SECTION 34
MISCELLANEOUS FURNISHINGS

34.1 Precast Concrete Kerbs

Precast concrete kerbs edging and quadrants unless otherwise specified in the Contract shall be hydraulically pressed complying with BS 340. They shall be laid and bedded in a layer of Class I mortar not less than 10mm and not more than 40mm thick on a concrete foundation of Class 20/20 concrete and shall be backed by Class 20/20 concrete to the dimensions shown on the Drawings

For kerbs of 12m radius or less kerbs of appropriate radius shall be used. At the end of kerb runs draper kerbs shall be used as directed by the Engineer.

Any unit of kerb edging or quadrant more than 3mm in 3m from line or level shall be made good by lifting and relaying.

34.2 Precast Concrete Edge Blocks

Precast concrete edge blocks shall be hydraulically pressed to the equipment of BS 340. They shall be laid and bedded in a layer of Class 1 mortar not less than 10mm and not more than 40mm thick on a concrete foundation of Class 20/20 concrete or other foundations as shown on the Drawings.

Any unit of block edging more than 6mm in 3m from line or level shall be made good by lifting and relaying.

34.3 Footways (Concrete Paved)

Precast concrete flags shall be hydraulically pressed complying with BS 368. Unless otherwise specified in the contract the flags shall be 50mm thick and except where cutting is necessary of uniform width of 600mm with a minimum length of 450mm and a maximum length of 600mm.

Flags shall be laid to the required crossfalls with a bond as described in the Contract and with joints at right angles to the kerb. Flags shall be bedded on a layer of Class 2 or 3 mortar. Alternatively where shown on the Drawings or permitted by the Engineer they may be bedded on a layer of clean sharp sand or screenings complying with BS 882 grading C or M, 25mm ±10mm thick.

Sub-base material and thickness shall be as shown on the Drawings laid and compacted as specified for the particularly type of material.

On circular work where the radius is less than 12m all flags shall be radially cut on edges to the required line. Paved areas should conform to the surface accuracies required for pavement wearing courses.

34.4 Brick Kerbs and Footways

Bricks for kerbs and footways shall comprise First Class Bricks or Picked Jhama bricks. Kerbs and footways shall be constructed to the dimensions shown on the Drawing.

Brick footways unless otherwise specified shall be a minimum of 60mm deep and shall be firmly bedded on a layer of sand or screenings complying with BS 8882 grading C or M 25mm ±10mm deep in a herring-bone pattern unless otherwise indicated and the joints between bricks shall be filled with Class 2 mortar.

Finished levels should conform to the accuracies required for concrete kerbs and paved areas.

34.5 Kilometer Posts and Right-of-Way Markers

34.5.1 General

Kilometer posts and right-of-way markers shall be of reinforced concrete as shown on the Drawings. The concrete and reinforcement shall be as specified for precast concrete.

If required, the kilometer posts and the right-of-way markers shall be set in a brickwork foundation as shown in the Drawings and the brickwork shall comply with the Specifications for structural brickwork.

34.5.2 Letters and Figures

Letters and figures as directed shall be inset 5mm deep in the face of the concrete pillar during casting or, for kilometer posts, in a plaster coating applied to the roughened surface of the letters and figures shall be painted black and the background shall be yellow, all in approved paint supplied in new sealed drums and from a reputable manufacturer.

34.5.3 Erection

The structural brickwork footing for the post, if required, shall be constructed in all respects in accordance with the Specifications for structural brickwork and the joints between bricks and between the bricks and the posts shall be filled with cement mortar to the satisfaction of the Engineer.

Posts shall be erected truly vertical to the depth shown and at the position marked on the Drawings and as directed.

Kilometer posts shall be erected in such a manner that, as the post is approached, the letters and figures seen on the visible face of the post will be those referring to the name of, and the distance to, the town towards which the traveller is proceeding. No part of the post or foundation shall be closer to the edge of the pavement than 2450mm.

34.6 Bus shelters

Bus shelters shall be constructed at each bus stop as shown on the Drawings.

The materials of the shelter shall be as specified in the following specifications:

(i) Concrete shall be provided mixed and placed as provided in Section 8 for Class 20/20 concrete.

(ii) Mortar shall be cement, sand, water and lime or gypsum, as necessary and as specified in Section 8.24.

(iii) Paint shall be from a reputable manufacturer as approved by the Engineer.

(iv) Timber shall be seasoned hardwood free of shakes and knots, treated with a preservative of known resistance to insect and fungus attack.

(v) Sheeting shall be cement fibre sheeting shaped as shown on the Drawings and as approved by the Engineer.

The base shall be excavated in the completed shoulder and the edge and rear walls shall be constructed in brickwork. The floor slab and steel columns shall be laid using specified sand, brickwork and concrete mixes and the surface finish shall be obtained by hard steel trowelling, not by the addition of cement.

The concrete pillars of the rear wall shall be completed with the roof bolts cast in. The timber beams shall be placed and the roofing sheets bolted into place with joints waterproofed.

The steel work shall be wire brushed and the final painting shall be completed. The bus stop sign shall be erected as shown on the Drawings.

The Contractor shall dispose of all surplus excavated material.

34.7 Safety Fences

a) Safety fences shall comprise untensioned rails, posts, blocking-out pieces and means for fixing, post-footings, and end anchorages as shown on the Drawings and detailed below. They shall be constructed to the alignment and within the tolerances shown on the Drawings so as to produce a flowing visual alignment, failing which the Contractor shall make good by adjusting the elevation of any rail as directed by the Engineer.

b) Rails shall be made of steel or approved non-ferrous alloy. They shall be at least 300mm in depth and corrugated in cross-section so that the road face has a central trough having a depth of at least 75mm. They shall be shaped so as to present no sharp edges to traffic and except where shown on the Drawings shall be straight and of uniform cross-section within manufacturing tolerances.

When a rail is freely supported over a span of 3 meters with the road face uppermost

and centrally loaded with a point load of 2000 kg the deflection measured at the center of the span shall not exceed 75mm.

Adjacent rails shall be connected by lap joints or fish plates using suitable bolts, nuts and washers, the bolt heads being such as to present no appreciable projection to traffic. Bolts, nuts and washers shall be strictly in accordance with the recommendations of the manufacturers of the safety fence rails. Lap joints shall be made in the direction of the adjacent traffic movement to avoid vehicles striking rail end.

