rock.

200 mm (minimum 100 mm under sockets) for pipes exceeding 300 mm internal diameter or for pipes of 300 mm internal diameter or less when bedded on rock.

The time interval between placing bedding material on the trench formation and commencing pipelaying shall be as short as is practicable.

The bedding material shall be compacted in layers not exceeding 200 mm with one pass of a plate vibrator for gravels and two passes for sands or other approved equivalent mechanical method. Hand tamping or punning will only be permitted where insufficient space is available to allow the use of mechanical plant.

Recesses shall be formed in the bedding to accommodate pipe joints while ensuring continuous even support along the pipe length. Bedding material shall be prevented from entering pipe joints. After the joint has been made bedding material shall be carefully placed and hand compacted beneath the joint barrel to close any void left by the recess.

Where the formation of the trench is of silt or soft clay and is below the natural water table a 75 mm blinding layer of sand shall be substituted for the specified bedding material directly above formation and carefully compacted if directed on site.

19.1.12.7 Placing Surrounds to Pipelines

Group A Pipe Materials

Except where concrete surrounds are detailed, either granular bedding material or approved selected excavated granular material shall be introduced at both sides of the pipe and compacted until it has been brought up to at least 150 mm above the crown of the pipe.

The methods of selecting excavated materials may include sieving either in bulk or above the trench.

Wherever practicable the placing and compaction of the surround material shall be carried out in sequence with the removal of the trench supports. In particular trench sheets or boards shall be raised clear of each layer prior to its compaction.
**Group B and C Pipe Materials**

Except where concrete surrounds are detailed Group B and C flexible pipelines shall be laid with granular bedding and surround, as specified, to at least 300 mm above the crown of the pipe (unless concrete protection slabs are detailed).

In narrow trenches and where the Contractor's method of working involves the use of trench sheets or other forms of trench support it is imperative that, unless Contractor is instructed to leave them in place and burn or cut off the tops, the trench supports are carefully withdrawn to a point above the crown of the pipe as the backfill material is placed to ensure that voids between surround and trench side will be eliminated.

**Compaction of Pipe Surrounds**

The granular material shall be carefully laid and compacted at the sides of pipes according to one of the following methods for alternative types of compaction plant as agreed with or directed by the Engineer's Representative.

**Alternative Methods**

<table>
<thead>
<tr>
<th>Surround Material</th>
<th>Max. Layer Thickness mm</th>
<th>Hand Rammer</th>
<th>Vibrating Plate</th>
<th>100 kg Rammer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gravel</td>
<td>200</td>
<td>2</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Sand</td>
<td>150</td>
<td>3</td>
<td>2</td>
<td>4</td>
</tr>
</tbody>
</table>

**19.1.12.8 Backfilling of Pipelines**

After completion of placement and compaction of the surrounds to the pipelines backfilling shall proceed using selected excavated materials or importing suitable backfilling as directed by the engineer and in accordance with the specifications for earthworks.

The use of power rammers will not be permitted over any pipe until the depth of fill above the crown of the pipe is at least 300 mm.

**19.1.12.9 Deflection Measurements on Group B and Group C Pipelines**

All Group B and C pipelines will be subjected to in-situ deflection measurements. Any section of pipe failing to meet the deflection criteria defined below shall have its surround material recompacted, such procedure being repeated until the in-situ deflection is found to be satisfactory. Pipes will be regarded as damaged and shall be removed from the trench and condemned if their in-situ deflection at any time exceeds the values stated.
<table>
<thead>
<tr>
<th>Type of Pipe</th>
<th>Deflection Criteria %</th>
<th>Damaged and not re-used</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After completion of Surround Permissible range vertical diameter elongated only</td>
<td>At least two weeks after completing to be the trench backfill. Maximum measured in any plane.</td>
</tr>
<tr>
<td>uPVC 10-15</td>
<td>0 - 1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>uPVC 15-25</td>
<td>0 - 1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>RP 30-40</td>
<td>0 - 1.5</td>
<td>2.0</td>
</tr>
<tr>
<td>RP 40-50</td>
<td>0 - 2.0</td>
<td>2.5</td>
</tr>
<tr>
<td>uPVC 25+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RP 50+</td>
<td>2.5</td>
<td>3.0</td>
</tr>
<tr>
<td>RP 15+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDPE 10+</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SDR' is the Standard Dimension Ratio, which is the ratio of pipe diameter divided by the pipe wall thickness.

In the above paragraph deflection shall be considered as the maximum difference between the measured in-situ diameter and the stated non-deflected diameter on any axis divided by the non-deflected diameter.

For pipelines of 600 mm diameter and above, internal measurements of deflection shall be made continuously in the vertical plane and readings shall be recorded at each pipe joint, at the mid-point of each pipe length, at any point where the limiting deflections above are exceeded and at any other point directed by the Engineer's Representative. Where the length of pipeline between manholes or access points exceeds 100 metres the measurements shall be taken progressively on completion of backfilling and shall be verified after temporary reinstatement of the trench within reasonable limits of each access point.

For pipelines smaller than 600 mm diameter deflections shall be checked by pulling through an approved cylindrical plug dimensioned to suit the permissible minimum deflected diameter of the pipe.

19.1.12.10 Stanks to Pipelines in Granular Bedding

Where pipes are laid on a granular bed or with a granular backfill, a stank, i.e. an impermeable barrier shall be provided across the full width of the trench and for the complete depth of the bedding and fill at intervals not exceeding 50 m, and generally mid-way between manholes.

The stank shall consist of:-

either a 300 mm long plug of fine grained clayey soil or a 300 mm long plug of a mixture of sand and bitumen consolidated in an approved manner.

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or a mixture of sand and clay, compacted to form an impermeable barrier at least one meter in length.

or a layer of thick polyethylene cut to fit around the pipe across the full width of the trench and laid on the granular bedding material at its natural repose angle.

All methods must form an impermeable barrier. Bitumen shall not be used for thermoplastic pipes.

19.1.12.11  Thrust and Anchor Blocks to Pressure Pipelines

Underground pressure pipelines shall be provided with concrete blocks as follows:-

Thrust/anchor blocks shall be provided at every installed bend, tee or angle branch.

Anchor/thrust blocks shall be provided on pipelines laid to gradients steeper than 1:20, up to 1:15 every third pipe shall be anchored, up to 1:10 every second pipe and at 1:5 every pipe shall be anchored.

Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both faces of anchor blocks.

Where details are not shown on the drawings the Contractor shall prepare proposals for thrust and anchor blocks and submit them to the Engineer's Representative for approval. Such approval shall not relieve the Contractor of his responsibility for the adequacy of his proposals.

Special details shall be shown on the drawings or instructed at site where environmental or ground conditions dictate.

19.1.12.12  Pipes Protruding from Structures, Concrete Surrounds and Anchor Blocks

Unless otherwise detailed a pipeline at or below ground level protruding from a structure shall have two flexible joints adjacent to the structure located as follows:-

<table>
<thead>
<tr>
<th>Pipe Diameter (mm)</th>
<th>Distance to First Joint (mm)</th>
<th>Distance between First and Second Joint (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 300</td>
<td>150</td>
<td>450 2.5 * dia.</td>
</tr>
<tr>
<td>300 to 100</td>
<td>300</td>
<td>1.5 * dia. 2.5 * dia.</td>
</tr>
<tr>
<td>above 1000</td>
<td>450</td>
<td>1.5 * dia. 2.5 * dia.</td>
</tr>
</tbody>
</table>

Method statements may propose that the first joint be formed by building an appropriate sleeve, collar or coupling into the wall of the structure. Where such a detail is proposed the sleeve, collar or coupling must be capable of maintaining an effective seal under the specified deflection and loading conditions specified for flexible joints "Joint Requirements and Limitations".
In the case of Group 'B' pipe materials, particular attention will be placed on elliptical deflection conditions.

These joints will be required at surrounds and anchor blocks unless directed otherwise on site.

**Group A and C Pipe Materials**

Between the structure and the first joint any disturbed ground below the pipe will be removed and replaced with Grade B concrete in the form of a cradle, all to the direction of the Engineer's Representative. The cradle shall not extend beyond the first joint.

Beyond the first flexible joint within the excavated working space of the structure the concrete fill shall be brought up 300 mm below the pipe invert only. Specified bedding materials will then be used.

**Group B Pipe Materials**

Within the excavated working space for the structure disturbed ground below the pipe will be removed and replaced with Grade B concrete to within 300 mm of the underside of the pipe. Specified bedding materials will then be used to support the pipe.

The width of the concrete backfill shall be not less than the nominal widths.

Where a flexible pipe passes through a rigid concrete face to a structure or surround the pipe shall be protected from stress concentration and possible fracture of the pipe at the concrete face. A 10 mm thick neoprene or other approved synthetic rubber strip shall be wrapped around and cemented to the pipe unless special wall protection units are used.

The neoprene will normally extend through the width of a wall to a dry chamber or structure but will be limited to 150 mm or 100 mm where exposed to liquid (groundwater or liquid inside the structure) a sealant groove shall be formed if detailed and filled with an appropriate, approved, joint sealant.

Care shall be taken to ensure that the rubber strip is not displaced during concreting.

Where a pipeline protrudes from a concrete surround, no protection from stress concentration will be required if the surround ends at a flexible joint leaving the next pipe free. If the surround ends on a pipe barrel the specified protection will be provided and, for pressure pipes only, the protruding pipe will be wrapped from the edge of the neoprene strip along to the next flexible joint at which the concrete surround is interrupted with an approved compressible material such as damp-proof sheeting or building felt of minimum thickness 2 mm.

19.1.12.13  Protection of Pipeline Components

All buried valves, couplings, flange adaptors, and other metal components shall be encased to guard against corrosion. Other pipe joints, valves and similar items on both buried and exposed pipelines shall be encased where specified or shown on the drawings.
The encasing shall be by one of the following methods, as detailed.

1) Surrounding with Grade B concrete.
2) Enclosed by an approved hot-poured bitumen compound.
3) Wrapped with tape.

Method (2) shall not be used with plastic pipes.

The item to be encased shall first be cleaned and its original surface treatment made good. The surface shall be dry before encasing is carried out, which shall not be done before the pipeline has been tested.

The bitumen compound shall be cast in purpose-built moulds in accordance with instructions issued by the supplier.

Before wrapping with tape the item to be encased shall be enclosed with an approved mastic or inert putty-like filler which shall be moulded by hand so as to provide a smooth surface for the tape. The tape shall be tightly spirally wrapped with 25 mm overlaps so as to enclose the whole of the item and a minimum of 150 mm of pipe length on each side. The enclosure shall be firmly wrapped with 25 mm overlaps so as to enclose the whole of the item and a minimum of 150 mm of pipe length on each side. The enclosure shall be firmly pressed out to prevent air being trapped under the wrapping.

19.1.12.14 Indicator Posts to Pressure Mains

Where pressure mains pass through waste ground or across roads, the Contractor shall erect indicator posts of approved precast reinforced concrete design at locations described to him by the Engineer's Representative.

The depth, location and size of the pressure main shall be detailed in Arabic and English, to an approved design, on an engraved plastic or non-corrodible plate attached to the post.

In addition at non-ventilated air valve chambers, the Contractor shall erect indicator signs on posts, to an approved design, at locations described to him by the Engineer's Representative.

The words 'WARNING Gas on Entry' together with an appropriate pictorial representation shall be detailed in Arabic and English, to an approved design, on an engraved plastic or non-corrodible plate attached to the post.

19.1.12.15 Enclosing Granular or Stone Surround with Filter Fabric

Where filter fabric is used to enclose granular or stone pipe surrounds, the fabric will be placed on the prepared trench formation and carefully supported during pipe laying operations. When the pipe has been laid complete with surround to the correct level the filter fabric shall be closed over the top of the surround by forming a 'lap' of minimum width 500 mm. All membrane joints shall be overlapped a minimum of 500 mm. Care shall be taken not to puncture or damage the membrane in any way during these operations or during backfilling of the trench.
19.1.12.16 Method of Measurement and payment for Pipe Laying

Method of Measurement and Payment for pipe laying shall include excavation in trench. Measurement for pipe trenches shall be the meter run for each pipe diameter and for each 0.5 meter depth stage or as in B.O.Q. Measurement shall be for the length of trench only and shall exclude manholes, gullies etc. Measurement for depth of each trench shall be the average of the depth at each end i.e. manhole to manhole or inlet to inlet, and shall be calculated from the existing ground level or from the finished grade level or from the finished subgrade level, whichever is the lowest to the trench invert level.

In the case where a pipe is (A) partly in fill and partly in original ground or (B) totally above original ground level and is enclosed in fill, the measurement for depth shall be the lesser of dimensions (i) and (ii) as calculated below.

Where trenches are to be excavated across existing roads or pavement which are to be re-opened to traffic on completion of the construction work specified herein, the depth of such trench excavation shall be calculated from the level of the top of the existing road or pavement to the trench invert level.

**Dimension (i)** - The depth between finished ground level or finished subgrade level, whichever is lower, and the underside of the pipe or pipe bedding (including concrete blinding) whichever is lower.

**Dimension (ii)** - The outer diameter of the pipe plus 1000 mm.

Length of pipes shall be measured along their center lines. Lengths of pipes in trenches shall include length occupied by fittings and exclude lengths occupied by pipes ad fittings comprising backdrops to manholes. Lengths of pipes entering manholes and other chambers shall be measured to the inside surfaces of the chambers except that pipes and fittings comprising backdrops to manholes shall be included in the items for the manholes.

Payment for excavation in all types of soil shall be included in the rate in the Bill of Quantities for pipework, which rate shall include for all temporary works dewatering, bracing, sheeting, pipe bedding, installation and jointing of pipes, testing, backfilling, compaction, and the use of approved surplus excavated material for filling (including compaction) in other areas of the site, for the disposal of surplus excavated material and/or unsuitable material as specified and for all other items necessary to complete the Works.
19.1.13 Pipe Work

19.1.13.1 Pipe Work within Structures

1) Pipework shall be supplied to the general arrangements and limits indicated on the Contract drawings and shall be supplied complete with all joint rings, gaskets, washers to each side of a bolted joint, nuts, bolts, grease and any other components necessary for the complete installation.

2) The layout and design of the pipework shall be such as to facilitate its erection and the dismantling of any section for maintenance of associated plant by inclusion of approved mechanical coupling or flange adaptors.

