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DIVISION 5
GRANULAR PAVEMENT

SECTION 5.1
AGGREGATE BASE

5.1.1 GENERAL

5.1.1.1 Description

This work shall consist of supplying, processing, hauling, spreading, watering and compacting graded aggregate on a prepared and accepted surface, in accordance with details shown on the Drawings or as directed by the Engineer, and maintaining the finished base as required. Processing shall include, where necessary, crushing, screening, separation, blending, and any other operation necessary to produce a material conforming to the requirements of these Specifications.

5.1.1.2 Related Work Specified Elsewhere

Related work specified elsewhere may include but shall not be limited to the following:

(a)	Traffic Management and Safety	:	Section 1.8
(b)	Field Engineering	:	Section 1.9
(c)	Materials and Storage	:	Section 1.11
(d)	Environmental Safeguards	:	Section 1.17
(e)	Grade Preparation	:	Section 3.3
(f)	Pavement Widening	:	Section 4.1
(g)	Shoulders	:	Section 4.2
(h)	Maintenance of Adjacent Roads and Bridges	:	Section 10.2

5.1.1.3 Dimensional Tolerances

(a) The finished surface levels shall comply with the Drawings, within the following tolerances :

Aggregate Base Material and Layer	Surface Level Tolerances relative to design level
Aggregate Class B used as Sub-base (Top Surface of Sub-base only)	Standard deviation 6 mm
Aggregate Class A Surfaces for Prime Coat or Surface Treatment (Pavement or Shoulder)	Standard deviation 6 mm
Unsealed Aggregate Class S shoulders (Top layer only)	To comply with: Article 4.2.1.3

Note :
Aggregate Class A and B are defined in Article 5.1.2

(b) The surfaces of all construction Aggregate Base layers shall not have any irregularities which can hold moisture and the camber of all such surfaces shall comply with that shown on the Drawings.

(c) The minimum total thickness of Aggregate Base shall not be less than the required thickness less one centimetre.

(d) The minimum total thickness of Aggregate Base Class A shall not be less than the required thickness less one centimetre.

(e) For Aggregate Base Class A surfaces for priming or surface treatment, when all loose material is removed by hard brooming, the maximum permitted deviation in surface smoothness shall be one centimetre from a straight edge 3 m long, laid parallel or transverse to the road centre line.

5.1.1.4 Reference Standards

SNI 03-1967-1990 (AASHTO T 89 - 02)	:	Cara Uji Penentuan Batas Cair untuk Tanah.
SNI 03-1966-1990 (AASHTO T 90 - 00 (2004))	:	Cara Uji Penentuan Batas Plastis dan Indeks Plastisitas Tanah.
SNI 03-2417-1991 (AASHTO T 96 - 02 (2006))	:	Cara Uji Keausan Agregat dengan Mesin Abrasi Los Angeles.
SNI 03-4141-96 (AASHTO T112 - 00 (2004))	:	Metode Pengujian Gumpalan Lempung dan Butir-butir Mudah Pecah dalam Agregat.
SNI 03-1743-1989 (AASHTO T180 - 01 (2004))	:	Cara Uji Kepadatan Berat untuk Tanah.
SNI 03-2828-1992 (AASHTO T191 - 02 (2006))	:	Metode Pengujian Kepadatan Lapangan dengan Alat Konus Pasir
SNI 03-1744-1989 (AASHTO T193 - 99 (2003))	:	Metode Pengujian CBR Laboratorium.

5.1.1.5 Submittals

(a) The Contractor shall submit the following to the Engineer at least 21 days prior to the proposed date of first using any material proposed for use as Aggregate Base:

(i) Two samples of 50 kg weight each of the material, one of which shall be retained by the Engineer for reference throughout the Time for Completion.

(ii) A statement of the source and composition of any material proposed for use as Aggregate Base, together with laboratory test data verifying that the material properties specified in Article 5.1.2.5 are met.

(b) The Contractor shall submit the following in written form to the Engineer immediately following completion of each section of the work and before any approval may be granted for the placing of other materials on top of the Aggregate Base:

(i) The results of particle grading test and plasticity index test as specified in Article 5.1.3.4.

(ii) The results of surface measurement tests and survey data verifying that the surface and thickness tolerances specified in Article 5.1.1.3 are met.

5.1.1.6 Weather Limitation

Aggregate Base shall not be placed, spread or compacted while rain is falling, and no compaction shall be carried out immediately after rain or otherwise when the moisture content of the material falls outside the range specified in Article 5.1.3.3.

5.1.1.7 Rectification of Unsatisfactory Aggregate Base

(a) Areas with a thickness or surface uniformity not satisfying the tolerances specified in Article 5.1.1.3, or which develop irregularities in the surface during or after construction, shall be rectified by loosening the surface and removing or adding materials as required, followed by reshaping and re-compacting.

(b) Aggregate Base which is too dry for compaction, in terms of the moisture content limits specified in Article 5.1.3.3 or as directed by the Engineer, shall be corrected by scarifying the material followed by sprinkling with an adequate quantity of water and thoroughly mixing.

(c) Aggregate Base which is too wet for compaction, as defined by the moisture content limits specified in Article 5.1.3.3 or as directed by the Engineer, shall be rectified by scarifying the material followed by intermittent working by approved equipment with rest periods between working under dry weather conditions. Alternatively, or if sufficient drying cannot be achieved by working and resting the loose material, the Engineer may direct that the material be removed from the work and replaced with suitable dry material.

(d) Rectification of Aggregate Base which does not meet the density or material property requirements of this specification shall be made under the direction of the Engineer and may include additional compaction, loosening followed by moisture content adjustment and re-compaction, removal and replacement of the material, or the use of an additional thickness of material.

5.1.1.8 Restitution of the Work Following Testing

All holes in the finished Work made by density testing or otherwise shall be backfilled with Aggregate Base material by the Contractor without delay, following inspection by the Engineer, and compacted to the density and surface tolerance requirements of this Specification.

5.1.2 MATERIALS

5.1.2.1 Material Sources

Aggregate Base material shall be selected from an approved source in accordance with these Specifications.

5.1.2.2 Aggregate Base Classes

The three different qualities of base course are specified as Class A, Class B and Class S. Generally, Aggregate Base Class A is base course quality for use in the layers immediately below a bituminous surfacing, while Aggregate Base Class B is for sub-base layers. Class S Aggregate Base shall be used for unsealed shoulders in accordance with the additional requirements of Section 4.2 of this Specification.

5.1.2.3 Coarse Aggregate Fraction

The coarse aggregate retained on the 4.75 mm sieve shall consist of hard, durable particles or fragments of rock and gravel. Material which breaks up when alternately wetted and dried shall not be used.

When produced from gravel, not less than 100 % by weight of the coarse aggregate shall be particles having at least one fractured face for **Aggregate Base Class A** and not less than 60 % by weight of the coarse aggregate shall be particles having at least one fractured face for **Aggregate Class B.**

5.1.2.4 Fine Aggregate Fraction

Fine aggregate passing the 4.75 mm sieve shall consist of natural or crushed sand and fine mineral particles. The fraction passing the No.200 sieve shall not be more than two-thirds the fraction passing the No.40 sieve.

5.1.2.5 Required Material Properties

All Aggregate Base shall be free from organic matter and lumps of clay or other deleterious matter and after compaction shall conform to the grading requirements given in Table 5.1.2.1 after compaction (using wet sieve testing) and to the properties given in Table 5.1.2.2.

Table 5.1.2.1 Aggregate Base Grading

Sieve Size		Percent Passing by Weight		
ASTM	(mm)	Class S	Class A	Class B
2”	50			100
1 ½”	37.5	100	100	88 – 95
1“	25.0	89 – 100	79 – 85	70 – 85
3/8”	9.5	55 – 90	44 – 58	30 – 65
No.4	4.75	40 – 75	29 – 44	25 – 55
No.10	2.0	26 – 59	17 – 30	15 – 40
No.40	0.425	12 – 33	7 – 17	8 – 20
No.200	0.075	4 – 22	2 – 8	2 – 8

Table 5.1.2.2 Aggregate Base Properties

PROPERTY	Class S	CLASS A	CLASS B
Abrasion of Coarse Aggregate (SNI 03-2417-1990)	0 - 40%	0 - 40 %	0 - 40 %
Plasticity Index (SNI 03-1966-1990)	4 - 15	0 - 6	0 - 10
Product Plasticity Index times Percentage Passing # 200	-	Max. 25	-
Liquid Limit (SNI 03-1967-1990)	0 - 35	0 - 25	0 - 35
Soft Fragments (SNI 03-4141-1996)	0 - 5%	0 - 5 %	0 - 5 %
CBR (SNI 03-1744-1989)	Min 50%	min.90 %	min.60 %

5.1.2.6 Blending of Aggregate Base Material

Blending of materials to meet the specified requirements shall be carried out in an approved crushing or blending plant, using suitable calibrated mechanical feeders providing a continuous flow of mix components in the correct proportions. Under no circumstances shall site mixing be used.

5.1.3 PLACING AND COMPACTING AGGREGATE BASE

5.1.3.1 Preparation of Formation for Base

(a) Where Aggregate Base is to be placed on an existing pavement or shoulder, all defects in the existing pavement or shoulder shall be rectified in accordance with Sections 8.1 and 8.2 of these Specifications.

(b) Where Aggregate Base is to be placed on a previously placed or prepared new subgrade or aggregate base layer, the layer shall be fully completed in accordance with Sections 3.3, 4.1, 4.2 or 5.1 of these Specifications, as appropriate to the location and type of the previous layer.

(c) The area being prepared for laying the Aggregate Base Material, in accordance with clauses (a) and (b) above, shall be completed and the approval of the Engineer obtained for at least 100 m ahead of the placing of the base at all times. For short repair sections less than 100 metres in length, the entire area of formation shall be prepared and approved before placement of the base.

(d) Where Aggregate Base is to be placed directly on an intact existing asphalt surfaced pavement, which in the opinion of the Engineer is still in a good condition, scarification of the asphalt surface pavement shall be needed to obtain improved friction resistance.

5.1.3.2 Spreading

(a) Aggregate Base shall be delivered to the road bed as a uniform mix and shall be spread at a moisture content within the range specified in Article 5.1.3.3. The moisture in the material shall be uniformly distributed throughout.

(b) Each layer shall be spread in one operation at a uniform rate which will produce the required compacted thickness within the specified tolerances. Where more than one layer is to be placed the layers are to be as nearly equal in thickness as possible.

(c) Aggregate Base shall be spread and shaped by any approved method which does not cause segregation of the fine and coarse aggregate particles. Segregated material shall be corrected or removed and replaced with graded material.

(d) The minimum loose layer thickness for any construction layer shall be twice the aggregate base maximum particle size. The maximum loose layer thickness shall not exceed 20 cm, except where otherwise directed by the Engineer.

5.1.3.3 Compacting

(a) Immediately following final mixing and shaping, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the

Engineer to a density of at least 100 % of the maximum modified dry density as determined by SNI 03-1743-1989 Method D.

(b) The Engineer may direct that pneumatic tired rollers be used for the final surface compaction, if static steel wheeled rollers are considered likely to cause excessive breakdown or degradation of the aggregate base.

(c) Compaction shall be carried out only when the moisture content of the material is within the range of 3% less than optimum moisture content to 1% more than optimum moisture content, where the optimum moisture content is defined by the maximum modified dry density determined by SNI 03-1743-1989 Method D.

(d) Rolling operations shall begin along the edges and progress gradually towards the centre, in a longitudinal direction. On super-elevated sections rolling shall begin at the low side and progress towards the high side. The rolling operation shall continue until all roller marks are eliminated and the layer is uniformly compacted.

(e) Material along curbs, walls, and at other places not accessible to the roller shall be compacted using approved mechanical tampers or compactors.

5.1.3.4 Testing

(a) The amount of supporting test data required for initial approval of the quality of the material will be as directed by the Engineer but shall include all the tests specified in Article 5.1.2.5 on at least three representative samples from the proposed material source, selected to represent the range of material quality likely to be obtained from the source.

(b) Following approval of the quality of a proposed Aggregate Base material, the full range of material quality tests performed shall be repeated subsequently, at the discretion of the Engineer, in the event of observed changes in the material or in its source or to its method of production.

(c) A program of routine material quality control testing shall be carried out to control variability of the material being brought on site. The extent of the testing shall be directed by the Engineer but for every 1000 cubic metres of material produced the testing shall include no less than five 5 plasticity index tests, five 5 particle grading tests, and one (1) maximum dry density determined using SNI 03-1743-1989 Method D. CBR tests shall be carried out from time to time as directed by the Engineer.

(d) The density and moisture content of the compacted material shall be routinely determined using SNI 03-2828-1992. The test shall be made to the full depth of the layer at locations directed by the Engineer, but not more than 200 m apart.

5.1.4 MEASUREMENT AND PAYMENT

5.1.4.1 Method of Measurement

(a) Aggregate Base shall be measured as the number of cubic metres of compacted material required, complete in place and accepted. The volumes to be measured shall be based on the cross sections shown on the Drawings where the required thickness is uniform and on the cross sections approved by the Engineer where the required thickness is not uniform, and lengths measured horizontally along the centre line.

(b) The work of preparing and maintaining the new subgrade or existing pavement and shoulders on which the Aggregate Base is to be placed shall not be measured or paid for under this Section, but shall be paid for separately from the applicable pay items for Grade Preparation and Reinstatement of Existing Pavement or Shoulder under Sections 3.3, 8.1 and 8.2 of these Specifications.

5.1.4.2 Measurement of Rectified Work

Where rectification of unsatisfactory Aggregate Base has been directed by the Engineer in accordance with Article 5.1.1.7, the quantities to be measured for payment shall be those which should have been paid if the original work had been acceptable. No additional payment shall be made for the extra work or quantities necessitated by the rectification.

Where adjustment of moisture content has been directed by the Engineer prior to compaction, no additional payments shall be made for adding water or drying out the material or for any other work required to obtain a satisfactory moisture content.

5.1.4.3 Basis of Payment

The quantities determined, as provided above, shall be paid for at the price per unit of measurement respectively for each of the particular pay items listed below and included in the Bill of Quantities, which prices and payment shall be full compensation for winning, supplying, placing, compacting, finishing and testing the materials, the maintenance of the surface under traffic, and all other costs necessary or usual to the proper completion of the work prescribed in this Article.

Pay Item No.	Description	Unit of Measurement
5.1.1	Aggregate Base Class A	Cubic Metre
5.1.2	Aggregate Base Class B	Cubic Metre
5.1.3	Aggregate Base Class S	Cubic Metre

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SECTION 5.2

UNSEALED ROAD BASE

5.2.1 GENERAL

5.2.1.1 Description

This work comprises the supply, transportation, spreading and compacting for the construction of unsealed road base and running course on a prepared subgrade or base surface. The supply of materials will include, as necessary, crushing, screening, mixing and any other operations required to obtain material meeting the requirements of this Specification.

