CHAPTER 3 PAVEMENT WORKS

SECTION 3.1 SUBBASE COURSE

3.1.1 CRUSHED AGGREGATE SUBBASE COURSE

3.1.1.1 Description

3.1.1-1.1 This item shall consist of a subbase course composed of crushed aggregates constructed on a prepared subgrade or underlying course in accordance with these specifications, and in conformity with the dimensions and typical cross section shown on the Drawings.

3.1.1.2 Materials

3.1.1-2.1 The subbase material shall consist of hard durable particles or fragments of granular aggregates. This material will be mixed or blended with fine sand, clay, stone dust, or other similar binding or filler materials produced from approved sources. This mixture must be uniform and shall comply with the requirements of these specifications as to gradation, soil constants, and shall be capable of being compacted into a dense and stable subbase. The material shall be free from vegetable matter, lumps or excessive amounts of clay, and other objectionable or foreign substances. Pit-run material may be used, provided the material meets the requirements specified.

TABLE 1. GRADATION REQUIREMENTS

Sieve designation (square openings) as per ASTM C 136	Percentage by weight passing sieves (%)
3 inch (75.0 mm)	100
No. 10 (2.0 mm)	20 - 100
No. 40 (0.450 mm)	5 - 60
No. 200 (0.075 mm)	0 - 15

The portion of the material passing the No. 40 (0.450 mm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than 6 when tested in accordance with ASTM D 4318 or JIJ 058-94.

In those cases where frost penetration is a problem, the maximum amount of material finer than 0.02 mm in diameter shall be less than 3%.

3.1.1.3 Construction Requirements

3.1.1-3.1 Spreading and Laying

a. When the course design thickness is greater than 16 cm, spreading and laying must be performed for each layer.

b. The surcharge for the spreading and laying shall in principle be 1.3–1.4 of the compaction thickness.

c. The crushed stone for each layer shall be gathered all at once in order to facilitate leveling through the surcharge.

3.1.1-3.2 Compaction

a. Compaction shall follow the principles of "start slow and then speed up" as well as "first roll lightly and then heavily." The roller tracks shall overlap by 30 cm when using a two wheel roller and by half the back wheel when using a three wheel roller. The compaction shall begin from the edges (edges shall be rolled two or three times, to stabilize the crushed stone and prevent the stones from shifting outward beyond the edges), and progress gradually towards the center.

b. The crushed stone shall first be stabilized with a light roll of 6–8 tons, and the speed shall be no more than 30 m per minute. If an 8–10 ton medium size roller is to be used to stabilize the crushed stone, the rolling speed shall be no more than 25 m per minute. Moreover, water shall be sprinkled before rolling, and care must be taken that the crushed stone is not broken into small pieces.

   After this rolling, the roller shall be replaced with a 12 ton roller, and the crushed stone shall be rolled at a speed in excess of 30 m per minute. Immediately after rolling, water shall be sprinkled to maintain moisture in the crushed stone.

c. If the crushed stone is rolled excessively so that the stones become spherical or contain substantial gravel dust, the portion that has been excessively rolled shall be excavated, the minute stone fragments shall be removed by a sieve, new polygonal stone fragments shall be added and this area shall be rolled again.

d. The main crushed stone layers must be compacted properly before laying the joint sealing filler.

e. When compacting the joint sealing filler it shall be advisable to switch to a 12–15 ton heavy roller. The rolling speed may be increased to 40 m per minute. Immediately after compacting the joint filler shall be wiped, water shall be sprinkled on the surface, and comparatively large voids shall be filled with pebbles.

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f. The crushed stone subbase course after compacting and sealing shall be hard and evenly flat. The joint filler also must not stick up from the surface or be gathered into a single layer.

3.1.1-3.3 The quality of crushed stone subbase course shall meet the following standads:

Quality Standards for Crushed Stone Subbase Course

Inspection Category	Quality Specification	Explanation
Compacting Density	Dry Density ≥ 2.1 kg/L	Test at least one location every 100 m using the sand replacement method
Surface Smoothness	Voids ≤ 15 mm	Test with a 3 m straightedge
Thickness	Permitted Margin of Error ± 10%, but not more than ± 2 cm	
Width	At least the specified width	Measure the length from the center line to both ends.
Height of Subbase Layer	Permitted Margin of Error + 1 cm – 2 cm	Measure the 1 horizontal cross-section every 10 m. The interval between measured locations shall in principle not exceed 10 m.
Exterior	Compacting is to be performed with a 12 ton or heavier roller. No roller marks shall be left. The surface shall be hard, stable and flat, and voids shall be leveled.	

SECTION 3.1.2 CEMENT-STABILIZATION TREATED SUBBASE COURSE

3.1.2.1 Description

3.1.2-1.1 This item shall consist of a base course composed of crushed aggregate and cement uniformly blended and mixed with water. The mixed material shall be spread, shaped, and compacted in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross sections shown on the Drawings.

3.1.2.2 Materials

a. Cement

(i) The type of cement shall be as provided in the Drawings.
(ii) The cement shall meet the requirement of JIS R 5210 or GB 175.

b. Water

(i) The water shall not contain any oil, acid, salt, concrete, organic impurities or other substances that would have an adverse impact on the concrete or steel materials.
(ii) Sea water shall not be used as mixing water.
(iii) The Engineer may instruct that tests be performed pursuant to JIS A 5308 Annex 9, if the Engineer determines such to be appropriate. The expenses for such tests shall be borne by the Contractor.

c. Aggregate

(i) The aggregate to be used for the cement-treated subbase shall not contain substantial amounts of soft stone, silt, clay clumps, debris, tree or grass roots or other substances that would have an adverse impact on the mixing of the cement with water.

(ii) Gradation of Aggregate shall be as follows:

Gradation of Aggregate

Sieve Size (mm)	Percentage by Weight Passing Sieves
50	100
40	95–100
20	50–100
2.5	20–60
0.075	0–15

Quality Specifications for Aggregate shall be:

Category	Testing Method	Specification
Plasticity Index (P.I) for Passing through 426 μm Sieve	JIS1205	9 or less

d. Storing of Cement.

(i) The cement shall be stored separately according to type, in a silo or warehouse that is resistant to moisture.

(ii) When the cement is to be stored in a silo, care must be taken that there is no cement accumulation on the floor that does not pour out freely.

Packed cement shall be stored on a floor at least 30 cm above the ground, and must be stacked in a manner convenient for transport and inspection. Moreover, cement bags shall not be stacked to a height of more than 13 bags.

(iii) Cement that has been stored for an extended period must be tested prior to use, and may not be used if the cement no longer meets the specifications, or if clumps have accumulated during storage.

(iv) If cement has reached an excessively high temperature, the cement may only be used after the cement is cooled to an appropriate temperature.

e. Storage of Aggregate

(i) Aggregate that differs in type or granularity must be stored separately by classification.

If the maximum measurements of the aggregate are 40 mm or above, the aggregate must be stored, in two separate categories.

(ii) The aggregate must be stored so that the surface water is as consistently the same as possible.

(iii) During acceptance, storage and handling, the aggregate shall be prevented from dividing into large and small particles, and care shall be taken to prevent any debris or dirt from mixing into the aggregate.

(iv) Aggregate to be used during cold periods shall be stored in a facility that prevents snow from entering and prevents freezing.

(v) Aggregate to be used during hot months shall be stored in a facility which prevents exposure to direct sunlight.

3.1.2.3 Construction Requirements

a. Mix Proportion

(i) Prior to mixing, the Contractor shall determine the mix proportion for the cement stabilizer, submit the related data to the Engineer and obtain the Engineer's approval.

(ii) The cement shall be mixed according to the mixing specifications for the cement stabilizer, with the necessary volume of water mixed in, and cured for 6 days. The mix proportion shall be determined by the Contractor at a mixture that yields a uni-axial compressive strength of at least 2.0 N/mm2 after 1 day of water permeation, and submitted to the Engineer for approval.

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3.1.3 LIME FLY ASH STABILIZED CRUSHED STONE SUBBASE COURSE

3.1.3.1 Description

3.1.3-1.1 This item shall consist of a subbase course composed of lime fly ash stabilized crushed stone, which is a mixture of a specific quantity of lime, fly ash and crushed stone, with the appropriate quantity of water mixed in, which mixture has been compacted and cured, and the strength of which meets the design requirements for pressure resistance values.

3.1.3-1.2 The mixed material shall be spread, shaped, and compacted in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross sections shown on the Drawings.

3.1.3.2 Materials

3.1.3-2.1 Lime fly ash stabilized crushed stone materials must meet the following specifications:

a. Lime

Lime shall be quicklime powder. The lime must meet the specifications of "Quicklime Powder for Architectural Works" (JC/T 480-92).

b. Fly ash

SiO_2, Al_2O_3 and Fe_2O_3 shall constitute at least 70% of the content of the fly ash. Furthermore, the combustion loss shall not exceed 10%, and the specific surface area shall be at least 2500 cm^2 per gram. The dried fly ash shall be transported in a closed container to prevent environmental pollution from dust spreading, and the fly ash shall be stored in a warehouse that can keep out wind and rain. Any caked fly ash shall be crushed at the time of use, or pressed through a sieve, and at the same time any hazardous impurities shall be removed.

c. Crushed Stone

Unsieved crushed stone of 0–50 mm shall be used for the lower sub-base for the lime fly ash stabilized crushed stone. The percentage remaining after passing through a 50 mm sieve shall be no more than 10%, and the Los Angeles coefficient shall be no more than 35%.

The maximum diameter for the crushed stone particles in the upper sub-base of the lime fly ash stabilized crushed stone layer shall be no more than 30 mm, and

the Los Angeles coefficient shall be no more than 30%. The crushed stone must meet the following specifications:

Sieve Size (mm)	0.075	0.5	1	2	5	10	20	30
Percentage by Weight Passing (%)	0–10	10–20	20–40	28–50	40–65	55–80	90–100	100

d. Water

It shall be sufficient to use standard potable water.