The strength in tension of the rails and of the joints between adjacent rails shall be not less than 35000 kg.

c) Posts on which the rails are mounted shall be strictly in accordance with the Drawings in all details. Posts shall be spaced at distances no greater than 3 meters center to center.

Rails shall be separated from each post by means of blocking out pieces, as detailed on the Drawings.

Alternatively, posts may be of 150 x 75 x 5mm pressed steel channel of total length 1800mm which shall be driven by means of a suitable drop hammer to a depth as shown on the Drawings, in this case blocking out pieces shall be of pressed steel channel.

d) All steel parts shall after fabrication be galvanized by the hot-dip process in accordance with BS 729. Any damaged areas shall be repaired in accordance with the requirements of Appendix D of BS 729.

SECTION 35
PAVEMENT COURSES - IMPROVED SUBGRADE, SUB-BASE, BASECOURSE

35.1 GENERAL

The permanent road pavements to be constructed in the Contract generally consist of the following pavement courses, unless indicated otherwise in the Drawings:

- Improved Subgrade
- Lower Sub-Base
- Upper Sub-Base
- Base Course
- Bituminous Wearing Course (Specified in Section 28 of Technical Specifications)

Some road connections and temporary roads such as connecting roads may not include all of these pavement courses, as indicated on the relevant drawings.

Salvaged existing pavement materials shall not be used in the permanent road works but may be used in temporary road works with the prior approval of the Engineer.

Generally, construction of the permanent road pavements shall only be undertaken outside the Monsoon Season (normally July to October each year) in suitable weather and site conditions.

Payment for items covered in this section of the Specification shall be for finished compacted quantities approved by the Engineer. Payment shall be based on actual compacted thickness and width or the thickness and width indicated in the Drawings whichever is the lesser quantity.

35.2 IMPROVED SUBGRADE

35.2.1 Description

This item consists of the furnishing, hauling from outside the right-of-way, placing, shaping, compacting and testing of soil, sand or soil aggregate mixtures above the compacted subgrade or embankment fill to form the lowest layer of the pavement if indicated in the pavement cross-section drawings in accordance with these specifications and to the lines, grades and thickness and in the locations shown on the Drawings or approved by the Engineer. The thickness of the Improved Subgrade layer will be confirmed by the Engineer following evaluation of the effective strength (CBR) of the existing subgrade or embankment fill material used. Refer also to Articles 29.

35.2.2 Material

Improved subgrade shall be any suitable natural soil or sand or any blend or mixture of soils

(natural or manufactured), broken brick or aggregate complying with the following requirements:

- Maximum particle size - **37mm**
- Plastic Index (AASHTO T 90) - **less than 6%,**
- Material passing 0.075 mm sieve (AASHTO T 11) **- minimum 12%, maximum 30%**
- Soaked (4 days) CBR at 98% Maximum Dry Density (AASHTO T 99 Method D, Standard Compaction) as determined by AASHTO T 193 using 6 kg surcharge load - **minimum 10%**

The Contractor shall submit to the Engineer for approval samples and detailed descriptions of the materials proposed to be used for improved subgrade (including procedures for reliable control of blending and mixing of components where relevant) together with test results demonstrating that the above requirements are satisfied,

35.2.3 Construction Method

The improved subgrade shall be placed in uniform layers of maximum loose thickness 200 mm on the top of compacted subgrade or embankment fill shaped as required to required camber or crossfalls. Blends of materials preferably shall be mixed off site by approved methods but if sufficient labor or equipment capable of mixing materials in place are provided then the materials may be laid loose in uniform layers of thickness appropriate to the required final proportions and the layers shall be thoroughly and evenly mixed together to a uniform color and texture in a dry state. Prior to compaction the materials shall be re-mixed with water to near the optimum moisture content and only then shall be compacted to a density of not less than 98% of the maximum dry density (AASETO T-99 Method D, Standard Compaction).

Whichever method is adopted, prior to placing any materials, the Contractor shall demonstrate by providing samples to the Engineer and by laboratory test results that the proposed material or materials meet the specified requirements, and if mixing is required shall have determined appropriate mix proportions and mixing procedure.

The materials in place shall be compacted to the specified density at a moisture content close to the optimum. The compacted layer shall be of the thickness shown on the Drawings within a tolerance of -15 mm to +10 mm. The average of at least 3 depths measured over any 100 m length shall be within a 5 mm variation from the required depth.

Any deficiencies in material shall be made up by scarifying the material and adding and mixing in new material as required and re-compacting as specified, except that deficiencies may be made up with material of the next layer above but at the Contractor's expense.

Excess material shall be trimmed off and disposed of off site and shall not be paid for.

When the improved subgrade cannot be extended to the outer slope surface of an embankment or to the slope of a side drain, for example in urban areas, it shall be drained by

a system of sand drains to the approval of the Engineer.

35.2.4 Testing

The density shall be tested at last five times for every 1000 sq.m of completed work. Samples shall be removed from the pavement and shall be tested for plasticity index, compaction (MDD) and soaked CBR at least once for each 500 meters length of road pavement. Where the material does not meet the requirements of the Specification at the conclusion of two additional tests, the material represented by the substandard samples shall be removed and replaced as specified or the faults shall be corrected by methods approved by the Engineer at the Contractor's expense. Construction of the next pavement layer (normally sub-base) shall not commence until all testing has been completed and the works have been approved by the Engineer.

35.2.5 Protection and Repair

Works shall be programmed to minimize the risk of damage to the completed improved subgrade layer by weather or traffic movement before the next pavement layer is constructed.

Any damage that does occur shall be rectified at Contractor's expense to the approval of the Engineer.

