

DIVISION 5

ROADS AND PAVEMENTS

5.1 SURVEY AND LAYOUT

5.1.1 GENERAL

1. Division 1, "General Requirements" of these Specifications and shall apply to this Section whether herein referred to or not.
2. Applicable requirements under Section 2.3, "Surveys, Soundings, Soil Investigations and Installation of Markers" and Section 4.1 "Survey and Layout" for building works shall apply to this section.

5.1.2 SCOPE OF WORK

This Section covers survey and layout work.

5.1.3 SURVEY AND SETTING OUT OF WORKS

1. The Contractor shall carry out the survey by means of transversing and leveling connected to the approved established reference points.
2. The stations shall be established in accordance with Sub-section 2.3.6.
3. The Contractor shall establish at least three (3) permanent monuments and three (3) benchmarks in the port area on locations approved by the Engineer that can serve conveniently as reference points of future construction.

5.2 CONCRETE WORKS FOR ROADS AND PAVEMENTS

5.2.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.2.2 SCOPE OF WORK

1. This Section includes all cast-in-situ concrete under roads and pavement work.
2. Applicable provisions and requirements under Section 3.2 "Concrete Works" shall apply to this Section.

5.2.3 CLASSES OF CONCRETE AND USAGE

1. Strength Requirements

Classes of Concrete shall conform with the applicable requirements in Sub-section 3.2.7.1.

2. Usage: The classes of concrete to be used shall be as follows:

- | | |
|----------------------|--------------------------|
| 1) Class B2 Concrete | : For roads and pavement |
| 2) Class C Concrete | : For utility RC works |
| 3) Class D Concrete | : Leveling concrete |

5.3 DEMOLITION/BREAKING OF EXISTING PAVEMENT AND DISPOSAL OF MATERIALS

5.3.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.3.1.1 DESCRIPTION

This work shall consist of the breaking of existing pavement and disposal of unsuitable or excess materials including the removal of all superficial obstructions on the site in the way of or otherwise affected by the works as shown on the drawings. The Contractor shall clear each part of the site at times and to the extent required or approved by the Engineer.

The Contractor shall submit his proposed method of breaking of existing pavement and disposal of materials including materials, equipment, and all related works for the approval of the Engineer.

5.3.2 DEMOLITION AND CLEARING

1. Demolition

Where shown on the drawings or directed by the Engineer, dilapidated pavement and structures, or part of structures, masonry, and like material within the roadway and sidewalk shall be demolished by the Contractor. Where only a part of a structure has to be demolished, the Contractor shall take all possible care to ensure that only such part is demolished and shall make good at his own expense any damage beyond that part. During demolition, the Contractor shall take every precaution to protect the unaffected roadway, structure, embankment and all other existing works from damage and likewise ensure the safety of his workmen and the general public.

When the area on which an embankment is to be placed has been cleared, The Engineer may order the surface of the existing ground to be scarified so that the filling material will bind into the original ground. The cost of such work, if so required, shall be included in other items of work and shall not be paid for separately.

2. Disposal of Materials

- a. All demolished materials shall be removed or deposited off the site in dumps to be provided by the Contractor in a manner approved by the Engineer. If however, in the opinion of the Engineer, the demolished material is suitable for filling, the Engineer will direct that the material be used. The Contractor may, with the written approval of the Engineer, use for the purposes of the works any cleared materials which are at his disposal.

5.3.3 MEASUREMENT AND PAYMENT

1. Demolition/breaking of existing pavement to be paid for shall be measured by square meters of the pavement in its original position for material actually demolished and disposed.
2. The quantities determined will be paid for at the contract unit prices for the pay items as shown in the Bill of Quantities which prices and payment shall be the full compensation for the demolition and disposal of all materials inclusive of all labor, equipment, tools and incidentals necessary to complete the items and as certified by the Engineer.

5.4 EXCAVATION AND DISPOSAL OF UNSUITABLE MATERIALS

5.4.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.4.2 CLEARING AND GRUBBING

Prior to the start of excavation and grading operations, all superficial obstructions including trees, shrubs and the like on the Site in the way of or otherwise affected by the Work shall be removed as shown on the drawings. The Contractor shall clear each part of the Site at times and to the extent required or approved by the Engineer.

All combustible materials from clearing operation shall be completely burned or removed from site of work or otherwise disposed of as directed by the Engineer.

Stumps shall be removed entirely. Roots and matted roots shall be grubbed out to at least 450 mm below the existing surface and shall be backfilled with suitable material and compacted to the required density.

5.4.3 STRIPPING

The areas from which stripping of top soil may be required shall be indicated on the drawings. The Contractor shall remove top soil from such portions of these areas and to such depth as the Engineer may require. No stripping of top soil of any designated area shall be less than 150 mm in depth. The top soil removed shall be transported, deposited in stock piles at locations approved by the Engineer and/or spread and compacted with a light roller where indicated on the drawings or where directed by the Engineer.

The top soil shall be kept separate from other excavated materials and shall be completely removed to the required depth from any designated area prior to the beginning of regular excavation or embankment work in the area. No payment will be made for top soil removed from places other than those ordered.

5.4.4 **EXCAVATION**

5.4.4.1. ROADWAY EXCAVATION

The Contractor shall carry out all excavation required along the roadway and sidewalk regardless of the type of soil or obstructions thereat. All excavation shall be carried out to lengths, widths, depths and profiles necessary of the construction of the roads shown on the drawings or to such other dimensions as may be approved in writing by the Engineer.

Excavation shall be carried out in such a way as to avoid disturbance to the surrounding ground and other existing works.

Particular care shall be taken to maintain stability when excavating in close proximity to existing structures, and for underground utilities. The Contractor shall comply with all instructions of the Engineer regarding the supporting of the sides of excavation and shall be entirely responsible for the sufficiency of all temporary timbering and supports to the excavation. Any unsound formation areas or underground utility uncovered as a result of the excavation shall be reported to the Engineer immediately for his instructions.

5.4.4.2. EXCESS EXCAVATION

If for any cause whatsoever excavations are carried out beyond their true line and level, other than at the direction of the Engineer, the Contractor shall at his own cost make good to the required line and level with appropriate grade of filling or by other approved material and in such manner as the Engineer may direct.

5.4.4.3. DISPOSAL OF UNSUITABLE AND EXCESS MATERIALS

If in the opinion of the Engineer, the excavated material is unsuitable for backfill, the Engineer will direct that the material be removed from the site and disposed of in an approved location. All excess materials shall also be disposed of where directed by the Engineer.

5.4.5 **MEASUREMENT AND PAYMENT**

1. The quantity to be paid shall be the area in square meters of the clearing and grubbing works completed in accordance with these specifications.
2. The quantity to be paid shall be the area in square meter of the stripping works completed in accordance with these Specifications.

Payment shall be per unit of quantity listed in the Bill of Quantities, price of which includes payment for labor, materials, tools and equipment necessary to complete the work.

3. The cost of excavation of material which is incorporated in the works in embankments or in other areas of fill shall be deemed to be included in the items relating to the parts of the work where the material is used. Measurement of unsuitable or surplus material shall be the net volume in its original position, in cubic meters.

For measurement purposes, surplus suitable material shall be calculated as the difference between the net volume of suitable material required to be placed in fill and the net volume of suitable material arising from any excavation, in cubic meters.

The Contractor shall be deemed to have included in the contract unit prices all costs for the disposal of unsuitable or surplus material.

4. The quantities determined as provided above shall be paid for at the appropriate contract unit price for each of the particular pay items shown in the Bill of Quantities which prices and payment shall constitute full compensation for all the costs of obtaining and preparing as required by the particular item.

5.5 FILLING

5.5.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.5.1.1 DESCRIPTION

This work shall consist of the construction of embankments and other areas of fill not specified elsewhere by furnishing, placing, compacting and shaping suitable material of acceptable quality obtained from approved sources in accordance with the specifications and to the lines, level, grades, dimensions and cross section shown on the drawings and as required by the Engineer. Unless otherwise stated, the term "embankment" shall include all areas of fill.

The Contractor shall submit his proposed method of filling including materials, equipment, and all related works for the approval of the Engineer.

5.5.2 MATERIAL REQUIREMENTS

Material requirements of Sub-section 3.8.2 are applicable.

5.5.3 EXECUTION

The specification of Sub-section 3.8.3 are applicable.

5.5.4 MEASUREMENT AND PAYMENT

See Sub-section 3.8.5.

5.6 SUBGRADE PREPARATION

5.6.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.6.1.1 DESCRIPTION

The subgrade preparation shall be the part of the work which is the preparation for the support of the sub-base or, if there is no sub-base, the surfacing of the pavement structure. It shall extend to the full width of the road including the shoulders as shown in the drawings or as specified herein. Unless otherwise agreed by the Engineer subgrade preparation of a section of road shall not commence unless the Contractor is able, after the completion and acceptance of the work, to commence immediately pavement construction.

5.6.2 MATERIAL REQUIREMENTS

Unless otherwise stated in the Contract and except when the subgrade is in rock cut, all materials below subgrade level to a depth of 150 mm or to such greater depth as may be specified shall meet the requirements of selected borrow for topping, e.g., soil of such gradation that all particles will pass a sieve with 75 mm (3 inches) square openings and not more than 15 percent will pass the 0.075 mm (No. 200) sieve, as determined by AASHTO T 11. The material shall have a plasticity index of not more than 6 as determined by AASHTO T 90 and liquid limit of not more than 30 as determined by AASHTO T89.

5.6.3 EXECUTION

1. Prior Works

Prior to commencing the preparation of the subgrade all culverts, ditches, drains and drainage outlets shall be completed. No work shall be started on the preparation of the subgrade before the prior works are herein approved by the Engineer.

- 2.** Where the new pavement is to be constructed immediately over an existing gravel surfaced pavement and if so specified in the Contract the pavement shall be scarified, thoroughly loosened, reshaped and recompactd in accordance with item 3 below.

3. Unless otherwise ordered by the Engineer a variable load pneumatic tired roller shall be used to proof roll the subgrade. The roller shall have a load variable within the range of at least from 15 to 45 tons, on an overall width not greater than 3.2 m and shall have tires whose pressures are variable up to not less than 620 KN/sq.m. The wheels shall be in row and shall be capable of considerable vertical movement relative to each other without appreciable variation in loading either by each supporting a separate ballast unit, or by virtue of an efficient interconnecting suspension system. The ballast shall be in a form which permits rapid adjustment of loads. The total loaded weight and tire pressure used at any time shall be as directed by the Engineer. The pneumatic tired roller shall not be towed over completed sub-bases or surfacings without the prior approval of the Engineer on each occasion. The proof rolling shall consist of one pass of the roller along the center of each lane of the traveled way.

The subgrade shall be compacted to a depth of 150 mm to the requirements of Table 5.6.1. This work shall comply with all the specified requirements for compaction of earthwork.

Table 5.6.1 Compaction Requirements

Soil Type Classification According to AASHTO M 145	Test Method for Determining Moisture Density Relations	Minimum Relative Density Field Dry Density as % of Maximum Dry Density as Determined by the Specified Test Method
A - 1 A - 2 - 4 A - 2 - 5 A - 3	AASHTO T 180 (4.54 kg rammer) Method D	90%
A - 2 - 6 A - 2 - 7 A - 4 A - 5 A - 6 A - 7	AASHTO T 99 (4.54 kg rammer) Method D	95%

4. Protection of Completed Work

Any part of the subgrade that has been completed shall be protected and any damage resulting from default of the Contractor shall be repaired as directed by the Engineer without additional payment.

