6 PAVEMENT

6.1 Subgrade Preparation

The subgrade shall be that part of the work which is prepared for the sub-base. It shall extend to the full width of the roadbed and the base of any structures including the shoulders and laybys or such limited areas as shown on the Drawings or as instructed by the Engineer.

Work on subgrade preparation shall only be carried out immediately prior to laying the sub-base.

6.2 Prior Works

Culverts, drain pipes and any other minor structures below the subgrade level, including fully compacted backfill shall be completed before work is begun on the subgrade. Ditches, drains, outlets for drainage, and head walls for culverts shall be in such operative condition as to ensure prompt and effective drainage and to avoid damage to the subgrade by surface water.

Any subgrade areas failing to meet the planned elevation due to settlement or any other cause, or which have become damaged since completion of earthwork, shall be removed, material replaced or added, recompacted and finished to the specified lines, grades and cross-sections as directed by the Engineer.

No work shall be started on the preparation of the subgrade before the prior works herein described have been approved by the Engineer.

6.3 Construction

The Contractor shall provide and use templates and straightedges to check the accuracy of the work and to ensure adherence to the requirements of this Specification.

6.4 Degree of Compaction

All material down to a depth of 20 centimeters below the subgrade level shall be compacted to at least 100 percent of the maximum dry density as determined according to AASHTO T99.

6.5 Protection of Completed Work

Any part of the subgrade that has been completed shall be protected against drying out and cracking, and any damage shall be repaired as directed by the Engineer.

6.6 Sub-base

This work shall consist of supplying and placing of untreated crushed stone materials between the subgrade and the sub-base, in accordance with this Specification and in conformity with the lines, grades, thickness and typical cross-sections shown on the plans or established by the Engineer.

Sub-base materials shall be crushed stone or crushed or natural gravel, conforming to the quality requirements of AASHTO M147, except that wear shall not exceed 5% as determined by AASHTO T96 (using abrasive charge grading A).

The sub-base grading shall conform to grading A of AASHTO M147 and the aggregate shall not show a loss greater than 10% when subjected to 5 cycles of the sodium sulphate soundness test.

When crushed gravel is used, not less than 50 percent by weight of the particles retained on the No. 4 sieve shall have at least one fractured face.

The subgrade shall be constructed, prepared, and finished as provided in this Specification before placing aggregate sub-base course material. The thickness of the sub-base shall be as shown on the Drawings or as instructed by the Engineer.

Before supply or incorporation of any material into the works the Contractor shall provide the engineer with details of each nominated material, together with 4 recent certificates (no older than 3 months) from an approved testing facility, which demonstrate that the material meets the requirements of this Specification.

Sub-base aggregate shall not be spread until the supporting subgrade has been approved by the Engineer.

6.6.1 Spreading Sub-base

The Contractor's method of spreading granular sub-base shall be subject to the approval of the Engineer. If the Engineer is not satisfied with the Contractor's method of spreading, he may require the use of a spreader box at no extra cost. Spreader boxes shall be self propelled wheel type or tracked vehicles and adjustable to place the material in layers of the specified thickness without undue disturbance to the prepared subgrade.

The granular sub-base material shall be placed in uniform layers so that the compacted depth does not exceed 15 cm.

6.6.2 Compaction of Sub-base

Immediately following final spreading and smoothing, each layer shall be compacted to full width by means of smooth-wheel power rollers, pneumatic-tyred rollers or other approved compaction equipment. Rolling, shall progress gradually from the low to the high point of the cross section parallel to the centreline of the road, and shall continue until the entire surface has been rolled.

Sub-base material shall be compacted to produce the required density through the full depth of each layer of at least 95 percent of the maximum density determined in accordance with AASHTO T180, method D. In place field density determinations shall be made in accordance with AASHTO T191. The Engineer will make measurements of test holes at random during progress of the work to confirm compliance with the Specification and to determine the depth of uncompacted layers required to produce the designated nominal depth of sub-base.

Cutting the test holes and refilling with materials properly compacted shall be done

by the Contractor under the supervision of the Engineer, at the Contractor's expense.

A CBR of 30% shall be achieved in the top surface of the final layer of sub-base.

Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. At all places not accessible to the roller, the material shall be compacted thoroughly with approved tampers or compactors. The material shall be both bladed and rolled until a smooth, even surface has been obtained. Where surfaces fail to meet the tolerance requirement the Contractor shall remove and replace the sub-base as directed by the Engineer without any additional cost.

6.7 Base course

This work shall consist of supplying and placing of untreated crushed stone materials between the sub-base and the concrete slab or bituminous treated base, in accordance with this Specification and in conformity with the lines, grades, thickness and typical cross-sections shown on the plans or established by the Engineer.

Base course materials shall be crushed stone or crushed or natural gravel, conforming to the quality requirements of AASHTO M147, except that wear shall not exceed 5% as determined by AASHTO T96 (using abrasive charge grading A).

The base course grading shall conform to grading A of AASHTO M147 and the aggregate shall not show a loss greater than 10% when subjected to 5 cycles of the sodium sulphate soundness test.

When crushed gravel is used, not less than 50 percent by weight of the particles retained on the No. 4 sieve shall have at least one fractured face.

The sub-base shall be constructed, prepared, and finished as provided in this Specification before placing base course material. The thickness of the base course shall be as shown on the Drawings or as instructed by the Engineer.

Before supply or incorporation of any material into the works the Contractor shall provide the engineer with details of each nominated material, together with 4 recent certificates (no older than 3 months) from an approved testing facility, which demonstrate that the material meets the requirements of this Specification.

Base course aggregate shall not be spread until the supporting sub-base has been approved by the Engineer.

6.7.1 Spreading Base course

The Contractor shall be spread using a spreader box. Spreader boxes shall be self propelled wheel type or tracked vehicles and adjustable to place the material in layers of the specified thickness without undue disturbance to the prepared sub-base.

The granular base course material shall be placed in uniform layers so that the compacted depth does not exceed 15 cm.

6.7.2 Compaction of Base Course

Immediately following final spreading and smoothing, each layer shall be compacted to full width by means of smooth-wheel power rollers, pneumatic-tyred rollers or other approved compaction equipment. Rolling, shall progress gradually from the low to the high point of the cross section parallel to the centreline of the road, and shall continue until the entire surface has been rolled.

Base course material shall be compacted to produce the required density through the full depth of each layer of at least 98 percent of the maximum density determined in accordance with AASHTO T180, method D and the finished. In place field density determinations shall be made in accordance with AASHTO T191. The Engineer will make measurements of test holes at random during progress of the work to confirm compliance with the Specification and to determine the depth of uncompacted layers required to produce the designated nominal depth of base course.

Cutting the test holes and refilling with materials properly compacted shall be done by the Contractor under the supervision of the Engineer, at the Contractor's expense.

A CBR of 80% shall be achieved in the top surface of the final layer of base course.

Any irregularities or depressions that develop shall be corrected by loosening the material at these places and adding or removing material until the surface is smooth and uniform. At all places not accessible to the roller, the material shall be compacted thoroughly with approved tampers or compactors. The material shall be both bladed and rolled until a smooth, even surface has been obtained. Where surfaces fail to meet the tolerance requirement the Contractor shall remove and replace the base course as directed by the Engineer without any additional cost.

6.8 Bituminous Pavements-General

The work described in this section covers the supplying and laying of new construction to form the completed pavements as shown on the Drawings and as instructed by the Engineer.

6.8.1 Bitumen Distributor

The bitumen distributor shall be self-powered and have pneumatic tyres of such width and number that the load produced on the road surface shall not exceed 100 kilograms per centimeter of tyre width. It shall be so designed, equipped, maintained, and operated that bituminous materials at even heat may be applied uniformly on variable width of surface up to 5 meters at readily determined and controlled rates of from 0.2 to 3.0 lt per square meter with uniform pressure, and with an allowable variation from any specified rate not to exceed 0.1 lt per square meter.

Distributor equipment shall include an instrument for measuring the speed of travel accurately at low speeds, the rate of flow of asphaltic material through nozzles, the temperature of the contents of the tank, and the pressure. These instruments shall be so located that the operator can easily read them whilst operating the distributor.

The distributor shall be equipped with a separate power unit for the pump, and full circulation spray bars which shall be adjustable laterally and vertically. The spray

bars on the distributor shall be controlled by a man riding at the rear of the distributor in such a position that the operation of all sprays is in his fall view. The distributor shall incorporate one or more hand operated lances but these shall only be used in areas inaccessable to the main spray bars.

6.8.2 Bitumen Heater

The bitumen heater shall be of the oil jacket type or else incorporate an automatic agitator to prevent local overheating of the material. The heater should incorporate a thermometer.

6.8.3 Bitumen Mixing Plant General

The bitumen mixing plant shall have sufficient storage space for each size of aggregate. The different aggregate sizes shall be kept separated until they have been delivered to the cold aggregate feeding system. The storage yard shall be maintained neat and orderly and the separate bins shall be readily accessible for sampling.

Mixing plants shall be of sufficient capacity and coordinated to adequately handle the proposed bituminous constructions.

