



Rehabilitation of Electricity Power Distribution Network in three areas in the Gaza strip

Technical Specification

for

Electrical & Civil Works

Technical Specifications For Installation and Civil Works

Scope of works

General

The scope of works shall include the necessary civil works, handling, transportation to sites, erection of all equipment and materials for the construction and installations of the distribution lines and networks, then Coordination with GEDCo to energize the installed lines and testing Before Acceptance.

Coordination

A detailed plan / methodology of the Works shall be prepared by the Contractor in taking into account that any existing network is to remain operational during the works.

The necessary power cut-offs and disturbances for the consumers shall be reduced to a minimum and the Contractor shall prepare a time schedule for these temporary shutdowns in close co-operation with the Engineer.

The Contractor shall anticipate these operations so that sufficient notice of the disturbances shall be given in advance in order to allow Gedco to inform the public.

Rehabilitation and extension of networks

Since modifications in the present network and repair works on existing lines and switchgear equipment are foreseen, the Contractor will have to inspect all sites and lines for which rehabilitation and extension works are called for. The situation described in the present document may have deviated from the actual situation at site.

This preliminary site visit is deemed as imperative since the rehabilitation and extension will have to be performed on equipment in operation.

The following task description for rehabilitation works is therefore of indicative character only and may not be complete in every respect.

The work for the rehabilitation of MV and LV lines shall be done according to the specifications and based on the unit prices given for Rehabilitation Work.

The price offered for the dismantling of the existing networks in the Schedule of Price shall be understood as total sum including all labor, site equipment and vehicles, necessary for loading, transportation, unloading, dismantling of old equipment and lines, erection and installation of new equipment and lines and cables as well as all auxiliary and ancillary work deemed necessary. The dismantled equipment shall be returned and delivered to the GEDCo's warehouse.

Lines Routes

The routes for the MV and LV lines are given in the drawings annexed to the present document.

The quantities of equipment for the medium and low voltage networks are resulting from the engineering studies and from preliminary site visits and the basis of line length and angles, taking into account the span data of the poles given in the related specifications.

The final line route of the lines will be rechecked by the Contractor and Gedco after the contract award.

The final and detailed line route survey and profile drawings are in the responsibility of the Contractor.

MV Lines

General

All the descriptions and line length indications are given in the detailed drawings.

The works to be executed shall consist of:

- a) The construction of new overhead three-phase single-circuit 22kv Distribution lines, including load-break Switches.
- b) The installation of 22kV underground cables and their connections, including switchgears (load-break switches, Ring main Units, etc.).

All of the new MV overhead lines are to be designed and constructed for operating 22kV system voltage and equipped with a conductor of type ACSR or Copper.

All of the new MV underground cables are to be designed and constructed for operating 22kV system voltage and equipped with XLPE Cables.

Overhead MV Lines

The main tasks to be performed in the construction of the lines shall include, but not necessarily be limited to, the following:

- a) Carry out the line survey on base of the maps and drawings supplied by the Engineer
- b) Verify the repartition of MV towers
- c) Set up of future tower locations at sites and stake-out the tower bases
- d) Clear out the rights-of-ways for distribution lines (overhead and underground)
- e) Checking of quantities of materials and equipment
- f) Loading at GEDCo's warehouse, transportation to site, unloading at site of all equipment, materials and cables
- g) Line survey and staking of towers
- h) Setting-out the tower location to Avoid harming and damaging the infrastructure during the stage of implantation and construction by initiating consultations and communications with the relevant authorities and municipalities
- i) Excavation

- j) Set-out and erect the towers bases
- k) Supply the materials necessary for and construct the tower foundations
- 1) Install the buried earthing system at each tower
- m) Erect the towers complete with cross arms and necessary frames
- n) Install the insulators (strings and/or pin type) and associated hardware
- o) Install the Neutral wire accessories
- p) Perform the pulling-out, stringing and clamping of phase conductors and Neutral wire
- q) Install anti-climbing devices
- r) Install complete, including the dead-end insulator assemblies at dead end poles, all insulators, conductors, Neutral wires and accessories required to terminate a line on the dead end poles
- s) Installing transformers with all accessories
- t) Install the tower-mounted load break switches
- u) Installation of tower-mounted lightning arresters
- v) Connect all equipment to the earthing rods
- w) Testing of the earthing System for all poles and towers, or as directed by the Engineer
- x) Testing of the lines and tower-mounted equipment
- y) Provide the necessary staff and instruments and assist Gedco teams in the commissioning stages of the networks.

The Contractor is requested to quote firm unit rates for the different types of foundations and towers as set out in the Schedule of prices. These unit rates will be considered as flat rates covering all foundation costs for any type of soil encountered along the line and no adjustment of the rates will be permitted.

If, according to the Bidder and following the site visit, necessary types of foundations are missing in the Bill of Quantities, the Bidder shall provide to the Engineer a description of this finding-out.

The number of towers set out in the Schedule of Prices against each type may change, as well as the numbers of specific types of foundations. Their numbers will be adjusted and remunerated according to the quoted unit rates. This will, however, is entitled the Contractor to a change of the quoted unit rates or to any other additional claim after the signature of the Contract but not limited rates exceed 10% of the value of the contract.

Low voltage overhead lines

Rehabilitation of existing low voltage lines

30 years ago the existing low voltage networks consist mainly of steel or wooden poles that were originally erected with different types of bare conductors either made up from aluminum or copper and stranded conductors.

The Contractor shall:

- □ dismantle all poles, hardware, conductors and fittings which have to be discarded and warping the old conductors and cables to move all them to Gedco Warehouse ;
- **□** Reinstate and clean the areas affected by the dismantling works.

The final details of rehabilitation and the real quantity of materials and conductors shall be carried out by the Engineer and the Contractor during their joint site visit.

Rehabilitation shall be done preferably with new metallic poles especially at angle and dead end points. No stay wires are used for new steel poles.

All bare conductors shall be replaced by aerial bundled conductors (ABC).

Materials returned to GEDCo warehouse from the project, this materials will counted before implementation and signing the official receipt by the contractor and supervising engineer.

New LV Lines

The new LV lines shall be erected on steel poles or wooden poles with low voltage bundled cables.

The main tasks to be performed in the construction of the LV lines shall include but not necessarily be limited to the following:

- a) Verify the line survey (profile, repartition of LV poles) shown on the maps and drawings supplied by the Engineer
- b) Clearing the rights-of-ways before construction
- c) Checking of quantities of materials and equipment which will used
- d) Checking of quantities of materials witch will returned to GEDCo warehouse
- e) Loading at warehouse, transportation to site, unloading at site of all equipment, materials, poles and cables
- f) Staking of poles
- g) Setting-out the poles locations at site
- h) Excavations
- i) Erect the poles complete with hard wares and necessary devices
- j) Install and connect the earthing system.
- k) Perform the pulling-out, stringing and clamping of conductors
- 1) Perform the connections between feeders and branch feeders and install necessary clamps
- m) Connect subscribers to the network and install necessary clamps
- n) Perform the connections to the distribution switchboard or Load Break Switch
- o) Installation and connections of the street lighting fixtures
- p) Commissioning and testing of the lines.
- q) Provide the necessary staff and instruments and assist GEDCo in the commissioning stages of the networks.

Design conditions

Site conditions

The climatic conditions are as follows:

- geographic location
- □ altitude
- mean ambient temperature
- : as abovementioned
- : from -10 m to 200 m above sea level
- : from plus 5° to 40°C

- max and min ambient temperature
- □ humidity
- □ annual average rainfall
- □ maximum wind velocity
- □ pollution

: 95% : 700 mm

- : from 10 (normal) to 80 km/h (gale)
- : light, few sand wind

from 2° to plus 45°C

Electrical Systems data

The MV systems are rated 22 KV three phase type, 50Hz, three phase conductors and one Neural distributed along the network.

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The LV systems are rated 400/230 V, three phase type, 50Hz, solidly earthed, four wires including the three phase conductors and the neutral distributed along the network.

Description	Unit	22 Kv	0.4 kV
Nominal system voltage phase to phase	kV	22	400/230
Highest voltage	kV	24	1
Minimum Design Short circuit Current (1 sec. arch test)	kA	25	25
Impulse withstand voltage $(1.2/50 \ \mu \text{ sec wave})$	kV	125	12
Power frequency withstand voltage (1min.)	kV	50	2.5
Rated creepage distance over outdoor insulators (33mm/kV)	mm	800	100
Creepage distance over outdoor insulators for the areas near the sea (44mm/kV)	mm	1050	100

Basic design of MV overhead lines

The MV overhead lines are designed on the basis of PEA (Palestinian Energy Authority) and IEC (Israeli Electricity Company) standards, as follows:

General

- □ conductors will be ACSR {Rabbit(61.7mm2), 95/15(109.7mm2) & 150/25 (173.1mm2)};
- line supports will be hot dip galvanized channel steel shape or lattice type steel square towers or wooden Poles;
- □ foundation in concrete B200;
- □ Straight Insulators will be Pin type polymeric or Porcelain;
- □ Large angle and dead-end towers will be equipped with glass or polymeric required tension set insulators.

Steel towers

Two types of towers shall be used:

- Channel shape type, for straight line and small line deviations;
- Square lattice type, for large angle, line dead-ends and long distance.

The standard height of towers is 12 m from ground level to top. When required, this height can be increased by installing tower extension or longer bases as required. All towers shall be erected on corresponding steel bases embedded in concrete foundations.

Insulators

Insulator strings shall be polymeric type with required fitting or strings composed of individual, insulator units consisting of glazed porcelain or toughened glass shell and metallic caps and pins with ball and socket fittings, according to I.E.C. standards

The fixation of the conductor to the insulator strings shall be by bolted type strain clamps.

Pin type insulators

All pin type insulators will be mounted vertically. The insulator shall be mounted complete with stud assembly, nuts and lock washers on the cross-arm and/or at tower top. The conductor shall be fixed to the insulator on the appropriate groove by prefabricated ties.

Conductors sag and span:

The phase conductors and the Neutral wire are selected as being aluminum conductor steel reinforced type ACSR Rabbit, 95/15 & 150/25 and all sag and span and tension calculations as per Gedco Specification, Will be submit to the contractor by the Gedco engineer to apply and the Contractor shall follow calculation tables and drawings accurately.

Earthing resistance values

The resistance values to earth of the all installations shall not be higher than:

- □ Required tests shall be taken in the presence of GEDCO engineer.

Basic design of LV overhead lines

Lines

The LV lines shall be aerial isolated bundled conductors (ABC) supported on wooden or steel poles.

Taking into account the low impedance of this type of overhead line and:

- □ maximum distance of 30 m between customers;
- □ customers each side of the street;
- □ 7 % maximum voltage drop.

According to the cables capacity, generally outgoing feeders from the transformer will be by 150mm² or 95mm² phase conductors; laterals will be by 95mm² or 50mm² cross section

Supports for low voltage lines

LV line supports will be wooden or hot galvanized steel channel poles.

The following functional types of poles shall be used for the LV lines:

The standard pole height shall be 9 m for steel channel poles and 8.5m for wooden Poles

The loads imposed on the poles are:

- wind loads on conductors, structures
- weight of conductors
- conductor tensions
- **a** additional loads such street lighting fixtures, stays, etc.

If necessary, at line deviations, tap-off and dead end, poles may be stayed or a structure may be adopted provided that the stay does not hamper pedestrians and vehicles traffic nor create any danger to the public.

Stay(s) must be installed exactly opposite either to the bisector or the tee-off or to the line direction; the distance at ground level from the stay to the pole must be at least 0.6 times the pole height above ground.

Line conductors

The line conductors shall be insulated bundle cables, referred to as ABC (aerial bundle conductors) the cross-sections of which range from 3x50 sq.mm to 3x150 sq.mm. The neutral conductor is an insulated cable and is used as a messenger having a cross-section of 95, 70 or 54.6 sq.mm and sometimes using self-supporting ABC cables.

Connections of LV lines

All LV lines shall be connected to load break switches witch mounted on transformers steel poles.

The LV ABC Cables should be clamped by Plastic cable ties as instructions of Gedco engineer.

The contractor should supply and install necessary Concrete B300 Reinforcing with mild steel base for stay unit as flow Dimensions:



Basic design of distribution Transformers

<u>General</u>

The distribution Transformers shall be of tower-mounted type and shall be equipped with the necessary steel frames supporting the intermediate insulators, the glass fuse holder, the transformer and the distribution L.V Load Break Switch.

Each distribution Transformers shall be protected on the MV side by surge arresters.

Transformers

All transformers 22/0.4kv outdoor, at primary side, transformers are protected by surge arrestors and glass fuses. The transformer capacity ranges from 250 to 800 kVA.

General Requirements

Contractor's obligations

The Contractor shall act as a complete construction organization furnishing all supervision, labor, tools, camps, storage yards, apparatus, equipment and conveyances necessary for the specified works.

GEDCo shall provide all Materials, supplied by others, for the Work and the Contractor shall furnish all other material required for the Work covered by this Specification.

The Contractor shall provide for storage at site of all materials to the extent required, shall haul and distribute all materials to the points where they are to be erected and shall erect the materials in accordance with this Specification and Drawings.

Site storage yards shall be secured and rented and guarded by the Contractor. These storage yards shall be kept neat and clean and growth of grass and weeds shall be controlled.

The price bid under each item shall include all labor equipment, materials, expenses and costs which are not to be classified under any other item or items and which may be necessary to completely perform the work to be done under said items in the manner herein set forth and specified.

The Contractor shall, without additional compensation therefore, co-ordinate and joins together all the various subdivisions of the work and produces, test and operates complete erected lines.

The Contractor shall carry the sole responsibility for the employment and the assignment of his personnel to this project according to the regulations in force.

The Contractor shall be responsible for assigning the staff and personnel having the necessary competence and experience to carry out the tasks required for the works.

All work shall be done and completed in a thoroughly workmanlike manner in accordance with best modern practice for construction of distribution lines, notwithstanding any omissions from this Specification or Drawings.

Auxiliary work

All and any kind of work, material, services, safety measures, etc., as well as all tests and samples requested by the Engineer and required for the completion of the work, shall be included in the contract amount. The auxiliary work comprises, but is not necessarily limited to, the following:

- a) Removal and storage of boundary stones, bench marks, etc.
- b) protection of survey points, designations by means of boards
- c) Survey and protection of all secondary survey points, profiles, etc.
- d) solution of difficulties where excavation may have to be carried out in layers
- e) Keeping off or diversion of water, including any pumping required, difficult work caused by water, etc.

- f) removal of any underground obstacles, buried pipes, waterworks, and the like which might interfere with excavation profiles, irrespective of whether or not such obstacles are specified in the Tender Specifications
- g) solution of difficulties resulting from the Tender Specifications with regard to fills, compaction tests, elimination of unsuitable material from fills and, if necessary, mixing of different soil materials
- h) transport of excavated material to fill or deposit, placing and spreading in layers according to conditions and drawings, and careful compaction
- i) solution of difficulties in transport due to existing site, ground and road conditions
- j) grading of intermediate and top fill surfaces and slopes to final levels required
- k) sorting of excavated material which, if necessary, is to be used for special purposes
- 1) Any expenditure for provision, maintenance and later removal of driveways; maintenance of existing ways and roads: provision, placing, maintenance and later removal of conveying and dumping equipment which might be required.

All and any kind of work, material, services, safety measures, etc., as well as, and if so requested by the Engineer, all tests and samples required during the works shall be included in the tender but are not necessarily limited to the following:

- a) measurements for the execution and payment of the work, including provision of the measuring equipment, gauges, marking-out pegs, etc., the maintenance of the gauges and marking out pegs during building construction, and the engagement of labor
- b) provision of small equipment and tools
- c) transport of all material and components, even if ordered by the Engineer, from the GEDCo's warehouses to the site storage, and return transport if required
- d) supply of all required materials
- e) securing the work against surface water, which must normally be reckoned with,
- f) safety measures during the work to prevent damages to all human beings (site personnel, GEDCo personnel, Engineer's personnel, public) as well as to public and private vehicles and properties according to the regulations in force
- g) protection of the placed concrete against heat, wind, cold, chemical attach, vibration, and drying outwork of proofing the quality of the building material and of the concrete in accordance with all of the requirements of the Tender Specifications
- h) laboratory test as directed by the GEDCo Engineer and according to standards
- i) removal of all pollution resulting from the Contractor's work, and of the Contractor's debris
- j) protection of the completed works and the articles handed over for construction against damage and theft until acceptance
- k) arrangement of any kind of joints required
- 1) fixing of embedded parts in proper position, material supplied by the Contractor and/or others
- m) Apparatus, equipment and tools required for testing.

Taking over of the equipment and materials by the Contractor

All equipment and materials shall be inspected by the Contractor, Gedco Engineer and the Head of the warehouse, or their representatives, before being handed over to the Contractor.

These equipment and materials shall be listed in details on a Taking-Over form signed by the concerned parties.

Return of surplus equipment and materials by the Contractor

In case of surplus of equipment and materials either delivered to the Contractor by GEDCo and which has not been used for the Works, such surplus shall be returned by the Contractor to GEDCo's warehouses.

On delivery at warehouses, all such equipment and materials shall be inspected by both the GEDCo Engineer and the Head of the GEDCo's warehouse or their representatives, in presence of the Contractor, or his representative, before being accepted as delivered equipment/materials to the GEDCo's warehouse.

After acceptance, these equipment and/or materials to be delivered shall be handed over to the warehouse and subjected to a Material Receipt Bill, signed by the GEDCo Engineer, the Warehouse Head and the Contractor, or their representatives.

Site survey

General

The Contractor shall keep damage within the right-of-way to a minimum, consistent with the successful execution of the erection works. The Contractor shall exercise all precautions to avoid damage to other property. The Contractor shall comply with all national and local regulations regarding barriers, roundabout ways, road and warning signs, etc. Damage to roads, footpaths, bridges, ditches, etc., caused by the Contractor shall be repaired at his own expense

Clearing of rights-of-way

The Contractor shall clear the right-of-way, fell any dispose of waste material along the entire length of a Electric line.

Cutting trees is acceptable only in cases of emergency and after taking approvals from municipalities and land owners.

GEDCo will make the necessary arrangements with landowners so as to permit the Contractor the trimming of trees located both inside and outside the right-of-way where trimming is necessary.

The Contractor shall remove and dispose of any felled trees, waste material and useless packaging material to the satisfaction of the Engineer.

Provisions for access to sites and poles

The Contractor shall provide and maintain all access from the main roads to the distribution line routes during erection as required by the Engineer and convenient to him.

The Contractor shall provide necessary Cars for the transfer of GEDCo project monitor engineers and surveyors from GEDCo to work sites and vice.

The Contractor shall comply with all national and local regulations regarding barricades, detour arrangements and warning signs. Damages to roads, footpaths, bridges, ditches, etc., caused by the Contractor shall be repaired at Contractor's own expense.

No separate payment shall be made to the Contractor on account of building or repairing the access lanes.

Handling and storage

After the towers and poles have been handed over to the Contractor at the GEDCo's warehouses, any material damage shall be replaced by the Contractor at no cost to GEDCo.

Where galvanizing is broken for any cause the bare metal shall be painted or regalvanized by the Contractor in accordance with approved galvanizing procedures. It is the Contractor's responsibility to bring to the attention of the Engineer any damage to galvanizing or any defects in structural steel observed during erection or any fabrication errors in steel. The Engineer shall then decide whether the material is to be rejected at the cost of the Contractor or used after repair.

Spanners and wrenches

During the erection of towers, no tool shall be allowed up the towers, except the box spanners and socket wrenches. Only tools designed to prevent nuts deformation and injury to galvanized coating by flaking or cutting will be permitted for use. The Engineer may order the testing of questionable tools before permitting their use.

Tightening of bolts

Each bolt shall be securely tightened in accordance with the manufacturer's recommendations. Proper tightness shall be spot checked by the Contractor with an accurately calibrated torque socket wrench. The Contractor shall specify the maximum torque that can be applied for each bolt size. The Contractor shall provide the Engineer with such calibrated torque wrench for checking proper tightness of the tower bolts. The Engineer will verify the bolts for proper tightness after conductors are installed.

Bolts that show any sign of thread stripping or other deformation shall be replaced. All towers shall be completely tightened before being erected and left in workmanlike condition, complete and safe in every respect.

Mismatched holes

A reasonable amount of drifting will be allowed in assembly of towers, but reaming for correction of mismatched holes due to shop errors will not be tolerated. Any drifting used shall not distort the metal or enlarge the holes.

Safeguarding of tower galvanization

During the erection of the conductors, insulators, and fittings, all necessary precautions shall be taken to avoid any damage to the structure galvanization by scraping; this requirement is applicable throughout the construction.

To avoid damaging the galvanization of the bolts and nuts, these must be tightened by means of socket wrenches.

Mounting of anti-climbing devices

Anti-climbing devices, constituted by pikes belts, shall be installed on each tower. The mounting height shall be about 4.00 meters above ground level, Or as determined by the supervising engineer.

Earthing of equipment, hardware and earth wire

All pole-mounted equipment such as overhead switches, steel frames, surge arresters, cable sealing ends (screens), shall be connected to the earthing System through a copper conductor.