The Contractor shall be responsible for all the consequences of traffic being admitted to the subgrade. He shall repair any ruts or ridges occasioned by his own traffic or that of others by reshaping and recompacting. He shall limit the amount of subgrade preparation to an area that can be maintained with the equipment available. He shall arrange for subgrade preparation and sub-base or base placing to follow each other closely. The subgrade, when prepared too soon in relation to the laying of the sub-base, is liable to deteriorate, and in such case the Contractor shall, without additional payment, repair, reroll, or recompact the subgrade as may be necessary restore it to the state specified herein.

5.6.4 **MEASUREMENT AND PAYMENT**

1. The quantity of subgrade preparation to be paid shall be measured by the area in square meters, compacted and accepted by the Engineer.
2. Payment of subgrade preparation shall be based on the number of square meters, as provided above, which price and payment shall constitute full compensation for furnishing all materials, labor, equipment, tools and incidentals necessary to complete the item and accepted by the Engineer.

5.7 AGGREGATE SUBBASE COURSE

5.7.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these Specifications; and apply to this Section, whether or not referred to herein.

5.7.1.1 DESCRIPTION

This Section shall consist of furnishing, placing and compacting an aggregate subbase course on a prepared subgrade in accordance with these Specifications and the lines, grades and cross sections shown on the Drawings, or as directed by the Engineer.

5.7.2 MATERIAL REQUIREMENTS

Aggregate for subbase shall consist of hard, durable particles or fragments of crushed stone, crushed slag, or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. The composite material shall be free from vegetable matter and lumps or balls of clay, and shall be of such nature that it can be compacted readily to form a firm, stable subbase.

The subbase material shall conform to Table 5.7.1, Grading Requirements.

Table 5.7.1 - Grading Requirements

Sieve Designation		Mass Percent Passing
Standard (mm)	Alternate US Standard	
50	2"	100
25	1"	55-85
9.5	3/8"	40-75
0.075	No. 200	0-12

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and plasticity index not greater than 12 as determined by AASHTO T 89 and T 90, respectively.

The coarse portion, retained on a 2.00 mm (No. 10) sieve, shall have a mass percent of wear not exceeding 50 by the Los Angeles Abrasion Tests as determined by AASHTO T 96.

The material shall have a soaked CBR value of not less than 25% as determined by AASHTO T 193. The CBR value shall be obtained at the maximum dry density and determined by AASHTO T 180, Method D.

5.7.3 EXECUTION

1. Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Section 5.6, "Subgrade Preparation", before placing the subbase material.

2. Placing

The subbase material shall be placed as a uniform mixture on a prepared subgrade in a quantity which will provide the required compacted thickness. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

The placing of material shall begin at the point designated by the Engineer. Placing shall be from vehicles especially equipped to distribute the material in a continuous uniform layer or windrow. The layer or windrow shall be of such size that, when spread and compacted the finished layer be in reasonably close conformity to the nominal thickness shown on the Drawings.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

3. Spreading and Compacting

When uniformly mixed, the mixture shall be spread to the plan thickness, for compaction.

Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, the aggregate subbase material shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer

shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

The moisture content of subbase material shall, if necessary, be adjusted prior to compaction by watering with approved sprinklers mounted on trucks or by drying out, as required in order to obtain the required compaction.

Immediately following final spreading and smoothing, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling shall progress gradually from the sides to the center, parallel to the centerline of the road and shall continue until the whole surface has been rolled. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. Along curbs, headers, and walls, and at all places not accessible to the roller, the subbase material shall be compacted thoroughly with approved tampers or compactors.

If the layers of subbase material, or part thereof, does not conform to the required finish, the Contractor shall, at his own expense, make the necessary corrections.

Compaction of each layer shall continue until a field density of at least 100 percent of the maximum dry density determined in accordance with AASHTO T 180, Method D has been achieved. In-place density determination shall be made in accordance with AASHTO T 191.

4. Trial Sections

Before subbase construction is started, the Contractor shall spread and compact trial sections as directed by the Engineer. The purpose of the trial sections is to check the suitability of the materials and the efficiency of the equipment and construction method which is proposed to be used by the Contractor. Therefore, the Contractor must use the same material, equipment and procedures that he proposes to use for the main work. One trial section of about 500 m² shall be made for every type of material and/or construction equipment/procedure proposed for use.

After final compaction of each trial section, the Contractor shall carry out such field density tests and other tests required as directed by the Engineer.

If a trial section shows that the proposed materials, equipment or procedures in the Engineer's opinion are not suitable for subbase,

the material shall be removed at the Contractor's expense, and a new trial section shall be constructed.

If the basic conditions regarding the type of material or procedure change during the execution of the work, new trial sections shall be constructed.

5. Tolerances

Aggregate subbase material shall be spread with equipment that will provide a uniform layer which when compacted will conform to the designed level and transverse slopes as shown on the Drawings. The allowable tolerances shall be as specified hereunder:

Permitted variation from design thickness of layer	± 20 mm
Permitted variation from design level of surface	+10 mm -20 mm
Permitted surface irregularity measured By 3-m straight-edge	20 mm
Permitted variation from design crossfall or camber	$\pm 0.3\%$
Permitted variation from design longitudinal grade over 25 m length	$\pm 0.1\%$

5.7.4 MEASUREMENT AND PAYMENT

1. Measurement

Aggregate subbase course shall be measured by the cubic meter (m^3). The quantity to be paid for shall be the design volume compacted in-place as shown on the Drawings, and accepted in the completed course. No allowance will be given for materials placed outside the design limits shown on the cross-sections. Trial sections shall not be measured separately but shall be included in the quantity of subbase herein measured.

2. Payment

The accepted quantities measured shall be paid for at the contract unit price for aggregate subbase course which price and payment shall be full compensation for furnishings and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

5.8 AGGREGATE BASE COURSE

5.8.1 GENERAL

5.8.1.1 DESCRIPTION

This Section shall consist of furnishing, placing and compacting aggregate base course on a prepared subgrade in accordance with this Specification and the lines, grades, thickness and typical cross-sections shown on the Plans, or as established by the Engineer.

5.8.2 PRODUCTS

5.8.2.1 MATERIAL REQUIREMENTS

Aggregate for base course shall consist of hard, durable particles or fragments of crushed slag or crushed or natural gravel and filler of natural or crushed sand or other finely divided mineral matter. The composite material shall be free from vegetable matter and lumps or balls of clay, and shall be of such nature that it can be compacted readily to form a firm, stable base.

The base course material shall conform to Table 5.8.2.1,

Table 5.8.2.1 - Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard mm	Alternate US Standard	Grading A	Grading B
50	2"	100	
37.5	1 1/2"	-	100
25.0	1"	60-85	
19.0	3/4"	-	60-85
12.5	1/2"	36-65	-
4.75	No. 4	20-50	30-55
0.425	No. 40	5-20	8-25
0.075	No. 200	0-12	2-14

The fraction passing the 0.075 mm (No.200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No.40) sieve shall have a liquid limit not greater than 25 and plasticity index not greater than 6 as determined by AASHTO T 89 and T 90, respectively.

5.8.3 EXECUTION

5.8.3.1 PREPARATION OF EXISTING SURFACE

The existing surface shall be graded and finished as provided under Section 5.6, "Subgrade Preparation", before placing the base material.

5.8.3.2 PLACING

The aggregate base material shall be placed as a uniform mixture on a prepared subgrade in a quality which will provide the required compacted thickness. When more than one layer is required, each layer shall be shaped and compacted before the succeeding layer is placed.

The placing of materials shall begin at the point designated by the Engineer. Placing shall be from vehicles especially equipped to distribute the material in a continuous uniform layer or windrow. The layer or windrow shall be of such size that when spread and compacted the finished layer shall be in reasonably close conformity to the nominal thickness shown on the Plans.

When hauling is done over previously placed material, hauling equipment shall be dispersed uniformly over the entire surface of the previously constructed layer, to minimize rutting or uneven compaction.

5.8.3.3 SPREADING AND COMPACTING

When uniformly mixed, the mixture shall be spread to the plan thickness, for compaction. Where the required thickness is 150 mm or less, the material may be spread and compacted in one layer. Where the required thickness is more than 150 mm, the aggregate base shall be spread and compacted in two or more layers of approximately equal thickness, and the maximum compacted thickness of any one layer shall not exceed 150 mm. All subsequent layers shall be spread and compacted in a similar manner.

The moisture content of base material shall, if necessary, be adjusted prior to compaction by watering with approved sprinkler mounted on trucks or by drying out, as required in order to obtain the required compaction.

Immediately following final spreading and smoothing, each layer shall be compacted to the full width by means of approved compaction equipment. Rolling shall progress gradually from the sides to the center, parallel to the centerline of the road, and shall continue until the whole surface has been rolled. Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding

or removing material until the surface is smooth and uniform. Along curbs, headers, and walls, and at all places not accessible to the roller, the base material shall be compacted thoroughly with approved tampers or compactors.

If the layer of base materials, or part thereof, does not conform to the required finish, the Contractor shall, at his own expense, make the necessary corrections.

The field density required of each layer is not less than 98 percent of the maximum dry density determined in accordance with AASHTO T 180 (ASTM D1557).

5.8.4 MEASUREMENT AND PAYMENT

1. Measurement

Aggregate base course will be measured by the cubic meter (m³). The quantity to be paid for shall be the design volume compacted in-place as shown on the drawings, and accepted in the completed course. No allowance shall be given for materials placed outside the design limits shown on the cross-sections. Trial sections shall not be measured separately but shall be included in the quantity of aggregate base course.

2. Payment

The accepted quantities, measured shall be paid for at the contract unit price for aggregate base course which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

5.9 CRUSHED AGGREGATE BASE COURSE

5.9.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.9.1.1 DESCRIPTION

This work shall consist of furnishing, spreading and compacting crushed aggregate base material of crushed gravel, crushed stone or crushed rock, constructed over a prepared subgrade or sub-base in one or more layers, in accordance with these specifications and shown in the drawings.

5.9.2 MATERIAL REQUIREMENTS

1. Material for crushed aggregate base course shall consist of crushed or partly crushed hard, durable gravel stone or rock fragments. It shall be clean and free from organic matters, lumps of clay and other deleterious substances. The material shall be of such a nature that it can be compacted readily under watering and rolling to form a firm stable base.
2. The base material shall conform to the grading requirements of Table 5.9.1, whichever is called for in the Bill of Quantities.

Table 5.9.1 - Grading Requirements

Sieve Designation		Mass Percent Passing
Standard Mm	Alternate US Standard	
37.5	1 1/2"	100
25	1"	-
19	3/4"	60-85
12.5	1/2"	-
4.75	No. 4	30-55
0.425	No. 40	8-25
0.075	No. 200	2-14

The portion of the material passing the 0.075 mm (No. 200) sieve shall not be greater than 0.66 (two thirds) of the fraction passing the 0.425 mm (No. 40 sieve).

The portion of the material passing the 0.425 mm (No. 40) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 as determined by AASHTO T 89 and 90, respectively.

The material passing the 19 mm (3/4 inch) sieve shall have a minimum soaked CBR-value of 80% tested according to AASHTO T 193. The CBR-value shall be obtained at the maximum dry density determined according to AASHTO T 180, Method D.

If filler, in addition to that naturally present, is necessary for meeting the grading requirements or for satisfactory bonding, it shall be uniformly blended with the crushed base coarse material on the road or in a pugmill unless otherwise specified or approved. Filler shall be obtained from sources approved by the Engineer, free from hard lumps and not contain more than 15 percent of material retained on the 4.75 mm (No. 4) sieve.

5.9.3 EXECUTION

1. Placing

Crushed aggregate base shall be delivered to the site of the works as a uniform mixture. No material shall be spread on a soaked surface.

2. Compaction Requirement

The compacted dry density of each layer of the compacted base shall not be less than 100 percent of the maximum dry density determined according to AASHTO T 180, Method D. The field density shall be determined according to AASHTO T 191.