35.3 AGGREGATE SUBBASE

35.3.1 Description

This item shall consist of compacted aggregate subbase for pavements and shoulders constructed in accordance with the requirements hereinafter set forth and in conformity with the lines, grades and cross sections shown on the Drawings or approved by the Engineer

Two different types of Sub-Base materials may be specified for use in the pavement and shoulder zones:

- Lower Sub-Base
- Upper Sub-Base

In principle, the Lower Sub-Base layer is intended to serve the following functions:

- provide a sufficiently permeable layer to effectively act as a "cut off' for capillary use of moisture in the embankment or subgrade fill below.
- provide an effective lateral drainage layer for water/rainfall that penetrates the upper pavement layers during construction and while in service (For this reason, the layer generally extends full width of the embankment or to side drains).
- provide a stable all-weather trafficable layer during construction of the pavement works for construction traffic and essential public traffic.

- provide a pavement layer of sufficient strength to meet the pavement design requirements and form a stable foundation for construction of the next pavement layer (Upper Sub-Base).

35.3.2 Materials

Materials for Sub-Base shall be sound, durable crushed/uncrushed rock, gravel, brick, or concrete, aggregate as specified below. The characteristics of these materials shall be such that they will compact to the density and stability required by the specifications and established as satisfactory by the Engineer. Materials may be processed from recovered structures and pavement materials or shall be provided by the Contractor as necessary.

The material shall be clean, sound, and durable, of uniform quality, and have no significant thin elongated, flaky or brittle pieces.

Coarse aggregates shall generally consist of crushed/uncrushed rock, gravel, brick or concrete. Fine aggregates (passing 4.75 mm) shall generally consist of crushed stone screenings, natural sand or selected suitable soils.

Blending and mixing of aggregates shall be undertaken before placing and spreading in the pavement course – in-situ mixing and blending shall not be permitted

No more than three different materials may be blended to produce the required combined aggregates mix.

Khoa (brick chips) if used, shall be prepared by breaking and/or crushing moderately to well burnt bricks. (The material shall be composed of hard durable particles, clean, and free from an excess of thin or elongated pieces).

Sub-Base materials shall meet the following requirements :

Characteristic	Lower Sub-Base	Upper Sub-Base
Fine Aggregates (Passing 4.75 mm Sieve)		
• Liquid Limit (AASHTO T89)	Less than 25%	Less than 20%
• Plasticity Index (AASHTO T90)	Less than 9%	Less than 4%
Coarse Aggregates (retained on 10 mm sieve)		
• Aggregate Crushing Value, (STP 7.7)	Less than 38%	Less than 35%
• Ten Percent Fines Value (STP 7.8)	Minimum 75 KN	Minimum 80 KN
• Broken faces (retained 4.75 mm sieve)		
- 1 or more faces	Minimum 50% by weight	Minimum 50% by weight
4 days Soaked CBR Value (AASHTO T 193) MDD determined by AASHTO T 180, Method D, Modified Compaction.	Minimum 20%, at 95% MDD	Minimum 40%, at 98% MDD
Deleterious materials		
• Lightweight Pieces (AASHTO T 113)	Less than 1.0%	Less than 1.0%
• Clay Lumps and Friable particles (AASHTO T 112)	Less than 1.0%	Less than 1.0%
Materials permitted to be included :		
- gravel and stone	Yes	Yes
- bricks	Up to 50% by weight	up to 20% by weight
- natural sand	Nil	Nil
- granular soil	Yes	Yes
- selected salvaged materials	Yes	Yes

Note : STP = Tests as described in "Standard Laboratory Test Procedures Manual for Quality Control Laboratories", BRRL, June 1983.

The aggregate shall be well and evenly graded within the following grading distribution limits, as determined by AASHTO T 27 and AASHTO T 11. Material meeting the following requirements may be obtained by blending if approved by the Engineer.

Sieve size (mm)	Total Percent Passing by weight	
	Lower Sub-Base	Upper Sub-Base
50	100	100
38	85-100	85-100
19	55-95	55-95
9.5	35-75	35-75
4.75	25-60	25-60
2.36	15-50	15-50
0.60	7-30	7-35
0.075	0-10	3-15

Note : Lower Sub-Base to have adequate permeability to also function as drainage layer.

The Contractor shall submit to the Engineer for approval, samples and detailed descriptions of the materials proposed to be used for each Sub-Base type (including procedures for reliable control of blending and mixing of components where relevant) together with test results demonstrating that the above requirements are satisfied.

35.3.3 Construction Methods

Any ruts, holes, defects or soft yielding places which occur in the subgrade or other underlaying pavement course by reason of any improper drainage conditions, traffic or hauling over the same, or for any other causes, shall be corrected and compacted to the required density and stability and shall comply with the smoothness requirement of the Specifications before aggregate subbase is placed thereon.

Stockpiling and loading methods shall be such as to permit ready identification of the materials to be used and shall be approved by the Engineer. Sites for stockpiles shall be clean prior to storing materials. The stockpiles shall be built up in layers not to exceed 1 meter height, and each layer shall be completely in place before the next layer is started. Aggregates shall not be removed from stockpiles within 100 mm of the ground until final clean up of the site of the work and no material which has become mixed with foreign matter or other sizes or grades of aggregates shall be used.

Combined subbase aggregates shall be placed in stockpiles in units of not less than 250 cubic meters at least seven days prior to their anticipated use in the work. The Contractor and Engineer shall sample and test each stockpile or each 250 cubic meters of stockpile to determine the quality of the material and assess it for approval for use in the various types of construction.

Aggregate subbase materials shall be evenly spread on the subgrade, or other underlaying course by the use of approved, self-propelled spreading machines capable of placing the materials true to line and grade without segregation and without damage to the subgrade or other course. Aggregate subbase materials shall be at or near optimum moisture content at the time of loading for transportation to the site, during and on completion of compaction.

The aggregate subbase materials shall be spread in courses of not less than 75 mm compacted thickness or of a greater depth up to that depth capable of being compacted as specified by the available equipment. In no circumstances, however, shall the uncompacted thickness of a layer be more than 200 mm. It is expected that smooth wheel vibrating rollers of a minimum mass of 10 tonnes will be required to achieve the compaction standard, if 200mm loose thickness layers are placed.

Compaction of the layer shall immediately follow the spreading operation and rolling or compacting shall begin at one edge of the course (the low edge on superelevated sections). Water in the amount that is necessary for compaction shall be added before and during rolling.