All steel frames, operator platforms, and in general all metallic supports installed on the structure shall be earthed through a copper conductor.

The grounding of the earth wire shall be through a short length of same conductor tapped from the overhead line by appropriate connector at one end, the other end being secured through a grounding terminal bolted on pole/tower body at a level nearing the line. The grounding terminal shall be connected to the pole/tower earthing System by copper conductor.

Inspection

Towers must be completely erected with all members in place and bolts securely tightened before any stringing of conductors or earth wire may be started. All towers shall be inspected by the GEDCo Engineer accompanied by the Contractor before the stringing operation.

Foundations of MV line towers

(This section are generally to be carried out in compliance with Section " <u>CIVIL WORKS</u> " of this specification.

General

This chapter applies for foundations for any approved type of distribution MV line pole / tower.

The details of measurements of foundations for each tower base should be providing from GEDCo.

Tower foundations shall normally be of either reinforced or mass concrete type. Each foundation shall be submitted by the Contractor for approval by the Engineer.

The tower foundation installation shall include tower site preparations, leveling, excavation, foundation placement measurements, assembly and placement of the approved foundation, backfill, compacting and cleanup of each site.

The Contractor shall remove all vegetation and other debris from the tower site which will interfere with his operation. Tower preparation shall be done in a manner which will prevent revision of the footing designs or requirements of leg or body extensions.

Settings

All foundations shall be assembled, placed, and set to the levels, measurements and batters shown on the approved setting diagram. For all settings a maximum tolerance of 6 mm or less, if indicated, will be allowed on any dimension.

Care shall be taken to ensure that all tower bases, stub-angles or anchor bolts are held in place as required to maintain their correct positions during backfilling or placing of concrete for a period of at least 12 hours thereafter.

The Contractor shall provide rigid steel templates or other means for accurately positioning and maintaining either the tower bases, or the stub-angles or the anchor bolts to the specified dimensional tolerance. If template is used, it shall be of a design approved by the Engineer.

Installation of tower earthing

The general arrangement of the earthing circuit shall be as shown on the drawings.

The Contractor shall install the earthing circuit and shall measure the footing earth resistance of each tower.

Where the value of such resistance is more than 5 Ω , any tower base shall be connected to a driven ground rod located at a minimum of 5 meters from the tower base. After such installation the earth resistance shall be measured again and if the resistance is higher than the specified value, the Contractor shall proceed to make similar installations for the remaining tower bases.

All wires shall be handled and installed in a workmanlike manner free from kinks and damage of any kind. Backfill of trenches for earthing conductor shall be thoroughly compacted.

Earthing of tower structure shall be made as required by soil conditions and the value of earth resistance at each tower location. Two or more ground rods per tower shall be installed depending on the requirements.

Installation of accessories

Insulators and fittings

Insulators and fittings shall be transported in appropriate boxes. All insulators shall be handled carefully during transportation, assembling and hanging.

Insulators having any apparent defects, shall be set aside by the Contractor for examination by GEDCo and if rejected shall be so disposed of that they cannot again be presented for use.

The insulators shall be clean when hung; the insulating portions shall be bright and all other parts free from dirt.

The insulator strings shall be assembled by the Contractor complete and in accordance with the details shown on the final equipment drawings.

For insulator strings:

- □ The Contractor shall ascertain that all safety pins and locking devices are in the proper locking position.
- During the whole erection operation, the assembled insulator strings shall be kept in such a position as to avoid any excessive strain on the pins, balls and sockets.
- □ Any suspension insulator strings shall be mounted so that the pin and locking device openings on the individual insulator units are on the Top of toward Arm.
- □ Insulator shall be placed according to fabricator's recommendations.

Installation of insulators and line hardware's

Insulators shall be clean when hung. Detergent and clean rags shall be used to remove mud, grease, dirt and other foreign matter. Disc surface shall be wiped to a bright finish and metal surfaces shall be free from any noticeable contamination.

Insulator strings shall be handled so as to avoid bent pins or chipped glaze. Chipped, cracked or score insulators shall not be installed; the Contractor shall immediately inform the Engineer about any defect encountered. Workmen shall not climb upon insulator strings after installation.

Hardware and accessories shall be handled to prevent contact with the ground. All items shall be clean and inspected for missing parts or visual defects before installation.

All connections shall be made in accordance with the GEDCo's drawings and as recommended by the manufacture, bolts firmly tightened, split pins inserted where required, all in a good workman-like manner according to the best practice of Distribution line construction.

Tension assemblies, respectively dead-end assemblies, shall be installed in accordance with manufacturer's recommendations.

The Contractor shall supply all necessary accessories, i.e. special tools, compressors, draw benches, etc. required for making dead-ends for conductors.

For the installation of the bolted type tension clamps, care has to be taken to guarantee the correct position of the conductor before being clamped by appropriate bolts tightened to the torque specified by the manufacturer.

All pins used in clevises, suspension clamps and other line hardware shall be installed in such a manner that the head of the pin is in the highest position so that the pin will not drop out if the split pin is lost.

All sockets shall be turned so that the open side faces the ground on all insulator assemblies which are to be installed in a substantially horizontal position in order to facilitate drainage of water.

Imperfectly or poorly galvanized hardware as detected by the Contractor and verified by the Engineer shall not be used. Such pieces shall be replaced with new hardware.

All the conductors shall be fixed by Distribution ties on the insulators.

Installation of conductors

Scope

This section covers the provision of the materials and the execution of all works needed for the complete erection of overhead lines.

The Contractor shall join string and sag the conductors in accordance with the final sag and tension tables supplied by the Engineer. The Contractor shall check the correctness of these tables and based on them he shall prepare his own initial sag and tension tables for use in field operations. The initial sag and tension tables are subject to approval by the Engineer.

General technical requirements

The Contractor shall make any necessary special arrangements for unrolling and sagging the conductors or cables where the route crosses buildings, roads, plantations, gardens or other ground over which the erection cannot be carried out in the normal manner.

No extra charge for handling of material or for any special precautions or methods necessary at such positions shall be allowed.

When the Contractor is about to carry out erection of the conductors or cables along or across power or telephone lines, public roads, waterways, he shall be responsible for giving the requisite notice to the appropriate Employers of the date and time at which he proposes to carry out the work.

The Contractor is responsible for the safety of utilities along or across which the works are being performed. In this way, protections shall eventually be placed to ensure the safety of these utilities. The number and placement, the specifications of such protections is under the responsibility of the Contractor. The price for these protections is included in the Contract Price. No additional payment shall be made for special crossings, such as power lines, roads, valleys and passing over cultivated or built-up areas.

No joints are admissible in spans crossing other lines, roads, buildings, or other obstacles.

At his own cost and at his own responsibility the Contractor shall take all necessary steps to avoid any accident, breakdown, power outage of other lines, and other inconveniences.

Conductors utilization scheme

The Contractor shall exercise his best care to optimize the use of the conductor's reels or drums (overhead wires and underground cables) in order to reduce the quantity of left-over conductors i.e. reducing the short lengths of cables/conductors that cannot be further fit to the networks.

In this view, the Contractor shall prepare, for each section of the networks, a utilization scheme of the conductors showing the expected length to be installed and the list of the reels intended to be required from the warehouse.

This document shall be transmitted by the Contractor to the GEDCo Engineer for information.

The list of the available reels of conductors and cables shall be provided by GEDCo to the Contractor for this purpose.

Drums

Drums shall be transported on either Lorries or trailers or purpose-built drum carriers; the drums shall not be rolled on the ground.

Drum battens shall only be removed if the drums are properly mounted at the drum station on the line and these battens shall be immediately refitted to the drums if any surplus conductor or cable remains thereon following the stringing of a section.

Unrolling, stringing and sagging

General

The fullest possible use shall be made of the maximum conductor lengths in order to reduce the number of joints to the minimum.

The number and location of line joints shall be approved by the Engineer.

Conductor Unrolling

The Contractor shall follow the regulations of IEEE Standards 524 "IEEE Guide to the Installation of Overhead Transmission Line Conductors" or other equivalent standards.

For the whole length of the lines, the conductor tension stringing method to be used will not cause damage to the conductors, and at no time allow the conductor to touch the ground or any obstacle such as walls, fences, and buildings.

Conductor or cable which has been unrolled must not be left overnight either on the ground or within 5 m above ground level.

Conductor shall be strung by the "controlled tension method".

Sections of the conductor or cable damaged by the application of gripping attachments shall be removed before the conductors are sagged in place.

Tools

The conductors, joints and clamps shall be installed using approved tools and in such a manner that no bird caging, over tensioning of individual wires or layers, or other deformation or damage to the conductors occurs.

Surface greasing of conductor

Unless otherwise specified by the cable manufacturer, the conductor shall be suitably cleaned and coated with grease of approved type at the joint of attachment of fittings immediately before final assembly of any fitting. All surplus grease shall be removed after assembly.

Sagging method

For determining sags, the "equivalent span" method is to be used for spans.

On steeply sloping ground however, the more accurate span-by-span analysis may be called for.

The Contractor shall ensure that as far as possible all conductors are subjected to identical loading treatment before sagging, and shall inform the GEDCo Engineer when the conductors are being sagged prior to clamping in, to permit the verification of sags if they wish.

Immediately after the conductors have been erected and clamped in, the mean sag of conductors shall not differ from the correct erecting sag by more than 30 cm, unless otherwise approved.

Furthermore, the difference between the sags of different phases shall not exceed 20 cm.

The Contractor shall record on approved schedules the particulars of the sagging on each section of the route. The date of stringing as well as the ambient temperature and conductor temperature shall also be recorded.

The Contractor shall provide suitable dynamometers, thermometers, sighting rods, levels and other approved apparatus necessary for the proper checking of the work.

Suspension insulator strings, which after stringing are inclined in the direction of the line, shall be straightened by the Contractor at his own expense and in accordance with a method approved by GEDCo.

After being pulled into the sheaves, the cable shall hang on the stringing block for at least 48 hours, before being pulled to the specified sag. Sag tables with initial sags shall be submitted to the GEDCo Engineer for approval.

For all towers types, the towers shall not be subjected to any loading during stringing or sagging which is not expressly shown on the tower loading sheets.

At all tension structures, the conductor shall be attached to the insulator assemblies by deadend tension clamps respectively and all nuts and compression fittings shall be adequately tightened in accordance with the recommendations of the Manufacturer.

Dead-end jumper loops, or jumper connections, shall be of proper length and formed so that electrical clearances are maintained with regards to all tower steel elements under normal loading conditions.

Clearances

At the time of sagging, the Contractor shall make sure that the minimum clearances are obtained under the most unfavorable working conditions.

The Contractor shall notify GEDCo immediately if, for any reason, these clearances cannot be achieved; for clearances not especially specified, the local laws and regulations shall apply.

During the stringing operation and before sagging is completed, the Contractor shall ascertain that all clearances would conform to the drawings and that the limiting requirements for clearances between the lowest conductor and surrounding obstacles at maximum sag are met.

If the above requirements are not found possible in particular cases, the Contractor shall bring the attention of the Engineer about these conditions and shall propose the means to cope with the difficulties.

Stringing

The conductors and Neutral wires shall be installed by conventional method for the MV lines. The method is subject to the approval by the Engineer.

The Contractor shall submit in writing for approval a complete and detailed description of the stringing equipment, stringing and sagging procedure intended for use.

The Contractor shall supply all necessary tools and stringing equipment which shall be subject to the approval of the Engineer. Under no circumstances shall the conductors be allowed to contact the ground or any other obstacle.

The stringing equipment and operation shall be such as to avoid overstressing tower structures or foundations. Any damage to towers or foundations occurring in such an operation shall be made good at the expense of the Contractor. Non-metallic lagging shall be used to protect any part of any structure which may be subject to abrasion by the pulling line or which may damage conductor passing over it.

Conductors shall be strung carefully to avoid loosening of strands, scraping, nicks or other damage.

The neutral wire should be fixed in low voltage insulator which installed on the tower according the specified drawings.

The Contractor should know the bending radius of all type cables and wires before installation.

Compression-type joints

The compression-type joints for phase conductors and Neutral Wire shall be compressed in strict compliance with the Manufacturer's recommendations, and in such a manner that they shall develop, when finished, full conductivity and full mechanical strength.

Particular care shall be taken to make sure that the cables and bores are clean before inserting the cables into the barrels. The ends of cables shall be cut off beyond any damaged or missing wires.

No joint will be permitted within 20 m of a suspension clamp or within 50 m of a tension clamp and not more than one joint per cable will be permitted in any one span.

Strain clamps

The strain clamps shall be of bolted type. The tightening of the bolts shall comply with the manufacturer's recommendations.

Splices

Full tension splices shall preferably be made with pre-formed line splices or alternatively compression joints.

When damage to a conductor does not exceed three Aluminium strands, either broken or nicked deeper than one-third of their diameter a repair splice or sleeve shall be installed and where this limit is exceeded the damaged section of the conductor shall be cut out and spliced with the above-mentioned preformed line splice or compression joint.

A maximum of one splice per conductor or Neutral wire will be allowed in any phase in any span. No splices shall be located in any span crossing main roads, valleys, major communication or power lines.

There shall be no joints in jumper conductors between tension strings. No joints shall be applied at less than 10 meters from attachment point at towers. In case of compression joints utmost care shall be taken to ensure that during jointing the sleeve remains well centered on the conductor core after compression.

Unsatisfactory joints shall be cut out and replaced at the Contractor's expense.

The making of compression joints and any application of repair sleeves shall be done only in the presence of the Engineer and shall be stamped with an approved stamp.

Records of the positioning and the characteristics of all splicing and application of repair sleeves shall be kept and handed-over to the Engineer.

Field tests

MV overhead lines

Prior to testing or energizing, the Contractor shall provide, for authorization, the GEDCo Engineer with a written statement that all temporary earthing points are disconnected and withdrawn and that the line is ready for energizing, indicating the tentative date and time at which he intends to carry out the tests.

After receiving the written approval from the GEDCo Engineer, the Contractor shall dispatch the information to public and his staff, and shall take the necessary measures to ensure that the safety conditions are met for the tests.

The Contractor shall conduct the tests in the presence of and as instructed by the GEDCo Engineer. If any failure is detected, the Contractor shall locate and determine the cause of failure and shall make any replacement or repair necessary or correct any errors in the installation to the satisfaction of the Engineer and at no cost to GEDCo.

A field test report shall be prepared by the GEDCo Engineer and signed by the GEDCo Engineer and the Contractor on the successful completion of the tests.

The report shall indicate the following:

- Geographical position of the line
- □ Length of the line and type of conductor
- □ Location of the testing equipment
- □ Ambient temperature
- **D** Temperature of the conductor
- Detailed description of the tests and results
- Date and hour of the tests

Tower-mounted MV load break-switches

Installation works

The MV load-break switches, to be installed at top of towers, are manually operated from the ground.

The typical arrangement is shown on the construction drawings.

The Contractor shall install the load-break switches and ancillary equipment at locations along the MV lines as indicated on the layout drawings.

The works, at each relevant tower, shall comprise the installation of the following:

- the load-break switch and its frame
- □ the control rod and the linkage
- the operating handle and its support
- the operator metallic platform with its fixations
- the connections of both ended MV lines to the load-break switch
- □ the installation and connections of the earthing conductor to the above mentioned equipment and to the earthing system.

The Contractor shall carry out the necessary adjustments, based on the manufacturer's instructions manual, to ensure the proper operation of the equipment.

The Contractor shall take all appropriate safety measures for his personnel during the erection works and for the connections of the load-break-switch to the MV lines.

Erection of low voltage line poles

General

This section covers the provision of the materials and the execution of all works needed for the complete erection of low voltage overhead lines.

The same general technical requirements of the medium voltage overhead lines are applicable.

The low voltage lines shall be of the bundled conductor type installed on hot galvanized steel poles.

The details of the equipment are given in the relevant drawings.

Handling and storage

The damages due to mishandling of the poles shall be replaced by the Contractor at no cost to GEDCo.

Where galvanization is damaged for any cause the Contractor shall do the proper process of steel isolation according to the directions of GEDCo Engineer.

It is the Contractor's responsibility to bring to the attention of the Engineer any damage to galvanization or any defects in structural steel observed during erection or any fabrication errors in steel.

The GEDCo Engineer shall then decide whether the material is to be rejected at the cost of the Contractor or used after repair.

Safeguarding of pole galvanization

During the erection of the conductors, insulators, and fittings, all necessary precautions shall be taken to avoid any damage to the structure galvanization by scraping; this requirement is applicable throughout the construction.

To avoid damaging the galvanization of the bolts and nuts, these must be tightened by means of socket wrenches.

Earthing of poles

Especially in regions where soil resistivity is high, each pole shall be earthed in order to minimize the risk of electric shock to human beings in case of either line earth fault or lightning stroke.

Stays and guy wires

Stays shall be installed at staked locations approved by the GEDCo Engineer. Points of attachment to poles shall be as shown on construction drawings. Stays shall be installed before conductors are strung.

Anchors and rods shall be in line with the strain and shall be so installed that approximately 20 cm of the rod remains out of the ground.

In cultivated fields or other locations, as deemed necessary, the projection of the anchor rod above earth may be increased to a maximum of 30 cm to prevent burial of the rod eye. Under no circumstances shall be backfilled and tamped in the same manner as for pole holes, as the anchor has to be set in undisturbed.

The setting of each anchor as regards to depth and position shall be inspected by the Engineer before the anchor hole is backfilled.

Stay insulators shall be installed on stay wires in accordance with construction drawings whenever stay wires are not bonded to a pole ground.

Inspection

The setting of all erected poles shall be inspected by the GEDCo Engineer before the installation of the overhead lines and in presence of the Contractor.

Installation of accessories

Fittings shall be transported in appropriate boxes.

Fittings having any apparent defects shall be set aside by the Contractor for examination by GEDCo and if rejected shall be so disposed of that they cannot again be presented for use.

Compression joints

Compression type joints should be used for joining the neutral messenger and the conductors.

Clamps

Use and installation of clamps for the bundled conductors shall be done according to the specifications.

Self-piercing connectors

The self-piercing connectors shall be used for all connections between the ABC feeders and branches, reconnecting existing and proposed connections and for the connections of the street lighting fixtures.

These connectors shall be installed according to the manufacturer's instructions and tightened at the specified torque.

Installation of conductors

Cable reels

Cables and conductors reels shall be transported on Lorries or trailers or reel carrier vehicles. The reels shall be not rolled on the ground.

Drum battens shall only be removed if the drums are properly mounted at the drum station on the line and these battens shall be immediately refitted to the drums if any surplus conductor or cable remains thereon following the stringing of a section.

Unrolling, stringing and sagging

General

The sags and tensions of the bundled conductors at various temperatures are annexed to this technical specification.

For ABC cable, the maximum sag has been calculated in consideration of a maximum ambient temperature without wind. For practical purposes, no additional temperature allowance has been taken into account since the messenger is the neutral conductor and is assumed to carry limited current under balanced conditions.

The Contractor shall follow the regulations of IEEE Standards 524 "IEEE Guide to the installation of Overhead Transmission Line Conductors" or the Code of Practice given in annex of the present document or other equivalent standards.

Conductor unrolling

For the whole length of the lines, the methods of tensioning and stringing which will not cause damage to the conductors and insulation shall be used, and at no time is the ABC bundle permitted to touch the ground or any obstacle such as walls, fences, and buildings.

The Contractor has therefore to provide the necessary staff to ensure that these conditions are respected during the operations.

Where it is necessary to provide scaffolding over roads or telecommunication lines in order not to interfere with the passage of traffic, etc. this shall be carried out at such times as may be convenient to the authority (Municipality, Village Council, etc.).

Flagmen and approved type of danger or warning notices shall be provided to ensure the safety of the public.

In principle, the unwinding of LV bundle will be done mechanically. Only for exceptional situations, manual unrolling and stringing can be allowed by GEDCo Engineer.

During unrolling and stringing, the cable drums will be installed in the axes of the line, at a minimum distance of 1.5 time height of the first pole.

The cable which has been unrolled must not be left overnight either on the ground or below 5.00 m above ground level.

Lengths of conductor or cable which are damaged by the grips, clamps or otherwise shall be discarded before the sagging operation.

Tower-mounted distribution transformers General

One type of distribution transformer is designed for the project. The typical single line diagram and layout are given in the drawings.

The transformer is of tower-mounted type, i.e. all equipment are fixed on the steel tower and protective equipment, switches and transformer are connected to the ended MV overhead conductors. The Pole can accommodate one or two transformer (capacity range from 250kVA up 800 kVA).

The transformer shall be equipped with the following:

- \square MV surge arresters
- □ fuse holder including glass fuses and surge arrestor
- □ LV load break switch for feeders
- □ Earthing system

Mounting of equipment

The Contractor shall carry out the installation works of the following:

- □ Transformer necessary arms
- Distribution transformer
- □ MV surge arresters
- □ Suspension glass insulators
- □ Fuse holders
- □ MV connections
- Connection between M.V isolating switch to transformer
- □ LV load break switches
- □ Low voltage cables from transformer to load break switch
- Connections from load break switch to low voltage cables
- □ Earthing system

Distribution transformer

The rating of the distribution transformer shall be checked at site to make sure that it corresponds to the required power capacity.