3) Where a common delivery pipe is used, individual pump delivery branches unless otherwise shown on the drawings shall be jointed to it in a horizontal plane and angled to prevent sharp changes of flow.

4) Adequate supporting and anchoring arrangements for all pipes shall be included which may take the form of straps, stays, tie bars or concrete cradles.

5) Cast iron pipes shall be provided with puddle flanges where they pass through the walls of underground or water retaining structures.

6) Small bore pipework for sump pumps, vents, etc. may be galvanised steel or approved plastic materials.

7) All pipes connected to pressure vessels, pumps etc. shall have flanged connections.

8) All pipes shall be checked for alignment and mating of flanges and connections before secured. Pipes shall not be sprung into position.

19.1.14 Standard of Covers and Gratings

19.1.14.1 Storm/Land Drainage

<table>
<thead>
<tr>
<th>REQUIREMENT</th>
<th>MANHOLE</th>
<th>GULLEY</th>
<th>GRATINGS</th>
<th>PUMPING</th>
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<tr>
<td></td>
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<td>UPSTAND KERB</td>
<td>STN.ACCESS COVER (3)</td>
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<td>EN (BS)</td>
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### 19.1.14.2 Sewerage

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<tr>
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</table>

**19.1.14.3 Notice**

1) In Arabic and English

2) European Standard (British Standard) Kite Mark or

3) European Equivalent.

4) Removable beam can be used only with special acceptance of the Engineer.

5) The guarantee is required that spare parts (e.g. covers only) shall be delivered by suppliers for at least 10 years after the contract is completed.

6) Covers shall be single seal, closed key ways.

7) All covers, gratings and frames shall be delivered to site with a transit protective coating.

8) Double triangular covers must be loosely coupled by bolts with nuts incapable of undue tightening and loosening.
20 PIPE WATER NETWORK

The Specifications for this project are divided into three Sections;

20.1 General Specifications for Water mains Distribution Systems and Fittings

20.2 Particular Specifications for this Contract

20.3 Technical Specification for Materials Supplied by the Contractor

20.3.1 General Specifications

20.3.1.1 Installation Conditions

The pipes and fittings, subject of the enclosed particular technical specification, are to be installed in the Gaza strip.

- place of installation: GAZA STRIP
- country: PALESTINE
- altitude: Sea Level
- outside temperature ranging between: 5 and 40 ° C
- temperature inside the buildings ranging between: 10 and 40 ° C
- relative humidity ranging between: 60 and 100 %
- climatic conditions: Mediterranean, dry summer, sub-tropical climate with mild winter
- soil: generally sand, clay

20.3.1.2 Traffic Safety, Control and Closing of Roads

The Contractor shall not close any road until the Authority having charge of the road surfaces shall have previously given the appropriate notice or made the appropriate order and without the Contractor having first obtained the written consent of the Municipality to close the road. In the event of such consent being refused, the Contractor shall have no claim for any additional payment.

1. The Contractor shall provide, erect and maintain such traffic signs, lamps, barriers and traffic control signals as may be necessitated by the construction of the Works in accordance with the Municipality and Police requirements. The Contractor shall submit proposals for dealing with such situations to the Engineer and Police for consent. Compliance with this Clause shall not relieve the Contractor of any of his other obligations and liabilities under the Contract.

2. The Contractor shall, after consultation with any statutory or other authority concerned, submit to the Engineer for his approval a program based on such consultation showing the scheme of traffic management he proposes for carrying out the Works before commencing any work which affects the use of
the public highway rights of way or parking areas and thereafter furnish such further details and information as necessitated by the Works or as the Engineer may require.

3. The Contractor shall not commence any work which affects the public highway until all traffic safety measures necessitated by the work are fully operational.

4. The traffic diversions and signs, lamps, barriers and traffic control signals shall be in accordance with the requirements of Municipality.

5. Traffic signs shall comply with the requirements of the Municipality.

6. The Contractor shall comply with the requirements of the Municipality.

6. The Contractor shall keep clean and legible at all times all traffic signs, lamps, barriers and traffic control signals and he shall position, re-position, cover or remove them as necessitated by the progress of the Works.

20.3.1.3 Inspection

The Contractor shall employ works foremen to supervise and inspect the work of the pipelaying gangs.

The Contractor shall submit and agree site records to the Engineer’s Representative on a weekly basis, including but not limited to the following;

1. Daily records of plant, materials and Engineers employed on the site.

2. Test certificates of all materials, concrete cubes tests and hydraulic tests undertaken.

3. Daily records of works installed and tested including, house connections,

4. Records of the trench conditions encountered.

5. Full records of all works undertaken to adequately support the measurement to be agreed.

6. Records of all delays to the programme.

7. Stock control and materials schedules cross-referencing.

8. Records and registers of all correspondence, technical queries, site instructions, variation orders, daily work record sheets, day work sheets, drawing issues, drawing revisions and any claims.

9. Marked up prints of specifications, construction drawings and standard details to fully reflect the as-built conditions.
20.3.1.4 Protection of Finishes

The Contractor shall take every care to prevent damage to the Works from whatever cause and shall ensure that adequate protection is given to all Works from the activities of following trades and nominated sub-contractors. Vulnerable parts of the work particularly liable to damage, shall be protected as may be reasonably required by the Engineer's Representative.

20.3.1.5 Co-Operation with Other Contractors

The Contractor shall note that other Works may be constructed in the Site of Works. He shall liaise, co-operate and co-ordinate his operations with the contractors of other Works and organize their respective contracts so as to minimise interference to each other and to the public.

20.3.1.6 Suppression of Noise and Pollution

The Contractor shall make every reasonable endeavor both by means of reasonable hours of work, temporary Works and by the use of particular plant or silencing devices to ensure that the level of noise or pollution resulting from the execution of the Works does not cause nuisance to the Public.

The Contractor shall take all such precautions as may be necessary in the conduct of the work to avoid water pollution, air pollution, noise pollution harmful to health, spreading of plant diseases and pests or damage to natural resources or the environment, all as is consistent with good practice and as required by applicable laws, ordinances and regulations or lawful orders or authority having jurisdiction.

20.3.1.7 Protection Equipment and Clothing

The Contractor shall provide and maintain all necessary protective and safety equipment and clothing for the operatives and Site staff and ensure that they are used.

20.3.1.8 Delays and Non-Productive Time

The Contractor shall be deemed to have allowed for all delay caused by difficulty in obtaining labour and materials or by suspension of part of the whole of the Works due to adverse and inclement weather conditions.

The Contractor shall allow for all costs incurred by non-productive time.

20.4 Particular Specifications

20.4.1 Excavation, Trenching and Backfilling
20.4.1.1 Scope of Works

This section covers trenching and backfilling work and shall include the necessary clearing, grubbing and preparation of the site; removal and disposal of all debris; excavation and trenching as required; the handling, storage, transportation and disposal of all excavated material; all necessary sheeting, shoring and protection work; preparation of subgrades; pumping and dewatering as necessary or required; protection of adjacent property; backfilling; pipe embedment; surfacing and grading; and other related work.

No classification of excavated materials will be made. Trenching work shall include the removal and subsequent handling of all materials excavated or otherwise removed in performance of the work, regardless of the type, character, composition or condition thereof.

20.4.1.2 Site Investigation

The Contractor shall be deemed to have visited the site of Works and satisfied himself as to the nature of the ground and made himself conversant with the local conditions to be encountered during the execution of the Contract.

20.4.1.3 Materials

Construction materials supplied by the Contractor shall include but not be limited to the following:

**Backfill**

Backfill and fill shall be structurally sound material such as sand or native soil free of rocks, lumps, vegetable and other organic materials, obtained from suitable excavated material and/or from approved borrow pits. The backfill shall be appropriate for the existing road or paving construction to be reinstated as required.

Water shall be clean potable water free from injurious amounts of oil, acid or any other deleterious mineral and/or organic matter.

Concrete for thrust blocks, chambers, cover slabs or used as fill for making up to correct level and areas of over-excavation, shall have a characteristic strength of 20 N/mm².

Pipe bedding and surrounds shall be sand.

**All pipes & the related fittings, valves, fire hydrant, saddles, …etc as specified later.**

The sand shall be clean coarse sand free from dirt or organic materials.

20.4.1.4 Site Preparation
Prior to commencing any excavation work, the Contractor shall establish a horizontal and vertical survey network, record existing ground elevations and stake the location of trenches to be excavated.

The Contractor shall prepare the site for construction by clearing, removing and disposing of all items not indicated on the Drawings to remain or so defined by the Engineer.

The Contractor shall obtain relevant excavation and road cutting permits as required before commencing work.

**Existing Utilities**

The Contractor shall ascertain the whereabouts of all existing utilities on the site both, above and below ground.

The Contractor shall be held responsible for all damages entailed on any of the utilities adjacent to the site resulting from the Works.

All proposed or existing utilities, including buried pipes, sewers, ducts, culverts, cesspits, chambers and the like, in the vicinity of the work site, are to be determined by the Contractor and the location of them is to be shown on the as-built drawings.

Prior to commencement of excavation, the Contractor shall establish the number and location of underground utilities and chambers in the immediate proximity of the work.

Where necessary, the Contractor shall use hand tools to excavate test pits prior to excavation to determine the exact locations of existing utilities. It shall be the responsibility of the Contractor to make such explorations sufficiently in advance of construction to enable the engineer to approve modifications, if any, to be made to the pipeline, structure or conflicting utility. The Contractor shall obtain the permission of the Engineer before commencing any test pits and shall fence, mark and protect them, as required by the Engineer. Test pits shall be refilled by hand as soon as practicable after the necessary information has been obtained.

Cutting of existing asphalt must be carried out by cutting saw.

As the excavation approaches sewers conduits, cables or other underground facilities, the excavation shall be continued with care by means of hand tools. Where necessary, the Contractor shall provide temporary support for the existing utilities to prevent damage during his operations. Notwithstanding these provisions, if damage to existing utilities results from the Contractor's operations, such damage shall be repaired without delay by the Contractor to the Utility owner’s satisfaction.

If damage to existing utilities causes disruption to Contractor's schedule of work by delaying work in the area of such damage, the Contractor shall re-adjust his programme, methods of working and resources so that critical dates in the schedule for the completion of the Contract are not affected. This shall not be deemed to be an instructed acceleration.
Removal of Existing Structures and Other Obstructions

This work shall include, but not be limited to, the removal of existing structures and other obstructions interfering with the Works. The salvaging of any of these materials for the use for the Engineer shall be as directed by the Engineer and unwanted materials shall be disposed off the Site in a satisfactory manner.

Cleaning and Grubbing

The Contractor shall perform the clearing and grubbing (if any), of top soil consisting mainly of loose soil, vegetable and organic matters, drift sand, unsuitable soil and rubbish by scarifying the areas to be excavated and sidewalks to a minimum depth of 300mm from the natural ground level. All materials resulting from the above operations shall be removed from the site, loaded and transported and off loaded, spread and leveled to approved dumps.

20.4.1.5 Setting-Out

The Contractor shall stake-out the work as shown on the Drawings and secure the Engineer's approval of his stake-out before proceeding with construction. If, in the opinion of the Engineer, modification of the line or grade is advisable before or after stake-out, the Engineer will issue detailed instructions in writing to the Contractor for such modification and the Contractor shall revise the stake-out for further approval in accordance with the relevant Clause of the Conditions of Contract.

20.4.1.6 Excavation

The Contractor shall perform all excavation true to line, width and depths shown on the Drawings or to such further lines, depths or dimensions or to reach suitable bearing strata as may be directed by the Engineer.

Keeping Excavations Free from Water

All excavations shall be kept clear of water by pumping or bailing or by wellpoint dewatering, but the latter system shall not be employed if any danger exists of withdrawing water from the foundations of the adjoining buildings and such water shall be discharged clear of the Works and the method adopted shall in no way contravene with regulations of the Municipalities.

The system or systems to be employed shall be approved by the Engineer. Such approval if given, shall not waive the Contractor's responsibilities and liabilities under the Contract.

Particular attention shall be paid to the installation of sheeting and shoring as may be necessary for the protection of the work and for the safety of personnel and public.

Storing of Suitable Excavated Material
During excavation, materials suitable for backfill shall be stockpiled on the site at adequate distance from the sides of the excavation to avoid over-loading and prevent collapse of the trench walls.

Disposal of Unsuitable and Surplus Excavated Material

Upon the order of the Engineer, all unsuitable and surplus materials shall be immediately removed, loaded and transported off the site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

20.4.1.7 Cutting Pavement and Surface Materials

The Contractor shall remove only as much of any existing pavement as is necessary for the installation of the works. The Engineer's Representative may require that the pavement shall be cut with pneumatic tools or cutting saw. Where pavements are removed in large sections, they shall be disposed of before proceeding with the excavation.

From areas within which excavations are to be made, loam and topsoil shall be carefully removed and separately stored to be used again as directed.

20.4.1.8 Sheet, Shorting and Bracing

Except where banks are cut back on a stable slope, excavation shall be sheeted, braced and shored as necessary to prevent collapse of the excavations. The Contractor shall furnish, put in place, and maintain such sheeting, bracing, etc..., as may be necessary to support the sides of the excavation and to prevent any movement of earth which could in any way diminish the width of the excavation to less than that necessary for proper construction, or could otherwise injure or delay the work, or endanger adjacent structures. If the Engineer's Representative is of the opinion that at any point sufficient proper supports have not been provided, he may order additional supports.

The Engineer may direct that sheeting and bracing be cut off at any specified elevation.

All sheeting and bracing not to be left in place shall be carefully removed in such manner as not to endanger the construction or other structures. All voids left or caused by the withdrawal of sheeting shall be backfilled immediately with approved material and compacted by ramming with tools especially adapted to that purpose, by watering or by other means as may be directed.

20.4.1.9 Trench Excavation

1st) General Requirements:
Trench excavation work shall be performed in a safe and proper manner with appropriate precautions being taken to safeguard workmen and existing structures and utilities against all hazards.

All trench excavation shall be open cut from the surface unless authorized by the Engineer and shall be excavated so that pipes can be laid straight at uniform grade without dips or humps between terminal elevations indicated on the Drawings.

No more trench shall be opened in advance of pipe laying than is necessary to expedite the work. The maximum length of open trench on any line under construction shall be 50m.

The pipe is to be laid in sand bedding, as indicated on the Drawings or directed by the Engineer. The trench is to be excavated by labour to, or to just below, the designated subgrade, provided that the material remaining at the bottom of the trench is not disturbed. The pipe is not to be laid directly on the trench bottom.