6.8.4 Plant Scales

Scales shall be accurate to 0.5 percent of any load that may be required and sensitive to one half the minimum gradation, which shall not be greater than 3.5 kg. Poises shall be designed to be locked in any position to prevent unauthorized change of position. In lieu of plant and truck scales, the Contractor may provide an approved automatic printer system which shall print the weights of the material delivered, provided the system is used in conjunction with an approved automatic batching and mixing control system. Such weights shall be evidenced by a weight ticket f6r each load. Public weighing facilities may be used if tested and sealed by the local authority, subject to approval by the Engineer of the weighing procedures.

6.8.5 Storage Tanks

Tanks for the storage of bituminous material shall be equipped to heat and hold the material at the required temperatures.

The heating shall be accomplished by steam coils electricity, or other approved means so that no flame shall be in contact with the tank. The circulating system for the bituminous material shall be designed to assure proper and continuous circulation during the operation period. Provision shall be made for measuring and sampling storage tanks.

6.8.6 Drier

The plant shall be provided with accurate mechanical means for uniformly feeding the aggregates into the drier so that uniform production and uniform temperature shall be obtained.

The plant shall include a drier or driers which continuously agitate the aggregates during the heating and drying process. For cold type bituminous mix, equipment for

mechanical cooling of the dried aggregate to the temperature prescribed for cold mixtures shall be provided, if required, and shall be capable of supplying prepared material for the mixer to operate at full capacity.

6.8.7 Screens and Bins

Plant screens, capable of screening all aggregates to the specified sizes and proportions and having normal capacities in excess of the full capacity of the mixer, shall be provided.

The plant shall include storage bins of sufficient capacity to supply the mixer when it is operating at full capacity. Bins shall be divided into at least 3 compartments and shall be arranged to assure separate and adequate storage of appropriate fractions of the mineral aggregates. Separate dry storage shall be provided for filler or hydrated lime when used and the plant shall be equipped to feed such material into the mixer or weighing hopper. Each bin shall be provided with overflow pipes, of such size and at such location as to prevent backing up of material into other compartments or bins. Each compartment shall be provided with its individual outlet gate, constructed so that when closed there shall be no leakage. The gates shall cut off quickly and completely. Bins shall be so constructed that samples can be readily obtained. Bins shall be equipped with adequate tell-tale devices to indicate the position of the aggregates in the bins at the lower quarter points.

6.8.8 Bituminous Control Unit

Satisfactory means, either by weighing or metering, shall be providing to obtain the proper amount of bituminous material in the mix within the tolerance specified. Means shall be provided for checking the quantity or rate of flow of bituminous material into the mixer.

An armoured thermometer of adequate range in temperature reading shall be fixed in the bituminous feed line at a suitable location near the charging valve at the mixer unit. The plant shall also be equipped with either an approved dia-scale, mercury-actuated thermometer, an electric pyrometer, or other approved thermometric instrument so placed at the discharge chute of the drier as to register automatically or indicate the temperature of the heated aggregates. The Engineer may require replacement of any thermometer by an approved temperature-recording apparatus for better regulation of the temperature of aggregates.

6.8.9 Dust Collector

The plant shall be equipped with a dust collector. constructed to waste or return uniformly to the hot elevator all or any part of the material collected as directed, without the escape of objectionable dust into the atmosphere.

6.8.10 Truck Scale

The bituminous mixture shall be weighed on approved scales furnished by the Contractor or on public scales at the Contractor's expense. Such scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy.

6.9 Safety Requirements

Adequate and safe stairways to the mixer platform and sampling points shall be provided and guarded ladders to other plant units shall be placed at all points where accessibility to plant operations is required. Accessibility to the top of truck bodies shall be provided by a platform or other suitable device to enable the Engineer to obtain sampling and mixture temperature data. A hoist or pulley system shall be provided to raise scale calibration equipment, sampling equipment and other similar equipment from the ground to the mixer platform and return. All gears, pulleys, chains, sprockets, and other dangerous moving parts shall be thoroughly guarded and protected. Ample and unobstructed space shall be provided on the mixing platform. A clear and unobstructed passage shall be maintained at all times in and around the truck loading area. This area shall be kept free from drippings from the mixing platform.

6.10 Field Laboratory

The Contractor shall provide a weatherproof building for use as a field laboratory by the Engineer. The structure shall have adequate work space for required testing operations and be provided with necessary heat, water supply, lighting and any other utilities as directed by the Engineer. This laboratory shall be maintained for the exclusive use of the Engineer, and shall be so located that details of the Contractor's plant are plainly visible from one window thereof. If conditions permit, this laboratory shall be adjacent to the weight-house.

6.11 Additional Requirements for Batching Plants

The equipment shall include a means for accurately weighing each size of aggregate in a weigh box or hopper suspended on scales and of ample size to hold a full batch without hand raking or running over. The gate shall close tightly so that no material is allowed to leak into the mixer while a batch is being weighed.

The equipment used to measure the bituminous material shall be accurate to plus or minus 0.5 percent of any load that may be required, and be sensitive to one half the minimum gradation, which shall be not greater than 2 kg. The bituminous material bucket shall be a non-tilting type with a loose sheet metal cover.

The length of the discharge opening or spray bar shall be not less than 3/4 the length of the mixer and it shall discharge directly into the mixer in the manner specified below. The bituminous material bucket, its discharge valve or valves, and spray bar shall be adequately heated. Steam jackets, if used, shall be efficiently drained and all connections shall be so constructed that they shall not interfere with the efficient operation of the bituminous scales. The capacity of the bituminous material bucket shall be at least 15 percent in excess of the weight of bituminous material required in any batch. The plant shall have an adequately heated quick acting, non-drip, charging valve located directly over the bituminous material bucket. The indicator dial shall have a capacity of at least 15 percent in excess of the quantity of bituminous material used in a batch. The controls shall be constructed so that they may be locked at any dial setting and shall automatically reset to that reading after the addition of bituminous material to each batch. The dial shall be in full view of the mixer operator. The flow of bituminous material shall be automatically

controlled so that it shall begin when the dry mixing period is over. All of the bituminous material required for one batch shall be discharged in not more than 15 seconds after the flow has started. The size and spacing of the spray bar opening shall provide a uniform application of bituminous material the full length of the mixer. The section of the bituminous line between the charging valve and the spray bar shall be provided with a valve and outlet for checking the meter when a metering device is substituted for a bituminous material bucket.

The batch mixer shall be an approved type capable of producing a uniform mixture within the job-mix tolerance. If not enclosed, the mixer box shall be equipped with a dust hood to prevent loss of dust. The clearance of blades from all fixed and moving parts shall not exceed 2-5 cm unless the maximum diameter of aggregate in the mix exceeds 3.0 cm, in which case the clearance shall not exceed 3.8 cm.

The mixer shall be equipped with an accurate time lock to control the operations of a complete mixing cycle. It shall lock the weight box gate after the charging of the mixer until the closing of the mixer gate at the completion of the cycle. It shall lock the bituminous material bucket throughout the dry and wet mixing periods. The dry mixing period is defined as the interval of time between the opening of the weigh box gate and the start of introduction of bituminous material. The wet mixing period is the interval of time between the start of introduction of bituminous material and the opening of the mixer gate. The control of the timing shall be flexible and capable of being set at intervals of 5 seconds or less throughout a total cycle of up to 3 minutes. A mechanical batch counter shall be installed as a part of the timing device and shall be so designed as to register only completely mixed batches. The setting of time intervals shall be performed in the presence and at the direction of the Engineer who shall then lock the case covering the timing device until such time as a change is to be made in the timing periods.

6.11.1 Additional Requirements for Continuous Mixing Plants

The plant shall include means for accurately proportioning each size of aggregate. The plant shall have a feeder mounted under each compartment bin. Each compartment bin shall have an accurately controlled individual gate to form an orifice for volumetrically measuring the material drawn from each compartment. The feeding orifice shall be rectangular with one dimension adjustable by positive mechanical means provided with a lock. Indicators shall be provided for each gate to show the respective gate opening in inches or centimeters.

The plant shall include a means of calibration of gate openings by weighing test samples. Provision shall be made so that materials fed out of individual orifices may be bypassed to individual test boxes. The plant shall be equipped to conveniently handle individual test samples weighing not less than 75 kg. Accurate scales shall be provided by the Contractor to weigh such test samples.

Satisfactory means shall be provided to afford positive interlocking control between the flow of aggregate from the bins and the flow of bituminous material from the meter or other proportioning device. This control shall be accomplished by interlocking mechanical means or by any other positive method satisfactory to the Engineer.

The plant shall include a continuous mixer of an approved type, adequately heated and capable of producing a uniform mixture within the job-mix tolerances. It shall be equipped with a discharge hopper with dump gates which shall permit rapid and complete discharge of the mixture. The paddles shall be adjustable for angular position on the shafts and reversible to retard the flow of the mix. The mixer shall have a manufacturer's plate giving the net volumetric contents of the mixer at the several heights inscribed on a permanent gauge. Charts or other approved means shall be provided showing the rate of feed of aggregate per minute at the plant operating speed.

