



**United Nation Development Programme
Programme of Assistance to the
Palestinian People**

**Emergency Water Supply and Rehabilitation Programme
PAL 10-00052737**

"Construction Of Tal El-Sultan Water Storage Tank"

General and Particular (Technical) Specifications

**Center for Engineering and Planning (CEP)
&
Engineering & Management and Planning (EMCC)**

A) General Specifications

1. INSTALLATION CONDITIONS

The pipes, fittings and appurtenances, subject of the enclosed particular technical specification, are to be installed in the Gaza strip.

- Place of installation: Tal Sultan /Rafah
- 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

2. TEMPORARY WORKS AND REINSTATEMENT

The Contractor shall provide and maintain all temporary roads and tracks necessary for movement of plant and materials and remove them on completion and make good all Works damaged or disturbed.

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

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 their sufficiency.

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 Operator and remove on completion of the Works.

The Contractor shall construct the valve chambers and lay the pipes and fittings to avoid all public utilities encountered during the progress of the Works, except those utilities specifically detailed on the Drawings as being required to be diverted.

The Contractor shall make good, at his own expense, all damage to properties, land surface, roads and any public or private utilities.

3. 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 Operator via the Engineer in advance, portions of the existing facilities may be taken out of service for short periods corresponding with periods of minimum service demands.

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

The Contractor shall be responsible for the stakeout surveys 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 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). All computations, survey notes and other records necessary to accomplish the Work shall be neatly prepared by the contractor and made available to the Engineer upon request or furnished upon Contract completion.

The Contractor shall provide all instruments, equipment, stakes and other material necessary to perform the Work.

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.

5. 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 Drawings may not show any utility services, any of which may exist in the area. There may be certain other facilities in the work areas not listed 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. Where pipelines, cess pits, subsurface structures and/or utilities encountered in the Work coincide with the location of the Operators chambers and/or water pipes and the Engineer deems it advisable, the location of the valve chambers and/or water pipes may be changed to avoid the facilities. Where the Engineer does not deem it advisable to relocate the Operator's chambers and/or 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 the facilities of the location and circumstances and shall cease Work, if necessary, until the Engineer can establish satisfactory procedures to properly divert the facilities in conflict with the Operator's chambers and/or water pipes.

6. SAFETY OF ADJOINING EXISTING BUILDINGS

The Contractor shall take all necessary precautions during the excavation for the Works particularly those excavations which are adjoining existing buildings and shall protect these 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 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 Operator 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.

7. 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.

8. WATER FOR THE WORKS

The Contractor shall obtain all necessary permission from the PWA and Municipalities to provide 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 on completion.

9. 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.

10. 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.

11. CUSTOMS AND LOCAL DUES

All state dues, tolls rates, duties, fees and charges in connection with the Works shall be paid under a provisional sum item.

12. MATERIALS, GOODS AND WORKMANSHIP

Pipes, valves and fittings to be supplied by the Operator and/or the Contractor are specified in Technical Specifications.

Materials to be supplied by the Contractor and his workmanship shall be of a quality fit for purpose and comply with the International and/or Local Standards and approved by the Engineer.

13. IMPORTED MATERIALS

The Contractor is required to produce documentary evidence that all imported materials or items (if any) have been ordered within one week from the date 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.

14. PERIODIC REPORTS

The Contractor must present to the Engineer's Representative detailed reports and schedules as stipulated in the Conditions of Contract, and shall prove to the 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.

15. PHOTOGRAPHS

The Contractor shall furnish the engineer's representative with a camera suitable for producing colour record photographs. The contractor will pay for all developing of the photographs taken by the Engineer's Representative. These costs shall be included in the unit prices of the works as listed in the Bill of Quantities.

16. 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 monitoring the Contractor's progress and to ensure that full compliance with the specifications and programme is being achieved, copies will be distributed to all persons concerned and full effect shall be given to all instructions contained therein.

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 Engineer's Representative.

17. CANCELLATION DUE TO SLOW PROGRESS

If the Engineer shall be of the opinion that the Contractor will be unable to complete any section of the Works by the time specified or by such extension thereof as he may be entitled to, under the Contract and the Contractor has failed to carry out steps and to expedite the work in accordance with the Conditions of Contract or, if the Engineer is of the opinion that such steps are inadequate, the Engineer may, by written order, omit the whole or any part of the uncompleted work included in that section and the Operator shall be at liberty to execute such omitted work by his own workmen or by other contractors. If the cost of such omitted or incomplete work shall exceed the sum which would

have been payable to the Contractor on due completion of the said work, then the Contractor shall, upon demand, pay the Operator the amount of such excess and it shall be deemed a debt due by the Contractor to the Operator and shall be recoverable accordingly.

18. 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.

19. 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 de-watering 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.

The Contractor shall be responsible 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.

20. 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.

21. SITE ALONG PIPELINES IN ROADS

Wherever practicable the Site along pipelines in roads shall be maintained for vehicular traffic and pedestrians.

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

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.

22. 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 relevant Authority.
5. Traffic signs 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.

23. ROADS TO BE KEPT CLEAN

The Contractor shall take great care and all reasonable precautions to ensure that the roads and thorough fares used by him either for the construction of the Works or for the transport of plant, labour and materials, are kept clean at all times.

24. PROGRAMMING

In preparing his programme of Works, the Contractor shall pay due regard to the priority required by certain Works, all periods required for statutory notices, other construction projects in the area and traffic management requirements of the Municipalities.

25. INSPECTION

The Contractor shall employ works foremen to supervise and inspect the work of the construction or pipe-laying 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 operators employed on the site.
2. Test certificates of all materials, concrete cube 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.

26. 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.

27. 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 organise their respective contracts so as to minimise interference to each other and to the public.

28. SUPPRESSION OF NOISE AND POLLUTION

The Contractor shall make every reasonable endeavour 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.

29. PROTECTIVE 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.

30. 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 Works due to adverse and inclement weather conditions. The Contractor shall allow for all costs incurred by non-productive time.

31. CLEANING UP

During its progress the work and adjacent areas affected thereby shall be kept clean and all rubbish, surplus materials and unattended equipment shall be removed and all damage repaired in a timely manner 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.

The Contractor shall restore or replace, when and as directed, any public or private property damaged by his work, equipment, to a condition at least equal to that existing immediately prior to the beginning of operations.

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 new condition.

32. PERMITS, LICENSES AND FEES

The Contractor shall obtain and pay for all construction permits and licenses. The Operator shall assist Contractor, when necessary, in obtaining such permits and licenses. The Contractor shall pay all governmental charges and inspection fees necessary to carry out the work. The Contractor shall also pay all charges of utility service companies for connections to the work. These costs shall be reimbursed through a provisional sum.

33. ASSISTANCE TO THE ENGINEER'S REPRESENTATIVE

The Contractor shall give such assistance and supply such labour as may be required by the Engineer's Representative in connection with the Contract when required.

Such labour shall be retained in the employment of the Contractor, but shall operate and perform their duties under the direction of the Engineer's Representative.

34. VEHICLES FOR THE ENGINEER'S STAFF

NA

35. OFFICES FOR THE ENGINEER'S REPRESENTATIVE

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 mobilisation period. The offices shall be of fixed type and shall have walls, ceiling and partitions lined with Mansonite 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.

The site offices shall be equipped, serviced and maintained in a clean, weatherproof and sanitary condition. Each operational site shall be provided with one office.

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

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.

The Contractor may either arrange for a temporary main water supply or alternatively provide tankered water supply.

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.

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

Specific Requirements

1. The Contractor shall be responsible for making all arrangements and payments in respects of any land required for the site of the office building.
2. 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.
3. The building shall become the property of the Contractor after the completion of the Works.
4. 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:

<u>Room No.</u>	<u>Description</u>	<u>Size Requirement</u>
1	Supervision	4m x 3m
2	Toilet	1.5m x 2m
3	Kitchen	2m x 1.5m

SCHEDULE OF Furniture

The Furniture 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:

<u>Item</u>	<u>Description</u>	<u>Quantity</u>
a	Desk with two locking drawers and chair	1
b	Chair plastic covered, padded steel frame	4
c	Samples cupboard	1
d	Four drawers steel filing cabinet	1
e	In/out tray	1

f	Waste paper basket	1
g	2 ring gas burner	
h	Fan	1

The costs for these items shall be included in the contractor's unit prices.

36. SIGNBOARDS AND BOARDS

The contractor shall erect signboards and boards in prominent positions adjacent to the work to the satisfaction of the engineer as per the attached sketch.

The materials of construction shall consist of the following:

Posts and Struts	Timber or Galvanised steel tubes coated in extruded grey PVC
Foundations	Concrete
Backboards	Timber or ply, painted white wood
Signboards	Plastic or other approved
Fixings	By the Contractor

The Contractor shall be responsible for the structural design of all posts, struts, fixings and foundations.

All the text and logo shall be dark blue on a white background

The number of main signboards to **be supplied is 1**.

The Contractor shall allow for all associated costs in providing, erecting and relocation of this number of signboards when entering an amount in the unit prices provided in the Bill of Quantities.

In addition to the main signboards mentioned above, the contractor shall supply and install portable two signboards 100x70 cm size and shall indicate names of (project, client, consultant, contractor and Municipality). The price of these signboards shall be included in the contractor's unit prices.

37. COMPUTER

The Contractor shall provide one computer and one laser printer as described below for the use of the Engineer's Representative and his assistants, throughout the period of construction

Computer should meet the following specifications (will be the property of the contractor once the project finishes):

- HP Compaq dc 7600 small form factor
- Microsoft®, Window ®, XP Professional –SP2
- Intel ® Pentium ® 4650 (3.4/800/2M)
- 1GB PC2-4200(DDR2-533)
- 1.44MB, Floppy Drive SFF
- 80GB SATA 3.0 Gb/s HARD Drive
- 16X DVD+/- RW Drive (LS/DL/DF)
- ATI RNX300SE, 128 MB PCIE DVI

- Integrated Broadcom Gigabit NIC
- HP standard keyboard PS/2
- HP USB optical mouse (cvt/slvr)
- 3/3/3(parts/labor/on-site)
- 17" Flat panel screen.
- HP USB 2-Button optional scroll mouse (Carbonated/ silver)
- HP USB 04 Standard Keyboard.

38. Minimum Contractor Staff and Salaries

Beside labours and technicians, the minimum contractor's staff should be as follows

- Project Manager 1
- Site Engineer 1
- Surveyor 1
- Office boy 1

The minimum salaries of the contractor's staff should be as follows

- Project Manager 25 US\$
- Site Engineer 20 US\$
- Surveyor 15 US\$
- Office boy 12 US\$
- Technician 15 US\$
- Labour 12 US\$

B) Particular (Technical) Specifications

1 EXCAVATION AND EARTHWORK

1.1 *Clearing and Grubbing*

1.1.1 *Description*

This work shall consist of clearing, grubbing the top layer (about 15 cm at least) and disposing of all vegetation and debris within the limits of the construction site, except such objects as designated to remain or is to be removed in accordance with other sections of the specifications.

1.1.2 *Construction Requirements*

The Contractor shall establish construction limits and where applicable, the Engineer or his Representative will designate all tree shrubs, plants, and other things to remain. The Contractor shall preserve all things designated to remain.

All surface objects and all trees, stumps, roots and other protruding obstructions, not designated to remain shall be cleared and/or grubbed.

Except in areas to be excavated, stump holes and other holes from which trees are removed, shall be backfilled with clean sand, moisture and compacted to 95% of the Modified Maximum Dry Density according to specification.

1.1.3 *Method of Measurement*

This work (clearing & grubbing) will be measured by m³ or as indicated in the BOQ. The depth will be measured from the existing natural level to the level reached after carrying out the work.

The Contractor has to perform grid survey after completing the clearing and grubbing. The new levels will be adopted as Datum Levels for all measurements to be carried out afterward for the coming excavations.

1.2 *General Excavation*

This Work shall consist of excavating the earthwork platforms removing and satisfactorily disposing of all materials taken from within the limits of the work, and shall include all excavation, preparation and completion of all platforms, *embankments and slopes*, as directed, and in conformity to the grades, and cross-section shown on the plans or established by the Engineer or his Representative.

1.2.1 *Classification of Excavation*

General Excavation

The Contractor shall visit the Site prior to making his tender and shall examine the nature of the earth and rock, its quantity, location and suitability to meet the specified requirements and base his bid prices solely on his own determination of soil conditions.

After Award of Contract, no claim based on source of soil information will be entertained for revision of bid prices.