Whenever unstable soil which in the opinion of the Engineer is incapable of properly supporting the pipe is encountered in the bottom of the trench, such soil shall be removed to the depth instructed and the trench backfilled to the proper grade with sand approved by the Engineer.

Hand excavation is the preferred method of excavation and is to be used wherever practicable.

2nd) Mechanical Excavation:

The use of mechanical equipment will not be permitted in locations where its operation would cause damage to trees, tree roots, buildings, culverts or other existing property, utilities or structures above or below ground. In all such locations hand excavation shall be used.

Mechanical equipment if used for trench excavation shall be of type approved by the Engineer. Equipment shall be so operated that the rough trench excavation bottom can be controlled, that uniform trench widths and vertical sidewalks are obtained at least from an elevation 20cm above the top of the installed pipe when accurately laid to specified alignment will be centered in the trench with adequate clearance between the pipe and sidewalks of the trench.

3rd) Alignment and Minimum Cover:

The alignment of each pipeline shall be fixed and determined from offset stakes. Horizontal alignment of pipes and the maximum joint deflection used in connection therewith, shall be in conformity with requirements of the section covering installation of pipe.

Pipe grades or elevations are not definitely fixed by the Contract Drawings, trenches shall be excavated to a depth sufficient to provide a minimum depth of backfill cover over the top of the pipe of 130cm for main lines with surface traffic, 80cm for main lines with no traffic including pavements and 60cm for house connections. Greater pipe cover depths may be necessary at certain locations, the locations and depths will
be determined by the Engineer. Measurement of pipe cover depth shall be made vertically from the outside top of pipe to finish ground or pavement surface elevation except where future surface elevations are indicated on the Drawings. Where there is no adequate minimum cover, concrete encasement shall be used as detailed on the Drawings or as directed by the Engineer.

20.4.1.10 Depth of Trench

The depth of trench shall be the sum of the specified cover to pipe plus pipe O.D plus 15cm minimum.

The trench bottom shall be straight and even so as to provide a good support for the pipe along its entire length and shall be free of roots, stones, lumps and other hard objects that may injure the pipe or its protective coating as applicable.

The sand bedding under the pipe shall be not less than 15cm.

20.4.1.11 Width of Trench

No wide unsupported trenches shall be permitted, in general, within the area of the works and therefore all trenches should conform to the minimum trench widths stated and shall be supported with the use of approved trench sheeting or sheet piles.

Pipe trenches shall be made as narrow as practicable and shall not be widened by scraping or loosening materials from the sides. Every effort shall be made to keep the sides of the trenches firm and undisturbed until backfilling has been completed and consolidated.

Trenches shall be excavated with vertical sides between the formation level and an elevation 30cm above the top of the pipe. In the vertical section, the maximum and minimum trench widths shall be the pipe outside diameter plus 40 and 30 cm respectively.

The width for payment shall be pipe OD plus 30 cm.

The trench width at the ground surface shall be excavated as narrow as practicable but may vary with, and depend upon its depth and the nature of the ground encountered.

20.4.1.12 Excavation for Valve Chambers

Excavation for the valve chambers shall be carried out to the dimensions, lines and grades shown on the Drawings or required by the Engineer.

Should it appear that the bottom of the excavation does not provide a solid base for the chamber, the Contractor shall be required to consolidate the bottom using hand tampers and increasing the moisture content, if required, all as directed by the Engineer.
Any over-excavation at the bottom of the structure shall be restored to the proper grade by filling the over-excavation with suitable material or shall be filled with concrete. In the case of over-excavation in the walls, whether caused by careless work or by the necessity to prevent slides by excavating to a slope or for any other reason, the Contractor shall remove all loose material from the excavation, construct the walls of the structure to the dimensions shown on the Drawings and fill the spaces between the structures and the sides of the excavation with compacted backfill in layers of 10cm thickness. The material of the backfill shall be moistened if necessary and compacted to the level of the adjacent natural soil.

20.4.1.13 Unauthorized Excavation

If the bottom of any excavation is taken out beyond the limits indicated or prescribed, the resulting void shall be backfilled at the Contractor's expense with thoroughly compacted, selected screened gravel or sand fill as directed by the engineer if the excavation was for a pipeline, or with concrete if the excavation was for a structure or a manhole.

20.4.1.14 Elimination of Unsuitable Material

Suitable material shall comprise all material that is acceptable in accordance with the Contract for use in the Works. Suitable material for earthworks shall be approved soil with a plasticity index not exceeding 6% obtained from excavations within the Works or from borrow pits approved by the Engineer. It shall not contain an excess of fines.

Unsuitable material shall be deemed to be:

- Rock particles exceeding 75mm in size.
- Organic material, stumps and other perishable material.
- Material susceptible to spontaneous combustion.
- Soils of liquid limit exceeding 40% and/or plasticity index exceeding 6%.
- Any other material which the Engineer may deem to be unsuitable for earthwork.

If material unsuitable for foundation (in the opinion of the Engineer's Representative) is found at or below the grade to which excavation would normally be carried in accordance with the Drawings and/or structure, the Contractor shall remove such material to the required width and depth and replace it with compacted, selected screened gravel, sand fill or concrete as directed by the Engineer's Representative.

20.4.1.15 Disposal of Surplus Excavation Materials

All surplus excavated materials shall be disposed of by the Contractor, except as otherwise directed or approved by the Engineer.
20.4.1.16 Access Across Trenches

The Contractor shall provide temporary, safe access across trenches at crossings where required for the accommodation of travel and to provide access to private property during construction and shall only remove them when the permanent access is reinstated.

20.4.1.17 Backfilling

In general, and unless other material is indicated on the Drawings or specified, material used for backfilling trenches and excavations around structures shall be suitable material.

20.4.1.18 Fill and Backfill Under Structures

Unless otherwise indicated or specified, all fill and backfill under structures shall be compacted.

The percentage of compacting for backfill shall be 95% maximum density at optimum moisture content.

20.4.1.19 Backfilling around Structures

The Contractor shall not place backfill against or on structures until they have attained sufficient strength to support the loads (including construction loads) to which they will be subjected, without distortion, cracking or other damage as practicable after the structures are structurally adequate and other necessary work has been done, special leakage tests, if required, shall be made. Promptly after the completion of such tests, the backfilling shall be started and then shall proceed until its completion. Suitable material shall be used in backfilling. Unequal soil pressure shall be avoided by depositing the material evenly around the structure.

The material shall be placed and compacted as specified below, insofar as applicable. Compacting shall be accomplished by water-jetting or puddling, if the nature of the material permits, otherwise by tamping.

Walls with fill on both sides shall have the fill constructed such that the difference in the top elevation of the fill on the two sides does not exceed 60cm at any time.

20.4.1.20 Backfilling Pipe Trenches

As soon as practicable after the pipes have been laid and tested, the backfilling shall be started and there after it shall proceed until its completion. Under no circumstances shall water be permitted to rise in unbackfilled trenches after the pipe has been placed.
Trenches shall not be backfilled at pipe joints until after that section of the pipeline has successfully passed any specified tests required.

**Bedding and Pipe Surround**

The pipes shall be bedded on 15cm sand with full 15cm sand surround. Sand fill around pipe shall be thoroughly compacted by careful hand tamping in layers 15cm in depth each side and over the crown of the pipe.

**Remainder of Trench**

The remainder of the trench above the zone around the pipe, shall be filled with suitable material and compacted by tamping or otherwise approved, in accordance with the nature of the material and the existing pavement or road construction.

**Tamping**

Suitable material shall be deposited and spread in uniform, parallel layers not exceeding 15cm thick before compacting. Before the next layer is placed, each layer shall be tamped as required so as to obtain a thoroughly compacted mass. The Contractor shall furnish and use an adequate number of power-driven tampers, each weighing at least 10kg for this purpose. Care shall be taken that the material close to the bank, as well as in all other portions of the trench, is thoroughly compacted.

To ensure proper compacting by tamping, the material shall first be wet by sprinkling. However no compacting by tamping shall be done when the material is too wet either from rain or too great an application of water to be compacted properly; at such times the work shall be suspended until the previously placed and new materials have dried out sufficiently to permit proper compacting or such other precautions shall be taken as may be necessary to obtain proper compacting.

No superficial load shall be placed on the exposed surface of the trench unless the backfill, if of non-cohesive sand is vibrated or tamped in layers not exceeding 15cm in depth until the Engineer's Representative is satisfied that sufficient settlement has occurred to alleviate live or impact loads.

**Miscellaneous Requirements**

Whatever method of compacting backfill is used, care shall be taken that stones and lumps shall not become nested and that all voids between stones shall be completely filled with fine material. The Contractor shall, as part of the work done under the items involving earth excavation and rock excavation as appropriate, furnish and place all other necessary backfill material.

All voids left by the removal of sheeting shall be completely backfilled with suitable materials, thoroughly compacted.

When required, excavated material which is acceptable to the Engineer for surfacing or pavement sub-base shall be placed at the top of the backfill to such depths as may be specified elsewhere or as directed. The surface shall be brought to the required grade and stones raked out and removed.
20.4.1.21 Preparation of Subgrade

The Contractor shall remove loam topsoil, loose vegetable, matter, stumps, large roots, etc., from areas upon which material will be placed for grading. The subgrade shall be shaped as directed by the Engineer and shall be so prepared for forking, furrowing or plowing that the first layer of the new material placed therein will be well bonded to it.

20.4.1.22 UPVC and MDPE Pipes, Fittings and House Connections

The contractor shall install and test the pipes, fittings and appurtenances, as indicated on the drawings and as herein specified.

1) Pipe Laying

Handling of Pipes

The contractor shall protect all pipes from damage while being handled. Procedures and equipment for handling the pipe units and fittings into position in the trenches shall be presented by the contractor to the engineer’s representative for approval by the latter prior to their being implemented and used in the works. If slings are used in the handling of the pipes they shall be provided with rubber linings to avoid injury to the pipe.

2) Installation of Pipe

Preparation of the trench bottom shall be such that when the pipe is placed it shall be true to line and grade as specified on the drawings or as directed by the engineer’s representative. Trenches shall be dry when the trench bottom is prepared.

Bedding material, shall be placed in the trench bottom to a depth of at least 15 cm below the bottom of the pipe. A continuous trough shall be formed to receive the bottom quadrant of the pipe barrel. Bell or coupling holes shall be formed so that, upon being placed, initially only the pipe barrel is in contact with the trench bottom.

Pipe units and fittings shall be inspected for damage and defects before and after placement in the trench. Any damaged or unsound item shall not be used and, if already placed in the trench, shall be removed and replaced with a sound unit at the cost and responsibility of the contractor.

Pipes shall be protected during handling against impact shocks and free fall. Pipes shall be kept clean at all times.

All pipes and fittings shall be cleared of all debris, dirt, etc., before being installed and shall be kept clean until accepted in the completed work. The Contractor shall pull a plywood proving disc or mandrel through each installed pipe to ensure no debris is left in the pipe bore as laying proceeds.
All pipes shall be laid and maintained to the required lines and grades. Fittings shall be at the required locations with joints centered and spigots pushed home to the manufacturers specified insertion depth. No deviation shall be made from the required line or grade except with the written consent of the engineer’s representative.

Deflection in horizontal or vertical alignment shall not be performed without the approval of the engineer’s representative as to the extent of the deflection. In no case shall such deflection be done at the pipe joint. Pipe joint deflections must not be greater than one degree. If any bending is required it should be done at the central portion of the pipe and not exceeding the limits specified by the manufacturer. Whenever the required deflection exceeds the permissible limits the contractor shall install proper bends in the line and anchor these as required. Care should be exercised to lay the pipe in such manner as to minimize the number of these high and low points.

After each pipe has been properly bedded, a minimum 15 cm. sand fill shall be placed between the pipe and the sides of the trench, and thoroughly compacted to hold the pipe in correct alignment.

Where the grade or alignment of the pipe is obstructed by existing utility services, the obstruction shall be avoided by modifying the alignment or grade (or such obstruction shall be relocated if instructed), all in accordance with the instructions of the engineer’s representative.

3) Jointing of Pipes

All joint surfaces shall be cleaned. Before forming the joint, the previously installed unit shall be checked to ascertain that a close joint exists with the previously installed unit and that the inverts conform to the required grade. The pipe shall not be forced to the required grade by mishandling. Immediately before jointing the pipe, the pipe end shall be lubricated in accordance with the manufacturer’s specification. Each pipe unit shall then be carefully pushed into place without damage to pipe or gasket. Approved devices shall be used to ease the pipe units together to the specified insertion depth. Spigot ends of UPVC pipes shall be pushed into the socket end strictly following the manufacturer’s instructions until it reaches the insertion depth. The pipe should never be over-inserted.

Except in the case of flanged fittings and when jointing to existing pipe lines of different materials, all joints will be:

- Electro-fusion for polyethylene pipes (63mm)
- Flexible joints with spigot and sockets sealed with rubber rings or gaskets.

Basic requirements for all types of joints are:
- Cleanliness of all parts.
- Correct location of components.
- Centralization of spigot within sockets.
- Strict compliance with the Manufacturer’s specification.

Long radius curves in the pipeline shall conform to the Manufacturers specification.
The deflection at joint of pipes used in the work shall not exceed one degree.

The Contractor shall take care that all pipes and couplings are clean and free of foreign matter before subsequent sections are jointed.

During jointing with electro-fusion care should be taken that joints are not moved before the cooling process has been completed.

The Contractor shall make himself and his employees acquainted with and comply with the instructions issued by the manufacturers of the various types of proprietary joints and couplings for incorporation in the work. The Contractor shall be responsible for obtaining copies of these instructions.

Connection of uPVC or MDPE pipes to flanged fittings shall be by means of flanged adapters or couplings (dressers). Connection of new plastic pipes to existing pipes of mainly asbestos and steel will be done by special flange adaptors, if required. Saddle connections to uPVC and Steel Mains shall be in accordance with the Contractors specifications. Connections may be made in the dry or under pressure.

All joints shall be capable of withstanding the various tests as specified in the applicable standards.

The pipes shall be laid and bedded in 15 cm. full sand surround except where concrete protection may be specified. The granular fill shall be placed over the full width of the bottom of the trench. The side fill shall be placed in thin layers and well compacted.