6.11.2 Hauling Equipment

Trucks used for hauling bituminous mixtures shall have tight, clean, smooth metal beds which have been thinly coated with approved material to prevent the mixture from adhering to the beds. Each truck shall have a cover of canvas or other suitable material of such size as to protect the mixture from the weather. When necessary, so that the mixture shall be delivered on the road at the specified temperature, truck beds shall be insulated and covers shall be securely fastened. The Engineer will determine the tare weight for each vehicle used in hauling mixtures to the road, as often as necessary, but in no case less than once during each work shift.

6.11.3 Bituminous Pavers

Bituminous pavers shall be self-contained, power-propelled units, provided with an adjustable activated screed or strike-off assembly, heated if necessary, and capable of spreading and finishing courses of bituminous plant mix material in lane widths applicable to the specified typical section and thicknesses shown on the Drawings. Pavers used for shoulders and similar construction shall be capable of spreading and finishing courses of bituminous plant mix material in widths shown on the Drawings. The paver shall be equipped with a receiving hopper having sufficient capacity for a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed.

The paver shall employ mechanical devices such as equalizing runners, straightedge runners, evener arms, or other compensating devices, to maintain trueness of grade and to confine the edge of the pavement to true lines without the use of satisfactory side forms. The equipment shall include blending or joint levelling devices for smoothing and adjusting longitudinal joints between lanes. The screed or strike-off assembly shall effectively produce a finished surface of the required evenness and texture without tearing, shoving or gouging the mixture. When laying mixtures, the paver shall be capable of being operated at forward speeds consistent with satisfactory laying of the mixture.

The Contractor shall furnish all necessary small tools and provide means for keeping them free from accumulation of bituminous material. He shall provide and have ready for use at all times enough tarpaulins or covers as may be necessary, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped, or spread but not compacted.

6.11.4 Rollers

Rollers shall be of the steel wheel and pneumatic tyre types and shall be in good condition, capable of reversing without back-lash. and shall be operated at speeds slow enough to minimize displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate shall not be permitted.

6.11.5 Aggregate Spreader

The aggregate spreader shall be self-propelled, of approved design, and supported by at least 4 wheels equipped with pneumatic tyres on two axles. The aggregate spreader shall be equipped with positive controls so that the required amount of material shall be deposited uniformly over the full width of the bituminous material. Other types of aggregate spreaders may be used provided they accomplish equivalent results and are approved.

6.11.6 Power Broom and Blower

A rotary power broom and power blowers shall be provided, and maintained in good working order, including regular cleaning of surfaces in contact with bituminous material.

6.12 Weather

Bituminous material shall not be laid in rain or in foggy weather and unless specified elsewhere, the surface being covered shall be clean and dry. Bituminous plant mix shall not be placed when weather conditions prevent the proper handling or finishing of the material.

6.13 Protection of Existing Work

Constructional plant used on pavements under construction shall be suitable in relation to the material, condition and thickness of the courses it traverses so that damage is not caused to the sub-grade or the pavement courses already constructed. Bituminous material shall be kept clean and uncontaminated for so long as it remains uncovered by succeeding layers or surface treatment. The only traffic permitted access to bituminous material shall be that engaged in laying and compacting the next course. At his own risk, the Contractor may allow traffic to use the binder course but this shall be subject to the Engineer's approval and he may require the Contractor at his own expense, to seal or otherwise protect the binder course. Should any bituminous material become contaminated, the Contractor shall make good by cleaning it to the satisfaction of the Engineer and if this proves impractical, he shall remove and replace the layer at his own expense.

Before undertaking any bituminous spraying, the surfaces of structures, kerbs, trees, etc., adjacent to the areas being treated shall be protected in such a manner as to prevent their being spattered or marred.

6.14 Layers of Bituminous Courses

A bituminous pavement shall be laid so that the compacted thickness of each layer does not exceed 105mm. Where any course of material exceeds this thickness, it shall be laid in 2 or more layers of equal thickness.

6.15 Overlay

When the contract calls for the overlay of existing pavement, any regulating required shall be carried out using the lowest layer(s) of material possible. All remedial works to the pavement shall be executed before commencement of overlay operations.

6.16 Finished Work Samples

The Contractor shall cut full depth plant mix samples as directed, from the finished course, for testing by the Engineer. Samples shall be neatly cut by a saw, core drill, or other approved equipment.

Each sample shall be one slab of at least 15 cm by 15 cm, or a number of cores, each with a minimum 10 cm, diameter totalling at least 230 square cm. At least one, but not more than three samples shall be taken for each full day's operations. The Contractor shall supply and finish new material to backfill voids left by sampling. Extra samples shall be taken whenever a substantial change has been approved and made in the job mix formula.

To check the rate of bituminous material actually applied, sheets of building paper 50 cm by 50 cm previously weighed, shall be laid on the surface to be treated and weighed again after application of the coat. The Contractor shall supply the material for this check and shall re-spray the areas from which the paper is lifted.

Based on the results of the above checks and subsequent laboratory analysis, the Engineer may instruct the removal and replacement at the Contractor's expense, of any material which does not fully comply with this Specification. The Engineer may also instruct an additional coat of material, or removal of excess material and/or may reduce the quantity of material approved for payment.

6.17 Scarify Pavement

This work shall consist of the removal of the upper layer or layers of an existing asphalt pavement where this is necessary to allow formation of a joint between existing and new work.

The work shall be done by machine or by hand in such a manner that the area scarified does not exceed that instructed by the Engineer. Any damage to asphalt or kerb designated by the Engineer to remain shall be made good to the Engineer's satisfaction. All material removed may be re-used on the site if it meets the requirements of this Specification, or otherwise disposed of.

6.18 Patching of Existing Pavements

This work shall consist of removal and replacement of damaged existing pavement in localized areas. The Engineer will designate the areas of pavement to be so treated

and all work shall be carried out as specified below and shall be paid for on the basis of the number of square meters so treated.

All material and work for Patching shall comply with this Specification, with the exception that machine laying of asphalt treated base course is not compulsory, and all compaction equipment may be varied to suit the size of the area being treated.

The area to be treated shall be marked on the surface and the existing pavement and subgrade removed to a depth of 50 cm. Pavement to remain shall be cut to form a vertical face and the edges of the excavation shall be straight and in neat lines. After preparation of the subgrade in accordance with Clause 6.1, 30 cm of the sub-base as used for new construction shall be laid in accordance with Clause 6.6.1. The sub-base shall then be primed in accordance with Clause 6.19 and 20 cm of base course laid in one layer, in accordance with Clause 6.7. Bituminous material in the existing pavement which will abut with the new base course shall be tack coated in accordance with Clause 6.20 or else lightly brushed with hot asphalt cement. The finished, level of the patched area shall be carefully formed to leave a smooth surface level with the adjacent existing pavement.

6.19 Bituminous Prime Coat

This work shall consist of furnishing and applying bituminous material to a previously prepared subgrade, sub-base or base course surface in accordance with this Specification and to the width shown on the typical cross sections or instructed by the Engineer.

The Contractor shall submit to the Engineer for approval, details of its proposed materials and methods including recent test results.

6.19.1 Bituminous Prime Coat Material

Bituminous material shall be of type and grade called for in the Drawings and shall conform to the requirements of the specifications listed below.

- Medium-curing cut back asphalt AASHTO M 82
- Rapid-curing cut back asphalt AASHTO M 81

The grade (with temperatures of application in degrees C shall be MC70 (43 - 85 degrees) or RC-250 (60 - 100 degrees).

6.19.2 Blotter Material

Blotter material shall be approved clean, dry sand or stone screenings free from any cohesive material. It shall contain no organic matter.

The Contractor shall, before commencing the work proper, carry out field trials to ascertain the rate of application. The trial methods shall be approved and performed in the presence of the Engineer.

6.19.3 Weather Limitations for the Application of Prime Coat

Prime coat shall be applied only with the approval of the Engineer who will specify

the grade to be used. The surface to be treated shall be dry or slightly damp, and the atmospheric temperature in the shade above 13°C and rising or above 15°C if falling.

6.19.4 Preparation of Surface

Immediately before applying the bituminous material all loose dirt and other objectionable material shall be removed from the surface with a power broom and/or blower as required. If the Engineer so orders, the surface shall be lightly bladed and rolled immediately prior to the application of bituminous material, in which case brooming or blowing shall not be required. When so ordered by the Engineer a light application of water shall be made just before the application of bituminous material. The area to be treated shall be approved by the Engineer prior to application.

6.19.5 Application of Prime Coat

Bituminous material shall be applied to the width of the section to be primed by means of a bitumen distributor in a uniform, continuous spread, The rate of application shall usually be in the range of 1.0 to 2.5 kg/sq.m. as directed by the Engineer.

Bituminous material shall be applied to the width of the section to be primed by means of a bitumen distributor in a uniform, continuous spread. The rate of application shall usually be in the range of 1.0 to 2.5 kg/sq.m, and the Engineer shall determine the rate and material grade to be used for each material being covered. Care shall be taken that the application of bituminous material at the junction of spreads is not in excess of the specified amount. Excess bituminous material shall be sponged from the surface.