3.1.3.3 Construction Requirements

3.1.3-3.1 The compaction density for the lime fly ash stabilized crushed stone for the upper sub-base shall be at least 98%, and the 7-day submerged compressive strength shall be at least 0.8 Mpa. The compaction density for the lime fly ash crushed stone for the lower sub-base shall be at least 96%, and the 7-day submerged compressive strength shall be at least 0.6 Mpa.

3.1.3-3.2 Testing shall be required to ensure that the mix proportion for the lime fly ash stabilized crushed stone meets the strength requirements stated above. The trial mix shall be as stated in the "Technical Specification for Construction of Highway Road-Bases" (JTJ 034-93). In the upper sub-base the mix proportion of the stabilized crushed stone and lime fly ash shall be at least 75 to 25, and in the lower sub-base this ratio shall be at least 70 to 30.

The lime fly ash stabilized crushed stone mix proportion test shall measure the 28-day compressive strength and the 28 day laboratory compressive strength rebound coefficient. For the lime fly ash stabilized crushed stone used in the upper-sub base, the 28-day compressive strength (one day submerged) shall be at least 2.0 Mpa and the 28-day laboratory compressive strength rebound coefficient shall be at least 550 Mpa. The lower sub-base lime fly ash stabilized crushed stone 28-day compressive strength (one day submerged) shall be at least 1.5 Mpa, and the 28-day laboratory compressive strength rebound coefficient shall be at least 450 Mpa.

Tests such as those for the moisture content, compaction density, compressive strength, and laboratory compressive strength rebound coefficient shall be as set forth in the "Testing Methods of Materials Stabilized With Inorganic Binders for Highway Engineering" (JTJ 057-94).

3.1.3-3.3 Prior to performing the actual lime fly ash stabilized crushed stone upper sub-base and lower sub-base work, proof laying must be performed and the necessary bearing capacity factor (K75) must be firmly established.

3.1.3-3.4 The lime fly ash stabilized crushed stone sub-base work shall be performed after the work for the existing channels in the pavement area, and the laying work for the drainage channels, hydrant pipes and cable ducts have passed inspection. The work for the lower sub-base shall be inspected by measuring the height of the sub-grade surface to ensure that this complies with the height specified in the Drawings. The following adjustments shall be taken if a difference of 20 mm or more is detected.

a. Remove the excess portion, and then re-perform rolling and compacting.

b. If the height is not sufficient, add crushed stone. The maximum diameter of the crushed stone particles shall be 50 mm, and shall be no more than 1/2 the thickness of the layer. After laying the crushed stone, re-perform rolling and compacting.

3.1.3-3.5 If the lime fly ash stabilized crushed stone work is being performed in the monsoon season, constant attention shall be paid to changing weather conditions, and care shall be taken to prevent excess moisture content in the mixed materials during the work. Further, mixing, hauling, spreading, and compacting shall be performed as quickly as possible, and water drainage from surfaces shall be removed. If rain falls on the mixed materials after spreading and rolling, the materials shall quickly be re-compacted, and compacted once again after the rain stops. If rain falls before spreading and rolling, and the mixed materials are moistened, the materials shall be allowed to dry in the sun to an appropriate moisture content, and rolling shall be performed after mixing with an appropriate quantity of lime. If rain continues for several days the work shall be temporarily halted.

3.1.3-3.6 The minimum temperature at the time of the work for the lime fly ash stabilized crushed stone shall be at least 5 °C, and the work shall be completed at least one month to one and a half months before the first frost (from -3 °C to -5 °C).

3.1.3-3.7 The lime fly ash stabilized crushed stone mixed materials shall be mixed intensively in a forced mixer or an impeller mixer. These materials shall not be mixed in the open air.

3.1.3-3.8 The lime fly ash stabilized crushed stone lower sub-base may be laid and rolled manually. For the upper sub-base, use of a spreading machine shall be desirable, but manual laying and rolling by a careful worker using simple equipment shall be permissible. If a spreading machine is not to be used, very close care shall be taken to ensure that the sub-base is flat and that the correct height has been maintained at all times.

3.1.3-3.9 Testing shall be performed after spreading and shaping the mixed materials. Compacting may be performed when the moisture content is within ±1% of the optimum moisture content. The compacting shall start with light pressure and shall steadily become stronger, and shall start slowly and steadily increase the pace. The

compacting shall also start from the edges and work towards the center. Initial compacting shall be performed once or twice using a caterpillar tractor or 8–10 ton tandem roller, after which the sub-base shall be inspected to confirm that there are no differences in level. Any sections that are higher than the specifications shall be graded to specification, and mixed material shall be added to any locations that are lower than specification, so that these locations also meet the specified height. When adding the mixed material, first the layer shall be excavated, softened and then moistened with water, following which the mixed material shall be added to the layer. Then the location shall be compacted with a large roller or a vibrating roller. During compacting the surface of the sub-base shall be kept constantly moist. If the surface becomes too dry, sprinkle as necessary with water. If there is excess water content in isolated locations, resulting in standing water, looseness or undulations, this shall be corrected by backfilling with new mixed material. When compacting, care shall be taken in finishing connecting sections between the area being compacted and surrounding sections. The length of the connecting sections shall at all times be longer than the length of the compacting machine. Normally when compacting one area a strip of 4–5 m shall be left uncompacted. When compacting the next area, the connecting section left uncompacted in the first area shall be excavated and softened. Then an appropriate amount of lime, fly ash and water shall be added and mixed in. Whereupon this connecting section shall be spread and rolled, and subsequently compacted together with the second section. The roller shall not change direction, or stop suddenly over sections on which compacting work has been completed, or on surfaces being compacted.

3.1.3-3.10 The time difference between work for each area being compacted shall be kept to an absolute minimum, to prevent hardening of the mixed materials, as well as to prevent any clearance from developing in junctures between sections.

3.1.3-3.11 The completion inspection and sprinkling and curing shall be performed immediately after the lime fly ash stabilized crushed stone sub-base is completed. Curing shall take place over seven days, during which time traffic shall be prohibited from passing over. Once the lower sub-base has been cured, the upper sub-base shall immediately be laid and rolled. The upper sub-base shall be compacted in two layers. After the lower layer is cured for seven days the upper layer shall be laid and rolled. The number of times per day for sprinkling water shall be determined on the basis of weather conditions, and the surface shall at all times be kept moist. Cracking from drying out shall at all times be prevented, even if the pavement concrete is not placed immediately after curing the upper level for seven days, by sprinkling the appropriate amount of water depending on weather conditions.

3.1.3-3.12 Any lime, or lime dust remaining in the area shall be removed before placing the pavement concrete, and care shall be taken to ensure that this debris does not get mixed in with sand or lime stored in the stockyard.

3.1.3-3.13 The work method and procedures for the lime fly ash stabilized crushed stone sub-base shall be as set forth in the "Technical Specification for Construction of Highway Road-Bases" (JTJ 034-93).

3.1.3-3.14 The frequency of materials testing for the lime fly ash stabilized crushed stone sub-base shall be as set forth in Table 8.2.2 of the "Technical Specification for Construction of Highway Road-Bases" (JTJ 034-93), excluding the two items in the table concerning organic substance and lead sulfate content, as well as the Cement No. and hardening time.

3.1.3-3.15 The quality tests, standards, testing methods and frequency for the lime fly ash stabilized crushed stone shall be as stated in the following table:

Number	Test	Standard	Testing Method and Frequency
1	Purity of Lime	±1%	At least 1 every 2000 m^2
2	Crushed Stone and Fly ash Content	±3%	Same as above
3	Uniformity of Mixing	The Mixture Shall Have a Consistent Color	By Human Eye
4	Relative Density	Upper Sub-Base: ≥ 0.98 Lower Sub-Base: ≥ 0.96	Sand Replacement Method, at least twice every 1000 m^2.
5	Thickness Precision	Upper Sub-Base: ± 20 mm Lower Sub-Base: ± 20 mm	Boring or Bit Inspection, at least twice every 2000 m^2
6	Width	Planned Width	Measure with a steel gauge in one location every 40 m.
7	Surface Smoothness	Upper Sub-Base (Upper Layer): ≤ 10 mm Upper Sub-Base (Lower Layer): ≤ 15 mm Lower Sub-Base: ≤ 15 mm	Inspect in three locations every 2000 m^2 using a 3 m gauge. In each location, measure three times in succession in a triangular shape, and take the average maximum clearance.
8	Height Accuracy	Upper Sub-Base (Upper Layer): +5 mm, -10 mm Upper Sub-Base (Lower Layer): +10 mm, -20 mm Lower Sub-Base: +10 mm, -20 mm	Measure using a level. Measure 1 cross-section every 10 m. The distance between measured points shall be 10 m.
9	Compressive Strength	The compressive strength shall conform to the requirements stated in 4.1.3.	The mixed material shall be sampled in different locations every 2000 m^2 and at least 6 test pieces shall be taken. The compaction relative densities of the test pieces shall be identical with the compaction relative densities onsite.
10	Exterior Inspection	There shall be no wave formations or clear tracks left from running a compacting roller of 12 tons or more over the surface. The surface should not have any undulations or springing, and the color should be consistent.	

3.1.4 MEASUREMENT AND PAYMENT

3.1.4.1 Method of Measurement

3.1.4-1.1 The quantity of each type of subbase course to be paid for shall be the number of square meters for each layer and thickness of subbase course actually constructed and accepted by the Engineer as complying with the Drawings and specifications except on-site hauling of subbase course materials. The quantity of subbase course material shall be measured in final position based upon depth tests or cores taken as directed by the Engineer, or at the rate of 1 depth test for each 420 square meters of subbase course, or by means of average end areas on the complete work computed from elevations to the nearest 3 mm.