5.2.1.2 Related Work Specified Elsewhere

(a)	Traffic Management and Safety	:	Section 1.8
(b)	Field Engineering	:	Section 1.9
(c)	Materials and Storage	:	Section 1.11
(d)	Environmental Safeguards	:	Section 1.17
(e)	Grade Preparation	:	Section 3.3
(f)	Aggregate Base	:	Section 5.1
(g)	Reinstatement of Existing Pavement	:	Section 8.1
(h)	Routine Maintenance of Pavement, Shoulders,		
(i)	Drainage, Road & Bridge Furniture	:	Section 10.1
(h)	Maintenance of Adjacent Roads and Bridges	:	Section 10.2

5.2.1.3 Dimensional Tolerances

(a) The minimum thickness shall not be less than the required thickness less one centimetre.

(b) When all loose aggregate is removed, the standard of smoothness of the compacted surface shall be such that there is no point in the surface that varies more than 1 cm from a 3 m straight edge placed either parallel to or at right angles to the centre line of the road.

(c) The surface shall not have any irregularities which can hold moisture.

(d) Unless otherwise directed by the Engineer or detailed in the Drawings, Unsealed Road Base shall be constructed with a cross-fall or camber in non-super elevated sections of 5 percent.

5.2.1.4 Reference Standards

Standar Nasional Indonesia (SNI) :

SNI 03-1967-1990 (AASHTO T 89 - 02)	:	Cara Uji Penentuan Batas Cair untuk Tanah.
SNI 03-1966-1990 (AASHTO T 90 - 00 (2004))	:	Cara Uji Penentuan Batas Plastis dan Indeks Plastisitas Tanah.
SNI 03-2417-1991 (AASHTO T 96 - 02 (2006))	:	Cara Uji Keausan Agregat dengan Mesin Abrasi Los Angeles.

British Standards :

British Standard BS812 : Method of Sampling and Testing of Mineral Aggregates, Sands and Fillers.

5.2.1.5 Submittals

(a) The Contractor shall submit the following to the Engineer at least 21 days prior to the proposed date of first using any material proposed for use as Unsealed Road Base:

(i) Two samples of 50 kg weight each of the material, one of which shall be retained by the Engineer for reference throughout the Time for Completion.

(ii) A statement of the source and composition of any material proposed for use as Unsealed Road Base, together with laboratory test data verifying that the material properties specified in Article 5.2.2.3 are met.

(iii) A statement of the methods and locations of production and blending of Unsealed Road Base material to meet the requirements of Articles 5.2.2.3 and 5.2.3.3

(b) Immediately following completion of each section of the work, the Contractor shall submit in written form to the Engineer the results of surface measurement tests and survey data verifying that the surface and thickness tolerances specified in Article 5.2.1.3 are met.

5.2.1.6 Weather Limitation

Unsealed Road Base shall not be placed, spread or compacted while rain is falling, and no compaction shall be carried out immediately after rain or otherwise when the moisture content of the material fails to comply with Article 5.2.3.4.

5.2.1.7 Rectification of Unsatisfactory Unsealed Road Base

(a) Areas with a thickness or surface uniformity not satisfying the tolerances specified in Article 5.2.1.3, or which develop irregularities in the surface during or after construction, shall be rectified by loosening the surface and removing or adding material as required, followed by reshaping and re-compacting.

(b) Rectification of Unsealed Road Base which does not meet the compaction or material property requirements of this specification shall be as directed by the Engineer and may include additional compaction, loosening followed by moisture content adjustment and re-compaction, removal and replacement of the material, or the use of an additional thickness of material.

5.2.1.8 Maintenance of Accepted Work

Notwithstanding the Contractor's obligation to carry out rectification of unsatisfactory or failed work as specified in Article 5.2.1.7 above, the Contractor shall also be responsible for routine maintenance of all completed and accepted Unsealed Road Base throughout the Time for Completion. Such Routine maintenance work is to be carried out in accordance with Section 10.1 of these Specifications and shall be paid for separately under Article 10.1.7

5.2.2 MATERIALS

5.2.2.1 Material Sources

Aggregate Base Material shall be selected from an approved source in accordance with Section 1.11 ”Materials and Storage” of these Specifications.

5.2.2.2 Unsealed Road Base Selection

This Specification covers the material property requirements for two categories of Unsealed Road Base, namely **Class C** and **Water-bound Macadam**. The Engineer shall finalize the selection of Unsealed Road Base classes to be used at the various locations along the contract during his initial design review or design revision based on the results of material tests on locally available materials carried out as part of the Contractors field surveys.

The use of water-bound macadam shall be confined to reinstatement and repair of existing water-bound macadam roads.

5.2.2.3 Material Property Requirements

Materials selected for use as Unsealed Road Base shall meet the requirements below and shall be free of lumps of clay, organic material, or other deleterious materials and shall have a quality such that a stable road surface can be obtained.

(a) Class C Unsealed Road Base

Aggregate for Class C Unsealed Road Base shall comprise crushed gravel, crashed rock or uncrushed natural gravel meeting the grading specifications in Table 5.2.2.1 below.

Table 5.2.2.1 Grading Requirements for Class C Unsealed Road Base

Sieve Size		Percent by Weight Passing
ASTM	(mm)	
3/4 “	19	100
No.4	4,75	51 - 74
No.40	0,425	18 - 36
No.200	0,075	10 - 22

Except as otherwise specified various components for Class C Unsealed Road Base may be mixed in situ on the prepared subgrade or sub-base in accordance with the provisions of Articles 5.2.2.4 and 5.2.3 of these Specifications.

The material shall also meet the requirements shown in Table 5.2.2.2 below.

Table 5.2.2.2 Material Properties for Class C Unsealed Road Base

PROPERTY	VALUE
Liquid Limit (SNI 03-1967-1990)	Max.40
Plasticity Index (SNI 03-1966-1990)	Min.6 and Max.20
Abrasion of Coarse Aggregate (SNI 03-2417-1991)	Max.50

(b) Water-Bound Macadam Unseated Road Base

(i) The coarse aggregate and key aggregate for Water-Bound Macadam Unsealed Road Base shall meet the grading requirements of Table 5.2.2.3 below. The coarse aggregate size used shall be compatible with the design thicknesses shown on the Drawings and the limits on layer depths given in Table 5.2.2.3.

Table 5.2.2.3 Grading Requirement for Water-bound Macadam

Aggregate Type	Sieve Size		Compacted Layer Thickness	
	ASTM	(mm)	(7-10 cm)	(5-8 cm)
			Percent by Weight Passing	
Coarse Aggregate	3”	75	100	-
	2 ½”	63	95 – 100	100
	2”	50	35 – 70	100
	1 ½”	37.5	0 – 15	95 – 100
	1”	25	0 – 5	35 – 70
	¾”	19	–	0 – 5
Fine Aggregate	3/8”	9.5	100	
	No.4	4.75	70 – 95	
	No.8	2.36	45 – 65	
	No.20	1.0	33 – 60	
	No.40	0.425	22 – 45	
	N0.200	0.075	10 – 28	

The coarse aggregate shall meet the following requirements:

- Abrasion of Coarse Aggregate (SNI 03-2417-1991) : Max. 40

The fine aggregate shall meet the following requirements :

- Plasticity Index (SNI 03-1966-1990) : Min.4 and Max.12
- Liquid Limit (SNI 03-1967-1990) : Max.35

5.2.2.4 Blending of Plastic Materials

(a) Blending of plastic materials shall not be undertaken where the unblended materials already meet minimum plasticity requirements, unless otherwise directed or approved by the Engineer.

(b) The plastic material shall be free of organic material.

(c) The plastic material shall not contain clods or clay lumps exceeding 4.75 mm in size.

(d) The moisture content of the plastic material and all other fractions shall be such that the plastic material remains friable before and during the mixing process.

(e) The materials shall be thoroughly and uniformly blended. The blending procedures used shall be to the satisfaction of the Engineer.

5.2.3 PLACING AND COMPACTING UNSEALED ROAD BASE

5.2.3.1 Preparation of Formation

Preparation of drainage, subgrade and sub-base if specified shall be completed and accepted for at least 100 m ahead of the placing of Unsealed Road Base material at all times.

5.2.3.2 Delivery of Materials

(a) Water bound Macadam coarse aggregate and Water bound Macadam fine aggregate shall be delivered to the roadbed as a uniform mix. The moisture content shall be sufficient only to bind the fine material, free moisture shall not be permitted. The moisture in the material shall be uniformly distributed throughout.

(b) Where Class C Unsealed Road base is supplied premixed, it shall be delivered to the roadbed in accordance with the requirements of Article 5.2.3.2.(a). Where the aggregate supplied is in two or more components, each component shall be supplied in accordance with the requirements of Article 5.2.3.2.(a), except that they shall be supplied dry.

(c) The minimum loose layer thickness shall be not less than twice the aggregate top size. Maximum thickness shall not exceed 20 cm unless otherwise specified or approved by the Engineer.

5.2.3.3 In Situ Mixing of Unsealed Road Base Aggregate

(a) Where the existing roadbed material is to be blended to form one of the components of the Unsealed Road Base, isolated areas of wet or poorer standard material shall first be dug out and replaced with material matching the remainder of the roadbed. The compacted roadbed shall be scarified over the entire area to a uniform depth. Where not otherwise specified, the depth of scarification shall be calculated to yield the correct proportion of roadbed material in the final road base mix. The roadbed material shall be thoroughly dried out and then mixed until the entire area is uniform longitudinally and transversely.

(b) The material components for each layer shall be placed to a uniform depth over the entire area. Soil stabilizing mixing machinery, agricultural soil scarifiers, plough disks or other suitable equipment shall be used to thoroughly mix the full depth of loose material. Alternatively, windrows of uniform cross section may be laid for the entire length where the road width is constant. The entire loose depth of material shall be bladed from one side of the road to the other until the material is uniformly mixed, then spread to a uniform depth.

(c) In situ mixing shall be permitted only when conditions are dry and dry weather may be expected for the entire duration of the work.

(d) Construction of water-bound macadam is specified in Article 5.2.3.5.

5.2.3.4 Compaction of Class C Road Base

(a) Immediately following initial shaping, each layer shall be thoroughly compacted with suitable and adequate compaction equipment approved by the Engineer.

(b) Final shaping of the upper sub-base layer shall be done after at least 2 passes of compaction equipment have traversed the entire area.

(c) Throughout the placing, shaping and compaction of the Unsealed Road Base layers, the aggregate shall be kept in a moist condition by rigidly controlled application of water in a manner which does not disturb surface fines. The Contractor shall remove any aggregate which, before the completion of compaction, has for any reason become so wet as to adversely affect the subgrade. Compaction shall not continue if the material shows signs of heaving or moving excessively. In this situation, the material shall be removed or rectified in accordance with Article 5.2.1.7.

(d) Rolling operations shall begin along the edges and progress gradually towards the centre, in a longitudinal direction. On super elevated sections rolling shall begin at the low side and progress towards the high side.

(e) Material along curbs, walls, and at other places not accessible to the roller shall be compacted using approved mechanical tampers or compactors.

(f) Compaction shall continue until the entire area has been evenly compacted to a hard, uniform dense surface and all roller marks are eliminated. A hard stable layer shall be formed under the rollers, tightly locking the aggregate in place.

(g) The addition of small quantities of low plasticity stone dust or sand may be permitted in the final stages of compaction to facilitate binding the surface layer. The dust or sand shall not be applied so thickly that coarse aggregate cannot be seen in the surface.

5.2.3.5 Construction of Water-Bound Macadam

(a) Layer Depths

Water-Bound Macadam Unsealed Road Base shall be constructed in layers meeting the layer depth requirements shown in Table 5.2.2.(c). The total depth of the completed Road Base shall be in accordance with the Drawings.

(b) Coarse Aggregate Spreading

Spreading may be accomplished, by mechanical means or, manually using baskets to spread the aggregate. A uniform thickness shall be spread.

(c) Coarse Aggregate Compaction and Shaping.

Initial compaction shall be by a 6 - 8 ton smooth wheeled roller. Compaction shall continue until a smooth and stable aggregate course is achieved. A minimum of 6 passes of the roller shall be applied to the entire area.

During compaction the smoothness of the surface shall be measured using a 3 metre straight edge. Any area where the tops of the coarse aggregate stones deviate from the straight edge line by more than 1 cm shall be rectified immediately, by loosening the aggregate and the addition or removal of coarse stone, before re-compacting to the required standard.

(d) Spreading and Compacting the Fine Aggregate

The fine aggregate shall be spread so that the surface voids in the coarse aggregate are entirely filled. The fine aggregate shall be watered and rolled to force the fine aggregate into the lower voids of the Road Base layer.

Watering and rolling, with additional fine aggregate as required shall continue until the entire depth of the Road Base layer has become densely choked with fine aggregate and a fine tight surface has been achieved.

5.2.4 TESTING

(a) The amount of supporting test data required for initial approval of the quality of the material shall be as directed by the Engineer but shall include all the tests specified in Article 5.2.2.3 on at least three representative samples from the proposed material source, selected to represent the range of material quality likely to be obtained from the source.

(b) Following approval of the quality of a proposed Unsealed Road Base material, the full range of material quality tests performed shall be repeated subsequently, at the discretion of the Engineer, in the event of observed changes in the material or in its source or in its method of production.

(c) A program of routine material quality control testing shall be carried out to control the variability of the material being brought on site. The extent of the testing shall be as directed by the Engineer but for every 1000 cubic metres of material produced the testing shall include no less than five (5) plasticity index tests and five (5) particle grading tests.

5.2.5 MEASUREMENT AND PAYMENT

5.2.5.1 Method of Measurement

(a) Unsealed Road Base shall be measured as the number of cubic metres of compacted material required, complete in place and accepted by the Engineer. The volumes to be measured shall be based on the cross sections shown on the Drawings where the required thickness is uniform and on the cross sections approved by the Engineer where the required thickness is not uniform, and lengths measured horizontally along the road centre line.

(b) In the case of Unsealed Road Base where the specified or approved thickness of road base is not entirely composed of new material but includes some reworked existing material, the volume for payment shall be based only on the compacted volume of new material placed, as calculated from cross sections taken by the Contractor and approved by the Engineer before the work is commenced.

(c) The work of preparing and maintaining the sub-base, subgrade or formation on which the Road Base is to be placed shall not be measured or paid for under this Section, but shall be paid for separately under the pay items for Grade Preparation under Section 3.3 of these Specifications.

(d) Water-Bound Macadam Unsealed Road Base and any associated cut off layer material shall not be measured or paid for under this Section but shall be paid for

separately under the pay items for Water-Bound Macadam for Minor Works under Section 8.1 of these Specifications.