The preliminary classification of general excavation as “Common Excavation” or will be shown on the plans. The Engineering geological information shown on the plans, from which the quantities of “Common Excavation” are estimated, is based on studies made in the field and represents the best information available to the Employer. Final adjustment of the

preliminary classification for embankment excavation as “Common Excavation” shall be determined by the Engineer or his Representative as the Work is opened up and performed.

Common Excavations

Common excavation shall consist of the removal and satisfactory disposal of all unclean, agricultural soil and residual materials. Within the Contract limits all Cut Material from the site, after deduction for material declared unsuitable by the Engineer or his Representative shall be considered to be available for use in filling.

1.2.2 Construction Requirements

All materials removed from the excavation shall be used in the filling in other places as directed, unless it is declared unsuitable and ordered to be wasted by the Engineer or his Representative. No excavation material shall be wasted without written permission from the Engineer or his Representative, and when such material is to be wasted, it shall be so placed, in the positions agreed by the Engineer or his Representative.

Excavated materials wasted by the Contractor, without written permission of the Engineer or his Representative, shall be replaced by the Contractor at his expense.

Where excavation to the finished graded platform level results in areas of unsuitable soil, the Engineer or his Representative may require the Contractor to remove the unstable materials and backfill to the finished graded section with approved material. The Contractor shall conduct his operations in such a way that the necessary cross-sectional measurements can be taken before the backfill is placed.

The Engineer or his Representative may designate as unsuitable those soils that cannot be properly compacted.

When the Contractor is required or directed to excavate unsuitable material below the surface of the original ground in fill areas, other than those required for clearing and grubbing, the depth to which these unsuitable materials are to be removed will be determined by the Engineer or his Representative. The Contractor shall schedule the work so that authorized cross-sections can be taken before and after the material has been removed.

1.2.3 Method of Measurement

When payment is specified on a volume basis in the Bill of Quantities, quantities of various classes of Excavation shall be computed by the Contractor and checked by the Engineer or his Representative. Quantity computations shall be based on the original cross-sections taken by the contractor, which were observed by and attested to by the Engineer or his Representative, and final cross-sections developed from were checked and attested to by the Engineer or his Representative.

Datum Levels reached after carrying out the Clearing and Grubbing will be the bases for computing the depth of excavation.

Any materials removed or excavated before these measurements have been taken and approved by the Engineer or his Representative will not be paid for.

The Engineer or his Representative will check all or part of the work, as he deems necessary, to determine conformance to the lines, grades, elevations and cross-sections submitted by the contractor. The contractor shall at his own expense, provide the equipment and labour, including filed parties, to assist the Engineer or his Representative in checking the work.

All slopes, line and grades shall be true, correct, and accurate and according to those shown in the plans or otherwise directed and approved by the Engineer or his Representative. The

platforms in cut shall be accurate to be authorized profile grade to plus or minus five (5) centimeters. Where discrepancies are found in the work the contractor shall make the necessary corrections.

Any over breakage below the depth shown on the plans or as otherwise directed and outside of the tolerances set for sub-grade in cuts will not be paid for.

Measurement will be made for unsuitable materials actually excavated and removed to obtain proper compaction in cut sections and in foundations for fill sections.

Where it is impractical to measure material by the cross section methods due to the erratic location of isolated deposits, acceptable methods involving three-dimensional measurements may be used, when approved by the Engineer or his Representative.

1.2.4 Basis of Payment

The amount of completed and accepted works, measured by cubic meter, will be paid for at the unit price(s) per cubic meter for “Common Excavation”, as shown in the Bill of Quantities, which price(s) shall be fill compensation for all excavation, hauling of the excavated material to any distance required by the Engineer or his Representative where the material will be dumped and properly leveled, trimming of slopes, clean up, preparation of platforms and for all other items necessary for the proper completion of the works.

1.3 Trench Excavation

1.3.1 General

Trench excavation means excavation in all materials of whatever nature encountered for trenches into which pipes and ducts etc. are to be laid, or appurtenances constructed. The term pipe shall mean pipe of all kinds and for whatever purposes.

The line and level of trenches shall be as shown on the drawings or as may be directed by the Engineer or his Representative. Before commencing trench excavations, the route of the trench shall be pegged out accurately, adjusted if found necessary before final route of trench is approved by the Engineer or his Representative. The natural ground level along the route shall be checked by the Contractor against drawings and its levels shall be agreed with the Engineer or his Representative.

Strong sight rails shall then be fixed and maintained at each change of gradient, and at as many intermediate points as may be necessary. On these rails shall be marked the Centerline and the level to which the excavation is to be carried out, such rails being not more than 20m apart. Alternate methods to maintain line and level of pipelines shall be to the approval of the Engineer or his Representative.

Trench excavation shall be carried out by such methods and to such lines dimension and depths as shall allow for the proper construction of the works, or as indicated on drawings or other parts of these documents. Notwithstanding the foregoing, any rock in trench excavation shall be so excavated that the clearance between the pipe, when laid, and the rock sides and bottom of the trench is kept to the minimum limits necessary to provide for the specified thickness of bedding and eventual concrete protection of the pipe.

Bell holes and holes and depressions for couplings, valves and the like shall be excavated the same distance below these installations. The materials excavated shall be used in the backfill or removed and disposed of by the Contractor, as required by the Engineer or his Representative. The trench shall be dug only so far in advance of pipe lying as the Engineer or his Representative shall permit.

The Contractor shall submit typical cross-sections of trenches for the Engineer or his Representative's approval according to specification and as directed by the Engineer or his Representative.

No length of trench excavation shall be started until the pipes and fittings to be laid in that length are available on the Site.

1.3.2 Obstructions

Where the grade or alignment of the pipes is obstructed by existing utilities (either shown or not shown on the drawings) such as conduits, ducts, pipes, branch connections etc. the obstructions shall be supported, relocated, removed, or reconstructed by the Contractor at his own cost unless opposite item has been included in the Bill of Quantity.

Whenever it is necessary to determine the location of existing underground utilities, the Contractor, after an examination of available records, shall make all explorations, excavation and survey as may be directed by the Engineer or his Representative to determine these locations. Only such tools and equipment as have been approved by the Engineer or his Representative shall be used by the Contractor to execute the work in a safe and efficient manner. If the obstructions encountered require alterations to the drawings, the Contractor shall, in accordance to the above investigations and in accordance with the indications received by the Engineer or his Representative, change the plan and profiles as necessary and submit the drawings to the Engineer or his Representative for approval.

The Contractor shall not make any deviation from the specified line and/or grade without approval by the Engineer or his Representative. Should any deviations in line and/or grade be permitted by the Engineer or his Representative for convenience to the Contractor, any additional costs for the thrust blocks, valves, air and vacuum assemblies, blow-off assemblies, extra pipe footage, manholes or other appurtenances shall be borne by the Contractor.

1.3.3 Trench Width

Unless otherwise specified or instructed the minimum trench width shall be 500 away from the pipe from each side at the specified level (depth).

1.3.4 Supporting Trench Excavations

An excavation must be properly supported or the sides adequately battered to a safe angle as soon as the excavation reaches 1.5 m.

The Contractor shall well and effectively support the sides of all trench excavation. This support shall include the use of steel sheet piles, where necessary, to prevent any fall or run from any portion of the ground outside the excavation into the trench and to prevent settlement of or damage to structures adjacent to the excavation. The Contractor shall be deemed to have made his own allowance for shoring up the sides of trenches, any extra excavation necessary to provide space for such support and for any other working space. If for any reason any portion of trench excavation shall give way, the Contractor shall at his own expense take all necessary remedial measures including the excavation and removal of all the ground thereby disturbed.

The Contractor shall not remove temporary works supporting the excavations until in the opinion of the Engineer or his Representative the permanent work is sufficiently advanced to permit such removal, which shall be executed under the personal supervision of a competent foreman.

Any advice, permission, approval or instruction given by the Engineer or his Representative relative to such support or the removal thereof shall not relieve the Contractor from his responsibilities under the Contract.

All temporary works supporting the excavation shall be removed during backfilling unless previous approval has been obtained from the Engineer or his Representative. Where temporary supports have been used in the excavation any such supports left in because it is impracticable to remove them shall be left in at the expense of the Contractor.

1.3.5 Undisturbed Ground

When excavating to specified levels for trench excavation or to specified limits for the face of any structure therein required to abut undisturbed ground, the Contractor shall not excavate the last 150 mm until immediately before commencing construction work except where the Engineer or his Representative permits otherwise.

Should the Contractor has excavated to within 150 mm above these specified levels or to within 150 mm of these specified limits before he is ready or able to commence the construction work he shall where required by the Engineer or his Representative excavate further so as to remove not less than 150 mm of material immediately before commencing the constructional work and any such further excavation and additional foundation material ordered by the Engineer or his Representative shall be at the cost of the Contractor.

1.3.6 Trenches not to be Left Open

Trench excavation shall be carried out expeditiously and, subject to any specific requirements of the Contract, the refilling and surface reinstatement of trench excavations shall be commenced and completed as soon as reasonably practicable after the pipes have been laid and jointed.

Pipe laying shall follow closely upon the progress of trench excavation, and the Contractor shall not be permitted to leave unreasonably excessive lengths of trench excavation to remain open while waiting testing of the pipes but in any case not more than 200m ahead of the pipe laying operation or greater lengths if approved by the Engineer or his Representative.

The Contractor shall take precautions to prevent flotation of pipes in locations where open trench excavations may become flooded, and these precautions may include the partial refilling of the trench leaving pipe joints exposed for tests of the joints.

If the Engineer or his Representative considers that the Contractor is not complying with any of the foregoing requirements he may prohibit further trench excavation until he is satisfied with the progress of laying and testing of pipes and refilling of trench excavation.

The Contractor will not be permitted to excavate trenches in more than one location in any one road at a given time without the Engineer or his Representative's permission.

1.3.7 Trench Foundation (Bedding)

Bedding material shall be clean natural sand unless not specified otherwise on drawings. All shattered and loose material shall be removed from the bottom of the trench excavations so that the bedding material rests on a solid and clean foundation.

Before bedding material is placed, any unsound material or soft spots naturally occurring in the bottom of any excavation shall be filled with selected material as directed by the Engineer or his Representative.

Where the Contractor is laying a pipe into a port in an existing structure, manhole chamber or thrust blocks, and where the backfill material to previous excavation beneath the pipe

formation, is not concrete, the backfill material shall be removed over its full depth and for the full width of the pipe trench shown on the Drawings. The resulting void shall be filled solid with selected material.

If in the opinion of the Engineer or his Representative a formation is unsound as a result of the Contractor failing to keep the excavation free from water or other materials the Engineer or his Representative will order the removal and disposal of the unsound material and the filling of the resulting void. The Contractor shall execute the work as directed and bear the costs of the same.

1.4 *Earth Filling*

This work shall consist of approved earth filling in layers not exceeding 300 mm loose material to grades and levels as shown in the drawings and as directed by the Engineer or his Representative, including preparation of the areas upon which they are to be placed, the compaction of approved materials with the limit of construction and where the unsuitable materials has been removed and the placing and compacting of approved materials in holes and pits and other depressions within the lines, grades, thickness as per the cross sections prepared by the contractor and approved by the Engineer or his Representative.

Filling to make up levels under building shall be executed with approved suitable material from existing ground levels up to underside of ground floor slab, and shall be placed in successive layers each having a finished thickness not exceeding 250 mm, watered and compacted prior to the placement of the succeeding layer.

The ground surrounding the building and pavements shall be filled with approved material, fine sand and coarse materials, free of foreign material, debris, clay lumps, organic and vegetation.

Coarse materials:

Such as sandy gravel, gravelly sand, etc. which is the material retained on sieve no. 4, and consists of crushed rock. It shall be clean, hard, tough and free from deleterious substance.

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

- | | |
|--|-----------------|
| 1. Gypsum content (expressed as S03) | 2 % max. |
| 2. Clay Lumps and friable particles | 8 % max. |
| 3. Elongated and flaky particles for crushed rock (Determined in accordance with BS 812 Part 1:1975) | |
| 4. Grait and Basalt | 40 % max. each, |
| 5. Lime Stone | 35 % max. Each. |
| 6. Maximum Dry density (g/cm^3) | 2.1 mm. |

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

Methods used in production of crushed rock shall ensure that the finished product will be as uniform as practicable. 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 fractured faces.

Any material passing 4.75 mm (No. 4) sieve and produced in the crushing process shall be incorporated in the base material up to the gradation limits for the particular class of aggregate involved. Crushed aggregate for base course delivered to road site shall meet the requirements of class A or class B gradations as shown in Table 3.1, when tested in accordance with specification 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 or his Representative. 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 % is allowed in upper limit for percentage of material passing sieve 200.