3. Tolerances

The base shall be laid to the designed level and transverse slopes as shown in the Drawings. The allowable tolerances shall be in accordance with Table 5.9.2.

Table 5.9.2 - Tolerances for Base

Variations	Base
Permitted variation from design thickness of layer	+10 mm -10 mm
Permitted variation from design level of surface	+5 mm -10 mm
Permitted Surface Irregularity measured by 3m straight edge	5 mm
Permitted variation from design crossfall or camber	±0.2 %
Permitted variation from design longitudinal grade over 25 m length	±0.1 %

5.9.4 MEASUREMENT AND PAYMENT

1. Measurement

Crushed aggregate base course will be measured by the cubic meter (m³). The quantity to be paid for shall be the design volume compacted in-place as shown on the drawings, and accepted in the completed course. No allowance shall be given for materials placed outside the design limits shown on the cross-sections. Trial sections shall not be measured separately but shall be included in the quantity of crushed aggregate base course.

2. Payment

The accepted quantities, measured shall be paid for at the contract unit price for crushed aggregate base course which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this Section.

5.10 CEMENT TREATED BASE COURSE

5.10.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.10.1.1 DESCRIPTION

The Work include the furnishing of labor, materials and equipment required for cement treated base course for port roads, storage and parking areas in accordance with the lines and grades shown on the Drawings and in conformity with these specifications.

5.10.2 MATERIAL REQUIREMENTS

5.10.2.1 CEMENT

Portland cement shall conform with the requirements of AASHTO M 85 (ASTM C-150). Only type I cement shall be used.

5.10.2.2 AGGREGATES

Aggregates for cement treated base shall consist of any combination of gravel, sand and stone fragments, and shall be lean, free from organic matter, lumps of clay and other deleterious substance, conforming to the following grading and quality requirements:

1. The aggregates shall have a grading curve within the limits for Class C given in the Table 5.10.3.

Table 5.10.3 Cement Treated Base Aggregate Grading

Sieve Designation		Percent Passing By Weight
Standard MM	Alternative US Standard	Class C
19	¾"	80-100
4.75	No.4	40-100
0.425	No. 40	10-100
0.075	No. 200	3-15

The aggregates shall be uniform mixture of coarse and fine aggregates prior to adding cement.

2. the coarse aggregates retained on a 4.75 mm (No.4) sieve shall have a percentage of wear by the Los Angeles Abrasion Test (AASHTO T 96) of not more than 50;
3. the material shall have loss of less than 12% when subject to five cycles of the Sodium Sulfate Soundness test according to AASHTO T 104; and
4. The sand equivalent determined according to AASHTO T 176 shall not be less than 20.

5.10.2.3 WATER

Water shall be free oil, acid, alkali or other deleterious substances, the quality of which shall be subject to the approval of the Engineer. Sufficient supply of water shall be made available throughout the work.

5.10.2.4 JOINT FILLER

Expansion joint filler shall be preformed conforming to the requirements.

5.10.3 EXECUTION

5.10.3.1 MIXTURE

Cement treated base shall have a cement content not less than 10% of the weight of the aggregate in the mixture.

5.10.3.2 EQUIPMENT

Before commencing the work, the equipment necessary for the work shall be on the site in good working condition, and shall be subject to the approval of the Engineer both as to the type and condition. The Contractor shall provide sufficient equipment with corresponding experienced operators to ensure efficient progress of the work.

5.10.3.3 PROPORTIONING AND MIXING

Cement treated base shall be mixed in-situ by either batch type mixing using revolving blade or rotary drum mixer, at the option of the Contractor. The aggregate and cement shall be proportioned by weight.

The water shall be proportioned by weight and there shall be means by which the Engineer may readily verify the amount of water per batch. The time of addition of water or the points at which it is introduced into the mixer shall be as approved by the Engineer.

The moisture content of the completed mixture during placing shall not be higher than the optimum moisture content and not lower than 3% below the optimum moisture content.

Cement shall be added in such a manner that is uniformly distributed throughout the aggregate during the mixing operation. Safe, convenient facilities shall be provided for sampling cement in the supply line.

The charge in batch mixer, shall not exceed that which will permit complete mixing of all the material. Dead areas in the mixer, in which the materials does not move or is not sufficiently agitated, shall be corrected.

The cement content of the completed mixture of cement treated base, after it has been spread on the subgrade and prior to initial compaction shall not be lower than the specified cement content shall only be made with the approval of the Engineer.

The aggregate and cement for cement treated base shall be brought to the site of the work before the addition of water. The equipment used and the method adopted shall be such that the material is crushed uniformly to the full depth of the layer to produce a homogenous material. Details of the equipment and method which the Contractor proposes to use for the work shall be subject to the approval of the Engineer.

5.10.3.4 SPREADING

Immediately prior to depositing cement treated base, the area to be covered shall be moistened and kept moist, but not excessively wet.

Segregation shall be prevented and the mixtures shall be free from pockets of coarse or fine material.

The mixed material shall be spread in widths acceptable to the Engineer. Except when placed as a leveling course, the maximum compacted thickness of any layer shall not exceed 250 mm and the minimum thickness shall not be less than 80 mm. When cement treated base is placed in more than one layer, the surface of the lower layer of compacted material shall be kept moist until covered with the next layer of cement treated base on surface is placed.

The treated mixture may be spread by such equipment which will consistently finish the base within the tolerance specified and which does not result in segregation. Cement treated base placed on areas inaccessible to mechanical spreading equipment may be spread in one layer by methods approved by the Engineer.

The use of motor graders may be permitted during spreading and compacting operations and to trim the edges and surfaces of the cement treated base after compaction in order to finish the base within the tolerances specified.

5.10.3.5 COMPACTING

After spreading, the materials shall be thoroughly compacted to the required lines, grades, and cross section by means of pneumatic tampers, or with other compacting equipment which consistently obtains the degree of compaction required.

Excess material may be placed as aggregate for shoulder construction subject to the following conditions:

1. Hardened lumps of trimmed materials shall be removed or reduced to the maximum size specified for shoulder aggregate prior to spreading additional shoulder aggregates.
2. The amount of trimmed material incorporated in the shoulder shall not exceed 25% of the designed volume of shoulder aggregate. When trimmings exceed this limit, the excess shall be removed.
3. The excess material shall be uniformly distributed in the shoulder area prior to spreading additional shoulder aggregate.
4. Following such trimming, the finished surface shall be thoroughly compacted so that the entire layer of cement treated base conforms to the compaction requirements hereinafter specified. Final compaction shall be accomplished in such a manner that no loose material remain on the surface and all tire marks are eliminated.

5.10.3.6 COMPACTION REQUIREMENTS

The relative compaction of cement treated base shall not be less than 100% of the maximum dry density determined according to AASHTO T134, Method B.

5.10.4 MEASUREMENT AND PAYMENT

5.10.4.1 GENERAL

Measurement and Payment shall be made in accordance with the item of work listed in the Bill of Quantities.

Each item listed shall be paid for in the appropriate unit price per quantity measured and accepted. Payment shall constitute full compensation for all labor, materials and equipment and all incidentals necessary to complete the work.

Cost for trial sections and all the necessary test to be performed in this sections shall be included in the unit price for the item listed in the Bill of Quantities.

5.10.4.2 CEMENT TREATED BASE COURSE

The quantity of cement treated base course to be paid for shall be measured by volume in cubic meter of materials placed and compacted as shown on the Drawings, accepted and certified by the Engineer.

5.11 AGGREGATE SURFACE COURSE

5.11.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.11.1.1 DESCRIPTION

This Section shall consist of a wearing or top course composed of gravel or crushed aggregate and filler material, whichever is called for in the Bill of Quantities, constructed on a prepared base in accordance with these Specifications and in conformity with the lines, grades and typical cross-sections shown on the drawings.

5.11.2 MATERIAL REQUIREMENTS

The aggregate shall consist of hard, durable particles or fragments of stone or gravel and sand or other fine mineral particles free from vegetable matter and lumps or balls of clay and of such nature that it can be compacted readily to form a firm, stable layer. It shall conform to the grading requirements shown in Table 5.11.1 when tested by AASHTO T 11 and 27.

Table 5.11.1 - Grading Requirements

Sieve Designation		Mass Percent Passing	
Standard mm	Alternate US Standard	Grading A	Grading B
25.	1"	100	100
9.5	3/8"	50-85	60-100
4.75	No. 4	35-65	50-85
2.00	No. 10	25-50	40-70
0.425	No. 40	15-30	25-45
0.075	No. 200	5-20	5-20

The coarse aggregate material retained on the 2.00 mm (No. 10) sieve shall have a mass percent of wear by the Los Angeles Test (AASHTO T 96) of not more than 45.

When crushed aggregate is called for in the Bill of Quantities, not less than fifty (50) percent of the particles retained on the 4.75 mm (No. 4) sieve shall have at least one (1) fractured face.

The fraction passing the 0.075 mm (No. 200) sieve shall not be greater than two-thirds of the fraction passing the 0.425 mm (No. 40) sieve.

The fraction passing the 0.425 mm (No. 40) sieve shall have a liquid limit not greater than 35 and a plasticity index range of 4 to 9, when tested by AASHTO T 89 and T 90, respectively.

5.11.3 EXECUTION

5.11.3.1 PLACING

Aggregate surface course shall be placed in accordance with the requirement of Section 5.9, Crushed Aggregate Base Course.

5.11.3.2 COMPACTING REQUIREMENTS

Aggregate surface course shall be compacted in accordance with the requirements of Section 5.9, Crushed Aggregate Base Course.

5.11.3.3 TRIAL SECTIONS

Trial sections shall be carried out for aggregate surface course in accordance with the requirements of Sub-section 5.7.3 .4.

5.11.3.4 SURFACE COURSE THICKNESS AND TOLERANCES

The aggregate surface course shall be laid to the designed level and transverse slopes shown on the drawings. The allowable tolerances shall be as specified hereunder:

Permitted variation from design thickness of layer	+15 mm -5 mm
Permitted variation from design level of surface	+15 mm -5 mm
Permitted surface irregularity measured by 3-m straight-edge	5 mm
Permitted variation from design crossfall or camber	+0.2%
Permitted variation from design longitudinal grade over 25 m length	+0.1%

5.11.4 MEASUREMENT AND PAYMENT

1. Measurement

The aggregate surface course shall be measured by the cubic meter (m^3). The quantity to be paid for shall be the number of cubic meters of aggregate including all filler placed, compacted and accepted in the completed course. No allowance will be given for material placed outside the design limits shown on the cross-sections. Trial sections shall not be measured separately but shall be included in the quantities as measured above.

2. Payment

The accepted quantity, measured as prescribed shall be paid for at the contract unit price for aggregate surface course which price and payment shall constitute full compensation for furnishing, handling, placing, watering and rolling all materials, including all labor and equipment, tools and incidentals necessary to complete the work prescribed in this section.

5.12 PORTLAND CEMENT CONCRETE PAVEMENT

5.12.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.12.1.1 DESCRIPTION

This work shall consist of constructing pavement of Portland cement concrete on a prepared base for roads and parking area in accordance with the specifications and the drawings.

The Contractor shall submit his proposed method of construction of cement concrete pavement including materials, equipment, and all related works for the approval of the Engineer.

5.12.2 MATERIAL REQUIREMENTS

5.12.2.1 CONCRETE

The class of concrete for the cement concrete pavement shall be Class B2, as specified in Section 3.2, "Concrete Works".

5.12.2.2 CONCRETE MATERIALS

Portland cement and fine and coarse crushed aggregates shall conform to the requirements of Section 3.2, "Concrete Works".