3.1.4-1.2 On-site hauling of subbase course materials will be measured by the number of cubic meters

3.1.4.2 Basis of Payment

3.1.4-2.1 Payment for each type of subbase course shall be made at the Contract unit price per square meter for each layer and thickness of subbase course. This price shall be full compensation for furnishing all materials, except hauling and curing; for all preparation, mixing, placing and compacting of these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

3.1.4-2.2 Payment shall be made at the Contract unit price per cubic meter for on-site hauling of subbase course materials. This price shall be full compensation for loading, hauling, and depositing; and for all labor, equipment, tools, and incidentals necessary to complete the item.

3.1.4-2.3 Payment shall be made at the Contract unit price per square meter for curing of subbase course materials. This price shall be full compensation for spraying water on these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item No.	Description of Work	Unit of Measurement
I-2-1	Runway	
14)*	Lime fly ash stabilized crushed stone (upper sub-base) (T 18cm)	square metre
15)*	Lime fly ash stabilized crushed stone (lower sub-base) (T 18cm)	square metre
I-2-2		
9)*	Crushed stone for sub-base course (T 20cm)	square metre

I-2-39	Hauling and Curing of Sub-base Materials	
11)	On-site hauling	cubic metre
12)	Curing	square metre

Note: The items marked with * represent items that reappear repeatedly within the B/Q. Here only the item No. firstly appears is shown.

SECTION 3.2 CEMENT CONCRETE PAVEMENT

3.2.1 Description

3.2-1.1 This work shall consist of pavement composed of cement concrete constructed on a prepared underlying surface in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the Drawings.

3.2.2 Materials

3.2-2.1 Cement.

Cement shall meet the requirements of GB 175. Portland cement shall be used for the cement concrete pavement.

In principle classes of cement shall be selected with reference to the pavement design strength indicated in the following table.

Pavement Design Strength (Mpa)		Cement Class
Flexural	Compressive	
4.5	30	Portland Cement No. 425 shall be used.
5.0	35	Portland Cement No. 525 shall be used.
5.5	40	Portland Cement No. 525 shall be used.

The properties of each type of cement shall conform to the various requirements for each category for the 1979 cement standards of the Chinese National Standards Inspection Bureau. A proper shipping report must be made for cement transported on site. Cement of different dates, manufacturers, types, and Cement Class must not be mixed during storage or transport.

No. 525 ordinary portland cement shall be used for concrete, with a 28-day design flexural strength of 5.0 Mpa. No. 425 or No. 525 ordinary portland cement shall be used for the shoulder concrete (28-day design tensile strength of 4.5 Mpa). Magnesium oxide content in the cement shall be 3% or less. The other quality

standards for the cement shall conform with GB 175, and the alkali content shall be 0.6% or less.

3.2-2.2 Fine Aggregate

Medium coarse river sand with a fineness modulus of 2.6–3.0 shall be appropriate for the fine aggregate. The mud content shall be 3% or less. If the mud content exceeds specifications, the sand shall be washed with water. A qualified testing facility shall be contracted and shall measure the alkali aggregate reaction pursuant to the "Test Methods of Aggregate for Highway Engineering (JTJ 058-94). No sand shall be used that has an alkali aggregate reaction.

The gradation of the fine aggregate must in principle conform to the following requirements:

Gradation for Fine Aggregate

Category	Type	Percentage by Weight Remaining on Sieves (%)					
		Sieve Designation (mm) (Square Openings)					
		0.16	0.315	0.63	1.25	2.50	5
1	Coarse Sand	90–100	80–95	71–85	35–65	5–35	0–10
2	Middle Sand	90–100	70–95	41–70	10–50	0–25	0–10

The hardness of the fine aggregate shall be tested using a sodium sulfate solution. Weight loss shall not exceed 10% after soaking the sample 5 times in the solution and drying.

Organic impurities contained in the fine aggregate must meet the requirements specified below:

a. mica content must not exceed 1% of weight;

b. ingredients with a specific gravity of less than 0.2g/cm^3 (light ingredients including lime or zinc) shall not exceed 1% of weight;

c. organic impurities must not have a deeper color than the standard color (observation through color comparison method). Fine aggregate that contains organic impurities with a deeper color than the standard color may only be used through mortaring with aggregate of a standard color, and if the mixture meets the requirements for compressive strength under a comparison test for flexural and compressive strengths.

d. The fine aggregate shall have a sulfide and sulfate content of less than 1% of weight (converted to SO_3).

3.2-2.3 Coarse Aggregate

Crushed stone shall be used for the coarse aggregate. The crush stone particles shall have a maximum diameter of 40 mm. A qualified testing facility shall be contracted and shall measure the alkali aggregate reaction pursuant to the "Test Methods of Aggregate for Highway Engineering (JTJ 058-94). No crushed stone shall be used that has an alkali aggregate reaction. The crushed stone shall be divided into two categories of 5–20 mm particles and 20–40 mm particles. After mixing these two categories, the coarse aggregate shall meet the following specifications.

Sieve Size (mm)	40	20	10	5
Percent by Weight Remaining (%)	0–10	50–70	70–90	90–100

The strength of the coarse aggregate shall be measured according the crushing index. A test pierce shall be taken of a 5x5x5 cm solid sample made from crushed stone or cobblestone that is saturated with water. The maximum compressive strength of this test pierce shall be at least 60 Mpa for igneous rock, and at least 80 Mpa for sedimentary rock.

Crashing Index for Crushed Stone and Cobblestone

Stone Quality	Concrete Class (Mpa)	Crush Index (%)	
		Crushed Stone	Cobble Stone
Sedimentary Rock	60–40	10–12	≤ 9
	40–30	12–14	9–11
Plutonic Rock	60–40	12–19	12–18
	40–30	19–21	18–20
Eruptive Rock	60–40	≤ 13	
	40–30	13–15	

The maximum particle size must not exceed 40 mm. The aggregate particles must be consistent, and must in principle meet the following requirements:

Particle Distribution	Nominal Particles (mm)	Percentage by Weight Remaining on Sieves (%)							
		Sieve Designation (mm) (Square Openings)							
		2.5	5	10	15	20	25	30	40
Continuous Particles	520	95–100	90–100	30–70		0–10			
	5–40		95–100	75–90		30–65			0–5
Single Particles	20–40			95–100		80–100			0–10

Course aggregate must conform to each of the following requirements:

a. Hardness.

The hardness must meet the values set forth in the following table:

Concrete Environment Conditions	No. of Immersions or Soaking	Percent of Weight Loss After Circulation
Normal Environmental conditions	5	Not more than 5
Regions Where Average Minimum Temperature in Coldest Month is Between -5 °C and -15 °C inclusive		
Regions Where Average Minimum Temperature in Coldest Month is -15 °C or Lower	5	Not more than 5

b. Wear Resistance.

Coarse aggregate must meet certain conditions for wear resistance, which consist of the following:

(1) The abrasion loss shall be measured using two drums, and the resulting weight loss must not be more than 7%.

(2) Measurement shall be made of the actual shock effects (using a steel ball), and the resulting weight loss shall be no more than 35%.

c. Needle and Fragment Content.

The needle and fragment content shall not be more than 15% of the weight.

d. Dirt Content.

The dirt content in the crushed stone, crushed cobblestone or cobblestone (i.e,. the total content of debris, mud or clay in particles smaller than 0.08 mm) shall be no more than 1% of the weight.

e. Noxious Material Content.

Sulfide and sulfate content for the crushed stone, crushed cobblestone or cobblestone as well as organic impurities in the cobblestone must meet the requirements prescribed in the following table:

Category	Quality Specification
Percentage of weight for sulfide and sulfate content converted to SO_3	1% or less

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Organic impurities contained in cobblestone (observed through color comparison method)	The color must not be deeper than the standard color. If the color is deeper than the standard color, a second inspecton shall be made using the concrete strength comparison test.

In addition to the methods stated in these Specifications the testing methods for crushed stone, crushed cobblestone or cobblestone shall be pursuant to the stipulations of the National Architectural Administration Standards (JGJ53--79).

3.2-2.4 CEMENTITIOUS MATERIALS.

a. Fly ash. Fly ash shall meet the requirements of ASTM C 618 or GB [ ].

b. Blast Furnace Slag. Ground blast furnace slag shall meet the requirements of ASTM C 989 or GB [ ].

3.2-2.5 PREMOLDED JOINT FILLER. Premolded joint filler for expansion joints shall conform to the requirements of ASTM D 1751 or GB [ ]. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

3.2-2.6 JOINT SEALER. The joint sealer for the joints in the concrete pavement shall meet the requirements of GB [ ] and shall be of the type(s) specified in the Drawings.

a. GB [ ] for Polyvinyl Chloride (PVC) joint sealer

b. GB [ ] for Polyurethane (PUT) joint sealer

3.2-2.7 STEEL REINFORCEMENT. Reinforcing bars shall conform to the requirements of applicable GB standards.

a. Round bars specified as 10 mm or less
GB 1498-91 or JIS G 3112 (Grade SR 24)

b. Deformed bars specified as 10 mm or more
GB 1499-91 or JIS G 3112 (Grade SD 30)

3.2-2.8 TIE AND SLIP BARS. Tie bars shall be deformed steel bars and conform to the requirements of ASTM A 615 or GB 1499-91.

Slip bars shall be round steel bars conforming to ASTM A 615 or GB 1498-91 and shall be free from burring or other deformation restricting slippage in the concrete.

3.2-2.9 WATER. Water used in mixing or curing shall be clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product. Water will be tested in accordance with the requirements of AASHTO T 26. Water known to be of potable quality may be used without testing.