Skipped areas or deficiencies shall be corrected. Building paper shall be placed over the end of the previous applications and the joining application shall start on the building paper. Building paper used shall be removed and satisfactorily disposed of.

6.19.6 Application of Blotter Material

In order to minimize possible damage by rain before the surface has completely dried, the Engineer may instruct that blotter material should be spread to cover any wet bituminous material. Blotter material shall be spread so that no wheels or tracks shall travel on uncovered wet bituminous material.

6.20 Bituminous Tack Coat

This work shall consist of preparing and treating an existing bituminous or concrete surface with bituminous material in accordance with this Specification and in conformity with the details shown on the Drawings or instructed by the Engineer.

The Contractor shall submit to the Engineer for approval, details of its proposed materials and methods including recent test results.

6.20.1 Bituminous Tack Coat Material

Bituminous material shall conform to the requirements of the specification listed below.

- Rapid-curing cut back asphalt: AASHTO M 81

The grade (with temperatures of application in degrees C) shall be RC-250 (60 - 100 degrees).

6.20.2 Preparation of Surface

The existing surface shall be patched and cleaned and shall be free of irregularities to provide a reasonably smooth and uniform surface to receive the treatment. Unstable, corrugated or damaged areas shall be removed and replaced or repaired as instructed by the Engineer. The edges of existing pavements, which are to be adjacent to new pavement, shall be cleaned to permit the adhesion of bituminous materials. The area to be treated shall be approved by the Engineer prior to application.

6.20.3 Application of Tack Coat

The bituminous material shall be uniformly applied with a pressure distributor within the 24 hours preceding placement of the covering course. The Engineer will specify the rate of the application which shall usually be in the range of 0.4 to 0.8 kg/sq.m.

Care shall be taken that the application of bituminous material at the junction of spreads is not in excess of the specified amount. Excess bituminous material shall be sponged from the surface. Skipped, areas or deficiencies shall be corrected.

The surface shall be allowed to dry until it is in a proper condition of tackiness to receive the covering course. Tack coat shall be applied only so far in advance of covering course placement as is necessary to obtain this proper condition of tackiness. Until the covering course is placed, the Contractor shall protect the tack coat from damage.

6.21 Seal Coat

This work shall consist of an application of bituminous material with an application of cover coat material in accordance with this Specification in conformity with the lines shown on the Drawings or established by the Engineer.

The approximate amounts of materials per square meter for seal coats shall be as follows:

- Bituminous material..... 0.7 - 1.5 1 per sq.m.
- Cover aggregate ..... 6.5 - 14.0 kg per sq.m.

The exact spread rates will be instructed by the Engineer.

6.21.1 Bituminous Seal Coat Material

Bituminous material shall conform to the requirements of the following specification.

- Rapid-curing cut back asphalt: AASHTO M 81

The grade (with temperatures of application in degrees C) shall be RC-250 (60 - 100 degrees) or that directed by the Engineer.

6.21.2 Weather Limitations for the Application of Seal Coat

Seal coat shall be applied only when the surface to be treated is dry or slightly damp, when the temperature of the road surface is 21 degrees Celsius or more.

6.21.3 Preparation of Surface

Seal coating operations shall not be started until the surface is thoroughly compacted by rolling and traffic. Bituminous material shall not be spread until the surface has been cleaned as required, and the section to be sealed has been approved.

6.21.4 Application of Seal Coat

Bituminous material shall be applied by means of a pressure distributor in a uniform, continuous spread over the section to be treated and within the temperature range specified. The quantity of bituminous material to be used per square meter shall be as directed. If the texture of the surface is such that bituminous material penetrates too rapidly, a preliminary application of from 0.2 to 0.5 liter per square meter of surface may be required. A strip of building paper, at least 100 cm in width and with a length equal to that of the spray bar of the distributor plus 30 cm, shall be used at the beginning of each spread. If the cut-off is not positive, the use of paper may be required at the end of each spread. The paper shall be removed and disposed of in a satisfactory manner. The distributor shall be moving forward at proper application speed at the time the spray bar is opened. Any skipped areas or deficiencies shall be corrected. Junction of spreads shall be carefully made to assure a smooth riding surface. The length of bituminous material shall not be in excess of that which approved spreading equipment can immediately cover with approved material.

The spread of bituminous material shall not be more than 15 cm wider than the width covered by the cover coat material from the spreading device. Under no circumstances shall operations proceed in such manner that bituminous material shall be allowed to chill set up, or otherwise impair retention of the cover coat.

The distributor, when not spreading, shall be parked so that the spray bar or mechanism shall not drip bituminous materials on the surface of the travelled way.

6.22 Cover Coat Material

Cover coat material shall be crushed stone, or crushed gravel and shall meet the requirements for surface course material in Clause 6.25. When crushed gravel is used, not less than 50 percent by weight of the particles retained on the No. 4 sieve shall have at least one fractured face Aggregates shall meet the gradation requirements of the following table.

Sieve Designation (mm)	Percentage Passing by Weight
12.5	100
9.5	85-100
4.75	10-30
2.36	0-10
0.300	-0

6.22.1 Application of Cover Coat

Immediately following the application of the bituminous material, cover coat for seal shall be spread in quantities as designated. Spreading shall be accomplished in such a manner that the tyres of the approved aggregate spreader at no Immediately following the application of the bituminous material, cover coat for seal shall be spread in quantities as designated. Spreading shall be accomplished in such a manner that the tyres of the approved spreader at no time contact the uncovered and newly applied bituminous material.

If directed, the cover coat material shall be moistened with water to eliminate or reduce the dust coating of the aggregate. Moistening shall be done the day before the use of the aggregate.

Immediately after the cover coat material is spread, any deficient areas shall be covered by additional material. Initial rolling shall begin immediately behind the spreader and shall consist of one complete coverage with a power roller. Pneumatic tyre rolling shall begin immediately after completion of the initial rolling and shall be completed the same day the bituminous material and cover coat materials are applied.

After the application of the cover coat material, the surface shall be lightly broomed or otherwise maintained as directed for a period of 4 days or as directed. Maintenance of the surface shall include the distribution of cover coat material After application of the cover coat material, the surface shall be lightly broomed or otherwise maintained as directed for a period of 4 days or as directed. Maintenance of the surface shall include the distribution of cover coat material over the surface to absorb any free bituminous material and to cover any area deficient in cover coat material. The maintenance shall be conducted so as not to displace embedded material. Excess material shall be swept from the entire surface by means of rotary brooms. The surface shall be swept at the time determined by the Engineer. The Contractor shall furnish a pilot car and driver to conduct traffic over completed seal coat at a maximum speed of 10 kilometers per hour for the first 24 hours after cover aggregate is applied, if so directed by the Engineer.

6.23 Bituminous Plant-mix Material

This work shall consist of aggregate and bituminous material mixed in a central plant and spread and compacted on a prepared surface in accordance with this Specification and in close conformity with the lines, grades, thicknesses and typical cross sections shown on the Drawings or established by the Engineer.

28 days prior to placement the Contractor shall submit to the Engineer for approval details of all materials and construction methods to be used for asphaltic concrete surfacing.

6.23.1 Plant-mix Material Composition

The bituminous material shall be composed of a mixture of aggregate, filler and hydrated lime if required, and asphalt cement. The several aggregate fractions shall be sized, uniformly graded and combined in such proportions that the resulting composite blend meets the job-mix formula and the following index of retained strength as determined in accordance with AASHTO T245.

	Surface &Binder Course
Stability: kg.	900
Flow: mm	2.5 – 4.0
Voids in total mix: %	3 – 5
Voids filled with Asphalt: %	75 - 85

In calculating the void characteristics of the mixture the Contractor shall allow for the asphalt absorbed by the aggregate and use the effective specific gravity of aggregate and the maximum specific gravity of the loose paving mixture (AASHTO T209).

The several aggregate and filler fractions for the mixture shall be sized, graded, and combined in such proportions that the resulting composite blend meets one of the following grading requirements.

Percentage Passing by Weight

Sieve Designation (mm)	Percentage Passing by Weight	
	Grade A	Grade B
50.0	-	
37.5	-	
25. 0	100	-
19.0	95 - 100	100
12.5	68 - 86	95 - 100
9.5	56 - 78	74 - 92
4.75	38 - 60	48 - 70
2.36	27 - 47	33 - 53
1.18	18 - 3 7	22 - 40
0.600	11 – 28	15 - 30
0.300	6 - 20	10 - 20
0.075	0 - 8	4 - 9

Grade A shall be used for asphalt binder course. Grade B shall be used for asphalt surface course.

Before stockpiling aggregate, the Contractor shall submit a proposed job-mix formula in writing, for use by the Engineer in setting the job-mix to be used with the proposed materials. The formula submitted shall propose definite single values for:

- The percentage of aggregate passing each specified sieve
- The percentage of bituminous material to be added, on the total aggregate basis
- The temperature of the mixture leaving the mixer
- The temperature of the mixture delivered on the road
- The grade of bituminous material

No asphalt concrete shall be manufactured until a job-mix formula has been submitted by the Contractor and approved by the Engineer.