The aggregate shall unless otherwise ordered by the Engineer be combined in properties to produce a mixture within the grading limits for combined aggregates shown in the Table 5.12.1

Table 5.12.1 - Grading of Combined Aggregates

US Standard Sieve		Percent Passing by Weight
mm	Alternative	Class C
50	(2")	80-95
37.5	(1 1/2")	65-87
25	(1")	50-75
19	(3/4")	45-66
9.5	(3/8")	38-55
4.75	(No. 4)	30-45
2.36	(No. 8)	23-35
1.18	(No. 16)	17-27
0.600	(No. 30)	10-17
0.300	(No. 50)	4-9
0.150	(No. 100)	1-3
0.075	(No. 200)	0-2

5.12.2.3 STORAGE OF CEMENT AND AGGREGATES

The storage of cement and aggregates shall conform with the requirements of Section 3.2, "Concrete Work".

5.12.2.4 ADMIXTURES

Admixtures shall only be used with the written permission of the Engineer. If air entraining agents, water reducing agents, set retarders or strength accelerators are permitted to be used, they shall not be used in greater dosages than those recommended by the manufacturer, or permitted by the Engineer.

5.12.2.5 TIE BARS AND DOWELS

Tie bars for joints and dowels shall be deformed steel bars conforming to the requirements specified in AASHTO M 31. Sizes shall be as indicated on the drawings. The deformed steel bars shall be Grade 40 and shall be shipped in standard bundles, tagged and marked in accordance with the code of Standard Practice of the Concrete Reinforcement Steel Institute.

5.12.2.6 JOINT FILLER

Preformed joint filler shall conform to the requirements of AASHTO M 153 or M 213. It shall be punched to admit the dowels where called for on the drawings. The filler for each joint shall be furnished in a single piece for the depth and width required for the joint.

5.12.3 EXECUTION

5.12.3.1 PROPORTIONING, CONSISTENCY AND MIXING OF CONCRETE

The proportioning, consistency and mixing of concrete shall conform with the requirements of Section 3.2.

5.12.3.2 TRANSPORTING AND DELIVERY OF MIXED CONCRETE

Transporting and delivery of mixed concrete shall be in accordance with the requirements of Section 3.2.

5.12.3.3 PREPARATION

The base shall be watered and thoroughly moistened prior to the placing of the concrete.

5.12.3.4 FORMWORK CONSTRUCTION

1. Formwork shall comply with the requirements of Section 3.2 under the title "Formwork" and with the requirements below.

Forms shall be of steel, of an approved section, and shall be straight and of a depth equal to the thickness of the pavement at the edge. The base of the forms shall be of sufficient width to provide necessary stability in all directions. The flange braces must extend outward on the base not less than 2/3 the height of the form.

2. All forms shall be rigidly supported on a bed of thoroughly compacted material during the entire operation of placing and finishing the concrete. They shall be set with their faces vertical so as to produce a surface complying with the tolerance requirements in Table 5.12.2.

Table 5.12.2 - Tolerances for Cement Concrete Pavement

Item	Tolerance
Permitted variation from design thickness of layer	±5 mm
Permitted variation from design level of surface	±5 mm
Permitted surface irregularity measured by 3 m straight-edge	5 mm
Permitted variation from design crossfall or camber	±0.2%

3. Except for the concreting of short sections, the length of formwork erected, checked and approved by the Engineer shall not be less than 150 m at the time of commencement of concreting on any one day.
4. Adjacent lanes may be used in lieu of forms for supporting finishing equipment provided that proper protection is afforded to the concrete of the adjacent lanes to prevent damage, and further provided that the surface of the concrete carrying the finishing equipment does not vary more than 3 mm in each 3 m length. Adjacent lanes in lieu of forms may not be used until the concrete is at least 7 days old. Flanged wheels of the finishing equipment shall not be operated on the concrete surface. The inside edge of supporting wheels of the finishing machine shall not operate closer than 100 mm from the edge of the concrete lane.
5. Alternative to placing forms, slip-forming may be used. Slip-form paving equipment shall be equipped with the travelling side forms of sufficient dimensions, shape, and strength to support the concrete laterally for a sufficient length of time during placement to produce pavement of the required cross section. No abrupt changes in longitudinal alignment of the pavement will be permitted. The horizontal deviation shall not exceed 20 mm from the proper alignment established by the Engineer.

5.12.3.5 JOINTS

1. All joints, longitudinal, transverse, etc. shall be constructed as shown on the drawings and shall be clean and free of all foreign material after completion of shoulder work and prior to acceptance of the work, and in accordance with the following provisions:

- a. Contact Joints

Contact joints are those joints made by placing fresh concrete against hardened concrete.

- b. Contraction Joints (Weakened Plane Joints)

Contraction joints shall be formed by cutting a groove in the pavement with a power driven saw at the locations shown on the drawings. The grooves shall be cut to a minimum depth of 50 mm and the width shall be cut to a minimum width possible with the type of saw being used, but in no case shall the width exceed 5 mm. Every fourth planned transverse weakened plane joint in the initial lane of concrete and also the first joint immediately after the transverse contact joint shall be sawed within 24 hours after

the concrete has been placed, the exact time to be determined by the Engineer. Every second planned transverse weakened plane joint shall be sawed within 48 hours after placing the concrete, the exact time to be determined by the Engineer. The remaining longitudinal and transverse weakened plane joints may be sawed at such time, after 24 hours, as the Contractor may elect, except they shall be completed before placing concrete in succeeding adjacent lanes and before permitting the Contractor's traffic or public traffic to use the pavement.

In succeeding lanes of concrete pavement, the transverse joints opposite those which have opened in the initial lane shall be sawed within 24 hours after the concrete has been placed, the exact time to be determined by the Engineer, but in all cases not more than 3 consecutive planned transverse weakened plane joints shall be omitted. The remaining longitudinal and transverse weakened plane joints may elect, except they shall be completed before placing concrete in the succeeding adjacent land and before permitting the Contractor's traffic of public traffic to use the pavement.

No sawing shall be done where transverse cracks exist. If a transverse crack falls within 1.52 m of the location of a propose sawed joint, the sawed joint shall be omitted. Joints sawed in violation of the provisions in this paragraph will not be paid for. At the discretion of the Engineer transverse weakened plane joints may be formed by placing a continuous strip of plastic or other material which will not react adversely with the chemical constituents of the concrete. The strip shall have a minimum thickness of 0.4 mm and a width of not less than 50 mm or more than 55 mm. After placement, the vertical axis of the joint material shall be within 10 degrees of a plane normal to the surface of the pavement. The top of the strip shall not be above nor more than 5 mm below the finished pavement surface. Final alignment of the strip shall conform to that shown on the transverse weakened plane joints and shall not vary more than 20 mm from the edge of a 3 m straight edge. The strip shall be placed by means of a mechanical installation device which shall vibrate the plastic concrete sufficiently to cause an even flow of concrete above the joint material. After installation of the joint material, the concrete shall be free of segregation, rock pockets or voids and the finished concrete surface on each side of the joint shall be in the same plane. Splices in the joint material shall not be permitted.

The Contractor shall maintain a standby multiple-bladed power joint saw, in operating condition, at the project site at all times

while concrete paving operations are underway, regardless of the type of weakened plane joint being constructed.

At the discretion of the Engineer, longitudinal weakened plane joints at traffic lanes in multi-lane monolithic concrete pavement may be formed by placing a continuous strip of plastic or other material which will not react adversely with the chemical constituents of the concrete. The joint insert material shall be of such width and character that when placed vertically in the concrete it will not bond with the concrete and will form an effective weakened plane joint of 50 minimum depth. The joint material shall be inserted with a mechanical device that places the material in a continuous strip, except where intervening structures break the continuity of paving. Splices in the joint material will be permitted provided that they are effective in maintaining the continuity of the joint material as placed. The joint material shall be placed in such manner that the top of the strip is not more than 3 mm below the finished surface of the concrete. The joint material shall not be deformed from a vertical position, either in the installation or in subsequent finishing operations performed on the concrete. The alignment of the finished joint shall be uniformly parallel with the center line of the pavement and shall be free of any local irregularity which exceeds 10 mm. The mechanical installation device shall vibrate the concrete during placing the strip sufficiently to cause the concrete to flow evenly about the joint material producing homogeneous concrete free of segregation and rock pockets or voids.

c. Expansion Joints

Expansion joints shall be formed at structure approaches as shown on the drawings.

Joints with Joint Sealant

At expansion joints in concrete slabs to be exposed, and at other joints indicated to receive joint sealant, pre-molded expansion-joint filler strips shall be installed at the proper level below the elevation with a slightly tapered, dressed-and-oiled wood strip temporarily secured to the top thereof to form a groove, which when surface dry, shall be cleaned of foreign matter, loose particles, and concrete protrusions, then filled approximately flush with joint sealant so as to be slightly concave after drying.

Jointing materials shall be as specified in Sub-section 3.2.2.8.

Finish of concrete at joints

Edges of exposed concrete slabs along expansion joints shall be neatly finished with a slightly rounded edging tool.

5.12.3.6 PLACING CONCRETE

The concrete shall be so deposited and spread that segregation will not occur, and a uniform layer of concrete whose thickness is approximately 20 mm greater than that required for the finished pavement. Rakes shall not be used for handling concrete.

In order to prevent the introduction into the concrete of earth and other foreign materials, the men whose duties require them to work in the concrete, shall in general, confine their movements to the area already covered with fresh concrete. Whenever it becomes necessary for these men to step out of the concrete, their footwear shall be washed or otherwise thoroughly cleaned before returning to the concrete. During the operation of striking off the concrete, a uniform ridge of concrete at least 70 mm in depth shall be maintained ahead of the strike-off screed for its entire length. Except when making a construction joint, the finishing machine shall at no time be operated beyond that point where this surplus can be maintained in front of the strike-off screed.

After the first operation of the finishing machine, additional concrete shall be added at all low places and honeycombed spots and the concrete rescreeded. In any rescreeding, a uniform head of concrete shall be maintained ahead of the strike-off for its entire length. Honeycombed spots shall not be eliminated by tamping or grouting.

Workers on the job shall have mobile footbridges at their disposal so that they need not walk on the wet concrete.

In conjunction with the placing and spreading, the concrete shall be thoroughly spaded and vibrated along the forms, bulkheads, and joints.

The internal vibrators shall be pneumatic, gas-driven, or electric type, and shall operate at a frequency of not less than 3,200 pulsations per minute.

Whenever the placing of the concrete is stopped or suspended for any reason, for a period of 30 minutes or longer, a suitable bulkhead shall be placed so as to produce a vertical transverse joint. If an emergency stop occurs within 2.5 meters of a contraction or an expansion joint, the concrete shall be removed back to the joint. When the placing of the concrete is resumed, the bulkhead shall be removed and new concrete placed and vibrated evenly and solidly against the face of previously

deposited concrete. Any concrete in excess of the amount needed to complete a given section, or that has been deposited outside the forms, shall not be used in the work.

The Contractor must provide suitable equipment for protecting the fresh concrete in case of rain, such as screens which will cause the rain water to run off beyond the edges of the paving, rain proof tarpaulins or other methods approved the Engineer. The equipment must be sufficient to shelter from rain an area equal to that paved in two hours of work.

5.12.3.7 FINISHING CONCRETE

The concrete shall be compacted and finished by a mechanical, self-propelled finishing machine of approved type, having two independently operated screeds. If a machine possessing only one screed is adopted, the screed will not be less than 450 mm wide, and shall be equipped with compensating springs to minimize the effect of the momentum of the screed on the side forms. The number of driving wheels, the weight of the machine, and the power of the motor shall be so coordinated as to prevent slippage. The top of the form and the surface of the finishing machine wheels shall be kept free of concrete or dirt.

The machine shall at all times be in first-class mechanical condition, and shall be capable of compacting and finishing the concrete as herein described. Any machine which causes displacement of the side forms from the line or grade to which they have been properly set, or causes undue delay due to mechanical difficulties, shall be removed from the work and replaced by a machine meeting the Specifications.