Table 3.1 Gradation of Base Course Aggregate by Class

Sieve Designation (Square Openings)	Percent by Weight Passing	
	<u>Class A</u>	<u>Class B</u>
50 mm (2 in.)	100	70-100
37.5 mm (1-1/2 in.)	75-100	55-85
25 mm (1 in.)	60-90	50-80
19.0 mm (3/4 in.)	45-80	40-70
12.5 mm (1/2 in.)	40-70	30-65
9.5 mm (3/8 in.)	30-65	20-50
4.75 mm (No. 4)	20-40	10-30
2.00 mm (No. 10)	8-20	5-15
0. (No. 40)	5-10	
0,075 mm (No. 200)		

The material shall contain a minimum of 40% sand equivalent at any stage of construction.

The loss in weight shall not exceed 45 % after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Abrasion Test).

The ratio of wear loss = $\frac{\text{Abrasion after 100 Rev.}}{\text{Abrasion after 500 Rev.}}$ should not be more than twenty percent of the maximum allowed abrasion after 500 revolution.

The crushed aggregate base course material shall have a 4-thy soaked CUR of not less than 80 when compacted at 100% of modified proctor BS 1377: Pan 4 and tested in accordance with BS 1377: Part 4. When tested for soundness in accordance with **AASHTO T 104**. The material shall not shown signs of disintegration and the 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.

The portion of aggregate, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (L.L.) of not more than 25 and plasticity index (P.I.) of not more than 6 when tested in accordance with BS 1377: Part 2, In case of using cohesionless 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 or his Representative, such solution may include single bituminous surface treatment, bonding material and other

necessary treatment all as directed and approved by the Engineer or his Representative. Provided that angularity test should be more than 8.

b) Fine Sand Materials

Fine Sand Materials shall consist of that portion of the total aggregate/fines passes no.4 sieve, such as sand, and silt sand.

The fill materials shall consists of the combination of coarse and fine sand and conform to the following grading:

Sieve Size	1/2"	3/8"	#4	#10	#30	#60	#200
%	90-100	80-90	58-72	42-50	28-38	8-18	2-5
Pass	70-100	60-85	50-75	30-60	20-40	10-25	0-10
	100	90-100	65-85	35-45	20-30	15-30	3-8

The fine sand shall conform to the following grading:

Sieve Size	#4	#30	#60	#200
%	100	80-100	30-50	4-8
	90-100	80-90	20-30	0-10
Pass	100	90-100	40-90	5-15

In addition, shall conform to the following physical requirements:

- Minimum CBR 35 % Coarse materials, Kurkar
 25 % Fine sand, sand

1.4.1 Construction Requirements

When layers of fill are to be placed and where new layers are to be compacted against existing, such layers shall be of sufficient width to permit operations of placing and compacting equipment and / or as directed by the Engineer or his Representative.

Earth fill required by the plans to be compacted shall be constructed as hereinafter described under the following Section "Compaction of Earthwork".

The Contractor shall have in operation a sufficient earth equipment to properly smooth and maintain the surface of each layer of freshly placed fill materials prior to and during rolling and compacting operations.

The Engineer or his Representative shall have full authority to require at any time the suspension of delivery of material to the site until previously delivered materials are properly placed and preceding layers are satisfactorily smooth and uniform and tested.

The contractor shall be responsible for the stability of all fill layers and shall replace all sections of same which, in the opinion of the Engineer or his Representative, have been damaged or displaced due to carelessness or neglect on the part of the contractor, or due to natural causes, such as storms, and not attributable to the unavoidable movement of the natural ground upon which the fill layer is made. During construction, when unsuitable material has been placed in site, its removal shall be at the expense of the contractor.

All material derived from excavation (common excavation) earth fill shall be used in the construction provided that the CBR after 4 days soaking is not less than 10% as tested according to BS 1377 test 16, when compacted to not less than 98%MDD, that they shall not contain more than 5% of water soluble salts and that shall not contain deleterious substances.

1.4.2 Method of Measurement and Payment

No separate or additional payment or measurement shall be made for the selection of materials for the earth fill as described above, and the unit price for approved fill materials from and compaction of fill materials only shall be applied, i.e. full compensation for the supply of material, shaping moisture correction and compaction to the required density.

The quantities to be paid for shall be the number of cubic meters after the execution of clearing and grubbing in the volume of compacted earth fill accepted by the Engineer or his Representative formed with materials resulting from Excavation.

Any shrinkage and/or change or reduction in volume due to mechanical compaction of materials from all sources for forming and grading of the surface in accordance with the drawings shall not be paid for directly but shall be considered subsidiary to all other pay items listed in the Bill of Quantities.

The quantities determined as provided above shall be for at the contract unit price bid per cubic meter of material in place. The price and payments shall be full compensation for the compaction in layers at the prescribed density, including the shaping of the slopes and the compaction trials if required and the furnishing of all equipment, labour, and all other items necessary for the proper execution of the work.

1.5 Compaction of Earthwork

This work includes compaction of earthwork by rolling or tamping or any type of combination in accordance with the requirements specified for on the plans, in the Special Specifications or requested by the Engineer or his Representative.

1.5.1 Testing Methods

Moisture — Density Test

A Moisture — density test (BS 1377: Part 4) and preliminary study will be made for each type of soil to be used in the construction of the work to determine the Maximum Density, the Optimum Moisture Content and the Moisture Range required of the soil for satisfactory compaction

The field density and actual moisture content of the compacted earthworks shall be determined by field tests according to BS 1377: Part 4.

Relative Density Test

For cohesion less free — draining soils for which impact compaction will not produce a well — defined moisture density relationship curve and the maximum density, the test for the relative density of cohesion less Soils (ASTM D 2049) shall be used to determine the relative density.

Relative density is defined as the state of compactness of a soil with respect to the loosest and densest states at which it can be placed by the laboratory procedures described in ASTM D 2049. The field density and actual moisture content of the compacted earthwork shall be determined by field tests according to BS 1377: Part 4.

Borderline Materials

In cases where borderline materials are encountered, both methods will be utilized and the method which results in the higher laboratory maximum density shall be used as the standard to which the field density is compared.

1.5.2 Equipment

Compaction equipment shall conform to the number and type outlined in the contractor's detailed programme of work as approved by the Engineer or his Representative.

Other types of rollers may be used if approved by the Engineer or his Representative and satisfactory performance shall be the basis for such approval.

1.5.3 Construction Requirements

The number of blades and rollers in use shall be sufficient to blade and compact adequately all material being delivered to the site. The Engineer or his Representative shall have full authority to suspend the delivery of material to the earth fill until previously delivered materials are properly placed and satisfactorily compacted.

1.5.4 Existing Foundation for Earth Fill

All vegetable matter shall be removing from the surface upon which the earth fill is to be placed and the cleared surface shall be completely broken up by ploughing, scarifying or stepping to a minimum depth of twenty (20) centimeters.

The materials of within the moisture range and compacted to an average density of not less than ninety—eight (98) percent of M.D.D. Specified by the curve of Modified Proctor Density, with no single density value below ninety —two (92) percent where the depth of fill is less than seventy —five (75) centimeter below sub-grade elevation and compacted to an average density of not less than ninety (90) percent, where the depth of fill is more than seventy five (75) centimeters below the sub-grade elevation, when the material of which the foundation is composed is cohesion less the same shall be compacted to an avenge relative density (ASTM D2049) of 70% with no single density value below 67% During the preparation of the earth fill foundation, in fill and in cut the area to be treated will be subject to at least ten (10) passes of heavy duty roller of at least 15 tons operating weight , to ascertain the presence of underground cavities, The passes will be executed at minimum speed and maximum vibration frequency.

No direct payment shall be made for earth fill foundation but their cost shall be considered subsidiary to the various Earthworks pay items.

1.5.5 Earth Fill

The compacted density of the soil forming the earth fill shall be equal to or greater than an average value of ninety eight (98) percent of M.D.D specified by the curve of Modified Proctor density with no single value below ninety two (92) percent. When cohesion less sand to construct the earth fill layers, the avenge relative density (ASTM D2049) of 70% shall be achieved with no single value below 67%.

Should the earth fill material consist of sand is not well graded, so there are difficulties in obtaining the required compaction the Engineer or his Representative may permit the

thickness of the layer to be increased in order to obtain the specified compaction in the lower 30 cm.

1.5.6 *Moisture Control Requirements*

When the moisture content of the earth fill soil does not fall within the required moisture range, water shall be added and thoroughly mixed into the soil, by approved methods or the material shall be aerated, whichever is needed to adjust the soil to the proper moisture content.

The amount of water to be added shall be only that amount that will, as determined by the Engineer or his Representative by field testes, provide moisture content in the soil within the required range plus a reasonable amount to compensate for evaporation and other unavoidable losses.

Water added in excess of this amount shall be considered as excess water and must be removed by aeration or other suitable means directed by the Engineer or his Representative. Satisfactory methods and sufficient equipment shall be used for the finishing and handling of the water so that there will be no undue loss due to evaporating or waste. If water is added to cut areas or borrow pits, the surface of the areas or pits shall be maintained in such a manner that will prevent undue loss of moisture. Contractor shall be responsible to provide clean water for watering, including pumping, watering, erecting water net work and constructing a temporally water tanks.

No extra amounts will be made for watering or re- watering several times until rate of compaction is reached.

1.5.7 *Tamping*

Whenever earth fill is placed adjacent to structures or at locations where it is not practicable to use a roller, the fill materials shall be tamped by use of mechanical reamers or tampers. Each layer shall be compacted to a density equal to or greater than obtained under the above rolling procedure for the type of compaction designated

Each successive layer shall contain only that amount of material, which will insure proper compaction, but in no instance shall any layer be greater than thirty (30) centimeters (loose measurement) in depth.

The Engineer or his Representative must approve each layer before the next layer is placed.

1.5.8 *Special Provisions for Other Rollers*

When special heavy rollers are used, the compacted thickness of the layer may be increased when approved by the Engineer or his Representative as long as satisfactory compaction is obtained, satisfactory compaction is defined as compaction which results in a uniform density throughout the entire depth of the layer equal to or in excess of the specified density. The maximum compacted thickness of the layer shall be established by the Engineer or his Representative of each type of heavy roller used and for the various types of soil encountered.

The Engineer or his Representative reserves the right to vary the compacted thickness of the layer as the work progresses to insure adequate compaction or to rescind approval of the heavy rollers.

1.6 Compaction Trials

Prior to the commencement of earth works the contractor shall construct trial compaction lengths as directed by the Engineer or his Representative. The soils used in the trials shall be those that will be used for the construction of earth fill and the compaction equipment to be used shall be that specified in the contractor's detailed programme of work and approved by the Engineer or his Representative.

The object of these trials is to determine the field moisture content of the material and the relationship between the numbers of compaction.

2 CONCRETE WORK

2.1 *General*

British Standards (BS) Documents referred to in this section are:

BS EN 197-1:2000	Composition, specification and conformity criteria for common cements.
BS 410	Test Sieves. Technical requirements and testing.
BS 410-1:2000	Test sieves of metal wire cloth.
BS 410-2:2000	Test sieves of perforated metal plate.
BS812-101:1984 (2000)	Guide to sampling and testing aggregates.
BS 812-2: 1995/ BS EN	1097-3:1998
BS 812-100:1990(1995)	
BS 812-2:1995/BS EN	1097-3:1998
BS 812-100:1990(1995)	
BS 812-102:1989	
BS 812-103.1:1985 (2000)	
BS 812-103.2:1989(2000)	
BS 812-103'4:1994 (2000)	
BS 812-105.1:1989 (2000)	
BS 812-105.2:1990(2000)	
BS 812-106:1985 (2000)	
BS 812-109:1990 (2000)	
BS 812-110:1990(2000)	
BS 812-111:1990 (2000)	
BS 812-112: 1990 (1995)	
BS 812-11:1990(1995)	
BS 812-113:1990(1995)	
BS 812-114:1989 (2000)	
85812-117:1988(2000)	
BS 812-118:1988 (2000)	
BS 812-119:1985(2000)	
BS 812-120:1989 (1995)	
BS 812-121:1989 (2000)	
BS 812-123:1999	
BS 812-124:1989	
BS 882:1992	Specification for aggregates from natural sources for concrete.
BS EN 1097-5:1999	Determination of the water content By Drying In A ventilated Oven
BS EN 1097-2:1998	Methods of the determination of resistance to Fragmentation
BS EN 1097-8:2000	Determination of the Polished Stone Value.
BS 4449 :1997	Specification for carbon steel bars for the reinforcement of concrete.
BS EN 12350-1:2000	Testing Fresh Concrete.
BS EN 12350-2:2000	Testing Fresh Concrete.
BS EN 12390-1:2000	Shape, Dimension and Other Requirements for Speciment and Moulds
BS EN 12390-2:2000	Marking and Curing Specimens for Strength Test
BS EN 12390-3:2002	Compressive Strength of test Specimens.
BS EN 12504-1:2000	Cored Specimens. Taking , Examining and Testing in compression
BS EN 12504-2:2001	Non Destructive Testing . Determination of Rebound Number

The All materials shall be subject to such tests as the Engineer or his Representative may direct and provision for such tests shall be included in the price for such materials inserted in the Bill of Quantities or Schedule of Rates unless otherwise provided for.