To facilitate the installation of equipment in the upper levels of the tower, it is recommended that the distribution transformer be first set in place on its supporting frame.

This supporting frame shall be securely fixed and balanced by bolting.

The distribution transformer shall be set in place on its supporting frame by means of truckmounted crane. It shall be securely fixed by bolting and temporarily protected by wooden planks on all exposed sides until all overhead equipment are installed.

The transformer will be connected to the MV feeder via M.V isolating switch

MV surge arresters

A set of three surge arresters shall be installed at tower top. The discharge terminals of the arresters shall be connected to the tower earthing circuit by a copper conductor running down and clamped along the steel structure, or connected with fuse holder on the transformer body

Pin type insulators

The steel frame supporting the pin type insulators shall be set in place and securely fixed to the tower structure.

The pin type insulators shall be located and fixed in accordance with the arrangement shown in the specifications.

Fuse holders

The steel frame supporting the Fuse holders shall be set in place and securely fixed to the transformer structure in accordance with the arrangement shown in the drawings.

The fuse links, selected in accordance with the transformer capacity, shall be installed in their fuse bases.

MV connections

The connections from the MV lines down to the terminals of the distribution transformer shall be carried out by using suitable conductor and the appropriate connectors.

Distribution load break switch

The rating of the distribution load break switch shall be checked at site to make sure that it corresponds to the required power capacity.

The steel frame supporting the distribution load break switch shall be set in place and securely fixed and balanced to the tower structure in accordance with the arrangement shown in the drawings.

The low voltage distribution load break switch is equipped with one main incoming switch and several outgoing feeders protected by fuses.

The LV fuses shall be selected for the protection of the LV feeders and shall be installed in their fuse bases.

Low voltage cables from transformer to L.V load break switch

The LV cables are of single core copper type. Their cross-section and the quantity of links shall be selected according to the transformer power capacity.

The cables shall be installed in flat formations (and not as bundle, since this arrangement decrease the carrying capacity of the cables) and clamped along the tower structure by appropriate fixing devices.

The cable extremities shall be fitted with compression lugs and connected to the equipment terminals by bolting.

Connections from load break switch to low voltage cables

The ABC overhead lines shall be directly connected to the load break switch outgoings. The length section of the ABC extending beyond the strain clamp shall run vertically along the tower structure and horizontally below the load break switch supporting frame.

Off-load field tests and checks

Poles and areas:

- Bases concrete for the high level of street
- □ Securing the Bolts and Accessories
- □ Direction of poles
- □ Balance of steel arms
- Connection of earthing systems and measure the grounding resistance

Lines and cables:

- □ Isolation of conductors
- □ Securing the distribution ties on insulators
- □ Connection of neutral line on poles
- Opening and closing the M.V load break switch
- □ Securing and reviewing all clamps
- □ Connection of earthing systems

Distribution transformer:

- □ Verification of off-load tap changer position
- Oil Level
- Connection of earthing systems with transformer and surge arrestors

Load break switch:

- □ Verification of LV fuses rating
- □ Operational checks of incoming switch
- $\Box \qquad R,S,T \text{ in order}$

Tools

The conductors, joints and clamps shall be installed using approved tools and in such a manner that no bird caging, over tensioning of individual wires or layers, or other deformation or damage to the conductors occurs. The Contractor shall respect the manufacturer's recommendations and shall use the appropriate tools.

Similarly to the stringing of the medium voltage lines, safe and suitable equipment will be used (non-exhaustive list): power-driven winch, tensioner, come-a longs, clamps, sheaves, pulling ropes, pulley blocks, swivels, wedge type come-along clamps, stockings, blocks and tackles.

The diameter and shape of the sheaves shall be selected to suit the conductors bundle; therefore, the Contractor will strictly follow the manufacturer's written recommendations.

22 KV Underground cable installations

General

Underground cable installation and termination shall be carried out by skilled, experienced workmen under competent supervision. The cable jointers should be qualified.

Civil works

This section are generally to be carried out in compliance with Section " <u>CIVIL WORKS</u> " of this specification.

Excavation and removal of concrete structures

The offered price shall be deemed to include all auxiliary work required for full completion of work in accordance with the drawings and conditions. Hence, the auxiliary work comprises, but is not necessarily limited to, the following:

- excavation and removal of concrete plates, beams, floors, boulders, rocks, stones or concrete foundations (if any)
- removal of drainage and the like under embankment fills, difficulties resulting from the specifications relating to fills, compaction tests, elimination of unsuitable material from fills
- any transport and intermediate storage
- removal of any buried pipes, waterworks, underground obstacles and the like which might interfere with the excavation profiles, irrespective of whether or not such structures are specified
- □ removal of loose earth at excavation bottoms and for fill concrete.

Disposal of excavated material

Excavated material suitable and approved for use as filling material shall be deposited as directed by the GEDCo Engineer. Surplus or material unsuitable for use as filling shall be disposed of by the Contractor; no additional payment shall be allowed for this work.

Excavation of cable trenches and joint pits

Prior to commencement of work, way leaves and consents shall be obtained for the execution of the work from the municipalities.

Width of trenches shall be kept as the minimum possible and shall be excavated to approved formations and dimension. Trenches shall have vertical sides and shall be close timbered and strutted where necessary to prevent the collapsing of side walls.

Unsuitable excavated material shall be removed from site and clean soil material shall be selected and screened for further backfilling.

An adequate guarding and/ or fencing shall be provided to all excavations for the protection and safety of the public, traffic and adjacent properties during excavation and before back filling.

The depth of excavated trenches with reference to the general ground level at the sites (and their width at the bottom) shall be according specified GEDCo Drawing

When intended for the laying of underground cables directly buried in soil, and prior to the cable pulling operation, the bottom of the excavated trench shall be covered with 10cm minimum thickness of clean sand bed layer.

Underground obstacles

The Contractor shall take all necessary precautions to prevent damage of existing services, cables and pipes. The Contractor will be liable for any damage that might occur. He shall make arrangements in good time for the Employer and Engineer to be present, when the cables and pipes are to be exposed and / or relocated or whenever necessary.

The costs of relocation (permanent and temporary) of any service shall be borne by the Employer after approval of the Engineer has been obtained.

If buried obstacles are encountered during excavation works, the Engineer has to be informed immediately and the demolishing and/or removal of such obstacle shall commence only after receipt of instructions from the Engineer.

The removal of any buried pipes, waterworks, underground obstacles and the like which might interfere with the excavation profiles, irrespective of whether or not such structures are described either in the Tender Specifications or the Bill of Quantity, must be included in the contract price.

Road crossing ducts

Cable ducts shall be in the form of PVC pipes. Ducts shall be completely embedded in concrete surrounding the ducts on all sides. Ducts shall have a rope exceeding the two edges of the pipes and shall be sealed at each end, with lean concrete or plaster sand bitumen or by other approved means to prevent the ingress of water and vermin.

It's necessary to install rubber ring on the edge of each pipe to avoid cable insulation damages.

Backfilling

The space between cables should be exactly as per GEDCo specifications and should be controlled by GEDCo engineer before backfilling.

After the cables have been laid, and after all required tests have been carried out successfully, the cable(s) shall be covered with specified clean sand layer, which shall be well watered and rammed and consolidated.

Cover tiles or concrete slabs (45 cm length x 45cm width x 5cm Thickness) shall be placed in continuous length.

Below the soil level, Acid / Alkali Resistant caution tape 150 mm wide in Phosphoric (yellow) color printed with black letters in indelible material shall be placed in continuous length, the text in English and Arabic languages should be:

CAUTION CAUTION CAUTION Electrical Cables Buried Below تحذیر تحذیر تحذیر خطر کابل کھرباء

It's should be use one warning tape for each network (three phase).

The top ground surface of the refilled trenches shall be temporarily reinstated in a thoroughly safe condition until complete consolidation of the soil is achieved.

Filling shall be approved selected material from excavation of predominantly granular material, free from slurry, muddy, organic or other unsuitable matter, and shall withstand compaction by ordinary means. Filling in trenches and around foundations shall be placed in layers and compacted at optimum moisture content by mechanical means where possible.

Filling around pipes and cables shall be carefully placed fine material to cover the pipe or cable completely before the normal filling is placed. All filled areas shall be left neat, smooth and well compacted, the top surface comprising normal site surface soil, unless otherwise directed.

The Contractor shall be responsible for the reinstatement of any surfaces or structures which may move or otherwise be affected by settlement of backfill.

If cables laying method were **Trefoil** Laying the Contractor should Supply and fixed the three cables together by using Natural Nylon Cable Ties with Size 7.5 mm and 1.8 Thickness and required Length as cable outer diameter.

Concrete works

All concrete and reinforced concrete works under this section are generally to be carried out in compliance with Section "<u>CIVIL works</u>" of this specification.

Installation works

Preliminaries

For underground cables directly buried in soil, and after the trench has been opened and the bottom sand layer has been completed, the Contractor shall install the cable rollers every four (4) meters and the angle rollers at each corner of the cable route.

Each roller shall be securely fixed to the ground.

The Contractor shall assign a foreman in charge of supervising the works and giving the instructions to the cable men.

The cable men shall be positioned inside and along the trench at convenient intervals so that the portion of cable length can be easily lifted and dragged by each cable man.

Cable unwinding

The cable drum shall be set on stand for this operation. The stand shall be installed in the longitudinal axis and near the open trench.

Refer to the sketches shown in the relevant MV underground cables - Code of Practices.

The drum covering battens shall be removed and the cable shall be unreeled by hand. The drum rotation shall be controlled by two (2) operators.

Cable laying

Special attention shall be taken to make sure that the cable extremity is securely protected.

The cable shall be run in the trench on the rollers and dragged by the cable men upon the instructions given by the foreman.

Care shall be taken so that the cable is not in contact with the ground during the pulling operation in order to avoid the damage to the outer sheath.

After laying the complete length of cable, the rollers shall be removed from the trench for further use.

Jointing and termination

Cable sealing shall be carried out strictly in accordance with the manufacturer's instructions and shall be of the best workmanship.

Joints and termination kits should be kept clean of any dust and sand.

The contractor should locate the exact location of termination joints carefully with GEDCo Engineer and should prepare final shop drawings of the cables including joints.

Cable protection

Electrical protection

The extremity of cables exposed to the risk of lightning strokes (as, for instance, cables rising along towers) shall be protected by surge arresters connected to each phase. The arresters discharge terminals shall be connected together at top of tower and linked to the tower earthing by a separate grounding conductor clamped along the steel structure.

Mechanical protection

At locations where the cables are raised in open air (as, for instance, along towers structures), the cables shall be protected against mechanical damage by galvanized steel cable tray fixed on the tower and fitted with cover or other means as approved by the Engineer.

The mechanical protection will extend up to a minimum height of 2 m from the ground level and will be connected to the earthing system.

Field tests

The field tests shall be carried out by the Contractor and witnessed by the GEDCo Engineer.

Continuity tests

Continuity tests shall be carried out on all cables after the cables are installed and before backfilling of the trenches.

Inspections

Inspection by GEDCo Engineer or their representative(s) shall be carried out at the following stages of work:

- a) open trench before laying of cables;
- b) cables laid in trench before backfilling;
- c) Testing the cables
- d) after protection tiles are laid;
- e) after warning tape or device is placed
- f) after completed backfilling and cleaning of site

Each successive step of work shall be carried out by the Contractor only after inspection and approval of the proceeding ones.

Technical Specification

Civil Works

1 <u>–EXCAVATION, EARTH WORKS AND ROAD WORKS</u>

1.1 GENERAL

The Contractor shall carry out all excavations, filling, backfilling and all other earthworks required in whatever material may be encountered.

The Works shall be executed accurately to the dimensions, levels, lines and profiles as indicated on the drawings or directed by the Engineer.

The Contractor shall reconstruct to the proper level and profile any filled areas which settle or spread during the execution of the work or during the maintenance period.

The Contractor shall drain and dewater the underground water to a level below the excavation by lowering the water table with a proper drainage and dewatering system approved by the Engineer.

1.2 SOIL INFORMATION

The Contractor shall be deemed to have visited the Site of Works and satisfied himself as to the nature of the ground and made him conversant with the local conditions to be encountered during the execution of the Contract. The contractor is requested to perform a soil test to determine the nature and bearing capacity of the soil surface if indicated clearly in the contract documents.

1.3 MATERIALS

1.3.1 Backfill and Fill

Backfill and fill shall be a structurally sound material such as; gravel or native soil free of rocks with size more than 5cm, lumps, vegetables and other organic materials obtained from suitable excavated material and/or from approved borrow pits.

1.3.2 Water

Water shall be clean potable water as specified under "Concrete Work"

1.3.3 Concrete

Concrete used as fill for making up the correct level areas of over-excavation shall be, where required by the Engineer of Class "B" as specified under "Concrete Work".

1.3.4 Hardcore

Hard-core under floor paving, etc. (Where shown on the drawings or as directed by the Engineer) shall consist of tough, sound and durable rubble stones (maximum 150mm), free from coatings, clays, seems or flows of any character. Fine aggregate for blinding the interstices of hard-core bed shall be as described in "Concrete Work".
1.3.5 Agricultural Soils, Gravel and Sand Fill

Agricultural soil shall be first choice top soil rich in organic materials and free from roots, stones and rubbish suitable for plantation and shall be obtained from an approved source. Gravel fill shall consist of graded gravel 50mm down to 20mm and blinded with clean coarse sand.

1.4 SITE PREPARATION

1.4.1 Existing Public Utilities

The Contractor shall ascertain the whereabouts of all existing public utilities on the site, both above and below ground. Such utilities shall be removed, sealed or rerouted in a manner prescribed by the Public Authorities concerned at the Contractor's own expense. The Contractor shall also be held responsible for all damages entailed on any of the public utilities adjacent to the Site resulting from the Works.

1.4.2 Removal of Existing Structures and Other Obstructions

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

1.4.3 Cleaning and Grubbing

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

1.5 SETTING-OUT

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

1.6 EXCAVATION

1.6.1 General

Excavation in any material whatsoever found including rock to reduce levels and to form foundations, bases, trenches, septic tanks, pools, pits and the like to depths shown on the drawings or as directed by the Engineer.

Completely remove all existing obstructions in the line of excavations such as wall, slabs, curbs, steps and the like.

When removing any trees and roots with diameter more than 80 mm, should be rooted out to a depth of up to 500 mm then re-filled with approved material in layers. Also when mass rocks and other obstacles are found, the same mechanism of rooting and backfilling should be carried out at the expense of the contractor.

Trimming the sides of excavations to the required profiles and levels as well removing all loose material should be executed prior to consecutive process.

Level and well ram and consolidate surface of ground and bottom of all excavations to receive concrete foundations, beds, etc.

Bottoms of excavations shall be approved by the Engineer's Representative before any concrete is laid.

Should the Contractor excavate deeper than is shown on the drawings or required by the Engineer's Representative, to obtain a solid bottom, he must fill up excavation to the proper level with concrete Class B at his own expense.

1.6.2 Excavation in Rocks

Rock shall be defined as boulders, exceeding 0.25m3 in volume or any kind of stone or rock formation which in the opinion of the Engineer's Representative requires for its removal drilling and blasting wedging, sledging or barring or breaking up with power-operated hard tool..

The definition shall exclude any soft or disintegrated rock which can be removed with a hard pick or mechanical excavator or shovel or loose, shaken or previously blasted rock or broken stone in rock fillings or elsewhere.

Blasting by explosives shall not be permitted without obtaining the written approval of the Engineer. If such approval is given the Contractor shall be solely responsible for:-

- 1. Obtaining permits, keeping record.
- 2. Storing permits, keeping record.
- 3. Taking all necessary precautions in compliance with the regulations pertinent to the use of Explosives.
- 4. Any damage that may occur due to the blasting operations where rock is encountered it shall be carefully excavated and the Contractor shall not be entitled to additional compensation unless otherwise specified in the Bills of Quantities.

1.7 PLANKING AND STRUTTING

The terms "planking and strutting" will be deemed to cover whatever methods the Contractor elects to adopt for shoring the sides of excavation and also for planking and strutting the excavations against the sides of adjoining buildings, public roadways, etc... The Contractor will be held responsible for shoring the sides of all excavations, adjoining building and the like and no claim for additional excavation, concrete or other material or workmanship will be considered in this respect.

In the event of any collapse of the excavations, the Contractor shall re-excavate and re-instate such excavations at his own expense. No additional excavations will be paid or should the Contractor batter the sides of the excavations.

1.8 KEEPING EXCAVATIONS FREE FROM WATER

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

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

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

1.9 STORING OF SUITABLE EXCAVATED MATERIAL

During excavation, materials suitable for backfill and fill shall be stockpiled on the Site at sufficient distance from the sides of the excavation to avoid overloading and prevent caverns or mixing with the concrete during the construction of foundations.

1.10 DISPOSAL OF UNSUITABLE AND SURPLUS EXCAVATED MATERIAL

Upon the order of the Engineer, all unsuitable and surplus excavated materials shall be immediately removed.

Loaded and transported off the site area by the Contractor to approved dumps and he shall abide by the relevant local regulations.

1.11 EXCAVATION FOR FOUNDATIONS AND SUB-STRUCTURE

The Contractor shall excavate to reach a suitable strata accepted by the Engineer or as shown by the Drawings during excavation for foundations, the bottom layer of excavation of minimum 200mm in thickness, shall be left undisturbed and subsequently removed manually only when the concrete in blinding is about to be placed in order to avoid softening or deterioration of the surfaces of the excavation.

Bottom of all excavations shall be formed to correct levels as shown on the Drawings or as directed in writing

1.12 EXCAVATION FOR TRENCHES

1.12.1 General

The Contractor shall provide all forms and bracings, and excavate trenches necessary to install all drainage, sewer water supply, electrical and telephone cables to the lines and grades complete in strict conformity with these specifications, applicable drawings and/or as directed by the Engineer.

1.12.2 Grading

The bottom of the trenches shall be accurately graded to provide uniform bearing and support for each section of the pipe on undisturbed soil at every point along its length, except for the portions of the pipe where it is necessary to excavate for bell-holes and for proper sealing of joints. Bell-holes and depressions for joints shall be dug after the trench has been graded.

Care shall be taken not to excavate below the depths indicated. Where rock shall be excavated to the required depth, uneven surface of the bottom trench shall be excavated 15mm deeper. Such depth, if in rock, shall be back-filled with concrete Class "B" as specified under "Concrete Work" and when in earth, shall be back-filled with approved sand at the Contractor's own expense.

Whenever unstable soil, which in the opinion of the Engineer, is incapable of properly supporting the pipe or duct is encountered in the bottom of the trench, such soil shall be removed to the depth required and the trench back-filled to the proper grade with sand, fine gravel or other suitable material approved by the Engineer.

The width of the trench for Drainage at and below the top of the pipe shall be such that the clear space between the barrel of the pipe and the trench wall shall be 20mm on each side of the pipe. The width of the trench above that level may be as wide as necessary for sheeting and bracing and the proper performance of the work.

Trench for Water Supply System shall be of a depth to provide minimum cover over the top of 300mm and avoid interference of water lines with other utilities. Width of trench shall be a maximum of 200mm on each side of the pipe.

The width of trenches for electrical and telephone cables shall be as specified in their relative section. Banks may be sloped or widened to facilitate placement of cables, but not to an extend that will cause interference with other utilities.

Excavation for appurtenant structures for manholes, septic tank, percolating pit and similar structures shall be sufficient to allow a minimum of 300mm of clear space between their outer surfaces shoring timbers which may be used to protect the banks.

1.13 BACKFILL AND FILL

Approved suitable excavated material as specified under "MATERIALS" shall be used in the backfilling and filling next to footings, foundations underground structures, under sub-floors, etc... and shall be laid in layers not exceeding 250mm and compacted with compaction equipment, as approved by the Engineer. Moisture content shall be adjusted as directed by the Engineer and 97% of dry weight compaction accordance to ASTM: D1557-70 shall be achieved.

At least one sample of core pit must be taken from each 100 m2 in buildings for each layer of backfill.

Heavy equipments should not work or pass through within the structural boundary of the building during the backfilling process.

Should the quantity of the excavated material be not sufficient for the process of backfill and fill, the Contractor shall obtain the quantity required of such backfill and fill from approved borrow pits and transport same to the Site of work at his own expense if not itemized in the

bills of quantities.

No backfill shall be executed until the footings, foundations, etc., have been inspected, measured and approved by the Engineer.

Trenches should be backfilled until all required tests are performed and until the Engineer has verified that the Utility systems have been installed in accordance with the Specifications and the Drawings. The backfill in the pipe zone must be placed and completed so as to provide and maintain adequate and even support around the pipe wall. If mechanical compaction equipment is need, care must be taken to prevent direct contact with the pipe.

1.14 BED OF HARDCORE

The bed of hardcore where shown on the Drawings or as directed by the Engineer shall be of an approved rubble stone as specified under "MATERIALS" and shall be laid under floor paving. The rubble stone for hardcore shall be hand-packed with sharp edge upward and wider (natural face) laid on the ground. The interstices of hardcore bed shall be filled with approved fines, wetted sufficiently and well consolidated. The thickness of the hardcore bed shall be as shown on the Drawings.