River water, pond water or other water may be used if the following requirements are met:

a. The water must not contain any noxious substances such as oil, carbohydrates, acid, alkaline or salt.

b. The ion density index (pH value) for the water must be between 4 and 9, and blue litmus paper must not change color when soaked in the water for one hour.

c. Impurities in the water must not be in excess of 200 mg/λ.

d. The sulfur chloride content must not exceed 2700 mg/λ (when converted to sulfur trioxide).

e. The total salt content must not be in excess of 5000 mg/λ.

3.2-2.10 COVER MATERIAL FOR CURING. Curing materials shall conform to one of the following specifications:

a. Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C 309, Type 2, Class B.

b. White polyethylene film for curing concrete shall conform to the requirements of ASTM C 171.

c White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C 171.

3.2-2.11 ADMIXTURES. The use of any material added to the concrete mix shall be approved by the Engineer. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the Engineer from the supply of material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

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a. Air-Entraining Admixtures. Air-entraining admixtures shall meet the requirements of ASTM C 260 or GB 8079-87 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entrainment agent and any chemical admixtures shall be compatible.

b. Chemical Admixtures. Water-reducing, set retarding, and set-accelerating admixtures shall meet the requirements of ASTM C 494 or GB 8079-87 , including the flexural strength test.

c. The type and quantity of admixture shall be determined on the basis of testing based on the demands for the work. The quality of the admixture shall conform to GB 8079-87. Furthermore, use of the admixture shall conform to GBJ 119-88. Use of a retarding water-reducing agent is recommended, and alkali additives with a pH value of 8 or more shall not be used. The quantity of admixture used shall be carefully controlled.

3.2-2.12 PAINT BITUMEN. Coating materials used to slip bars and tie bars shall be bituminous paint conforming to GB [ ].

3.2-2.13 MATERIAL ACCEPTANCE. Prior to use of materials, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate Chinese national test(s) for each material, the test results, and a statement that the material passed or failed.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

3.2.3 Mix Design

3.2-3.1 MIX PROPORTION

a. The strength of cement concrete pavement shall be determined mainly on the basis of the ultimate flexural strength in a three load points test. An ultimate compression strength test shall be performed using the portions bent in the flexural strength test conducted during the concrete mix proportion test.

b. The concrete mix proportion shall must have a flexural strength of at least 1.5 times the test strength for the concrete to be used in paving.

c. The quantity of cement used must not be less than 300 kg/m^3, and shall be determined depending on the conditions for roughness, durability and resistance to abrasion for the cement concrete pavement.

d. The concrete mix proportion shall yield the specified strength, and shall meet the requirements for abrasion resistance, durability and ease of working. To reduce small cracks on the surface, the ratio of water to cement shall be 0.44 or less. The amount of cement used shall be in the range of 30–32 Mpa.

e. When a curing mat is to be used for the cement concrete pavement, the concrete strength test shall be performed based on this curing mat, and the mixing proportion for the cement concrete work shall be determined on the basis of the same.

f. The consistency of the concrete shall be appropriate for ease of spreading and finishing. The slump shall be 10 cm or less, and the Vee Bee settlement time shall be in the range of 20–40 seconds. Measurements shall be taken at least twice each work-shift.

3.2-3.2 TESTING LABORATORY. The laboratory used to develop the mix design shall meet the requirements of ASTM C 1077 or JTJ 053-94. A certification that it meets these requirements shall be submitted to the Engineer prior to the start of mix design and shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A statement that the equipment used in developing the mix design is in calibration.

c. A statement that each test specified in developing the mix design is offered in the scope of the laboratory's services.

d. A copy of the laboratory's quality control system.

3.2.4 Construction Methods

3.2-4.1 EQUIPMENT. The Contractor shall furnish all equipment and tools necessary for handling materials and performing all parts of the work.

a. Batch Plant and Equipment. The batch plant and equipment shall conform to the requirements of ASTM C 94.

b. Mixers and Transportation Equipment.

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(1) General. Concrete may be mixed at a central plant, or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

(2) Central Plant Mixer. Central plant mixers shall conform to the requirements of ASTM C 94.

The mixer shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 19 mm or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

(3) Truck Mixers and Truck Agitators. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C 94.

(4) Nonagitator Trucks. Nonagitating hauling equipment shall conform to the requirements of ASTM C 94.

c. Finishing Equipment. The finishing equipment shall be of sufficient weight and power for proper finishing of the concrete. The finishing machine shall be designed and operated to strike off, screed and consolidate the concrete such that laitance on the surface is less than 3 mm thick.

d. Vibrators. Vibrator shall be either internal type with immersed tube or multiple spuds, or surface type vibrating pan or screed. For pavements 20 cm or more thick internal vibrators shall be used. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.06-0.13 cm. For pavements less than 20 cm thick, vibrating surface pans or screeds shall be allowed. Operating frequencies for surface vibrators shall be between 3,000 and 6,000 vibrations per minute.

The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases.

Hand held vibrators may be used in irregular areas.

e. Concrete Saws. The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations.

f. Side Forms. Straight side forms shall be made of steel and shall be furnished in sections not less than 3 m in length. Forms shall have a depth equal to the pavement thickness at the edge.

Flexible or curved forms of proper radius shall be used for curves of 30 m radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 3 mm in 3 m, and the upstanding leg shall not vary more than 6 mm) The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer.

g. Pavers. The paver shall be fully energized, self-propelled, and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross section. It shall be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown in the Drawings, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The paver shall be equipped with electronic or hydraulic horizontal and vertical control devices.

3.2-4.2 FORM SETTING. Forms shall be set sufficiently in advance of the concrete placement to insure continuous paving operation. After the forms have been set to correct grade, the underlying surface shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place sufficiently to maintain the form in position for the method of placement.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 3 mm at any joint. 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 oiled prior to the placing of concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete.

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3.2-4.3 CONDITIONING OF UNDERLYING SURFACE, SLIP-FORM CONSTRUCTION. The compacted underlying surface on which the pavement will be placed shall be widened approximately 1 m to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, the areas which will support the paving machine and the area to be paved shall be trimmed or graded to the plan grade elevation and profile by means of a properly designed machine. The grade of the underlying surface shall be controlled by a positive grade control system using lasers, stringlines, or guide wires. If the density of the underlying surface is disturbed by the trimming operations, it shall be corrected by additional compaction and retested at the option of the Engineer before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the Contractor. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. The underlying surface shall be protected so that it will be entirely free of frost when concrete is placed.

3.2-4.4 CONDITIONING OF UNDERLYING SURFACE, SIDE-FORM AND FILL-IN LANE CONSTRUCTION. The prepared underlying surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Damage caused by hauling or usage of other equipment shall be corrected and retested at the option of the Engineers. If damage occurs to a stabilized subbase, it shall be corrected full depth by the Contractor. A template shall be provided and operated on the forms immediately in advance of the placing of all concrete. Thse template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade. The underlying surface shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface shall not be permitted.

The template shall be maintained in accurate adjustment, at all times by the Contractor, and shall be checked daily.

3.2-4.5 HANDLING, MEASURING, AND BATCHING MATERIAL. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in such a manner that prevents segregation and intermixing of deleterious materials.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage.

Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot, or other approved device, to prevent loss of cement. The device shall be arranged to provide positive assurance that the cement content specified is present in each batch.

3.2-4.6 MIXING CONCRETE. The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C 94 or GB 50204-92. Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or nonagitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in nonagitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. Retempering concrete by adding water or by other means will not be permitted, except when concrete is delivered in transit mixers. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified in the mix design is not exceeded.

3.2-4.7 LIMITATIONS ON MIXING AND PLACING. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

a. Cold Weather. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 4 degrees C and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 2 degrees C.

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 10 degrees C at the time of placement.

Concrete shall not be placed on frozen material nor shall frozen aggregates be used in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 66 degrees C.

The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials.

b. Hot Weather. During periods of hot weather when the maximum daily air temperature exceeds 30 degrees C, the following precautions shall be taken.

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 35 degrees C. The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.

The finished surfaces of the newly laid pavement shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium.

When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the concrete surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

3.2-4.8 PLACING CONCRETE. The Contractor has the option of side (fixed) form or slip-form paving. At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 1 m.

Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 32 kg/cm^2, based on the average of four field cured specimens per 150 cubic meters of concrete placed. Subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 23 kg/cm^2.

a. Side-form Method. For the side-form method, the concrete shall be deposited on the moistened grade to require as little rehandling as possible. Unless truck mixers, truck agitators, or nonagitating hauling equipment are equipped with means for discharge of concrete without segregation of the materials, the concrete shall be placed and spread using an approved mechanical spreading device that prevents 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. Workers shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

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 centered above the joint assembly.

Concrete shall be thoroughly consolidated against and along the faces of all forms and previously placed concrete 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 20 seconds in any one location, nor shall the vibrators be used to move the concrete.

b. Slip-form Method. For the slip-form method, the concrete shall be placed with an approved crawler-mounted, slip-form paver designed to spread, consolidate and shape the freshly placed concrete in one complete pass of the machine so that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformance with requirements of the Drawings and specifications. The concrete shall be placed directly on top of the joint assemblies to prevent them from moving when the paver moves over them. Side forms and finishing screeds shall be adjustable to the extent required to produce the specified pavement edge and surface tolerance. The side forms shall be of dimensions, shape, and strength to support the concrete laterally for a sufficient length of time. Final finishing shall be accomplished while the concrete is still in the plastic state.

In the event that slumping or sloughing occurs behind the paver or if there are any other structural or surface defects which, in the opinion of the Engineer, cannot be corrected within permissible tolerances, paving operations shall be immediately stopped until proper adjustment of the equipment or procedures have been made. In the event that satisfactory procedures and pavement are not achieved after not more than 600 m of single lane paving, the Contractor shall complete the balance of the work with the use of standard metal forms and the formed method of placing and curing. Any concrete not corrected to permissible tolerances shall be removed and replaced at the Contractor's expense.