5.2.5.2 Measurement of Rectified Work

Where rectification of unsatisfactory Unsealed Road Base has been directed by the Engineer in accordance with Article 5.2.1.7, the quantities to be measured for payment shall be those which would have been paid if the original work had been acceptable. No additional payment shall be made for the extra work or quantities necessitated by the rectification.

Where adjustment of moisture content has been directed by the Engineer prior to compaction, no additional payments shall be made for adding water or drying out the material or for any other work required to obtain a satisfactory moisture content.

5.2.5.3 Basis of Payment

The quantities determined, as provided above, shall be paid for at the price per unit of measurement respectively for each of the particular pay items listed below and included in the Bill of Quantities, which prices and payment shall be full compensation for winning, supplying, placing, compacting, finishing and testing the materials, the provision of cutoff layers, the application of Running Course on the finished surface, and all other costs necessary or usual to the proper completion of the work prescribed in this Article.

Pay Item No.	Description	Unit of Measurement
5.2.1	Aggregate Base Class C	Cubic Metre

SECTION 5.3

PORTLAND CEMENT CONCRETE PAVEMENT AND LEAN CONCRETE SUB-BASE

5.3.1 GENERAL

5.3.1.1 Description

This work shall consist of constructing a Portland Cement Concrete Pavement (Rigid Pavement) and Lean Concrete Sub-base constructed in accordance with the thickness and typical cross sections shown on the Drawings or as instructed by the Engineer.

5.3.1.2 Related Work Specified Elsewhere

(a)	Traffic Management and Safety	:	Section 1.8
(b)	Field Engineering	:	Section 1.9
(c)	Materials and Storage	:	Section 1.11
(d)	Environmental Safeguards	:	Section 1.17
(e)	Quality Management	:	Section 1.21
(f)	Concrete	:	Section 7.1
(g)	Reinforcing Steel	:	Section 7.3

5.3.1.3 Dimensional Tolerances

(a) The requirement of 5.3.5.12 shall apply.

(b) The requirement of 5.3.9 shall apply.

5.3.1.4 Reference Standards

The requirement of 7.1.1.6 shall apply

5.3.1.5 Submittals

The Contractor shall submit details of his proposed Quality Control Plan for this aspect of the works in accordance with Section 1.21 of the Specification in addition to all other requirements included in Articles 7.1.1.7.(a), (b), (c) and (e).

5.3.1.6 Weather Limitation

The requirement of 7.1.1.9.

5.3.1.7 Rectification of Unsatisfactory Portland Cement Concrete (PCC) Pavement and Lean Concrete Sub-base

The requirement of 7.1.1.10 shall apply

5.3.1.8 Work Scheduling and Control of Traffic

(a) The requirement of 5.3.8 shall apply.

(b) Traffic control shall conform with the provisions of Section 1.8, Traffic Management and Safety.

5.3.1.9 Supply of Ready Mix Concrete

Concrete supplied as Ready Mix by an outside supplier must comply with the requirements of ASTM – C94 – Standard Specification for Ready Mix Concrete. Unless otherwise noted in the bid documents the ASTM C 94 "purchaser" shall be the Contractor. The General Conditions of Contract and the requirements of Specification Section 5.3 take precedence over ASTM – C 94. Application of ASTM C 94 shall not relieve the contractor of any of his duties under the Contract.

5.3.2 MATERIALS

5.3.2.1 Pavement Quality Concrete (P.Q.C)

The constituent materials for P.Q.C. shall comply with Section 7.1 of the Specifications unless otherwise stipulated within this Section :

5.3.2.2 Fine Aggregate for PCC Pavement

Fine aggregate must comply with AASHTO M6 and Article 7.1.2.4 of the Specification other than stated below. Fine aggregate must consist of clean, hard, uncoated grains of uniform quality, and must

(a) have a size less than ASTM sieve size No. 4 (4.75mm)

(b) have at least 50% (by mass) natural sand

(c) if two or more fine aggregates are to be blended, that from each source must comply with the requirements of the following table

(d) any manufactured fine aggregate fraction must be crushed rock complying with Article 5.3.2.3 and must be non-plastic when tested in accordance with SNI 03-1966-1990.

Fine Aggregate Properties

Property	Requirement	Test Method
Loose Unit Weight	1,200 kg/m^3 minimum	SNI 03-4804-1998
Water Absorption	5.0% maximum	SNI 03-1969-1990

5.3.2.3 Coarse Aggregate for PCC Pavement

Coarse aggregate must comply with AASHTO M80 and Article 7.1.2.4 of the Specification other than stated below. Air-cooled iron blast furnace slag may be used but steel-plant slag is not acceptable.

Property	Requirement	Test Method
Loss Angeles Abrasion loss	not more than 25% for 500 revolutions	SNI-03-2417-1991
Loose Unit Weight	1,200 Kg/m^3 minimum	SNI 03-4804-1998
Specific Gravity	2,100 Kg/m^3 minimum	SNI 03-1970-1990
Water Absorption	Slag: 6% max	SNI 03-1970-1990

Property	Requirement	Test Method
	Other: 2.5% max	
Particle shape 3:1 and 5:1 ratios	25% and 10% max. respectively	ASTM D-4791
Fractured Faces (2 or more)	80% minimum	Dot's Pennsylvania Test Method, PTM No.621

5.3.2.4 Cement and Fly Ash

Cement must comply with Specification Article 7.1.2.1

Fly ash must comply with AASHTO M295-98

5.3.2.5 Reinforcing Steel

Reinforcing steel shall be in accordance with Section 7.3 of these Specifications and such further details as are shown on the Drawings.

5.3.2.6 Slip Sheet Membrane

Membrane for waterproof underlay below the slab shall be polythene sheeting 125 microns thick or as specified by the Engineer. When an overlap of underlay materials is necessary this shall be at least 300 mm.

5.3.2.7 Admixtures

Chemical Admixtures shall comply with AASHTO M194-06 – Chemical Admixtures for Concrete, but they must not contain calcium chloride, calcium formate, triethanolamine or any other accelerator. The following conditions also apply :

(a) For combinations of two or more admixtures, their compatibility must be certified in writing by the manufacturers.

(b) For mixes with less than 50 kg/m^3 fly ash, the total alkali contribution (measured as Na_2O equivalent) from all admixtures used in any mix must not exceed 0.20 kg/m^3

(c) Super plasticizers and high range water reducers may be used with the permission of the Engineer.

5.3.2.8 Curing Compound

Curing materials shall be a Type 2 white pigmented liquid conforming to AASHTO M148 or other material satisfactory to the Engineer. Colourless or clear membranes will not be approved.

5.3.2.9 Joint Sealer & Filler

(a) Poured sealer for joints shall conform to the requirements of AASHTO M173.

(b) Preformed fillers for joints shall conform to the requirements of AASHTO M33, AASHTO M153, AASHTO M213, or AASHTO M220, as specified on the Drawings or by the Engineer and shall be punched to admit 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 unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape, by stapling or other positive fastening satisfactory to the Engineer.

5.3.2.10 Concrete

(a) Constituents of the Mix

The approval of mix constituent proportions shall be made on the basis of trial mixes developed by the Contractor generally in accordance with Section 7.1 of these Specifications but with the following specific requirements.

The coarse and fine aggregate shall be as specified in Section 7.1 of these Specifications. In determining the coarse aggregate/fine aggregate ratio the fine aggregate proportion shall be kept to a minimum. However, at least 40% by mass of the total aggregates in the concrete mix must be fine aggregate defined as aggregate passing a 4.75 mm sieve.

The combined aggregates shall contain not more than 2 % finer than 0.075 mm other than pozolanic material. The Contractor is allowed a choice of coarse aggregate up to a maximum size of 38 mm providing: the mix does not segregate; suitable workability for the plant being used can be achieved; and the surface regularity required can be maintained. The Engineer at his discretion, may order a change in the size of the coarse aggregate.

Additional measures, including a reduction in maximum aggregate size, may be required to control segregation of slip form concrete delivered by tip truck.

Once the appropriate batch proportions have been determined and approved they shall be varied only with the permission of the Engineer.

(b) Binder Content for PCC Pavement

The mass of cement incorporated in each cubic meter of fully compacted concrete for PCC Pavement shall not be less than 320 kg without flyash and 310 kg with flyash from 30 to 49 kg/m^3 and 300 kg with flyash of 50 – 70 kg/m^3 but shall in no case be more than 420 kg cement. The Contractor shall base his mix design on the leanest mix that meets all specified requirements.

The mass of cement incorporated in each cubic metre of fully compacted Lean Mix Concrete Sub Base shall be 250 kg/m3 of total binder comprising not less than 90 kg/m3 cement and if available, not less than 100 kg/m3 flyash.

(c) Strength

The minimum requirements for compressive and flexural strength at 28 days for PCC Pavement are given in the following table

Minimum Concrete Strengths for Rigid Pavement

Description	Provisional Compressive Strength	Flexural Strength
Trial Mix Concrete	400(1) kg/cm^2 @ 28 days	47 kg/cm^2 @ 28 days
Pavement Concrete (production control)	350(1) kg/cm^2 @ 28 days	45 kg/cm^2 @ 28 days
Test Methods	SNI 03-1974-1990	SNI 03-4431-1997
Test Specimen Size	150 mm dia. cylinder	500x150x150 mm beam

Note 1 Concrete for PCC Pavement in the permanent works must satisfy the minimum flexural strength requirements for Pavement Concrete given in the table. The minimum compressive strength value for production may be amended based on a comparison of flexural and compressive strengths achieved for a series of not less than 16 compressive and flexural strength tests of the approved mix design. Amendment of the minimum Compressive Strength values for production control given in the table shall be subject to the instruction or approval of the Engineer.

In respect of the minimum 7 days working strength this is provisionally specified as 80% of the minimum site working flexural strength. The Engineer may, at his discretion, at any time before or during concrete pavement operations, increase or decrease the minimum 7 days working strength.

The average crushing strength of Lean Concrete Sub-base at 28 days representing each day's work shall not be less than 50 kg/cm^2

(d) Consistence for PCC Pavement

Consistence of the concrete must be determined by measuring the slump in accordance with SNI 03-1972-1990. The Contractor must nominate a slump for each concrete mix within the ranges:

20 – 50 mm for concrete to be slipformed
50 – 75 mm for concrete to be placed manually (fixed-form)

The ratio of free water to cement for surface dry aggregate shall be determined by strength requirements but shall in no case exceed 0.48 by mass.

(e) Tolerances for Nominal Slump for Ready Mix Concrete

The tolerance permitted relative to the Contractor's nominated slump for any concrete mix shall be +/- 13 mm. Care shall be taken to ensure that a consistent method of test is adopted to minimizes random variations in the test result.

(f) Uniformity of Concrete Mix

Concrete mixture properties shall conform to the following table :

Concrete Uniformity Parameters

Test	Requirement, Expressed as Maximum Permissible Difference in Results of Tests of Samples Taken from Two Locations in the Concrete Batch
Weight per cubic metre calculated to an air free basis (kg/m^3)	16
Air content, volume % of concrete	1
Slump (mm)	25
Coarse Aggregate Content, portion by weight of each sample retained on No.4 (4.75 mm) sieve, %	6
Unit Weight of air free mortar (not less than 3 cylinders will be molded and tested from each of the samples) based on average for all comparative samples tested, %	1.6
Average compressive strength at 7 days for each sample, based on average strength of all comparative test specimens, %	7.5

(g) Sampling

For the purposes of this Article 5.3.2 and Article 5.3.9 a lot shall be defined as up to 50 m^3 for slip formed concrete and up to 30 m^3 for hand-paved concrete.

For each lot, two pairs of cylinder test specimens must be moulded for compressive strength testing, one at 7 days and the other at 28 days.

5.3.3 EQUIPMENT

5.3.3.1 General

Equipment shall conform to the requirements of Section 7.1 of these Specifications. Spreading may be by either the slip form or fixed form method.

5.3.3.2 Spreading and Finishing Machines

Spreading machines shall be designed so as to reduce to the minimum segregation of the mixed concrete. Finishing machines shall be equipped with at least two oscillating type transverse screeds or other comparable means of striking off concrete as required by Article 5.3.5 of these Specifications.

5.3.3.3 Delivery Vehicles

Transit agitators or mixers shall be capable of discharging concrete at the required slump. Concrete for slip forming may be transported by dump truck subject to the approval of the Engineer. Concrete mixes to be transported by dump truck shall be specifically designed for the purpose.

5.3.3.4 Concrete Mixing

Ready Mix concrete supply is permitted for fixed form paving subject to demonstration by the Contractor that specified delivery rates, quality and continuity can be provided by ready mix supply. A stationary mixer or mixers having a combined capacity of not less than 60 cubic meters per hour shall be provided for slip form paving unless it can be demonstrated that specified delivery rates, quality and continuity can be provided by ready mix supply.

5.3.3.5 Vibrators

Vibrators, for full width vibration of concrete paving slabs, may be either the surface pan type or the internal type with either immersed tube or multiple spuds. They may be attached to the spreader or the finishing machine, or may be mounted on a separate carriage. They shall not come in contact with the joint, load transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall not be less than 3,500 impulses per minute (58 Hz) and the frequency of the internal type shall not be less than 5,000 impulses per minute (83 Hz) for tube vibrators and not less than 7,000 impulses per minute (117 Hz) for spud vibrators.

When spud type internal vibrators, either hand operated or attached to spreaders or finishing machines, are used adjacent to forms, they shall have a frequency of not less than 3,500 impulses per minute (58 Hz).

5.3.3.6 Concrete Saw

When saw joints are elected or specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing with a water-cooled diamond edge saw blade or an abrasive wheel to the required dimensions and at the required rate. The Contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and continuously during concrete placement.

5.3.3.7 Forms

Straight side forms shall be made of metal having a thickness of not less than 5 mm and shall be furnished in sections not less than 3.0 m in length. Forms shall have a depth at least equal to the prescribed edge thickness of the pavement without horizontal joint, and a base width equal to not less than the depth of the forms. Flexible or curved forms of proper radius shall be used for curves of 30.0 m radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure setting so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward on the base not less than 2/3 the height of the form. Forms with battered top surfaces, and bent, twisted, or broken forms shall be removed from the work. Repaired forms shall not be used until inspected and approved. The top face of the form shall not vary from a true plane more than 3 mm in 3.0 m and the upstanding leg shall not vary more than 6 mm. The forms shall contain provisions for locking the ends of abutting form sections together tightly, and for secure setting.

5.3.4 JOINTS

Joints shall be constructed of the type and dimensions, and at the locations required by the Drawings. All joints shall be protected from the intrusion of injurious foreign material until sealed.

Longitudinal joints of Lean Concrete Sub-base shall be offset by at least 20 cm from the longitudinal joint of the concrete pavement to be superimposed.