Depth of back fill above the sand surround and surface material shall conform with the requirements for the appropriate road or pavement construction. The back fill material may be the excavated soil, provided it is suitable for compaction.

Adequate precautions shall be taken by the way of backfilling or other means to anchor each pipe securely to prevent floatation of the pipeline in the event of the trench being flooded or during possible concreting.

20.4.2 Service Connections

The existing service connections are to be replaced. New service connections shall be made between the saddle tees and the existing service connection pipe with new blue MDPE pipe below ground level (as per the Standard Detail). The Contractor shall provide the connector /adaptor fitting, connecting the blue MDPE pipe and the existing service pipe located above the 90° vertical elbow but below ground level. These fittings shall cater for the full range of existing service pipe types and diameters ranging from 10, 15, 20, 25, 32mm or other diameter, in either plastic or galvanized steel.

The Contractor shall make an assessment of the various types of existing service connections and their prevalence based on survey of a representative sample, and order sufficient quantities of the different types and sizes of connectors/adaptors required, to ensure any combination of existing service pipes can be connected.
These fittings shall be either P.E, brass or, if necessary, galvanized steel and must be suitable for use with potable water.

Where the existing Service connection above ground level is in poor condition, as assessed by the Engineers Representative, it shall be replaced with new black MDPE pipe up to the water meter stop valve connection. In this case the connector between the new blue and black MDPE pipes, below ground, shall be provided by the Engineer. The Contractor shall supply the necessary connector fitting between the new black MDPE pipe and the water meter stop valve.

The Contractor shall make an assessment of the various types and sizes of water meter stop valve arrangements, based on a survey of a representative sample, and order sufficient quantities of the different water meter stop valve connectors required to ensure any combination of existing stop valve meters and black MDPE pipes can be connected. These fittings shall be brass or, if necessary, galvanized steel and must be suitable for use with potable water.

Where new black MDPE pipes are installed above ground and outside the customers property boundary wall the Contractor shall supply a protective sleeve to fully enclose the exposed pipe from 500mm below ground to above the 90° elbow where the pipe passes through the boundary wall. This protective sleeve shall be designed by the Contractor and may be manufactured from galvanized steel (galvanised to 80 microns min DFT) and shall be securely fixed to the external wall with tamper proof fixings, to be supplied by the Contractor, all to be approved by the Engineers Representative.

Where new black MDPE pipes are installed within the customers property, the Contractor shall supply, where necessary, appropriate and sufficient numbers of brackets to adequately support the length of pipe from where the pipe passes through the customers wall and up to the water meter stop valve connection. The brackets shall be designed by the Contractor and shall be approved by the Engineers Representative before manufacture. The contractor shall provide all necessary fixings. The brackets shall support the pipe above the ground and fix the pipe in a position where it will not be exposed to accidental damage. The brackets shall incorporate a protective material around the pipe to prevent direct contact between the bracket and pipe which would wear or damage the pipe.

The contractor shall make an assessment of the likely types of brackets and fixings required based on a survey of representative sample, and order sufficient quantities to ensure that all new black MDPE pipes can be adequately supported.

20.4.3 Thrust Blocks, Anchors and Concrete Surrounding

If not otherwise instructed the Contractor shall provide thrust blocks at all bends, tees, branches and tapers and at blank ends as specified by the pipe Manufacturers and the Engineer. Enlargements shall be excavated in sides and bottom of the trench to accommodate anchorage and thrust blocks. The back of supports and blocks shall abut on to undisturbed solid ground. All loose material shall be removed before concreting.
The thrust blocks shall be designed by the Contractor in accordance with the BS.8110 - the structural use of concrete. The Contractor shall show that soil resistance is greater than or equal to 1.2 times the force exerted by the pipe when subjected to the test pressure. The soil resistance shall be calculated as the frictional resistance of the soil against the thrust block. The passive resistance of the soil shall not be considered in thrust block calculations.

Concrete shall extend to undisturbed ground on thrust faces of thrust blocks and on both faces of anchor blocks.

Where details are not shown on the drawings, the Contractor shall prepare proposals for thrust and anchor blocks and submit them to the Engineer’s Representative for approval. Such approval shall not relieve the Contractor of his responsibility for the adequacy of his proposals. Special details shall be shown on the drawings or instructed at site where environmental or ground conditions dictate.

Plywood plates, suitably moulded to the pipes barrel, shall be used to prevent direct contact between the concrete and UPVC pipes.

20.4.4 Location of Valves

The exact locations of valves shall be specified by the Engineer according to Drawings.

20.4.5 Pipes Protruding from Structures, Concrete Surrounds and Anchor Blocks

Unless otherwise detailed a pipeline at or below ground level protruding from a structure shall have two flexible joints adjacent to the structure located as follows:

<table>
<thead>
<tr>
<th>Pipe Diameter (mm)</th>
<th>Maximum distance to first joint (mm)</th>
<th>Distance between first and second joint (mm) Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 300</td>
<td>150</td>
<td>450</td>
</tr>
<tr>
<td>Max.</td>
<td></td>
<td>2.5 * dia., but not less than 450 mm.</td>
</tr>
</tbody>
</table>

20.4.6 Protection of Pipelines and Pipeline Components

20.4.6.1 Pipelines

Class A concrete protection slabs as detailed on the drawing shall be provided over the UPVC pipelines under roads when cover to the pipe is equal or less than 1m for pressure line.
20.4.7  Indicator Posts to Pressure Mains

Where pressure mains pass through open ground, not adjacent to roads, or where the danger of accidental breakage by excavation is evident, the Engineer may instruct the erection of indicator posts of an approved design. Details of the indicator post construction and spacing shall be shown on the drawings or be directed by the Engineer.

20.4.7.1 Cleaning, Testing and Disinfection

1) Cleaning and Inspection of Pipelines

During and until commissioning the Contractor shall provide and maintain wooden plugs in all open ends of pipes, to prevent the ingress of silt and deleterious matter into the pipelines.

After backfilling pipe trenches and completing chambers, hatch boxes etc. and before the trench surfaces are reinstated, the interior of pipelines shall be cleaned of silt and debris by approved methods for inspection by the Engineer's Representative as follows:

All newly constructed pipelines of 600mm (nom.) internal diameter and smaller shall have a loose plug passed through them to show that they are clear of obstruction and free from deflection. The loose plug shall be dimensioned to suit the permissible minimum deflected diameter of the pipe.

2) Hydrostatic Pressure Testing

General :-

After pipe laying, casting of concrete structures on the distribution network and partial backfill have been completed, the lines shall be tested over their entire length or, in the case of long lines, in sections. The pressure test shall only be performed in the presence of the Engineer's Representative.

The test pressure shall be determined by the Engineer in each case. The required pressure shall be obtained by means of a special pressure pump or by connecting the line to a suitable source of pressure.

Preparation for Pressure Test

The Contractor shall provide written notice to the Engineer of any tests two days before the test is to be carried out. All tests must be witnessed by the consultant’s Engineer. The Contractor shall maintain written records of the tests and provide copies of the records to the Engineer prior to the completion of the project.

The Contractor shall provide all water, fittings, pipe stoppers, test pump pressure gauges and the necessary equipment and tools for pipework. Hydraulic pumps, gauges and apparatus shall be equipped with locking devices to prevent tampering during the test period.
Filling of the distribution work with water shall not begin until 7 days after the last concrete structures have been cast. Prior to filling the lines, all joints and structures shall be inspected and be in good condition and proper functioning of all valves shall be ascertained. When testing a section not ending in a valve, the open end shall be a bulkhead and securely anchored. The testing installation and the working of the pump shall also be examined.

Prior to hydraulically testing the pipelines the Contractor shall provide adequate temporary thrust blocks at the ends of uncompleted sections, pipes shall be partially backfilled to about 500 mm above the crown of the pipe, in order to anchor the pipes during testing. Joints and fittings, however, shall remain uncovered until the pipeline has been tested satisfactorily.

The length of the section of pipeline to be tested may be determined by the contractor but shall not exceed 500 meters. Levels of the length of pipe under test shall be such that the minimum test pressure specified is achieved at all points whilst the maximum test pressure specified is nowhere exceeded.

**Filling the Distribution Network with Water**

The lines shall not be filled until the Engineer's written approval has been given. The lines shall be filled gradually and slowly in order to prevent water hammer or chattering in the pipes and to permit the escape of all air from the pipelines. The rate at which the lines are to be filled shall be determined by the availability of water. Consideration shall be given to filling mains at night, but always with the approval of the Municipality Engineer.

Before testing the line should be filled slowly and evenly with water through any convenient top or valve from the lowest end point. At every high point an automatic air release valve must be installed. After expelling all the entrapped air out of the test portion, all air release valves should be closed. If it is not possible to fill the line from the lowest point, an additional outlet should be added at the inlet point to release air at that point and this line/section should be kept filled for 24 hours before the pressure test.

At the commencement of filling, all blowout valves shall be open and each valve shall be closed after the water has flushed all dirt that may have accumulated in the pipes.

After the filling has been completed, but before the pressure is raised, all valves shall be inspected for water-tightness and all leaks in gaskets and stuffing boxes shall be stopped. Should this inspection show any leaks at the joints or defects in the valves that cannot be repaired while the lines are full or water, the lines shall be drained and the necessary repairs done. This inspection shall be repeated until all leaks are stopped.

Valves shall not be used to isolate sections forming the pipeline during testing operations.

**Pressure Test**
The pressure test shall be 1.5 times the maximum working pressure. The pressure shall be raised slowly to the specified test pressure and maintained at that pressure for a period long enough for the Engineer to examine the whole section under test. Thereafter, for a period of not less than 4 hours, the leakage of water as measured by the amount drawn into the pumps to maintain the pressure shall not exceed 1 litre per 100 millimeter of pipe diameter per kilometer of pipeline per 24 hours for each 30 meters head of pressure applied at the lowest point. Expected losses due to absorption shall be as specified by the pipe manufacturer.

Should any inspection be unsatisfactory or any test fail, the Contractor shall replace defective pipes, leaking joints or otherwise re-execute defective work as instructed following which cleaning and testing will be repeated until the Engineer’s Representative certifies the pipeline to be satisfactory.

The pressure test shall also serve as a strength test for the concrete anchor and thrust blocks, thus these structures shall be designed by the Contractor accordingly. Any structures failing the test shall be replaced by the Contractor at his own expense.

3) Disinfection and Flushing of Pipes

Pipelines, manholes, chambers/structures will be inspected again before commissioning or taking over (whichever is sooner) and shall be cleaned again in whole, flushing with clean water and a swab to be pushed through the length of the pipeline by hydrostatic pressure. The swab shall be first soaked in sterilizing solution.

Flushing of the new pipeline may be carried out by temporary connections to the existing water system if present in the working area. PWA will charge for giving the water to the Contractor as per for flushing including all other necessary requirements such as water tankers in the absence of mains water.

Upon completion of hydraulic tests the Contractor shall flush out the pipework with chlorinated fresh water and a cleaning swab will be passed through the pipework. This process will be continued until the flushing water runs clear.

The Contractor shall prepare a solution of chlorinated dosing solution using calcium hydrochloride at a rate of 77g/cu.m of system water volume, or with chlorinated water containing between 30 and 50 mg per liter of free chlorine. The solution shall be slowly pumped into the pipeline and a chloride level of 50 p.p.m. shall be maintained for a period of 8 hours.

The pipe work shall be flushed out until the chloride level drops below 0.2 ppm when tested with standard DPD (Diethyl-P Phenylendiamine) method and shall be clear of any detergent content when tested in accordance with BS 2690 - Part 11.

The Contractor shall provide the swab and water and shall be responsible for the disposal of water.

4) Connections Or Connections to Existing Pipelines
All final connections of new pipelines to existing pipelines will be carried out by the Contractor in the presence of the Engineers Representative and under the direction of the Municipality Engineers.

20.4.7.2 Manholes and Chambers

1) General

Other chambers and manholes to be supplied by the Contractor.

2) Cleaning

All manholes and valve chambers specified under this section shall be cleaned of any accumulation of silt, mortar, debris or any other foreign matter of any kind and shall be free of any such accumulations at the time of final inspection.

3) Construction of Manholes and valve Chambers

All manholes and chambers shall have reinforced-concrete bases. The Contractor shall construct all manholes, chambers, and special structures including transition chambers and outfall structures as indicated on the Drawings and herein specified.

Manholes, chambers, and special structures shall conform in shape, size, dimensions, materials, and other respects to the details indicated on the Drawings or as ordered by the Engineer.

Manhole and chamber cover slabs shall be either precast or cast in place reinforced-concrete as marked on the Drawings. The cast iron frames and covers for manholes and chambers shall be brought to grade by the number of courses of concrete blocks shown on the Drawings and a reinforced concrete frame into which the cast iron frame is embedded. Class B concrete shall be cast to a minimum thickness of 150mm around the concrete blocks for rigidity.

Manhole walls (rings) and cover slabs shall be either precast or cast in place reinforced-concrete. In precast construction rubber o-rings are to be placed in all joints except for the joint between the cast in place roof slab and the top wall ring. In below the manhole cover slab shall have removable plus or minus 30cm high concrete ring.

4) Formwork of Valve Chambers

The Contractor shall be responsible for the design and stability of the formwork. The Contractor shall submit a full program of work indicating the various phases for the erection and removal of forms and the manner in which he intends to execute.

5) Precast Elements

Precast elements shall be either of concrete or mortar as shown on the Drawings and as specified hereinafter.
- **Materials**

- **Precast Concrete Elements**

Precast concrete elements shall be of plain or reinforced concrete dimensions, thickness and reinforcement rods and bars shown on the Drawings and stated in the Bill of Quantities.

- **Precast Mortar Elements**

Moist tamped mortar precast elements shall be of a mixture of ordinary or tinted cement and sand (fine aggregate) approximately in the proportions of one part cement to two and one-half parts of sand. The sand shall be specially selected for colour and grading. The sand shall be screened through 1/8" inch square meshes and all oversize particles shall be discarded. Only sufficient water shall be used in mixing to permit the immediate removal of the member from the mould. The pattern, dimensions and thickness shall be as shown on the Drawings and/or as directed in writing by the Engineer.

- **Mortar**

Mortar for joining the precast elements shall be composed of one part of Portland cement and three parts of clean sand unless otherwise specified. The cement and sand shall conform to the requirements of ordinary Portland cement and aggregate for mortar specified herebefore.