The finishing machine shall be operated over each section of pavement two or more times and at such intervals as will produce the desired results. Generally, two passes of the finishing machine are considered the maximum desirable.

The concrete shall be vibrated, compacted, and finished by a vibratory finishing machine. The vibratory machine shall meet the requirements for ordinary finishing, and shall be one of the following types:

1. The machine shall have two independently operated screeds, the front screed shall be equipped with vibratory units with a frequency of not less than 3,500 pulsations per minute. There shall be not less than one vibratory unit for each 2.5 meters length, or portion thereof, of vibratory screed surface. The front screed shall be not less than 300 mm wide, and shall be equipped with a "bull nose" front edge built on a radius of not less than 50 mm. This type of vibratory finishing machine shall be operated in such manner that each section

of pavement will receive at least one vibratory pass, but not more than two passes, unless otherwise directed, or;

2. The machine shall be equipped with an independently operate vibratory "pan" (or pans) and two independently operated screeds; the "pan" shall be mounted in a manner that will not permit it to come in contact with the forms, and will permit vibration of the full width of the lane simultaneously. There shall be not less than one vibratory unit for each 2 m length, or portion thereof, of vibrating pan surface. The vibratory units in any individual pan shall be synchronized and have a frequency of not less than 3,500 pulsations per minute. The front screed shall be capable of operating in a position that will strike off the concrete at a sufficient height above the top of the forms to allow for proper compaction with the vibrating pan. This type of vibratory finishing machine shall be operated in such manner that each section of pavement will receive at least on vibratory pass but not more than two passes, unless otherwise directed the Engineer.

After the final pass of the finishing machine, and when the concrete has started to dry, the surface of the pavement shall be finished with an approved longitudinal float. The float may be operated either manually or by mechanical means. The float may be either of wood or metal, shall be straight and smooth and light in weight so as not to displace or sink into the concrete surface.

To be effective, the float shall be at least 300 mm wide and 3 m long. When manually operated, the float shall be moved from edge to edge with a wiping motion and advanced 1 meter or more.

The succeeding trip shall overlap the previous trip. A light smoothing float at least 3 meters long may be used provided approved by the Engineer.

The surface of the pavement shall be tested by the Contractor, before the final belting, with an approved standard straight edge 3 m in length. Irregularities so detected shall be corrected immediately. Special attention must be given to the concrete adjacent to transverse joints to insure that the edges therefore are not above the grade specified, or the adjacent concrete below grade. All depressions or projections discovered shall be corrected before any initial set has developed in the concrete.

After the concrete has been brought to the required grade, contour, and smoothness, it shall be finished by passing over the concrete a drag of one or two burlap cloths, which give the surface the required roughness. The vehicle used to carry these clothes may be independent of the

concrete-laying machine or may be incorporated with it, and may be operated either by hand or mechanically.

Hand finishing will be permitted only on variable width sections of the pavement and other places where the use of the finishing machine would be impracticable. Hand finishing shall be accomplished by means of the hand-operated strike-off template of either steel or steel-shod wood construction.

The striking template shall be operated forward with a combined longitudinal and transverse motion, and shall be so manipulated that neither end will be raised off the side forms. A similar tamper shall be used for tamping the concrete.

As soon as the concrete has attained its initial set, the edges of the pavement, the longitudinal joints, the construction dummy, and expansion joints not sawn shall be carefully finished with an edging tool having a radius of at least 5 millimeters. The tools, the special accessories for cutting impressed joints, and methods of workmanship shall be such as they will produce a joint whose edges are of the same quality of concrete as the other portions of the pavement. Methods and workmanship which make use of excess mortar or grout in this area shall be eliminated. Unnecessary tool marks shall be eliminated during construction, and the edges left smooth and true to line.

5.12.3.8 STRIKING FORMS

Forms shall remain in place at least 12 hours after the concrete has been placed. When working conditions are such that the early strength gain of the concrete is delayed, the forms shall remain in place for a longer period, as directed by the Engineer. Bars or heavy loads shall not be used against the concrete when still in the forms. Any damage to concrete resulting from removal shall be repaired promptly by the Contractor as directed by the Engineer without any additional payment.

5.12.3.9 CURING CONCRETE

Unless otherwise ordered by the Engineer, curing concrete shall be done by the curing compound method in accordance with the curing concrete requirements in Section 3.2.

Curing concrete by the other curing concrete methods shall conform with the curing concrete requirements in Section 3.2.

5.12.3.10 CLEANING AND SEALING JOINTS

After completion of the required curing and before opening of the pavement to traffic, all joints shall be thoroughly cleaned of all concrete aggregate fragments or other material.

After removal of side forms, the ends of transverse expansion joints at the edges of the pavement shall be carefully cleaned of any concrete within the expansion spaces for the entire depth of slab, care being taken not to injure the ends of the joints. Expansion and contraction joints shall then be poured with a hot joint sealer to the depth as indicated on the drawings. Joint sealer shall be poured using approved hand pouring pots, with liquid at a temperature not less than that recommended by the manufacturer.

5.12.3.11 OPENING TO TRAFFIC

The pavement shall be closed to traffic, including the vehicles of the Contractor, for a period of 21 days after the concrete is placed, or longer if, in the opinion of the Engineer, the weather conditions make it necessary to extend this time. The Contractor shall furnish, place and maintain satisfactory barricades and lights as directed, to exclude all traffic from the pavement. Any damage resulting to the pavement due to traffic shall be repaired or replaced at the expense of the Contractor. Paving mixers, mechanical concrete spreaders and finishers and other heavy paving equipment shall not be operated on completed concrete lanes in order to construct alternate lanes until after the regular curing period is completed. Even then, planks shall be laid on the finished pavement or other precautions taken to prevent damage to the concrete slab.

5.12.3.12 PAVEMENT SMOOTHNESS, THICKNESS AND TOLERANCE

The cement concrete pavement shall be laid to the designed level and transverse slope shown on the drawings. The allowable tolerance shall be in accordance with tolerance for cement concrete pavement under Table 5.12.2.

5.12.4 MEASUREMENT AND PAYMENT

1. The quantities of Portland cement concrete pavement to be paid for shall be measured by the area of the top surface, in square meters, calculated from its width and length of the designated thickness as shown on the drawings.
2. No separate measurement shall be made for individual items of Portland cement concrete pavement such as formworks, dowel bars,

joint sealer, joint filler, pavement markings, etc., as such shall be considered incidental to Portland cement concrete paving work described above.

3. The above quantities shall be paid for based on the quantities measured as provided above at the appropriate contract unit price for each of the particular pay items shown in the Bill of Quantities which price and payments shall be full compensation for all the costs of furnishing, placing, compacting and shaping material including all labor, equipment, tools and incidentals necessary to complete the work prescribed in this section.

5.13 BITUMINOUS PRIME AND TACK COAT

5.13.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.13.1.1 DESCRIPTION

This section shall consist of preparing and treating aggregate base course..

5.13.2 MATERIAL REQUIREMENTS

5.13.2.1 BITUMINOUS PRIME COAT AND TACK COAT

Asphaltic materials form prime coat shall be cut back asphalt MC-70 conforming to the requirements of AASHTO M-82.

Asphaltic material for tack coat shall be emulsified asphalt conforming to the requirements of AASHTO M-140.

5.13.3 EXECUTION

5.13.3.1 SURFACE CONDITION

Prime coat and tack coat shall be applied only when the surface to be treated is dry or slightly moist. No application shall be made when the weather is foggy or rainy.

5.13.3.2 EQUIPMENT

The liquid bituminous material shall be sprayed by means of pressure distributor of not less than 1000 liters capacity, mounted on pneumatic tires of such width and number that the load produced on the road surface will not exceed 1 KN (100 kgf) per cm width of tire.

The tank shall have a heating device able to heat a complete charge of bituminous liquid to 180 degrees C. The heating device shall be such that overheating will not occur. The liquid shall be insulated in such a way that the drop in temperature when the tank is filled with bituminous liquid at 180 degrees C and not heated will be less than 2 degrees C per hour.

The distributor shall be able to vary the spray width of the bituminous liquid in maximum steps of 100 mm to a total width of 4 m. The spraying bar shall have nozzles from which the liquid is sprayed fan shaped on the road surface equally distributed over the total spraying width. The distributor shall be designed so that deviation from the prescribed rate of application does not exceed 10% and shall be equipped with a device for hand spraying of the bituminous liquid.

5.13.3.3 APPLICATION OF PRIME COAT AND TACK COAT

Immediately before applying prime coat and tack coat, then full width of surface to be treated shall be swept with a power broom to remove all dirt and other objectionable material. Prime coat materials shall be applied by means of a pressure distributor and at a temperature between 40.5 – 85 degrees C, while tack coat material shall be between 10 – 71 degrees C.

The rate of application for prime coat shall be between 1.0 to 2.0 liter per square meter while for tack coat between 0.2 to 0.7 liter per square meter. The exact rate shall be as specified by the Engineer.

The prime coat shall be left undistributed for a period of at least 24 hours. The primed area shall not be open to traffic until it has penetrated and cured sufficiently so that it will not be picked up by the wheels of passing vehicles. The primed area shall be maintained until the next course is applied. Care shall be taken that the application of bituminous material is not in excess of the specified amount any excess shall be blotted with sand or removed as directed by the Engineer.

Tack coat shall be sprayed only so far in advance on the surface course as will permit it to dry to a “tacky” condition. The Contractor shall maintain the tack coat until the next course has been applied. Any area that has been fouled by traffic or otherwise, shall be cleaned and resprayed at the Contractor’s expense before the next course is applied.

All areas inaccessible to the distributor shall be sprayed manually using the device for hand spraying from the distributor.

Structures and trees adjacent to the area being treated shall be protected in such a way as to prevent their being spattered or marred.

5.13.4 MEASUREMENT AND PAYMENT

Bituminous Prime and Tack Coat shall be measured by the tonne (t). The quality to be paid shall be the number of tonnes of bituminous material applied and accepted in the completed work.

The accepted quantity, measured as prescribed in this Section shall be paid at the contract unit price for Bituminous Prime and Tack Coat which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools and incidentals necessary to complete this item.

5.14 ASPHALT CONCRETE PAVEMENT – PLANT MIX

5.14.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.14.1.1 DESCRIPTION

This Section consists of a surface course composed of minerals aggregate and bituminous material, mixed in a central mixing plant and placed on a prepared base in accordance with these Specifications and shall conform to dimensions and in conformity with the lines, grades, thickness and typical roadway cross section shown on the Plans or as approved by the Engineer.

5.14.1.2 GENERAL REQUIREMENTS

When shown on the Plans or when specified, the surface course shall be constructed in two or more layers.

Each layer shall be constructed to the required thickness, typical roadway section, elevations and shall be rolled, finished and approved by the Engineer before placement of any subsequent layer.

5.14.2 MATERIAL REQUIREMENTS

5.14.2.1 AGGREGATES

Coarse and fine aggregates shall be clean, hard, tough, sound particles free from decomposed material, vegetable matter and other deleterious substances.

Coarse aggregates, which is material retained on the No. 4 sieve, shall consist of crushed rock, crushed gravel or a mixture of natural and crushed gravel. Not less than 50 percent by weight of the coarse aggregates shall have least one fractured face.

Fine aggregates, which is material passing the No. 4 sieve, shall consist of gravel, sand, stone screenings or a mixture thereof. Not less than 50 percent by weight of the fine aggregates shall be crushed particles.