Transverse construction joints of Lean Concrete Sub-base shall be formed at the end of each day's work and shall form a true transverse vertical surface

5.3.4.1 Longitudinal Joints for PCC Pavement

Deformed steel tie bars of specified length, size, spacing and material shall be placed perpendicular to the longitudinal joints by approved mechanical equipment or rigidly secured by chairs or other approved supports to prevent displacement. Tie bars shall not be painted or coated with asphalt or other material or enclosed in tubes or sleeves except for future extension joints. When shown on the Drawings and when adjacent lanes of pavement are constructed separately, steel side forms shall be used which will form a keyway along the construction joint. Tie bars, except those made of rail steel, may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed or in lieu of bent tie bars, approved two-piece connectors may be used.

Longitudinal formed joints shall consist of a groove extending downward from, and normal to, the surface of the pavement. These joints shall be effected or formed by an approved mechanically or manually operated device to the dimensions and line indicated on the Drawings and while the concrete is in a plastic state. The groove shall be filled with either a premoulded strip or poured material as required.

The longitudinal centre joint shall be installed so that its ends are in contact with the transverse joints, if any.

Longitudinal sawn joints shall be cut by means of approved concrete saws to the depth, width and line shown on the Drawings. Suitable guide lines or devices shall be used to assure cutting the longitudinal joint on the true line as shown on the Drawings. The longitudinal joint shall be sawn before the end of the curing period or shortly thereafter and before any equipment or vehicles are allowed on the pavement. The sawn area shall be thoroughly cleaned and, if required, the joint shall immediately be filled with sealer.

Longitudinal permanent insert type joints shall be formed by placing a continuous strip of plastic material which will not react adversely with the chemical constituents of the concrete. The insert strip shall be of sufficient width to form a weakened plane to the depth required by the Drawings. Weakened plane type joints shall not be sawn. The insert strip thickness shall not be less than 0.5 mm and shall be inserted with a mechanical device that places the material in a continuous strip. Splices will be permitted provided they are effective in maintaining the continuity of the insert strip. The top edge of the insert strip shall be positioned below the finished surface as shown in the Drawings.

The insert strip shall not be deformed from a vertical position during installation or in subsequent finishing operations performed on the concrete. The alignment of the finished joint shall be uniformly parallel with the centreline of the pavement and shall be free from

excessive local irregularities in alignment. The mechanical installation device shall vibrate the concrete during the insertion of the strip in such a manner as to cause the disturbed concrete to return evenly along the edges of the strip without segregation or developing voids.

5.3.4.2 Transverse Expansion Joints for PCC Pavement

The expansion joint filler shall be continuous from form to form, shaped to the subgrade and to the keyway along the form. Preformed joint filler shall be furnished in lengths equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used unless approved by the Engineer.

5.3.4.3 The expansion joint filler shall be held in a vertical position. An approved installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joints shall not deviate more than 5 mm in the horizontal alignment from a straight line. If joint fillers are assembled in sections, there shall be no offsets between adjacent units. No plugs of concrete shall be permitted anywhere within the expansion space.

5.3.4.4 Transverse Contraction Joints

Transverse contraction joints shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement and, unless otherwise noted on the Drawings, shall include load transfer assemblies.

(a) Transverse strip contraction joints - These joints shall be formed by installing a parting strip to be left in place as shown on the Drawings.

(b) Formed grooves - These grooves shall be made by depressing an approved tool or device into the plastic concrete. The tool or device shall remain in place at least until the concrete has attained its initial set and shall then be removed without disturbing the adjacent concrete, unless the device is designed to remain in the joint.

(c) Sawn contraction joints - These joints shall be created by sawing grooves in the surface of the pavement of the width, depth, and at the spacing and lines shown on the Drawings, with an approved concrete saw. After each joint is sawn, the saw cut and adjacent concrete surface shall be thoroughly cleaned.

Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive ravelling, and generally not less than 4 hours but in no case more than 12 hours after final compaction of the concrete. All joints shall be sawn before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night, regardless of weather conditions. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. If extreme conditions exist which make it impractical to prevent erratic cracking by early sawing, the contraction joint groove shall be formed prior to initial set of concrete as provided above. In general, all joints should be sawn in sequence.

(d) Transverse formed contraction joints - These joints shall comply with the requirements of Article 5.3.4.1 above for the longitudinal formed joint.

(e) Transverse construction joints - Transverse construction joints shall be constructed when there is an interruption of more than 30 minutes in the concreting operations. No transverse joint shall be constructed within 3.0 m of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has not been mixed at the time of interruption to form a slab at least 3.0 m long, the excess concrete back to the last proceeding joint shall be removed and disposed of as directed.

5.3.4.5 Load Transfer Devices

Dowels, when used, shall be held in position parallel to the surface and centre line of the slab by a metal device that is left in the pavement. The metal device devices shall be anchored to the sub-base to prevent movement during concrete placing.

Dowel ends shall be carefully sawn to provide a smooth regular surface. The portion of each dowel lubricated as shown on the Drawings shall be thoroughly coated with approved bituminous material or an approved lubricant, to prevent the concrete from binding to that portion of the dowel. Dowels shall be reasonably free of burs or pitting and corrosion. A metal or PVC dowel cap or sleeve approved by the Engineer shall be furnished for each dowel bar used with the expansion joints. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be water-tight.

In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by a mechanical device approved by the Engineer.

Prior to placing concrete, the alignment tolerance of individual dowels at any locations as measured in the dowel assembly will be ± 2 mm for two thirds of dowels within a joint. In the finished slab, the alignment tolerance on dowel locations will be ± 3 mm.

5.3.4.6 Sealing Joints

Joints shall be sealed, with sealing compound conforming to Article 5.3.2.9 of these Specifications, as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including the Contractor's equipment. Just prior to sealing, each joint shall be thoroughly cleaned of all foreign material, including membrane curing compound and the joint faces shall be clean and surface dry when the seal is applied.

The sealing material shall be applied to each joint opening to conform to the details shown on the Drawings or as directed by the Engineer.

Material for seal applied hot shall be stirred during heating so that localized overheating does not occur. The pouring shall be done in such a manner that the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned. The use of sand or similar material as a cover for the seal will not be permitted.

5.3.5 CONSTRUCTION

5.3.5.1 General

Before commencing work on the concrete slab, all work on the sub-base, utility and other ducts, relevant drainage and other affected works shall be completed to the satisfaction of the Engineer.

A level survey will be carried out on the underlying sub-base and any location more than 5 mm higher than the design level will be rectified prior to any further work being carried out.

5.3.5.2 Form Setting and Slip Form Level Control

Forms and level control devices (wire line or other) shall be set sufficiently in advance of the point where concrete is being placed to permit the performance and approval of all operations required within and adjacent to the form lines. Forms shall be staked into place with no less than 3 pins for each 3.0 m section. A pin shall be placed at each side of every joint. Form sections shall be tightly locked, free from play or movement in any direction. The forms shall not deviate from true line by more than 5 mm at any point. Forms shall be so set that they will withstand without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and coated with a form release agent or oiled prior to the placing of concrete.

The alignment and grade elevation of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

Form tops and level control devices shall be set to a level tolerance not exceeding -10 mm to + 10mm relative to the designed finished surface level. In addition forms and level control devices shall be set such that at no point the thickness of concrete base after placing and compaction will be less than the design thickness.

5.3.5.3 Placing Concrete

The concrete shall be deposited on the grade in such a manner as to require as little rehandling as possible. Unless truck mixers, truck agitators, or non-agitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade in such a manner as to prevent segregation of the materials. Placing shall be continuous between transverse joints without the use of intermediate bulkheads. Necessary hand spreading shall be done with shovels, not rakes. Workmen shall not walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

Where concrete is to be placed adjoining a previously constructed lane of pavement and mechanical equipment will be operated upon the existing lane of pavement, that lane shall have attained at least 90% of the strength specified for 28 days concrete. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after 3 days.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies, by means of vibrators

inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 5 seconds in any one location.

Concrete shall be deposited as near to expansion and contraction joints as possible without disturbing them, but shall not be dumped from the discharge bucket or hopper onto a joint assembly unless the hopper is well centred on the joint assembly.

Should any concrete materials fall on or be worked into the surface of a completed slab, they shall be removed immediately by approved methods.

5.3.5.4 Placing of Reinforcement

Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the Drawings. When reinforced concrete pavement is placed in two layers, the bottom layer shall be struck off and consolidated to such length and depth that the sheet of fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off and screeded. Any portion of the bottom layer of concrete which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be firmly positioned in advance of concrete placement or it may be placed at the depth shown on the Drawings in the plastic concrete, after spreading, by mechanical or vibratory means.

At joints between mats of steel fabric reinforcement the first wire of one mat shall lie within the complete mesh of the previous mat and the overlap shall be not less than 450 mm.

Reinforcing steel shall be free from dirt, oil, paint, grease, mill scale, and loose or thick rust which could impair the bond of the steel with the concrete.

5.3.5.5 Machine Finishing

The concrete shall be distributed or spread as soon as placed and shall be struck off, vibrated and screeded by an approved finishing machine. The machine shall go over each area of pavement as many times and at such intervals as necessary to give the proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other vibration tending to affect the precision finish.

During the first pass of the finishing machine a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length.

5.3.5.6 Hand Finishing

Where slabs are so small or irregular, or with the permission of the Engineer when the Site is so restricted or limited as to make the use of the methods specified in Article 5.3.5.5 above impracticable, concrete shall be evenly distributed and spread by hand without pre-compaction or segregation.

Concrete to be compacted by a vibrating beam shall be struck off at such a level that the surface level after all entrapped air has been removed by compaction is above that of the side forms. The concrete shall be compacted by a steel or steel-shod hardwood compacting beam not less than 75 mm wide, 225 mm deep with an energy input of not less than 250 W per meter width of slab, the beam being lifted and moved forward by increments not exceeding the beam width. Alternatively, a vibrating twin beam compactor of equivalent power may be used. When compacting layers of concrete exceeding 200 mm in depth, or when directed by the Engineer sufficient additional internal vibration shall be provided over the whole width of the slab to produce full compaction. After every 1.5 m length of slab has been compacted the vibrating beam shall be taken back 1.5 m and then drawn slowly forward whilst vibrating over the compacted surface to provide a smooth finish.

The surface shall then be regulated by at least two passes of a scraping straight-edge with blade length not less than 1.8 m. If the surface is torn extensively by the straight-edge, owing to irregularities in the surface, a further pass of the vibrating beam shall be made, followed by a further pass of the scraping straight-edge.

When laying reinforced concrete two layer construction shall be used. The first layer shall be spread, struck off and compacted to a level so that the reinforcement when placed shall have the required depth of cover. Immediately after placing the reinforcement the top layer of concrete shall be laid and finished.

5.3.5.7 Floating

After the concrete has been struck off and consolidated, it shall be further smoothed, trued, and consolidated by means of a float, using one of the following methods as specified or permitted.

(a) Hand method - A hand-operated longitudinal float not less than 3.5 m in length and 150 mm in width, properly stiffened to prevent flexibility and warping shall be used. The longitudinal float, operated from foot bridges resting on the side forms and spanning but not touching the concrete, shall be worked with a sawing motion, while held in a floating position parallel to the road centre line, and passing gradually from one side of the pavement to the other. Movement ahead along the centre line of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or fluid material shall be wasted over the side forms on each pass.

(b) Mechanical method - The mechanical float shall be of a design approved by the Engineer and shall be in good working condition. The float shall be accurately adjusted to the required crown and coordinated with the adjustments of the transverse finishing machine.

As an alternative to the mechanical float above, the Contractor may use a machine composed of a cutting and smoothing float or floats, suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on, and constantly in contact with, the side forms.

If necessary, following one of the preceding methods of floating, long-handled floats having blades not less than 1.5 m in length and 150 mm in width may be used to smooth and fill in open-textured areas in the pavement. Long-handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing, one of the preceding methods of floating. When strike-off and consolidation are done by the hand method and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of the long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and residue shall be removed from the surface of the pavement by a straightedge 3.0 m or more in length. Successive drags shall be lapped one-half the length of the blade

5.3.5.8 Surface Correction

After the floating has been completed and the excess water removed, but while the concrete is still plastic, depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Surface corrections shall continue until the entire surface is found to be free from observable departures and the slab conforms to the required grade and cross section.

The variation of the surface from the testing edge of a straightedge between any two contacts with the surface shall not exceed the allowable tolerance specified in Article 5.3.5.12 of these Specifications.

5.3.5.9 Edging

As soon as the concrete has been struck off and consolidated, the edges of slabs along the forms and at the joints shall be carefully finished with an edging tool to form a smooth rounded surface of the required radius which unless shown otherwise on the Drawings shall be 12 mm.

5.3.5.10 Surface Finish

After the completion of joints and edging and before the application of curing compound, the surface of the PCC Pavement shall be brushed in a direction parallel to the centre line of the pavement.

A brushed finish shall be formed with a wire broom not less than 450 mm wide. The broom shall have two rows of tufts made from 100mm long 32 gauge wire with 20mm between the centres of each tuft. The two rows of tufts shall be offset in a zigzag arrangement maintaining the 25 ~~20~~ mm centre to centre spacing with the second row of tufts offset by 12.5 ~~10~~ mm from the first row. Each tuft shall have 14 wires which shall be replaced if the shortest wire length wears down to less than 90mm in length.

The average textured depth shall not be less than 0.75 mm.

5.3.5.11 Level Survey

Within 24 hours of placing, the Contractor must survey the surface levels for conformity of the layer surface and thickness.

The level at any point on top of the layer for Lean Concrete Sub-base must not vary by more than 10 mm below or 10 mm above the design level (-10, +10 mm) and for PCC pavement must not vary more than 10 mm below or 10 mm above the design level (-10, +10 mm).

Lean Concrete Sub-base shall have a cross-fall equal to the design cross-fall with tolerance of ± 0.3 %

5.3.5.12 Surface Test

As soon as the concrete has hardened sufficiently, the Lean Concrete Sub-base or PCC pavement surface shall be tested with a 3.0 m straight-edge. Areas showing high spots of more than 5 mm but not exceeding 12.5 mm in 3.0 m shall be marked and immediately ground down with an approved grinding tool to an elevation where the area or spot will not show surface deviations in excess of 5 mm when tested with a 3.0 m straight-edge. Where the departure from correct cross section exceeds 12.5 mm, the pavement shall be removed and replaced by and at the expense of the Contractor.

Any area or section so removed shall be not less than 3.0 m in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3.0 m in length, shall also be removed and replaced.

5.3.5.13 Curing

The exposed surfaces of PCC Pavement shall be cured by the application of a sprayed curing compound, complying with Article 5.3.2.8 of these Specifications, applied immediately after the surface finish brushing in accordance with the following conditions:

(a) The curing must form a continuous and unbroken film, and be applied uniformly in two applications :

(i) The first within 15 minutes of the surface reaching the “low sheen” bleed water condition, and

(ii) The second 10 to 30 minutes later or as recommended by the manufacturer.