Properly representative samples of all materials to be used in the works shall be submitted by the Contractor for the Engineer or his Representatives approval when required.

Where tests are required by the Engineer or his Representative, the Contractor shall take samples and send to a firm experienced in analysis of the material. Reports shall be submitted to the Engineer or his Representative.

Contractor shall bear all expenses consequent to the provision, taking and cartage, etc. of samples, in addition to the costs of performing the tests and reporting the results.

The Engineer or his Representative reserves the right to reject any material which, in his opinion is objectionable in any respect, notwithstanding its apparent compliance with the relevant Standards. Any such rejected material shall be removed from the site at the Contractor's expense at once.

2.2 *Formwork for Concrete*

The Contractor shall supply, design, erect, strike and remove the formwork and be entirely responsible for its stability and safety so that it will carry the fresh concrete and all incidental loadings and preserve it from damage and distortion during its placing, vibration, ramming, setting and curing. It shall be so constructed as to leave the finished concrete to the dimensions shown on the Drawings and of a material capable of providing the surface finish specified. In any event, the maximum permissible deflection under all loads shall not exceed 2 mm or 1/600 of the free span, whichever is less.

Formwork shall be of new timber and / or metal and shall include all temporary concrete moulds and their supports. Bolts to be used for fixing the formwork shall be approved by the Engineer or his Representative before starting the work.

For concrete surfaces which are to remain exposed wrought formwork shall be used. Wrought formwork shall be of timber or steel framing lined with 12 mm thick smooth-faced plywood or an equal lining approved by the Engineer or his Representative, or of metal, suitable to obtain a fair face finish on the concrete. All external angles or fair faced in-situ concrete shall have chamfers formed with 15x15 mm (5/8"x5/8") wrought hardwood angle fillets planted in the angles of the formwork, unless larger chamfers are shown on the drawings.

Formwork ready to receive concrete shall be thoroughly clean and the internal faces properly painted with approved shutter oil or other preparation. Joints shall be tight to prevent leakage.

Wherever required and prior to placing of the reinforcement the internal surfaces of all formwork shall be treated with an approved mould oil.

All formwork shall be inspected and approved by the Engineer or his Representative prior to concreting. This approval, however, does not relieve the Contractor of any of his responsibilities.

The striking of all formwork shall be carried out with the greatest of care to avoid damage to concrete.

The formwork to vertical surfaces such as walls, columns and sides of beams may be removed in accordance with the table below although care must be taken to avoid damage to the concrete, especially to arrases and features.

Minimum periods for striking other formwork should be in accordance with the following table; or as directed by the Engineer or his Representative.

	Ordinary Portland cement Concrete
Slabs (roof slab - dome)	20 days
Vertical Walls	5 days
Beam soffits (props left under)	7 days
Props to beams	14 days
Vertical Walls	7 days
Props to beams	14 days
Vertical surfaces as walls, columns and sides of beams	3 day

Formwork, shuttering, props, or any other means of temporary or semi-permanent support shall not be removed from the concrete until the concrete is sufficiently strong to carry safely the load (dead and temporary).

The Contractor shall inform the Engineer or his Representative when he is ready to strike the formwork, or remove any form of temporary support, and shall obtain his written consent before proceeding.

The times given for the removal of props are based on the assumption that the total live plus dead weight to be supported at the time of removal is not more than one half of the total design load.

For horizontal members where the loading is to be a higher proportion of the total design load these times may need to be increased.

The Contractor shall be responsible for any damage to the concrete work caused by or arising from the removal and striking of the forms and supports any advice, permission or approval by the Engineer or his Representative relative to the removal and striking of forms and supports shall not relieve the Contractor from this responsibility.

Any work showing signs of damage through premature loading is to be entirely reconstructed at the Contractor's expense.

The Contractor shall confirm positions and details of all

- (a) Permanent fixings
- (b) Pipes and conduit
- (c) Holes and chases

To ensure that alterations are not made without the knowledge and approval of the Engineer or his Representative.

The Contractor shall fix inserts or box out as required to correct positions before placing concrete, and shall form all holes and chases. He shall not cut hardened concrete without approval.

2.3 *Reinforcement for Concrete*

Steel reinforcement shall generally be hot rolled mild, medium or high yield steel smooth round or deformed bars complying with BS 4449 or similar approved standard.

In case any other type of reinforcement is required, it shall comply with the requirements of the BOQ and drawings.

All reinforcement shall be free from rust and mill scale and any coating such as oil, clay, paint etc. that might impair the bond with the concrete.

Manufacturer's test certificates for all classes of reinforcement shall be supplied when required. *Specimens sufficient for three tensile tests and three cold-bending tests per ten tons of bars* or fraction thereof and for each different size of bar shall be sampled under the supervision of the Engineer or his Representative. Testing shall be in accordance with BS 4449 or other approved standard and batches shall be rejected if the average results for each batch are not in accordance with the specification. *All tests should be made on the Contractor's expense.*

All steel is to be totally free from dirt, paint, loose rust or scale when in position ready for concreting.

The Contractor shall cut and bend bars to 135 4466 and to schedule provided unless otherwise instructed by the Engineer or his Representative.

Straight sections of bars must be kept out of winding. *The internal radius of bends shall in no case be less than four times the diameter of the bar*, except for stirrups, column binders, and wall shear bars which are to be bent to fit closely around the main bars.

Great care is to be taken to bend stirrups and columns binders separately and to the sizes shown.

All bars will be cut and bent cold using approved machines.

Lengthening of bars by welding, and rebinding of incorrectly bent bars will not be permitted, except where requested by the Engineer or his Representative.

The Contractor shall provide on site facilities for hand bending to deal with minor adjustments.

Splices in reinforcing bars shall be formed by lapping, and shall be staggered. Except as otherwise indicated on the drawings the minimum overlap of lapped splices shall be 40 bar diameters or 400 mm whichever is greater.

The steel is to be fixed in position exactly as indicated, and the bars are to be securely wired together with 1.6 or 1.4 mm soft galvanized iron wire or approved spring galvanized steel clips wherever necessary to prevent any displacement during concreting.

Spacers, chairs and the like, temporary or permanent, are to be used as required to ensure that the steel has the exact amount of cover indicated. No permanent spacers may show on a surface where a fair faced concrete finish or a brushed aggregate finish is required. Type of spacers shall be approved by the Engineer or his Representative before starting the work.

Unless otherwise indicated, the minimum cover to the reinforcing bars is to be as listed below or equal to the diameter of the bar, whichever is greater.

Position	Minimum cover - mm
Main bars in internal faces of walls,	40
Main bars in external faces of walls	40
Main bars in raft foundation (base slab) slabs (dome)	50
Main bars in top of roof slab (dome)	30
<i>Bars (walls, beams, columns, slabs and foundations)</i>	
<i>Near faces wetted or contact with soil</i>	75

The placing of all reinforcement will be checked by the Engineer or his Representative 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 is set.

The insertion of bars into or removal of bars from concrete already placed will not be permitted. Reinforcement temporarily left projecting from the concrete at the joints shall not be bent without the prior approval of the Engineer or his Representative.

Secondary reinforced concrete members for which no reinforcement details are given in the drawings or the BOQ shall have a minimum ratio of reinforcement area to concrete area of 0.35%

2.4 *Concreting*

2.4.1 *Cement*

The cement used shall be Portland Cement conforming in all respects to BS EN 197-1:2000, unless otherwise required, bags shall contain 50 kg net \pm 1%.

The Contractor shall at all times furnish the Manufacturer's statement of the above Standard Specifications together with the date of manufacture, certified by an independent agency in the country of origin approved by the Engineer or his Representative.

The cement shall be delivered to the site by the Contractor in the original sealed and branded bags or containers of the manufacturer in batches not exceeding 100 tons and shall be stored in a proper manner off the ground to prevent deterioration. Each batch shall be stacked separately and used in the order of delivery. No cement shall be used which has been manufactured more than twelve months prior to its proposed use on site.

All cements whether stored in bulk, bags, or containers in warehouses or on site shall be sampled for testing according to ASTM C183 (Methods of Sampling Hydraulic Cements) . Test samples over and above those specified shall be taken at any time if so requested by the

Engineer or his Representative. Testing of cement shall be in accordance with the methods required by BS EN 197-1:2000 or any other accepted by the Engineer or his Representative.

2.4.2 Aggregates

This specification covers fine and coarse aggregates other than lightweight aggregates for use in the production of concrete.

When lightweight aggregates are required, they will be defined in the BOQ.

The aggregates shall be crushed gravel or stone and shall comply with BS 882 for graded or single size aggregate and shall be obtained from any quarry approved by the Engineer or his Representative. For convenience part of Clause 5 of BS 882 (grading) including Tables 1, 2 and 3 are reproduced herein.

Coarse aggregate: the grading of coarse aggregate, when analysed by the method given for sieve analysis in BS EN 1097 shall be within the limits given in Table 4.1.

Fine aggregate: the grading of a fine aggregate, when analysed by the method of sieve analysis described in BS EN 1097, shall be within the limits of one of the grading zones given in Table 4.2, except that a total tolerance of up to 5 per cent may be applied to the percentages under-lined. This tolerance may be split up; for example, it could be 1 per cent on each of three sieves and 2 per cent on another, or 4 per cent on one sieve and 1 per cent on another.

The fine aggregate shall be described as fine aggregate of the grading zone into which it falls, e.g. BS 882, Grading Zone I.

NOTE: It is intended that individual zones should not be specified in contract documents relating to concrete but that the concrete mixes should be modified to make the best use of the materials readily available.

If approved by the Engineer or his Representative, Single-sized aggregate to BS 882 Table 4.1 may only be used for reinforced concrete when combined in two or more sizes to provide a well-graded mixture approved by the Engineer or his Representative.

Sampling and testing of aggregates shall be as required by BS 882 and in accordance with BS 812 'Methods for Sampling and Testing of Mineral Aggregates, Sands and Fillers'. All sampling shall be done by or under the supervision of the Engineer or his Representative.

The combined percentage of sulphates and chlorides by weight in coarse and fine aggregates shall not exceed 0.05 per cent (500ppm) of the combined weight of total aggregates.

Just before use the aggregate will be washed down with potable water to reduce the content of sulphates chlorides and other extraneous material.

Table 4.1: Coarse Aggregate

BS 410 Test Sieve	Percentage by weight passing BS sieves							
	Nominal Size of Graded Aggregate		Nominal size of Single – Sized aggregate					
mm	400 mm to 5 mm	200 mm to 5 mm	14 mm to 5 mm	63 mm	40 mm	20 mm	14 mm	14 mm
75.5	100	-	-	100	-	-	-	-
63.0	-	-	-	85-100	100	-	-	-
37.5	95-100	100	-	0-30	85-100	100	-	-
20	35-70	95-100	100	0-5	0-25	85-100	100	-
14	-	-	90-100	-	-	0	85-100	100
10	10-40	30-60	50-85	-	0-5	0-25	0-50	85-100
5	0-5	0-10	0-10	-	-	0-5	0-10	0-25
2.36	-	-	-	-	-	-	-	0-25

Table 4.2: Fine Aggregate

BS 410 Test Sieve	Percentage by Weight passing Bs Sieves			
	Grading Zone 1	Grading Zone 2	Grading Zone 3	Grading Zone 4
mm				
10.00	100	100	100	100
5	90-100	90-100	90-100	95-100
2.36	60-95	75-100	85-100	95-100
1.18	30-70	55-90	75-100	90-100
Microns				
600	15-34	35-59	60-79	80-100
300	5-20	8-30	12-40	15-50
150	0-10	0-10	0-10	0-15

The choice and preparation of sites for stockpiling of aggregates, the number and sizes of stockpiles and the methods adopted to prevent segregation of component sizes shall be agreed with the Engineer or his Representative.

Coarse aggregate shall be stockpiled in three separate grading: 38-19mm, 19-10mm, 10-5mm when aggregates of different grading are stockpiled close together the stockpiles shall be separated by bulkheads.

Stockpiles are to be on concrete or other hard surface sufficiently sloped so that water is not retained in the base of the stockpiles.