Any irregularities that develop in the surface of the aggregate subbase course during compaction shall be corrected by loosening the surface, adding or removing material and re-

compacting until the surface presents a smooth regular appearance. The finished surface of the course shall conform so nearly to that indicated on the Drawings or approved by the Engineer that it will nowhere vary more than 10 mm from a straight edge, 3 meters long, applied to the surface parallel to the centreline of the pavement, nor more than 12 mm from a template conforming with the cross sections shown on the Drawings. The Contractor shall furnish all the straight edges, full width templates, calibrated wedges and other devices necessary to control construction of aggregate subbase course to these surface tolerances. The finished subbase course shall not be used for the carriage of through traffic but may be used for the carriage of essential local traffic only. Any damage which is done to the finished aggregate subbase course by traffic shall be repaired by loosening, reshaping, re-compacting, use of necessary water and the addition of more aggregate subbase course material if necessary. Reshaping and re-compacting operations shall be done at the expense of the Contractor.

The surface of each finished subbase layer shall be within +0 mm or -10 mm of the elevation shown on the Drawings or instructed by the Engineer. The depth over each 100 meters length of completed subbase shall be measured in at least 3 places and the mean depth shall not be less than the required depth. Deficiency in depth shall be corrected or made up in the next pavement layer above at the Contractor's expense.

In the case where the course is allowed to stand more than 24 hours before the application of a prime coat or the placing of a subsequent course, the Contractor shall regularly sprinkle the surface of the course with water, at his own expense, so that the course is prevented from drying out through its depth.

The field density/compaction standards to be achieved shall be as follows:

- Lower Sub-Base
  - minimum 95% Maximum Dry Density determined for the material by AASHTO T 180, Method D (Modified Compaction)

- Upper Sub-Base
  - minimum 98% MDD determined by AASHTO T 180, Method D (Modified Compaction).

35.3.4 Testing

After approval is given by the Engineer pursuant to Section 35.3.2, the Contractor can proceed with production and procurement of the required materials.

Before commencing spreading and compaction of subbase, the work, the Contractor shall furnish to the Engineer test results and a sufficient quantity of the materials intended for use in order that the Engineer can check the maximum dry density in accordance with AASHTO T-180 (Method D) and the CBR. During the construction the gradings shall be checked on samples from each 250 cubic meters of stockpiled aggregate and if there is an appreciable change in grading or shape of the aggregate, or a change of source of aggregate, the Contractor shall furnish sufficient samples with test results to the Engineer in order to

establish a new value for the density requirements. Field tests for moisture content and dry density shall be in accordance with AASHTO T 191 or other method approved by the Engineer (such as Nuclear Density Meter).

To demonstrate compliance of the completed subbase works with the specifications the Contractor shall ensure that sampling and testing is carried out to the minimum frequency indicated in Table 35.3.4 below. Sampling of aggregates shall be in accordance with AASHTO T 2. Payment for the works shall not be made until the required test results are available, confirming that the works meet specification requirements.

Table 35.3.4: Minimum Testing Requirements for Lower Sub-Base and Upper Sub-Base

Description	Test	Minimum Frequency
Stockpiled Materials	• Gradation (AASHTO T 27 and T 11)	1 per 250 m^3
	• Broken Faces	1 per 250 m^3
	• Soaked CBR (AASHTO T 193)	1 per 500 m^3
	• Deleterious Materials (AASHTO T 112 and AASHTO T 113)	1 per 500 m^3
	• Liquid Limit (AASHTO T 89)	1 per 500 m^3
	• Plasticity Index (AASHTO T 90)	1 per 500 m^3
	• Aggregate Crushing Value (STP 7.7)	1 per 500 m^3
	• Ten Percent Fines Value (STP 7.8)	1 per 500 m^3
	• Maximum Dry Density (AASHTO T 180 Method D)	1 per 250 m^3
In-situ Properties after Construction	• In-situ Dry Density (AASHTO T 191)	2 per 100 m length of road pavement
	• Plastic Index of sample (AASHTO T 90)	1 per 200 m length of road pavement
	• Soaked CBR of remoulded sample (AASHTO T 193)	1 per 200 m length of road pavement
	• Gradation of sample (AASHTO T 27 and T 11)	1 per 200 m length of road pavement
	• Layer thickness	3 per 100 m length of road pavement

35.4 BASECOURSE

35.4.1 Description

This item shall consist of a compacted aggregate base course constructed in accordance with the requirements hereinafter set forth and in conformity with the lines, grades and cross sections shown on the Drawings and approved by the Engineer.

35.4.2 Materials

Materials for base course shall be sound, durable crushed rock, or crushed gravel, or natural sand or non-plastic soil as specified below. The characteristics of these materials shall be such that they will compact to the density and stability required by the specifications and established as satisfactory by the Engineer.

Coarse and fine aggregate materials may be blended and mixed to obtain the required specifications as set out below. Coarse aggregates shall generally consist of durable crushed or broken stone. Fine aggregates (passing 4.75 mm sieve) shall consist of crushed stone screenings and/or natural sand, and/or non-plastic soil binder.

The materials shall be uniformly blended by mixing predetermined quantities of coarse and fine aggregate and at the time of compaction the moisture content shall be within plus or minus two percent of the optimum moisture content. Blending and mixing of aggregates shall be undertaken before placing and spreading in the pavement course – in-situ blending and mixing shall not be permitted. No more than three different materials may be blended to produce the required combined aggregate mix. The aggregate used for base course shall meet the following requirements:

Characteristic	**Base Course**
Fine Aggregates (Passing 4.75 mm sieve) • Liquid Limit (AASHTO T 89) • Plasticity Index (AASHTO T 90)	 Less than 20% Less than 4%
Coarse Aggregates (Retained 10 mm sieve) • Aggregate Crushing Value (STP 7.7) • Ten Percent Fines Value (STP 7.8) • Broken Faces (retained 4.75mm sieve) - 1 or more faces - 2 or more faces	 Less than 30% Minimum 125 KN Minimum 75% by weight Minimum 50% by weight
Deleterious Materials • Light weight pieces (AASHTO T 113) • Clay Lumps and Friable Particles (AASHTO T 112)	 Less than 1% Less than 0.5%
Soaked CBR Value (4 days) (AASHTO T 193) MDD determined by AASHTO T 180 Method D, Modified Compaction	 Minimum 80% at 98% MDD
Materials Permitted to be included - bricks - natural sand - selected salvaged materials - stone, gravel	 Not permitted Maximum 10% by weight Not permitted Yes

Combined Grading (Total percent Passing by Weight)	
50mm	100
38mm	90-100
19mm	60-80
9.5mm	40-60
4.75mm	25-45
2.36mm	15-32
0.60mm	10-20
0.075mm	0-5

The Contractor shall submit to the Engineer for approval, samples and detailed descriptions of the materials proposed to be used for base course (including procedures for reliable control of blending and mixing of components, where relevant) together with test results demonstrating that the above requirements are satisfied.