(b) On a fixed-formed surface, the first application must be within 30 minutes of stripping and the second must be 15 to 45 minutes later.

(c) Fully operational spraying equipment will be a pre-condition for paving to proceed.

(d) Each application must be at the rate on the test certificate for curing efficiency, subject to a minimum value of 0.20 ltr/m^2, except that :

For areas sprayed by other than a mechanical sprayer, the application rate must be 25% higher than the rate stated on the test certificate for curing efficiency, subject to a minimum value of 0.20 ltr/m^2. These areas include the faces of formed joints and sections of slip formed edges which were supported by temporary forms at the time of initial spraying.

(e) Any section on which the application does not conform must be re-sprayed within six (6) hours of testing at an application rate not less than twice the deficiency in the original application.

(f) The curing film must be maintained intact in a continuous and unbroken membrane until an insitu strength of 300 kg/cm^2 is achieved. Any damage to the curing membrane must be made good by hand-spraying of the affected area.

Additionally, any adjoining hardened PCC Pavement of age less than 7 days adjoining the commencement of each paving run must be resprayed with a single application for a minimum length of 7 m and extend to areas trafficked by persons during placement at the construction joint.

Lean Concrete Sub-base shall immediately on completion of finishing be cured until at least 70% of the required strength is attained. Curing of the surface shall be achieved by one of the following methods :

(a) Covering until the next pavement layer is laid with impermeable plastic sheeting, adequately secured from being blown off the surface and with the joints overlapped at least 300 mm and set to prohibit egress of moisture.

(b) The entire surface sprayed uniformly with white pigmented curing compound.

(c) Continual mist spraying covering the entire surface and maintaining a permanently moist condition for the full duration of the curing period. Intermittent wet curing will not be accepted

5.3.5.14 Removal of Forms

Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least 12 hours. Forms shall be removed carefully so as to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as required in 5.3.5.13 above.

Minor areas of honeycomb shall be cleaned, wetted, and neatly patched with stiff mortar in the proportions of 1 part cement to 2 parts fine aggregate. Patching shall not be carried out until the honeycomb areas have been inspected and method of patching approved by the Engineer.

Major honeycombed areas will be considered as defective work and shall be removed and replaced. Any area or section so removed shall not be less than 3.0 m in length nor less than full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 3.0 m in length shall also be removed and replaced.

5.3.6 TRIAL LENGTH

The Contractor shall demonstrate the plant, equipment and method of construction by laying an initial trial length not less than 30 m long at a location provided by the Contractor outside the permanent works. Subsequent trial lengths may be instructed by the Engineer if any aspect of the initial trial proves unsatisfactory.

Following approval by the Engineer of the initial trial a comprehensive trial length at least 150 m and not more than 300 m long shall be carried out within the permanent works. This comprehensive trial shall demonstrate all aspects of the work and shall include each type of joint to be used in the Works.

The Contractor shall submit to the Engineer at least one month prior to the date proposed for the initial trial length, a detailed description of the plant, equipment and method of construction. No development of the plant shall be permitted either during this trial length or when pavement concrete is being laid in the permanent works.

The Contractor shall not continue with the laying of pavement quality concrete in the permanent works until approval to a comprehensive trial has been given or permission has been given by the Engineer to proceed with another comprehensive trial.

For the comprehensive trial to be acceptable, the length of pavement shall conform, without remedial works, to the Specification.

If the comprehensive trial length does not conform with the Specification the Contractor shall construct another trial length. Trial lengths which do not conform with the Specification shall be removed unless the Engineer permits otherwise.

Trial length outside the permanent works may not be required where the amount of concrete pavement work is limited, such as at Bus Bay areas only. Determination of non requirement of the trial length will be solely decided by the Engineer.

5.3.7 PROTECTION OF PAVEMENT

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by his own employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, or crossovers, etc.

Any damage to the pavement, occurring prior to final acceptance, shall be repaired or the pavement replaced, as directed by the Engineer.

5.3.8 OPENING TO TRAFFIC

The Engineer will decide when the PCC Pavement shall be opened to traffic. The pavement will not be opened to traffic until test specimens moulded and cured in accordance with AASHTO T23 have attained not less than 90% of the minimum compressive strength or minimum flexural strength at 28 days of 350 kg/cm^2 and 45 kg/cm^2 respectively. If such tests have not yet been conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening to traffic, the pavement shall be cleaned and joint sealing completed.

Neither equipment nor traffic, including construction vehicles, will be allowed on the finished surface of Lean Concrete Sub-base until the concrete attained at least 70% of the required strength.

After the curing period such equipment and vehicles required for the continuation of works will be permitted to traffic on the Lean Concrete Sub-base.

Lean Concrete Sub-base shall be maintained in a proper condition prior to placing the next pavement layer. Any damage from any cause whatsoever shall be repaired by replacement of the area in question at the expense of the Contractor

5.3.9 TOLERANCE IN PAVEMENT THICKNESS

Actual concrete pavement thickness will normally be determined by the difference in values from the level surveys carried out before and after the rigid pavement is placed. In the event of any area of concrete thickness discrepancy being revealed by the two level surveys, the Engineer may request that cores be drilled to determine the actual concrete thickness in these areas. In the event that coring is required, the thickness of the pavement in these areas will be determined by average caliper measurement of cores tested in accordance with AASHTO T 148-07.

For the purpose of establishing an adjusted unit price for pavement, units to be considered separately are defined as lots as described in Article 5.3.2.10 (g)

Other areas such as intersections, entrances, crossovers, ramps etc., will be considered as one unit, and the thickness of each unit will be determined separately. Small irregular unit areas may be included as part of another unit.

In calculating the average thickness of the pavement, measurements which are in excess of the specified thickness by more than 5 mm will be considered as the specified thickness plus 5 mm,

Areas found deficient in thickness by more than 12.5 mm shall be evaluated by the Engineer, and if in his determination the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the Drawings.

5.3.10 RIDING QUALITY

The riding quality of each lane of the main carriageway and ramps will be measured for International Roughness Index (IRI). The rigid pavement shall be divided into lots for measurement. Each lot shall comprise a single lane section of not less than 200 metres length and shall exclude bridges, bridge approach slabs, intersection gore areas, utility covers and similar obstacles. *(Note:a lot for riding quality measurement may differ from the lot defined by Article 5.3.1.10 (g)) for strength and thickness).*

An initial measurement shall be taken after completion of the first six lots to allow work methods to be assessed . If roughness readings are worse than the zero penalty level given by Article 5.3.10.1 c modifications to the work method and Quality Control Plan shall be proposed by the Contractor and agreed or revised by the Engineer. Work shall not recommence until work method changes have been agreed. The procedure shall be repeated with further IRI testing until a zero penalty riding quality is achieved.

Further IRI tests shall be at times instructed or approved by the Engineer. An IRI survey of all rigid pavement permanent works not previously tested shall be carried out on completion of the works. There shall be no separate payment for IRI testing.

If the riding quality of any lot exceeds IRI 4 m / km the contractor shall undertake necessary rectification after which the lot shall be retested.

5.3.11 MEASUREMENT AND PAYMENT

5.3.11.1 Measurement

The quantity to be paid for under this item will be the number of cubic metres of Rigid Pavement, Rigid Pavement Single Wire Mesh and Lean Concrete Sub-base and Price Adjustment of completed and accepted works as measured complete in place. The width for measurement will be the width of the pavement shown on the typical cross section of the plans, additional areas such as ramps where shown on the drawings or as otherwise directed in writing by the Engineer. The length will be as shown on the drawings or as measured by the Engineer. The length will be measured along the centre line of each roadway. The thickness shall be the design thickness.

Joints, dowels, tie bars and reinforcing steel required for the work of this Article will not be measured for separate payment.

Trial lengths placed outside the permanent works shall not be measured for payment.

Measurement of deductions for non compliant work and of incentive payments to be included under Pay Item 5.3.3 Incentive / Penalty Adjustments shall be made in accordance with the following:

a) Thickness Deficiency

Where the average thickness of PCC Pavement for any lot is deficient in thickness by more than 5 mm, but not more than 12.5 mm, a deduction will be made determined as the product of the design quantity of Rigid Pavement or Rigid Pavement Single Wire Mesh within the lot, the deduction given by the Table and the Contract Unit Price:

CONCRETE PAVEMENT THICKNESS DEFICIENCY

Deficiency in Average Thickness Determined by Cores or by level survey within a lot	Deduction (percent of Unit Price)
0 to 5 mm	0 percent
6 to 8 mm	20 percent
9 to 10 mm	28 percent
11 to 12.5 mm	32 percent
>12.5 mm	Either to be removed or to be retained without payment

When the thickness of pavement is deficient by more than 12.5 mm and the determination of the Engineer is that the area of such deficiency should not be removed and replaced, there will be no payment for the area retained.

No additional payment will be made or additional quantity measured for any pavement thickness in excess of that shown on the Drawings.

(b) Strength Deficiency

If the strength compliance of the concrete pavement within any lot is not achieved, but all other aspects comply with the specification, the Engineer may, at his discretion accept the concrete pavement with the following adjustments:

If the 28 day compressive strength of test cylinders for any lot is less than 90% of the minimum specified concrete compressive strength then the lot represented by the test cylinders must be removed and replaced.

Concrete with a 28 day cylinder compressive strength of between 90 and 100% of the minimum specified compressive strength may be accepted subject to a deduction of 4% of the unit rates for PC concrete pavement for each 5 kg/cm^2, or part thereof, deficiency in strength applied to the design quantity within the lot and the and the Unit Price.

(c) Price Adjustment for Riding Quality

Incentive payments or deductions will be made for riding quality in accordance with the following table. The incentive or deduction will be applied to individual lots as the product of the design quantity for the lot, the Contract Unit Price and the incentive or penalty defined by the Table.

International Roughness Index for Lot	Incentive or penalty as percentage of Unit Price for Rigid Pavement or Rigid Pavement Single Wire Mesh represented by one Lot
< 1.5	+4%
1.5 - < 2	+2%
2 - < 3	full payment (= 0 % penalty)
3 - < 4	- 2 %
≥ 4	- 4%
> 5	grind or overlay at contractors expense

5.3.11.2 Basis of Payment

(a) General

The accepted quantities of Rigid Pavement, Rigid Pavement Single Wire Mesh and Lean Concrete Sub-base determined as provided above will be paid for at the contract price per cubic metre which price and payment will be full compensation for furnishing and placing all materials, including, but not limited to, Portland cement concrete, reinforcing steel, forms, dowels, tie bars,d joint materials and slip sheet membrane, carrying out trial lengths, taking cores and roughness measurements for price adjustment, and all other material, labour, equipment and incidentals necessary to complete the work as shown on the Drawings or instructed by the Engineer.

(b) Price Adjustment

Penalty and incentive sums shall be calculated by the Engineer for each lot that is subject to a strength, thickness or riding quality penalty or incentive as described above. The sum of all such adjustments shall be determined and included in Payment Certificates as a single lump sum payment or deduction under Pay Item 5.3.3 Incentive / Penalty Adjustments.

A record of all related test results, calculations and correspondence shall be maintained by the Engineer. Incentive / Penalty calculations and backup data shall be provided by the Engineer as backup to Payment Certificates.

Pay Item .	**Description**	**Unit of Measurement**
5.3.1	Rigid Pavement	Cubic Metre
5.3.1 a	Rigid Pavement Single Wire Mesh	Cubic Metre
5.3.2	Lean Concrete Sub-base	Cubic Metre
5.3.3	Incentive / Penalty Adjustments	Lump Sum

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SECTION 5.4

SOIL CEMENT BASE

5.4.1 GENERAL

5.4.1.1 Description

This work shall consist of providing a base course of cement stabilized locally won soil on a prepared sub grade including the spreading, shaping, compacting, curing and finishing of the material, all in accordance with the requirements of these Specifications and in conformity with the dimensions and typical cross sections shown on the Drawings and to the lines and grades established by the Engineer.

5.4.1.2 Related Work Specified Elsewhere

(a)	Traffic Management and Safety	:	Section 1.8
(b)	Field Engineering	:	Section 1.9
(c)	Materials and Storage	:	Section l.11
(d)	Environmental Safeguards	:	Section 1.17
(e)	Excavation	:	Section 3.1
(f)	Fill	:	Section 3.2
(g)	Grade Preparation	:	Section 3.3
(h)	Prime Coat and Tack Coat	:	Section 6.1
(i)	Single and Double Surface Dressing	:	Section 6.2
(j)	Maintenance of Adjacent Roads and Bridges	:	Section 10.2

5.4.1.3 Dimensional Tolerances

(a) Dimensional tolerances for the prepared subgrade shall be in accordance with Article 3.3.1.3.

(b) At any surveyed cross section, the average thickness of any compacted lift or series of lifts of Soil Cement Base, as measured by survey and/or coring, shall be no more than 10 % greater or less than the thickness designated or approved by the Engineer.

(c) At any surveyed cross section, the average thickness of finished Soil Cement Base of acceptable strength and homogeneity, as measured by Scala Penetrometer or tests on cores, shall be equal to or greater than the design thickness shown on the Drawings or directed by the Engineer.

(d) The finished surface of the final lift of Soil Cement Base shall conform reasonably closely to the design grade and shall be not less than one centimetre below the design level at any point.

(e) The finished surface of the final lift of Soil Cement Base shall deviate by no more than 2 cm from a 3 metres long straight edge placed on the surface parallel to she road centre line or from a template placed transversely.

(f) The Contractor should note that poor surface shape of the final lift of Soil Cement Base will lead to greater asphalt quantities being required in the overlay to meet the specified asphalt surface smoothness tolerances. Since Hot Asphalt Mixtures are paid for on the basis of design nominal dimensions rather than by weight, such

additional asphalt quantities shall represent a loss to the Contractor. The smoothest possible finish to the Soil Cement Base will therefore give the Contractor the best economic solution and also produce the best road.