All aggregates are to be handled from the stockpile in such a manner as to secure a typical grading of the material, care being taken to avoid crushing the aggregates and contamination with extraneous matter.

Aggregates need not be stockpiled when a crushing-screening plant is used in tandem with a batching plant properly equipped with several bins for different sized aggregates having the appropriate weighing scales at such bin such that a mix of the desired gradation is obtained consistently and the whole operation is conducted to the satisfaction of the Engineer or his Representative.

2.4.3 Water

Unless otherwise authorized in writing by the Engineer or his Representative only water from potable supply system may be used for mixing concrete and other products containing cement.

Similarly only potable water may be used for curing concrete and cement products during the first 24 hours after pouring. Later, fresh water, or other water containing not more than 4750 ppm dissolved solids of which not more than 1000 ppm may be chlorides, may be used for curing.

No additives of any kind shall be used in the concrete without the express approval in writing of the Engineer or his Representative.

2.4.4 Quality of Concrete

Concrete shall be a mixture of cement, aggregates and water as covered respectively by aforementioned Sections. The mix proportions, workability and strengths of the various types of concrete shall conform to Tables 4.3 to 4.5.

The terms contained in Tables 4.3 to 4.5 are defined as follows: WATER/CEMENT RATIO (W/C): the term water/cement ratio means the ratio by weight of the water to the cement in the mix, expressed as a decimal fraction. The water is that which is free to combine with the cement in the mix.

This includes free water in the aggregate but excludes water absorbed or to be absorbed by the aggregate. The aggregate for this purpose shall be taken in a saturated surface-dry condition.

The absorption of the aggregates shall be determined in accordance with BS EN 1097 or any other method approved by the Engineer or his Representative.

The strengths specified are for ordinary Portland cement to BS EN 197-1:2000; if other types of cement are specified, the required strength shall be as defined in the Bills of Quantities.

Table 4.3: Grades of Concrete

Grade	Minimum works cube strength kg/cm ²		Max Agg. mm	Limits of agg/ Cement ratio by weight		Use of concert if not otherwise specified
	At 7 days	At 28 days		Max.	Min.	
	100	150	20	10:1	8:1	Plain concrete foundation
B-150	100	150	37	10:1	8:1	Blinding layer under RC Foundations
B-200	150	200	20	7:1	5:1	RC structures in general
	150	200	37	8:1	6:1	RC Foundation
B-250	175	250	20	5.5:1	4:1	High load columns
	175	250	37	6.5:1	4.5:1	High load foundation
B-300	200	300	20	5:1	3:1	As specified
	200	300	37	5:1	3:1	As specified
B-400*	300	400				
	300	400				

***Note: for grade of concrete B-400, trail mix shall be applied and approved by the engineer or his representative.**

Table 4.4: Standard Mixes

Grade of concrete	Minimum works Cube Strength kg/cm ²		Weight of dry sand per 50 kg of cement	Weight of dry coarse aggregate per 50 kg of cement						Max design W/C ratio
	7 days	28 days		Low	Med.	High	Low	Med.	High	
			Kg	Kg	Kg	Kg	Kg	Kg	Kg	
B-150	110	150	100	200	180	150	245	210	200	0.60
B-200	150	200	91	193	159	136	226	193	170	0.55
B-250	175	250	80	170	136	113	204	170	147	0.50
B-300	200	300	68	147	113	91	170	136	113	0.45
B-400*	300	400								

***Note: for grade of concrete B-400, trail mix shall be applied and approved by the engineer or his representative.**

Table 4.5: Workability

Degree of workability	20 mm Max. size aggregate		37 mm Max Size aggregate		Use for which Concrete is suitable
	Slump mm	Compacting Factor	Slump mm	Compacting Factor	
Low	13-25	0.82	13-50	0.82-0.88	Simply reinforced sections with vibration
Medium	25-50	0.88-0.94	50-101	0.88-0.94	Heavily reinforced sections with vibration
High	50-127	0.94-0.97	101-117	0.94-0.97	Sections with heavily congested reinforcement where vibration is difficult

The cubes used for the compression tests shall be 150x150x150 mm as specified in BS 1881. In case cylinders are used for determination of concrete compressive strength in accordance with ASTM C 39, the corresponding cube strength shall be obtained by using a multiplication factor of 1.2.

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 C23 1, 'Air Content of Freshly Mixed Concrete by the Pressure Method'. At least one test for each 120 cubic meters of concrete shall be made.

SLUMP: the slump of the freshly mixed concrete shall be determined in accordance with BS EN 12350-2:2000. At least one morning and one afternoon test shall be made and whenever directed by the Engineer or his Representative.

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 BS EN 12390-3:2002.

SAMPLING FOR COMPLIANCE TEST: Works Test Cubes shall be those used for control during construction and shall be made and tested in accordance with BS EN 12350-1:2000 and BS EN 12390- 2:2000.

Recommended Minimum Rates Sampling

Average Rate of Sampling One Sample (6 cubes) per	Maximum quantity of concrete at risk under any one decision
10 m ³ or 10 batches	40 m ³
20 m ³ or 20 batches	80 m ³
50 m ³ or 50 batches	200 m ³

The Contractor when tendering having knowledge of the source and types of cement, aggregate, plant and method of placing he intends to use shall allow for the aggregate/cement ratio and water/cement ratio which he considers will achieve the strength requirements specified and will produce a workability which will enable the concrete to be properly compacted to its full depth and finished to the dimensions and within the tolerances shown on the Drawings. In any event the aggregate/cement ratio and the water/cement ratio shall not exceed the upper limits specified in Table 4.3 for each type of concrete. Furthermore, the quantity of cement per cubic meter of concrete shall in no case be less than the minimum specified in Table 4.6.

Table 4.6: Minimum Cement Content

Grade of Concrete	Minimum Cement Content (kg/m ³)
B-150	200
B-200	225
B-250	250
B-300	275
B-400	325

As soon as possible after signature of the Contract, the Contractor shall prepare such trial mixes as required to satisfy the Engineer or his Representative that the specified concrete strengths will be obtained using the materials and mix proportions in accordance with the above clauses. The proportion of cement shall be increased if necessary to obtain the strengths required.

From each trial mix, six Preliminary Test Cubes shall be made and tested at 7 days and four at 28 days, the test at 7 days being intended to give an early indication of possible variation from the required strength. If the difference between the highest and lowest test results from any one trial mix is more than 15 per cent of the average of the strength test results, the test is to be discarded and a further trial mix made, unless all test results so obtained are above the required strength. Separate trial mixes are required for each type of concrete. The trial mix or mixes agreed by the Engineer or his Representative shall be designated job mixes and used as a basis for actual concrete production.

2.4.5 *Batching and Mixing of Concrete*

All concrete shall be batched by weight and mixed mechanically. Hand mixing shall not be allowed except only upon the written permission of the Engineer or his Representative.

Concrete may either be batched and mixed on site or outside the site and transported thereto.

When mixed outside the site and transported to it, batching and mixing shall be in accordance with ASTM Specification C94, 'Standard Specification for Ready-Mixed Concrete'.

When mixed on site, batching and mixing shall be as follows:

BATCHING BY WEIGHT: The cement and each size of aggregate shall be measured by weight. The water may be measured by weight or volume. The weight-batching machines used shall be of a type approved by the Engineer or his Representative and shall be kept in good condition while in use on the Works. Checks are to be made as required by the Engineer or his Representative to determine that the weighing devices are registering correctly.

BATCHING AGGREGATE BY VOLUME: When batching aggregates by volume is allowed as and when required, the cement shall be batched by weight and the water by weight or volume - Each size of aggregate shall be measured in metallic containers the depth of which is at least equal to their greatest width. The containers shall be of such shape that their volume can be easily checked by measurement.

MIXING CONCRETE: the location of the batching and mixing plant shall be agreed with the Engineer or his Representative.

The amount of concrete mixed in any one batch is not to exceed the rated capacity of the mixer. The whole of the batch is to be removed before materials for a fresh batch enter the drum.

On cessation of work, including all stoppages exceeding 20 minutes, the mixers and all handling plant shall be washed with clean mixing water. If old concrete deposits remain in the mixer drum, they shall be rotated with clean aggregate and water prior to production of new concrete.

Concrete mixed as above is not to be modified by the addition of water or in any other manner to facilitate handling or for any other reason.

2.4.6 Work in Cold or Hot Weather

Concrete is not to be mixed or placed at a shade air temperature below 2 deg. C on a rising thermometer or at a shade air temperature below 3 deg.C on a falling thermometer.

When the shade air temperature is 25 deg .C and rising, special precautions shall be taken during concreting operations, such as shading of the aggregates and plant, cooling of the mixing water or other methods approved by the Engineer or his Representative. So that the temperatures of the concrete when placed shall not be in excess of 32 deg .C

Fresh concrete placed at these temperatures shall be shaded from the direct rays of the sun to the satisfaction of the Engineer or his Representative for a period of at least 24 hours.

2.4.7 Placing

Concrete shall be conveyed from the mixer to its final position in any suitable manner, provided there is no segregation, loss of ingredients or contamination.

It shall be placed in its final position before initial setting takes place and within 20 minutes of the addition of the water to the mixer without using any additives. In case additives will be used, the manufacturer specifications of such additives must be handed over to the Engineer or his Representative to be approved before using it.

The order of placing concrete shall be such as to prevent water from collecting at the ends, corners and along the faces of forms. It shall not be placed in large quantities at a given point and allowed to run or be worked over a long distance in the form.

Whenever possible concrete shall be placed and compacted in even layers with each batch adjoining the previous one.

The thickness of the layers shall be between 150 and 300 mm for reinforced concrete and up to 450 mm for plain (non-reinforced) concrete, the thickness depending on the width of forms, the amount of reinforcement and the need to place each layer before the previous one stiffens.

Concrete shall not be allowed to drop freely for more than 2 meters. To convey the concrete as near as possible to its final position, drop chutes of rubber or metal shall be used for small sections and bottom dump buckets or other suitable vessels for large sections.

Concrete shall be carefully compacted when placed to ensure a dense and uniform mass free from air holes and cavities. All concrete types shall be compacted by vibration. Vibration shall be performed by mechanical or electro - mechanical vibrators. The vibrators shall be of the plunger (poker) type for insertion in the concrete except that plate type vibrators (external) shall be used if requested by the Engineer or his Representative.

The plunger (poker) type vibratos shall have a diameter compatible with the lowest spacing of reinforcement, a sufficiently high frequency and be properly handled by experienced personnel. They shall be immersed at regular intervals close enough to vibrate all of the concrete, but not too close to affect previously vibrated and partially set concrete. Each immersion shall continue until shortly after air bubbles cease to appear on the surface of the concrete, but shall not last more than 30 seconds. The vibrators shall be withdrawn gradually and vertically to ensure that no air pockets are formed.

When external vibrators are used as directed by the Engineer or his Representative, they shall be clamped to the forms whenever possible to avoid large impact during handling, and the forms shall be so constructed as to withstand the additional vibrations.

All vibrations, compaction and finishing operations shall be completed within 15 minutes from the time of placing the concrete in its final position. Until it has hardened sufficiently to carry weight without distortion, workers shall not be allowed to walk over freshly placed concrete.

Concreting of any one part or section of the work shall be carried out in one continuous operation, and no interruption of concreting work will be allowed without the approval of the Engineer or his Representative. Where beams and slabs together form an integral pan of the structure they shall be poured in one operation.

A record is to be kept by the Contractor on site of the time and date of placing the concrete in each portion of the works and the number and identification of the Works Test Cubes, corresponding to these portions. Such records are to be handed to the Engineer or his Representative weekly during the progress of the work.

2.4.8 *Admixtures*

No admixtures of any type shall be used in the preparation of concrete or concrete products unless so required or directed by the Engineer or his Representative. In case any such admixtures are used the rates and methods of application shall be strictly in accordance with the manufacturer's instructions, which must be approved by the Engineer or his Representative before using it.

2.4.9 *Curing*

Freshly placed concrete shall be protected from rain, dust storms, chemical attack and the harmful effects of heat, wind, flowing water, vibrations and shocks. This protection shall continue until the concrete is sufficiently set such that it is no longer damaged by these factors.

The Engineer or his Representative shall determine when the protection is no longer required, but in any case this shall not be less than 24 hours after the time of placing.

Concrete shall be cured for at least seven days and as required by the Engineer or his Representative. Curing shall be effected by the direct application of water to the surface of the concrete or by other approved curing methods or curing compounds applied in accordance with the manufacturer's specifications.

In case the application of such curing compounds is delayed for any reason, the concrete shall be kept moist until the application is made.