3.2-4.9 STRIKE-OFF OF CONCRETE AND PLACEMENT OF REINFORCEMENT. Following the placing of the concrete, it shall be struck off to conform to the cross section shown on the Drawings and to an elevation such that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the Drawings. When reinforced concrete pavement is placed in two layers, the bottom layer shall be struck off to such length and depth that the sheet of reinforcing steel 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. If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place, it 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 positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.

Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM or GB specification requirements.

3.2-4.10 JOINTS. Joints shall be constructed as shown on the Drawings and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the Drawings. Joints shall not vary more than 13 mm from their designated position and shall be true to line with not more than 6 mm variation in 3 m.

The surface across the joints shall be tested with a Contractor furnished 10-foot (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4 inch (6 mm) shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the Drawings.

a. Construction. Longitudinal construction joints shall be slip-formed or formed against side forms with or without keyways, as shown in the Drawings.

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the Contractor shall remove the excess concrete back to the previous planned joint.

b. Contraction. Contraction joints shall be installed at the locations and spacing as shown on the Drawings. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. When the groove is formed in plastic concrete the sides of the grooves shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the Drawings.

c. Expansion. Expansion joints shall be installed as shown on the Drawings. The premolded filler of the thickness as shown on the Drawings, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

d. Dummy joints.

(1) The grooves for each of the pavement joints shall be cut by sawing. If the depth of the joints is not more than 30 mm, the grooves may be cut directly using a 7 mm thickness diamond toothed saw. If the depth of the joints is greater than 30 mm, the grooves may be cut once using a combination diamond tooth blade, or the cut may be made twice using two diamond tooth blades of differing thickness. The cut using the 7 mm blade shall be to a depth of 30 mm, and the cut using the 3mm–4mm blade shall be to the depth indicated in the Drawings.

(2) The date on which joint cutting by cutter is to begin shall be determined through testing. The outer forms shall be removed after the compressive strength reaches at least 10 Mpa. In locations bordered on both sides by previously laid concrete, the concrete shall be laid only after the compressive strength of the concrete layers on both sides reaches at least 15 Mpa. The cutting speed shall be suited to a compression strength for the cement concrete of 60–100 kg/cm^2. The necessary strength expansion curve shall be tested in the laboratory for the each different air temperature, and the cutting time for the cement concrete shall be determined on the basis of the work

conditions together with the cutting tests onsite. In principle, when there is a substantial difference in temperatures between day and night, aqueous rock crushed stone shall be used for the concrete aggregate, and when existing pavement is being repaired for the concrete pavement, the cutting time shall be pursuant to the lowest permitted value for the concrete hardness. When there is little difference in temperatures between day and night, comparatively hard stone such as granite or cobblestone shall be used as the aggregate for the concrete, and when a new concrete pavement is being laid, the cutting time shall be pursuant to the highest permitted value for the concrete hardness. The actual cutting time appropriate shall be confirmed through cutting tests on site.

In order to assist the smooth progress of cutting of the concrete pavement, it is recommended that water reducing agents shall not be used when the air temperature during the execution of the work is less than 20°C. If the air temperature is lower than +10°C, it is recommended that a high-early strengthening agent be used.

(3) In order to ensure smooth progress of the cutting work, a sufficient quantity of cutters must be kept on hand. In principle when calculating based on a 400L mixer one cutter should be available for each mixer. When calculating for a 1000L mixer, 3 cutters should be kept on hand for each mixer. If the thickness of the concrete pavement is less than 22 cm, it will be necessary to increase the number of cutters by 1/4 to 1/3.

(4) After cutting, all openings shall be filled with straw rope, to prevent sand, rocks or other debris from falling into the joints.

(5) To prevent concrete from entering irregular contraction fissures, several contraction joints shall be used manually for each joint in regions where there is a substantial temperature difference during the daytime and which are arid.

e. Keyways. Keyways shall be formed in the plastic concrete by means of side forms or the use of keyway liners which are inserted during the slip-form operations. The keyway shall be formed to a tolerance of 1/4 inch (6 m) in any dimension and shall be of sufficient stiffness to support the upper keyway flange without distortion or slumping of the top of the flange. The dimensions of the keyway forms shall not vary more than plus or minus 1/4 inch (6 mm) from the mid-depth of the pavement. Liners that remain in place permanently and become part of the keyed joint shall be made of galvanized, copper clad, or of similar rust-resistant material compatible with plastic and hardened concrete and shall not interfere with joint reservoir sawing and sealing.

f. Tie Bars. Tie bars shall consist of deformed bars installed in joints as shown on the Drawings. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the Drawings. They shall be held in position parallel to the pavement surface and in the middle of the slab depth. When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. These bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed in the female side of the keyed joint provided the installation is made without distorting the keyed dimensions or causing edge slump. If a bent tie bar installation is used, the tie bars shall be inserted through the keyway liner only on the female side of the joint. In no case shall a bent tie bar installation for male keyways be permitted.

When setting tie bars to the butt joint, the tie bar, chair and crossbar shall be assembled first, and the tie bar assembly shall be set in the designated location, so that the tie bar assembly bonds properly to the concrete.

g. Slip Bars.

(1) Requirements for Slip Bars.

The slip bars must be completely straight. Asphalt shall be applied to one end of the bars. The length of this asphalt shall be one-half the length of the slip bars, or longer than approximately 20 mm–30 mm. The thickness of the asphalt application shall be at least 1 mm. If the slip bar is to be used for an expansion joint, one end shall be treated with asphalt, but the slip bar must first be firmly placed in its socket.

(2) Location of Slip Bars.

The slip bars shall be placed on top of the slip bar spacer before the concrete is placed. The concrete shall then be placed in the designated locations. Once compacting reaches half of the thickness, the slip bar shall be placed on top of the slip bar spacer at the exact position. Placing shall then be performed again for the remaining half of the concrete, and after compacting with a finisher, the zinc plated steel cables holding the slip bars in place shall be immediately cut, and the slip bar spacer shall be removed.

Once the slip bar has been firmly installed pursuant to the design location, special care shall be required to prevent shifting left or right or up and down.

(3) An expansion board of 20 mm in thickness that has been treated for anticorrosion shall be required for the entire depth of the joint for an expansion board. Placement of this expansion board shall in principle be

the same as the previous paragraph. However, the slip bar shall be fixed in place a second time using the slip bar sparer, after the expansion board has been inserted, pursuant to the design, and the slip bar spacer shall be placed at the exact position. After this, concrete shall be poured simultaneously on both sides of the expansion board. Whereupon the concrete shall be compacted, and the slip bar spacer shall be removed.

3.2-4.11 FINAL STRIKE-OFF, CONSOLIDATION, AND FINISHING.

a. Sequence. The sequence of operations shall be the strike-off, floating and removal of laitance, straightedging, and final surface finish. The addition of superficial water to the surface of the concrete to assist in finishing operations will not be permitted.

b. Finishing at Joints. The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in paragraph 3.2-4.8a. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine, to, over, and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 20 cm from the joint. Segregated concrete shall be removed from the front of and off the joint; and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

c. Machine Finishing. The concrete shall be spread as soon as it is placed, and it shall be struck off and screeded by a finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give to proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided. When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation 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. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the

striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

d. Hand Finishing. Hand finishing methods will not be permitted, except under the following conditions: in the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade; in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical. Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete when reinforcement is used.

The screed for the surface shall be a least 0.6 m)longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal.

Consolidation shall be attained by the use of suitable vibrators.

e. Floating. After the concrete has been struck off and consolidated, it shall be further smoothed and trued by means of a longitudinal float using one of the following methods:

(1) Hand Method. Long-handled floats shall not be less than 3.6 m in length and 15 cm in width, stiffened to prevent flexibility and warping. The float shall be operated from foot bridges spanning but not touching the concrete or from the edge of the pavement. Floating shall pass gradually from one side of the pavement to the other. Forward movement along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or laitance in excess of 1/8-inch (3 mm) thick shall be removed and wasted.

(2) Mechanical Method. The Contractor may use a machine composed of a cutting and smoothing float(s), suspended from and guided by a rigid frame and constantly in contact with, the side forms or underlying surface. If necessary, long-handled floats having blades not less than 1.5 m in length and 15 cm in width may be used to smooth and fill in open-textured areas in the pavement. When the crown of the pavement will not permit the use of the mechanical float, the surface shall be floated transversely by means of a long-handleds float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and laitance in excess of 3 mm thick shall be removed and wasted. Successive drags shall be lapped one-half the length of the blade.

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f. Straight-edge Testing and Surface Correction. After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a Contractor furnished 4.8 m straightedge swung from handles 1 m longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance in excess of 1/8-inch (3 mm) thick shall be removed from the surface of the pavement and wasted. Any 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 smoothness requirements of paragraph 3.2-5.2d. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

3.2-4.12 SURFACE TEXTURE. The surface of the pavement shall be finished twice with a wooden trowel and once with a steel trowel for all newly constructed concrete pavements.

a. First the surface is created with a wooden trowel (length 80 cm–160 cm), and is spread through rubbing the surface. This has the effect of further distributing the cement milk evenly over the concrete surface. The thickness of the cement milk in general shall be 3 mm–5 mm.

b. After waiting for the water content to rise to the surface of the concrete, the surface is smoothed again with the wooden trowel. This has the effect of spreading the water evenly over the surface.

c. Once the water has risen to the concrete surface and has been spread over the surface, a steel trowel is used to spread the surface. The exterior should be firmly compacted and there most not be any gravel exposed, marks from spreading, holes, air bubbles or fissures.