5.4.1.4 Reference Standards

Standar Industri Indonesia (SII) dan Standar Nasional Indonesia (SNI) :

SII-13-1977 (AASHTO M85 - 07)	:	Semen Portland
SNI 03-3422-1994 (AASHTO T 88 - 00 (2004))	:	Cara Uji Analisis Ukuran Butir Tanah.
SNI 03-1967-1990 (AASHTO T 89 - 02)	:	Cara Uji Penentuan Batas Cair untuk Tanah.
SNI 03-1966-1990 (AASHTO T 90 - 00 (2004))	:	Cara Uji Penentuan Batas Plastis dan Indeks Plastisitas Tanah.
SNI 03-1742-1989 (AASHTO T 99 - 01 (2004))	:	Cara Uji Kepadatan Ringan untuk Tanah.
SNI 03-6886-2002 (AASHTO T134 - 05)	:	Metode Pengujian Hubungan Kadar Air dan Kepadatan pada Campuran Tanah Semen
SNI 13-6427-2000 (AASHTO T135 - 97 (2005))	:	Metode Pengujian Uji Basah dan Kering Campuran Tanah Semen Dipadatkan
SNI 03-6412-2000 (AASHTO T144 - 86)	:	Metode Pengujian Kadar Semen pada Campuran Segar Semen Tanah
SNI 03-2828-1992 (AASHTO T191 - 02 (2006))	:	Metode Pengujian Kepadatan Lapangan dengan Alat Konus Pasir.
SNI 03-1744-1989 (AASHTO T193 - 99 (2003))	:	Metode Pengujian CBR Laboratorium.
SNI 03-6798-2002 (ASTM D 1632 - 63)	:	Tata Cara Pembuatan dan Perawatan Benda Uji Kuat Tekan dan Lentur Tanah Semen di Laboratorium.
SNI 03-6887-2002 (ASTM D 1633 - 94)	:	Metode Pengujian Kuat Tekan Bebas Tanah Semen.
SNI 19-6426-2000 (BS 1924 Test 18)	:	Metoda Pengujian Pengukuran pH Pasta Tanah Semen untuk Stabilisasi

AASHTO :

AASHTO T 26 - 79 (2004)	:	Quality of Water Used in Concrete

5.4.1.5 Submittals

The Contractor shall at the times and frequencies indicated the following to the Engineer :

(a) Samples

Samples of all materials proposed for use in the Works, together with test data confirming the material properties and quality as required by these Specifications shall be submitted to the Engineer for approval before they are incorporated in the Works. Samples of all materials approved for use by the Engineer shall be retained by the Engineer throughout the Time for Completion for reference purposes. The

Contractor shall provide on site storage for all such samples (and also for cores) in a watertight lockable shed fitted with shelves, as directed by the Engineer.

(b) Cement Delivery to Site

Inventory records, showing the quantities of cement delivered to the site and the exact location of the storage of each consignment within the Contractor's on-site store, shall be submitted to the Engineer daily whenever delivery takes place, together with a certificate showing the place of manufacture and the results of the tests specified in the Indonesian Industrial Standard SII-13-1977.

(c) Cement Usage Tallies

Daily records shall be kept showing the amount of cement actually laid in the Works, as specified in Article 5.4.2.1, and shall be submitted to the Engineer at the end of each day. Records submitted at a later date will not be accepted by the Engineer nor included in calculations to establish the quantities of cement to be paid for.

(d) Survey Data

Immediately before any portion of the Works is commenced, all necessary levels shall be taken and agreed with the Engineer and the required cross section drawings submitted to and approved by the Engineer (refer Article 1.9.4, "Setting Out of Work").

(e) Control Testing

The Contractor shall be responsible for carrying out the control testing of the Works specified in Article 5.4.6 and shall furnish the results of control tests to the Engineer on the same date, or the day following the date, on which the test is completed, when carried out in accordance with the specified standard testing procedures.

(f) Scala Dynamic Cone Penetrometer Tests

Dynamic Cone Penetrometer tests shall be recorded on the standard forms where provided in the Drawings. The blow count records shall be signed by both the Contractor and the Engineer in the field immediately following each test and a carbon copy submitted to the Engineer immediately on signing. The graphical plots of the penetrometer data shall be submitted to the Engineer no later than the end of the following work day.

(g) Core Records

All cores taken shall be labeled clearly to indicate the location from which they were taken and shall be submitted to the Engineer together with written records showing average height and location of every core. All cores shall be retained for reference by the Engineer (in a lockable waterproof store provided by the Contractor) for the full duration of the Contract.

5.4.1.6 Weather Limitations

Soil for Soil Cement Base shall not be placed, spread or pulverized while rain is falling, and pulverization shall not be carried out immediately after rain or otherwise when the moisture content of the material is too high for satisfactory pulverization (refer Article 5.4.5.3.(b)).

Cement shall be placed only when the surface is dry, when rain is not likely to fall and when the pulverized soil is in a satisfactory condition. In the case of sudden rain during the cement spreading operation, spreading shall be stopped and the cement already spread shall be quickly mixed into the soil mass, followed by rapid compaction to minimize rain damage. Final blending and shaping may have to be completed after the rain has stopped, if approved by the Engineer. Where rain damage is severe, or if the quality of the affected work is in doubt, the Engineer shall order rectification of the work in accordance with Article 5.4.1.7.

5.4.1.7 Rectification of Unsatisfactory Soil Cement Base

Soil Cement Base which does not meet the tolerance or quality criteria specified in these Specifications shall be rectified by the Contractor as directed by the Engineer. Such rectification may include:

(a) Changes in the mix proportions for the subsequent Works.

(b) Repulverizing the Soil Cement Base already laid (if reasonably possible) and remixing with additional cement.

(c) Removal and replacement of those portions of the work which the Engineer deems to be unsatisfactory.

(d) Overlay of the affected work by an additional layer of Soil Cement Base, the thickness of which shall be as directed by the Engineer and may be up to the full design thickness as shown in the Drawings.

If large widely spaced shrinkage cracks develop during the early curing period, the Engineer may request additional rolling to cause deliberate cracking of the material and thereby minimize the potential effect of the cracking on pavement deterioration by producing a preferential pattern of closely spaced fine cracks. For well developed cracks in which further large movement is not expected, the Engineer may direct rectification using cement grout. Rectification of cracking may also include adjustment of the mix to reduce the cement content of the material not yet placed.

5.4.1.8 Restitution of Work Following Testing

All holes in the finished work made by testing shall be backfilled by the Contractor without delay. Holes resulting from penetrometer testing shall be filled with cement grout and rammed with a fine rod to remove any trapped air bubbles, to the satisfaction of the Engineer. Larger holes such as those caused by density tests or cores shall be filled with Soil Cement Base material and compacted to the density and surface tolerances required in these Specifications.

5.4.1.9 Work Scheduling and Control of Traffic

(a) No later than 14 days after the placing of the final lift of Soil Cement Base, the hot mix asphalt overlay is to be placed. To ensure that this condition is met, the Engineer shall ascertain that the Contractor's hot mix asphalt production facilities are in place and operational before giving approval for the placing of the final Soil Cement Base lift.

(b) The Contractor shall be responsible for ensuring that no traffic is admitted to the newly constructed Soil Cement Base, under any circumstances, until the asphalt

overlay is in place and he shall prohibit such traffic by the provision of a detour or by half width construction.

(c) Traffic control shall conform with the provisions of Section 1.8, Traffic Management and Safety.

5.4.2 MATERIALS

5.4.2.1 Portland Cement

(a) The cement to be used for Soil Cement Base shall be Ordinary Portland Cement complying with the requirements of Indonesian Industrial Standard SII-13-1977 Portland Cement Type I. Cement shall be obtained from manufacturers that are approved by the Ministry of Trade and Industry, Republic of Indonesia.

(b) The Engineer may call for quality tests on each consignment of cement on arrival on site, and also at any time after it has been stored on site prior to use, to ascertain if the cement has deteriorated in any manner during transit or storage. No cement shall be allowed to be used until it has been accepted by the Engineer.

(c) All cement to be used in the Works shall be stored on site in accordance with the provisions of Section 1.11 and Article 7.1.1.8 of these Specifications, and shall be inventoried on arrival under supervision of the Engineer. The inventory records shall be signed in confirmation of their correctness by both the Contractor and the Engineer. The amount of cement placed in the Preliminary Field Trials or in the Works shall also be recorded in detail and no cement shall be placed except when the Engineer or his representative is on site to supervise and record the laying. Both the Contractor and the Engineer shall sign the daily record showing the amount of cement actually placed in the Works.

5.4.2.2 Water

The Contractor shall make his own arrangements to provide and ensure a sufficient supply of approved water for the manufacture and curing of the Soil Cement Base and shall submit water samples for approval by the Engineer, together with a statement defining the source or sources, before commencing the Works. Water used in the Works shall be fresh and free from sediment and dissolved or suspended matter which may be harmful to the manufacture of the Soil Cement Base as specified, and shall conform with the requirements of AASHTO T26. The Engineer may request further sampling and testing of water at intervals throughout the duration of the Contract and if at any time samples prove unsatisfactory the Contractor shall be required at his own cost either to change to a new supply or to make arrangements acceptable to the Engineer to remove the offending water.

5.4.2.3 Soil

(a) Soil suitable for use in Soil Cement Base shall, before pulverization, conform to the following particle size requirements when wet sieved:

(i) Maximum size of any rock particles to be less than 75 mm.

(ii) Less than 50 % passing a No.200 sieve when sieved wet.

(iii) Following pulverization of the soil further particle size limits must be checked, in accordance with Article 5.4.5.3.(c).

(b) Low-plasticity or lateritic soils exhibiting good strength properties are to be selected in preference to low strength, highly plastic or expansive soils.

(c) The soil shall be free of organic matter able to interfere with the hydration of Portland Cement. When tested in accordance with Test 18, BS1924, the pH value after a lapse of 1 hour shall be greater than 12.2. This test shall only be performed if directed by the Engineer, as in a case where `unusually slow hardening or low strengths are being obtained for the soil cement mix.

(d) The soil shall be such that satisfactory Soil Cement Base, as required by these Specifications, can be produced using cement contents within the range specified in Article 5.4.3. Soil not meeting the soil property requirements specified in Article 5.4.3 shall not necessarily be rejected if it can be shown that Soil Cement Base meeting the requirements given in Table 5.4.3 can be produced from the soil.

(e) All proposed soil borrow areas shall be inspected and approved by the Engineer prior to use. Approval shall not be granted unless the Contractor has provided soil samples, taken from the borrow area under the supervision of the Engineer, and testing under the supervision of the Engineer has confirmed that the soil properties meet the requirements of these Specifications. The Engineer's approval of use of a borrow area shall not be construed to mean acceptance of Soil Cement Base made from soil from that borrow area nor to mean a waiver of any kind of the Contractor's responsibility to construct satisfactory Soil Cement Base meeting the specified requirements.

5.4.3 MIXES

5.4.3.1 General Composition of the Mixture

The Soil Cement Base mixture shall be comprised of approved soil, cement and moisture. The cement content to be used shall be fixed by the Engineer on the basis of laboratory test data and Preliminary Field Trials, but shall be in the range 3 % to 12 % by weight of the oven dry soil in its natural state (that is, before mixing with cement).

5.4.3.2 Laboratory Mix Design (UCS Method)

(a) For each new soil borrow area to be used, and from time to time as directed by the Engineer during the use of any given borrow area, the Contractor shall carry out laboratory trial mixes under the supervision of the Engineer to establish :

(i) Whether or not Soil Cement Base with satisfactory strength and volume change characteristics can be made from the soil.

(ii) The cement content required to achieve the target mix strength.

(iii) The moisture and density limits required for field compaction control.

(b) The mix design procedure involves the following steps:

(i) Determine the moisture density relationship for the soil using at least four different cement contents (AASHTO T134 - 76) and plot the test results on Graph I on the standard form (Sheet No.1.10.2 Drawings). The peak value on each moisture-density curve defines the Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) for the cement content used.

(ii) Plot the MDD and OMC Values for each cement content on Graph II (Sheet No.1.10.2 Drawings) and connect the test points with smooth curves to obtain for the soil the variation of MDD and OMC with varying cement content.

(iii) Using at least four different cement contents, make a series of specimens for testing unconfined compression strength (UCS) compacting the specimens to the MDD and OMC values determined in (a) above. Following a curing period of 7 days, test the specimens in accordance with the procedure given in ASTM D1633 - 63 and plot the strength values obtained on Graph III (Sheet No.1.10.2 Drawings). Draw a smooth curve through the test points and select the mix cement content as that which corresponds to the specified target strength of 24 kg/cm^2.

(iv) Enter the selected cement content on Graph II, already plotted in (ii) above, and read off the applicable MDD and OMC values for a Soil cement mix at the selected cement content. Use these MDD and OMC values to determine suitable density and moisture limits for field compaction control, and plot the limits on Graph IV (Sheet No.1.10.2 Drawings).

(v) Determine the swelling and shrinkage characteristics of the soil cement mixture by testing in accordance with AASHTO T135 - 76 and com-pare the results with the limits given in Table 5.4.3.

5.4.3.3 Laboratory Mix Design (CBR Method)

(a) All the steps given in Article 5.4.3.2 above shall be followed except that the California Bearing Ratio (CBR) test may be used as an alternative to UCS testing in step (iii). However, in the case of cohesive soils, since CBR test values generally give a less accurate indication of the mix strength than do UCS test values, the Engineer shall direct the Contractor to carry out both UCS and CBR tests each time a new soil type is encountered, and on the basis of comparing the results be way if he considers necessary, alter the CBR specifications from those given in Table 5.4.3 so that for the soil in question they correlate more closely with the tics specifications (which shall remain fixed as given in Table 5.4.3 in all cases).

(b) If CBR testing is used, the procedure given in AASHTO T193 - 72 shall be followed (2.5 kg rammer) except that after molding the specimens shall be cured as follows:

(i) The molded samples shall be placed together in a large plastic sack.

(ii) The atmosphere inside the sack shall be kept moist by placing an open-pan filled with water into the plastic sack. Care shall be taken to avoid spilling the water or otherwise letting the samples come into direct contact with the water.

(iii) The plastic sack must be completely sealed and stored for a period of exactly 72 hours, and must be kept in a shaded location.

(iv) After the 72 hours curing, the samples shall be removed from the plastic sack and shall be completely immersed in a water bath for a period of 96 hours, following which the CBR strength tests shall be performed.

Other steps in the mix design procedure are as given above in Article 5.4.3.2

5.4.3.4 Required Mix Properties

The Soil Cement Base shall conform with the requirements given in Table 5.4.3.

Table 5.4.3 Required Properties of Soil Cement Base

TEST	PROPERTY LIMITS (AFTER 7 DAYS CURING)			TEST METHOD
	Minimum	Target	Maximum	
Unconfined Compressive Strength (UCS) kg/cm^2	20	24	35	SNI 03-6887-2002 (ASTM D1633-94)
California Bearing Ratio (CBR) %	100*	120*	200*	SNI 03-1744 -1989
Average Scala Penetration Resistance over the central third of the layer tested (SPR) blow/cm	1,0* (1,0+)	1,3* (0,8+)	2,5* (0,4+)	Appendix 5.4.A of Specifications
Scala Penetration Resis-tance defining lower limits of Effective Depth of the layer (SPR) blow/cm	0,8* (1.3+)	-	-	Appendix 5.4.A of Specifications
Wetting & Drying Test (i) % Weight Loss (ii) % Volume Change	 - -	 - -	 7 2	SNI 13-6427-2000 (AASHTO T135 - 97 (2005))

Note :

* *These values may be adjusted by the Engineer to correlate with the specified UCS values, following calibration tests for each soil type.*

\+ *Figures in brackets are the equivalent penetrability in cm/blow.*

5.4.4 FIELD TRIALS

5.4.4.1 Preliminary Field Trials for Selected Mixes

(a) For each new soil type proposed to be used, the soil cement mix design indicated by the laboratory procedures described in Article 5.4.3 shall be confirmed by constructing a 200 metres long trial strip of the proposed Soil Cement Base material using the lift thicknesses, construction plant and construction and quality control procedures proposed for use in the Works.