The combined aggregate shall conform to the grading shown in the following table:

Table 5.14.1 Grading of Combined Aggregate

U.S. Standard Sieve mm4		Percent Passing	
		Binder Course	Surface Course
25	(1 inch)	100	-
19	(3/4 inch)	95 – 100	100
12.5	(1/2 inch)	68 – 86	95 – 100
9.5	(3/8 inch)	56 – 78	74 – 92
4.75	(No. 4)	38 – 60	48 – 70
2.36	(No. 8)	27 – 47	33 – 53
1.18	(No. 16)	18 – 37	22 - 40
0.600	(No. 30)	13 – 28	15 – 30
0.300	(No. 50)	9 – 20	10 – 20
0.075	(No. 200)	4 – 8	4 – 9

When the combined grading of the coarse and fine aggregates is deficient in material passing the No. 200 sieve, additional filler material shall be added. The filler material shall consist of finely divided rock dust, hydrated lime, hydraulic cement or other suitable mineral material and shall conform to the following gradation:

U.S. Standard Sieve	Percent Passing By Weight
No. 30	100
No. 50	95 – 100
No. 200	70 – 100

The coarse and fine aggregates shall meet the following requirements:

1. The percentage of wear by the Los Angeles Abrasion test American Association of State Highway and Transportation Official T 96 (AASHTO T 96) shall not be more than 40.
2. The loss when subjected to five cycles of the Sodium Sulfate Soundness test (AASHTO T 104) shall be less than 12.
3. The Sand Equivalent (ASSHTO T 176) determined after all processing except for addition of asphalt cement shall not be less than 35.
4. All aggregates shall have a liquid limit of not more than 25 and a Plasticity Index of not more than 6 as determined by AASHTO T 89 and T 90, respectively.

5. The amount of thin and elongated pieces (pieces with thickness less than $\frac{1}{5}$ of the length), by weight shall be less than 5 percent.

5.14.2.2 ASPHALT MATERIAL

Asphalt binder to be mixed with the aggregate shall be paving asphalt penetrations grade 85-100 as shown in the Bill of Quantities and shall meet the requirements of AASHTO M 226, Penetration Graded Asphalt Cement.

5.14.3 EXECUTION

5.14.3.1 PRIOR WORK

Asphalt concrete shall be laid after the application and curing of prime coat and acceptance of the Engineer of the primed area.

5.14.3.2 EQUIPMENT

The equipment shall be either a batch plant or continuous mix plant of adequate capacity, coordinated and operated to produce a mixture within the limits of these Specifications.

1. ASPHALT CONCRETE

Satisfactory means either by weighing, metering, or volumetric measurement, shall be provided to obtain the proper amount of ingredients of asphalt concrete, and all measuring devices shall be sensitive to a two percent tolerance of the amount required. Means shall be provided for checking the quantity or rate of flow of asphalt concrete ingredients into the mixer. Suitable means shall also be provided, either by steam jacketing or other insulation, for maintaining the specified temperature of the asphalt concrete.

2. CONTROL OF MIXING TIME

The plant shall be equipped with positive means to govern the time of mixing to the satisfaction of the Engineer.

The time of mixing shall be considered as the interval between the time the asphalt is spread on the aggregate and the time the same aggregate is discharged from the mixer.

5.14.3.3 PREPARATION OF AGGREGATES

Before being fed to dryer, aggregates shall be separated into two or more sizes and stored separately. One storage unit shall contain aggregate of such size that 80 percent will pass Sieve No. 4 and the other unit shall contain aggregate of such size that 80 percent will be retained on Sieve No. 4.

Should the Contractor choose to use natural fine material, a separate storage unit for such material shall be provided in addition to the two units mentioned above in this paragraph. If filler is used as a separate component, it shall also be stored and measured separately and accurately before being fed into the mixer.

In placing the materials in storage or in moving them from storage to the mixer, any method which causes segregation or uncontrolled combination of materials of different grading shall be discontinued and the segregated or degraded materials shall be rescreened, or wasted, and, if necessary, passed through the dryer before being mixed.

Fine and coarse aggregates shall be fed into the dryer at a uniform rate and the rate of feed shall be maintained within 10 percent of the amount set. Coarse and fine aggregates shall be dried and heated so that when delivered to the mixer they shall be at a temperature 25 degrees C above the temperature of the asphalt being used, or as directed by the Engineer.

5.14.3.4 JOB MIX FORMULA

The Engineer shall determine together with the Contractor a Job Mix Formula for the asphalt concrete mixture, establish among other things on basis of Marshall Tests made with specified aggregates and asphalt to be used. Modifications of the mix must only be made with the approval of the Engineer.

5.14.3.5 PREPARATION AND COMPOSITION OF THE MIXTURE

The components shall be combined so as to produce a mixture conforming to the following composition by weight:

	<u>Percentage</u>
Total aggregate (including filler)	96-94
Asphalt	4-6

The exact percentage of asphalt in the mix shall be based on the Job Mix Formula.

5.14.3.6 SPREADING AND COMPACTING

All mixture shall be spread at a temperature of not less than 107 degrees C and all initial rolling shall be done immediately after spreading. The mixture shall not be placed on any wet surface or when weather conditions will otherwise prevent its proper handling and finishing.

Asphalt pavers shall be self-propelled mechanical spreading and finishing equipment, provided with a screed or strike-off assembly capable of distributing the material to not less than the full width of a traffic lane.

Screed action shall include any cutting, crowning or other practical action which is effective on the mixture without practical action which is effective on the mixture without tearing, shoving or gouging, and which produces a surface texture of uniform appearance. The screed shall be adjustable to the required section and thickness. The paver shall be provided with either a full width roller or tamper or other suitable compacting devices. Pavers that leave ridges, indentations or other marks in the surface that cannot be eliminated by rolling or prevented by adjustment in operation shall not be used.

Where a course previously laid is joined to a course to be laid later, the first course shall be cut back and painted with asphalt as directed by the Engineer.

The mix shall be compacted immediately after placing. Initial rolling with a tandem steel roller or a three-wheeled steel roller shall follow the paver as closely as possible. Immediately following the sealing of the longitudinal joints, rolling shall commence at the outside edges and progress towards the centerline. Intermediate rolling with a pneumatic tired roller shall be done immediately behind the initial rolling. Final rolling shall eliminate marks from previous rolling. In areas too small for the roller, a vibrating plate compactor or hand tamper shall be used to achieve thorough compaction.

Rolling shall continue as long as required to attain a minimum compaction of 97 percent of the Marshall density of the approved Job Mix.

5.14.3.7 REQUIREMENTS FOR THE MIXTURE

When tested according to the Marshall Method, the bituminous mixture shall conform to the following requirements:

a) Stability, Kg.	550 min.
b) Flow, 2.5 mm, percent	8-16
c) Voids in total mix, percent	5-7
d) Aggregates voids filled with Asphalt cement, percent	70-80

The mixture shall have a minimum dry compressive strength of 1.4 MPa (200 psi.).

The loss in Marshall stability by submerging specimens in water at 60 degrees C for 24 hours as compared to the stability measured after submerging in water at 60 degrees C for 20 minutes shall be 25 percent maximum.

The density in place shall be tested by cores taken from the various courses. The cores will be used to test the density by either ASTM Method of Test D 1188, "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens", or ASTM Method of Test D 2726, "Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface Dry Specimen", whichever is applicable.

5.14.3.8 TOLERANCE

Asphalt pavement shall be laid and compacted to the designated level and traverse slope as shown on the Drawings. The allowable tolerance shall be as specified below:

a. Permitted variation from design Thickness of layer	±	5 mm
b. Permitted variation from design Level of layer	±	5 mm
c. Permitted surface irregularity Measured by 3-M straight -edge	±	6 mm
d. Permitted variation from design Crossfall or Camber	±	0.2%

5.14.4 MEASUREMENT AND PAYMENT

Asphalt concrete pavement to be paid for shall be measured by the number of square meters place in accordance with the contract and accepted in completed work by the Engineer.

5.15 CONCRETE WALK

5.15.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.15.1.1 DESCRIPTION

This section shall consist of the construction of Portland Cement Concrete Walk with Concrete Block in accordance with this specification and to the lines, grades, levels and dimensions shown on plans, or as required by the Engineer.

5.15.2 MATERIAL REQUIREMENTS

5.15.2.1 PORTLAND CEMENT CONCRETE

The concrete walk inclusive of concrete block (0.2 m x 0.4 m) shall be Class C concrete. The concrete shall satisfy the following requirements:

- a. Concrete materials shall conform with the requirements of Section 3.2, "Concrete Works."
- b. Maximum 28th day compressive strength shall be 21 MPa (3,000 psi).
- c. Maximum aggregate size is 19 mm.
- d. Maximum water cement ratio is 0.52.

5.15.2.2 EXPANSION JOINT FILLER

Unless otherwise specified, the preformed joint filler shall have a thickness as indicated on the drawings and shall conform with the requirements of Section 5.12, "Portland Cement Concrete Pavement."

5.15.2.3 FORMS

Forms shall be of wood or metal approved by the Engineer and shall extend to the full depth of the concrete. All forms shall be straight, free from warps and of adequate strength to resist distortion.

5.15.2.4 BED COURSE MATERIAL

Bed course material shall be crushed aggregate conforming to the requirement in Section 5.9, "Crushed Aggregate Base Course."

5.15.3 EXECUTION

Excavation shall be made to the required depth and to a width that will permit the installation and bracing of the forms. The foundation shall be shaped and compacted to a firm even surface conforming to the section shown on the Drawings. All material from soft areas shall be removed and replaced with suitable material.

The bed course material shall be compacted in layers not exceeding 100 mm, to the depth, line and levels shown on the drawings.

All forms shall be staked securely in position at the correct line and level. Preformed joint filler shall be set in the position shown on the drawings before the placing of the concrete is started.

The mixing, placing, finishing, and curing of concrete shall be as specified in Section 3.2, "Concrete Works." The concrete shall be placed to the total depth shown on the drawings.

The surface shall be cut through to a depth of 25 mm with a trowel at intervals of 3 m, or where required, in straight lines perpendicular to the edge of the concrete walk. Expansion joints shall be provided not more than 15 m of the length of the concrete walk.

The surface shall then be brushed. The edges of the concrete walk and the transverse cuts shall be shaped with a suitable tool so formed as to round the edges as shown on the drawings.

5.15.4 MEASUREMENT AND PAYMENT

1. The quantity of Portland cement concrete walk to be paid for shall be the volume in cubic meters of concrete inclusive of concrete block as shown on the drawings complete in place and accepted by the Engineer.
2. The quantity of base course to be paid for shall be the volume in cubic meters of bed course materials as shown on the drawings complete in place, compacted, and accepted by the Engineer.

5.16 CURB

5.16.1 GENERAL

Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.16.1.1 DESCRIPTION

This Section shall consists of construction of curb in accordance with these specifications and in conformity with the lines and grades shown or established by the Engineer.

5.16.2 MATERIAL REQUIREMENTS

5.16.2.1 CLASS OF CONCRETE

The concrete for the curb shall be grade B2. The concrete shall satisfy the following requirements.

Concrete material shall conform with the requirements of Section 3.2, "Concrete Works."

Minimum 28 day compressive strength shall be [25] Mpa ([3,500] psi).

Maximum aggregate size 19 mm.

Maximum Water-cement Ratio 0.52.

5.16.2.2 MORTAR BASE

Cement mortar shall be composed of one part Portland cement and three parts fine aggregate by volume and sufficient water to make the mortar of such consistency that can be handled easily and spread with a trowel.

5.16.2.3 BASE COURSE

Base course material shall be crushed aggregate conforming to the requirements in Section 5.9, "Crushed Aggregate Base Course."

5.16.2.4 JOINT FILLER

Expansion joint filler shall be preformed conforming to the requirements of AASHTO M 153 or M 173.

5.16.3 EXECUTION

Excavation shall be made to the required depth and the base upon which the curb is to be set shall be compacted to a firm, even surface. All material from soft areas shall be removed as directed and replaced with suitable material.