If a change in sources of material is made, a new job-mix formula shall be established before the new materials are used, subject to the approval of the Engineer.

Values shall be proposed within the limits specified for the particular type of bituminous concrete called for. The Engineer will determine a job-mix formula with single values for the above-mentioned and so notify the Contractor in writing.

The mixture furnished by the Contractor shall conform to this job-mix formula, within the following range of tolerances and within the grading ranges above.

Aggregate passing the 4.75 mm and larger sieve	± 7 percent
Aggregate passing the 2.36 mm through the 0. 150 mm sieve	± 4 percent
Aggregate passing the 0.075 min sieve	± 2 percent
Bituminous material	0.4 percent
Temperature leaving the mixer	6 degrees C
Temperature delivered on the road	6 degrees C

When unsatisfactory, results make it necessary, the Engineer may establish a new job-mix formula and so notify the Contractor in writing. Should a change in sources of material be proposed, a new job-mix formula shall be established before the new material is used.

The plant mixed material shall be tested after blending or mixing at the plant or prior to final incorporation in the work.

6.24 Coarse Aggregate

The coarse aggregate (retained on the 2.36 mm sieve) shall consist of clean tough, durable fragments free from an excess of flat, elongated, soft or disintegrated pieces and free from stone coated with dirt or other objectionable material. The percentage of wear when tested according to AASHTO T96, shall be as follows:

For use in asphalt base course - not more than 50
For use in asphalt binder and surface course - not more than 40.

The sodium sulphate soundness loss shall not exceed 9 percent and the magnesium sulphate soundness loss shall not exceed 12 percent. When crushed gravel is used, not less than 50 percent of the particles by weight retained on the 4.75 mm sieve shall have at least one fractured face.

6.25 Fine Aggregate

The fine aggregate (passing a 2.36 mm sieve) shall have General Characteristics and Soundness in accordance with AASHTO M 29.

6.26 Filler

Mineral filler, when required, shall consist of limestone dust, portland cement or other non plastic mineral matter from sources approved by the Engineer. Mineral filler shall be dry, free flowing, free from lumps and other objectionable material and when tested by means of laboratory sieve, shall meet the following gradation requirements.

Sieve Designation (mm)	Percentage Passing by Weight
0.600	100
0.180	95 – 100
0.075	65 - 100

6.27 Bituminous Material for Surface and Bridge Course

The bituminous material for surface course shall comply with the following requirements:

Items		Requirement	Test Method
Penetration at 25^{0}C, 1/10mm		60~ 80	JIS K 2207
Softening point, ^{0}C		55.0~ 65.0	JIS K 2207
Ductility at 10^{0}C, cm		More than 100	JIS K 2207
Penetration Ratio after Heating %		Less than 110	
Thin film over test	Loss of heating %	Less than 0.6	JIS K 2207
	Penetration of residue %	More than 55	JIS K 2207
Solubility in trichloroethance %		More than 99.0	
Flash point, Cleveland Open Cup ^{0}C		More than 260	JIS K 2265
Density at 150C, g/cu.cm		More than 1000	JIS K 2249

6.28 Pavement on Steel Deck

Bonding

The surface on steel deck slam shall be cleaned by approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dirt and loose material, and has been approved by the Engineer.

Material and Construction

The bituminous materials shall apply to asphalt rubber liquid bonding agent. The liquid bonding cost spread 0.2 l per square meter two times placing by using roller bucket equipment.

Care shall be taken the application of material a minimum twelve (12) hours after spread its material.

Water Proofing Asphalt Concrete

The bituminous material shall be composed of a mixture of aggregate, filler, vegitable fibber and asphalt cement.

The coarse and fine aggregate fraction for the mixture of sized and graded, vegitable fibber, asphalt cement content and combined the following proportions.

Max size of aggregate	Combined (%)		Air Void (%)	Asphalt Content (%)	Filler (%)	Vegitable Fibber (%)	Asphalt Grade
	2.36mm	7μm					
13mm	20-35	8-13	3-4	6.5-6.7	10.5	0.3	60-80

6.29 Additional Equipment

In addition to all other requirements for equipment in this Specification the Contractor shall provide suitable means for keeping all small tools clean and free from accumulation of bituminous material. He shall provide and have ready for use at all times enough tarpaulins or covers, as may be directed by the Engineer, for use in any emergency such as rain, chilling wind, or unavoidable delay, for the purpose of covering or protecting any material that may have been dumped, or spread but not compacted.

6.30 Preparation of Bituminous Plant-mix Material

The bituminous material shall be heated to the specified temperature in a manner that shall avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature at all times. The maximum temperature of asphalt cement delivered to the mixer shall not be more than 2°C above the temperature as specified in (c) hereof for aggregate. Asphalt cement shall not be used while it is foaming nor shall it be heated above 175°C at any time.

6.30.1 Preparation of Aggregates

The aggregates for the mixture shall be dried and heated to the required temperature. Flames used for drying and heating shall be properly adjusted to avoid damage to the aggregate and to avoid soot on the aggregate. Immediately after heating and drying, the aggregates shall be screened into three or more fractions as specified and conveyed into separate compartments ready for batching and mixing with bituminous material. When asphalt cement is used, the temperature of the aggregates as introduced into the mixer, including the tolerance permitted by the job-mix formula, shall not exceed that at which the asphalt cement has a Saybolt Furol viscosity of 100 seconds, determined by AASHTO T72. It shall not be lower than is required to obtain complete coating and uniform distribution of the aggregate particles and to provide a mixture of satisfactory workability.

6.30.2 Mixing

The dried aggregate shall be combined in the mixer in the amount of each fraction of aggregates required to meet the job-mix formula. The bituminous material shall be measured or gauged and introduced into the mixer in the amount specified by the job-mix formula.

After the required amounts of aggregate and bituminous material have been introduced into the mixer, unless otherwise specified, the materials shall be mixed until a complete and uniform coating of the particles and a thorough distribution of the bituminous material throughout the aggregate is secured. Wet mixing time shall be determined by the Engineer for each plant and for each type of aggregate used.

For plant mix bituminous pavement, the mixture shall be produced as closely as practicable to the lowest temperature that shall produce a workable mix within the specified temperature range.

6.30.3 Transporting, Spreading and Finishing

The surface on which the mixture is to be placed shall be cleaned by approved mechanical sweepers or blowers and/or hand brooms, until it is as free from dirt and loose material, and has been approved by the Engineer. No traffic shall be permitted on surfaces which have been approved by the Engineer.

The mixture shall be transported from the mixing plant to the point of use in vehicles conforming to the requirements of Clause 6.29. No loads shall be sent out so late in the day as to prevent completion of the spreading and compaction of the mixture during daylight hours unless with the Engineers approval and satisfactory illumination is provided. Each vehicle shall be weighed after each loading at the mixer and a record shall be kept of the gross weight, tare, net weight, and time of day of each load operation. The mixture shall be delivered at a temperature between 125°C and 160°C for asphalt mix.

The mixture shall be laid upon an approved surface, spread and struck off to the grade and elevation established. Bituminous pavers shall be used to distribute the mixture either over the entire width or over such partial width as may be practical.

The longitudinal joint in one layer shall offset that in the layer immediately below, by approximately 15cm; however, the joint in the top layer shall be at the centre line of the pavement if the roadway comprises two lanes in width, or at lane lines if the roadway is more than 2 lanes in width, unless otherwise directed.

On areas where irregularities; or unavoidable obstacles make the use of mechanical spread and finishing equipment impracticable, the mixture shall be spread, raked and luted by hand tools. For such areas the mixture shall be dumped, spread and screeded to give the required compacted thickness.

When production of the mixture can be maintained and when practical, pavers shall be used in echelon to place the wearing course in adjacent lanes.

The Contractor shall carry out such tests as are necessary to determine the uncompacted thickness of mixture to be laid for compaction to conform to the

required finished depths. The uncompacted material immediately behind the paver shall then be measured at frequent intervals and adjustments made to ensure conformity with the nominal depths.

6.30.4 Compaction

After the bituminous mixture has been spread, struck off and surface irregularities adjusted, it shall be thoroughly and uniformly compacted by rolling. The specific gravity of the consolidated mixture, as determined by AASHTO T230 shall be not less than 95 percent of the specific gravity of laboratory compacted specimens composed of the same materials in like proportion.

Laboratory specimens shall consist of cylinders of the mixture compacted by the procedures of AASHTO T167. For aggregates containing particles with diameters over 25 mm, 150 x 150 mm cylinders shall be used and the procedures of T167 modified to employ 10 repetitions of a moulding load of 85 kg per square cm with no appreciable holding time after each application of the full load.

The surface shall be rolled when the mixture is in the proper condition and when the rolling does not cause undue displacement, cracking or shoving.

The number, weight and type of rollers furnished shall be sufficient to obtain the required compaction while the mixture is in a workable condition. The sequence of rolling operations and the selection of roller types shall provide the specified pavement density.