Timber formwork covering the concrete shall be moistened with water at frequent intervals to keep it from drying during the curing period. Metal formwork exposed to the sun must be shaded from its direct rays, painted white or otherwise protected during the curing period.

2.4.10 *Formed Finishes*

- **Basic finish**

General requirements

- (a) Produce an even finish with a sheet material.
- (b) Arrange panels in a regular pattern.
- (c) Blowholes not more than about 10 mm in diameter will be permitted but otherwise surface is to be free from voids honey combing and other large defects.
- (d) Variation in color resulting from the use of a form discoloration due to contamination or grout leakage.

The finish will be left as struck; making good or small defects will normally be permitted but only after inspection by the Engineer or his Representative. All blowholes shall be filled with a matching mortar to an approved sample unless otherwise instructed by the Engineer or his Representative. All faces shall be protected from damage, especially arises.

All faces shall be protected from rust marks and other surface disfigurements. Form tie holes shall be filled with a matching mortar to an approved sample accepted by the Engineer or his Representative.

2. Fine finishes (**Fair Face**)

General Requirements:

- a) Produce a smooth even finish with an impervious sheet metal
- b) Make panels as large as is practicable and arrange to approval.
- c) Blowhole not more than about 5mm in diameter will be permitted but otherwise surface is to be free from voids, honey combing and other defects.
- d) Variation in colour resulting from the use of an impervious form lining will be permitted, but the surface is to be free from discoloration due to contamination or grout leakage.
- e) Concrete cover spacers shall be used only if approved.

The finish is to be left as struck. Making good will not normally be permitted. All form tie holes are to be filled with a matching mortar to an approved sample. Wire form ties shall not be used. Approval of the Engineer or his Representative for the position of tie holes is to be obtained before use.

2.4.11 Quality Control Testing

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 Cube moulds.
- Slump cones.
- Thermometer.
- Any other accessories as required by the Engineer or his Representative.

All samples and testing shall be done in the presence of the Engineer or his Representative or his authorized representative either on site or in an approved testing laboratory in the area.

The frequency of testing shall be as noted in the clauses of this section and whenever required by the Engineer or his Representative.

The works Test Cubes shall be made as follows for types of concrete (A), (B) & (C):

- (a) At least three times weekly per mixing plant.
- (b) At least once for three individual parts of the structure.
- (c) At least once per 100 cubic meters of Concrete or fraction thereof.

At least six cubes shall be made at one time. Two of the six cubes are to be tested at seven (7) days. The remaining four cubes are to be tested at 28 days, and their average strength must not fall below the minimum strength specified for each type of concrete and the lowest test result shall not be more than 20% below the average of the four cubes.

When the result of 7-day test is unsatisfactory, the Contractor should be remove and replace the defective concrete without waiting for the 28-day test, If the result of the 28-day test is unsatisfactory all concreting shall be stopped at the Contractors expense and shall not proceed further without the written permission of the Engineer or his Representative.

The Contractor shall then, in accordance with the instructions of the Engineer or his Representative, remove cores and test same or conduct in- institutes in accordance with CP 144 from or on suspect portions of the works, under the supervision of the Engineer or his Representative.

Concrete judged by the Engineer or his Representative to be defective shall be forthwith cut out, removed and replaced at the Contractors own expense.

In the event of strengths consistently higher than those specified being obtained, a reduction in the number of tests may be authorized by the Engineer or his Representative.

2.4.12 Position of Reinforcement

The actual concrete cover to all steel at any point should not be smaller than the required nominal cover by more than 5 mm.

The effective depth of fully or nearly fully stressed tensile reinforcement should not be less than that given on the drawings by an amount exceeding 5 per cent of the effective depth of the section being considered or 5 mm whichever is the greater.

2.4.13 Ready mixed concrete

Ready- mixed concrete as defined in BS 1926, batched off the site will be used with agreement of the Engineer or his Representative and shall comply with all requirements of the Contract. The quality and strength of cements shall be determined by site tests. No test results supplied by Ready-Mix Supplier shall be accepted as proof of the quality and strength of the concrete.

The concrete shall be carried in purpose made agitators operating continuously, or in truck mixers. The concrete shall be compacted and in its final position within 1 hour of the introduction of cement to the aggregate or as agreed by the Engineer or his Representative. The time of such introduction shall be recorded on the Delivery Note together with the weight of the constituents of each mix.

When truck mixed concrete is used, water shall be added under supervision either at the site or at the central batching plant as agreed by the Engineer or his Representative but in no circumstances shall water be added in transit.

Unless otherwise agreed by the Engineer or his Representative truck mixer units and their mixing and discharge performance shall comply with the requirements of BS 4251. Mixing shall continue for the number and at the rate of revolutions recommended in accordance with BS 4251 or, in the absence of the manufacturer's instructions, mixing shall continue for not less than 100 revolutions at a rate of not less than 7 revolutions per minute.

Prior to any ready mixed concrete being ordered, the Contractor shall submit to the Engineer or his Representative details of the supplier and shall arrange for the Engineer or his Representative to inspect the supplier's works if required.

Truck—mixer units shall be maintained and operated strictly in accordance with the manufacturer's recommendations.

2.4.14 Concrete Surface Hardener

Monolithic surface hardening compound is to provide a highly abrasion resistance surface with a dry shake method.

The abrasion resistance of the hardening compound shall comply, and the compressive strength not less than 70N/mm after 28 days, tested according to the BS EN 12390.

The hardening compound shall be applied in rate of 7 kg/m² on the floor surface at the time when the concrete has stiffened to the point when light foot traffic leaves an imprint of about 3 mm.

The hardening compound shall be applied in two application stages:

Stage 1: using 1/2 to 2/3 of the required material. When the material becomes uniformly dark by the absorption of moisture from concrete then the floating can be applied.

Stage 2: spreading the remaining material on the surface, and apply floating to the surface after the moisture being absorbed.

Final finishing of each element (wall, foundation, roof slab & base slab) shall be done using mechanical trowelling machine

Curing for the surface shall be applied as clarified above.

3 ASPHALT WORKS

3.1 *General*

The Contractor shall construct the area to be paved in accordance with the applicable specifications stipulated herein after, in conformity with the alignment, dimensions, and typical sections shown on the Drawings, or as directed by the Representative Engineer.

3.1.1 *Scope of Work*

For the purpose of these specifications, the following type of asphalt works is designated:

- Leveling and compacting the Sub grade.
- Preparing, leveling and compacting the Sub-base.
- Preparing, leveling and compacting of base - course.
- Prime coat.
- Single asphalt surface layer.

3.2 *Sub grade*

All subgrade materials of A6 or A1 soil groups classification by AASHTO, which are unsuitable as subgrade, should be totally removed for a minimum depth of 60cm and replaced by selected fill of minimum CBR of 25%.

The contractor shall prepare the roadbed surface by sprinkling, rolling and lightly scarifying, where necessary, until the proper crown is obtained. The roadbed shall be well compacted, smooth, hard and uniform, all irregularities having been bladed out and rolled down.

All soft and yield material or other portions of the subgrade, which will not compact readily, shall be removed and all loose rock or boulders found in excavation shall be removed or broken off to a depth of not less than 15 cm below the surface of the subgrade. All holes or depressions made by the removal of materials, as described above, shall be filled with approved material, and the whole subgrade brought to line and grade compacted to 95% of maximum dry density.

3.3 *Sub-Base*

3.3.1 *General*

The Contractor shall provide the sub base material free from dirt, organic matter, shale or other deleterious matter and shall be of such quality that it will bind readily to form a firm stable sub base. The sub base material shall conform to the requirements specified in the following Classes:

All Sub-base materials shall conform to the following physical requirements:

- | | |
|---|--------------|
| ▪ Loss of Sodium Sulphate Soundness Test (AASHTO T 104) | 15% Maximum. |
| ▪ Liquide Limite (AASHTO -T- 89) | 25 maximum. |
| ▪ Plasticity Index (AASHTO -T- 90) | 6. |
| ▪ Sand Equivalent (AASHTO 1 176) | 25 minimum. |
| ▪ CBR CBS 1377) after 4 days soaking | 40% minimum. |

3.3.2 Class A Sub-Base

The sub base material shall consist of well-graded gravel with sand and silt, confirming the following requirements.

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90-100
No.4	35-70
No.	0-15

3.3.3 Class B Sub-Base

The sub base material shall consist of uniform mixtures of gravel and/or stone fragments with sand, silt and clay, confirming the following requirements:

Sieve Size	Percent Passing
2 incch	100
1-1/2 inch	70-100
1 inch	55-85
3/4 inch	50-80
3/8 inch	40-70
No.4	30-60
No. 10	20-50
No.40	10-30
No.200	5-15

3.3.4 Class C Sub-Base

The sub base material shall consist of well graded sand-gravel, confirming the following requirements:

Sieve Size	Percent Passing
1 inch	100
3/8 inch	65-100
No.4	35-75
No. 10	25-55
No. 40	10-45
No. 200	5-15

3.3.5 Construction

The sub base aggregate shall be spread in layers not exceeding 20 cm by means of approved mechanical box spreaders, distributing the material to the required width and loose thickness. When the required sub base thickness is greater than 20 cm, the material shall be placed in layers of equal thickness; in no case shall a layer be less than 15 cm thick.

Segregation shall be avoided and the segregated materials shall be remixed until uniform. Suitable precautions shall be taken to prevent rutting of the sub grade during the spreading of the sub base materials. The sub base aggregate shall be compacted to an average value of 98% of the maximum dry density determined in accordance with the latest modified AASHTO T-180 Method D with no single value below 96%.

After completion the compaction, the surface of material shall be well closed, free from movement under the compaction plant and free from corruption planes, ridges, cracks or loose materials.

The finished surface of the base-course shall not vary at any point by more than 1 cm below the grade established by the Representative Engineer, and the total thickness of the base-course shall not vary by more +0.50 cm . In addition to level checking, longitudinally the surface shall be checked with a straight edge (4m long), where irregularities in this direction shall not vary by more than 1 cm.

Minimum of (4) levels of the base at the total longitudinal side shall be taken and if (2) or more of these levels exceed the tolerance given the Contractor shall re-grade the entire length of the area. If one of these levels exceeds the tolerance then the Contractor shall make good this point.

One sample every 100m shall be tested for Grading, Loss by Abrasion, Maximum Dry Density, CBR, Plasticity Index and Sand Equivalent. One in-situ Density tests every 300m of sub base laid.

3.4 *Base – Course*

3.4.1 *General*

The Contractor shall provide only an aggregate material for the base-course consisting of hard, durable, crushed limestone or crushed gravel, provided that the crushed aggregates retained on sieve No. 4 shall have 80% by weight of at least two fractured faces, which have to be crushed by approved crushing plant and shall be free from any organic matter or any other deleterious substances and also free from clay balls.

All base-course aggregates shall confirm to the following physical requirements:

▪ Loss of Sodium Sulphate soundness Test (AASHTO T 104)	12% Maximum
▪ Loss of Magnesium Sulphate Soundness Test (AASHTO T 104)	18% Maximum
▪ Loss by Abrasion Test (AASHTO T 96)	40% Maximum
▪ Thin and Elongated Pieces by Weight (larger than 1-inch thickness less than 1/5 length)	5%
▪ Friable Particles (AASHTO T 112)	0.25% maximum
▪ Liquid Limit (AASHTO -T- 89)	25 maximum
▪ Shrinkage Limits (AASHTO -1- 89)	4% maximum
▪ Plasticity Index (AASHTO -T- 90)	(3-6) %
▪ Sand Equivalent (AASHTO T 176)	40 minimum
▪ Maximum Dry Density (AASHTO T 180)	2.10 gr/cc
▪ CBR (BS 1377) after 4 days soaking	90% minimum

3.4.2 *Aggregate Base Course - Type A*

The coarse materials shall be crushed rock or crushed gravel confirming to the following gradation:

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90-100
1-1/2 inch	35-70
1 inch	0-10
1/2 inch	0-5

The fine materials of the base course shall be quarry screenings or natural material of suitable binding quality, and free from foreign or organic matter, dirt, shale, clay and clay lumps, or other deleterious matter and shall conform the following requirements:

Sieve Size	Percent Passing
3/8 inch	100
No.4	85-100
No.100	10-30

The combined material shall consist of a mixture of all aggregate uniformly graded drum coarse to fine, conforming the following gradation.