- **Fabrication**

Precast concrete or mortar elements shall be cast in mortar-tight metal lined timber moulds and shall be mechanically vibrated when cast. The Precast elements shall be removed from the moulds as soon as practicable and shall be kept damp for a period of at least 10 days. Any elements that shows checking or soft corners or surfaces shall be rejected. The method of storage and handling shall be such as to preserve true and even edges and corners, any precast element which becomes chipped, marred or cracked before or during the process of placing shall be rejected, sampling of precast elements shall be submitted to the Engineer for approval, prior to fabrication, at the Contractor's own expense.

- **Workmanship**

All precast concrete or mortar elements shall be well cleaned and thoroughly wetted with clean water before placing in their positions shown on the Drawings. The precast elements shall be bedded and jointed in cement and sand mortar (1:3) mix and the joints raked out on both faces to receive plaster or pointing as indicated on the Drawings and/or stated in the Bill of Quantities to the satisfaction of the Engineer.

20.4.7.3 **Abandonment**
Water mains to be abandoned shall be isolated from the network supply by physically cutting the pipe to provide a clear distance of one metre from the existing supply pipe to be retained in service. In addition the cut ends shall be plugged with grout, type G2, to a distance of one metre from the cut end. The Contractor shall provide a sacrificial form within the pipe end to prevent loss of grout down the length of the abandoned main during placement of the grout plug.

Where existing mains to be abandoned have been laid on the surface or at a very shallow depth where it would not be appropriate to leave the abandoned pipe in position, then the Engineers Representative shall instruct its removal and disposal off site as required. In such cases the former trench of the abandoned pipe shall be leveled off and the ground level dressed off locally.

20.4.7.4 Reinstatement of Roads and Paving

All roads and pavings shall be fully reinstated to the existing roads and paving specification to the entire satisfaction of the Municipality Roads Department.

20.4.7.5 Miscellaneous Welding

1) Cutting and Preparing Pipes for Welding

Square cuts shall be in a plane perpendicular to the pipe axis. Oblique cuts shall be done accurately to the required angle in such a manner that the cut edge is in one plane. Pipe ends for butt welding shall be beveled to an angle of 30° with the plane of the edge, with a permissible variation of +5° or -0°.

All cutting shall be done with a mechanical tool, or by acetylene flame cutting by means of a special cutting device or Arc-air (carbon electrode with air jet). Flame cut surfaces shall be filed smooth.

Cutting of mortar-lined pipes shall always be done with Arc-air cutting equipment. After the metal has been cut through to the mortar lining, the latter shall be carefully broken along the cut and pipe edge prepared for welding as required above in subsection 30518(a).

2) Welding of Flanges

The welding of flanges to pipes shall be of the same quality as that specified for pipe welds. Slip-on flanges shall receive an interior weld inside the flange opening, in addition to the external weld. Weld-neck flanges shall be attached to pipe ends as specified above for the welding together of pipes, care being taken to ensure a perfect concentric alignment between pipe and flange. When welding on flanges, care shall be taken that the face of the flanges is perpendicular to the pipe axis. Flanges faces shall be kept free from weld material of other defects such as splutter, dirt, etc. All defects in the flange faces that may interfere with the proper sealing of flanges shall be repaired.
3) **Welded Elbows**

These shall consist of suitable obliquely cut pieces of pipe ("miters") welded together. These miters shall be cut to the exact dimensions shown on the drawings and accurately fitted together so that after welding the completed elbow will have the exact shape and dimensions shown on the drawings. The ends of the miters shall be beveled for welding as specified above.

In all elbows having diameter of more than 10" the seams between miters shall also receive an internal weld pass, which shall be made after the weld root has been thoroughly cleaned.

4) **Fabrication on Branch Outlets**

Fabricated T and Y branch connections shall be produced by cutting the branch pipe to the correct intersection shape to fit the curvature of the main pipe, cutting the required opening in the main pipe and welding the branch pipe to the main pipe.

The quality of welds shall be specified for pipe connections. The inside of the pipe intersection shall be cleaned and smoothed to ensure unobstructed flow in the pipe.

Where shown on the drawings or instructed by the Engineer, the Contractor shall installed weld reinforcement saddles to fabricated T and Y branches specified above. The saddle shall cut and bent to the required shape and slipped over the branch, its outside edges shall be welded to the main pipe, while the edge of its opening shall be welded to the branch pipe. Quality of welds shall be as specified above for welding of pipes.

5) **Fabrication on Pipe Reducers**

The Contractor shall fabricate the reducers from steel plate properly cut, rolled and welded or by cutting out wedge-shaped pieces form a length of pipe the diameter of which shall be equal to the larger diameter of the required reduces, squeezing the pipe together to the shape of the reducer and welding along the cut edges, which shall be straight and beveled for welding, the gap between them being of uniform width over the whole length. On pipes having a diameter of more than 10" an internal pass shall be added to each weld, which shall not protrude more than 1.5mm into the inside of the pipe. The ends of the pipe reducer shall have edges in parallel placed perpendicular to the pipe axis and shall be beveled for butt welding.

6) **Prefabricated fittings**

Prefabricated elbows, tees and reducers shall be jointed to pipes by square butt welds or by lap welds as specified above for pipe-welding, care being taken that the true alignment and correct position of the fitting are ensure.

7) **Installation of valves and Fittings**

- **General:**
Before being installed, the valves and fittings, and especially valve seats, shall be cleaned of any dirt that may have entered them.

When installing the valves, their correct position shall be ensured by means of a spirit level.

Fitting the valves to pipes shall be done accurately, but without using force. Fitting of valves by tightening bolts forcibly or by any other method that will cause internal stresses in the valve or flanges will not be permitted.

8) Weld Inspection and Tests of Various Welds

- General:

The Engineer’s representative himself or by his authorized agent will exercise a continuous control of the welding work and will inspect the quality of the welds. In addition to routine supervision and visual inspection of the completed welds, the Engineer’s Representative will have the right to request samples to be cut from the welds for destructive tests. If so required by the Engineer’s Representative, welds shall also be tested by radiography.

- Destructive Tests:

General: Destructive tests will include all or part of the following, at the discretion of the Engineer’s Representative:
Break Test.
Bend Test.
Tensile Test (in special cases).

Both the Contractor and the Engineer will endeavor to ensure the proper execution of the welds, so as to avoid altogether or minimize the number of destructive tests.

- Frequency of Tests:

Should one of the samples taken for the destructive tests not meet the standards of acceptability set out below, the Contractor will be required to cut additional samples from the same weld or from other welds made by the same welder. If one of the new samples does not meet the requirements, the Contractor will be required to cut more samples until a clear picture of the extent of defective welds is obtained. Should such additional tests show that the quality of the welds is unacceptable, as determined by the Engineer, the Engineer may require the Contractor to remove and re-weld all welds made by the welder concerned. In the event of the test sample meeting the requirements of the Specification, the cost of cutting the sample and preparing and testing the specimens, and that of patching the pipe where the sample fail to meet the above requirements, all such cost, as well as the cost of all additional tests that may be required, to determine the extent of the defective welds as aforesaid, shall be borne by the contractor.

- Taking Samples for Bend Test, Break Test, and Tensile Test:
Bend Test, Break Test and Tensile Test shall be cut from the pipe in the forms of strips 5cm wide, perpendicular to the weld seam and expending 10cm on either side of the weld, so that the weld will be located in the center of the sample.

The opening resulting from cutting the sample shall be closed by welding on a patch of steel plate having a thickness not less than that of the pipe wall.

The cost of patching up opening as herein described shall be included in the cost of taking samples as specified above.

**Bend Test:** The bend test samples shall be bent in a suitable jig in the field or in the shop. The bend shall be located exactly over the weld with the weld face on the convex side. The sample shall be considered as meeting the requirements if it will not break and no cracks larger than 3mm in any direction will appear on the convex side of the bend.

**Break Test:** The break test sample shall be hacksaw-notched on both edges across the center of the weld to ensure breaking of the sample in the weld. The sample shall be supported on both sides of the weld and broken by a strong hammer blow. The required result is the broken surface shall show full penetration of the weld and no burns or excessive slag inclusions. The break surface shall not show more than one gas pocket per square centimeter, provided that no gas pocket has a diameter of more than 1.5mm.

**Tensile Test:** Samples for tensile strength and elongation tests shall be send for testing to an authorized laboratory. These tests will serve as a control of the welding procedure and of the quality of the electrodes but not to test the welder’s ability. In this test the samples shall show a tensile strength not less than that required of the steel of which the pipes are made.
20.4.7.6 Safety Procedures

1) Safety

The Contractor is responsible for the safety of personnel and the public during the contract period.

The Contractor shall make himself familiar with the condition of the site before tendering in order to assess the nature of safety problems he is likely to encounter and the safety requirements.

The Contractor shall appoint a Safety Officer who shall be responsible for all aspects of safety. He shall be conversant with and experienced in construction and traffic safety techniques and emergency procedures, and shall be on site at all times operatives are working. He shall enforce and supervise the safety procedures at all places of works and make sure that adequate safety equipment are available in good working conditions to all places of works at the time works are on-going.

The Contractor shall provide a written statement detailing proposed safe methods of work with the tender. Accident procedures and emergency procedures shall be fully detailed.

No persons shall be allowed to enter a confined space until the safe methods of work have been agreed upon and fully implemented to the satisfaction of the Engineer.

The Contractor shall make sure, prior to commencement of works on site, that adequate safety equipment, apparatus and devices are available.

It shall be explicitly understood that safety is the responsibility of the Contractor and use of any of these procedures as outlined under this clause shall not relieve him of his responsibilities under the Contract.

2) Traffic Control

Prior to initiating any work at a site, the Contractor shall prepare, for the approval of the Engineer, a plan for the diversion and control of traffic around the work site. The approved traffic control plan shall be submitted to the Traffic Police for review. Work at the site may not commence until the traffic control plan has been approved by the Traffic Police.

The traffic control plan shall include a street plan of the work site showing all traffic lanes and building access that will be affected by the work. The proposed system of traffic diversions and the manner of control shall be clearly illustrated, including the location and types of traffic barriers, warning signs and warning lights to be used. The plan should indicate the anticipated schedule of works for which traffic must be diverted. For road-diversions and road signs.
The traffic control plan shall take into consideration the requirements of the work crew for access to the work site, for positioning and parking of vehicles needed for the work and for the temporary storage of equipment and materials.

### 20.4.8 Technical Specification for Used Materials

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### 20.4.9 Preliminaries
20.4.9.1 General

1. This specification relates to the supply of pipes and fittings by the Engineer to the Contractor. It includes the provision of pipe jointing, cutting, drilling and tapping equipment and the provision of training in the installation of the pipeline system.

2. This specification has been based on current practice and the pipes and fittings comply with the relevant International Standards, (ISO’s) or British Standards, (BS’s) listed in Appendix A as well as the Israeli requirements enacted by the Israeli Institute for Standards for part of the Goods.

3. The water network system existing in the Gaza strip comprises mainly Imperial dimensioned pipes and fittings therefore provision of Imperial dimensioned pipes and fittings are detailed for the rehabilitation work. MDPE pipes are available in metric dimensions only.

4. All pipes and fittings to be supplied shall be pressure rated to PN 10.

20.4.9.2 Protection

1. All materials shall be securely packed in crates or boxes for protection against damage during transit.

2. Flanges of valves shall be protected by wooden discs temporarily bolted on or secured by steel strapping. Spindle caps of valves shall be removed and secured to the inner side of one of the wooden discs by means of a steel strip. Otherwise they shall be packed in a case. The projecting end of the spindle shall be well wrapped with straw rope covered by hessian cloth and secured in place by binding wire which shall be carried under the flange of the gland.

3. All plain ends shall be adequately protected by straw rope secured in place by binding wire or strap. None of the packings will be returnable. The cost of packing shall be included for in the schedule rates.

4. The materials supplied shall be of the appropriate grade and quality and shall be adequately protected against the climatic conditions in the Middle East.

5. All plastic materials shall be protected from direct sunlight and appropriate coverings supplied for use at the delivery and storage areas.

20.4.9.3 Identification
1. The Contractor shall be responsible to ensure that each separate item, crate, or package has permanently attached to it, in a conspicuous position, an identification plate of weather-resistant material on which are engraved or stamped:

- the manufacturer's name
- contents description and quantity
- serial number or reference number identifiable on the delivery note and cross referenced to the purchase order item references.
- weight

20.4.10 Handling

1. Care shall be taken during loading, transporting, and unloading to prevent damage to the pipes, fittings, or coatings. Under no circumstances shall pipes or fittings be dropped or rolled against one another. All pipes and fittings shall be examined. Any damage to the coatings shall be repaired as directed by the Engineer.

2. All pipes shall be bundled or packaged in such a manner as to provide adequate support, and protection for the ends during transportation from the manufacturer to the Purchaser. All special provisions for ocean shipment shall be provided.

20.4.11 Pipes

20.4.11.1 General

1. All pipes supplied shall be suitable for potable water supply.

2. Pipes shall not be exposed to sunlight for any extended period.

3. Any pipes (or fittings) with an indentation greater than 10% of the wall thickness shall be rejected. Any pipes (or fittings) distorted out of round by more than 5% shall be rejected.

4. All pipes shall be pressure rated to PN 10.

5. Pipes shall bear clear and permanent markings showing the nominal diameter, pressure rating, type, year of manufacture and the manufacturer's name or trade mark. Markings on pipe lengths shall always be at the same end. Painting of data shall be acceptable for all pipe material.
6. All ISO, or alternative, recommended tests including witnessed tests shall be carried out and certified in writing to the Engineer, on delivery of the batches.

20.4.12 Unplasticised Polyvinyl Chloride (UPVC) Pipes

1. UPVC pipes shall have spigot and socket joints with rubber O-ring gaskets.

2. All joints shall have the same characteristic strength as the connecting pipe.

20.4.13 Medium Density Polyethylene (MDPE) Pipes

1. The raw material from which the pipes are made shall be composed substantially of medium density polyethylene to which may be added only those additives that are required for manufacture of the pipes. The raw material shall contain carbon black of not less than 2\% by weight.

2. Dimensions and tolerances shall comply with ISO Standards.

20.4.14 Pipe Fittings

20.4.14.1 General

1. Pipe fittings shall comprise any of the following items; flanged, spigot, and socket fittings, couplers, flanged couplings, tees, elbows, bends, reducers, extension pieces, or any other special fitting identified in the schedule of pipes and fittings. Valves and Accessories are specified separately later.