1.15 PLACING OF AGRICULTURAL SOIL, GRAVEL AND SAND

The agricultural sifted soil as specified under "MATERIALS" shall be spread in the flower boxes and beds to the thickness shown on the Drawings after thorough watering and on a bed of 100mm thick graded gravel blinded with clean coarse sand to the satisfaction of the Engineer.

1.16 EXCAVATIONS OF CUTTINGS IN CARRIAGE WAYS

- 1. Hauling of material from cuttings or borrow pits to the embankments or other areas of fill shall proceed only when sufficient compaction plant is operating at the place of disposition to ensure compliance with the requirements of specifications.
- 2. Any excess depth excavated below formation level tolerance shall be made good by back filling with suitable material of similar characteristics to that removed, compacted in accordance with specification.
- 3. The slopes of cuttings shall be cleared of rock fragments which move when prized by a crow bar.
- 4. Construction traffic shall not use the surface of the bottom of a cutting unless the cutting is in rock or the Contractor maintains the level of the bottom surface at least 30cm above formation level. Any damage to the sub-grade arising from such use of the surface shall be made of good by the Contractor at his own expense, with material having the same characteristics as the material which has been damaged.

1.17 FILLING AND FORMING OF EMBANKMENTS AND OTHER AREAS OF FILL

- 1. Embankments and other areas of fill shall be formed of material defined as "suitable material"
- 2. All earthworks material placed in or below embankments, below formation level in cuttings or else wherein the works shall be deposited and compacted as soon as practicable after excavation in layers of thickness appropriate to the compaction plant used or as a permitted departure therefore. Embankments shall be built up evenly over the full width and shall be maintained at all times with a sufficient camber and a surface sufficiently even to enable surface water to drain readily from them. During the construction of embankments, the Contractor shall control and direct constructional traffic uniformly over their full width. Damage to compacted layers by constructional traffic shall be made good by the Contractor.
- 3. In areas of shallow filling where after removal of topsoil the ground level is within 30cm of formation level constructional traffic shall not use the surface unless the Contractor brings up and maintains the surface level at least 30cm above formation level. Any damage to the sub-grade arising from such use shall be made good by the Contractor at his own expense with material having the same characteristics as the damaged materials.

1.18 COMPACTION OF EMBANKMENTS AND OTHER AREAS OF FILL

- 1 All materials used in embankments and as filling elsewhere shall be compacted as soon as practicable after deposition.
- 2 Variation from the method of compaction stated below or the use of plant not included therein will be permitted only if the Contractor demonstrates at site trials that a state of compaction is achieved by the alternative method equivalent to that obtained using the approved methods. This procedure shall be agreed and approved by the Engineer.
- 3 The Engineer may at any time carry out comparative field density tests determined in accordance with B. S. 1377 test No. 14 on material, which he considers has been, inadequately compacted. If the test results when compared with the results of similar tests made on adjacent approved work in similar materials carried out in accordance with specification, show the state of compaction to be inadequate and this held to be due to failure of the Contractor to comply with the requirements of the Contract, the Contractor shall carry out such further work as the Engineer may decide is required to comply with the terms of the Contract.
- 4 The Contractor shall not less than 24 hours before he proposes to carry out compaction processes during periods of overtime, apply in writing to the Engineer for permission to do so.

1.19 MEASUREMENTS

All measurement of cut, backfill and fill of different materials should be using the engineering calculations or otherwise mentioned in the other contract documents or as directed by the Engineer.

2 -CONCRETE WORKS

2.1 SCOPE

This section describes and specifies work required for plain and reinforced concrete, including formwork intended to be used for the Project under the Contract in accordance with the Drawings, Bills of Quantities and as directed by the Engineer.

At the beginning of each month, the Contractor shall submit to the Engineer his concreting programme for that month, stating the pouring dates, so that adequate checking and supervision can be provided before and during the pouring operation. No pouring shall be allowed unless the Engineer has been given a week-advanced notice of the intention to pour.

2.2 APPLICABLE TESTS AND CODES

Prior to commencement of concrete work, the Contractor shall submit samples to the Engineer before sending them to the laboratories for testing, to establish the probability of the materials passing tests for specified requirements.

After the Engineer is convinced that the samples with their sources are truly representative samples and sufficient materials are available on the Site for the completion of all concrete works under the Contract, the samples shall be approved and sent to the laboratories for testing. Upon the Engineer's request, the Contractor shall have the tests made, at his own expense in the laboratories approved by the Engineer.

All concrete aggregates, cement and water shall be sampled and tested as frequently as deemed necessary by the Engineer. All tests samples shall be obtained in accordance with the latest editions of the American Society for Testing and Material (ACI) Code or any equally approved standard.

2.3 MATERIALS

2.3.1 Cement

2.3.1.1 General

Cement shall be Portland Type originating from approved manufacturers in sealed and labeled bags, each 50 kgs. Not capacity, name and brand of the manufacturer shall plainly be identified thereon and delivered to the site in good condition. Cement delivered in bulk shall be accepted only if a central mixing plant is used. The Quality of cement shall conform to the Standard Specification for PORTLAND CEMENT of ASIM Designation: C150-74 Type I-for use in general concrete construction and Type V- for use when high sulphate resistance is desired.

2.3.1.2 Storage of Cement

All cement shall be stored in suitable weatherproof and approved storage sheds which will protect the

cement from dampness. Storage sheds shall be erected in locations approved by the Engineer. Provision for storage shall be ample, and the consignment of cement as received shall be separately stored in such a manner as to provide easy access for the identification and inspection of each consignment. Cement shall be used in the order of its delivery to site, new deliveries shall not be used unless the cement from earlier deliveries has be completely used. Stored cement shall meet the test requirements at any time after storage when a re-test is ordered by the Engineer all the expense of the Contractor.

The Contractor shall keep accurate records of the deliveries of cement and of its use in the work.

Copies of these records shall be supplied to the Engineer in such form as may be required.

2.3.1.3 Rejection

The Contractor shall notify the Engineer of dates of delivery so that there will be sufficient time for sampling the cement either at the mill or upon delivery.

The provisional acceptance of the cement at the mill shall not deprive the Engineer of the right to reject on a reset of soundness at the time of delivery of the cement to the site.

Package of cement varying by 5 percent or more from the specified weight shall be rejected and if the average weight of packages in any consignment, as shown by weighing 50 packages taken at random, is less than that specified, the entire consignment shall be rejected and the Contractor shall remove it forthwith from the Site at his own expense and replace it with cement of satisfactory quality.

Stale cement or cement reclaimed from cleaning bags shall not be used and cement which for any reason has become partially set, or contains lump or caked cement, shall be rejected.

2.3.2 Aggregates

2.3.2.1 General Requirements

All aggregates shall consist of tough, hard, durable uncoated particles. The Contractor shall be responsible for the processing of this material to meet the requirements of the Specifications. Approval of aggregate quality and/or gradation shall not waive the responsibility of the Contractor to provide concrete of having the minimum strength specified.

2.3.2.2 Storage

Coarse and fine aggregates shall be delivered and stored separately on site in such a manner as to prevent segregation and contamination or the admixture of foreign materials. Aggregate which has become segregated or contaminated with foreign matter during storage or handling will be rejected and shall be removed and replaced with material of acceptable quality at the Contractor's expense.

Aggregates of the quality and color selected shall be stored in sufficient quantity to avoid interruption of concreting work at any time.

2.3.3 Fine Aggregate

2.3.3.1 General Requirements

All fine aggregate shall conform to Standard Specification for Concrete Aggregates of ASIM Designation: C-33 and also to the detailed requirements give in Table 2-1 (appended here below). It shall not contain harmful materials such as iron pyrites, coal, mica, and shale.

Alkali, coated grains, or similar laminated materials such as soft and flaky particles, or any material which may attack the reinforcement, in such a form and in sufficient quantity to affect adversely the strength and durability of the concrete. Fine Aggregate passing sieve No. 4 shall not contain any voided shells.

Fine aggregates shall be washed thoroughly with de-mineralized water to ensure compliance with the appropriate requirements and limitations of the specifications.

The Contractor shall provide and maintain for this proposes sand-washing plant and equipment.

Fine Aggregate from different sources of supply shall not be mixed or stored in one pile nor used alternately in the same class of construction or mix.

Sieve Analysis	
Grading Sieve	Percent of Passing
3/8	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10
No. 200	0-3
Fineness modulus	2.50- 2.15
Organic Impurities	The color shall have an intensity not darker than two-thirds the intensity of the standard color solution. (Not darker than Plate 2 as determined by the Standard Method of Test for Organic Impurities in Sands for Concrete of ASTM Designation C - 40
Chlorides soluble in	Not more than 0.10 percent by weight when expressed as sodium
dilute Nitric Acid	chloride (NACL).
Total Acid soluble	Not more than 0.50 percent by weight when expressed as sulpher
sulphates	trioxide(S03)
Silt	Not more than 2 percent
Mortar strength	Compression ration less than 95 percent
Soundless	Weighted average loss when subjected to 5 cycles of the soundless test using magnesium sulfate, not more than 10 percent

Table 2-1: Detailed requirements for Fine Aggregate

2.3.4 Coarse Aggregate

2.3.4.1 General Requirements

All coarse aggregate for concrete shall conform to Standard Specifications for Concrete Aggregates of ASTM Destination: C-33 Coarse aggregate shall consist of gravel, crushes gravel, or crushed stone, having hard, strong durable pieces, free from adherents. It shall not contain harmful materials such as iron pyrites, coal, mica, alkali, laminated materials, or any material which may attack the reinforcement, in such a for or in sufficient quantity to affect adversely the strength and durability of the Concrete. Coarse aggregates shall be washed thoroughly with de-mineralized water to ensure compliance with the appropriate requirements

and limitations of the specifications. The Contractor shall provide and maintain for this purpose approved washing plant and equipment.

2.3.4.2 Deleterious Substances

The amount of deleterious substances shall not exceed the following limits:

Max. Permissible Limit Percent by Wt.:	
Soft fragments	2.00
Coal and lignite	0.50
Clay lumps	0.25
Materials passing the No.200 sieve	1.00
Thin or clognated pieces (length greater than 5 times average thickness)	4.00
Other local deleterious substances	0.00
Chlorides soluble in dilute Nitric acid when expressed as Sodium	0.05
Chloride (NaCL)	
Total acid soluble sulphates when expressed as sulpher trioxide (S03)	0.50

2.3.4.3 Percentage of Wear

Coarse aggregate shall conform to the following requirements: Percentage of wear, Los Angeles test, not more than (30)

2.3.4.4 Grading

Coarse aggregate, when tested according to the requirements of ASTM, shall meet the following gradation and shall be uniformly graded within the limits stated in Table 2-2 here below:

ASTM	Percentage by Weight Passing					
	Grading (3/4" to No.4)	Grading (1" to No.4)	Grading (2" to No.4)			
2 ¹ / ₂ inch			100			
2 inch	•		95-100			
1 ¹ / ₂ inch		100				
1 inch	100	95-100	35-70			
³ / ₄ inch	95-100					
¹ / ₂ inch		25-60	10-30			
3/8 inch	20- 55					
No. 4	0-10	0-10	0-5			
No. 8	0-5	0-5				
No. 200	0-1	0-1	0-1			

 Table 2-2: Grading Analysis for Coarse Aggregate

2.3.5 Combined Aggregate

Approved fine and coarse aggregate on each batch of concrete shall be combined in proportions as approved by the Engineer, according to test results giving the required compressive concrete stress as specified per type of Concrete.

The combined aggregate gradation using the ³/₄ in. to No. 4 gradation shall be used for concrete members with reinforcement to close or permit proper placement and consolidation

of the concrete. Change from one gradation to another shall not be made during the progress of the work unless approved by the Engineer. Such changes are admitted only after being proved by test results.

2.3.6 Aggregate for Mortar

2.3.6.1 General Requirements

Aggregate for motor shall conform to the Standard Specification for Aggregate for Masonry Mortar of ASTM Designation: C-144 and shall consist of hard, strong, durable uncoated mineral or rock particles, free from injurious amounts of organic or other deleterious substances.

2.3.6.2 Organic Impurities

Fine aggregate for mortar when subjected to the Calorimetric test for organic impurities and producing a color darker than the standard color shall be rejected.

2.3.7 Water

2.3.7.1 Quality of Water

Water for mixing of concrete shall be fresh, clean and free from injurious amounts of oil, acid, or any other deleterious mineral and/or organic matter. It shall not contain chlorides such as sodium chloride in excess of 700 ppm. It shall not contain any impurities in amount sufficient to cause a change in the time of setting of Portland Cement of more than 10 percent, nor a reduction in compressive strength of mortar of more than 5 percent compared to results obtained with distilled water.

The PH of the water for mixing and curing of concrete shall not be less than PH 4.5 or more than PH 8.5.

2.3.7.2 Tests for Water

When required by the Engineer the quality of the mixing water shall be determined by the Standard Method of Test for quality of water to be used in concrete, as specified in B.S. 3148: 1959 Tests for Water for Making Concrete.

In sampling water for testing, care shall be taken to ensure the containers are clean and that samples are representative.

2.3.7.3 Admixtures

Admixtures in concrete shall be used only when approved by the Engineer and shall conform to the requirements of the ASTM Standard Specifications Designation c-494-68 for Water Reducing and Retarding Admixtures, and C-260-69 for Air entraining Admixtures for Concrete, and waterproofing and watertight.

The Contractor shall ensure that the admixture supplied for use in the work is equivalent in composition to the admixture subjected to test under this Specification. Tests shall be made whenever practicable using the cement, aggregates, admixtures proposed for specific work, because the specific effects produced by chemical admixtures may vary with the properties of

the other ingredients of the concrete.

The specific effects produced by chemical admixtures may vary with the properties of the other ingredients of the concrete.

Admixture that contains relatively large amounts of chloride shall accelerate corrosion of reinforcing steel and shall be the cause of rejection.

Water reducing and retarding admixtures shall comply with the physical requirements of ASTM tests and shall be approved in writing by the Engineer.

When the admixture is delivered in packages or containers, the proprietary name of the admixture, the type and the weight or volume shall be plainly marked thereon. Similar information shall be provided in the shipping advises accompanying packaged or bulk shipments of admixtures.

The admixture shall be stored in such a manner as to permit easy access for proper inspection and identification of each shipment, and in a suitable weather-tight store that will protect the admixture from dampness.

Costs of such admixtures, sampling and testing shall be at the Contractor's expense.

2.4 COMPOSITION OF CONCRETE

The cement content, coarse aggregate size, water content, consistency and the approximate weights of fine and coarse aggregate (saturated surface-dry basis) for the class of concrete shall be within the requirements of Table 2-3 (I) and Table 2-3 (II) Below.

The weight of fine and coarse aggregate given in Table 2-3 (II) below is based on the use of aggregates having bulk specific gravities, in a saturated surface-dry condition, 2.65-5%. For reasonably well graded materials of normal physical characteristics, the use of the below indicated proportions, together with specified water content to obtain the required consistency, will result in concrete of the specified cement content, plus or minus two (2) percent.

For aggregate having specified gravities outside the ranges indicated in the Table 2-3 (II) below, the weights shall be corrected by multiplying the weights shown in Table 2-3 (II)below by the ration of the specific gravity of the aggregate and 2.65.

The relative weights of fine and coarse aggregate per sack of cement given in Table 2-3 (II) below are based on the use of natural sand having a fineness modulus within the range of 2.70 and 2.90 and methods of placing which do not involve high frequency vibration. When sharp, angular manufactured sands, or extremely coarsely graded sands are used, the relative amount of fine aggregate should be increased. For finer sands the relative amount of fine aggregate should be decreased. In general, the least amount of sand which will insure concrete of the required workability for the placing conditions involved should always be compensated for by changing the weight of coarse aggregate in the opposite direction by a corresponding amount.

lass of oncrete	Compressi ve strength at 28 days (in Kg/cm ²)	Minimum cement content (Kg)	Coarse aggregate size	Max. water content (Liter per	Consister in sl (m	ncy range lump lm)
\cup 5	Cube			Bag)	vibrated	non
						vibrated
А	250	375	³ / ₄ inch or 1 inch-	27	50-100	75-125
			No. 4 as required			
			by the Engineer			
В	200	350	Ditto	27	50-100	33-125
С	150	250	2 inch- No. 4	30	25-50	50-75

 Table 2-3 (I): Requirements of concrete composition

Table 2-3	(III)	: Rec	uirements	of	concrete	com	position-	Continue
	·/			· · -			000101011	

Class of concrete	Cylinder compressive strength at 28 days	Approximate Weight (Saturated Surface-Dry) of Fine and Coarse Aggregate per Sack (50Kgs) of Cement					
	(kg/cm^2)	Rounded coa	rse aggregate	Angular coar	rse aggregate		
		Fine (Kg)	Coarse (Kg)	Fine (Kg)	Coarse (Kg)		
А	250	40	170	95	150		
В	210	95	180	100	160		
С	140	140	370	160	340		

Table 2-3 (II) is given for indicative purposes and is not binding.

The total sodium chloride content of any materials used for making concrete shall be less than:

- For mass concrete..... 1.5 percent
- For reinforced concrete...... 0.7 percent

Expressed as a percentage, by weight of the cement.

In calculations made under the provisions of this clause, any chloride, other than sodium chloride in the materials shall be converted to the equivalent of sodium chloride and be added to the amount of sodium chloride. The sulphate content shall not exceed 0.03 percent by weight of the cement.

2.5 PROPORTIONS

2.5.1 General

After the materials provided by the Contractor have been accepted for the works, the proportions and equivalent batch weights shall be determined which will produce concrete having not less than the strength required.

2.5.2 Trial Mixes

The actual proportions shall be determined on the basis trial mixes made by the Contractor and conducted with the content being determined by means of yield test in accordance with American Society for Testing Material (ASTM) Designation (C-138). The proportions will be such as to required (within a tolerance of plus or minus one (1) percent, the cement content shown in Table I as the minimum cement content, provided, however, that if the materials supplied by the Contractor are of such a nature or are so graded that proportions based on the minimum cement content cannot be used without exceeding the maximum allowable water content specified in Table I, the proportions will be adjusted so as to require the least amount of cement which will produce concrete of the required plasticity and workability without exceeding such maximum allowable water content. No additional compensation will be made for the increase in quantity of cement required.

2.5.3 Contents

The mixes required will be designated in kilograms of fine and coarse aggregate exclusive of free water, per sack (50 Kilograms) of cement and in liters of total mixing water per sack of cement on the basis of the required amount of cement per cubic meter of concrete.

2.5.4 Batch Weights

Since the proportions are designated in terms of aggregate in surface-dry condition, the equivalent batch weights to be used in the work shall be corrected periodically to take into account the actual moisture content of the aggregates at the time of use.

2.6 CONCRETE COMPRESSION AND SLUMP TESTS

2.6.1 Cubical Test

The Compression Strength of Concrete shall be obtained according to cubical tests locally done. Test cubes made in the field shall have a dimension of 15cm, At least 3 separate batches of concrete shall be made for trial and these shall be tested for compliance with the requirements of the table below, at least 3 test cubes being made from each batch of concrete. Once a mix is approved no substantial change in the materials or proportions of materials being used shall be made without the approval of the director of works who may then require further trial mixes to be produced. The compressive strength of the concrete will be taken as the arithmetic mean of the strength of all the cubes tested.

The following table 2-4 will be used to compare test results:

Table 2-4: Compressive Strength results of samples of concrete at 28 days. (Mixed by
Weight)

Kind of Concrete	Mean value At 28 days Kg / cm ²	Minimum Individual Value at 28 days Kg / cm ²	Mean value At 28 days Kg / cm ²	Minimum Individual Value at 28 days Kg / cm ²
	In case of 3-4 samples taken		In case of 5 samples or more	
B - 150	185	130	175	130
B - 200	240	170	230	170
B - 250	300	215	290	215
B - 300	360	255	345	255
B - 350	420	300	405	300

Test at 7 days must not be less than 75% of the required strength at 28 days

2.6.2 Slump Tests

Slump tests shall be carried out periodically to ensure the appropriate water cement ratio in accordance with the Standard Method of Test of Slump of Portland Cement Concrete of the ASTM Designation: C-143.

2.6.3 Test of Hardened Concrete in the Structure

Where the results of specimens indicate that the concrete does not meet specification requirements, core boring tests conforming to the current issue of ASTM Designation: C-42 shall be performed, as directed by the Engineer, all at the Contractor's expense.