35.4.3 Construction Method

Refer also to Article 35.4.5 - Trial Section of Base Course.
Any ruts, holes, defects or soft yielding places which occur in the underlying subbase by reason of any improper drainage condition, traffic or hauling over the same, or for any other cause, shall be corrected and compacted to the required density and stability and shall comply with the smoothness requirements of the Specification before aggregate base course is placed thereon.

Stockpiling aggregates for proportioning by any method approved by the Engineer shall be accomplished in a manner that will ensure separation of different sized aggregates and prevent segregation and degradation of the aggregates.

Stockpiling and loading methods shall be such as to permit ready identification of the materials to be used and shall be approved by the Engineer. Sites for stockpiles shall clean prior to storing materials. The stockpiles shall be built up in layers not to exceed 1 meter height and each layer shall be completely in place before the next layer is started. Aggregates shall not be removed from stockpiles within 100 mm of the ground until final clean up other sizes or grades of aggregates shall be used.

Base course aggregates shall be placed in stockpiles in units of not less than 250 cubic meters at least seven days prior to their anticipated use in the work. The Contractor and Engineer shall sample and test each stockpile or each 250 cubic meters of stockpile to determine the quality of the material and assess it for approval for use in the various types of construction.

The combined aggregates shall be handled and transported without segregation or loss of moisture. The vehicles used for hauling shall be clean and free of all harmful material.

Base course materials shall be evenly spread on the subbase by the use of approved, self-propelled spreading machines capable of placing the materials true to line and grade without segregation and without damage to the subbase.

The aggregate base materials shall be spread in courses of not less than 75 mm compacted thickness and not greater than 200 mm compacted thickness. Compaction shall be carried out using heavy vibrating power rollers, heavy rubber tyred rollers or plate compactors for small widths.

Base course shall be compacted to the full width shown on the Drawings. Either shoulder material or extra base material shall be placed and compacted with the base course layer to provide edge support and to allow full width compaction. Base course material only will be paid for to the limits of the lines shown on the Drawings.

Compaction of the base course shall immediately follow the spreading operation and compaction shall begin at the edges of the course. When the shoulder backing is firmly compacted, the rolling shall proceed inward until the crown part is reached. In the case of superelevated curves the compaction shall be from the low side to the high side, in the manner described above, until the shoulder backing at the high side is firmly compacted. Water in the amount that is necessary for compaction shall be added during rolling.

In narrow base widening, inaccessible to the main compaction equipment, the compaction may be performed with approved reciprocating or vibratory tampers or other methods approved by the Engineer. Unless the excavation is performed accurately by cutting to neat lines, the requirement for backing up the edge as stated above will apply for each course. The same density requirement as stated herein shall be achieved.

Any irregularities that develop in the surface of the aggregate base course during compaction shall be corrected by loosening the surface adding or removing material and re-compacting until the surface presents a smooth regular appearance. The finished surface level of the base course shall conform closely to that indicated on the Drawings or approved by the Engineer so that it will nowhere vary more than 10 mm from a straight edge 3 meters long applied to the surface parallel to the centreline of the pavement, nor more than 12 mm from a template conforming with the cross sections shown on the Drawings. The Contractor shall furnish all the straight edges, full width templates, calibrated wedges and other devices necessary to control construction of aggregate base course to these surface tolerances.

The finished surface of the base course layer shall be a dense tight mosaic with no loose or segregated areas, suitable for application of a prime coat. To achieve this surface finish the Contractor may need to add crusher fines or similar material.

The upper surface of the base course shall in no place be more than 10 mm above the planned elevation nor more than 5 mm below the planned elevation and the mean of three measurements of thickness taken in any 100 meters long section by digging holes shall be at least equal to the required base course thickness.

For construction of wide roads, the finished base course shall not be used for the maintenance of through traffic but may be used for the maintenance of essential local traffic only. Any damage which is done to the finished aggregate base course by traffic shall be repaired by loosening, reshaping, re-compacting watering as required and the addition of more aggregate base course material, if necessary. Repair operations shall be done at the expense of the

Contractor. When a section has been completed as described above it shall be allowed to surface dry before the application of a bituminous prime coat. If a prime coat is not provided, a "running course" of suitable loose aggregate may be placed immediately. In either case (the application of a prime coat or the placing of temporary "running course") the Contractor shall sprinkle the surface of the course with water, at his own expense, so that the base course layer is prevented from drying out through its depth.

The field density/compaction standard to be achieved for Base Course shall be:

- Minimum 98% of Maximum Dry Density determined for the material by AASHTO T 180 Method D (Modified Compaction).

35.4.4 Testing

After approval is given by the Engineer pursuant to Section 35.4.2, the Contractor can proceed with production and procurement of the required materials.

Before commencing the work, the Contractor shall furnish to the Engineer a sufficient quantity of the materials intended for use together with test results in order that the Engineer can check the maximum dry density in accordance with AASHTO T-180 (Method D) and the CBR. Base course aggregate shall be placed in stockpiles in units of not less than 250 cubic meters at least seven days prior to their anticipated use in the work. The Engineer and Contractor will sample and test each stockpile or each 250 cubic meters of stockpile to confirm the quality of the material and give approval for use in the permanent works. During construction, grading shall be checked on samples from each 250 cubic meters of stockpile. If there is an appreciable change in grading of the aggregate from stockpiled samples or from samples in place and compacted on the roadbed, as determined by the Engineer, or a change of source of aggregate, the Contractor shall furnish sufficient samples with test results to the Engineer in order to establish a new density for the field density requirements.