(b) The trial strip shall be placed either off-site or if requested by the Contractor and approved by the Engineer on the basis of satisfactory laboratory results for the properties of the proposed soil, on the roadway forming part of the Works.

(c) However, in this latter case, if the trial section in any way does not perform satisfactorily, or if the Soil Cement Base placed does not in all respects meet the requirements of these Specifications, then the trial strip shall be entirely removed from the roadway and the subgrade prepared again after the trial has been carried out.

(d) If the Engineer approves the retention of the trial strip for incorporation as a part of the Works, the Soil Cement Base material shall be measured and paid for as apart of

the Works. For trial strips constructed off-site there shall be no payment. All stages of the construction, curing and testing of the trial strip shall be closely supervised by the Engineer who may request variations in the work procedures or in the quantity and type of testing as he deems necessary to obtain the maximum possible useful information from the trial. The checks made during the trial shall include, but not necessarily be limited to determination of the following:

(i) The general suitability, efficiency and effectiveness of the Contractor's proposed method and plant, determined in terms of his speed and overall ability and success in carrying out the trial.

(ii) The degree of pulverization of the soil achieved, determined by both visual inspection and by recording the number of passes of the pulverizer required to achieve the degree of pulverization specified in Article 5.4.5.3.(c).

(iii) The optimum moisture content for pulverization of the soil, determined by pulverizing at various moisture contents on different sections of the trial strip and comparing the degree of pulverization achieved with the moisture content determined by laboratory tests on samples taken during the pulverization operations

(iv) The mix homogeneity achieved by the spreading and mixing techniques employed, determined visually during the operation and by comparing the strength variation from point to point as indicated by Scala Penetrometer testing carried out after 7 days at a frequency in accordance with Article 5.4.6.5.

(v) The effectiveness of rolling and compaction, determined by Scala Penetrometer testing immediately following each pass or series of passes of the compacting plant, to establish approximately the relationship between number of passes and compaction achieved, and confirmed by carrying out sand cone field density tests in the finished work at a frequency in accordance with Article 5.4.6.4.(b).

(vi) The “bulking ratio” between the pulverized loose soil and the compacted mix, to establish the thickness of loose material required to produce the designated lift thickness of compacted mix.

(vii) The adequacy of the soil cement mix design, determined by carrying out CBR and/or UCS tests on 7 day cured specimens molded from mix samples taken just before rolling, at a frequency in accordance with Article 5.4.6.4.(a) and confirmed if considered necessary by the Engineer by UCS tests on core specimens taken from the finished trial strip.

(viii) The practicality of the density and moisture limits for compaction control established by the laboratory mix design, determined by carrying out field density and moisture content tests immediately following compaction of the mix and comparing the results with the proposed limits.

(ix) The correlation between CBR and UCS for the trial soil cement mix (in the event that CBR testing is approved or directed by the Engineer for the subsequent strength control monitoring), determined in step (vii) above by preparing and testing specimens for both test methods and comparing the average strengths obtained by each method for tests at 1 day, 7 days and 28 days.

(x) The correlation between the Scala Penetration Resistance (SPR) and the strength (CBR and/or UCS) for the trial soil cement mix, determined by carrying out penetrometer testing immediately after compaction (step (v) above), 7 days after compaction (step (iv) above) and 28 days after compaction, and comparing the average SPR values obtained for each series with the results of UCS and CBR tests carried out as for step (ix) above.

(xi) The need and most appropriate method for crack inducement and control by proof rolling, determined by observation of the trial strip during the curing period and, if excessive shrinkage cracks develop, by the controlled application of various types and weights of roller.

(xii) The most appropriate type of membrane and method for curing the Soil Cement Base, determined on the basis of visual appearance of the surface and on the rate of moisture loss as determined by moisture content tests.

(xiii) The Scala Penetration Resistance (SPR) limit to be used to determine "Effective Depth" of the Soil Cement Base layer, determined flow the penetration records obtained in step (x) above at locations where the depth of satisfactory material is accurately known (from cores taken subsequently at the penetrometre test points and from strength tests carried out on the soil cement mixture sampled from the penetrometer test locations before compaction).

(xiv) The number of lifts required to achieve satisfactory Soil Cement Base for the full design depth, determined by varying the number of lifts used on different sections of the trial strip; where use of a single lift is proposed, the use of two or more thinner lifts shall also be tried and evaluated.

(xv) Based on the data obtained from the trial strip, and not sooner than 14 days following laying of the trial strip, the Engineer may give the Contractor approval to proceed as planned, or approval to proceed contingent on whatever modifications to the mix design or construction procedure he deems necessary, or he may refuse approval to proceed and instead direct the Contractor to undertake further trials on the proposed material, or to propose a different soil or to change or increase the capacity of his plant and equipment.

5.4.5 PLACING AND MIXING

5.4.5.1 Preparation of Subgrade

(a) Subgrade preparation work shall be carried out in accordance with this Article and the provisions of Section 3.3 of these Specifications to the grades, lines and dimensions shown on the Drawings or directed by the Engineer.

(b) Subgrade means the prepared soil surface on which further road work construction is to be carried out. Except where raising of the pavement grade is indicated on the Drawings, the subgrade level shall be essentially coincident with the existing road surface, unless otherwise directed by the Engineer.

(c) The existing road surface shall be cleared of any unsatisfactory material and then proof rolled. Any irregularities or depressions that develop in the surface of the subgrade during compaction shall be corrected by loosening the surface of these

places and adding, removing or replacing material, adjusting the moisture content if necessary, and re-compacting so that the surface is smooth and uniform.

(d) The 20 cm of soil directly beneath the subgrade shall be compacted so that the density, as determined by SNI 03-2828-1992, is nowhere less than 95% of the maximum dry density obtained in accordance with SNI 03-1742-1989.

(e) Unless otherwise approved by the Engineer, the CBR value of the soil in the prepared subgrade when tested in accordance with SNI 03-1744-1989, shall be at least 6 % (six percent) after four days soaking when compacted to 100 % of the maximum dry density as determined according to SNI 03-1742-1989. Where this strength condition cannot be obtained, the Engineer may direct the Contractor to carry out subgrade improvement works involving removing and replacing the unsuitable material, or overlaying it with granular material in such proportions as is necessary to enable the Specifications to be met.

(f) On completion of compaction and before commencing the next operation, the surface of the subgrade shall comply with the surface to tolerances specified in Article 3.3.1.3 of the Specifications.

(g) Any area of subgrade that becomes muddy, broken-up or loose due to weather conditions or is otherwise damaged before commencement of the placing of the Soil Cement Base shall be corrected to conform to these Specifications at the Contractor's own expense.

(h) Prior to laying each section of Soil Cement Base, the prepared compacted subgrade shall be cleaned of all dust and other deleterious materials by air jetting or other approved means, and shall be moistened if necessary, as directed by the Engineer.

5.4.5.2 Selection of Method of Mixing and Placing

(a) Mixing of the soil, cement and water shall be accomplished either by the mix-in-place method or the central-plant-mix method. Plant-mix operations are usually confined to soils with low plasticity. An indication of the upper limit of soil plasticity that it is feasible to handle in a central plant may be obtained by multiplying the plasticity index of the soil by the percentage of the soil finer than a No.40 mesh sieve. If this value is less than 500 the plant-mix method should be possible.

(b) The various types of mix-in-place plant available can conveniently be classified into four groups:

(i) Agricultural disc harrows, agricultural disc ploughs, and motor graders.

(ii) “Light” rotavators with less than 100 HP engines.

(iii) Heavy duty rotavators with greater than 100 HP engines (often called “Pulvimixers”);

(iv) Single-pass soil stabilization machines (normally powered by at least 100 HP engines).

The upper limits of soil plasticity that it is practicable to process with there various types of plant are indicated in Table 5.4.5.

Table 5.4.5 A Guide for Selection of Suitable Equipment

GUIDE TO TYPE OF PLANT	PLASTICITY INDEX OF THE SOIL MULTIPLIED BY THE PERCENTAGE FINER THAN No. 40 SIEVE	APPROX. MAX. DEPTH CAPABLE OF BEING PROCESSED IN ONE LIFT (cm)
Central mix plant	< 500	No limit
Agricultural disc harrows, disc ploughs etc. and motor graders	< 1000	12 to 15
Light rotavators (< 100 hp)	< 2000	15
Heavy duty rota-vators (> 100 hp)	< 3500	20 to 30 depending on soil type and horse power
Single pass stabilizers	< 2000 to 3000 depending on the horse power	20

Note:
Equipment shall not be accepted or rejected on the basis of this table, which is given only as a general guide to assist the Contractor.

5.4.5.3 Placing and Mixing Using the Mix-In-Place Method

(a) Soil from the approved borrow areas shall be placed and spread evenly on the prepared subgrade and the moisture content adjusted as necessary to the optimum value for pulverization of the soil. If drying is necessary, the rate of drying it shall be maximized by continual turning of the soil using agricultural harrows, or similar equipment, and/or by an initial few passes of the pulverizer as soon as the soil is dry enough for this to be practically feasible.

(b) The optimum soil moisture content for pulverization shall be below the moisture content for Maximum Dry Density, as defined by SNI 03-1742-1989, and shall be designated by the Engineer on the basis of the Preliminary Field Trials described in Article 5.4.4 of this Specification. Unless, otherwise approved by the Engineer, on the basis of the pulverization work shall be carried out when the moisture content of the soil is within 2% (by weight of dry soil) of the value so designated.

(c) Before any cement is added, the soil shall be so pulverized that, except for stone or gravel particles, it meets the following requirements when sieved dry:

(i) Passing 25 mm sieve : 100 %

(ii) Passing No.4 sieve : 75 %

(d) The pulverized soil shall be spread at a thickness such that after compaction the designated lift thickness shall be attained, within the tolerances specified in Article 5.4.1.3.(b). The correct thickness of loose material to be laid shall be as determined in the Field Trials (Article 5.4.4 above). The number of lifts to be used to attain the full design thickness of Soil Cement Base shall be as directed by the Engineer and shall be based on the homogeneity and degree of compaction that can be achieved by the Contractor. A direction by the Engineer to increase the number of lifts shall not be considered grounds for an extension of the construction period.

(e) Following satisfactory pulverization of the soil, in accordance with the criteria given in Article 5.4.5.3.(c) above, cement shall be spread uniformly on the soil, either by hand or by a mechanical spreader. at a rate of application calculated to result in the design cement content as designated by the Engineer on the basis of the Laboratory mix design and Preliminary Field Trials. For the case of hand spreading, a guide to the spacing required for laying out standard 40 kg sacks of cement is given on the Drawings.

(f) After the cement is spread evenly, a series of passes of the mixing plant shall be given until the soil and cement are uniformly mixed throughout, as indicated by a uniform color of the mix. The maximum number of passes required shall be as designated by the Engineer on the basis of the Preliminary Field Trial (Article 5.4.4.1 above) and on the basis of the homogeneity of mix being obtained in the on going Works, as indicated by the Scala Penetrometer control testing.

(g) Unless otherwise directed by the Engineer, the work of soil placing, soil pulverization and soil cement mixing shall always be carried out from the bottom of any grade towards the top (that is, in an uphill direction).

(h) When the cement and soil are deemed to be thoroughly mixed, the moisture content shall be increased as necessary to bring it within the moisture content limits determined by the laboratory mix design procedure described in Article 5.4.3.2 or as designated by the Engineer on the basis of the Preliminary Field Trial or otherwise. Generally, the lower moisture content limit shall be fixed as the laboratory Optimum Moisture Content (OMC) for the soil cement mixture and the upper limit shall be 2 % (by weight of soil cement mixture) higher than OMC, as given in Article 5.4.3 of this Specification. The added water shall be thoroughly mixed into the soil cement using additional passes of the mixing plant and compaction commenced immediately thereafter.

5.4.5.4 Mixing and Placing Using the Central Plant Method

(a) Stationary mixing plants may be of the weigh batching or continuous feed type and may incorporate either paddle mixers or pan mixers.

(b) If weigh batching is used, the appropriate measured amounts of material and cement shall first be placed in the mixer, water being then added as necessary to bring the moisture content of the resulting mixture within the range designated for field compaction. Special care shall be taken with batch type paddle mixers to ensure that the cement is spread uniformly in the loading skip and that it is fed evenly along the mixing trough. With both paddle and pan mixers, the cement shall be proportioned accurately by a separate weighing or proportioning device from that used for the material being stabilized. The material shall be thoroughly mixed so that the cement is uniformly distributed throughout.

(c) If a continuous feed batching system is used, the mixing paddles, baffles and rate of feed of materials shall be adjusted to give a uniformly mixed material. Sprays used for distributing water into the mixer shall be adjusted to give uniformity of moisture content throughout the mix.

(d) The number and capacity of vehicles for transporting plant mixed material shall be suited to the output of the mixing plant and to the construction rate required to complete the Works within the designated Construction Period.

(e) The mixture shall be placed on the moistened subgrade in a uniform layer and be spread using a paving machine or spreader box operated with a mechanism which levels off the material to an even depth. The material shall be spread at a thickness such that after compaction the designated lift thickness shall be attained, within the tolerances specified in Article 5.4.1.3.(b).

5.4.5.5 Compaction

(a) Compaction of the soil cement mixture shall be commenced as soon as possible following mixing and the whole operation, including shaping and finishing, shall be completed within 60 minutes of the cement first coming in contact with the soil. Accordingly, the overall operation of placing, mixing and compacting Soil Cement Base shall be carried out in short sections and each section of material shall be completely compacted and shaped before any mixing is commenced on the next section.

(b) The maximum permissible length of each work section shall be designated by the Engineer on the basis of the Contractor's production capacity and capability, as demonstrated during the Preliminary Field Trials (Article 5.4.4) or subsequently, but shall not be greater than 200 metres in any event. In the case of the Engineer restricting the length of the work section, the restriction may be removed if the Contractor demonstrates to the Engineer's satisfaction that he has increased his production capacity sufficiently, but in no case shall the Engineer's restriction of the length of work section be considered valid grounds for a claim for extension of time for completion.

Initial compaction shall be by means of sheep foot, pneumatic tired or smooth wheeled rollers, which shall not be permitted to bear directly on hardened or partially hardened soil cement material previously laid.