- 1. Hardened concrete is identical to specifications if the results of specimens test follow the conditions:
- At least the average compressive strength of samples testing coincides the required design strength for the concrete.
- No compressive strength of any of the sample specimens deviates from the required design strength for the concrete by (85%).
- Cubes are standard size (150 × 150 × 150) mm and age (28) days mainly to the requirements of comparing strength. The nominal compressive strength is the minimum value of all the values of the testing samples, which does not allow the existence of values lower than more than (5) percent of the number of sample tests.
- The contractor to submit to the supervisor written reports from an authorized laboratory for all of the tests carried out according to specifications and within period of not more than (24) hours of the implementation of the testing.
- 2. If the cube tests fail to pass the above; Core Specimens must be carried out at (3) specimens for each sample of hardened concrete which had not achieved the conditions of the sub-item mentioned above. Note that taking the specimens, water treatment and testing are in accordance with the requirements of American Standard (ASTM -C 42), this is coincided to the concrete specifications if the test results match following conditions:
- At least the average compressive strength of the specimens of a sample is (85%) of the strength provided by the design.
- At least the compressive strength of an individual specimen from a sample is (75%) of the strength provided by the design.
- 3. If test results fail to pass the condition stated in item (B) of this section, found not conform to these specifications, and must then be completely removed from the site at the expense of the contractor, as the same contractor bears full responsibility for any damage that might be caused to the sound elements as a result of the demolition and removal.
- 4. As exception to what is stated in paragraph (C) of this section, for the slabs and beams only, if the average value of compressive strength of the samples equivalent to the standard cubes (150 * 150 * 150) mm is not less than (150Kg/cm2); loading test might be carried out only upon the client request and at the contractor's expense to ensure the ability of the concrete elements to bear loads according to engineer and the designer. If the elements pass the load test, then the slabs and beams are considered structurally accepted.

5. Loading Test

• Load test must be carried out at the site for the slabs and beams of reinforced concrete that are under the age of (56) days by authorized and experienced laboratory in that field.

The loads must be equivalent to that part of the actual dead loads and shall be placed on the slabs and beams prior to loading the total loads by (48) hours and remain until the end of the test.

- The slabs and beams must be loaded by a total of (0.85) multiplied by (1.4 Dead Load + 1.7 Live Load) Less Dead Load actually performing (48) hours before. Special devices should be placed at the bottom of slabs and beams to measure deflection. These devices should be installed on fixed frames to ensure the stability of these devices, and the preliminary readings to be taken prior to process of loading. The loads must be placed gradually and systematically for (24) hours, without causing any vibrations or shocks and batches of not less than (4) equal installments, and then taking the readings , which identifies the maximum deflection; that is the difference between this reading and reading pre-loading. Then the loads are lifted and left unloaded for two (24) hours, the readings are taken for the final deflection which determines the value of self-retrieval as the difference between this reading, and reading pre-lift.
- 6. Passing the test
- The structural elements could succeed in passing the test, if not exceed the maximum deflection (D) in mm as per the formula:

$$D = (50 L2) / h$$

Where:

L = Span loaded in meters of the following values: the distance between the centers of supports or clear span loaded plus the height of the structural element which is smaller. h = height of the structural element (mm)

• The slabs and beams fail to pass the test if wide cracks appear or signs of failure during the test, or if they do not achieve the value of deflection (D).

2.7 MEASUREMENT OF MATERIALS

Materials shall be measured by weight, except as otherwise specified or where other methods are specifically authorized by the Engineer. The apparatus provided for weighing the aggregates and cement shall be suitably designed and constructed for this purpose. Each size of an aggregate and the cement shall be weighed separately. The accuracy of all weighing devices shall be such that successive quantities can be measured to within 1% of the desired amount. Cement in standard packages (sack) need not be weighed. The mixing water shall be measured by a measuring device susceptible of control accurate to plus or minus half percent of the capacity of the tank but not exceeding 2 liters. All measuring devices shall be subject to the Engineer's approval.

Where volumetric measurements are exceptionally authorized by the Engineer for projects where the amount of concrete is small, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the fine aggregate.

2.8 MIXING OF CONCRETE

2.8.1 General

Unless otherwise authorized by the Engineer, concrete shall be machine mixed.

The mixing of concrete or mortar shall not be permitted when the temperature is above 40 C or when the temperature is below 5 C.

2.8.2 Mixing on Site

Concrete shall be thoroughly mixed in a batch mixer conforming to the requirements of B.S. 1305 Batch type concrete mixers which will ensure a uniform distribution of the materials throughout the mass.

The mixer shall be equipped with adequate storage and a device for accurately measuring and automatically controlling the amount of water used on each batch. Preferably mechanical means shall be provided for recording the number of revolutions for each batch and automatically preventing the discharge of the mixer until the materials have been mixed within the specified minimum time.

The entire contents of the mixer shall be removed from the drum before materials for a succeeding batch are placed therein.

All concrete shall be mixed for a period of not less than 1 ¹/₂ minutes after all materials, including water, are in the mixer. During the period of the mixing the mixer shall operate at the speed for which it has been designed, but this speed shall be not less than 14 nor more than 20 revolutions per minute.

The first batch of concrete material placed in the mixer shall contain sufficient excess of cement, sand and water to coat the inside of the drum without reducing the required mortar content of the mix. Upon the cessation of mixing for a considerable period, the mixer shall be thoroughly cleaned.

2.8.3 Truck Mixing

Truck mixers, unless otherwise authorized by the Engineer, shall be of the revolving drum type, watertight, and so constructed that the concrete can be mixed to ensure a uniform distribution of materials throughout the mass. All solid materials for the concrete shall be accurately measured in accordance with Section C.7 and charged into the drum at the proportioning plant.

Except as subsequently provided, the truck mixer shall be equipped with a tank for carrying mixing water. Only the prescribed amount of water shall be placed in the tank unless the tank id equipped with a device by which the quantity of water added can be readily verified. Truck mixers may be required to be provided with means by which the mixing time can be readily verified by the Engineer.

The maximum size of batch in truck mixers shall not exceed the maximum rated capacity of the mixer as stated by the manufacturer and stamped in metal on the mixer. Truck mixing shall be continued for not less than 50 revolutions after all ingredients including the water, are in the drum. The speed shall not be less than 4 r.p.m., nor more than a speed resulting in a

peripheral velocity of the drum of 70 meters per minute.

Nor more than 100 revolutions of mixing shall be at speed in excess of 6 r.p.m. Mixing shall begin within 30 minutes after the cement has been added either to the water or aggregate. When cement is charged into a mixer drum containing water or surface-wet aggregate and when the temperature is above (33 C) is used this limit shall be reduced to 1245 minutes; the limitation on time between the introduction of the cement to the aggregates and the beginning of the mixing may be waived when, in the judgment of the Engineer, the aggregates are sufficiently free from moisture, so that there will be no harmful effects on the cement.

2.8.4 Partial mixing at the Central Plant

When a truck mixer provided with adequate mixing blades is used for transpiration, the mixing time at the mixing plant may be reduced to 30 seconds and the mixing completed in the truck mixer. The mixing time in the truck mixer shall be as specified under the Section C.8.3 for truck mixing.

2.8.5 Plant Mix

Mixing at a central plant shall conform to the requirements for mixing at the Site and shall conform to

the applicable requirements of the Standard Specification for Ready-Mixed Concrete of ASTM Designation: C-94.

2.8.6 Time of Hauling and Placing Concrete

If the distance from the mixing plant to the construction Site is so great that between the time of mixing and pouring the concrete, the temperature is below 40 C and the traveling time is more than 30 minutes, truck mixers must be employed.

When truck mixers are used, concrete shall be discharged and placed in its final position in the forms within thirty (30) minutes after water is first added to the mix.

2.8.7 Delivery

The rate of delivery of concrete during concreting operations shall be such as to provide for the proper handling, placing and finishing of the concrete. The rate shall be such that the interval between batches shall not exceed 20 minutes. The methods of delivering and handling the concrete shall be such as will facilitate placing with the minimum of re-handling and without damage to the structure of the concrete.

2.8.8 Re-tempering

The concrete shall be mixed only in such quantities as are required for immediate use and any concrete which has developed initial setting shall not be used. Concrete which has partially hardened shall not be re-tempered or remixed.

2.9 HANDLING AND PLACING CONCRETE

2.9.1 General

Prior to pouring concrete in any structure, the Contractor shall secure a written order to commence from the Engineer. In preparation for the placing of concrete all sawdust, chips, and other construction debris and extraneous matters shall be removed from the interior of forms, struts, stays and braces, serving temporarily to hold the forms in correct shape and alignment, pending the placing of concrete placing has reached an elevation rendering their service unnecessary. These temporary members shall be entirely removed from the firms and not buried in the concrete. Concrete shall be placed so as to avoid segregation of the materials and the displacement of the reinforcement. The use of long troughs, chutes and pipes for conveying concrete from the mixer to the forms shall not be permitted unless the authorization in writing of the Engineer is obtained. In case an interior quality of concrete is produced by the use of such conveyers, the Engineer may order discontinuance of their use and the substitution of a satisfactory method of placing. Open troughs and chutes shall be of metal lined and shall be of rounded cross section to avoid the accumulation of concrete in corners. The chutes shall be equipped with baffles or be in short lengths that reverse the direction of movement. The slope shall be steep enough (1 vertical to 2 or 2 ¹/₂ horizontal) to permit flow requiring a slump greater than specified or required for placement.

All chutes, troughs and pipes shall be kept clean and free from coating of hardened concrete by thoroughly flushing with water after each run. Water used for flushing shall be discharged clear of the structure. When placing operations would involve dropping the concrete more than 1.50 meter, it shall be deposited through sheet metal or other approved pipes. As far as practicable, the pipes shall be kept full of concrete during placing and their lower ends shall be kept buried in the newly placed concrete. After initial setting of concrete, the forms shall not be jarred and no strain shall be placed on the ends of reinforcement bars which project.

2.9.2 Hot Weather Concreting

The temperature of concrete when placed shall not exceed 27 $^{\circ}$ C when the relative humidity is 50 percent or less and shall not exceed 32 $^{\circ}$ C for values of relative humidity between 50 percent and 70 percent, the max temperature of concrete shall be found by interpolation.

In lieu of above, the temperature of concrete when placed shall not exceed 32 $^{\circ}$ C, regardless of the relative humidity.

The Contractor shall comply with the above requirements by the following procedures:-

- Cooling the mixing water and/or replacing 50% of the mixing water by crushed ice. When crushed ice is used it shall be stored at a temperature that will prevent formation of lumps. The ice shall be completely melted by the time mixing is completed.
- Shading aggregate stockpiles and/or keeping moist by sprinkling then with water.
- Cement shall not be used if its temperature exceeds 77 °C.
- Painting the mixer drum white and spraying it with cool water or shading the mixer from direct sunrays.
- Maintaining the mixing time and delivery time to the minimum acceptable.
- Sprinkling of forms sub-grade and reinforcement with cool water prior to placement of concrete.

Water reducing and retarding admixture shall be used in all concrete work when the temperature of concrete exceeds 27 $^{\circ}$ C. The water cement ratio inclusive of free surface moisture on aggregates and any admixtures shall be kept to a minimum.

2.9.3 Vibrating Concrete

Concrete, during and immediately after depositing, shall be thoroughly compacted. The compaction shall be done by mechanical vibration subject to the following provisions:

- Vibration shall be internal unless special authorization of other methods is given by the Engineer or as provided herein.
- Vibration shall be of a type and design approved by the Engineer. They shall be capable of transmitting vibration to the concrete at frequencies of not less than 4500 impulses per minute.
- The intensity of vibration shall be such as to visibly affect mass concrete of 25mm slump.
- Contractor shall provide a sufficient number of the vibrators to properly compact each batch immediately after it is placed in the forms.
- Vibration shall be manipulated so as to thoroughly work the concrete around the reinforcement and embedded fixtures, and into the corners and angles of the forms.
- Vibration shall be applied only by experienced operators under close supervision, at the point of deposit and in the area of freshly deposited concrete. The vibrators shall be inserted and withdrawn out of the concrete slowly. The vibration shall be of sufficient duration and intensity to thoroughly compact the concrete, but shall not be continued so as to cause segregation. Vibration shall not be continued at any point to the extent that localized areas of grout are formed.
- Application of vibration shall be at points uniformly spaced and not farther apart than twice the radius over which the vibration is visibly effective.
- Vibration shall not be applied directly or through the reinforcement to sections or layers of concrete which have hardened to the degree that the concrete ceases to be plastic under vibrations. It shall not be used to make concrete flow in the forms over distances so great as to cause segregation, and vibrators shall not be used to transport concrete in the forms.
- Vibrator shall be supplement by such spading as it necessary to ensure smooth surface and dense concrete along form surfaces and in corners and locations impossible to reach with the vibrators.
- The use of implements such as compressors which are likely to disturb or disarrange reinforcement or formwork shall not be permitted.

Concrete shall be placed in horizontal layers not more than 300mm thick as hereinafter provided. When less than a complete layer is placed in one operation, it shall be terminated in

a vertical bulkhead. Each layer shall be placed and compacted before the preceding batch has taken initial set to prevent injury to the green concrete and avoid surfaces of separation between the batches. Each layer shall be compacted so as to avoid the formation of a construction joint with preceding layer which has taken initial set.

When the placing of concrete is temporarily discontinued, the concrete after be coming firm enough to retain its form, shall be cleaned of laitance and other objectionable material to a sufficient depth to expose sound concrete. To avoid visible points as far as possible upon exposed faces, the top surface of the concrete adjacent to the forms shall be smoothed with a trowel.

Immediately following an approved discontinuance of placing concrete all accumulations of mortar splashed upon the reinforcement bars and the surfaces of forms shall be removed. Dried mortar chips and dust shall not be puddle into the unset concrete. If the accumulations are not removed prior to the concrete becoming set, care shall be exercised not to injure or break the concrete steel bond at and near the surface of the concrete while cleaning the reinforcement bars.

2.9.4 Joints

Expansion joints shall be formed in the positions indicated and to the details shown on the Drawings or otherwise ordered by the Engineer. The expansion joints shall be filled with bitumen impregnated fiberboard to its full depth and width. The filling will be permitted to be used as permanent formwork only for the second casting. Where the fiberboard is exposed, it shall be cut back for a depth of at least 1cm. from the chamfered edges, filled and pointed with a resilient liquid poly sulphide polymer sealant. Whenever the placing of the concrete is discontinued other than at the expansion faces, this discontinuity shall form a construction joint. Construction joints are to be made only along a horizontal or vertical plane except that in the case of inclined or curved members they shall be at right angles to the principal axis. Care shall be taken to prevent offsetting of the joint and to ensure water tightness. The joints shall in every way satisfy the requirements of the Engineer, and be in accordance with the Drawings.

Unless otherwise shown on the Drawings, construction joints will not be allowed in the supported portion slabs, beams and beam like members. At construction joints the laminate film and porous layer of the already set concrete shall be removed and the surface keyed by hacking and then wire-brushed and thoroughly cleaned. Immediately before adding the new concrete, the surface it to be thoroughly wetted and a 1-cm thick coating of a fresh cement/sand mortar (having the same proportion of cement/sand as concrete in the mix) applied to the surface. The new concrete is then to be well compacted into the old.

The number of construction joints should be kept as few as possible consistent with reasonable precautions against shrinkage. Concreting should be carried out continuously up to construction joints.

Where it is necessary to introduce construction joints, careful consideration should be given to their exact location, which should be indicated on the drawings.

2.10 PRECAST HOLLOW CONCRETE BLOCKS [HOURDIS] FOR RIBBED SLABS:

2.10.1 Material and Manufacture

Aggregate shall be so sized, graded, proportioned and thoroughly mixed in a batch with such proportions of cement and clean water as to produce a homogeneous concrete mixture. However, in no case shall the proportion of cement in the mixture be less than five (5) standard [each weighing 50 Kgs] per cubic meter of concrete.

Pre-cast hollow concrete blocks (hourdis) for a ribbed slab shall be manufactured in approved vibrated, machine.

If for any reason the strength requirement is not achieved, cement shall be increased at the Contractor's own expense. The blocks shall be cured for twelve (12) consecutive days and shall be at least twenty-one (21) days old before incorporation in the Works. The blocks shall be of an approved pattern of withstanding a compressive force applied at the ends of 30 kgs/cm2 based on the gross sectional area of the block obtained without deducting voids.

The blocks shall be hard, sound, durable, sharp, clean with well defined arises, free from cracks and flaws or other defects and of the dimensions shown on the Structural Drawings. The blocks shall be obtained from an approved local factory.

2.10.2 Workmanship

Pre-cast hollow concrete blocks (hourdis) shall be laid exactly in a line with the cells on the long dimensions.

Close edge blocks shall be used at the end; the dimensions of the ribs and size of reinforcing bards shall be exactly according to the Structural Drawings, In narrow width specially made half blocks shall be used and full block shall not be used along their length (with the calls along the long dimensions of the rib.)

The blocks are to be laid on adequate forms. All blocks shall be cleaned and thoroughly wetted with clean water before the concrete is poured and laborers shall not be allowed to walk on them. Any block found to be defective or damaged during concreting operations shall be removed and replaced before pouring the concrete, all at the contractor's expense.

2.11 FORMWORK

2.11.1 General

The Contractor shall be responsible for the design and stability of the formwork. The contractor shall submit a full program of work indicating the various phases for the erection and removal of forms and the manner in which he intends to execute all concrete works.

2.11.2 Material

All forms shall be of wrought lumber and shall be built mortar tight and of sufficient, rigidity to prevent distortion due to the pressure of the concrete and other loads incident to the construction operations. Forms shall be constructed and maintained so as to prevent warping and the opening of joints due to shrinkage of the lumber.

The forms shall be substantial and unyielding and shall be so designed that the finished

concrete will conform to the proper dimensions and contours. The Contractor shall take into consideration the effect of vibration on the formwork, and shall be responsible for any damage or default resulting thereof.

2.11.3 Workmanship

Forms shall be inspected by the Engineer prior to installation of reinforcement

The number of spacing of the form struts and braces shall be such that the forms will be braced rigidly and uniformly lock joints between form sections shall be free from play or movement.

The shape, strength rigidity, water tightness and surface smoothness of re-used forms shall be maintained at all times. Any warped or bulged lumber must be resized before being re-used. Forms which are unsatisfactory in any respect shall not be re-used.

Metal tie rods or anchorages within the forms shall be so constructed as to permit their removal to a depth of at least 40mm from the face within injury to the concrete. In case ordinary wire ties are permitted, all wires, upon removal of the forms, shall be cut back at least 10mm.

From the face of the concrete with chisels or nippers for green concrete, nippers are necessary. All fittings for metal ties shall be of such design that the cavities produced upon their removal are the smallest possible.

The cavities shall be filled with non-shrinkage material mortar and the surface left sound, smooth, even and uniform in color.

All forms shall be treated with special approved oil and saturated with water immediately before placing the concrete. For members with exposed faces, the forms shall be treated with approval material to prevent the adherence of concrete.

Any material which will adhere to or discolor the concrete shall not be used.

The contractor shall provide means for accurately measuring the settlement of the forms during placement of the concrete and shall make all necessary corrections as directed by the Engineer way release the contractor of his responsibility for the correctness of these schedules.

All reinforcement shall be placed strictly in accordance with the drawings and as instructed in writing by the Engineer. Nothing shall be allowed to interfere with the required disposition of the reinforcement, and the Contractor shall ensure that all parts of reinforcement are placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part small be in actual contact with the bars, around which they are intended to fit. Placed correctly in position and are temporarily fixed where necessary to prevent

The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part small be in actual contact with the bars, around which they are intended to fit.

displacement before or during the process of tamping and ramming the concrete in place.

2.11.4 **Removal of Form-work**

In the determining of the time for removal of forms, consideration shall be given to the location and character of the structure, the weather and other conditions influencing the setting of the concrete and the materials used in the mix. In general, the forms of any positions of the structure shall not be removed until the concrete is strong enough to prevent injury to the concrete when the forms are removed. Unless otherwise directed by the Engineer forms shall remain in place for the following specified period of time:

	1		01	1				
•	Centering under beam	ıs						: 21 days
•	Floor slabs							: 21 days
_	XX 7 11 1 · 1	C 1	1 /1		11 C	1	C	2 1

Walls, columns, sides of beams and other vertically formed surfaces : 3 days

Method of form removal likely to cause overstressing of the concrete shall not be used. In general, the forms shall be removed from the bottom upwards. Forms and their supports shall not be removed without the written approval of the Engineer. Supports shall be removed in such a manner as to permit the concrete to uniformly and gradually take the stresses due to its own weight.

Centers shall be gradually and uniformly lowered in such a manner as to avoid injurious stresses in any part of the structure.

The Contractor shall include in his prices for any formwork which may have to be left in position due to the impossibility of removal of same.

2.12 REINFORCEMENT

2.12.1 General

The contractor shall prepare for his own use bar bending schedules from the information given on the drawings and in these specifications. These schedules shall be submitted to the Engineer for approval which shall in no way release the contractor of his responsibility for the correctness of these schedules.

All reinforcement shall be placed strictly in accordance with the drawings and as instructed in writing by the Engineer. Nothing shall be allowed to interfere with the required disposition of the reinforcement, and the contractor shall ensure that all parts of reinforcement are placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place. The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part small be in actual contact with the bars, around which they are intended to fit. Placed correctly in position and are temporarily fixed where necessary to prevent displacement before or during the process of tamping and ramming the concrete in place.

The ties, links or stirrups connecting the bars shall be taut so that the bars are properly braced the inside of their curved part small be in actual contact with the bars, around which they are intended to fit. . .