Field tests for density shall be in accordance with AASHTO T-191 or other method approved by the Engineer (such as Nuclear Density Meter).

To demonstrate compliance of the completed base course works with the specifications, the Contractor shall ensure that sampling and testing is carried out to the minimum frequency indicated in Table 35.4.4 below. Sampling of aggregates shall be in accordance with AASHTO T-2. Payment for the works shall not be made until the required test results are available, confirming that the works meet specification requirements.

Table 35.4.4 Minimum Testing Requirements for Base Course

Description	Test	Minimum Frequency
Stockpiled Materials	• Gradation (AASHTO T 27 and T 11)	1 per 250 m^3
	• Broken Faces	1 per 250 m^3
	• Soaked CBR (AASHTO T 193)	1 per 250 m^3
	• Deleterious Materials (AASHTO T 112 and AASHTO T 113)	1 per 500 m^3
	• Liquid Limit (AASHTO T 89)	1 per 500 m^3
	• Plasticity Index (AASHTO T 90)	1 per 500 m^3
	• Aggregate Crushing Value (STP 7.7)	1 per 500 m^3
	• Ten Percent Fines Value (STP 7.8)	1 per 500 m^3
	• Maximum Dry Density (AASHTO T 180 Method D)	1 per 250 m^3
In-situ Properties after Construction	• Insitu Dry Density (AASHTO T 191)	2 per 100 m length of road pavement
	• Plastic Index of sample (AASHTO TO 90)	1 per 200 m length of road pavement
	• Soaked CBR of remoulded sample (AASHTO T 193)	1 per 200 m length of road pavement
	• Gradation of sample (AASHTO T 27 and T 11)	1 per 200 m length of road pavement
	• Layer thickness	3 per 100 m length of road pavement
	• Surface tolerances/Irregularities (transverse and longitudinal)	1 set per 50 m length of road pavement.

35.4.5 Trial Section of Base Course

At least 10 days before laying of base course is planned to commence in the permanent works, the Contractor shall construct a trial section of 400 to 800 m^2 with a minimum length of 100 m at a location to be approved by the Engineer. For this trial the Contractor shall use the materials mix proportions, blending mixing, laying and compaction plant, layer thicknesses and procedures that are proposed for the main work. Field tests and laboratory tests shall be carried out as directed by the Engineer to confirm that specified standards have been achieved, including in-situ density, thickness tolerances, surface tolerances, and surface finish. If the trial section is successful then the Engineer will approve commencement of the base course layer in the permanent works. If the initial trial section is not successful, the Contractor may be instructed by the Engineer to undertake a subsequent trial section at the Contractor's expense.

SECTION 36
LIGHTING

36.1 General

This Section shall be read and construed in conjunction with other Sections of this Volume of the Contract Documents. Where there is any conflict between those Sections and this Section, then the latter shall take precedence.

36.2 Extent of the Works

Lighting shall be installed at three (3) bridge locations as well as its approach sections, six (6) at-grade intersections, two (2) merging/diverging ramps and one (1) toll plaza as shown on the Drawings. Lighting up devices for Rupsa Bridge shall be installed at central four piers, MP3 – MP6.

The Works covered by this Section shall include for the design, manufacture, works testing, delivery, installation, site testing, commissioning and maintenance for the maintenance period of the following together with all miscellaneous equipment, auxiliaries, fixings, materials, works and things of all kinds, whether specified herein or not, as are necessary for the efficient and safe completion of the Works:

(a) Road lighting columns with lanterns and auxiliaries.
(b) Pole mounted substations and low voltage distribution panels.
(c) High voltage overhead lines from nearest available sources to bridges and roads.
(d) High voltage cabling from pole mounted substations.
(e) Low voltage cabling from distribution panels to lighting columns.
(f) Construction foundations for lighting columns for bridge and roads.
(g) Earthing systems.
(h) Miscellaneous items described herein.

36.3 Standards, Materials and Workmanship

All materials used and work carried out shall be of very high quality and proven reliability and in accordance with the best modem practice.

Mention herein of British Standards and Codes of Practice shall be read as an indication of the quality of design, performance, materials, and workmanship required and the Contractor shall if he so desires use other National Standards and Codes of Practice provided that they are at least equal to the British Standards and Codes of Practice specified.

The whole and any part of the Works shall comply with the requirements of BS 4533 as applicable in respect of performance requirements, or equivalent National Standards as are applicable, and with Local Regulations of the Bangladesh Power Development Board.

36.4 Equipment Standards and Finishes

All equipment shall be fully tropicalized in accordance with British Standard Code of

Practice CP 1014 and shall be suitable for operation in the climatic conditions, temperature ranges and wind forces prevailing at the site. All equipment shall be robust heavy duty type, industrial pattern and the enclosures shall be vermin proof, dust-tight and weatherproof.

Enclosures and other exposed parts shall be of ample weight and thickness and where required by the Specification shall be galvanized. Elsewhere they shall be constructed of approved non-corrodible materials, treated with approved coatings or galvanized. All metal surfaces shall be properly cleaned, prepared and primed before finish painting. All fixings for covers and supports shall be plated or sheradized, and greased before assembly.

36.5 Galvanizing

Where required by the Specification articles shall be hot-dip galvanized in accordance with BS 729. Articles for galvanizing shall be fabricated to provide faces which can be readily cleaned and coated. No cutting, reaming, drilling, grinding or welding shall be permitted after galvanizing.

36.6 Radio Interference

No equipment shall cause radio of television interference. Devices used for the purpose of suppressing interference shall comply with the appropriate British or National Standard.

36.7 Tests on Completion

On completion of manufacture at the maker's factory and of erection at Site, the Contractor shall arrange for witness tests which are to be carried out together with other tests necessary to prove compliance with this Specification. All tests shall be carried out in the presence of the Engineer or the Engineer's Representative, who shall have the right to reject the whole or any part of the Works found unsatisfactory of not in compliance with this Specification. No approval in consequence of the tests shall guarantee that the whole or any portion of the works may not be rejected before or after delivery to site, should such Works or any portion thereof not conform to this Specification.