2. Pipe fittings shall be suitable for potable water supply.

3. Pipe fittings shall conform to ISO Standards.

4. All Pipe fittings shall be pressure rated PN 10.

5. All ISO, or alternative, recommended tests and witnessed tests shall be carried out and certified in writing to the Engineer, on delivery of the batches.

6. Pipe fittings shall bear clear and permanent markings showing the nominal diameter, pressure rating, type, year of manufacture and the manufacturers name or trade mark. Markings on pipe fittings shall
always be at the same end. Painting of data shall be acceptable for all pipe fitting materials.

7. Pipe fittings shall be compatible with the associated pipes and have equal or higher pressure ratings as the associated pipes.

8. The Contractor shall provide sufficient quantities of inert, waterproof filler paste, flange wrapping tape and paste, to protect all bolted connections of flanges, couplers and fittings.

9. All pipe fittings specified to be coated with ‘epoxy paint’ shall be defined to mean that they are coated with epoxy resin powder electro-statically applied to a thickness of 250 microns. The Contractor shall submit full details and technical specification of any alternative protective coating system proposed at the time of tender, for approval by the Engineer.

20.4.15 Materials

1. Pipe fittings may be fabricated from either uPVC, MDPE, mild steel, stainless steel, ductile iron or copper alloy.

2. uPVC fittings shall be formed in injection moulds or machined from extruded stock. Fittings fabricated by solvent cement techniques shall not be accepted.

3. Materials, properties and strengths of the fittings made of uPVC shall equal or exceed those of the pipe.

4. MDPE fittings shall be supplied by the same manufacturer and shall be made from the same raw material and with the equivalent or superior quality requirements as those of the MDPE pipe.

5. Materials shall comply with ISO Standards.

20.4.16 Couplings and Flange Couplings

1. All couplings fabricated from mild steel or ductile iron shall be descaled and coated with epoxy paint or similar approved by the Engineer.

2. Straight couplings, flanged couplings, tees and elbows of 50mm or less shall be manufactured in gunmetal or MDPE.

3. Couplings shall be supplied with a central register or locating plugs. The central collar shall be 1.5 times thicker than the equivalent standard pipe thickness.
4. Every coupling, and flange coupling shall be capable of withstanding without leakage the pressure rating of the section of pipeline it is supplied with.

5. The pressure rating shall be clearly stamped on all couplings and flange couplings.

6. Flange couplings for jointing plain ended pipes to specials shall be capable of maintaining a watertight joint over a range of axial movement of at least 25mm and an angular deflection of not less than 2 degrees.

20.4.17 Flanged Fittings

1. All flanged fittings, fabricated from mild steel or ductile iron, shall be descaled and coated in epoxy paint or similar approved by the Engineer.

2. Flanges shall comply with ISO Standards and bolt holes shall straddle the vertical axis of the flange.

3. All steel flanges shall be welded to the pipe by the electric arc process or other approved method. The flanges shall be of the raised face type and shall be truly faced over their whole width. Bolt holes shall be drilled on centre lines, truly in line end to end with the longitudinal axis. All flanges shall be rated as PN 10. All flanges shall be adequate to withstand test pressures for the specials to which they are attached.

4. Flanged joints shall be furnished complete with gaskets, bolts, nuts and washers.

5. The Contractor shall provide additional gaskets, bolts, nuts and washer sets, equivalent to 5% of the scheduled quantity, to allow for wastage or losses during the rehabilitation installation works.

6. All gaskets shall be full faced and suitable for potable water supply in the Middle East climate. The Contractor shall demonstrate the suitability of the gasket at the time of tender.

7. Bolts and nuts shall be in carbon steel and shall be hot-dipped galvanised spun (to a standard sufficient for a saline environment). The bolts shall be hexagonal head type, and their dimensions shall conform to ISO Metric Black Hexagon Bolts, Screws and Nuts. “Normal Thickness Nut Type, or similar approved by the Engineer.

20.4.18 Valves
20.4.18.1 General

2. Valves shall be suitable for potable water supply.

3. All protective coatings shall be non-toxic and shall not foster micro biological growth nor impart any odour, taste, cloudiness or discoloration to the water. All ferrous surfaces in contact with water shall be coated with epoxy paint or similar approved by the Engineer.

4. Valve bodies shall give the following information
   - Year of manufacture
   - Manufacturer’s name.
   - Working pressure;
   - Size of valve;
all to be cast in raised letters, upon an appropriate part of the body. Where appropriate the marking shall have a minimum size of 25mm (1 inch), raised 3mm (1/8 inch).

1. After completion of assembly, each valve shall be shop operated three times from the fully open position to the fully closed position and returned to fully open under no flow condition to demonstrate that the assembly is working.

2. All valves shall be hydraulically tested at the place of manufacture to the pressures specified and shall satisfactorily pass the specified tests before they are packed for delivery.

3. The operating gear of valves shall be such that one man can open and close the valve against an unbalanced head 15% in excess of the maximum to be encountered in service.

4. Packed glands shall be arranged for easy replacement of the packing, which shall be accessible without removal of the valve from the pipe and while the valve is still in service. Precautions shall be taken to prevent corrosion of the valve spindles in contact with the gland packing.

5. Flanges of valves shall be to PN10.

20.4.19 Gate Valves

1. Gate valves shall conform to ISO Standards.

2. All Gate valves shall be fabricated in ductile iron.

3. The minimum working pressure of all gate valves shall be PN10.
4. Gate valves shall be of the resilient face type.
5. The operating stem shall have ‘o’-ring seals.
6. The direction of opening for all gate valves shall be anti-clockwise as viewed from the top.
7. Valve ends shall be flanged type.
8. All external body and flange surfaces shall be coated with epoxy paint, or similar approved by the Engineer.
9. All interior surfaces except the finished and seating surfaces, shall be coated with epoxy paint, or similar approved by the Engineer.
10. For resilient faced gate valves, a hydrostatic test pressure equal to twice the rated working pressure of the valve shall be applied to the body with the gate in the open position. The test shall show no leakage through the metal, flanged joint, or stem seals. Subsequently, a test shall be made from each direction at the rated working pressure to prove the sealing ability of each valve from both directions of flow. The test shall show no leakage through the metal, pressure-containing joints, or past the seat.

20.4.20 Air Valves

1. Air valves shall be fabricated to ISO standards.
2. All air valves shall have flanged ends.
3. All air valves shall be fabricated in ductile iron and pressure rated to PN 10.
4. Air valves shall be of single and double orifice type.
5. All air valves shall have a means of isolation. Each air valve may be supplied with a horizontally positioned isolating valve of the same size, with bevel gearing arrangement for vertical operation and a set of flange jointing materials including nuts, bolts, washers and joint gaskets for insertion between the air valve and isolating valve. The bevel gear pinion shall be of corrosion proof steel. The Contractor may propose an alternative, for approval by the Engineer.
6. All surfaces, except the finished or seating surface shall be coated with epoxy paint, or similar approved by the Engineer.
7. Double orifice air valves shall be of ‘aerokinetic’ type incorporating hydrodynamic principles suitable for air exhausting during charging or venting when emptying of the main. The ball-sealed orifice shall always remain open while air is discharged and shall be immediately
closed when the water rises in the valve to lift the ball and seal the orifice. The escaping turbulent air or a mixture of air and water spray (even at the critical velocity of 300 m/sec) shall not cause the ball to be thrown into the discharging air stream and be blown shut prematurely during the filling of the water main at high rate. Under no circumstances shall the large orifice ball blow shut prematurely.

8. The ball of the large orifice shall bear a calculated mathematical relation with the inlet diameter of the valve i.e. the average cross-sectional area of escaping air stream, so that the ball will be blown shut by a stream of water but held down by a stream of air. The weights of each ball of the same size and type shall not differ by more than 2%.

9. Single orifice air valves shall be relief in action and shall operate such that the ball cannot be held against the orifice by air pressure alone.

10. The design of the valve shall be such as to allow maximum free air discharge and inflow at pressure differentials of plus 0.5 bar and minus 0.2 bar respectively. The Contractor shall submit with his Tender, curves for free air discharge and inflow against various air pressures at valve inlet.

11. The orifice shall be either copper alloy or stainless steel, not less than 3 mm and tapering to 10 mm suitable to release accumulated air within the pipe. The profile of the orifice shall be such as to avoid damage to the ball surface. The orifice shall be protected by a suitable plug of stainless steel. All air valves shall be made insect proof by providing stainless steel screens at the vents leading into the atmosphere.

12. The low pressure cover shall be designed to withstand the full operating thrust in the working condition. A neoprene seat ring shall be held securely in place under the low pressure cover by a joint support ring to prevent it from sagging when the ball is not sealing the orifice.

13. After completion of machining but before assembly the valve body shall be hydraulically tested to twice the working pressure for a period of 5 minutes and thereafter compressed air at a slightly higher pressure shall be released through the valve inlet to check the function of the ball.

14. Subsequently the hydraulic pressure shall be reduced to 0.5 bar and there shall be no leakage through any of the orifices.

20.4.21 Fire Hydrants
1. Fire hydrants shall be ‘Street Fire Hydrant’ type, for below ground operation.

2. Fire hydrant nominal flange size shall be 80mm diameter.

3. All fire hydrants shall be pressure rated to PN 10.

4. Hydrant thread to be 2.5 inch Round Thread Outlet.

5. Direction of opening to be anti-clockwise as viewed from the top.

6. Nozzle size to be 2.5 inch

7. Operating nut shall be key-bar operated

8. The body and cap of the hydrant shall be fabricated from, ductile iron.

9. The fire hose connection shall be fabricated from cast bronze having the following properties;

   **Chemical Composition:**
   - Copper: 82.0-87.0%
   - Lead: 4.0-6.0%
   - Tin: 4.0-6.0%
   - Zinc: 4.0-7.0%

   **Mechanical Properties:**
   - Tensile Strength: 210 Mpa minimum
   - Yield Strength: 95 Mpa minimum
   - Elongation: 15%

10. ‘O’ rings and gaskets shall be suitable for potable water supplies.

11. All foundry and machine work shall be in accordance with standard good practice.

12. When assembled hydrants shall be well fitted and smooth operating.

13. All joints shall be faced true and watertight under operating and test pressures.

14. All iron parts receiving bronze mountings shall be made true and smooth, and the bronze mounting shall be finished to fit.

15. All castings shall be clean and sound without defects that would impair their service. No plugging, welding, or repairing of such defects shall be permitted.

16. All like parts of the same model and size produced by the same manufacturer shall be interchangeable.
17. Each hose connection shall have caps attached to the barrel by chains.

18. All internal and external surfaces, except seating surfaces shall be coated in epoxy paint.

20.4.22 Accessories

20.4.22.1 Surface Boxes and Chambers

1. All surface boxes shall be fabricated from ductile iron.

2. Surface boxes shall be heavy duty and resistant to damage or displacement by heavy traffic.

3. Surface boxes shall be either square opening or round with chains attached to the covers and frame.

4. Covers shall have the letter ‘W’ on the top surface.

5. All chamber boxes shall be fabricated in uPVC, have the equivalent clear opening dimensions of the respective surface box and shall be 300mm deep.

20.4.23 Tapping Saddles

1. Tapping saddles shall be of the type fitted to the top of the pipe and shall be capable of allowing insertion of the ferrule cock under working pressure.

2. Tapping saddles may be fabricated from ductile iron or copper alloy.

3. The Contractor shall ensure full compatibility of the saddle with the under-pressure equipment and ferrule cocks, and shall provide full details of the system at the time of tender.

20.4.24 Ferrule Cocks

1. Ferrule cocks shall be fitted to the top of the pipe and shall be capable of being fitted under working pressure.

2. Ferrule cocks are to be fabricated in copper alloy.
20.4.25 Repair Collars

1. Repair collars shall be of the split or wrap around type.

2. Repair collars shall be fabricated from ductile iron, or stainless steel.

20.4.26 Stop Taps

1. Stop taps shall be manufactured for underground operation and operated from the surface by a stop tap key.

2. Stop taps shall be manufactured from copper alloy or other material to be approved by the Engineer. Full details including alternative standards shall be provided by the Contractor at the time of tender.

20.4.27 Combined Tracer and marker Tape

1. The combined tracer and marker tape shall be manufactured in metallic mesh, 100mm wide, of maximum opening size of 25mm and shall be detectable by an electronic mains locator at a depth of 1m.

2. The metallic strip is to be protected from corrosion by PVC coating colored blue.

3. Other material may be considered subject to the Contractor submitting alternative details at the time of tender.

20.4.28 Manuals and Technical Specifications

1. The Contractor shall supply full technical specifications for the items to be supplied at the time of tender. In addition he shall provide full instruction manuals which describe the correct methods and procedures necessary to construct the pipeline system in accordance with best practice.

2. The Contractor shall provide, at the time of tender, details of the of the equipment necessary to correctly install the pipeline system including under-pressure tapping machines, pipe cutters, chamfering (beveling) tools, joint making equipment, lubrication materials and loose tools.

3. Five sets of all instructions and operating manuals for each type of valve and appurtenance shall be provided by the Contractor.