Unless otherwise directed, rolling shall begin at the sides and proceed longitudinally parallel to the road centre line each trip overlapping one half the roller width, gradually progressing to the crown of the road. When paving in echelon or abutting a previously placed lane, the longitudinal joint should be rolled first followed by the regular rolling procedure. On superelevated curves the rolling shall begin at the low side and progress to the high side by overlapping of longitudinal trips parallel to the centre line.

Rollers shall move at a slow but uniform speed with the drive roll or wheels nearest the paver. Rolling shall be continued until all roller marks are eliminated and at least the minimum density indicated above has been attained. Care shall be exercised in rolling not to displace the line and grade of the edges of the bituminous mixture.

To prevent adhesion of the mixture to the rollers, the wheels shall be kept properly moistened with water or water mixed with very small quantities of detergent or other approved material. Excess liquid shall not be permitted. Along forms, headers, walls and other places not accessible to the rollers, the mixture shall be thoroughly compacted with hot hand tampers, smoothing irons or with mechanical tampers. On depressed areas, a trench roller may be used or cleated compression strips may be used under the roller to transmit compression to the depressed area.

Any mixture that becomes loose and broken, mixed with dirt, or is in any way defective shall be removed and replaced with a fresh hot mixture, which shall be compacted to conform to the surrounding area. Any area showing an excess or deficiency of bituminous material shall be removed and replaced. No traffic shall be

permitted on the final course in less than 12 hours after completion unless authorized by the Engineer.

6.30.5 Joint, Trimming Edges and Clean-up

Placing of the bituminous paving shall be as continuous as possible. Rollers shall not pass over the unprotected end of a freshly laid mixture unless authorized by the Engineer. Transverse joints shall be formed by cutting back on the previous run to expose the full depth of the course. Where pavers are not used in echelon to place the wearing course in adjacent lanes and where the edges of the previously laid wearing course are, in the opinion of the Engineer, in such condition that the quality of the completed joint shall be affected, longitudinal joints shall be trimmed to a vertical face and to a neat line. The exposed edges of the completed mat shall be cut off true to the required lines. Material trimmed from the edges and any other discarded or rejected bituminous mixture shall be removed from the roadway and disposed of by the Contractor as instructed by the Engineer. When directed by the Engineer, a brush coat of bituminous material shall be used on contact surfaces of joints just before additional mixture is placed against the previously rolled material.

6.30.6 Surface Tolerance

The variation of the surface from the testing edge of a straightedge between any two contacts with the surface shall not exceed the allowable tolerances. For base course and binder course, the test for conformity shall be made immediately after initial rolling and variation shall be corrected by removing or adding materials as may be necessary. Rolling shall then be continued as specified. Removal or addition of material to the surface course shall not be permitted after rolling has commenced.

Work on surface course shall be carefully controlled to ensure that material as laid shall conform with the allowable tolerance.

6.31 Overlay and Regulating

Where the contract requires the overlay of an existing pavement this shall be carried out strictly in accordance with the Engineer's instructions. The Engineer may instruct that a layer of the pavement be laid over a partial width or to a restricted length if this is necessary to facilitate the regulation of levels.

6.32 Frequency of Tests on Asphaltic Constituents

The minimum frequency of testing of asphaltic constituents shall be:

Characteristic Analysed	Minimum Frequency of Testing
Coarse Aggregate:	
Grading	One each 200 tonne per source
Particle Shape	One each 200 tonne per source
Wet Strength	One each 500 tonne per source
Wet/Dry Strength Variation	One each 500 tonne per source
Resistance to Stripping	One each 500 tonne per source
PAFV	One each 100 tonne per source
Fine Aggregate:	One each 200 tonne per source

Grading	
Filler: Particle Size Distribution	3 compliance tests per source, then one per month
Voids	
Binders: Characteristics in Table 506.1	One test per batch (max 3 days) with approved transport procedures in place
Bitumen Adhesion Agent Resistance to Stripping	Certificate of compliance with each batch

Note: The above frequencies may be relaxed at Engineers discretion where high compliance with this Specification is attained, or tightened where variations in quality become apparent.

6.32.1 Frequency of Tests on Asphaltic Mixes

The minimum frequency of testing of asphaltic mixes shall be:

Characteristic Analysed	Minimum Frequency of Testing
Grading of combined aggregate	One each 100t, or at least one per day, whichever is more frequent
Binder Content	One each 100t, or at least one per day, whichever is more frequent
Air voids in compacted asphalt	One each 100t, or at least one per day, whichever is more frequent
Voids filled with bitumen	One each 100t, or at least one per day, whichever is more frequent
Voids in mineral aggregate (Dense graded asphalt only)	One each 100t, or at least one per day, whichever is more frequent
Index of retained strength	One each 100t, or at least one per day, whichever is more frequent
Marshall Mix Properties	One per mix for each combination of aggregate source.
Stability, flow, Stiffness	
Relative compaction of asphalt	One per 500m^2 per layer provided a minimum of 6 per lot or per day

Completed work shall not be opened to traffic without the prior consent of the Engineer.

6.32.2 Tolerances for Roadway Construction

The following tolerances for pavement construction after completion of the work shall not be exceeded. All pavement work shall be carried out in the dimensions, shapes, and levels shown on the drawings. The Engineer may waive certain requirements and apply other tolerances as he may deem necessary and as are appropriate for the case at hand.

Horizontal Alignment	- 50 mm
Vertical Alignment and Elevations	
- Top of compacted subgrade	+ 25 mm - 50 mm
- Top of compacted granular subbase course	+ 20 mm - 20 mm
- Top of cpmpacted bit. treated base course	+ 15 mm - 15 mm
- Top of compacted bit. binder or surface course	+ 10 mm - 10 mm
- Top of concrete pavement	+ 10 mm - 10 mm
Thickness of compacted granular subbase	+ 10% - 5%

When a 3 metre straightedge is laid on the surface parallel to and perpendicular to the centre line, the surface variation from the lower edge of the straightedge shall not exceed:

- Compacted subgrade	12 mm
- Compacted granular subbase course	8 mm
- Compacted bit base course	6 mm
- Compacted bit binder course	4 mm
- Compacted bit surface course	3 mm
- Concrete pavement	3 mm

The tolerance for absolute dimensions of kerbs shall be in accordance with that given for surface course above.

Flatness of surfaces as measured using a three metre straightedge laid on the-top or face of the kerb or on the surface of gutters shall not vary more than 3 mm from the edge of the straightedge, except at grade changes or curves.

When any tolerances in this Clause are exceeded the Contractor shall determine the full extent of the area which is out of tolerance and shall submit to the Engineer for his approval the proposed method of rectification.

When the surface level of a surface course is not in accordance with these tolerances, the full depth of the layer shall be removed and replaced with fresh material. The width to be removed shall be the fall width of paving laid in one operation and the minimum length shall be 15 m.

6.33 Measurement and Payment

(1) Subgrade

The work for subgrade shall be measured in cubic metres from cross-sections taken as shown on the Drawing. The rate shall include full compensation for benching, spreading, drying, watering, compaction, trimming and furnishing

labour, materials, tools, equipment and incidentals necessary to complete the work to this specification and as directed by the Engineer.

(2) Subbase & Base Course

The work measured for subbase and base course as provided above shall be paid for at the scheduled rate for the items listed above. The rate for subbase and base course shall be made in accordance with Clause 10 (Pavement) of the Preamble. In addition, the rate for subbase shall include the removal of overburden and its disposal, the maintenance of the borrow pit and the construction of access roads where required at the borrow pit.

(3) Asphalt Concrete Pavement

This work, measured above, as specified in Clause 10 (Pavement) of the Preamble shall be paid be for at the scheduled rate respectively, for each of the items listed above. The rates shall be full compensation for furnishing, mixing and placing all materials, including all labour, equipment, tools and incidentals necessary to complete the work including the rectification of any defective work. The rate for covering aggregate shall also include for the producing aggregate, including crushing and screening, and clearing, removal of overburden and the construction of access roads where required at the river deposit area. Interim payments may be made on the quantity of cover aggregate satisfactorily.

7 PILING

The work shall consist of cast-in-place concrete piles constructed by either a reverse circulation drill method or other method and steel casing methods in accordance with this Specification and with the requirements shown on the Drawings.

Cast-in-place concrete piles shall be constructed, in accordance with the details shown on the Drawings, of concrete Class B-2, mixed and placed in accordance this Specification.

Reinforcement shall comply with the provisions of this Specification.

The Cast-in-place Concrete Pile Construction Method Statement, including the detailed programme and procedures, shall contain all information as requested on material, equipment, methods of work etc, and be approved in writing by the Engineer.

The Contractor shall furnish the Engineer daily with a detailed record of the construction of piles.

7.1 Drilled Holes for Cast-in-place Concrete Piles

All holes for concrete piles cast in drilled holes shall be drilled to the tips of piles. The length of piles shall be as instructed by the Engineer. The drilling machine shall be such that the hole can be maintained exactly vertical during drilling operations.