A layer of crushed aggregate as shown on the drawings shall be placed to form a bed for the curb.

Forms to hold the concrete shall be built and set in place as described in Section 3.2, "Concrete Works." Forms for at least 50 m of curb shall be in place and checked for alignment and grade before concrete is placed. Curbs constructed on curves shall have forms of either wood or metal and they shall be accurately shaped to the curvature shown on the drawings. Mixing, placing, and curing of concrete shall be as described in Section 3.2 and in accordance with the requirements given below.

The top of the curb shall be floated smooth and the edges rounded to the radii shown on the drawings. In finishing concrete, only the mortar normally present in the concrete shall be permitted for finishing. The use of a separate mortar finishing coat or the practice of working dry cement into the surface of the concrete will not be permitted.

The curb shall be constructed in uniform sections of not more than 15 m to 10 m in length except where shorter sections are required to coincide with the location of expansion or contraction joints of the concrete pavement or for closures but no section shall be less than 2 m long. The sections shall be separated by sheet templates set perpendicular to the face and separated by sheet templates set perpendicular to the face and top of the curb. The templates shall be approximately 5 mm in thickness, of the same width as that of the curb and not less than 50 mm greater than the depth of the curb. Templates shall be set carefully and held firmly during the placing of the concrete and shall remain in place until the concrete has set sufficiently to hold its shape, but shall be removed while the forms are still in place. The preformed joint filler may be used in place of the sheet template referred to above, on the approval of the Engineer. In this event the fiber board shall be pre-cut to the shape of the curb so that its outer edge will be flushed with the abutting curb.

Expansion joints shall be formed in the curb at intervals of 15 m to 18 m to coincide with the expansion joints of cement concrete pavements or as shown on the drawings.

Contraction joints will be executed at 3 m intervals.

The forms may be removed within 24 hours after concrete has been placed. Minor defects shall be repaired with cement mortar. Plastering shall not be permitted on the face of a curb and all rejected curbs shall be removed and replaced by the Contractor without additional cost. All surfaces which will be exposed in the finished construction of the curb shall be finished, while the concrete is still "green" by wetting a wood block or float and rubbing the surfaces until they are smooth.

Immediately upon the completion of the rubbing down operation the surface shall be moistened and kept moist for 3 days or cured by other approved method.

After the concrete has set sufficiently so as not to be damaged, spaces at the back of the curb excavated for placing the curb shall be refilled to the required elevation with suitable earth or granular material, which shall be tamped in layers of not more than 150 mm each until firm and solid.

5.16.4 **MEASUREMENT AND PAYMENT**

The curb constructed in the manner and of the materials shown on the drawings shall be measured and paid for by the length of its type of curb along its front face at the finished grade elevation.

No measurement and payment will be made for preformed joint filler. It shall be deemed included in the unit cost of curb.

5.17 SECURITY FENCE AND GATES

5.17.1 GENERAL

Volume I, preceding these Technical Specification and Division 1, "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.17.1.1 DESCRIPTION

The work consist of furnishing of all labor, materials, equipment and incidentals necessary to construct the security fence and gates as shown on the drawings and shall be in conformity with the requirements of these Specifications and as directed by the Engineer.

5.17.1.2 DETAILED SHOP DRAWINGS

Before materials for the security fence and gates are ordered, the Contractor shall submit to the Engineer for approval complete shop drawings, including details of the security fence and gates.

5.17.2 MATERIAL REQUIREMENTS

5.17.2.1 EARTHWORKS

Base Course shall conform to Section 5.9, "Crushed Aggregate Base Course".

5.17.2.2 CONCRETE WORKS

Concrete hollow blocks shall be 150 mm CHB conforming with the requirements of ASTM C 129 and shall have a minimum compressive strength of 2.4 MPa (350 psi).

Mortar shall be mixed in proportions by volume of one part Portland cement and three parts sand. Mortar materials shall conform with the requirements of CHB under Section 4.4, "Masonry Works".

Concrete for RC footing of fence, gate posts and concrete fill in gate post pipes shall be Class C, with a minimum compressive strength of 21 MPa. Reinforced concrete materials shall conform with the requirements in Section 3.2, "Concrete Works" and as shown on the drawings.

Reinforcing steel shall be intermediate Grade 40, conforming to ASTM A 615.

5.17.2.3 STEEL AND METAL WORKS

All steel fencing materials, except padlocks, shall be hot-dip galvanized/zinc-coated. All pipe materials shall be galvanized iron (G.I.) pipe of the standard weight schedule 40, seamless, conforming to ANSI. Cyclone wire fence fabric shall be 50 mm diamond mesh fabricated from gauge 10 galvanized wire, painted finish.

Castors, stay bolts and other accessories shall be as shown on the drawings or as directed by the Engineer.

Padlocks shall be fully weatherproof, pin tumbler, with solid extruded bronze case or its equivalent as approved.

Steel gates material shall be as shown on the drawing and conform to the requirements of Section 3.15, "Steel and Metal Works."

5.17.3 EXECUTION

5.17.3.1 PREPARATION

The existing ground surface along the fence alignment and gates shall be cleared of all obstruction, leveled and compacted. All obstruction that may render the security fence ineffective shall be removed.

5.17.3.2 ERECTION OF FENCE

Concrete shall be prepared and cast in accordance with Section 3.2, "Concrete Works". Concrete hollow blocks shall be set plumb and true to the required height as shown on the drawings.

Excavation shall be in accordance with Section 4.2 "Excavation and Backfill for Buildings".

Leveling base course shall be placed and compacted in accordance to Section 4.2, "Excavation and Backfill for Buildings."

GI pipe and cyclone wires shall be set in reinforced concrete foundations and spaced as shown on the drawings.

5.17.3.3 INSTALLATION OF GATES

Gate frame and gate shall be plumb and square and shall swing freely to touch without galling and windling. Surface damage due to erection and fabrication shall be primed with zinc-chromite primer and two coats of touch-up paint.

5.17.3.4 REPAIR AND CLEANING

Damaged galvanized surface shall be repaired as follows:

1. Damaged surfaces shall be cleaned with steel brush removing loosened and cracked spelter coatings and two coats of approved zinc pigment paint shall be applied on damaged areas.
2. Areas disturbed by the operations shall be cleaned and trimmed.

5.17.4 MEASUREMENT AND PAYMENT

The quantity of security fence shall be measured by the length in linear meters of fence inclusive of earthworks and the details indicated on the drawings. It shall also include all accessories installed complete and accepted by the Engineer.

The quantity of gate shall be measured and paid for by the number of set of each type of gate, furnished installed and accepted by the Engineer.

5.18 GROUTED RIPRAP

5.18.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.18.1.1 DESCRIPTION

This section shall consist of the furnishing and placing of grouted riprap, furnished and constructed in accordance with these Specifications and to the lines and grades and dimensions shown on the drawings.

5.18.2 MATERIAL REQUIREMENTS

5.18.2.1 STONES

Stones for riprap shall consist of rock as nearly rectangular in section as is practical. The stones shall be sound, tough, durable, dense, resistant to the action of air and water, and suitable in all respects for the purpose intended.

Unless otherwise indicated on the drawings, stone for riprap shall have a minimum weight of 15 kg to a maximum of 25 kg with at least 50 percent of the stones weighing more than 20 kg.

5.18.2.2 MORTAR

Mortar for grouted riprap shall consist of sand, cement and water conforming to the requirements given under Section 3.2, "Concrete Works," mixed in the proportion of one part cement to three parts sand by volume, and sufficient water to obtain the required consistency.

5.18.3 EXECUTION

5.18.3.1 EXCAVATION

The bed for riprap shall be excavated to the required depths and properly compacted, trimmed and shaped.

The riprap shall be founded in a toe trench dug below the depth of scour as shown on the drawings or as ordered by the Engineer. The toe trench shall be filled with the same size of required stones unless otherwise specified.

5.18.3.2 PLACING

Stones placed below the water line shall be distributed so that the minimum thickness of the riprap is not less than that specified.

Stones above the water line shall be placed by hand or individually by machines. They shall be laid with close, broken joints and shall be firmly bedded into the slope and against the adjoining stones. Each stone shall be laid with its longest axis perpendicular to the slope in close contact with each adjacent stone. The riprap shall be thoroughly rammed into place as construction progresses and the finished surface shall present an even, tight surface. Interstices between stones shall be filled with small broken fragments firmly rammed into place.

Unless otherwise provided on the drawings, riprap shall have a minimum thickness of 300 mm measured perpendicular to the slope.

The surface of riprap shall not vary from the theoretical surface by more than 100 mm at any point.

5.18.3.3 GROUTING

Stones shall be placed by hand or individually by machine as specified for riprap placed above the water line. The spaces between the stones shall then be filled with cement mortar throughout the thickness of the riprap as specified in Sub-section 15.18.2.2, "Mortar." Sufficient mortar shall be used to completely fill all voids, except that the face surface of the stones shall be left exposed.

Grout shall be placed from bottom to top of the surface swept with a stiff broom. After grouting is completed, the surface shall be cured as specified in Section 3.2, "Concrete Works," for a period of at least three (3) days.

5.18.4 MEASUREMENT AND PAYMENT

The quantities to be measured for payment shall be the number of cubic meters of grouted riprap, including stones placed in the toe trench laid in position and accepted.

The computation of the quantities will be based on the volume within the limiting dimensions designated on the drawings or as determined by the Engineer.

The quantities measured as provided above shall be paid for at the contract unit price, and shown in the Bid of Quantities, which price and payment shall be full compensation for excavation and preparation of

the bed, for furnishing and placing all materials including backfill, and all labor, equipment, tools and incidentals necessary to complete the items.

5.19 PAVEMENT MARKINGS

5.19.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.19.1.1 DESCRIPTION

The Section shall consist of placing markings on the finished pavement. The work shall include the furnishing of non – reflective pavement marking paint, whichever is called for in the Contract, sampling and packing, preparing the surface, and applying the paint to the pavement surface, all in accordance with this Specification.

The paint shall be applied to the size, shape and location of the markings shown on the Plans, or as required by the Engineer.

5.19.2 MATERIAL REQUIREMENTS

5.19.2.1 PAINT

Paint shall be mixed at the factory, ready for application without the necessity of using thinners and shall be of a smooth uniform quality. It shall be mill-ground and shall conform to the composition given in Table 5.19.1.

Table 5.19.1
Composition of Pavement Marking Paint

Composition of Solvent			
Material		Composition by Volume	
Raw Tung Oil		15%	
Normal Butyl Alcohol		17%	
Acetone cp (dimethyl Ketone)		34%	
Denatured Alcohol (Formula No. 1)		34%	
The alcohol and acetone shall first be mixed then the oil added to form a clear solution at 21° C			
Composition of Pigment			
Material	Color	White	Yellow
Titanium dioxide (anatase) ASTM D 476		100	
Medium chrome yellow		-	66%
Para toner (light) CP		-	Note 1
Extender		-	34%
Pigment		42-45%	23%
Vehicle		58-55%	77%

Notes:

1. Para toner to standard shade.
2. One part by volume amyl acetate shall be added to 100 parts pints,
3. Sufficient prussian blue shall be added to the tung oil for the white paint to overcome its yellowish tint.

The volatile material shall be of a character that has a minimum solvent action on asphalt and be such that the gums and non-volatile components will entirely dissolve in the volatile material and will not precipitate from the solution. The non-volatile material shall be of such quality that it will not darken or become yellow when a thin section is exposed to sunlight.

Other pavement marking paints may be submitted by the Contractor as an alternative to the above, for the Engineer's approval.

5.19.2.2 BALLOTINI FOR REFLECTIVE ROAD PAINT

Ballotini shall consist of beads of good quality, optically clear, lead-free glass with not less than 90% reasonably spherical and free from flaws. The beads shall contain not more than one percent of sharp angular particles and not more than one half percent of foreign matter and shall be free from flowing under normal atmospheric conditions.