2.12.2 Type and Quality of Steel Reinforcement

1. Hot-Rolled Steel Plain Rods and Bars

Hot rolled steel plain rods and bars shall conform to the strength requirements and minimum elongation of the Standard Specification for Deformed Billet-Steel Bars of Grade 40 with minimum yield strength 2400Kg/cms (35000 psi) for concrete Reinforcement of ASTM Designation (A-615) or equivalent.

2. Deformed Steel Rod and Bars

Deformed steel and bars shall conform to the requirements of the Standard Specification for Deformed Billet-Steel Bars of grade 60 with minimum yield strength 4200 kg/cm2 (60000 psi) for concrete reinforcement of ASTM Designation (A-615) or equivalent.

2.12.3 Wire

Wire for bending reinforcement bars shall be of soft black annealed mild steel wire. The diameter of the Wire shall not be less that 16 S.W.G. (1.6mm) and the binding shall be twisted tight with proper pliers. The free ends of the binding wire shall be bent inwards.

2.12.4 Order Lists

Before ordering material, all order lists and bending diagrams detailed in accordance with the latest revision of AGI Building Code shall be furnished by the contractor for the approval of the Engineer, and no material shall be ordered until such lists and steel bending diagrams have been approved. The approval of order lists and bending diagrams by the Engineer shall in no way relieve the contractor of his responsibility for the correctness of such lists and diagrams. Any expenses incurred to the revision of material furnished in accordance with such lists and diagrams to make and comply with the design drawings including cut and waste shall be borne by the contractor.

2.12.5 Protection of Material

Steel reinforcement shall be protected at all times from injury. When placed in the work, it shall be free from dirt, detrimental scale, paint, oil, loose, rust, grease or other foreign substances.

2.12.6 Fabrication

Bar reinforcement shall be bent to the shapes shown on the Drawings and Steel Bending (Diagrams), bending dimensions and scheduling of bars for the reinforcement of concrete. All bars shall be bent cold, unless otherwise permitted by the Engineer. No bars partially embedded in concrete shall be bent except as shown on the plans or specifically permitted by the Engineer.

2.12.7 Placing and Fastening

All steel reinforcement shall be accurately placed in the position shown on the drawings and firmly held during the placing and setting of concrete. Bars shall be tied at all intersections except where spacing 300mm in each direction, in which case alternate intersections shall be tied.

Distance from the forms shall be maintained by means of stays, blocks ties, hangers, or other approved supports. Blocks for holding reinforcement from contract with the forms shall be pre-cast mortar blocks of approved shapes and dimensions or approved metal or plastic chairs. Metal chairs which are in contact with the exterior surface of the concrete shall be galvanized. Layers of bars shall be separated by pre-cast mortar blocks or by other equally suitable devices. The use of pebbles, pieces of broken stone or brick, metal pipe and wooden blocks

shall not be permitted. Reinforcement in any member shall be placed and then inspected and approved by the Engineer before the placing of concrete begins. Concrete placed in violation of this provision may be rejected and its removal is required.

2.12.8 Splicing

All reinforcement shall be furnished in the full lengths indicated on the drawings. Splicing bars, except where shown on the drawing, will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible.

Additional splices, other than those shown on the drawings; and allowed by the Engineer, shall be at the contractor's own expense.

The cost of all supports for holding reinforcement bars shall be borne by the Contractor.

2.13 CURING AND PROTECTION

2.13.1 Water Curing

All concrete shall be cured for a period of time required to obtain the full-specified strength but not less than seven (7) consecutive days. Unformed surfaces shall be covered with sand burlap, or other approved fabric mats kept continually wet. If the forms are removed before the end of the curing period, curing shall be continued as on the uniformed surfaces. When burlap, sand or other approved fabric materials are used, they shall not cause any undesirable finish such as rough surface and discoloring where exposed to light. Unhardened concrete shall be protected from heavy rains or flowing mechanical

injury and the Contractor shall submit for the Engineer's approval his construction procedure which is designed to avoid such an eventually. No fire or excessive heat shall be permitted near or in direct contact with concrete at any time. Water for curing shall conform to Section 2.3.6.

2.13.2 Curing with Curing Media

Curing medium shall meet all requirements of the specifications for Liquid Membrane-Forming Compounds for Curing Concrete of ASTM Designation: C-309 and test for water retention by concrete curing materials of ASTM Designation: C-156.

The compound shall be applied to the concrete surface by means of a sprayer, roller or lamb's wool applicator and shall be sprayed on. Ample time shall be allowed for the concrete surface to harden and to prevent any damage. The compound shall give a drying time not to exceed thirty minutes, and shall be applied undiluted directly from the manufacturer's labeled container in accordance with the manufacturer's directions and to the satisfaction of the Engineer.

The compound shall be completely compatible with adhesives, joint sealants and cement grout.

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2.13.3 Payment

No separate payment shall be made for curing with water or with curing media. The cost of such curing shall be deemed to be included in the Unit Prices of "CONCRETE WORK".

2.14 CONCRETE [FAIR FACE] EXPOSED SURFACES

2.14.1 Formwork

Formwork for exposed concrete surface shall conform to the applicable requirements of Section C 14, in addition to those Specifications.

All concrete surfaces that are to be left exposed to view as a finished surface except for precast concrete units, shall be produced by vertical metal shuttering.

The quantity of the surface of concrete exposed to view shall be consistent throughout the project and the following methods shall be adopted to obtain the required finish.

Metal forms of an approved type for pre-cast units

The Contractor may submit alternative proposals for the Engineer's approval if he so desires.

The Contractor is to submit to the Engineer for his approval shuttering details and sequence of operation relating to fair face concrete work. Sample panels shall be constructed for all their face concrete finishes and following the Engineer's approval the panels will remain on site and constitute a standard which must be maintained throughout the duration of the Contract.

2.14.2 Coating Forms with Mineral Oil

In addition to the above forms or linings, the forms shall be coated before placing reinforcement with an

approved colorless mineral oil free of kerosene.

All surplus oil on form surfaces and any oil on reinforcing steel shall be removed.

2.14.3 Samples and Workmanship

The Contractor shall submit for approval a sample panel not less than 600x1200mm to demonstrate the quantity of the exposed concrete produced by forms at his own expense. The quantity of the finished work shall be measured against the quality of the approved sample panel and the work of inferior quality shall be repaired or replaced as directed by the Engineer without any additional cost.

The quality of the finished surfaces shall be uniform in color and consistency, whether in color or in texture, in any of the finished surfaces, the Engineer may order the repair or the demolition of the portion of concrete work and the reconstruction of same at the expense of the contractor and the contractor shall have no right to claim for any expenses or time delay incurred.

Alternatively the Engineer may order the contractor to plaster all exposed surfaces and bushhammer the entire area of, concrete in the project so as to render all exposed surfaces of concrete consistent throughout the project at the contractor's own expense.

2.15 MONOLITHIC SMOOTH FINISH SURFACES

All concrete surfaces which are not in acceptance condition and which are required to be surface-finished as designated herein shall be rubbed to a smooth and uniform texture with a carborundum brick and clear water as soon as the forms are removed and the concrete is ready to hone. The loose material formed on the surface shall be removed as soon as it dries by rubbing the surface with burlap or other approval material. A cement wash shall not be used. Concrete surface shall be free from honeycombing, air holes, fins and projections arising from defective mixings, placing or formwork. When the formwork has been stuck off, the surface of concrete shall be left untouched until inspected by the Engineer. Any defective concrete work shall at the discretion of the Engineer be demolished completely and rebuilt or cut out and made good with concrete of the same proportions as the original. Such rectifications shall be to the satisfaction of the Engineer and at the Contractor's own expense.

3 SUB BASE AND BASE COURSES

3.1 General

Locating sources and manufacturers of materials are the responsibility of the contractor.

Prior to starting quarry or borrow pit operations, the contractor shall obtain written permission from the Authorities or Owner concerned.

The contractor shall submit to the Engineer, 10 days prior to the scheduled beginning of crushing and screening, a statement of origin of all stone and/or gravel aggregates and granular materials.

The contractor shall submit for testing and approval, representative samples of all materials needed. Samples shall be taken by the contractor in the presence of the Engineer. Approval of specific sources of materials shall not be considered as final approval.

The contractor may conduct necessary tests in the Field Laboratory in the presence of the Engineer and the contractor's Materials Engineer.

Samples shall satisfy all specified test requirements. The contractor shall furnish all necessary labor, transport, tools and equipment required by the Engineer.

3.2 Granular Material for Sub-Base

<u>Granular material</u> for use in sub-base courses shall be naturally occurring gravel, blended as necessary with fine or coarse material and screened to produce the specified gradation. Crushing of natural granular material shall not normally be required, unless for the purpose of meeting the gradation requirements, or when shown on the Drawings (to produce a higher quality sub-base with improved mechanical stability).

<u>Gravel</u> shall consist of hard, durable and sound stones, free from deleterious substances not mentioned below.

Other requirements are:

Crystalline gypsum (expressed as SO3)	5% max.
Clay lumps and friable particles	10% max

Flakey and elongated particles

Crushed rock	40% max. Each
Crushed gravel	45% max. Each
Natural gravel	50% max. Each
Determined in accordance with BS812 Section	105.1: 1985 and BS812 Part 1 1975)

Maximum dry density

Maximum dry density is 2.05gm/cm^3 as min. Chart content (determined by percentage by weight insoluble in hydrochlo

Chart content (determined by percentage by weight insoluble in hydrochloric acid) should be specified in special technical specification.

<u>Granular materials</u> delivered to the road site shall meet the requirement of class A or B as shown in Table 3.1, when tested in accordance with AASHTO T-27 after dry mixing and just

before spreading and compacting. The Class of granular material to be used shall be as shown on the Drawings or otherwise as selected by the Engineer. The actual gradation shall, in all cases, be continuous ad smooth within the specified limits for each Class. If gradation is tested after compaction, a tolerance of 3% is allowed in the upper limit for the percentage of material passing sieve no. 200.

Gradation of Granular Material by Class, shown table 13-1

Siava Designation	Percent by weight passing			
(Square openings)	Class A	Class B		
63 mm (2-1/2 in.)	100			
50 mm (2 in.)	80-100	100		
37.5 mm (1-1/2 in.)	70-95	80-100		
25 mm (1 in.)	55-90	60-95		
12.5 mm (1/2 in.)	45-75	47-80		
4.75 mm (No.4)	30-60	30-60		
2.00 mm (No. 10)	22-48	22-45		
0.425 mm (No.40)	10-30	10-30		
0.075 mm (No. 200)	5-12	5-12		

 Table 13-1: Gradation of Granular Material by class

Sand equivalent

The material shall contain a minimum of 25% sand equivalent at any stage of construction.

Loss weight of granular material

The loss weight of granular material shall not exceed 45% after 500 revolution, when tested in accordance with AASHTO T 96 (Los Angelos Abrasion Test).

The ratio of wear loss =
$$\frac{A brasion after 100 \text{ Re } v}{A brasion after 500 \text{ Re } v}$$
.

Should not be more than twenty percent of the maximum allowed abrasion after 500 revelations.

Soaked CBR

The granular material shall have a 4-day soaked CBR of not less than 30 when compacted at 100% of modified proctor AASHTO (T 180-D) and tested in accordance with AASHTO T 193.

Soundness

When tested for soundness in accordance with AASHTO T 104, the material shall not show signs of disintegration and the percentage loss in weight after 5 cycles shall not exceed 12% in the case of the sodium sulphate test and 18% in the case of the magnesium sulphate test.

Portion of granular material

The portion of granular material, including any blended material, passing the 0.425 mm (No. 40) mesh sieve shall have a liquid limit (L.L) of not more than 27and a plasticity index (P.I.)

not grater than 6 when tested in accordance with AASHTO T 89 and T 90. Non-Plastic condition might be accepted if crushed limestone is used provided that angularity test (R) value shall not be less than 8.

Additional fine material

If additional fine material is required to correct the gradation of the granular material, or for adjusting the L.L. or P.I. of the fraction passing 0.425 mm (No. 40) sieve, it shall be uniformly blended and mixed with the granular material. Additional fine material for these purposes shall be obtained from the crushing of stone, gravel, or slag, if naturally occurring fine materials not available.

3.3 Aggregate for Base Courses:

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

It shall consist of hard durable and sound particles or fragments of stone, free from other substance. Other requirements are gypsum, or flaky particles.

Other requirements

Gypsum content (expressed as SO₃) 2 % max.

Clay lumps and friable particles 8 % max.

Elongated and flakey particles for crushed rock (Determined in accordance with BS 812 Part 1: 1975)

Granit and Basalt40 % max each.Lime stone35 % maxMinimum dry density (g/cm3)2.15 % minLinear shrinkage not exceed 3%3%

Gradation of Base course Aggregate by class, shown in table 13-2.

Tuble 10 2. Gradation of Dase course Aggregate by class					
Siava Designation	Percent by weight passing				
Sieve Designation	Class A	Class B			
50 mm (2 in)		100			
37.5 mm (1.5 in)	100	70-100			
25 mm (1 in)	75-100	55-85			
19 mm (3/4 in)	60-90	50-80			
12.5 mm (1/2 in)	45-80				
9.5 mm (3/8 in)	40-70	40-70			
4.75 mm (No 4)	30-65	30-60			
2 mm (No 10)	20-40	20-50			
0.425 mm (No 40)	8-20	10-30			
0.075 mm (No 200)	5-10	5-15			

Table 13-2: Gradation of Base course Aggregate by class

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

The loss weight shall not exceed 40 % after 500 revolutions, when tested in accordance with AASHTO T96 (Los Angeles Abrasion Test).

The ratio of wear loss should not be more than twenty percent of maximum allowed abrasion after 500 revolutions.

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

When tested for soundness is accordance with AASHTO -104, the material shall not show signs of disintegration and the loss by weight shall not exceed 12 % in 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) sieve shall have a liquid limit (L.L.) of not more than 25 and plasticity index (P.I) of not more than 6, and not less than 3 when tested in accordance with AASHTO T 89 and T 90.

If additional fine material is required to correct the aggregate gradation or for adjusting the L.L or P.I. of fraction passing the 0.425 mm (No 40) sieve, it shall be uniformly blended and mixed with the aggregate material.

Elongated and flakiness not to exceed 35% for each.

3.4 GRANULAR SUB-BASE COURSES

3.4.1 Scope

These Works shall consist of furnishing granular sub-base material of the required Class, mixing, spreading on prepared sub-grade, compacting and finishing, all as and where shown on the Drawings.

3.4.2 Materials

All materials shall conform to the relevant requirements of Section "Materials", in respect of granular material Class A or Class B for sub-base construction.

3.4.3 Sub-grade Surface Preparation

The sub-grade shall have previously been constructed in accordance with the requirements of Section "Sub-grade Construction and Topping" and properly maintained and kept well drained thereafter.

At all special grade control points, such as at bridge structures, existing pavements, etc. The sub-grade shall be lowered to a depth sufficient to permit construction of the sub-base course to the specified elevations and thickness.

Transitions shall be of sufficient length to avoid abrupt change of grade and shall be within plus or minus 3% of the final design grade unless otherwise directed. Surplus material shall be removed and disposed of.

The sub grade shall be inspected and approved immediately prior to commencement of subbase construction. Any soft, yielding material shall be removed and replaced by approved topping material. Holes, depression and other irregularities shall be made good as directed and the sub-grade re-compacted as necessary and finished ready to receive the sub-base course.

3.4.4 Equipment

Equipment used to handle, place, spread, water, compact and finish sub-base shall conform to the requirements of Section "Contractor's Plant and Equipment" and with the Contractor's approved Work Program.

3.4.5 Construction

3.4.5.1 Stockpiling of Granular Material

Stockpiling procedures shall conform to the relevant requirements of Section "Materials".

Methods used for stockpiling granular material and removing it from stockpiles shall not result in significant degradation or segregation nor the introduction of significant amounts of foreign materials or extraneous matter.

Granular material adversely affected, in the opinion of the Engineer, by stockpiling or handling procedures shall be incorporated in the Works regardless of previous approval of such material, until the deficiencies have been rectified in an acceptable manner.

3.4.5.2 Mixing and Spreading

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

The sub-base material shall be placed on the subgrade in a uniform two layers each 150 mm thickness (after compaction).

If approved, heavy duty vibratory compaction equipment is used, the sub base may be in one 300 mm layer (after compaction) provided compaction tests with appropriate testing equipment indicate that the specified compaction standard will be attained and uniform throughout the thickness.

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

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

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

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

3.4.5.3 Compaction

The Contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces, If the Contractor delays placing of succeeding layers of material to the extent that additional water is required to prevent raveling or excessive drying, the application of such water shall be carried out as directed and at the Contractor's expense.

The sub-base material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass.

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

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

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

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

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

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

3.4.5.4 Tolerances

The fully compacted and completed sub-base course shall conform to the lines, grades and cross sections as shown on the Drawings.

The elevations of the finished sub-base course shall be checked by the Contractor in the presence of the Engineer at maximum intervals of 10 m and at intermediate points as directed.

The tolerance on elevations of finished surface shall be plus 10 mm to minus 20 mm, minus

tolerance shall be compensating by the proceeding layer.

When the finished surface is tested with a 3 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 10 mm.

All areas which exceed the specified tolerances shall be corrected by removing the defective sections of sub-base and reconstructing them or, if approved, by adding new material mixing and re-compacting and finishing to the specified standard.

3.4.5.5 Maintenance of Completed Sub-base

Following completion and acceptance of the sub-base course, it shall be maintained by the Contractor at his own expense. The sub-base shall be bladed, broomed and otherwise maintained, keeping it free from raveling and other defects until such time as the base course is placed. Water shall be applied at such times and in such directed by the Engineer.

3.4.6 Testing

Every 500 linear meter of sub-base material or whenever there is a change in the material source shall be subject to a full set of tests after mixing in situ and, if found satisfactory, shall be approved for compaction. This approval shall not deem to constitute acceptance of the sub-base course.

Sampling and testing shall conform to the relevant requirements of Section 1.05- "Control of Materials and Standards for Sampling and Testing".

Compaction shall be tested in accordance with AASHTO T 191 or AASHTO T 205. If there is a delay between the construction of any layer and the following layer, if necessary and required by the Engineer the compaction of the lower layer may be recertified to ensure that it has not loosened due to traffic, passage of construction equipment, adverse weather conditions or otherwise.

3.5 AGGREGATE BASE COURSES

3.5.1 Scope

These works shall consist of furnishing crushed aggregate base course material of class a, mixing, spreading, compacting and finishing, all as and where shown in the Drawings.

3.5.2 Surface Preparation

The sub-grade surface shall be inspected and approved prior to commencement of base construction, Holes, depressions and other irregularities shall be made good as directed an the sub-grade re-compacted as necessary and finished ready to receive the base course layer.

3.5.3 Equipment

Equipment used to handle, place, spread, water, compact and finish base course in accordance with contractor's Work program approved by the Engineer.

3.5.4 Construction

3.5.4.1 Stockpiling of Base Course Material

Stockpiling method of aggregates and moving them from stockpiles shall not result in significant degradation or the introduction of significant amounts of foreign materials. Aggregate materials adversely affected, in the opinion of the Engineer, by stockpiling or handling procedures shall not be incorporated in the works regardless of previous approval of such material until the deficiencies have been rectified in an acceptable manner.

3.5.4.2 Mixing and Spreading

Base course material shall be mixed with water to reach the specified moisture content range at the time of compaction. The mixed material shall be handled and placed on subgrade in a uniform layer as to not cause segregation. All segregating material shall be removed and replaced with well-graded material, "Skin" patching will not be permitted and spread to the required width and shall be delivered such that it is ready for compaction without farther shaping.

3.5.4.3 Compaction

The contractor shall plan the sequence of operations so that the least amount of water will be lost by evaporation from uncompleted surfaces.

The base course material shall be compacted by means of approved compaction equipment, progressing gradually from the outside towards the center, with each succeeding pass uniformly overlapping the previous pass. Rolling shall continue until the entire thickness of each base layer is thoroughly and uniformly compacted to 100% AASHTO T 180 (Method D) maximum density:

The edges and edge slops of the base course shall be bladed or otherwise dressed to conform to the lines and dimension shown on the Drawings.

Materials which have dried out prior to final compaction, or which has dried and decompacted subsequent to final compaction, shall be watered and recompacted. If the contractor failed to return the material to its original or specified condition with respect to compaction, thickness and surface tolerance the contractor shall scarify the material and reconstruct the base course on a re-approved subgrade surface or to the satisfaction of the Engineer.

3.5.4.4 Tolerances

The dully-compacted base course shall conform to the lines, grades and cross sections as shown in the drawings.

The elevations of base course shall be checked at intervals of 20 m on straight and 10 m on curves, the tolerance on elevations of surface shall not exceed $\pm 10 \text{ mm or } -05 \text{ mm}$, and not exceed 12 mm between any two contact points tested with a 4 m long straight edge placed parallel to, or at right angles to center line.

All areas which exceed the specified tolerances shall be scarified and corrected to specified standard.
3.5.4.5 Maintenance of Completed Base Course

Following completion and acceptance of base course, it shall be maintained by contractor at his own expense. The surface shall be broomed and rolled keeping it free from defects until such time as the following course is placed. Water shall be applied at such times and in such quantities as directed.