The Contractor shall be responsible for arranging the tests at his own or at his manufacturer's factory and site and for giving notice to the Engineer at least two weeks before the date on which the respective tests are to be carried out and shall submit to the Engineer for approval full details for the procedures he intends to adopt and the measurements and readings it is intended to take. The Contractor shall provide the Engineer with copies of typed test certificates within two weeks of the completion of the tests. All manufacturer's certificates of test, etc., showing the requirements of the appropriate British Standard, or other relevant National Standard, are to be supplied to the Engineer.

36.8 Instruction Manuals

The Contractor shall provide not later than six weeks after the date of commissioning of the first stage of the Works, six copies of operation and Instruction Manuals applicable to the Works covered by this Section of the Specification.

A draft of the manuals shall be submitted to the Engineer for approval not later than twelve weeks before the date fixed for commissioning of the Works and any modifications to the form or extent of its contents reasonably required shall be incorporated in the final version of the manuals.

The manuals shall bound in substantial covers in book form with the title of the Contract and the particular equipment clearly marked on the front cover.

The manuals shall include general arrangement drawings, full sets of wiring diagrams, fill technical details for operation, adjustment and maintenance of equipment, charts or specifications arid full dismantling and assembly instructions as appropriate.

Each manual shall contain fully detailed spares lists complete with correct spares ordering references and all manufacturers' names and works addresses.

Catalogue data included in the manuals shall be edited to delete all references to superfluous or misleading information.

The manuals shall be sectioned with inserts referenced and each manual shall commence with a comprehensive index of information that is included.

36.9 Spares

A price list of recommended spares for three years' normal operation of the equipment including one complete lamp change throughout shall be set out in the appropriate schedule submitted with the Tender.

The list shall include a full description of each item, the quantity to be supplied and the manufacturer's part reference number. The spares shall be greased or protected, as appropriate, and wrapped and packed in robust wooden boxes and delivered to the Employer's stores as directed. Spares for each separate item of plant shall be separately packed in an appropriately marked box with a list of contents affixed to the underside of the lid.

36.10 System Voltages

The system voltages will be as follows:

High voltage (HV):	11,000 Volts, 50Hz, 3-phase, 3-wire
Low voltage (LV) :	400/230 Volts, 50 Hz, 3-phase, 4-wire with earthed neutral

All electrical equipment shall be rated for the above voltages as applicable. Before ordering any plant or materials the system voltages shall be confirmed with the Engineer.

36.11 Site Climatic Conditions

All plant, equipment and materials shall be suitable for operation under the climatic conditions obtaining at the Site.

36.12 Setting Out

Before any part of the Works are begun on Site the Engineer and Contractor shall together survey the Site of the Works or part of the Works and shall establish the routes of cables and cable trenches and the positions of equipment and shall agree all records of the survey, routes and positions upon which the measurements of the Works will be based. Failing such survey and agreement of records being prepared jointly and signed by the Contractor, the records of survey by the Engineer shall be final and binding on the Contractor.

The Contractor shall give to the Engineer not less than 24 hours notice of his intention to set out part of the Works. The Contractor shall provide, at his own expense, all assistance, equipment and instruments which the Engineer may require for checking the setting out.

36.13 Working Drawing and Calculation

Within 60 days of the commencement of the Works the Contractor shall, at his own expense, prepare and submit for the approval of the Engineer copies in duplicate (in the first instance) of the working drawings and calculations including those for lighting levels and voltage drops. The Engineer will, after any alterations which he may require have been made by the Contractor, record on the copies as amended his approval and will return one copy to the Contractor who shall carry out the work in accordance therewith. The Contractor shall forward to the Engineer three additional copies of the working drawings as approved.

If the Contractor wishes to propose modification or alterations of any detail of the Works for which he is not responsible for design or specification, he shall prepare at his own expense such detailed drawings and shall submit them to the Engineer in accordance with the above calling the Engineers attention to the proposed modification or, when required, such further information, calculations, etc., as the Engineer may require.

In all cases where drawings for any work included in the Contract are specified or required to be supplied by the Contractor for the approval of the Engineer or where the Contractor opts to propose modifications to the Engineer's design any alteration to such drawings which the Engineer may require shall be made without charge.

The approval of the Engineer of all or any of the drawings and calculations shall not relieve the Contractor of his responsibility in connection with the execution of the Works.

36.14 Alterations to Approved Working Drawings

In all cases where drawings are specified or required to be supplied by the Contractor for the approval of the Engineer for any work included in the Contract, and alteration to such drawings which the Engineer may require to have made, shall be made by the Contractor to the Engineer's satisfaction at the Contractor's own expense.

36.15 Contractor to Work to Other Approved Working Drawings

The contractor shall, where so directed by the Engineer, be required to work to other

approved working drawings wheresoever drawings for works not included in the Contract are related to particular details of the Works.

36.16 Lighting Columns

36.16.1 Columns and Brackets

Lighting columns shall be located on both sides of the bridge and bridge approaches and shall be of tapered tubular steel section, or of octagonal section welded steel plate and shall be manufactured in accordance with BS 1840. They shall be provided with welded base plates suitable for bolting to concrete foundations. Structural steels shall comply with BS 4360 and welding shall comply with BS 5135.

Where columns are equipped with bracket arms, the bracket arms shall be fixed to the columns positively so that the bracket arms cannot rotate. The bracket arms and lanterns shall provide an angle between 3° and 5° above the horizontal when assembled with the columns, and shall have spigots of adequate dimensions to support the lanterns. To ensure minimum discomfort glare there must be a balanced relation between the nominal height overhang projection and design attitude. Contractor shall comply with BS 5649 part 2 with BS 5489 for fabrication and supply of brackets.

If the use of area floodlights is considered as an alternative to road lighting columns, the floodlight shall be fixed to a plate welded to the top of the column.

All column metalwork shall be hot dip galvanized in accordance with Article 36.5 of this Section.

The base compartment shall be of adequate dimensions to accommodate a MCB cut-out and the lantern ballast units, mounted on a non-hygroscopic base board, and shall provide full access for termination of cables. An earthing terminal shall be provided within the base compartment comprising a 25mm long x 10mm diameter (minimum) set screw with two washers and locknuts.