(c) After initial rolling, shaping using a grader may be necessary before applying the finishing rolling. Compaction shall be completed using pneumatic tired or smooth wheeled rollers in conjunction with graders to bring the Soil Cement Base to the design shape. Generally, one light application of water shall be included with the finishing rolling to rectify drying of the surface during the compaction operation. The degree of compaction achieved throughout the Soil Cement Base layer shall be in excess of 97 % of the laboratory maximum dry density or in excess of such other higher density limit as may be established by the Engineer from the laboratory mix design test results, from the Field Trials, or from the on going quality control testing.

(d) Special care shall be taken to obtain full compaction in the vicinity of both longitudinal and transverse joints. Before any new material is mated with previously compacted material, the latter shall be cutback to produce a vertical face in fully compacted cemented material of the required layer thickness. Material at the transverse joint between the end of the previous work section and the beginning of the new section shall be compacted by rolling transversely (across the road) so that the full roller pressure can be brought right up to the joint without any direct bearing of the equipment on the previously laid material. In addition, the Engineer may direct that hand operated tamping compactors be used to ensure adequate compaction at the joints.

(e) The finished surface of the Soil Cement Base shall be well closed, free from movement under the construction plant and without compaction planes, ridges, cracks or loose material. All loose, segregated or otherwise defective areas shall be rectified in accordance with Article 5.4.1.7.

(f) Immediately following compaction and shaping of the final lift of Soil Cement Base, stone chippings meeting the property requirements of Section 6.2 of the Specifications are to be spread evenly on the surface of the Soil Cement Base and embedded into the surface by rolling. The chippings shall be 13 mm nominal size and the application rate shall be approximately 12 kg/m^2.

5.4.5.6 Curing

(a) Immediately following compaction and shaping of the Soil Cement Base and embedment of the stone chippings, a curing membrane shall be placed over the work and maintained in position for a period as stated in (b) below. The curing membrane may be:

(i) approved impermeable plastic sheeting, adequately secured from being blown off the surface and with joints overlapping at least 300 mm on and act to prevent loss of moisture; or

(ii) hessian cloth which shall be kept continuously damp throughout the curing period; or

(iii) other material proven effective during the Preliminary Field Trial and approved by the Engineer.

(b) The curing membrane shall be maintained in place for a period of 7 days following the mixing and placing of the Soil Cement Base, or as otherwise directed by the Engineer on the basis of the Field Trial. Curing shall be continued until the asphalt to be placed on the Soil Cement Base can be laid. At that time the curing membrane shall be removed and the bituminous Prime Coat applied in accordance with the provisions of Section 6.1 of the Specifications. However, no Prime Coat shall be permitted to be applied during the initial 24 hours of the curing period.

(c) No traffic or construction equipment shall be allowed to run on the road surface until the asphalt overlay has been placed. During the interim period the Contractor shall maintain traffic flow past the Works by the provision of suitable diversions or detours, in accordance with the requirements of Article 5.4.1.9 and Section 1.8 of these Specifications.

(d) Controlled rolling of the Soil Cement Base may be directed by the Engineer during the early curing period to minimize the size and spacing of shrinkage cracks. The extent of this rolling shall be determined during the Preliminary Trial, as described in Article 5.4.4.1.(c).

(e) When Soil Cement Base is to be constructed in two or more lifts, each lift already placed shall be cured in accordance with these Specifications for at least 7 days before the next lift may be placed.

5.4.6 QUALITY CONTROL

5.4.6.1 Control of Subgrade Preparation

(a) The frequency of compaction control testing of the subgrade shall be as directed by the Engineer on the basis of prevailing site conditions. At the minimum, sand cone density tests shall be required at intervals along the project of no more thin 200 m,

and at least one laboratory maximum dry density determination shall be carried out for every 10 field density tests perform.

(b) The frequency of sampling and testing the subgrade soils for CBR shall be as directed by the Engineer on the basis of the variety of soil types encountered. At least one CBR test shall be required for each subgrade soil type occurring along the project.

5.4.6.2 Control of Soil Pulverization

(a) Samples of the pulverized soil shall be taken and tested on site, for conformance with the particle size criteria given in Article 5.4.5.3.(c), at the rate of five samples for each work section (of 200 metres or less).

(b) If any single test fails, then pulverization shall be continued for that whole work section.

5.4.6.3 Control of Moisture for Mix-in-Place Operations

(a) Unless otherwise directed by the Engineer, moisture control sampling and testing during placing and mixing shall be carried out at intervals of no more than 100 metres along the project, and at each sampling location shall involve taking and testing samples as follows :

(i) A sample of the soil as it is first spread on the road (to establish the drying or wetting requirements before pulverizing).

(ii) A sample after mixing of the cement into the soil (to establish how much water to add to achieve the designated moisture content for compaction).

(iii) One or more samples after mixing the added water into the soil cement mixture (to check that the designated moisture content for compaction has been achieved).

(b) The moisture content test values shall generally not be obtained until after each section of work has already been compacted; however, the test results from each days work are to be taken into account in optimizing the following day's operations.

5.4.6.4 Control of Compaction of Soil Cement Base

(a) Immediately prior to commencing compaction, samples of the loose soil cement mix shall be taken from locations as directed by the Engineer and spaced no more than 500 metres apart along the project. The sampling locations selected shall coincide with cross-sections being monitored by survey leveling and by Scala Dynamic Cone Penetrometer (refer Article 5.4.6.6). Sampling shall be carried out as rapidly as possible, to minimize delay to the commencement of rolling. The samples taken shall be sealed immediately in waterproof plastic bags or containers for transport to the site laboratory where they shall (without delay, to minimize moisture loss) be used to mould test specimens for both maximum dry density tests and strength tests (either UCS or CBR, as directed by the Engineer). Unless otherwise directed by the Engineer, two specimens shall be prepared for maximum dry density determination (using SNI 03-1742-1989 compaction) and four specimens shall be prepared for strength testing (per SNI 03-1744-1989 if for CBR tests, or per ASTM D1632 if for UCS tests).

(b) Immediately following the completion of compaction of each lift, field density tests (SNI 03-2828-1992) shall be carried out, at locations as directed by the Engineer and spaced no more than 100 m apart along the road. Every fifth test location shall correspond to a location from which the loose soil cement samples were taken prior to rolling. The density and moisture content results from the sand cone tests shall be compared against the average maximum dry density and optimum moisture content measured for the two specimens molded as described in (a) above, to determine the percentage of compaction achieved in the field and whether or not moisture control in the field is adequate.

5.4.6.5 Control of Strength and Homogeneity of Soil Cement Base

(a) Following molding, the four strength test specimens described in Article 5.4.6.4 above shall be cured at high humidity inside a sealed plastic sack, using the method described in Article 5.4.3.3.(b) except that two of the specimens shall be cured in the sack until tested while the other two specimens shall be removed from the sack after 3 days and soaked in a water bath for a further 4 days before testing. All four specimens shall be tested for strength 7 days after molding and on the same day that Scala Penetrometer tests are carried out in the field at the cross-section from which the soil cement specimens were originally taken. The average of the two strength values obtained for the soaked specimens shall be recorded as the laboratory strength of the soil cement for the section of work from which it was sampled, and shall be compared against the "target strength" specified in Table 5.4.3 or designated by the Engineer. From this laboratory strength value, the strength of the Soil Cement Base in the field shall also be estimated, consideration being given to the level of compaction achieved in the field, and the value compared against the minimum specified or designated value.

(b) The average of the two strength values obtained for the un-soaked specimens shall be compared against the average blow count values for the Scala Penetrometer tests carried out at the sampling location, and the comparison used by the Engineer to check and, if he considers necessary, adjust the calibration between Scala Penetration Resistance (SPR) and strength (UCS or CBR).

(c) The results of the Scala Penetrometer tests carried out for layer thickness monitoring, as specified in Article 5.4.6.6, shall be used also to assess the overall average strength and homogeneity of the soil cement material constructed. Using the strength calibrations shown in the Drawings (Sheet 1.10.5), adjusted if necessary as provided in (b) above, an average strength value for the middle one third portion of the overall Soil Cement Base layer shall be determined from each penetration record. The average of these estimated strength values over each 200 metres (or less) section of Soil Cement Base shall be greater than the target strength specified in Table 5.4.3, and no value shall be less than the minimum strength specified in Table 5.4.3.

(d) In the event of any dispute regarding the actual strength in place of the finished Soil Cement Base, the Engineer shall direct the Contractor to take and test cylindrical cores of the material. Each such core shall be cut so that its height is exactly twice its diameter, and the ends shall be made smooth and square to the axis of the core. When tested in unconfined compression, the strength of such core specimens shall exceed the minimum limit given in Table 5.4.3.

5.4.6.6 Monitoring of Soil Cement Base Thickness

(a) The thickness of finished Soil Cement Base shall be monitored by the Contractor under the supervision of the Engineer, at 50 metres intervals along the road using

level surveys and Scala Penetrometer tests. Two different thicknesses shall be measured:

(i) the "Placed Thickness" ; and

(ii) the "Effective Thickness".

(b) The Placed Thickness of finished Soil Cement Base shall be defined and monitored as the calculated difference in levels before and after placing the Soil Cement Base, at designated monitoring points on surveyed cross sections every 50 m along the project.

(c) The Effective Thickness shall be defined and monitored as the thickness of finished Soil Cement Base material having strength in excess of the minimum limit specified in Table 5.4.3, as measured by the Scala Penetrometer at the same cross sections as those monitored by level survey. For this measurement, the penetrometer blow count shall be calibrated for strength in the manner described in Article 5.4.6.5 and the lower limit of the Effective Thickness shall be taken as the point at which the graphed blow count curve, after smoothing to remove variations due to experimental reading error, drops below the lower limit of Scala Penetration Resistance specified in Table 5.4.3 or as determined by the Engineer on the basis of the field trials. To avoid inconsistencies, the penetrometer test shall always be performed in the same standard manner of these Specifications (Appendix 5.4.A) and the blow count curve shall be plotted by assuming that the blow count value obtained for each blow applies at the depth measured after the blow has been delivered.

(d) At each cross-section to be monitored for thickness, the points to be leveled or tested by penetrometer shall be spaced equally from each other and shall include a point on the road centre line, a point at the outer edge of the hard shoulder on both sides of the road, and intermediate points as required. Unless otherwise directed by the Engineer, the total number of monitoring points per cross section shall be five.

Where the Soil Cement Base has been constructed in half width strips, two test points placed on either side of the longitudinal joint shall be used in place of the test point at the road centre line.

(e) The same monitoring points shall be used for both the level survey and the penetrometer tests. Generally the penetrometer tests shall only be carried out following placing of the final (uppermost) lift of Soil Cement Base however, if such tests are carried out on the intermediate soil cement lifts as well, the monitoring points shall be progressively shifted 20 cm along the road for each new lift, to avoid the possibility of the cone tip passing through material already disturbed by previous tests in the underlying layers.

(f) Any penetrometer test for monitoring the Effective Thickness shall not be used as a basis of measurement for payment unless both the Contractor and the Engineer, or their authorized representatives, have witnessed the test and signed the record of blow counts at the time of testing.

(g) In the event of any dispute regarding the graphical plotting of the blow count data, or of the interpretation of Effective Thickness derived therefrom, the Engineer's decision shall be final and shall govern, except where in such a case the Contractor elects, or is directed by the Engineer, to carry out coring to confirm the depth of well cemented material at the monitoring point or points in dispute.

5.4.6.7 Cement Content

In the case of unsatisfactory Soil Cement Base in which the poor quality is suspected to be due to insufficient cement content, the Engineer may direct the Contractor to carry out tests to accordance with AASHTO T144 to determine by analytical means the actual cement content of samples of soil cement mix taken from the defective work.

5.4.7 MEASUREMENT AND PAYMENT

5.4.7.1 Measurement of the Work

(a) The quantity of Soil Cement Base to be measured for payment shall be the number of cubic metres of required work completed as prescribed in this Section, calculated as the product of the length of the section being measured, the average accepted width and the average accepted thickness. Measurement shall be carried out by the Contractor and supervised by the Engineer.

(b) The quantity of Soil Cement Base accepted for measurement shall not include zones where the Soil Cement Base is less strong than the specified or approved strength, or contains loose or segregated or otherwise defective material.

(c) The average accepted thickness of Soil Cement Base measured for payment for any section shall be the average of the accepted thicknesses of Soil Cement Base measured at all the monitoring points within that section. The accepted thickness of Soil Cement Base at each monitoring point shall be the "Effective Thickness as defined in Article 5.4.6.6.(c) or the "Placed Thickness" as defined in Article 5.4.6.6.(b) or the design nominal thickness as shown on the Drawings, whichever is the least. These three thicknesses shall all be monitored at the same monitoring points, which shall be located as specified in Article 5.4.6.6.

(d) The accepted average width of Soil Cement Base measured for payment for any section shall be the average of the accepted widths measured at all monitoring cross sections within that section. The accepted width at each monitoring cross section shall be the design width of the top surface of the Soil Cement Base, as shown in the Drawings or as approved by the Engineer, or the placed width of the top surface of accepted material, whichever is the lesser. The location of monitoring cross section shall be as specified in Article 5.4.6.6.

(e) The longitudinal length along the road of Soil Cement Base shall be measured along the road centre line, using standard engineering surveying procedures.

(f) Where rectification of unsatisfactory Soil Cement Base has been directed by the Engineer in accordance with Article 5.4.1.7, the quantities to be measured for payment shall be no greater than those which would have been paid if the original work had been accepted. No additional payment will be made for the extra work or quantities necessitated by the rectification.

(g) The quantity of cement to be measured for payment for any given section of the work shall be the actual weight, measured in kilogram, mixed into the Soil Cement Base that has been accepted for payment in accordance with Article 5.4.7.1.(b), as calculated by the following formula :

$$\text{Weight of total cement used} \times \frac{\text{Accepted quantity of Soil Cement Base}}{\text{Placed quantity of Soil Cement Base}}$$

where the weight of total cement used for the section of work being measured is as recorded on the daily cement usage tallies and the placed quantity of Soil Cement Base is the number of cubic metres of material, calculated as the product of the average placed width, the average placed thickness and the length of the section, inclusive of all rejected areas.

No payment shall be made for cement that is wasted or discarded, nor for cement that is used in areas that are deemed unacceptable as Soil Cement Base.

No separate measurement shall be made for stone chipping to be used as specified in Article 5.4.5.5.(g) and this work shall be included in the materials to be used for Soil Cement Base.

5.4.7.2 Basis of Payment

(a) The quantity of subgrade preparation, determined as provided above shall be paid for in accordance with Article 3.3.4 of these Specifications.

(b) The quantities of cement and soil cement base, determined as provided above, shall be paid for at the Contract Price per unit of measurement, for the Pay Items shown below and in the Bill of Quantities. The rates shall include for all materials, labor, plant, tools, testing and other work incidental to satisfactory completion of the work.

Pay Item No.	Description	Unit of Measurement
5.4.1	Cement for Soil Cement Base	Ton
5.4.2	Soil Cement Base	Cubic Metre