3.5.5 Testing

Sub base and base Course material shall be tested in accordance with the table shown below at stock pile and at the mixing plant for control on site tests, and if satisfactory shall be approved for use. This approval shall not be deemed to constitute acceptance of base course for full payment purposes.

Required Tests and Minimum Repetition for Base course material, shown in table 13-3.

Source of Materials		Control on Site (The Road)	
Required Test	Repetition Required for all Test	Required Tests	Repetition Required for all Test
1-Gradation of materials	* Test for each source	1. Proctor	* test for every 500 Lm for each layer
2- Plasticity Index	* for every 1000 m^3	2. Gradation of materials	* when materials changed
3- Abrasion	* When materials changed or every 1000 m^3	3. Plasticity Index	
4- C.B.R.		4. C.B.R.	
5- Sand equivalent		5. Abrasion	
6-Percentage of Fractured Grains		6. Sand equivalent7. Clay Lumps &Friable particles8. Field Density9. Thickness	

Table 13-3: Required Tests and Minimum Repetition for Base course

Compaction test: for every layer at least 3 samples taken for one street or 1000 m^2 from layer area, or 200 linear meter of road which is smaller.

3.5.6 Measurement

- 1. The net area executed must be measured (without the area under the curb stone).
- 2. The area of manholes and gullies is to be deducted from measurement.

4 -BITUMINOUS CONSTRUCTION

4.1 Material

4.1.1 Scope

All material sources and the quality of materials proposed for use in the works shall be approved prior to procurement or processing material from such sources. Inspection, sampling, testing and re-testing as necessary, shall be at the contractors expense.

4.1.2 Sampling and Testing of Aggregate

In order to ascertain the properties of aggregate materials, the contractor shall submit for testing and approval, representative samples of all materials intended for corporation in the works, prior to starting quarry operations, the samples shall be taken by contractor in the presence of the Engineer.

Tests performed by the contractor shall utilize in assessing the locations, extent of deposits and quantities of materials which will conform to the specifications when properly processed. All testing as carried out by the contractor shall in no way obviate the need for further testing by Engineer.

Approval of specific sources of materials shall not be considered as final approval and acceptance of materials from such sources.

Unsatisfactory materials whether in place or not, shall be removed promptly from the site. The contractor shall furnish all necessary material, labor, tools, and equipment and transport required by the engineer for such inspections.

4.1.3 Aggregates for Bituminous Paving Mixes

- 1. Aggregate for use in bituminous, binder and wearing courses, shall consist of crushed stone.
- Course aggregate shall be the fraction of crushed aggregate material retained on 4.75 mm (No. 4) sieve. Fine aggregate shall be the fraction of crushed aggregate material passing 4.75 mm (N0. 4) sieve. Mineral filler shall be added when the combined grading of course and fine aggregates is deficient in material passing 0.075 mm (No. 200) sieve.
- 3. The material from hot bins passing the number 40 sieve (0.425 mm) when tested in accordance with AASHTO T90 shall be non plastic.
- 4. Aggregate shall not contain gypsum more than 1% and the course fraction of the aggregate shall not contain more than:
 - 5% chert and flint for aggregate to be used in the Wearing course.
 - 5% chert and flint for aggregate to be used in the Binder course.
- 5. Aggregates shall be of uniform quality, free from decomposed stone, organic matter, shale.
- 6. The percentage by weight of friable particles, clay lumps, and other deleterious matter shall not exceed 1% as determined by AASHTO T112.

- 7. Aggregate particles shall be clean, hard, durable and sound. Crushing shall result in a product such that, for particles retained on 4.75 mm (No. 4) sieve, at least 90% by weight shall have 2 or more fractured faces.
- 8. The flakiness index and the elongation index test should be conducted in accordance with BS 812, the flakiness and elongation index must be less than 30.
- 9. Aggregates shall be washed if directed, to remove any clay lumps, organic matter, adherent dust or clay films or other extraneous or deleterious matter that may prevent or detract from proper adhesion of bitumen to the aggregate particles.
- 10. Material filler shall consist of finely divided mineral matter such as limestone dust if added separately; hydrated lime; other non-plastic mineral filler, free from clay and organic impurities; or Portland cement, conforming to AASHTO M17.
- 11. Combined course and fine aggregates for bituminous mixes, including mineral filler, when tested in accordance with AASHTO T27 and T11, shall conform to gradations shown in Table shown below (Table 14-1):-

Sieve Designation	Binder Course Percent Passing	Wearing Course Percent Passing
1" (25.0mm)	-	-
3/4" (19.0mm)	100	100
1/2 " (12.5mm)	82±9	89±9
3/8" (9.5 mm)	72±9	82±9
No. 4 (4.75mm)	54±9	66±9
No. 8 (2.36mm)	41±9	53±9
No. 16 (1.18mm)	32±9	41±9
No. 30 (0.600mm)	24±9	31±9
No. 50 (0.300mm)	17±7	21±8
No. 80 (0.150mm)	12±5	13±6
No. 200 (0.75mm)	5±2	4.5±2.5

 Table 14-1: Gradation of Aggregates for Bituminous Mixes

12. The loss in weight of aggregate after 500 revolutions, when tested in accordance with AASHTO T96, shall not exceed 35%.

Ratio of wear loss =

is less than or equal 25.

- 13. When tested for soundness in accordance with AASHTO T104 the course aggregate (retained on No. 4 sieve) shall not shown sings of disintegration and the loss by weight after 5 cycles shall not exceed 9% in the case of the sodium sulphate test and 12% in the case of the magnesium sulphate test.
- 14. When tested for resistance to stripping in accordance with the AASHTO T-182 at least 95% coated particles should be achieved. Scandinavian test shall be carried out and at last 60% of the coarse aggregate surfaces area shall remain coated with a bitumen film especially for exposed surfaces other wise anti stripping agent must be added to achieve the required coating.

- 15. The material shall contain minimum 50% sand equivalent. Test sample shall be taken from hot bins.
- 16. Minimum Dry Specific Gravity (g/cm3) 2.55 min
- 17. Water absorption not exceed 2%

4.1.4 Heating of Bitumen

- 1. Heating equipment shall be of an approved type. Any method of heating that introduces free steam or moisture into the bitumen will not be approved.
- 2. Bitumen shall not be heated more than 170degrees C. materials heated in excess of this temperature will be rejected and shall not be used in the works.
- 3. Heating of bitumen shall be uniform and under control at all times, to the specified temperature. The circulation system shall be of adequate size to insure proper and continuous circulation of bitumen during the entire operating period.
- 4. Thermometers of adequate range (calibrated in 2 degrees c increments) for accurately measuring the temperature of the bitumen, shall be located so as to be readily visible and shall be kept clean and working order at all times.

4.2 BITUMINOUS PRIME AND TACK COATS

4.2.1 Scope

This work shall consist of furnishing and applying and MC cutback bitumen prime coat to a previously constructed aggregate base course and applying tack coat on Asphalt or concrete surfaces all as and where shown on the Drawings.

4.2.2 Medium Curing Cutback Bitumen

- 1. MC-70 cutback bitumen for prime coat shall be used as recommended by ASTM D2399-83 for open and tight surface, and RC-70 should be used as tack coat.
- 2. All surfaces to receive either prime or tack coats shall conform to the specified tolerances and compaction requirements and shall be properly cleaned and finally approved before applying any bitumen material.
- 3. Application of prime and tack coats shall be performed only when the surface to be treated is sufficiently moist and atmospheric temperature is above 15 C. There should be no fog, rain, strong winds, dusty conditions, or dust storms.
- 4. The surface of all structures shall be protected in an approved manner during the equipment operation. The contractor shall be responsible for making good any staining or damage of the structures to the satisfaction of the Engineer.
- 5. Traffic shall not be permitted to surfaces after they have been cleaned and prepared for prime coat application.

- 6. The contractor shall maintain prime or tack coats until it is covered by the subsequent pavement course.
- 7. Any area where the coats have been damaged shall be cleaned of all loose material and re-applied at the contractor's expense.
- 8. Applying temperature of MC- 70 shall be 45-80C.
- 9. Areas to be primed shall be including 200 mm widths outside the edge of the permanent line.
- 10. Application rate for prime coat shall be 1 lit/sq.m and tack coat application shall be 0.7 lit/sq.m.
- 11. Asphalt pavement shall not be placed on prime coat before 24 hours, and no traffic is allowed to pass on prime coat.
- 12. The minimum solid residue by evaporation by weight must exceed 50 % when tested according to ASTM D 1461-85.
- 13. The Ash content of residue by weight must not exceed 7 % when tested according to AASHTO T-83(2000).
- 14. The drying time for prime coat must not exceed 24 hour.
- 15. The density range from 990 to 1010 gm/l when tested according to ASTM D 70

4.3 BITUMINOUS COURSES

4.3.1 Scope

This work shall consist of the general requirements of furnishing materials, mixing at a central mixing plant, spreading and compacting bituminous courses.

4.3.2 Job Mix and Project Mixes

- 1. The contractor shall submit certificate of origin of all material used in the mix for approval of the engineer, the material must be of best kinds.
- 2. The contractor shall submit his proposed Job Mix Formula for approval, at least 30 days prior to beginning production so that the life of the submitted Job Mix should not exceed 6 months from the date of submittion for small size projects but to be furnished particularly for large size projects. Therefore, samples from materials use in the preparing mix design (aggregates and bitumen) shall be sent to specialized laboratories to be tested for final approval of mix design.
- 3. The Job Mix Formula is established by the contractor, under the supervision of the engineer, in the field laboratory mix design procedures shall conform to the Marshall method of mix design. All trial mixes shall be prepared and tested by the contractor in the presence of the Engineer.
- 4. The Job Mix Formula shall specify a combination of mineral aggregates including filler

and bitumen in such proportions as to produce a Job Mix which is within the limits of the specified gradation and bitumen content ranges and which meets the Marshall Test requirements. It shall also stipulate the mixing temperature at discharge from the mixer which, unless otherwise directed, shall be 170 degrees C.

- 5. The Marshall Test procedure shall be used to determine the percentage of bitumen to be incorporated in the mix. The Job Mix Formula shall take into consideration the absorption of bitumen into the aggregates. Air voids shall be calculated in accordance with the procedure given in the Asphalt Institute Manual, MS-2.
- 6. When compacting specimens on accordance with the Marshall Test procedure, the number of blows applied with the compaction hammer shall be 75 on each side.
- 7. In order to meet the requirements, an approved additive such as Portland cement, hydrated lime or liquid antistrip agent, may be required in the Job Mix. Portland cement shall meet the requirements of ASTM M 85. Hydrated lime shall meet the requirements of ASTM C207, Type N. Cement or hydrated lime will normally be required in the approximate range of 2-3% by weight of the aggregates and shall be added at the cold feed in dry or slurry form as directed. Liquid antistriping agent, if needed will normally be required in the approximate range of 0.6-1.0% by weight of the bitumen, or according to the manufacturers specifications.
- 8. Upon receipt of approval of the Job Mix Formula, the Contractor shall adjust his mixing plant to proportion the individual aggregates, mineral filler and bitumen to produce a final project mix within the limits given in Table shown (14-2) with respect to the Job Mix gradation

Sieve Designation	Specified Tolerances		
(square openings)			
9.5 mm $(3/8 \text{ in.})$ and above	$\pm 5.0\%$		
4.75 mm (No. 4)	$\pm 4.0\%$		
2.36 mm (No. 8)	$\pm 4.0\%$		
1.18 mm (No. 16)	$\pm 4.0\%$		
0.600 mm (No. 30)	$\pm 4.0\%$		
0.300 mm (No. 50)	$\pm 4.0\%$		
0.150 mm (No. 100)	$\pm 4.0\%$		
0.75 mm (No. 200)	$\pm 1.5\%$		
Bitumen Content	$\pm 0.3\%$		
Temperature of Mix on discharge	\pm 5 C of the specified mixing		
temperature	_		

 Table 14-2: Maximum Variations of Project Mix from Approved Job Mix

- 9. Conformance to gradation requirements will be determined on the extracted aggregate in accordance with AASHTO T 30. The bitumen content shall be determined in accordance with AASHTO T 164.
- 10. The participation of the Engineer in the preparation of the Job Mix Formula shall in no way relieve the Contractor of responsibility for producing project mixes meeting the specified requirements.

4.3.3 Spreading and Finishing Equipment

- 1. Bituminous course shall be spread and finished using approved type, self contained, power-propelled pavers of sufficient capacity. Pavers shall be provided with electronically controlled vibratory screed or strike-off assembly and shall be capable of spreading and finishing the course of bituminous mix to the proper thickness and in lane widths applicable to the typical cross sections shown on the Drawings.
- 2. The pavers shall employ mechanical devices such as equalizing runners, straightedge runners, evener arms or other compensating devices, to maintain trueness of grade and confine the edges of the mix to true lines without the use of stationary side forms. Joint leveling devices shall be provided for smoothing adjusting longitudinal joints between lanes.
- 3. The paver shall be equipped with receiving hopper having sufficient capacity for a uniform spreading operation. The hopper is equipped with a distribution system to place the mix uniformly in front of the full length of the screed.
- 4. The screed or strike-off assembly and extensions shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mix.
- 5. The paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mix. Speed shall be fully adjustable
- 6. The Contractor shall make available, for reference by the engineer, the manufacturer's instruction and operating manuals for each paver intended for use.

4.3.4 Surface Preparation

- 1. When the bituminous mix is to be placed on a base course, the surface shall be prepared to meet the appropriate specified compaction and surface tolerance requirements. The surface shall hen be primed as specified "Bituminous Prime Coat". No bituminous mix shall be laid on a prime coat until it has been inspected and approved.
- 2. Broken, soft, or unstable areas of aggregate base course shall be removed and replaced. The areas shall be excavated to a depth as directed and refilled with the specified bituminous mix.

4.3.5 Delivery, Spreading and Finishing

4.3.5.1 Delivery of Mix to Site

- 1. A sufficient number of haul vehicles shall be provided so that adequate supplies of mix are delivered to ensure that continuous paving will be achieved.
- 2. Hauling equipment for aggregates and bituminous mixes shall consist of vehicles having dump bodies suitable for dumping materials in a windrow or in spreader boxes. The bodied shall be so constructed that their volume measurement can be accurately determined. They shall be constructed and maintained such that loss of materials during hauling operations will not occur.
- 3. Dump controls shall be capable of operation from the driver's seat.

- 4. Hauling equipment for hot bituminous mixes shall have tight, clean, smooth metal beds which are periodically thinly coated with a lime solution or other approved material to prevent adherence of the mix. All hauling units shall be equipped with a canvas or other approved type cover which shall be used to cover the hot material upon loading at the mixing plant and shall not be removed until the mix is discharged into the paver.
- 5. The dispatching of the hauling vehicles to the site shall be so scheduled that all material delivered is placed at least 90 minutes before sunset to allow sufficient time for compaction.
- 6. Delivery of material shall be at a uniform rate and in an amount well within the capacity of the paving and compacting equipment.
- 7. The mix delivered to site must have a temperature range from 139° to 163° .
- 8. Each haul vehicle shall be weighed after each loading at the mixing plant and accurate records shall be kept of the gross weight and net weight of each load, for each vehicle dates and time of loading.

4.3.5.2 Setting out Reference Line

- 1. The Contractor shall survey the centerline profile and crown of the existing surface or base and determine a reference grade line which will be submitted for approval. A reference line of wire or suitable cord shall be installed at a uniform grade parallel to the approved reference grade line such that conformance with the required geometrics, surface tolerance and minimum thickness requirements shall be ensured.
- 2. The reference line shall be maintained taut and free from sags at all times during spreading and initial compacting operations.
- 3. A wire or cord reference line shall be installed on both sides of the paver for the initial bituminous course being laid. Thereafter only one reference line will normally be required, if the paver is equipped with adequate automatic super elevation control.

4.3.5.3 Spreading and Finishing

- 1. Bituminous mixes shall be laid only when the air temperature is at least 5 degrees C or above when the existing surface is free from moisture, and when the weather is not foggy, rainy, dusty or excessively windy (particularly at low temperatures).
- 2. After completion of surface preparation, the bituminous mix shall be spread and finished true to crown and grade by approved automatically controlled bituminous pavers. The mix may be spread and finished by approved hand methods only where the engineer determines that machine methods are impracticable. Hand methods include heated hand tampers of at least 10 kg weight and approved type mechanical (vibratory) tampers.
- 3. The paver shall spread the bituminous mix without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture and free from hollows, transverse corrugations and other irregularities.
- 4. The paver shall be operated at a speed which gives the best results for the type of pavers being used and which coordinates satisfactorily with the rate of delivery of the mix to the

paver. A uniform rate of placement shall be achieved without repeated intermittent operation of the paver.

- 5. The mix shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mix during daylight hours.
- 6. If during laying, the paver is repeatedly delayed because of lack of mix or if the paver stands at one location for an extended period, resulting in the (unrolled) mat under and adjacent to the rear of the spreader falling below the minimum temperature for breakdown rolling, the affected portion of mat shall be cut out and discarded and a transverse joint shall be constructed. Paving shall not recommence until the engineer is satisfied that paving will proceed without interruptions.
- 7. Contact surfaces of curbing, gutters, manholes, and similar structures shall be painted with a thin, uniform coating of tack coat material. The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be 10 mm above the edge of such structure.
- 8. If during the paving operations, it is found that the spreading and finishing equipment in operation leaves in the pavement surface tracks or indented areas or other objectionable irregularities that are not satisfactorily corrected by the scheduled operations, the use of the equipment shall be discontinued, until faults are corrected to the approval of the engineer. If this is not possible, other satisfactory spreading and finishing equipment shall be provided by the contractor.
- 9. Transverse joints in succeeding layers shall be offset by at least 2 m. Longitudinal joints shall be offset at least 150 mm.
- 10. Bituminous mix shall be spread in one or more layers so that, after rolling, the nominal thickness of each layer of the compacted bituminous material does not exceed 2 to 3 times maximum size of aggregate. This maximum thickness may be increased slightly when such increase is more appropriate to total pavement thickness and provided the engineer determines that such increased thickness will not be detrimental to the quality of the finished bituminous course, and the contractor can show that the required density is attained throughout the layer thickness.
- 11. Transitions and structure approaches shall meet the design criteria for geometrics, the surface tolerance specifications, and shall not be visually discontinuous or abrupt in appearance.

4.3.5.4 Joints and Edges

- 1. All joints between old and new pavements or between successive days' work shall be as to ensure thorough and continuous bond between the old and new material.
- 2. Before placing fresh mix against previously laid, the contact surface shall be cut back to a near vertical face, and shall be sprayed or painted with a thin uniform coat of tack coat material. Longitudinal joints shall be made by overlapping the paver screed on the previously laid material (cut back as necessary) and depositing a sufficient amount of fresh mix so that the joint formed will be smooth and tight.

- 3. Unsupported edges of bituminous layers shall be rolled immediately following the rolling of the longitudinal joint. The material along the unsupported edge may, if approved, be raised slightly by hand methods, to ensure that the full weight of the roller will bear fully on the edge material
- 4. On completion, the longitudinal edges of bituminous pavement shall be true to the width and alignment as shown on the drawings. The edges shall be cut back if necessary prior to rolling, additional mix placed manually in a longitudinal strip adjoining each pavement edge, and the edge rolled down to a neat 3:1 (H:V) slope.
- 5. Transverse joints shall be carefully constructed and thoroughly compacted to provide a smooth riding surface. Joints shall be straight-edged and string-lined to assure smoothness and true alignment

4.3.5.5 Compaction

- 1. After spreading and strike-off, and as soon as the mix conditions permit the rolling to be performed without excessive shoving or tearing, the mixture shall be thoroughly and uniformly compacted, using approved types, sizes and number of rollers. Rolling shall not be prolonged to the point where cracks appear or shoving or displacement occurs.
- 2. All rollers shall be self-propelled vibratory steel wheel, 2-axle tandem steel-tired and pneumatic-tired types, in proper operating condition, capable of reversing without backlash or tearing of the surface, and shall be operated at numbers of rollers required is 3, of which one must be pneumatic type. The Contractor shall select a suitable method and pattern of rolling that will achieve the required compaction, to engineers approval.
- 3. Prior to use on site of pneumatic-tired rollers, the contractor shall furnish, for reference and retention by the engineer, manufacturers' charts or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of tire loadings for each type and size of compactor tire to be used. The contractor shall ensure that tire pressures are maintained at all times in conformity with such charts or tabulations. The maximum allowable tolerances shall be plus or minus 35 KN/sq.m (5 psi).
- 4. Rollers should move at a slow but uniform speed, generally with the drive roll or wheels nearest the paver.
- 5. Breakdown rolling shall be consist of 3 complete coverage unless otherwise directed. Rolling shall be longitudinal, and overlapping on successive trips by at least one half the width of the rear wheels.
- 6. To prevent adhesion of the mix to the rollers, the wheels shall be kept lightly moistened with water. Excessive use of water will not be permitted.
- 7. The initial or breakdown rolling shall be followed by intermediate rolling involving 3 coverage with pneumatic-tired rollers unless otherwise specified.
- 8. Finishing rolling shall then be carried out by means of tandem power steel rollers unless otherwise designated. If specified density is not achieved, changes shall be made in size and number of rollers being used to ensure the compaction requirements are met.