3.2-4.13 ROUGH FINISHING. Rough finishing of concrete pavement shall conform to the following requirements.

a. Under normal conditions, as soon as the water reflection can no longer be seen on the concrete surface, grooves shall be made in the concrete surface, using a brush.

b. The grooves must be perpendicular to the direction in which aircraft will run on the runway.

c. The roughness of the rough finishing must meet the requirements for slip prevention for the runway surface. Normally, once the rough finishing for the concrete runway has been completed, the average depth of the grooves measured by the sand fill method shall be as follows:

Runway, Rapid Exit Taxiway	≥ 0.50 mm
Taxiway, Ramp Parking, Apron	≥ 0.40 mm

Any areas for which there are particular design conditions shall be finished pursuant to the design requirements as indicated in the drawings.

d. The concrete pavement for the rough finish shall be rough, but shall be firm. No gravel shall appear on the surface, and the surface shall not be flaked.

e. For the brushing for the rough surface it shall be permissible to use normal boar bristle or nylon fiber brushes. The effect of the brushing shall be confirmed through testing to determine whether or not the brushes are suitable.

f. Brushes shall be washed constantly to prevent cement from adhering and hardening to the brushes.

3.2-4.14 CURING. Immediately after finishing operations are completed and marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the methods below. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour during the curing period. The curing period shall be determined through testing. If no tests are performed, the standard curing period shall be 14 days.

a. Impervious Membrane Method. The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of 4 liters to not more than 14 square meters. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any

cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or other approved means. Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface.

b. Polyethylene Films. The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units shall be lapped at least 450 mm. The sheeting shall be placed and weighted to cause it to remain in contact with the surface and sides. The sheeting shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the pavement. Unless otherwise specified, the sheeting shall be maintained in place for 14 days after the concrete has been placed.

c. Waterproof Paper. The top surface and sides of the pavement shall be entirely covered with waterproofed paper. The units shall be lapped at least 450 mm. The paper shall be placed and weighted to cause it to remain in contact with the surface covered. The paper shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the slab. The surface of the pavement shall be thoroughly saturated prior to placing of the paper. Unless otherwise specified, the paper shall be maintained in place for 14 days after the concrete has been placed.

d. White Burlap-Polyethylene Sheets. The surface of the pavement shall be entirely covered with the sheeting. The sheeting used shall be such length (or width) that it will extend at least twice the thickness of the pavement beyond the edges of the slab. The sheeting shall be placed so that the entire surface and both edges of the slab are completely covered. The sheeting shall be placed and weighted to remain in contact with the surface covered, and the covering shall be maintained fully saturated and in position for 14 days after the concrete has been placed.

e. Curing in Cold Weather. The concrete shall be maintained at a temperature of at least 10 degrees C for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

3.2-4.15 REMOVING FORMS. Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing.

After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated in paragraph 3.2-4.14.

Major honeycombed areas shall be considered as defective work and shall be removed and replaced.

3.2-4.16 ASPHALT COATING ON KEY JOINTS Key-joints shall be manufactured using steel forms in the shape of a protruding key joint. After removing the form, the exposed surfaces shall be promptly coated with asphalt.

3.2-4.17 SEALING JOINTS. The joints in the pavement shall be sealed in accordance with the following methods.

a. Time for Joint Sealing.

In principle the faster the joints are sealed the better. The optimal method is to perform joint sealing after the cutter joints are completed, and after drying through curing.

b. Cleaning the Joints.

Cleanliness, or lack thereof, will have a direct effect on the joint sealing. For this reason this process must be fully and carefully executed. First all sand, mud and other foreign objects must be removed from the joints with a hook. After this dust and particles or other debris shall be blown out using an air compressor, leaving the joint clean. The cleanliness and dryness of every joint must be maintained. At the same time all debris removed shall be gathered and transported so that it does not affect the joints.

c. Joint Filler Work.

The joint filler work must be performed under normal temperature conditions. At the same time the injector must be able to maintain the appropriate temperature. If the air temperature falls below 20 °C, the concrete joints shall be heated using a torch lamp, and joint filling shall be performed with heat being applied. Joint filling materials shall be determined through mixing tests. The method for filling the joints shall be determined on the basis of specific conditions such as the quality of the joint filler materials used in each location and the work season.

3.2-4.18 PROTECTION OF PAVEMENT. The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. This shall include workers to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, and protection of unsealed joints from intrusion of foreign material, etc. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. The Contractor shall have available at all times,

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materials for the protection of the edges and surface of the unhardened concrete. Such protective materials shall consist of rolled polyethylene sheeting at least0.1 mm thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

3.2-4.19 OPENING TO TRAFFIC. The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C 31 or JTJ 50204-92 have attained a flexural strength of 3,800 kPa when tested in accordance with ASTM C 78 or JTJ 053-94. If such tests are not 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.

3.2.5 Material Acceptance

3.2-5.1 ACCEPTANCE SAMPLING AND TESTING.

a. Quality of Materials

Specified inspections and tests shall be performed for the cement, water, fine aggregate, coarse aggregate, admixture and steel bars. The tests shall be pursuant to JTJ 053-94 (Testing Methods of Concrete for Highway Engineering), and JTJ 058-94 (Test Methods of Aggregate for Highway Engineering).

The types of joint filling materials and the forming measurements shall be as set forth in the Drawings. The quality of the materials shall conform with the specifications set forth in the table below.

Item	Specification
Consistency	Under 20 Seconds
Hardening Time	6–24 Hours
Elasticity	Penetration 3–5 mm, Recovery Rate at least 75%
Plasticity	0 mm (no cracking or loosening)
Penetration	No more than 9 mm
Elongation (-10 °C)	At least 15 mm

b. Testing and inspection shall be performed during the work, and records shall be taken for mix proportion mixing, forming, joints, finishing, appearance (including exposure of aggregate, beehiving, pockmarked surface, cracks, laitance, breaking corners, buried clumps).

c. The concrete compressive strength shall be tested using a beam test piece and a column test piece. The form of the beam test piece shall be rectangular parallelepiped, 15 cm x 15 cm x 55 cm. The column test piece samples shall be obtained by boring the concrete blocks onsite. Samples shall be taken at the ratio of one location per 10,000 m^2. The test piece tests shall conform with JTJ 053-94 (Testing Methods of Concrete for Highway Engineering). At the same time as the concrete distribution test is performed, the correlative relation between the compressive strength in the column test piece, and the tensile strength in the beam test piece, shall be analyzed.

d. The thickness inspection of the concrete pavement blocks shall be made through sampling the boring cores onsite.

3.2-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the completed pavement:

(1) Flexural strength
(2) Surface smoothness
(3) Faulting
(4) Roughness
(5) Straightness of joints
(6) Thickness, length, and widths
(7) Pavement height
(8) Others

b. Flexural strength

(1) Testing of the concrete shall be performed by the contractor. The main strength test for the concrete shall be for the maximum flexural strength. Specimens shall be samples that have been aged for 28 days. No more than 5% of the average value for each sample group shall be lower than the design strength. At the same time the average strength of the specimens for any group must not be less than 90% of the design strength.

(2) Extracting, creating, curing and measurement of strength for the concrete specimens shall be pursuant to AASHTO T97 or ASTM C78, which is known as a beam test with third-point loading.

(3) The concrete specimens must meet the following requirements:

i) When the volume of the concrete work is in excess of 5,000 m^3, two concrete specimen groups shall be created for each 400 m^3 in pavement.

ii) When the volume of the concrete work is 5000 m^3 or less, two concrete specimen groups shall be created for each 200 m^3 in pavement.

iii) The strength test (bending test) shall be carried out on the 7th and 28th day of aging. If the concrete work quality has stabilized some time after work has been completed, and if there has been no change in the materials used, the bending test on the 7th day of aging may be shortened or omitted.

(4) Variation Control

i) Variation and consistency in the strength of the concrete shall be as determined in the following table:

Work Control Level	Standard Deviation σ for Bending Strength (in kg/cm^2)
Superior	≤ 6
Passing	≤ 8
Failing	>8

The standard deviation shall be calculated as set forth below:

ii) Valuation of consistency.

Determination of test sample statistics:

1) Samples shall be taken of the runway, the parallel taxiway, the access, terminal apron and aprons (including fueling apron, holding bay and cargo apron).

2) Statistical requirements:

The 28 day aging samples for each zone shall be divided into several groups, and the bending strength for each group shall be measured.

The standard deviation will be obtained using the following formula

$$\sigma = \sqrt{\frac{1}{n-1}\left(\Sigma X_1^2 - n\bar{X}^2\right)}$$

Symbols:

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σ = Standard Deviation (kg/cm^2)

n = Number of test sample groups for each zone

ΣX_i^2 = The sum of the squares of the strengths for each zone

$\overline{X}^2$ = The square of the arithmetical average of the strength for each zone.

Evaluation method.