20.4.29 Guarantees and Warranties
1. The Contractor shall furnish the Engineer with guarantees and/or warranties for all materials supplied on delivery of the batches or consignments of materials. The minimum period of guarantee or warranty shall be 1 year beyond the date of the final delivery. The Contractor shall state the period for which they remain in force.
### Appendix A – List of Standards

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<td>Predominantly key-operated cast iron gate valves for underground use.</td>
</tr>
<tr>
<td>Gate Valves</td>
<td>ISO 5996 : 1984</td>
<td>Cast iron Gate valves.</td>
</tr>
<tr>
<td>Ductile Iron</td>
<td>BS2789</td>
<td>Spheroidal - graphite cast iron</td>
</tr>
<tr>
<td>Rubber Joints</td>
<td>BS 2494 : 1990</td>
<td>EPDM type rubber Type W.</td>
</tr>
<tr>
<td>Protective Coatings</td>
<td>WRC FR 0028</td>
<td>Fusion Bonded Epoxy - Powder</td>
</tr>
<tr>
<td>Hydrants</td>
<td>BS 750</td>
<td>Underground Fire Hydrants.</td>
</tr>
<tr>
<td>Joints</td>
<td>ISO 3458 :1976</td>
<td>Assembled Joints between fittings and polyethylene (PE) Pressure pipes. Test of leakproofness under internal pressure</td>
</tr>
<tr>
<td>Joints</td>
<td>ISO 3459:1976</td>
<td>Polyethylene pressure pipes-Joints assembled with mechanical fittings - internal under - pressure test method and requirement</td>
</tr>
<tr>
<td>Material</td>
<td>ISO/BS Standard</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>-----------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Joints</td>
<td>ISO 3501:1976</td>
<td>Assembled joints between fittings and polyethylene (PE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure pipes - test of resistance to pull-out.</td>
</tr>
<tr>
<td>Joints</td>
<td>ISO 3503:1976</td>
<td>Assembled joints between fittings and polyethylene (PE)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pressure pipes - test of Leakproofness under internal pressure when subjected to bending.</td>
</tr>
<tr>
<td>Stop Valves</td>
<td>BS 5154:1991</td>
<td>Specification for copper alloy globe, globe stop and check, check and gate valves.</td>
</tr>
</tbody>
</table>
21 **INSPECTION, TESTING AND COMMISSIONING**

21.1 Inspection and Testing of Pipelines

21.1.1 Cleaning and Inspection of Pipelines

During and after construction the Contractor shall take reasonable measures, including the provision of plugs where appropriate, to prevent the ingress of deleterious matter into pipelines.

After backfilling pipe trenches and completing chambers, hatch boxes etc. and before the trench surfaces are reinstated, the interior of pipelines shall be cleaned of slit and debris by approved methods for inspection by the Engineer's Representative as follows:-

Pipelines of 600 mm (nom.) internal diameter and smaller shall have a loose plug passed through them to show that they are clear of obstruction and free from deflection. The loose plug shall be dimensioned to suit the permissible minimum deflected diameter of the pipe.

Pipelines greater than 600 mm (nom.) internal diameter will after cleaning be inspected from the inside and the Contractor shall provide a suitable trolley for this purpose.

Pipelines will be inspected again before commissioning or taking over (whichever is sooner) and if required by the Engineer's Representative shall be cleaned again in whole or in part.

21.1.2 Testing of Pipelines General

Prior to commencement of flushing or testing approval shall be obtained to the method of disposal of all fluids used for flushing or testing purposes.

Under no circumstances will permission be given for the discharge of such fluids into the drainage system.

If permission is given to use new or existing pipelines or culverts, which are not part of a live system, they shall be thoroughly cleaned of all silt and any resulting damage made good after use.

If lagoons for the storage of such fluids are permitted, they must be suitably protected with fencing and attended by day and night to prevent access by the general public and will not be sited adjacent to buildings. Approved means of preventing the formation of mosquito larvae on the surface of the lagoons will be employed.

Testing of pipelines shall in all cases be applied in the presence of the Engineer's Representative. The Contractor shall provide complete plant and all struts, thrust blocks, etc., as may be necessary for effectively testing the pipelines to the specified pressures.

For both gravity and pressure pipelines only testing of new or replaced sections of pipelines and fittings will be required under the Contract, in accordance with this Specification, unless detailed otherwise. Such testing will be carried out before making final connections to the existing network. However where tees or other fittings are inserted into existing pipelines and where lengths of pipeline are
replaced no backfilling will be allowed at the tees or fittings or at the joints between new and existing pipework until the pipeline has been returned to service and a visual inspection of all such fittings and joints made at the network pressure.

Should any inspection be unsatisfactory or any test fail the Contractor shall replace defective pipes, leaking joints or otherwise re-execute defective work as instructed following which cleaning and testing will be repeated until the Engineer's Representative certifies the pipeline to be satisfactory.

21.1.3 Testing of Non-Pressure Pipelines

Ogee jointed pipelines shall not be tested or subject to infiltration limitations.

All other non-pressure pipelines of 750 mm nominal and smaller internal diameters shall be given a preliminary test when the pipeline is bedded and jointed before backfilling and a final test after backfilling.

Unless otherwise instructed non-pressure pipelines shall be tested in sections between manholes. In addition pipelines shown as straight lines on the drawings shall be subjected to a light as detailed in the pipelaying specification.

Preliminary and final tests will not normally be applied to pipelines greater than 750 mm (nom.) internal diameter and acceptance of these pipelines will be dependent on satisfactory visual inspection of the pipes and joints.

Preliminary Test

Air shall be pumped into the pipeline until a pressure of 100 mm head of water is indicated on a water manometer and the pressure shall not fall to less than 75 mm during a period of 5 minutes.

The Contractor will not be permitted to commence testing later than 4 hours after sunrise or earlier than 4 hours before sunset during the summer period unless otherwise directed by the Engineer.

Final Test

The part of the pipeline under test shall be filled with water to a level 1.25 m above its highest point. After standing for 30 minutes the water shall be topped up if necessary and in the following 60 minutes the loss of water shall not exceed 7.5 litters per meter of diameter per 30 m of length of pipeline under test.

Where in the opinion of the Engineer's Representative the above test is not sufficiently indicative of water tightness by reason of high ground water levels the test will not be applied. Acceptance of the pipelines will then depend on satisfactory inspection or testing for infiltration as referred to below, and air test of the pipeline in manhole lengths.

Testing Gravity Sewers

1- Sewers shall be tested by the contractor after they are jointed and before any concreting or backfilling is commenced, other than such as may be necessary for structural stability whilst under test.

2- Sewers up to and including 750mm nominal diameter shall be tested by means of an air or water test and sewers greater than 750mm nominal diameter by a visual examination.

3- A further test shall be carried out after the backfilling is completed.
Air Test for Gravity Sewers

As soon as a length of pipe has been laid and before backfilling, when applicable and when ordered it shall be subjected to the following Preliminary Test: air shall be pumped into pipeline by suitable means a pressure of 300 mm head of water is indicated on a water manometer and the test will not be satisfactory if the air pressure fails to less than 275 mm during a period of 5 minutes. Pipelines shall be given a Final Test using water after they have been backfilled, cleaned and inspected.

Pipelines of 675 mm or more internal diameter shall have each joint individually tested by means of an approved joint testing apparatus. Pipelines of lesser size shall be tested in convenient lengths by filling with water under pressure.

Unless specified elsewhere, the test pressure shall be 900 KN per square meter (91.8 m head) for cast iron and asbestos cement pipes shall be 50% above the manufacturer's rated working pressure for the approved pipes for steel, plastic and other pipes.

The pressure test shall be sustained for a period of 30 minutes and the volume of water required to maintain the test pressure shall be determined in an approved manner.

The test will not be considered satisfactory if the rate of loss of water from full pipe exceeds 1 litter per hour per 100 mm diameter per kilometer of pipeline under test, or from an individual joint test, if the loss of the pressure during the test period exceeds 70 KN per square meter.

Each test shall be restricted to pipes of one class and wherever practicable the length of pipeline to be pressure tested at one time shall not exceed 500 meters. Particular care must be taken to isolate air valves, etc, not to apply higher pressure than specified at any point on the pipelines and to ensure that the pipelines are adequately anchored before any test is carried out.

Wooden plugs shall be provided and maintained in all open ends of the pipelines so as to exclude silt and deleterious matter until the pipelines are commissioned.

Water Test for Gravity Sewers

1- The test pressure for sewers shall not be less than 1.2m head of water above the pipe soffit or ground water level, whichever is the higher, at the highest point and not greater than 6m, head at the lowest point of the section. Steeply graded sewers shall be tested in stages in cases where the maximum head, as stated above, would be exceeded if the whole section were tested in one length.

2- The sewer shall be filled with water and a minimum period of 2 hours shall be allowed for absorption, after which water shall be added from a measuring vessel at intervals of 5 minutes and the quantity required to maintain the original water level noted. Unless otherwise specified, the length of sewer shall be accepted if the quantity of water added over a 30 minutes period is less than 0.5 liter per liner meter of nominal diameter.

3- Notwithstanding the satisfactory completion of the above test. If there is any discernible leakage of water from any pipe or joint, the pipe shall be replaced and/or the joint remade, as appropriate, and the test repeated until leakage is stopped.
CCTV Inspection of Gravity Sewers

1- Before a CCTV inspection is carried out and prior to the issuing of a Final Certificate, the Contractor shall confirm in writing to the Engineer that all of the following conditions have been met.
2- All planned connections have been made in accordance with specifications and standards.
3- The sewer and manholes are clean.
4- All debris has been removed from connected sewers and drains and,
5- All highway construction proposed above the sewer is complete except for its final surfacing.
6- The contractor shall afford all reasonable facilities for personnel employed in the execution of CCTV inspection work in the site.

Infiltration Test

After completion of backfilling and restoration of normal subsoil conditions all pipelines and manholes shall be examined for infiltration which shall be nil.

21.1.4 Testing of Pressure Pipelines

21.1.4.1 Preparation for Pressure Test

The Contractor shall provide written notice to the Engineer of any tests two days before the test is to be carried out. All tests must be witnessed by the consultant’s Engineer. The Contractor shall maintain written records of the tests and provide copies of the records to the Engineer prior to the completion of the project.

The Contractor shall provide all water, fittings, pipe stoppers, test pump pressure gauges and the necessary equipment and tools for pipework. Hydraulic pumps, gauges and apparatus shall be equipped with locking devices to prevent tampering during the test period.

Filling of the distribution work with water shall not begin until 7 days after the last concrete structures have been cast. Prior to filling the lines, all joints and structures shall be inspected and be in good condition and proper functioning of all valves shall be ascertained. When testing a section not ending in a valve, the open end shall be a bulkhead and securely anchored. The testing installation and the working of the pump shall also be examined.

Prior to hydraulically testing the pipelines the Contractor shall provide adequate temporary thrust blocks at the ends of uncompleted sections, pipes shall be partially backfilled to about 500 mm above the crown of the pipe, in order to anchor the pipes during testing. Joints and fittings, however, shall remain uncovered until the pipeline has been tested satisfactorily.

21.2 Testing of Water Retaining Structures

21.2.1 Testing of Water-Retaining Structures
As soon as possible after completion, all water retaining structures shall be tested for watertightness. Each structure shall be filled with water and shall stand for a period of three days, to allow for absorption. The structure shall be considered satisfactory if, subsequent to this period, there shall be no fall in level over a period of 24 hours (after making the allowance for rainfall and evaporation) and no visible leaks, or damp surface areas.

This shall be carried out before any backfilling and before the application of any external concrete protection has taken place.

21.2.2  Testing and Commissioning of Gas Holding Structures Associated with Sludge Designation

Specification not included in this Contract.
21.3 Inspection and Testing of All Manufactured Items

21.3.1 Works Testing and Inspection

All manufactured items for incorporation in the Works shall be offered for inspection, examination and witness testing and shall be supported by certificates to demonstrate compliance with this specification and with the approved manufacturing and testing standards specifications.

Where manufactured items are to be shipped the packaging shall also be offered for inspection before dispatch.

Inspections when required shall be carried out by the Engineer or his appointed Inspecting Engineer.

The Contractor shall give to the Engineer and the Inspecting Engineer reasonable notice, which shall normally be of two weeks, of the date and place at which plant will be ready for prescribed testing.

If the tests are beyond the resource of the manufacturer he shall make arrangements for these to be carried out elsewhere. Any variation of this requirement shall be agreed and confirmation in writing shall be obtained from the Engineer.

The Contractor shall supply four unpriced copies of all suborders for manufactured items. Two copies of each of these suborders shall be forwarded to the Engineer and two to the appointed Inspecting Engineer at the time of the sub-orders shall indicate the Works for which the Item is required, state in detail the inspection and test requirements, give sufficient information for ready identification and shall state that these items will be subject to witness testing and inspection.

Four copies of all test certificates and, where relevant curves shall be supplied to the Inspecting Engineer within two weeks of completion of any witnessed tests.

Where witness tests are not required the test certificates and curves shall be forwarded to the Inspecting Engineer within two weeks after instructions to waive witness tests have been received.

On each certificate sufficient information shall be provided to enable the Engineer to issue a release certificate including the Contract Number and details shall be given for ready identification of the material or equipment to which the certificate refers.

No inspection or passing by the Engineer, the Inspecting Engineer or the Engineer's Representative of the work, plant or materials covered by this Contract, whether carried out or supplied by the Contractor, shall release him from any of his obligations under the Contract.

The Contractor shall be entirely responsible for complying with the above testing and inspection requirements, including the provision of test certificates, curves and any other information required by the Engineer and shall ensure that due care is taken by himself and his Sub-Contractors or suppliers before presenting the Plant for inspection or test. If unauthorised delivery has taken place the Contractor may be required to arrange for the Plant to be returned to the manufacturer for inspection and/or witness testing by the Inspecting Engineer.
All apparatus, instruments and connections required for the tests shall have been tested for accuracy within the preceding 12 months.

Any equipment used in the testing of the Plant shall in all respects comply with the appropriate safety regulations and/or requirements regarding electrical apparatus for the safety of the Plant and the men working thereon.

The Contractor shall carry out tests as stated in the approved standard; performance tests and such other tests as are necessary, in the opinion of the Engineer, the Engineer's Representative or his Inspecting Engineer, to determine that the Plant complies with the Specification either under test conditions in the manufacturer's works, on site or elsewhere or in the ordinary working.

Where pumps are included in the Contract, at least one unit of each size shall be tested with the suction rigged to conform to site conditions.

All cast metal components designed for the retention of liquids, e.g. pump casings, gear boxes, engine crank cases, etc., shall be checked for soundness after machining etc., but before assembly or painting by treating with paraffin or similar method.

Where tests and inspection have been completed to the Engineer's satisfaction, and when the test certificates, curves etc., have been checked, the Engineer will confirm acceptance in writing and the Plant shall not be incorporated in the work or delivered until this acceptance has been received.

21.3.2 Testing and Certification of Motors

Witness testing may be waived on standard types of small motors from recognised manufacturers and on small components used in the manufacture of units of plant.

Motors of 15 kW and above shall be witness tested for performance to the approved standard.