Completed piles and existing structures very close to the drilling area shall be protected from the influence of piling and the Contractor's proposals for this shall be submitted to, and approved by the Engineer, at least two weeks before the start of piling.

Drilled holes shall be protected from collapse by providing a bentonite slurry, steel casing pipe or other method approved by the Engineer. If used the steel casing pipe shall be rigid and project at least 50 cm. above ground level.

The level of water or bentonite slurry inside the drilled hole shall always be kept approximately 2 m higher than the natural ground water level. Water supplied from a municipal water supply system or a river is allowed for this purpose.

All loose material existing at the bottom of the hole after drilling operations have been completed shall be removed by air lift or suction pump before placing concrete.

Placement of reinforcement shall not commence until the Engineer has approved the cleaning and measurement of the bore.

7.2 Reinforcement for Cast-in-place Concrete Piles

Reinforcement shall be positioned as shown on the Drawings. The connecting portions of main bars with hoops shall generally be welded by arc fillet welding.

During the placing of the reinforcement in the hole, the verticality and position of the reinforcement shall be carefully controlled to prevent collapse of the drilled hole

or damage to the walls.

7.2.1 Permanent Steel Casing

Material steel pile with rib shall be shop-fabricated and shall have the type, weight, quality and dimensions specified in JIS A 5525 (Steel Pipe: SKK-41), ASTM A500 (Steel Pipe Grade B), or as shown on the Drawings.

The Contractor shall submit a certificate by the manufacturer to the Engineer for approval prior to furnishing steel pile.

7.3 Casting of Cast-in-place Concrete Piles

Concrete shall be placed in one continuous operation from tip to cut-off elevation by tremie tubes and shall be carried out in such a manner as to avoid segregation. The tip of the tremie shall generally be 2m lower than the fresh concrete surface.

Concreting of each pile shall not commence until the Engineer has approved the cleaning of the bore and placement of reinforcement.

Placement of tremie concrete shall not commence until full evidence of successful trials of tremie concrete placement methods and testing of the concrete is provided to the Engineer.

The Contractor shall initially cast an additional length of pile above the finished level of the top of the pile and subsequently remove any defective concrete to ensure satisfactory bonding of the pile head to the footing structure.

7.4 Test Drilling

This work shall consist of test drilling using rotary wash drilling for the investigation of sites on which any structural foundation is to be provided.

When testing is required the Contractor shall take several test bores at each structural site to get the exact soil profile or as otherwise directed by the Engineer. Where rock is outcropping on the surface the Engineer may dispense with test bores.

7.5 Depth of Bores

The test bores shall be taken down to the bearing stratum and into it sufficiently to prove its continuity. Generally this shall be five meters. When bearing stratum has not been reached within 50 meters of the surface, the test bore may be stopped after the approval of the Engineer.

7.6 Tests Required on All Holes

Standard penetrating tests shall be taken at two (2) meter intervals or at each change of strata whichever is lesser. The static ground water level shall be recorded for each hole. In rock core drilling the full core shall be recovered and stored in core boxes for inspection by the Engineer.

7.7 Logging of the Bores

If so requested by the Engineer, the Contractor shall supply on the working day following completion of the bore the following information:

- Structure name
- Bore position and code number
- Reduced level of top of the bore
- Date and time of boring
- Diameter of bore
- Type of plant used
- Depth to which bore was cased
- Depth to base of each stratum from the surface
- Description of strata
- Depth and results of tests
- Static water level
- Remarks

All descriptions and classifications of soils shall be in accordance with "Procedures for Testing Soils, ASTM".

7.8 Further Tests That May Be Required

The Engineer may call for more elaborate testing than described above at any structure site if he finds that the information is not adequate.

When instructed by the Engineer, undisturbed core samples shall be taken in cohesive soil strata.

The sampling cylinder is to be sealed and used for transport of the core from site to testing laboratory. All laboratory testing shall be the responsibility of the Contractor.

7.9 Test Piles

The Engineer may instruct the load testing of cast-in-place concrete piles. Details of the loading test are given in the Special Specifications.

The results of the sonic logging of a pile shall be approved by the Engineer prior to the commencement of base grouting at that pile.

The Testing Company and their specialist Site Engineer will be subject to the Engineer's approval.

The load cells and the surrounding section of pile shall be grout filled by pressure grouting after completion of the tests. Grouting shall not proceed until the test results have been reported and accepted by the Engineer.

7.10 Load Test on Cast in Place Pile

The Contractor shall test cast in place piles using an Osterberg cell to isolate and obtain ultimate end bearing and side shear data for the bored piles to verify their capacity to carry the design loads.

7.11 Installation of Osterberg Cell in Cast in Place Pile

Upon reaching the final toe elevation, the pile bottom shall be cleaned and approved by the Engineer. The cell assembly, bearing plates, related hydraulic supply, and instrumentation shall be lowered into the pile attached to the reinforcing steel cage. The bottom of bearing plate shall be a minimum of 500 mm above the bottom of the pile.

A cone or funnel, shaped guide system made from rebar will be installed just above the tremmie hole to simplify the insertion of the tremmie pipe. The tremmie pipe base shall be located slightly above the bottom of the pile to allow concrete flow.

Concrete placing procedures shall be required to avoid segregating the concrete during the first initial pour below the cell assembly plate. The concrete mix should allow for workability (minimum of 200 mm slump) and have enough retarder to complete the concreting without an early set. There are holes cut in the bottom cell assembly bearing plate to allow the concrete to flow up around and above the cell assembly bearing plate.

When the concrete is sufficiently high (at least 2m) above the cell assembly the tremmie can be withdrawn from the cell assembly level. The concrete will then be placed by pumping (or tremmie) to the cut off level as per standard/approved concreting procedures.

7.12 Load Test Procedures

The load tests of cell assembly bearing plate shall be performed in accordance with ASTM D1143 Quick Load Test.

Test Report

The following items at least shall be included in the load test of cell assembly bearing plate report.

- Photos of test
- Apparatus of test
- Procedures of test
- Results of tests
- Interpretation of allowable bearing capacity
- All associated conditions and observations pertaining to the cell assembly bearing plate test, including date, list of personnel, weather conditions, and air temperature at time of load increments and irregularity in routine procedure.
- Calibration sheets of testing equipment calibrated within 3 months of actual test and the original calibration sheets shall be made available for inspection

7.13 Sonic Logging Test on Cast in Place Piles, Diaphragm Walls and Barrettes

The Contractor shall carry out sonic logging testing to examine the general condition of bored piles, diaphragm walls and barrettes. This system is used in the verification of concrete integrity, locating defects and evaluating repair effectiveness. The testing involves lowering ultrasonic probes to access tube bottoms and recording the

passage of ultrasonic pulses from a source in one tube to receivers in other tubes.

Test Equipment for Sonic Logging Test

The sonic logging test system consists of 4 basic components for testing applications. These four components are:

- a Personal Computer with a high-speed data acquisition card with acquisition and analysis software;
- Pulser and Apmlifier modules installed;
- a depth measurement wheel assembly; and
- three transducers.

These components are interconnected by cables to form a complete system.

The testing with sonic logging system is typically done as a two-step process with the data acquisition/analysis program. The first step is data collection, while the second step is data processing, display and storage. Both steps are done using the computer program.

All component of listing of the sonic logging test shall be submitted to the Engineer for approval.

7.13.1 Method of Time Measurement for Sonic Logging Test

The sonic logging test measures the time it takes for an ultrasonic pulse to travel from a signal source in one access tube to a receiver in another access tube.

In uniform, good quality concrete, the travel time between equi-distant tubes will be relatively constant and correspond to a reasonable concrete pulse velocity from the bottom to the top of the foundation.

In uniform, good quality concrete, the sonic logging test will also produce records with good signal amplitude and energy.

Longer travel times and lower amplitude/energy signals indicate the presence of irregularities such as poor quality concrete, void, honeycombing and soil intrusions. The signal will be completely lost by the receiver and the sonic logging test recording system for the more severe defects such as void and soil intrusions.

7.13.2 Test Procedure for Sonic Logging Test

Prior to testing the tubes are filled with water for improved conductivity. The probes are lowered to the bottom of two adjacent tubes and pulled simultaneously at a steady rate, stating from the bottoms of the tubes, over the depth of measurement. A depth wheel controls the resolution of the collected data. Measurements are made automatically and recorded. The probes are pulled to the top of the shaft, thus giving a complete assessment of the concrete quality between two tubes.

The sonic logging test tests are typically performed between all the perimeter tubes to check the outer perimeter of the shaft. Additional diagonal sonic logging tests are also performed to check the integrity of the inner core of the shaft.

7.13.3 Rating Criteria for Sonic Logging Test

The sonic logging rating criteria is based on the percentage reduction of the signal velocity through the flawed area versus the signal velocity through sound material immediately adjacent to the flaw. This insures that the signal arrival times used to calculate the signal velocities are measured through the same amount of material, which is very important if tube pair not evenly spaced from the shaft top the bottom.