A relative comparison shall be made of the results obtained through the calculation made under the above conditions, and the concrete strength quality for each work category shall be evaluated on the basis of this comparison.

c. The quality standards (tolerance) for categories other than strength and consistency shall be as set forth in the following table:

Quality Standards for Cement Concrete Pavement Other than Strength and Consistency

Inspection Category	Quality Standards (Tolerance, etc.)	Explanation
Surface Smoothness	Voids must be less than 3 mm. No more than 15% of the voids shall be over 3 mm	Measure using a 3 m straightedge, using a sample inspection for each block for a total of 1/5 of the blocks.
Faulting	Faults in vertical direction shall be no more than 3 mm. Faults in horizontal direction shall be no more than 2 mm	Sample inspection for each block for a total of 1/10 of the blocks.
Roughness	The roughness values for the runway and the rapid exit taxiway shall be in excess of 0.5 mm. No more than 15% of these values shall be less than 0.5 mm. For other pavement the roughness values shall be 0.4 mm and no more than 15% of these values shall be less than 0.4 mm.	To be measured using the sand fill method. Three locations shall be inspected for each block, for a total of 1/10 of the blocks. The position of these three locations shall be on both ends of the opposing angle line and in the middle of this line.
Straightness of Joints	The tolerance shall be ±10 mm.	To be measured using a 20 m thread. A sample inspection shall be made of 1/10 of all joints.
Thickness	The tolerance shall be ±5 mm	Inspection shall be made after removing the forms. A sample test shall be made of each block for a total of 1/10 of all joints.
Length	Runway -- 1/4000 Other -- 1/3000	Measurement shall be made using a steel coil scale that has been tested with a transit and standard scale to confirm that it meets the standards. The measurement and testing shall be conducted in accordance with the Class 3 Traverse Measurement Standards

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Inspection Category	Quality Standards (Tolerance, etc.)	Explanation
Width	1/2000	Measurement shall be made using a steel coil scale from the center line to both sides. One location shall be measured every 200 m.
Pavement Height	The tolerance shall be ±5 mm	Measurement shall be made for the horizontal cross section in one location every 10 meters. The distance between measured locations shall not exceed 10 m.
Measurement of center of buried objects	The tolerance shall be ±10 mm	The vertical and horizontal directions shall be measured using a steel coil scale.
Exterior	The concrete pavement must not have cracks, exposed rock, dips, foot marks or holes or unevenness such as beehiving. The joints must not be missing ends or angles. The joints must be fully filled with joint filler, and the joint filler must be well adhered and hard. There should be no foreign matter in the holes, and the ends of the joints must be cleanly aligned.	

3.2.6 Contractor Quality Control

3.2-6.1 QUALITY CONTROL PROGRAM. The Contractor shall develop a Quality Control Program in accordance with Section 5.8 of the General Provision. The program shall address all elements which effect the quality of the pavement including, but not limited to:

a. Mix Design
b. Aggregate Gradation
c. Quality of Materials
d. Stockpile Management
e. Proportioning
f. Mixing and Transportation
g. Placing and Consolidation
h. Joints
i. Dowel Placement and Alignment
j. Flexural or Compressive Strength
k. Finishing and Curing
l. Surface Smoothness

3.2-6.2 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.

A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

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a. Fine Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily in accordance with ASTM C 136 or JTJ 058-94 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture Content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C 70 or ASTM C 566 or JTJ 058-94.

b. Coarse Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C 136 or JTJ 058-94 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture Content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C 566 or JTJ 058-94.

c. Slump. Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in Section 3.2-5.1. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C 143 or JTJ 053-94 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C 172 or JTJ 053-94.

d. Air Content. Four air content tests, shall be performed for each lot of material produced in accordance with the lot size defined in Section 3.2-5.1.

3.2-6.3 CONTROL CHARTS. The Contractor shall maintain linear control charts for fine and course aggregate, gradation, slump, and air content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the Contract item number, the test number, each test parameter, the Action and Suspension Limits, or Specification limits, applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems

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and assignable causes before they occur. If the Contractor's projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the Engineer may halt production or acceptance of the material.

3.2-6.4 CORRECTIVE ACTION. The Quality Control Plan shall indicate that appropriate action shall be taken when a process is believed to be out of control. The Plan shall detail what action will be taken to bring a process into control and shall contain sets of rules to gauge when a process is out of control.

3.2.7 Chip Leveling

3.2-7.1 The leveling layer shall be the sub-base surface for the concrete pavement, and consequently the materials used for the leveling layer must be clean and stable, and contain no foreign matter, including limestone or soil clumps, grass or roots. Asphalt chip screed or medium grain sand may be used to create the leveling layer. When laying the leveling layer with chip screed, the optimum method shall be to use stone chips for the portion containing stone granules.

3.2-7.2 The thickness of the leveling layer shall in principle be 2 cm–3cm. When laying once, the layer shall be consistent, and a line shall be placed for leveling. After fully sprinkling with water (sprinkling with water shall be prohibited if asphalt is used to make the leveling layer), the layer shall be compacted three or four times with a 6–8 ton light roller, and the layer must be compacted firm and flat. If the shoulder subbase is to be used as a work road, it shall be advisable to lay the leveling layer for the subbase surface to a somewhat looser consistency.

3.2-7.3 Quality specifications for leveling layer shall be as follows:

Inspection Category	Quality Specification	Explanation
Height of Subbase Layer	Permitted Margin of Error ±5 mm	Measure 1 horizontal cross-section every 10 m. The interval between measured locations shall in principle not exceed 10 m.
Surface Smoothness	Voids ≤ 10 mm	Test with a 3 m straightedge
Exterior	The surface shall be firm, stable and flat.	

3.2.8 Precast Concrete Block

3.2-8.1 This item shall consist of construction of precast concrete blocks for runway shoulder, B-taxiway shoulder and cargo apron in accordance with these Specifications, at the specified locations and conforming to the lines, grades, cross sections and dimensions shown on the Drawings.

3.2-8.2 Materials for precast concrete blocks shall meet the requirements of Section 4.3 of this Special Provision.

3.2-8.3 Construction methods for precast concrete blocks shall conform to Section 4.3 of this Special Provision.

3.2.9 Method of Measurement

3.2-9.1 Cement concrete pavement shall be measured by the number of square meters of pavement concrete for each design strength and pavement thickness, as specified in-place, completed and accepted. The quantity of pavement concrete shall be measured in final position based upon depth tests or cores taken as directed by the Engineer, or at the rate of 1 depth test for each 300 square meters of pavement, or by means of average end areas on the complete work computed from elevations to the nearest 3 mm.

No measurements or other allowances shall be made for form-work. No deductions in area shall be made for the volumes of reinforcing steel or embedded items.

Curing of pavement concrete shall be measured by the number of square meters of surface area.

3.2-9.2 Chip leveling shall be measured by the number of square meters of leveling layer as in place, completed and accepted.

3.2-9.3 Asphalt coating on joints or expansion joint board shall be measured by the number of square meters of materials in place, completed and accepted.

3.2-9.4 Curing shall be measured by the number of square meters of each type of cover materials for curing, in place, completed and accepted.

3.2-9.5 Dummy joint cutting or joint sealing or surface texture finishing shall be measured by the number of liner meters of materials in place, completed and accepted.

3.2-9.6 Reinforcing steel shall be measured by the calculated theoretical number of tons placed, as shown on the Drawings, complete in place and accepted. The unit weight used for deformed bars shall be the weight of plain square or round bars of equal nominal size.

3.2-9.7 Precast concrete blocks shall be measured by the number of cubic meters of concrete in accordance with the dimensions shown on the Drawings.

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3.2.10 Basis of Payment

3.2-10.1 Payment shall be made at the Contract unit price per square meter for cement concrete pavement for each design strength and pavement thickness or chip leveling. Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the Drawings.

3.2-10.2 Payment shall be made at the Contract unit price per square meter for asphalt coating on joints or expansion joint board or curing; at the Contract unit price per meter for dummy joint cutting or joint sealing or surface texture finishing; at the Contract unit price per cubic meter for concrete block; and at the Contract unit price per ton for reinforcing steel. These prices shall be full compensation for furnishing all materials and for all preparation, delivering, placing and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item No.	Description of Work	Unit of Measurement
I-2-1	Runway	
1)*	Cement concrete 5.0Mpa (T 46cm)	square metre
2)*	Cement concrete 5.0Mpa (T 45cm)	square metre
3)*	Cement concrete 5.0Mpa (T 42cm)	square metre
4)*	Cement concrete 5.0Mpa (T 39cm)	square metre
5)*	Cement concrete 5.0Mpa (T 37cm)	square metre
6)*	Cement concrete 5.0Mpa (T 35cm)	square metre
7)*	Cement concrete 5.0Mpa (T 32cm)	square metre
8)*	Cement concrete 5.0Mpa (T42~37cm)	square metre
9)*	Cement concrete 5.0Mpa (T42~35cm)	square metre
10)*	Cement concrete 5.0Mpa (T42~32cm)	square metre
11)*	Cement concrete 5.0Mpa (T46~37cm)	square metre
12)*	Cement concrete 5.0Mpa (T46~39cm)	square metre
13)*	Cement concrete 5.0Mpa (T42~39cm)	square metre
	Chip leveling (T 2cm)	square metre
16)*	Asphalt coating on joint (T 2mm)	square metre
17)*	Dummy joint cutting (W0.4cm, D8cm)	metre
18)*	Dummy joint cutting (W0.8cm, D3cm)	metre
	PVC joint sealing (W0.8cm)	metre
19)*	PUT joint sealing (W0.8cm)	metre
20)*	Traction type finishing	metre
	Pressure type finishing	metre
22)*	Curing (film)	square metre
I-2-2		
1)*	Precast concrete block	cubic metre

11)*	Expansion joint board (T 2cm)	square metre
17)*	Curing (sheet)	square metre

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6)	Tie bar	ton
7)	Slip bar	ton
8)	Re-bar for earthing	ton
9)	Anchor bar	ton

Note: The items marked with * represent items that reappear repeatedly within the B/Q. Here only the item No. firstly appears is shown.

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SECTION 3.3 GROOVING

3.3.1 Description

This item shall consist of saw-cutting the pavement surface forming transverse grooves in accordance with size, configurations, and locations shown on the Drawings.

3.3.2 Size an Configuration of Groove

For new concrete pavements that have hardened, transverse grooves shall be saw-cut in the pavement with the following size and configurations.

Section	:	6 mm x 6 mm
Interval	:	32 mm
Length	:	40 m of runway center in section and full section of rapid exit taxiway
Area to be grooved	:	as indicated on the Drawings

3.3.3 Construction Requirements

a. Preparations

(1) Cleaning: debris, soil, or other foreign materials on pavement surface to be grooved shall be removed and cleaned prior to grooving work.