The grading of the ballotini shall be as follows:

mm	US Standard Sieve Alternative	Percentage Passing By Weight
1.18	No. 16	100
0.850	No. 20	65-75
0.600	No. 30	45-55
0.300	No. 50	15-25
0.180	No. 80	0

5.19.3 EXECUTION

The painting of lane markers and traffic strips shall include the cleaning of the pavement surfaces, the application, protection and drying of the paint coatings, the protection of pedestrians, vehicular or other traffic, the protection of all parts of the road structure and its appurtenances against disfigurement by spatters, splashes or smirches of paints or of paint materials, and the supplying of all tools, labor and traffic pain necessary for the entire work.

The paint shall not be applied during rain or wet weather or when the air is misty, or when in the opinion of the Engineer, conditions are unfavorable for the work. Paint shall not applied upon damp pavement surfaces, or upon pavement which has absorbed hear sufficient to cause the paint to blister and produce a porous film of paint.

The application of paint shall preferably be carried out by a machine specially made for this purpose but where brushes are used, only round or oval brushes not exceeding 100 mm in width will be permitted. The paint shall be so applied as to produce a uniform, even coating in close contact with the surface being painted.

Traffic paint shall be applied to the pavement at the rate of 0.33L/m² and shall dry sufficiently to be free from cracking in from 15 to 30 minutes.

5.19.4 MEASUREMENT AND PAYMENT

1. The quantity of pavement markings to be paid for shall either be the length as shown on the Plans of painted traffic line of the stated width or the area as shown on the plans of symbols, lettering, hatchings, and the like, completed and accepted. Separate items shall be provided for premixed reflectorized traffic paint and reflectorized thermoplastic pavement markings.
2. The quantities measured as determined in item 1 above shall be paid for at the appropriate contract unit price for the Pay Items shown in

the Bid Schedule which price and payment shall constitute full compensation for furnishing and placing all materials, sampling and packing, for the preparation of the surface, and for all labor, equipment, tools and incidentals necessary to complete the item.

5.20 ROAD SIGN

5.20.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.20.1.1 DESCRIPTION

This Section shall consist of furnishing and installing road signs in accordance with this Specification and to the details shown on the Plans, or as required by the Engineer.

The road signs shall comply in all respects with the "Philippine International Road Signs Manual" published by the Department of Public Works and Highways, Manila. The categories of road signs are designated in the Manual, namely, danger warnings signs, regulatory signs and informatory signs, respectively.

Road signs shall be classified as standard or non-standard. Standard signs consist of all warning signs, regulatory signs and informatory signs with the exception of direction signs, place identification signs and the like. Non-standard signs consist of all informatory signs which are not classified as standard signs.

The size of warning and regulatory signs is the length of the side of triangular signs (measured from the points of inter-section of the extension of the edges), the horizontal width of octagonal signs and the diameter of circular signs.

5.20.2 MATERIAL REQUIREMENTS

5.20.2.1 SIGN PANELS

Sign panels for warning, regulatory and informatory signs shall be manufactured from aluminum sheeting at least 3 mm thick.

5.20.2.2 REFLECTIVE SHEETING

The reflective sheeting used on the road signs shall consist of spherical lens elements embedded within a transparent plastic having a smooth, flat surface with a protected precoat adhesive which shall be pressure sensitive for manual application, or tack free heat activated for mechanical vacuum-heat application.

The minimum reflective brightness values of the reflective sheeting as compared to magnesium oxide (MgO) shall be as given in Table 5.20.1. The brightness of the reflective sheeting totally wet by rain, shall not less than 90% of the given values.

Table 5.20.1
Reflective Brightness of Traffic Signs Surfaces

Color	Angle of Incidence	Angle of Divergence	Minimum Reflective Brightness Value Compared with MgO
Red	-4 deg	0.5 deg	15
	20 deg	0.5 deg	10
	50 deg	0.5 deg	3
White	-4 deg	0.5 deg	75
	20 deg	0.5 deg	70
	50 deg	0.5 deg	70
Yellow	-4 deg	0.5 deg	35
	20 deg	0.5 deg	35
	50 deg	0.5 deg	10
Blue	-4 deg	0.5 deg	6
	20 deg	0.5 deg	4.5
	50 deg	0.5 deg	0.5

The reflective sheeting shall be sufficiently flexible to permit application and adhesion to a moderately embossed surface. It shall show no damage when bent 90deg over 50 mm diameter mandreal.

The sheeting shall be solvent-resistant so as to be capable of withstanding cleaning with petrol, diesel fuel, mineral spirits, and turpentine methanol.

The adhesive shall permit the reflective sheeting to adhere accurately 48 hours after application at temperatures of up to 90deg C.

The reflective material shall be weather-resistant and, following cleaning in accordance with manufacturer's recommendations, shall show no discoloration, cracking, blistering, peeling or any dimensional change.

Samples of reflective sheeting shall be submitted to the Engineer for approval.

5.20.2.3 POSTS AND FRAMES

Wide flange posts and frames shall be fabricated from structural steel conforming to ASTM A 283 Grade D. In lieu of wide flange steel posts, the Contractor may use tubular steel posts conforming to ASTM A 501. All posts shall be thoroughly cleaned, free from grease, scale and rust and shall be given one coat of rust-inhibiting priming paint and two coats of gray paint.

5.20.2.4 NUTS AND BOLTS

Nuts, bolts, washers and other metal parts shall be hot-dip galvanized after fabrication in accordance with the requirements of AASHTO M 111.

5.20.3 EXECUTION

5.20.3.1 EXCAVATION AND BACKFILLING

Holes shall be excavated to the required depth to the bottom of the concrete foundation as shown on the Plans.

Backfilling shall be carried out by using suitable material approved by the Engineer and shall be compacted in layers not exceeding 150 mm in depth. Surplus excavated material shall be disposed by the Contractor as directed by the Engineer.

5.20.3.2 ERECTION OF POSTS

The posts shall be erected vertically in position inside the formwork of the foundation block prior to the placing of the concrete and shall be adequately supported by bracing to prevent movement of the post during the placing and setting of concrete. The posts shall be located at the positions shown on the Plans.

5.20.3.3 SIGN PANEL INSTALLATION

Sign panels shall be installed in accordance with the details shown on the Plans. Any chipping or bending of the sign panels shall be considered as sufficient cause to require replacement of the panels at the Contractor's expense.

The exposed portion of the fastening hardware on the face of the signs shall be painted with enamels matching the background color.

All newly erected traffic road signs shall be covered until ordered removed by the Engineer.

5.20.4 MEASUREMENT AND PAYMENT

1. The quantities of standard reflective warning and regulatory road signs shall be the number of such signs of the size specified, including the necessary posts and supports erected and accepted.
2. The quantities measured as determined in item 1 above shall be paid for at the contract unit price for the Pay Items shown in the Bid Schedule which price and payment shall be full compensation for furnishing and installing road signs, for excavation, backfilling and construction of foundation blocks, and all labor, equipment, tools and incidentals necessary to complete the Item.

5.21 LANDSCAPING

5.21.1 GENERAL

Division 1 "General Requirements" contain provisions and requirements essential to these specifications; and apply to this Section, whether or not referred to herein.

5.21.1.1 DESCRIPTION

The work shall consist of furnishing, placing and compacting topsoil, laying grass sods and planting of shrub in accordance with the Specifications where shown on the Drawings, or ordered by the Engineer.

5.21.2 MATERIAL REQUIREMENTS

5.21.2.1 TOPSOIL

Topsoil furnished by the Contractor shall consist of a natural friable surface soil without mixture of undesirable subsoil, refuse, or foreign materials. It shall be reasonably free from roots, hard clay, coarse gravel, stones larger than 50 mm in diameter, noxious wood, tall grass, brush, sticks, stubble, or other litter and shall be subject to the approval of the Engineer.

5.21.2.2 GRASS SOD

The sod shall consist of a healthy, dense and dwell rooted growth of living grass.

The grass sod shall be cut into uniform squares approximately 300 mm and shall have a minimum thickness of 50 mm (excluding grass blades). Sods shall be subject to the approval of the Engineer.

5.21.2.3 SHRUB

The shrub shall be healthy and well rooted seedling of santan.

5.21.2 EXECUTION

5.21.3.1 TOPSOIL

Topsoil shall be obtained from approved sources. The Contractor shall notify the Engineer at least seven (7) days before he intends to start stripping operations. After inspection and approval by the Engineer and

prior to stripping any topsoil the Contractor shall remove noxious weeds and tall grass, brush, roots and stones larger than 50 mm in diameter.

The topsoil shall be evenly spread on the areas indicated on the Plan to the line and level shown on the Drawings and compacted with a light roller to a depth of not less than 100 mm. Spreading shall not be done when the ground topsoil is excessively wet, or otherwise in a condition detrimental to the work. The roadway surfaces shall be kept clean during hauling and spreading operations.

After spreading has been completed, large clods, stones, roots, stumps and other loose lying material shall be raked up and removed. Any erosion, irregularities of grade or other incidental damage to the surface of topsoil prior to the laying of grass sods shall be repaired to the Engineer's satisfaction.

5.21.3.2 SODDING

The areas to be sodded shall be as shown on the Drawings. The surface of the area to be sodded shall be loosened and brought to a reasonably fine texture to a depth of approximately 20 mm. The bed upon which the sod is to be placed shall be moistened to the loosened depth, if not naturally sufficiently moist, and the sod shall be place thereon within 24 hours after having been cut.

Unless otherwise required, the sod on slopes shall be laid horizontally, beginning at the bottom of the slopes and working upwards, when placing sod scour checks or similar constructions, the length of the strips shall be laid at right angles to the direction of flow of the water.

As the sod is being laid it shall be lightly tamped with suitable wooden tampers, sufficiently to set the sod into the underlying soil.

At points where it is anticipated that water may flow over a sodded area, the highest edge of each sod shall be turned into the soil to be below the adjacent area, and a layer of earth shall be placed over this juncture, and thoroughly compacted. At the limits of sodded area, the end strips shall be turned in and treated similarly.

On all slopes stepper than one vertical to three horizontal the sod shall be pegged with stakes, 200-300 mm in length, spaced as required by the nature of the soil and steepness of slope. Stakes shall be driven into the sod at right angles to the slope until flushed with the bottom of the grass blades.

After the staking has been completed, the surface shall be cleared of loose sod, excess soil, or other foreign material, whereupon a thin layer

of top soil shall be scattered over the sod as top dressing and the areas shall then be thoroughly moistened by sprinkling with water.

The Contractor shall regularly water and maintain sodded areas in satisfactory condition for the duration of the Contract and until final acceptance of the work by the Engineer.

5.21.3.3 SHRUBBING

Shrubs seedling shall be planted in location shown on the Drawing or as directed by the Engineer. Distance between plants shall be 150 mm.

After planting of shrubs, the area planted shall be protected from foot and other traffic by temporary barricade until such time that the plant has already established roots in the surrounding soil.

The Contractor shall likewise water and maintain shrubs for the duration of the Contract and until final acceptance of the work by the Engineer.

5.21.3 MEASUREMENT AND PAYMENT

The work of top soiling, and sodding shall each be measured by the area, in square meters, which has been soiled, planted or placed in accordance with the Specifications and accepted.

Shrub shall not be measured for direct payment, but cost will be deemed included in the unit cost of sodding.

The quantity measured as prescribed above shall be paid for at the contract unit price for the pay items shown in the Bill of Quantities, which payment shall be full compensation for furnishing and placing all materials, for watering and for all labor, equipment, tools and incidentals necessary to complete the item.

The top soil material will not be measured separately and such shall be considered as part and incidental to top soiling sodding cost.