Type test certificates shall be provided and shall include the following information for all motors:

1. Approved standard of manufacture
2. Class of insulation
3. Size and type of cable fittings
4. Type of bearings, sizes and lubricant
5. Type and rating of heaters
6. Brush sizes and maker (if fitted)
7. Line current all phases
8. Phase current balance
9. Efficiency and P.F. at 100%, 75% and 50% Full load

After initial witness testing each motor shall be combined with its driven units and witness tested to demonstrate satisfactory performance, correctness of assembly and ease of re-assembly at site. The assembled units shall be adequately marked and dowelled.
21.3.3 Site Testing and Commissioning of Mechanical and Electrical Plant

(1) Cables laid underground shall be tested in accordance with the appropriate standard specification and to the local Electricity Company's requirements for insulation resistance, and continuity of earth circuit in the presence of the Engineers' Representative before the cable trenches are back-filled. All joints made during the installation of cables which prove faulty when tested shall be remade and re-tested to the satisfaction of the Engineer.

(2) The connections of all electrical circuits shall be proved to be correct and the whole installation shall be tested for insulation resistance and earth loop resistance in the presence of the Engineer or the Engineer's Representative and the local Electricity Company's Representative with instruments provided by the Contractor. Any faults or defects shall be remedied at the Contractor's expense. Certificates in accordance with approved standard regulations of all service authorities shall be issued to the Engineer.

(3) On completion of erection all pipelines shall be tested to ensure tightness of joints and connections to a pressure agreed between the Contractor and the Engineer. Test pressures will not exceed standard specification requirements unless otherwise specified.

(4) Lubricating and fuel lines, sumps, tanks, etc., shall be adequately flushed to remove any foreign matter before being put to use.

(5) On completion of erection of each item of Plant the Contractor shall test and check it and as far as is possible proving it under working conditions.

(6) As soon as is practicable after erection the Contractor will be required to co-operate under the supervision of the Engineer in test running the completed installation (of which the Plant may form the whole or a part) and, as far as is possible, proving it under working conditions.

(7) The installation shall then be operated continuously by the Contractor(s) for 24 hours, or such time as the Engineer may specify, during which time the Contractor will check that the installation is complete, in safe working order and fulfills the function for which it is intended.

21.3.4 Testing of Lifting Equipment

The Contractor shall set and fix runway beams and rails for traveling cranes within the dimensional tolerances permitted by the crane manufacturer.

Before lifting equipment is used it shall be tested to lift and maintain a minimum test load of 125% of the safe working load. During this overload test each movement in turn shall be maneuvered and the equipment shall sustain the load under full control.

The Contractor shall provide the necessary test loads and carry out the tests on all the equipment he has supplied.

The tests shall be carried out in the presence of the Engineer's Representative, who may require to measure deflections or make other observations during the tests. The tests may also need to be witnessed by others.
Special Specification

The project is financed by the Government of Brazil and under direction and supervision of United Nation Development Project/PAPP (UNDP/PAPP).

Project Period: 5 (Five) Calendar months.

1) Scope of Works:

a) The works includes construction and rehabilitation of Wadi Gaza Bridges i.e Al Moghraqa Box Culvert and Johr El Diek Bridge and the works will be done as illustrated in the tender documents.

b) Definition of the project location and levels using total station and level device.

c) The contractor will supply all workmanship, materials, equipments, machineries and whatever needed to complete the tasks assigned through the tender documents.

d) Works have to be executed within the official working hours. In case the contractor wishes to work beyond them, he has to obtain a written approval from the Engineer.

e) The contractor’s operative team:
The contractor has to employ Technical staff throughout the life cycle of project implementation and until preliminary handing over of the project. CV’s and work experience should be submitted in the process of approving the site staff. The technical staff is as follows:

- Project manager (civil or arch engineer) (1) Experience not less than 7 years
- Newly graduate Engineer (1)
- Forman (2) Experience not less than 3 years

The technical staff should be engaged on site on full time basis and have the sufficient experience and capabilities of carrying out their duties. Otherwise, the supervision will have the full right to stop the works on site.

f) Time Schedule:
The contractor has to submit a time schedule showing different activities of the project and the sequence of work activities using MS-Project for the approval of the engineer before the initiation of work activities. The contractor has to do all modifications deemed necessary to work activities as per the instructions of the engineer.
The contractor shall carry out take off quantity of works to be executed before the start up of work activities. Written approval on the scope of works shall be obtained prior to execution process.

g) Schedule of material supply
The contractor has to supply all raw materials and store it on site after signing the contract immediately. Accordingly, no delays are accepted due to delay in or insufficient material supply for works in the local market. Hence a schedule for material supply is needed before starting up activities.
The schedule of works should include the dates and quantities of material supply as well as the equipment supply to assure proper planning of work activities.
h) Work plan
The contractor has to submit a written work plan that illustrates the methodology followed in implementation of work activities in the project

i) Samples and catalogues:
The contractor has to submit all samples and/or catalogues for all materials to be used on the project to verify their compliance with the technical specifications as follows:

* The samples will be handed along with the request of material approval as per the schedule of material supply such that one week is allowed to obtain the material approval before the order of material supply is placed.
* The sample and catalogue should show the data of technical specification. In case there is no possibility to obtain a sample, the catalogue might be accepted after the engineer approval.

j) Cash – Flow
The contractor has to submit a cumulative cash flow chart (s-curve) expected during implementation. Updates should be carried out on regular basis to adapt the actual expenditure on the project.

k) Monthly reports and photographs.
The contractor has to submit monthly reports in three copies reflecting the actual progress of works in %, executed work activities, difficulties faced and photos showing such progress.

l) Closures of borders.
The closure of borders is expected risk and the contractor has to assure proper storage of materials such that to keep work activities ongoing. No financial claims will be accounted in case of any closure taking place.

m) Contract documents:
All tender documents stipulated in the ITB should be submitted, signed and stamped.

   It is deemed that all mentioned in the technical specification (General and Specific), drawings, bill of quantity, prebid meeting notes and/or any addendum thereof are included in the unit prices of the items and no extra charges will be paid in that respect.

2) Workmanship:
a) The contractor has to engage competent workers to achieve the workmanship stated in the tender documents. It is expected that best local practices be utilized in case no specific workmanship is identified.

3) Drawings:
a) The contractor has to abide to any additional detail or general drawings issued by the engineer and will be considered as part of the contract.
b) The contractor will develop shop drawings for all work activities and submit for approval. No activity can be started unless engineer approves relevant shop drawing.
c) The contractor should submit three copies of the shop drawings a week ahead of required approval. In case of changes required, the contractor will resubmit the drawings with changes and obtain approval before execution of works.

d) As Built Drawings:
The contractor is responsible to submit as built drawings before the preliminary handing over in four hard copies A3 size and two CD's. They should show all details (architectural, structural, mechanical, and electrical along with services routes, trenches, manholes, and levels ..etc) for the review and approval of the engineer.

4) Discrepancies and mistakes in tender documents:
   a) In case there is discrepancy in the tender documents, the engineer will verify the correct specification of any items in the tendering stage.
   b) In case there is missing information in the contract documents or discrepancy or improper description of details of the items, it doesn’t relieve the contractor from carrying out the item in the most correct manner as if identified and properly described in the original documents.
   c) The contractor has to acknowledge the engineer in case of omission, discrepancy or mistakes in the tender documents in the tendering stage and price according to the engineer's answer.

5) Inspection of site:
   a) The contractor is deemed to have visited and investigated the site and identified all site conditions in terms of ground nature the access to site, availability of water, electricity and workmanship and all factors affecting execution of work activities before submitting his offer. All such factors are deemed to be taken into consideration while pricing.

6) Sub-contractors:
   Sub-contractors are dealt with according to General Conditions of Contract.

7) Equivalence and Engineers’ instruction:
   Wherever Equivalence and Engineers’ instruction are mentioned within the contract documents, they are interpreted to be dealt with /or executed according to the consent of the engineer.

8) Site Meetings:
   Periodical site meetings will be carried out and the contractor or duly authorized delegate should attend the meetings.

9) Specifications:
   In case there is no clear specification of items or missing specification of items, it is deemed that the contractor has based his prices on first quality materials and best practices in implementation in the local market.

10) Take off quantities and pricing:
    a) Description of items
       The tender documents are complementary and self explanatory and what is deemed necessary in one is deemed necessary in all. Accordingly, the item specification is not limited to item description in the bill of quantity but rather to the tender documents as a whole.
    b) Quantities
       i) Net measurements of quantities as executed or erected in place will be used in the project ignoring losses and overlapping parts.
       ii) Quantities are based on actual measurements on site.
       iii) The quantities in the Bill of Quantity are only an estimate. Actual quantities will be measured on site and approved by the engineer.
       iv) The contractor should inform the owner or his representative about any increase in quantities prior to execution in a written form. In case of extra
quantities are executed without informing the owner or the engineer and obtaining approval on the implementation will not be accounted in the quantities due to the contractor.

c) Pricing
i) Description of items: The contractor is deemed that he understood all items within the bill of quantities and that he included all required expenses for permanent or temporary activities and components inclusive but not limited to overhead, profit, fees for services, materials, samples, losses in materials, equipments,…etc, to achieve and maintain the works in first grade quality and in the correct form. No claims will be accepted for comprehensiveness in pricing.

ii) The contractor shall not include price of item in another one. All prices of items should be adequate to execute the relevant task individually.

iii) The contractor is deemed to base his price according to proper breakdown of cost. Hence, he is expected to submit such price analysis within 48 hours upon request.

iv) The unit rates shouldn't include VAT. All payments will be processed according to Zero VAT invoices all according to PA rules and regulations in that respect. The contractor has to include all expenses that might occur in his overhead expenses and no claims will be accepted regarding this issue.

v) Price shall include fees of testing according to specification and engineer's instruction. UNDP has the right to change the testing laboratory from time to time.

vi) The contractor has to submit valid income and VAT tax clearance issued by the Ministry of finance along with the tender.

11) Project Sign Boards:

a) The contractor has to supply and install two project sign boards. They will be made up of painted steel sheet 200cmX350cm including painted steel pipes 3" in diameter to hold the sign and fixed in place by concrete footings 50 cm x50 cm x50 cm before the start up of work activities. All information and logos that have to be included on the board will be handed by the engineer during the mobilization period.

b) The contractor will supply and fix two Italian Carara marble sign 120cm x 100cm x 3cm (one for each bridge). All information and logos that have to be included on the board will be handed by the engineer before the partially handing over of the project.

12) OFFICES FOR THE ENGINEER'S REPRESENTATIVE

a) The Contractor shall provide suitable site offices for the use of the Engineer's Representative and his assistants, throughout the period of construction. The site offices shall be constructed in a location approved by the Engineer's Representative during the mobilization period. The offices shall be of fixed type and shall have walls, ceiling and partitions lined with (Masonite) hardboard or similar material. All rooms shall have glazed windows complete with fly screens. Adequate fitted hardware, electrical switches, sockets, lighting, and plumbing fittings, sanitary ware and fittings and fixtures etc., shall be provided as necessary for the different areas.

b) The site offices shall be equipped, serviced and maintained in a clean, weatherproof and sanitary condition.
c) The electrical installation shall provide for simultaneous use of all electrical appliances.
d) The Contractor shall arrange for a temporary power supply to the offices and provide and maintain adequate diesel generator sets. All electricity bills shall be paid by the Contractor.
e) The Contractor may either arrange for a temporary main water supply or alternatively provide tanker water supply.
f) Throughout the duration of the Contract, the Contractor shall ensure an uninterrupted supply of water and electricity to the offices. The offices shall be completed and all the equipment provided by the Commencement of the Permanent Works.
g) The Contractor shall provide all items listed in the attached Schedules.

13) TRANSPORTATION AND COMMUNICATIONS:
   • The contractor shall provide to the sole use of the supervision engineer a new car in good conditions (Model not less than 2003, motor 1600cc) from the date of contract signature until project handing over with all insurances (Comprehensive insurance) and fees with 1200 NIS fuel per month and all required maintenance during the project period.
   • The contractor must submit 8 Jawal cards 50NIS each with total 400NIS monthly.

14) Specific Requirements
   1. The Contractor shall be responsible for the security of the building and its contents at all times, cover all the operation and maintenance costs for the building and equipment provided and shall employ watchmen for this purpose.
   2. The building shall become the property of the Contractor after the completion of the Works.
   3. All offices furniture shall remain the property of the Contractor and will be returned to the contractor after the completion of the works.

SCHEDULE OF OFFICES
The requirements of the site offices on this contract are as follows:

<table>
<thead>
<tr>
<th>Room No.</th>
<th>Description</th>
<th>Size Requirement</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>engineer office</td>
<td>4m x 6m</td>
</tr>
<tr>
<td>2</td>
<td>Toilet</td>
<td>1.5m x 2m</td>
</tr>
<tr>
<td>3</td>
<td>Kitchen</td>
<td>2m x 1.5m</td>
</tr>
<tr>
<td>4</td>
<td>sample room</td>
<td>2m x 2m</td>
</tr>
<tr>
<td>5</td>
<td>Steel Shed</td>
<td>6m x 4m</td>
</tr>
</tbody>
</table>

SCHEDULE OF FITTINGS
The fittings required under this contract for the site offices indicated in the schedule of offices shall be to the Engineer’s approval and are as follows (after the project handing over, all assets to be the property of the contractor):

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>New Desk with two locking Drawers and chair</td>
<td>1</td>
</tr>
<tr>
<td>b</td>
<td>Chair plastic covered, padded steel frame</td>
<td>6</td>
</tr>
<tr>
<td>c</td>
<td>Samples cupboard</td>
<td>1</td>
</tr>
<tr>
<td>d</td>
<td>Four drawers steel filing cabinet</td>
<td>1</td>
</tr>
<tr>
<td>e</td>
<td>In/out tray</td>
<td>1</td>
</tr>
<tr>
<td>f</td>
<td>Waste paper basket</td>
<td>1</td>
</tr>
<tr>
<td>g</td>
<td>2 ring gas burner</td>
<td>1</td>
</tr>
<tr>
<td>h</td>
<td>Digital Camera (Olympus)</td>
<td>1</td>
</tr>
<tr>
<td>i</td>
<td>computer (Pentium 4) With (Deskject 1300 printer + UPS + LCD monitor + table)</td>
<td>1</td>
</tr>
<tr>
<td>L</td>
<td>Flash pen 512 MB</td>
<td>1</td>
</tr>
<tr>
<td>M</td>
<td>all the office stationary as per engineer instruction during all the project period</td>
<td>1</td>
</tr>
<tr>
<td>N</td>
<td>Refrigerator</td>
<td>1</td>
</tr>
<tr>
<td>R</td>
<td>fan + warmer</td>
<td>1</td>
</tr>
</tbody>
</table>

(1) The costs for these items shall be included in the contractor’s unit prices.