Sieve Size	Percent Passing
2-1/2 inch	100
2 inch	90-100
1-1/2 inch	75-90
1 inch	65-80
3/4 inch	60-75
1/2 inch	50-70
No. 4	45-55
No. 10	10-26
No. 40	30-45
No. 200	5-15

3.4.3 Aggregate Base Course - Type B

The Base course material shall consist of uniform mixture of crushed rock and/or gravel with sand, silt and clay, conforming the following gradation:

Sieve Size

Sieve Size	Percent Passing
1-1/2 inch	100
1 inch	75-100
3/4 inch	60-90
No. 4	30-65
No. 10	25-50
No. 40	25-40
No. 200	5-10

The fraction passing No. 200 sieve shall not be greater than 70% of the fraction passing No. 40 sieve.

3.4.4 Construction

Aggregate for base-course shall be delivered to the area to be paved as a uniform mixture and shall spread in layers not exceeding 15 cm in compacted depth, including any binder that is to be blended on the road. Spreading shall be done by means of approved self-propelled stone box spreaders, distributing the material to the required width and loose thickness. Segregation shall be avoided and the base-course shall be free from pockets of coarse or fine materials.

The finished surface of the base-course shall not vary at any point by more than 1 cm below the grade established by the Representative Engineer, and the total thickness of the base-course shall not vary by more ± 0.50 cm. In addition to level checking, longitudinally the surface shall be checked with a straight edge (4m long), where irregularities in this direction shall not vary by more than 1cm.

A minimum of (4) level of the base at the total longitudinal side shall be taken and if (2) or more of these levels exceed the tolerance given the Contractor shall re-grade the entire length of the area. If one of these levels exceeds the tolerance then the Contractor shall make good this point.

The aggregate base shall be compacted to not less than 100% of the maximum dry density determined in accordance with the latest modified AASHTO T-191, T-205 or T-205 and T-239.

The base-course shall be maintained in a condition satisfactory to receive surfacing material. Aggregate base-course which does not conform to the above requirements, shall be reshaped or reworked, watered and thoroughly re-compacted to conform to the specified requirements at the Contractors own expense.

One sample every 1000m shall be tested for Grading, Soundness, Loss By Abrasion, Maximum Dry Density, CBR, Plasticity Index and Sand Equivalent. One in-situ Density tests every 300m of sub base laid.

3.5 Prime Coat And Tack Coat

3.5.1 General

The following specifications and standards shall be applied for tests to be carried by the contractor when and as directed by the Representative Engineer.

American Association Of State Highway and Transportation Officials (AASHTO) and American

Society For testing and Materials (ASTM).

T 40 Sampling Bituminous Materials.

M 82 Specification for Cut-Back Asphalt (Medium Curing type).

M 140 Specification for Emulsified Asphalt.

D 2995 Recommended Practice for Determining Application Rate of Bituminous Distributors.

The bituminous prime and tack coats shall consist of an application of an asphaltic material respectively on a previously prepared and approved sub base/ base or layer of bituminous base and or binder courses.

The bituminous material to be used for the prime coat shall be medium curing Cut-Back Asphalt, grade MC70, in conformance with AASHTO standard M82. It shall be applied in quantities of not less than 0.8 l/m² and not more than 1.7/m².

The bituminous material to be used for the tack coat shall be Emulsion Asphalt, grade SS-lh confirming the requirements of AASHTO M140. It shall be applied in quantities of not less than 0.3 l/m and not more than 0.75 l/m².

All samples of bituminous material shall be taken according to the requirements of AASHTO T 40.

3.5.2 Equipment

The equipment used by the Contractor shall include a power broom or a power blower or both; a self - propelled, pneumatic roller, or steel-wheeled tandem (5 to 14 tons) or both; mechanical or self-propelled aggregate spreading equipment that can be adjusted to spread accurately the specified amounts per square meter, a pressure distributor and equipment for heating the asphalt material. Pneumatic - tired rollers shall have a total compacting width of not less than 120 cm and shall have minimum contact pressures of 2.8 kg/cm or as specified by the Representative Engineer. Other equipments are to be used in addition to, or in lieu of the specified equipment when approved by the Representative Engineer.

The pressure distributor shall be designed and operated to distribute the asphalt material in a uniform spray with atomization, in the amount and between the limits of temperature specified. It shall be equipped with a tachometer having a dial registering feet or meters of travel per minute. The dial shall be visible to the truck driver so he can maintain the constant speed required for application at the specified rate. The pump shall be equipped with a bitumeter having a dial registering liters, or gallons per minute passing through the nozzles. The dial shall be readily visible to the operator.

Means for indicating accurately the temperature of the asphalt material at all times shall be provided. The thermometer reservoir shall not be in contact with a heating tube.

The spray bar shall be adjustable to a reasonable width. A hose and spray nozzle attachment shall be provided for applying asphalt material to paths and areas inaccessible to the spray bar.

The distributor shall be provided with heating attachments and the asphalt material shall be circulated during the entire heating process

3.5.3 Application of Prime coat

The Representative Engineer will select the rate of application for the asphalt primer to be used. The Contractor shall keep a record of the application rates selected tentatively an application rate of 0.8-1.7 Kg/m of MC 70 shall be used.

Application of the asphalt prime shall be made uniformly at this rate with the pressure distributor. The asphalt prime shall be applied at the temperature of 60 °C for the MC-70 and 75 °C for the SS-lh. When heating is required, precautions shall be taken to avoid fire hazard.

Application shall be made when the surface is dry or slightly damp and, unless otherwise permitted by the Representative Engineer, when the air temperature in the shade is not less

than 10°C. After application of the asphalt prime, at least forty - eight (48) hours shall elapse before further applications are made.

Before beginning application, building paper shall be spread over the surface, from the joint back, for a sufficient distance for the spray bar to begin spraying and be operating at force when the surface to be treated is reached. After the asphalt is applied the building paper shall be removed and destroyed.

The spray bar shall be shut off instantaneously at each construction joint to assure a straight line and the hill application of asphalt prime up to the joint. If necessary to prevent dripping, a drip pan shall be inserted under the nozzle when application is stopped. A hand spray shall be used to apply primer material necessary to touch up all spots unavoidably missed by the distributor.

Following the application, the primed surface shall be allowed to dry for a period of not less than 48 hours without being disturbed or for such an additional period of time as may be necessary to permit the drying out of the prime until it will not be picked up.

The surface shall then be maintained by the Contractor until the surfacing has been placed and no traffic (other than that necessary for the Contractor) shall be allowed on the primed surface before placing of the surface treatment

3.6 Hot Mix Asphalt Surfacing

Scope work shall consist of the construction of one or both of the following asphaltic concrete courses:

- Bituminous Base Course
- Bituminous Binder Course
- Bituminous Wearing Course

Construction shall be in accordance with these specifications and in conformity with lines, grades and thickness as shown on drawings or established by the Representative Engineer.

3.6.1 Materials

Mineral Aggregates

Shall consist of coarse aggregates, fine aggregates and filler materials and shall be tested in accordance to ASTM C 294 and 295.

Coarse Aggregates

- Shall be of the material retained on an AASHTO No.4 sieve and consists of crushed rock or crushed gravel.
- Shall be clean, hard tough, durable and sound. Shall be of uniform quality and free from decomposed stone, organic matter, shale, clay, lumps and other deleterious substances.
- Flakiness and elongation index shall not exceed 30% when tested according to BS 812.
- Shall consist of the product obtained by crushing material that has been screened in such a manner that not less than 90% of the material to be crushed is returned on an AASHTO No. 3/8-inch sieve.

- Shall be regulated so that at least 90% by Wight of the material retained on an AASHTO No.4 sieve shall consist of pieces with at lease 2 mechanically fractured faces.
- Water absorption not more than 2% when tested according to BS 812.
- Los Angeles Abrasion test of not more than 30% according to AASHTO T 96 according to the size of tested aggregates at 500 revolutions.
- Crushing value not more than 25% according to BS 812- Part 3 : 1975
- Soundness Loss (sodium and magnesium sulphate) not more than 5% according to AASHTO T 104 according to the size of the tested aggregates.

Fine Aggregates

- Shall be of the material passes an AASHTO No.4 sieve and at least 90% by weight shall consist of pieces having at least 2 mechanical fractured face.
- Maximum value of Water Absorption shall be 2% when tested according to BS 812.

Combined Aggregates

- Shall meet the following physical requirements:
 - 1- Specific gravity 2.65 Wm minimum
 - 2-Sand Equivalent (AASHTO T 176) 70 minimum
 - 3- Plasticity Index (AASHTO T 90) Non-plastic
 - 4- The following gradation shall confirm AASHTO T 11 and AASHTO T 27

Standard Sieve Size	Total Percent Passing (By Weight)		
	Base Course	Binder Course	Wearing Course
1-1/2 inch	100	-	-
1 inch	70-100	100	-
3/4 inch	50-80	80-100	100
1/2 inch	-	63-85	80-100
3/8 inch	25-50	57-77	65-85
No. 4	10-30	40-60	46-63
No. 10	5-20	25-45	30-50
No. 80	1-4`	8-17	10-20
No. 200	3-6	5-10	5-12

Filler Material

When the combined grading of the coarse and fine aggregate is deficient in material passing No. 200 sieve, filler conforming to the requirements specified hereafter shall be added.

Mineral filler shall comply in all respects with AASHTO Standard Specification M17.

The amount of commercial filler to be added shall be only that amount necessary to make the combined grading of the material comply with the grading requirements for the complete mixture.

In no case shall the amount of commercial filler added exceed three percent (3%), sample obtained from hot bins, by weight of the combined aggregate. The material passing No. 200 sieve may consist of fine particles of the aggregates or mineral filler, or both. It shall be free from organic matter and clay particles.

Asphalt

Asphalt to be used shall be Asphalt Cement grade 60/70 confirming the requirements of AASHTO.

The asphalt cement shall be homogeneous, free from water and shall not foam when heated to 175°C. The percentage of asphalt cement, by weight to be added to the aggregate shall be as follows:

Pavement	Asphalt Cement Percent by Weight Of the Total Mix
Base	3.4 to 4.30
Binder	3.85 to 4.75
Wearing	4.75 to 5.25

The exact percentage of asphalt cement shall be fixed by the Representative Engineer based on the Marshall Tests carried out by the Contractor when submitting the job mix design for approval.

3.6.2 Job Mix Formula

The Contractor shall submit for the Representative Engineer’s approval a job mix formula within the limits of these specifications.

The maximum permissible variation from the job mix formula within the specification limits shall be as follows:

Standard Sieve Size	Permissible Variation Percent by Weight of Total Mix
3/8 inch and larger	± 5.00
No. 4	+ 5.00
No. 8	± 4.00
No. 200	± 1.50
Asphalt Cement	± 0.30
Temperature of mixing and placing	+ 0.10 °C

Mix Test Criteria

Test requirements and criteria for the paving mixes prepared these specifications shall be as follows:

Properties	Bituminous Base Course	Bituminous Binder Course	Bituminous Wearing Course
No. of Compactive blows each end specimen	75	75	75
Minimum Stability (Kg)	900	1300	1500
Flow mm	2-4	2-4	2-4
Percent air voids	3-7	3-7	3-5
V.M.A. using Bulk S/Gr. (Tolerance -1%)	13	13	14
V.F.B	60-70%	60-70%	60-70%
Loss of stability max. 25 (soaking 24 hours compared with 30 min. At 60c for all specimens in water bath.)	Max. 25%	Max. 25%	Max. 25%

The mix formula shall take into consideration the absorption of asphalt into the aggregates.

Laboratory test specimens of paving mixes, combined in the proportions of the job mix formula, shall be prepared and tested in accordance with the procedures of the Marshall method of mix design as detailed in the 'Asphalt Institute Manual - MS2' and ASTM method of Test D 1559.

The Representative Engineer will make frequent gradation analyses of the hot aggregates and of the completed mix to be certain that the materials being used and produced are within the tolerances of the job mix formula and the specifications of the mix number being used.

If the mix is found to be outside the job mix formula tolerances or outside of the specification limits, correction shall be made in quantities measured from the hot bins and adjustments made the cold bin feeders and the Contractor shall submit a new mix design.

3.7 General Equipment Requirements

All equipment furnished by the Contractor shall meet the requirements of this section and shall be maintained in its best mechanical condition. Equipment shall be serviced and lubricated away from the paving site; units drip fuel, oil, or grease shall be removed from the site until such leakage is corrected. The trucks used for hauling bituminous mixture shall have tight, clean, smooth metal beds which have been thinly coated with a minimum amount of paraffin oil, lime solution or another approved material to prevent mixture from adhering to the beds.

Each vehicle shall be equipped with a canvas cover or other suitable material as to protect the mixture from the weather.

Rolling equipment shall be self-propelled. The wheels on the rollers shall be equipped with adjustable scrappers and the rollers shall have water tanks and sprinkling apparatus, to keep the wheels wet and prevents the surface material from sticking.