- 9. The compacted density shall be equal to or more than 97% and 98% for binder course and wearing course, respectively, of average Marshall bulk specific gravity for each day production unless otherwise directed by the engineer.
- 10. If after re-testing the density achieved is 0.5% or less below the specified density, the asphaltic layer will be accepted in the works subject to a 10% reduction to the billed rates. If on the other hand the density achieved is greater than 0.5% below the specified density the asphaltic material shall be removed and new materials laid to the specification at the contractor's cost.

4.3.5.6 Test for Bituminous Pavements

1. Minimum Tests Required as shown in table 14-3 below:

Work item	Tests at Source of material	Frequency of tests	Tests at road site	Frequency of tests
1- Materials	1- Specific	- Test for each		
used in Asphalt	gravity	source		
mix (at	and			
Batching plant)	water absorption	- When		
	2- Abrasion test	materials quality changes		
	3- Chert content	- As requested		
	4- Clay lumps	_		
	and friable			
	materials			
	5- Flaky and			
	elongated			
	particles			
	6- Soundness			
2- Materials	1- Gradation	- Test for each		
used in Asphalt		source		
mix (from hot	2- Specific	- when materials		
bins)	gravity and	quality changes		
	water absorption			
	3- Plasticity index	- As requested		
	4-Sand equivalent			
	5- Stripping with			
	asphalt			
3- Asphalt mix	1. Complete mix	-For each		
design (At	design in	project		
batching plant)	accordance with	-When materials		
	American Asphalt	quality changes		
	Institute (MS2)	-When results		
	2. Loss of	are not		
	stability	consistent with		
		the mix design		

Table 14-3: Minimum Test Required for Bituminous

Work item	Tests at Source of material	Frequency of tests	Tests at road site	Frequency of tests
		results		
4- Asphalt	At Batching plant 1- Stability 2- Flow 3- Extraction (binder content and gradation) 4- Air voids 5- Voids in mineral aggregates	 As requested Test each 3 working days Test for each batching plant As requested 	Behind spreader 1- Stability 2- Flow 3-Extraction (binder content and gradation 4-Air voids 5- Voids in mineral aggregates	-Test each working day - Test for each batch - As requested
	6- Daily Marshall density		6-Marshall density	
	7-Loss of Stability	- Once a week - As requested	7- Road density and thickness (after final compaction	Test each 200lin.m. per laneAs requested
			8-Loss off stability	- Once a week - As requested

- 2. The Marshall Bulk specific gravity shall be determined in accordance with AASHTO T 166 or AASHTO T 275. The Marshall specimens shall be prepared from the same material used in construction, taken from samples of fresh bituminous mix at the mixing plant or from trucks delivering mix to the site. Oven heating for up to 30 minutes to maintain the heat of the sample is permissible.
- 3. The bulk specific gravity of the mix as placed and compacted in situ shall be determined from 100 mm nominal diameter core samples, or slab samples cut from compacted layer on the road at locations designated by the engineer who may require additional tests to determine limits of areas deficient in density, or for recheck.
- 4. Samples for in situ bulk specific gravity determinations shall be taken in sets of 2 from each pavement location. Minimum frequency of sampling for each bituminous layer shall be one set/lane/500 m, with a minimum of one set per day of placing bituminous layers.
- 5. The contractor shall, cut the samples with an approved core drill in the presence of the engineer. The equipment shall be capable of cutting the mixture without shattering the edges or otherwise disturbing the density of the specimen. The contractor shall fill and compact all test holes at his own expense.

4.3.6 Surface Tolerances

- 1. The fully compacted and completed bituminous course shall conform to the lines, grades and cross sections as shown on the drawings.
- 2. The elevations of the finished course shall be checked by the contractor in the presence of the engineer at maximum intervals of 25m and at intermediate points as directed.
- 3. When the finished surface is tested with a 4 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the test edge between any 2 contacts points shall not exceed the tolerances specified 6.0 mm.
- 4. All areas which exceed the specified tolerances shall be corrected by removing the defective sections of bituminous course and reconstructing them or, if approved, by adding new material and recompacting and finishing to the specified standard or increasing the thickness of the succeeding course.
- 5. The tolerances specified for evenness of finished surfaces for all types of bituminous course, shall not invalidate the tolerances specified for construction thickness and elevations of such courses.

4.3.7 Determination of Thickness of Course

- 1. Cylinder core samples shall be taken as specified for in situ bulk specified gravity core samples.
- 2. Thickness of bituminous course shall be determined by average caliper measurement of cores, rounded upwards to the nearest mm.
- 3. Paved sections to be measured separately shall consist of each 200 lin.m section in each traffic lane. The last section in each traffic lane shall be 200 m plus the fractional part of 200 m remaining. Other areas such as intersections, entrances, etc. shall be measured as one section and the thickness of each shall be determined separately. Small irregular unit areas may be included as part of another section.
- 4. One core shall be taken from each section by the contractor at approved location and in the presence of the engineer. When the measurement of the core from any paved section is not deficient by more than 3 mm from the specified thickness, the core will be deemed to be off the specified thickness as shown on the drawings.
- 5. When the measurement of the core from any paved section is deficient by more than 3 mm but not more than 15% from specified thickness layer, 2 additional cores spaced at not less than 100 m shall be taken and used together with the first core to determine the average thickness of such section, if it failed again, 15% will reduction from unit price.
- 6. When the measurement of the core from any paved section is less than the specified thickness by more than 15% from specified thickness layer, the average thickness of such section shall be determined by taking additional cores at not less than 5 m intervals parallel to the centerline in each direction from the affected location until, in each direction, a core is taken which is not deficient by more than 15% from specified thickness layer, Exploratory cores for deficient thickness will not be used in average thickness determinations, if it failed again, Asphalt layer will remove or replacement.

- 7. Any deficiencies in the total thickness of bituminous courses shall be subject to a proportional reduction in the area of (wearing) course measured for payment. Alternatively, the contractor shall construct all at his own expense, a wearing course overlay, if practicable in the judgment of the engineer. Any such overlay shall be a minimum of 30 mm compacted thicknesses and to the specified standard of the course it is overlaying.
- 8. If the deficiency in total asphalt layers thickness is from 0 -3 mm, full payment will be made, on condition that deficiencies are not found in more than 10% of the total project. Deficiencies exceeding 3 mm shall be left to the substantial handing -over procedure.

4.3.8 Measurement

- 1. Bituminous course shall be measured by sq.m for furnished, paved compacted, tested and approved areas placed according to drawing.
- 2. Any correction, tests, samples, etc. shall not be measured for direct payment.

4.4 BITUMINOUS BINDER AND WEARING COURSES

4.4.1 Scope

These works shall consist of furnishing materials, mixing at mixing plant, spreading and compacting bituminous binder and wearing course on an approved aggregate base course as and where shown in the drawings.

4.4.2 Materials

- 1. Materials shall conform to relevant requirements of section" Materials" mentioned before.
- 2. Unless otherwise shown on drawings, bitumen for binder and wearing course construction shall be 60/70 penetration graded bitumen.

4.4.3 Job Mix and Project Mix

- 1. The Job Mix formula shall be established by the contractor in accordance with the procedure and requirements of section "Bituminous Course" mentioned before.
- 2. The Job Mix for bituminous binder and wearing courses shall conform to the following composition limits, as shown in Table 14-4:

Property Medium-Light			
	Binder	Wearing	
Marshall Stability at 60c	900	900	
(kg)			
Flow (mms)	2-4	2-4	
Voids in Mineral aggregate	13.5	14.5	
%			

 Table 14-4: Job Mix Requirements to Bituminous Courses

Property Medium-Light		
	Binder	Wearing
Voids in total mix (%)	3-7	3-5
Stiffness (kg/mm)	500 (Min)	400 (Min)
* Loss of stability (%)	25(Max)	25(Max)
Asphalt Content (% in	4.5-6	5-7
weight)		

* This test to be carried out in accordance with AASHTO T 165-82.

* After the Job Mix Formula has been established and approved, all subsequent mixes shall conform to it within the allowable tolerances.

4.4.4 Equipment

Plant and equipment for mixing, hauling, placing and compacting bituminous binder course and wearing course materials, shall conform to the relevant requirements of section "Bituminous Course".

4.4.5 Surface Preparation:

Preparation of surface upon which bituminous binder course and the bituminous wearing course mixes are to be laid, and the use of prime coat, shall be appropriate to type and condition of such surface and shall conform with the relevant requirements of section "Bituminous Courses".

4.4.6 Delivery, Spreading and Finishing

4.4.6.1 General

The delivery, spreading and finishing of bituminous mixes for binder and wearing courses shall conform with the relevant requirements of Section "Bituminous Course" and to the following particular requirements.

4.4.6.2 Rollers

- 1. Initial breakdown rolling shall be carried out by use of 2 dual-drum steel-wheeled rollers each of minimum weight 7,000 kg. These rollers shall be purpose made for compaction of hot bituminous courses.
- 2. Intermediate rolling shall be carried out by of at least 2 self-propelled, tandem pneumatic smooth-tired rollers each capable of exerting contact pressures of up to 690 kN/sq.m (100 psi) and ballast- adjustable to ensure uniform wheel loadings.
- Final rolling shall be carried out by use 2, 2-axle tandem, steel-tired rollers each of minimum weight 10.000 kg, capable of exerting contract pressures of up to 65 kg/cm (350 Ib/in.)

4.4.6.3 Standard of Compaction

The compacted density of the bituminous wearing course shall be not less than 98% of the average Marshall Bulk density for each day's production.

4.4.7 Sampling and Testing

Sampling and testing shall conform to the relevant requirements of Section "Bituminous Course".

4.4.8 Surface Tolerances

- 1. Surface tolerances shall conform with the relevant requirements of Section "Bituminous Course ", and to the following particular requirements.
- 2. The tolerances on elevations of the final bituminous wearing course surface shall not be greater than 10 mms.
- 3. When the finished wearing course surface is tested with a 3 m long straightedge, placed parallel to, or at right angles to the centerline, the maximum deviation of the surface from the testing edge between any 2 contact points shall not exceed 5.0 mm.

4.4.9 Determination of Thickness

- 1. Procedures for determining the average compacted thickness of bituminous binder and wearing course shall conform with the relevant requirements of Section "Bituminous Courses" and the following particular requirements.
- 2. Cores for thickness measurements of binder course shall be used to determine if changes are necessary in the constructed thickness of the wearing course to rectify and thickness deficiencies in the binder course.

4.4.10 Measurement

- 1. Bituminous binder course and bituminous wearing course shall be measured by sq.m. of mix finished, spread, compacted, completed and accepted; measurements shall be of the areas and thickness as shown on the drawings.
- 2. Deficiencies in thickness of wearing course shall, unless an overlay is constructed at contractor's expense, result in proportion only of the wearing course area being measured for payment. Proportions shall be determined in accordance with the thickness deficiencies and area proportions mentioned in section "Bituminous Course".
- 3. All other items shall not be measured for direct payment and their cost shall be included in bituminous binder course and bituminous wearing course price.

4.5 PAVEMENT MARKINGS FOR TRAFFIC

4.5.1 Scope

- 1. These Works shall consist of the furnishing and application, of the traffic markings and to highway pavements for the guidance, control and safety of vehicular and pedestrian traffic.
- 2. White (Class A) and yellow (Class B) painted markings shall include centerlines, lane lines, border (edge) lines, pedestrian crossing lines, stop lines, directional arrows, lettering and symbols using the following materials as appropriate and as on the

Drawings.

4.5.2 PAINT AND THERMOPLASTIC MATERIALS

Reflective Paint (RP)

- 1. RP shall consist of a mixture of binder, white or yellow pigment and filler specifically compounded for cold application and adhesion to finished paved areas. Paint shall be reflective by adding reflective spheres before adhesion the film dries or sets.
- 2. White and yellow RP shall conform to AASHTO M248 Type III. The surface application glass spheres shall conform to AASHTO M247, Type I.

4.5.3 APPLICATION

4.5.3.1 Equipment for Pavement Marking

- 1. The equipment used for pavement marking shall consist of approved types of truck-mounted units, or motorized equipment, or manually operated equipment, depending on the type of marking required. The truck-mounted or motorized unit for centerlines, lines, and edge lines shall consist of a mobile, self-contained unit carrying its own material and capable of operating at a maximum speed of 10 km/h while applying paint. The hand applicator equipment shall be sufficiently maneuverable to install centerlines, lane lines; edge lines gore striping, run lines, crosswalks, stop lines, arrows, and legends
- 2. Spraying equipment shall be capable of satisfactorily applying the paint under pressure with a uniformity of feed through nozzles spraying directly on the pavement. Each paint tank shall be equipped with cut-off valves which will enable broken (skip) lines to be sprayed automatically. Each nozzle shall have a mechanical bed dispenser that will operate simultaneously with the spray muzzle and distribute the beads in a uniform pattern at the rate specified. Each nozzle shall also be equipped with suitable line guides and shall provide a method for cleaning the surface of dust just prior to paint application.
- 3. The spray machine for application of reflective paint lines and other markings shall have an attachment to accurately regulate the rate of application and a tachometer or other approved device to ensure uniform paint application at the designated rate. It shall be adjustable to enable the painting of 1 or 2 adjacent lines simultaneously along the centerline. The paint shall be properly agitated while in operation.
- 4. An automatic glass sphere dispenser with synchronized automatic cut-off shall be attached to the applicator machine. The dispenser shall utilize pressure type spray guns which will embed the spheres into the surface to at least 0.5 times the sphere diameter. The dispenser shall also be equipped with an automatic cut-off synchronized with the cut-off of the thermoplastic material.
- 5. Hand equipment shall be used only for painted markings, including arrows, crosswalks, stop lines, symbols and legends, and it shall hold a minimum of 25kg and not more than 100kg of molten material unless otherwise agreed between the Engineer and the supplier.

4.5.3.2 Setting Out and Pavement Preparation

1. The Contractor shall set out all control points necessary for locating paint lines and markings. On irregular widths of roads, the locations of boarder (edge) lines shall be adjusted so as to fall continuously on the pavement.

The locations of all painted markings shall be accurately established and shall be subject to approval before application commences. Markers shall not be located over longitudinal or transverse pavement joints.

- 2 The area of road surface on which marking is to take place shall be free of dirt, grease, oil, moisture, lose or unsound layers, and any other material which could adversely affect the bond. The areas shall be thoroughly cleaned to the satisfaction of the Engineer before proceeding with painting.
- 3. Pavement marking shall not proceed when there is moisture on the pavement surface or the air is misty; or the surface temperature of the pavement is below 10 degrees C; or when wind or other conditions may cause a film of dust to be deposited on the surface, or in other conditions that, in the opinion of the Engineer, could displace, damage, or adversely affect the bonding of the material to the pavement surface. Any markings damaged due to water or rain within 20 minutes after application, shall be removed and replaced at the Contractor's expense.

4.5.3.3 Painting and Adhesive Film Application

- 1. The use of Class A (white) paint or Class B (yellow) paint and the type of paint material shall be in accordance with the design standards and as shown on the drawings.
- 2. Application of the various categories of point to the pavement surface shall be carried out in accordance with the equipment manufacturer's recommendations and as shown on the drawings and directed by the engineer.
- 3. Painting applications may include centerlines, border (edge) lines, 'no passing' lines, intersection markings chevron striping (in gross areas), pedestrian crossings, letters, arrow, symbols and other special purpose pavement markings.
- 4. Preformed reflective thermoplastic film shall be utilized only where specified for markings such as intersection markings, lettering, arrows, symbols and other special purpose markings. Application shall be in accordance with the manufacturer's recommendations and shall be carried out in the presence of the Engineer.

4.5.3.4 Reflective Paint (RP) Application

- 1. Traffic paint shall be thoroughly mixed in the shipping container before placing in the machine tank. The paint machine tanks, connections, and spray nozzles shall be thoroughly cleaned each day with thinner before starting any spraying.
- 2. The minimum wet film thickness for all painted areas shall be 0.4 mm.

The minimum rate of application for 100 mm width paint lines shall be as follows:

a- Continuous (solid) paint lines: 40 ltr/km for smooth surfaces and 50 ltr/km for rough surfaces.

b- Broken (skip) paint lines: 14 ltr/km for smooth surfaces and 17.5ltr/km for rough surfaces (assuming gap length is double the length of paint line).

Rates shall be modified proportionately for other widths of traffic lines.

- 3. The measured application rate shall not vary from the approved rate by more than 5% in any 1/km. At any point where a check indicates a variation in exceeds of 5% painting shall be stopped and the equipment adjusted or replaced. Identifiable areas of deficiency shall be corrected as directed.
- 4. Immediately following the application of paint, a uniform application of glass beads shall be applied at the rate of 0.6-0.7 kg/ltr of paint.

4.5.3.5 **Protection of Markings**

- 1. Immediately following the application of paint lines and other markings on pavement open to traffic, traffic cones and other devices shall be placed alongside or over the paint at intervals not exceeding 10 m and shall remain on place until the paint has dried.
- 2. Traffic shall be prevented from crossing wet paint lines and the Contractor shall use sufficient numbers of flagmen, barricades, or other protection, particularly at crossings to prevent traffic from crossing wet paint. Section of paint which have been damaged by traffic before the paint has cured, shall be repaired and pavement outside the painted area cleaned at the contractor's expense.

4.5.4 Sampling and Testing

- 1. All material shall be shipped to the job site in undamaged, sealed, original packaging clearly identifying each material as to name, color, manufacturer, batch number, and date of manufacture. All material shall be accompanied by certified test results verifying compliance with all specified physical and chemical requirements.
- 2. All paint products and other materials designated by the engineer shall be sampled for testing. Sampling shall be performed by the contractor in the presence of the engineer. Materials shall be sampled in their original containers. All samples shall be packaged for shipment as approved by the engineer. Samples shall be transported to the mobile field laboratory or to an approved independent laboratory, as directed by the engineer. Paint materials shall not be used until approved by the employer.

4.5.5 Measurement

Painted pavement lines and painted pavement markings shall be deemed to be included in the price of the painted surfaces.

4.6 CONCRETE CURBS AND SIDEWALKS

4.6.1 Scope

This work shall consist of furnishing and constructing concrete curbs and concrete paving to sidewalks as and where shown in the Drawings.

4.6.2 Materials and Precast Manufacture

4.6.2.1 Concrete

Portland cement concrete shall be class B 300 for all in situ and precast concrete unless otherwise indicated.

4.6.2.2 Mortar

Mortar shall consist of cement and fine aggregate having the same proportions used in the concrete construction.

4.6.2.3 Precast Concrete Units

- 1. All precast units shall be manufactured to the dimension shown on the drawings. Manufacturing tolerances shall be 3mm in any one dimension. End and edge faces shall be perpendicular to the base.
- 2. For horizontal curves of radius less than 10m, curb units shall be manufactured to the radius shown and in such circumstances where straight elements or portions of straight elements shall not be used.
- 4. Precast units shall be cast upside down in approved steel molds under conditions of controlled temperature and humidity. The engineer's approval of the samples will not be considered final and the engineer may reject any precast units delivered to the site which do not meet the required standards.

4.6.3 Precast Concrete Curbs

- 1. The sub-grade shall be excavated to the dimensions as shown in the drawings, and the surface of sub-grade shall be leveled and compacted to at least 95% AASHTO T180 maximum density.
- 2. The Base Coarse under the curb is to be placed to the required level and compacted and tested according to the base course specifications.
- 3. Forms for the concrete base shall be approved wood or steel. All forms shall be sufficiently strong and rigid and securely staked and braced to obtain a finished product correct to the dimensions, lines and grade required. Forms shall be cleaned and oiled before each use.
- 4. Concrete shall be placed, compacted and shaped to the sections shown on the drawings taking in account expansion joints. Concrete shall be compacted with an approved internal type vibrator or if approved, by hand spudding and tamping.

Edges shall be rounded if necessary by the use of wood molding or by the use of an edger as applicable. The concrete base shall be finished to a true and even surface with a wood float. Concrete shall be membrane or water cured for at least 7 days before precast units are placed thereon.

- 5. Precast units from approved factory shall be set accurately in position in mortar on the concrete base. Joints pattern precast units shall not be mortared unless otherwise shown on the drawings. Units shall be closely spaced and every 10 m run shall be provided with an expansion joint.
- 6. Where curbs or gutters are installed on existing concrete pavement and using epoxy resin adhesive, the installation procedures shall conform to those specified for raised pavement markers in Section "Pavement Markings for Traffic".
- 7. After curbs have been installed, forms shall be erected and concrete backing, shall be placed as shown on the drawings.

Pavement courses shall not be laid against curbs until the concrete backing has membrane or water cured for at least 14 days.

8. The tolerances on alignment of completed precast shall be as specified for in situ concrete construction.

3. The area adjacent to completed and accepted curbs shall be backfilled with approved material to the top edges of the curbs to 95 % AASHTO T180 maximum density.

10. The curb to be painted by white, red, and black colors according to traffic requirement, the paint must be after cleaning the curb, with one prime coat and two faces colored approved road paints.

11. Test: 5 curbs must be tested for every 1000 curbs