(2) Grooving area: Area to be grooved shall be marked so that it can be clearly discriminated even at night.

(3) Grooving machine shall be approved through trial grooving in advance.

(4) Water tanker used for grooving shall be able to supply water of more than 160 litres per minute.

(5) Water shall not contain harmful substances such as oil, acid, salt, etc.

(6) Sufficient lighting necessary for the work during night shall be provided.

b. Construction

(1) Grooving shall be performed at right angles to the runway center line within the specified area.

(2) Clearance

(i) Fifteen centimeters clearance shall be maintained in grooving where a cable for lighting exists.

(ii) Seventy-five millimeters clearance shall be maintained in grooving where there exists expansion joint or transverse contraction joint for concrete pavement.

(3) Groove depth: Care shall be taken that the depth of groove is not deeply formed than designed.

(4) Grooving shall be carried out in parallel with transverse joint in case of concrete pavement.

(5) Cleaning shall be continued during the work and the Contractor shall request the Engineer's inspection for status of cleaning before the area is used to aircraft.

(6) Alignment toleranceshall be plus or minus 38 mm in alignment for 23 m. Groove tolerance shall be minimum depth 5 mm, except that not more than 60 percent of the grooves shall be less than 6 mm.

3.3.4 Measurement and Payment

a. Measurement

Saw-cut grooving shall be measured by the number of square meters of saw-cut grooving as specified in-place, completed, and accepted.

b. Payment

Payment for saw-cut grooving shall be made at the Contract unit price per square meter for saw-cut grooving. Payment shall be full compensation for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item No.	Description of Work	Unit of Measurement
I-2-1-21*	Grooving	square metre

Note: The items marked with * represent items that reappear repeatedly within the B/Q. Here only the item No. firstly appears is shown.

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SECTION 3.4 PAVEMENT MARKINGS

3.4.1 Description

This item shall consist of the painting of numbers, letters, markings, guidelines, stripes and other signs on the pavement surfaces of runway, taxiways, loading apron, and G.S.E. service road applied in accordance with these Specifications and at locations shown on the Drawings, or as directed by the Engineer.

3.4.2 Materials

The paint shall be Thermo Plastic type, white and yellow traffic paints and shall conform to AASHTO M249 or GB [ ] or equivalent but without surface application of glass beads.

3.4.3 Construction Requirements

a. Weather Limitations

The painting shall be performed only when the existing surface is dry and clean, and when the weather is not excessively windy, dusty, or foggy. The suitability of the weather will be determined by the Engineer.

b. Equipment

All equipment for the work shall be approved by the Engineer and shall include the apparatus necessary to properly clean the existing surface.

The mechanical marker shall be an approved type marking machine suitable for application of traffic paint. It shall produce an even and uniform film thickness at the required coverage and shall be designed so as to apply markings of uniform cross sections and clear-cut edges without running or spattering and within the limits for straightness set forth herein.

c. Preparation of Existing Surface

Immediately before application of the paint, the existing surface shall be dry and entirely free from dirt, grease, oil, acids, laitance, or other foreign matter which would reduce the bond between the coat of paint and the pavement. The surface shall be thoroughly cleaned by sweeping and blowing as required to remove all dirt, laitance, and loose materials. Areas which cannot be satisfactorily cleaned by brooming and blowing shall be scrubbed as directed with a water solution of trisodium phosphate (10% Na3Po4 by weight) or an approved equal solution. After scrubbing, the solution shall be rinsed off and the surface dried prior to painting.

Existing markings or stripes which are to be abandoned or removed shall be obliterated or obscured by the best methods suited for the purpose and to the satisfaction of the Engineer.

d. Layouts and Alignment

On those sections of pavements where no previously applied figures, markings, or stripes are available to serve as a guide, suitable layouts and lines of proposed stripes shall be spotted in advance of the paint application. Control points shall be spaced at such intervals as will insure accurate location of all markings.

The Contractor shall provide an experienced technician to supervise the location, alignment, layout, dimensions and application of the paint.

Single stripes shall be applied wholly on one side of the longitudinal pavement joints. Double or multiple stripes shall be centered over similar joints.

e. Application

Markings shall be applied at the locations and to the dimensions and spacings indicated on the Drawings or as specified. Paint shall not be applied until the layouts, indicated alignment, and the condition of the existing surface have been approved by the Engineer.

The paint shall be mixed in accordance with the manufacturer's instructions before application.

In the application of straight stripes, any deviation in the edges exceeding 1.3 cm. in 15 m. shall be obliterated and the marking corrected. The width of the markings shall be as designated within a tolerance of 5%. All paintings shall be performed to the satisfaction of the Engineer by competent and experienced equipment operators, laborers, and artisans in a neat and workman like manner.

The Contractor shall furnish a certified report on the quality of materials ordered for the work. This report shall not be interpreted as a basis for final acceptance. The Engineer shall be notified upon arrival of shipment for inspecting and sampling of the materials. When required, all emptied containers shall be returned to the paint material storage of made available for tallying by the Engineer. The containers shall not be removed from the airport or destroyed without permission. The Contractor shall make an accurate accounting of the paint materials used in the accepted work.

f. Color

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Numbers, letters, guidelines and marking signs for Taxiway and Aircraft parking apron shall be yellow. Marking signs for the G.S.E. service road shall be white.

g. Protection

After application of the paint, all markings shall be protected while the paint is drying. The fresh paint shall be protected from injury ro damage of any kind. The Contractor shall be directly responsible and shall erect or place suitable warning signs, flags or barricades, protective screens, or coverings as required. All surfaces shall be protected from disfiguration by spatter, splashes, spillage, drippings of paint of other materials.

h. Defective Workmanship or Material

When any material not conforming to the requirements of the specifications or Drawings has been delivered to the project or incorporated in the work or any work performed is of inferior quality, such material or work shall be considered defective and shall be corrected as directed by the Engineer, at the expense of the Contractor.

3.4.4 Measurement and Payment

The quantity of markings to be paid for shall be in square meter of painting performed in accordance with these Specifications and accepted by the Engineer.

Payment shall be made at the Contract unit price per square meter for painting. This price shall be full compensation for furnishing all materials and for all preparation, layouting, and application of the materials, and for all labor, equipment, tools and incidentals necessary to complete the item.

Payment shall be made under:

Item No.	Description of Work	Unit of Measurement
I-2-40		
1)	Runway (Yellow, W10m)	square metre
2)	Runway (Yellow, W1.5-3.0m)	square metre
3)	Runway (Yellow, W0.9m)	square metre
4)	Taxiway (Yellow, W0.15-0.3m)	square metre
5)	Apron (Yellow, W0.15-0.3m)	square metre
6)	Apron (Yellow, W0.6m)	square metre
7)	Apron (Red, W0.2m)	square metre

SECTION 3.5 ANCHOR BEAM

3.5.1 Description

3.5-1.1 This item shall consist of anchor beams for constructed in the pavement concrete in accordance with these specifications, at the specified locations and conforming to the lines, grades, and dimensions shown on the Drawings or required by the Engineer.

3.5.2 Materials

3.5-2.1 CONCRETE. Concrete for beam body shall meet the requirements of Section 3.2.2 of this Special Provision.

Backfill concrete shall meet the requirements of Section 4.2 of this Special Provision.

3.5-2.2 STEEL REINFORCEMENT. Reinforcement bar shall meet the requirements of Section 4.2 of this Special Provision.

3.5.3 Construction Methods

3.5-3.1 EXCAVATION.

a. Foundations for anchor beams shall be excavated to the lines and grades or elevations shown on the Drawings. The excavation shall be of sufficient size to permit the placing of the full width and length of the structure or structure footings shown.

b. The foundation base upon which the item is to be built shall be compacted to a firm uniform grade. All soft and unsuitable material shall be removed and replaced with suitable approved material. When required, a layer of approved granular material, compacted to the thickness indicated on the Drawings, shall be placed to form a foundation base.

c. When using equipment to excavate the anchor beam foundation , care must be taken to ensure that no damage is caused to the soil structure for the bottom of the foundation.

d. Boulders, logs, or any other objectionable material encountered in excavation shall be removed. All satisfactory materials shall be hauled and placed in fills, and unsuitable materials shall be placed in spoil areas or as directed by the Engineer.

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3.5-3.2 CONCRETE WORK. The forms for and the mixing, placing, finishing, and curing of concrete and placement of reinforcement shall conform to the requirements of Section 4.2 of this Special Provision.

3.5.4 Method of Measurement

3.5-4.1 The quantity of unclassified excavation to be paid for shall be the number of cubic meters, measured in original position, of material excavated and disposed in accordance with the Drawings, or as directed by the Engineer.

3.5-4.2 Concrete shall be measured by the number of cubic meters in accordance with the dimensions shown on the Drawings or ordered by the Engineer. No separate measurements shall be made for form work, bracing and finishing of the concrete, which shall be included in the concrete.

3.5-4.3 BACKFILLING. After the beam body concrete has set sufficiently, the spaces adjacent to the beam shall be refilled to the required elevation with C15 class in-situ concrete specified on the Drawings.

3.5.5 Basis of Payment

3.5-5.1 Payment for excavation shall be made at the Contract unit price per cubic meter. These prices shall be full compensation for excavation, hauling and disposing excavated materials, and for furnishing all labor, equipment, tools, and incidentals necessary to complete the item.

3.5-5.2 Payment shall be made at the Contract unit price per cubic meter for beam body concrete or backfill concrete; and at the Contract unit price per ton for reinforcement bar. These prices shall be full compensation for furnishing all materials and for all preparation, delivering, placing and installation of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item No.	Description of Work	Unit of Measurement
I-1-41-1	Excavation	cubic metre
2	Beam body concrete (5.0Mpa)	cubic metre
3	Backfill concrete (C15)	cubic metre
4	Reinforcement bar	ton