The base compartment door shall be weatherproof and be fitted with concealed hinges and a tamper-proof locking device standard on all columns. Hinge assemblies shall be fitted to one vertical side of the door and shall be manufactured from stainless steel. The door shall incorporate a spring device to retain the door in its fully open position to facilitate access for maintenance purposes. Twelve door keys shall be handed over to the Engineer's Representative on completion of the Contract.

36.16.2 Column Identification

All columns shall be identified by 3-character Bengali and English numerals as instructed by the Engineer's Representative. The numerals shall be 50mm high painted on the column approximately 1.2m above ground level. Columns shall have the number facing the oncoming traffic a one direction only.

36.16.3 Flag Brackets

Each column shall be provided with a flag bracket at mid-height position. The brackets shall be of galvanized steel construction arranged for clamping around the column and shall be fitted with four flag sockets.

36.16.4 Termination Units

An enclosed termination unit constructed of high grade phenolic materials shall be provided in the base compartment of each column. It shall be suitable for terminating single core 25mm^2 PVC cable/ PVC sheathed cables loop connected and for accommodating the cable glands.

A miniature circuit breaker of 10 Amp rating for single arm columns shall be provided for the phase connection to the lanterns. The neutral shall be connected direct through terminals. Circuit breakers shall be fitted with thermal overload and magnetic short circuit tripping devices.

36.16.5 Internal Wiring of Columns

Internal wiring in columns between the termination units, ballast units and lanterns shall be carried out using EPR insulated CSP sheathed flexible cables 300/500V volt grade with minimum 2.5mm^2 stranded copper conductors in accordance with BS 6500 as applicable.

36.17 Lanterns and Auxiliaries

36.17.1 Construction

Road lighting lanterns and area floodlights shall be weatherproof, dust-tight, enclosed type and shall comply with BS 4533, having protection class IP-54 as applicable, and shall be complete with all necessary integral lamp control gear for proper operation of a SON lamp.

The lanterns shall be constructed of die cast aluminum or heavy gauge reinforced aluminum sheet. Where reflectors are used to control the light distribution they shall be constructed of high purity aluminum.

The design of the optical system and the bowl sealing arrangement shall provide easy and minimal maintenance. The gasket between the lamp compartment and bowl shall be resilient and non-deteriorating, and it shall be positively retained in its seating, with not more than one joint, and shall not work loose or deform in normal operation or during maintenance of the lanterns.

The refractor bowl or front visor shall be hinged and secured by an adequate number of stainless steel fasteners. The hinge assembly should permit easy removal of the bowl for replacement purposes. in the closed position the bowl shall be firmly attached to the body of the lantern., bearing uniformly on the gasket. When the bowl is allowed to swing under its

own weight from the closed position it shall not become detached or knock against the body of the lantern column or supporting structure.

36.17.2 Column Mounted Lanterns

Lanterns for mounting on 10 m high columns (including projection height of overhanging part) shall have a principal transverse optical axis parallel to the road surface. The lanterns shall be of the side entry type and shall be securely locked to the bracket arm spigots to prevent movement by vibration or wind effects.

Area floodlights for mounting on 10 m high columns shall have a wide angle distribution with suitable cut off to prevent glare to incoming traffic.

36.17.3 Ballast Units

Ballast units comprising lamp control gear, capacitors, radio interference suppression devices and all other auxiliaries shall in each case be of the built-in type and fitted within the lantern's body.

The ballast units shall have a maximum of 20% harmonics and shall comply with BS 4782 or BS 2812 as applicable. They shall be of the solid filled type and have voltage toppings in 10 volt steps from 230 to 180 volts. All toppings shall be brought to suitable marked terminals to which lamp and supply connections can be made. Capacitors shall be totally enclosed and shall be designed to give an overall circuit power factor of not less than 0.85 lagging.

The ballast units shall be designed so that the operation of the lighting installation does not produce a level of radio interference exceeding the limits given in BS 800. The recommendations of the British Standard code of Practice, CP 1006, for the control and suppression of radio interference, shall also be adhered to.

36.17.4 Replacement of Lamps and Control Gear

The Contractor shall, at his own expense, replace all lamps or ballast units in the equipment which fail within 100 hours of running time after the date of completion of each stage of the Works

36.18 Pole Mounted Substations

36.18.1 Description

The location of substations shall be selected to provide the optimum conditions where the voltage drop in the low voltage cables is such that the voltage at any lighting column is not less than 190 Volts.

Each substation comprises an 11 kV incoming supply fuse, an 11 kV/400 V transformer. Transformer, platform channels, DOF, LA, LA brackets and all accessories for cable termination arrangements.

36.18.2 Transformers

The 11 kV/400 V transformer shall comply with BS 171, be double wound and rated for continuous operation. The primaries shall be delta connected and the secondaries star connected to vector group Dyn-11.

The kVA ratings shall be selected to meet the design loads with a minimum of 20% spare capacity.

36.18.3 11 kV Fuse Switches

The 11 kV fuse switches shall be at 100 A with a fuse size selected to match the loads and provide discrimination. The short circuit fault rating shall be selected to be greater than the system supply short circuit fault rating.

The switches shall be of the fault make, load break type with the following features:

- spring assisted, manually operated, main with ON/OFF indication and means of padlocking in either position.
- circuit earthing switch with OFF/EARTH indication and operating mechanism above.

36.18.4 LV Distribution Board

The distribution equipment shall housed in a fabricated steel enclosure with hinged door. All copper work with in the unit shall be rigidly supported and fully shrouded to obviate the possibility of accidental contact with live metal from the front with the door open. There will be a provision in fixing the whole unit on RCC base. The unit shall be fully rain proof.

The following shall be housed within the enclosure:

- 1 set of 3 phase 4 wire busbars of current rating to suit the transformer;
- 1 set of isolating links on LV side of transformer;
- TPN distribution units complete with HRC fuse links in carriage, and bolted neutral links or MCBs;
- compression glands for LVC /SWA /PVC cables;
- 13 A metal clad switched socket outlet with RCD protection.

The design of distribution units must be such that current reading of all phases can safely and readily be made with tongtester.

36.18.5 Earthing

All units of a substation, shall be bonded together with HDBC copper, and an earth terminal shall be provided, complete with cable socket, for connection to the system earth, all bonded to the armouring of the cables. The neutral busbar shall be connected to the earth terminal via a test link.