3.8 Elements for All Plants

3.8.1 Uniformity

The plants shall be designed, coordinated and operated to produce a uniform mix within the specified job mix tolerances

3.8.2 Sampling and Testing

Stockpiles and bins will be sampled for gradation analyses and examined for dust coating and for other purposes, in compliance with stated requirements. Gradation analyses of each hot bin will be performed and a combined analysis conducted at least twice a day once in the forenoon, and once in the afternoon. If materials do not run uniform, more frequent tests will be made.

When requested by the Representative Engineer, the Contractor shall provide representative samples by taking aggregate from each bin through the mixing chamber (without asphalt) into a truck or other receptacle. At least one sample shall be taken from each truck of the hot mix being delivered to the site. Samples will be used to determine compliance with general and special requirements set forth in these specifications.

3.9 Construction Method

3.9.1 Weather Limitations

When the moisture of the aggregate in the stockpile or from the dryer in the plant interferes with the quality of mix production, or with normal plant operations, or when pools of water are observed on the base, then mixing and placing of hot-mix asphalt will not be permitted.

The temperature of the surface on which the hot-mix asphalt is placed shall not be less than 5°C. When the surface temperature on which the material is to be placed falls below 10°C, precautions shall be taken to compact the mix before it cools too much, to obtain the required density.

All truck loads shall be delivered continuously and immediately spread and compacted. In cold weather and for shall be delivered at a temperature within 5°C of that temperature specified by the Representative Engineers Representative.

3.9.2 Preparation of Area

The area to be paved shall be true to line and grade, and have a dry and properly prepared surface prior to the start of paving operations. It shall be free from all loose screenings, and other loose or foreign material. The surface shall be primed as specified. The surface of structures in actual contact with asphalt mixes shall be painted with a thin, complete coating of asphalt material to provide closely bonded water - tight joint.

3.9.3 Proportioning and Mixing

To aid in determining the proper temperature of the completed batch, current viscosity data shall be available at the plant at all times.

With information relative to the viscosity of the particular asphalt being used, the temperature of the completed mix at the plant and at the paver shall be designated by the Representative Engineer after discussing with the Contractor the hauling and placing conditions.

The asphalt shall be heated so that it can be distributed uniformly throughout the batch. For mixing applications, the specified temperature will generally be such that the asphalt viscosity is within the range of 150-300 centistokes (75-ISO seconds, Saybold Fuyol). The material shall be sufficiently fluid to produce a complete coating on every particle of aggregate within the specified mixing time. The temperature of the aggregates and asphalt

immediately prior to mixing shall be approximately that of the completed batch. When the mix is produced in a batch type plant the aggregate shall be weighed accurately in the designated proportions to provide the specified batch weight. The temperature of the aggregate at the time of introduction into the mixer shall be as directed by the Representative Engineer with a tolerance of $\pm 5^{\circ}\text{C}$. In no case, however, shall temperature of the mixture exceed 165°C .

3.9.4 Transportation of Mix

The mix shall be transported to the job site in vehicles and painted, or sprayed, with a limewater, soap or detergent solution, at least once a day or as often as required.

After this operation the truck bed shall be elevated and thoroughly drained no excess solution shall be permitted. The dispatching of the vehicles shall be so scheduled that all material.

Delivery of material to the paver shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.

3.9.5 Spreading and Finishing

Spreading and finishing shall be conducted in the following manner:

3.9.6 Mechanical Paver

The binder and surface courses shall be spread and struck-off with a mechanical paving machine connected with an automatic sensor. The paving machine shall be operated so that material does not accumulate and remain along the sides of the receiving hopper. Equipment which leaves tracks or indented areas which cannot be corrected in normal operation, or which produces flushing or other permanent blemishes or fails to produce a satisfactory surface shall not be used. Lines for the paver to follow will be established by the Representative Engineer parallel to the centerline of the proposed roadway. The paver shall be positioned and operated to follow closely the established lines. In backing trucks against the paver, care shall be taken not to jar it out of its proper alignment.

As soon as the first load of material has been spread, the texture of the unrolled surface shall be checked to determine its uniformity.

Segregation of materials shall not be permitted. If suspended until the cause is determined and corrected. Transverse joints in succeeding courses shall be offset at least 60 cm.

Any irregularities in alignment left by the paver shall be corrected by trimming directly behind the machine. Immediately after trimming, the edges of the course shall be thoroughly compacted by tamping. Distortion of the pavement during this operation shall be avoided.

Edges against which additional pavement is to be placed shall be straight and immediately vertical. A lute or covered rake shall be used immediately behind the paver when required to obtain a true line and vertical edge. Any irregularities in the surface of the pavement course shall be corrected directly behind the paver. Excess material forming high spots shall be removed by a shovel or lute. Indented areas shall be filled with hot mix and smoothed with the back of a shovel being pulled over the surface.

Fanning of material over such areas shall not be permitted.

3.9.7 Hand Spreading

In small areas where the use of mechanical finishing equipment is not practical, the mix may be spread and finished by hand, if so authorized by the Representative Engineer. Wood or steel form, approved by the Representative Engineer, rigidly supported to assure correct grade and cross-section, may be used. In such instances, measuring blocks and intermediate strips shall be used to aid in obtaining the required cross-section. Placing by hand shall be performed carefully; the material shall be distributed uniformly to avoid segregation of the coarse and fine aggregate.

Broadcasting of material shall not be permitted. During the spreading operation, all materials shall be thoroughly loosened and uniformly distributed by lutes or covered rakes. Material that has formed into lumps and does not break down readily shall be rejected.

Following placing and before rolling, the surface shall be checked with templates and straight edges and all irregularities shall be corrected.

Heating equipment used for keeping hand tools free from asphalt shall be provided. Caution shall be exercised to prevent high heating temperatures which may burn the material. The temperature of the tools when used shall not be greater than the temperature of the mix being placed. Heat only shall be employed to clean hand tools; petroleum oils or solvents shall not be permitted.

3.9.8 Compaction

General

Except for small jobs, such as driveways, at least two rollers shall be required at all times. As many additional rollers shall be used as necessary to provide specified pavement density.

During rolling, the roller wheels shall be kept moist with only sufficient water to avoid picking up the material

After the edges have been compacted rolling shall start longitudinally at the sides and gradually progressing toward the centre of the pavement.

The rollers shall move at a slow but uniform speed with the drive roll or wheel nearest the paver. The speed shall not exceed 5 kph for steel-wheeled rollers or 8 kph for pneumatic - tired rollers.

The line of rolling shall not be changed suddenly. If rolling causes displacement of the material, the affected areas shall be loosened at once with lutes or shovels and restored to the original grade of the loose material before being re-rolled.

Heavy equipment or rollers should not be permitted to stand on the finished surface before it has been compacted and has thoroughly cooled.

Rolling shall be in the following order:

- a) Transverse joints.
- b) Outside edge.
- c) Initial or breakdown rolling , beginning on the low-side and progressing toward the high side.

- d) Second rolling , same procedure as (c).
- e) Finish rolling.

The compaction temperature (laboratory) shall be (viscosity) of bitumen is 280 ± 3^0 centistokes, as follows 148 ± 3^0 for 60/70 penetration.

Transverse Joints

Transverse joints shall be held to a minimum and thoroughly compacted to provide a smooth riding surface. Joints shall be straight edges and string - lined to assure smoothness and true alignment. If a joint is formed with a bulkhead, such as a board, to provide a straight line and vertical face, it shall be checked with straight edges before fresh material is placed against it to complete the joint. If a bulkhead is not used to form the joint and the roller is permitted to roll over the end of the new material, the line shall be located back of the rounded edge a sufficient distance to provide a true surface and cross-section. If the joint has been distorted by traffic or by other causes, it shall be trimmed to line.

In either case, the joint face shall be painted with a thin coating of asphalt before fresh material is placed against it.

To obtain through compaction of these joints, material placed against the joint shall be tightly crowded against the vertical face of the joint.

To accomplish this, the paving machine shall be positioned so that the material shall overlap the edge of the joint by 3 to 5 cm. The depth of the overlapped material shall be kept uniform.

The coarse aggregate in the overlapped material that was dislodged through raking or lusting shall be removed from the pavement surface and discarded.

A tandem roller shall be placed on the previously compacted material transversely so that no more 15 cm of the rear rolling wheel rides on the edge of the joint.

The roller shall be operated to pinch and press the mix place at the transverse joint. The roller shall continue to roll along this line, shifting its position gradually across the joint, in 15 to 20 cm P17 increments, until the joint has been rolled with the entire width of the roller wheel. Rolling joint is obtained.

Edges

Care shall be exercised in consolidating the course along the entire length of the edges. Before it is compacted, the material along the unsupported edges shall be slightly elevated with a tamping tool or lute. This will permit the full weight of the roller wheel to bear on the material to the extreme edges of the mat. In rolling pavement edges, roller wheels shall extend 5 cm to 10 cm beyond the pavement edge.

Breakdown Rolling

Breakdown rolling shall commence at a temperature of not less than 135°C and immediately follow the rolling of the longitudinal joint and edge. Rollers shall be operated as close to the pavement as necessary to obtain adequate density without undue displacement. The breakdown roller shall be operated with the drive roll or wheel nearest the finishing machine. Exceptions may be made by the Representative Engineer when working on steep slopes.

When both three-wheeled rollers and tandem rollers are used, the three-wheeled rollers shall work directly behind the paver following by the tandem rollers. Only experienced roller operators shall be used for used this work.

Second Rolling

Pneumatic-tired rollers shall be used for the second rolling. The second rolling shall follow the breakdown rolling as closely as possible and while the paving mix is still of at a temperature that will result in maximum density from this operation.

Pneumatic-tired rollers shall be continuous (at least three complete coverages) after the initial rolling until all of the mix placed rollers on the hot paving mix which causes undue displacement will not be permitted.

Finish Rolling

The finish rolling shall be accomplished with two-axle tandems or three-axle tandems while the material is still warm enough for the removal of the rollers marks. If necessary to obtain the required surface finish, the Representative Engineer shall specify the use of pneumatic - tired rollers. All rolling operations shall be conducted in close sequence.

In places inaccessible for the operation of standard rollers as specified, compaction shall be performed by trench rollers or others. The trench roller shall be operated at the direction of the Representative Engineer until the course is thoroughly compacted. Hand tamping, manual or mechanical, may be used in such areas if it proved to the Representative Engineer that such operations will give the desired density.

Shoulder

The shoulder material shall not be placed against the edges of the pavement until the rolling of the surface course has been completed.

Adequate precaution shall be taken to prevent distortion of the pavement edge from specified line and grade. When the rolling of the surface course has been completed and the edges have been thoroughly compacted, shoulder material shall be immediately placed against the edges and rolled.

Density and Surface Requirements

The completed pavement shall have a relative compaction equal to or greater than 98% (from daily Marshall) of a laboratory specimen and made form plant mix conforming to the result of density from samples taken on site.

The final surface shall be of uniform texture and shall conform to line and grade shown on the plans. Before final acceptance of the project, or during the progress of the work, the thickness of all courses will be determined by the Representative Engineer.

All unsatisfactory work shall be repaired, replaced or corrected.

Both density and thickness shall be carefully controlled during construction and shall be in full compliance with the plans and specifications. During compaction, preliminary tests as an aid for controlling the thickness shall be made by inserting a flat blade, correctly graduated, through the material to the top of the previously placed base, or by other means approved by the Representative Engineer.

In checking compacted depth, the cutting of the test holes, refilling with acceptable materials, and proper compaction shall be done by the Contractor under the supervision of the Representative Engineer.

For the purpose of testing the surface on all courses, a 3- meter long aluminum straight edge at the longitudinal direction shall be used.

Any irregularities which vary more than 3 mm in 3 meters 10% of the thickness shall be corrected. Irregularities which vary may develop before the completion of rolling shall be remedied as may be required. Should any irregularities or defects remain after the final compaction, the surface course shall be removed promptly and sufficient new material lay to form a true and even surface. All minor surface projections, joints, and minor honeycombed surfaces shall be ironed smooth to grade as might be directed by the Representative Engineer.

Sampling and Testing

Samples shall be collected by an approved saw or core drill, from the compacted moisture on the road. The equipment shall be capable of cutting the mixture without shattering the edges of the specimen or otherwise disturbing the density of the specimen.

The swaged samples shall be 10 cm (nominal) and cored samples shall be 10 cm in diameter (nominal).

Densities will be determined in accordance with AASHTO T 166, from the collected samples. Samples shall be collected in sets of 2 from the same location on the road and every 250 m or as directed by the Representative Engineer.

Penetration test in accordance with AASHTO T 49-80 will be carried out as directed by the Representative Engineer as well as ring ball test.