Rating Criteria for Drilled Shaft (Bored Piles) and Diaphragm Walls:

Type	Description
Good (G)	No signal distortion and decrease in signal velocity of 10% or less are indicate of good quality concrete
Slight defect (S)	Minor signal distortion and a lower signal amplitude with a decrease in signal velocity between 10% and 25%. Results indicative of minor contamination or flawed concrete.
Major Defect	Severe signal distortion and much lower signal amplitude with a decrease in signal velocity 25%or more. Results indicative of bentonite slurry contamination or soil intrusion and/or poor quality concrete.
No Signal (NS)	No signal was received. Highly probable that a soil intrusion or other severe defect has absorbed the signal.
Water (W)	A measured velocity of 1450 to 1500m/s. This is indicative of water intrusion.

The condition rating for the test piles are evaluated against acceptability criteria as indicated by following table.

Acceptability Criteria for Drilled Shafts and Diaphragm Walls:

Description	Acceptability
At any particular depth, not more than 3 sets of data show condition rating S & other G	O.K
At any particular depth, only 1 set of data show condition rating D, not more than 1 set of data show condition rating S & others G	O.K
At any particular depth, 1 set of data show condition rating NS	Not O.K
At any particular depth, 1 set of data show condition rating D	Not O.K

Note: Condition "Not O.K" may require further testing for accurate delineation of defect area and/or recommendation on remedial measures as listed below;

- Crosshole Tomography Analysis
- Low or High Strain Integrity Tests
- Coring to required depths at selected locations

7.14 Measurement and Payment

(1) Cast-in-place Concrete Piles

Measurement and Payment for cast-in-place concrete piles shall be based on the length to be left in place and shall be made in linear metres in accordance with sub-clauses 11.1 of the Preamble.

(2) Pile Load Test and Sonic Logging Test

The load test piles for cast-in-place concrete and reinforcement will be paid separately under the corresponding items for the supply, driving, boring and excavation and cast-in-place reinforced concrete. The length of test piles shall be specified on the Drawings.

Anchors and anchor piles which are necessary for testing piles, will not be paid for separately but considered as included in the load test item of the Bill of Quantities.

Measurements for Pile Load Tests and Sonic Logging Test shall be made on the basis of the number of load tests completed and accepted by the Engineer. Payment for load tests shall be made for the number stated in the Bill of Quantities and the schedule rate shall include full compensation for the cost of materials, labour and equipment, including furnishing, supplying and setting testing apparatus and the cost of recording, analysis and reporting of each load test and incidental items necessary to complete the work in accordance with this Specification and instruction by the Engineer.

8 CONCRETE GENERALLY

8.1 General

Concrete work shall consist of the general items pertaining to the required class or classes of concrete, with or without reinforcement, constructed in accordance with this Specification and the lines, levels, grades and dimensions shown on the Drawings, and as required by the Engineer. Portland cement concrete shall consist of a mixture of cement, water and coarse and fine aggregates.

The proposed sequence and method of placing all concrete shall be submitted to the Engineer for approval one month prior to concrete placement.

The placing of any concrete shall not commence until the Engineer has inspected and approved the formwork, reinforcement, anchorages, etc. against which the concrete is to be placed, in these particular sections of work which have been previously notified to the Contractor.

8.2 Concrete Classes and their Use

The use of each class of concrete shall be as follows unless otherwise shown on the Drawings or directed by the Engineer:

Class	Use of Each Class of Concrete
A	- Precast prestressed concrete segments and box girders
B	- In-situ prestressed concrete box girders
B	- Precast prestressed concrete I-girders
B	- Pylons
C	- Prestressed concrete hollow slabs
D - 1	- Reinforced concrete deck slabs
D - 1	- Diaphragms of prestressed concrete I- girder
E	- Reinforced concrete cantilevered pier heads, pier columns and footings for piers
D - 2	- Cast-in -place reinforced concrete piles
E	- Pipe culverts
D - 1	- Precast reinforced plate concrete for slabs
E	- Abutments, skirt around footing
E	- Approach slabs
E	- Box culverts, retaining walls
F	- Foundations of street lighting poles
F	- Concrete foot-paths, kerbs (non- reinforced), manholes and drainage inlets and outlets
E	- Head walls, apron of pipe culverts
G	- Levelling concrete stone
G	- Backfill concrete in masonry, protection, and as specified on the Drawings
P	- PPC-Pavement at toll plaza

8.3 Determining the Proportions and Batch Weights

No structural concrete shall be placed in the works until the relevant mix has been approved by the Engineer.

The proportions and batch weights for concrete shall be determined as prescribed

below. The determinations shall be made after the materials furnished by the Contractor have been accepted.

8.4 Trial mixes

The Contractor shall, at least thirty five (35) days prior to the commencement of concreting, have laboratory trial mixes prepared which shall be witnessed by the Engineer.

The laboratory trial mixes shall be so designed by the Contractor that the resultant compressive or flexural strength result as applicable, (Preliminary Test Result), shall show an adequate working strength margin, in accordance with normal good practice, so that the probability of site working strength test values falling below the minimum specified strength is reduced to a value not exceeding 5%.

The Engineer will determine the proportions on the basis of the trial mixes conducted with the materials to be used in the work.

The proportions for the trial mixes shall be based on the values given in the table below adjusted as described in this clause. However the proportions given in the table are approximate values for the convenience of the Contractor's estimate only, excepting that it shall be understood that:

- The water cement ratios given shall be absolute maximum values.
- The cement contents given shall be absolute minimum values.
- The minimum compressive strength values given shall be taken to mean the minimum site working strength.

Once mixes have been produced which have satisfied the trial mix requirements, the Contractor shall submit full details for each mix, including test results, mix proportions, aggregate sources, moisture condition, gradings, slumps, methods of mixing and transport, and quality control to the Engineer for approval. No concrete shall be used in the Works until the mix design has been approved by the Engineer.

Preparation and testing of trial mixes shall be required for each class of concrete before the concrete can be used in the Works. The plant and methods used for the final trial mixes shall be those proposed for use in the Works and mixes shall be full working batches for the plant employed.

One batch of the proposed mix in each class of concrete shall be made on each of three different days. The volume of each batch shall be the full capacity of the mixer. Three samples of concrete shall be taken from each batch and each tested in accordance with the relevant requirements as outlined in Clause 8.5 for each batch of concrete. The testing shall be conducted as follows:

Slump:	Immediately upon discharge from the mixer and again 15, 30,and 45 minutes later.
Bleed:	30, 60, and 90 minutes after discharge from the mixer
Setting time:	2 tests
Density (fresh concrete):	2 tests

Density (hardened concrete):	2 tests
Compressive strength:	3 cylinders at 1 day (only where called for in the pecification) 3 cylinders at 3 days (only where called for in the Specification) 3 cylinders at 7 days 3 cylinders at 28 days 3 cylinders at 56 days
Drying Shrinkage:	3 specimens (only where called for in the Specification)
Adiabatic temperature rise:	1 sample (concrete for pile caps only) (refer to Appendix A)
Wash out resistance:	3 samples (tremie concrete for bored cast in place piles only) (refer to Appendix A)
Chemical Content:	1 test
Elastic Modulus:	3 tests, conducted to AS 1012, Part 17 in saturated and dried condition.

Each batch shall be tested to establish uniformity of mixing.

Additionally, the Contractor shall carry out laboratory trials with the proposed mixes to establish the influence of temperature on workability and setting time. Concrete shall be produced at the upper and lower limits of expected fresh concrete temperature during the works and shall be tested for slump and setting time in accordance with the above.

If the concrete fails to meet the requirements of this Specification, the Contractor shall re-design the mix and re-submit the details as described above to the Engineer for approval.

When trial mixes satisfying the requirements of this clause have been developed the Contractor shall submit full details for each mix including calculations, strength results, gradings of individual aggregates, combined gradings, mix proportions, water to cement and aggregate to cement ratios, slumps and compaction factors to the Engineer. Full details shall be submitted to the Engineer preferably one calendar month, but not less than two weeks, before concreting commences.

8.5 Standard Proportions of Concrete for Use in Structures

CLASS DESCRIPTION	A	B	C	D – 1	D – 2	E	F	G	P
Maximum size of coarse aggregate (mm)	20	20	20	20	20	20	25	40	25
Slump[1] (cm)	7.5± 2.5	7.5± 2.5	7.5± 2.5	7.5± 2.5	15.0+2.	7.5± 2.5	5.0± 2.5	5.0±1 2.5	Max. 5
Maximum Water/cement ratio W/C (%)	30	37.5	42.4	48.6	50.0	62.0	70.2	88.2	40.0
Water content W (kg/m^3)	150	170	176	185	205	192	207	163	160
Cement content C (kg/m^3)	500	450	415	380	410	310	295	185	400
Fine aggregate S (kg/m^3)	711	720	705	819	786	865	880	910	791
Coarse aggregate G (kg/m^3)	1082	1100	1147	1044	1004	1020	1130	1205	1077
Minimum 28 day Compressive Strength by cyl. test [2] (30 x 15(D) cm) (MPa)	50	40	35 -	30	30	24	20	15	-
Minimum 28 day flexural strength[3] (MPa)		-	-	-	-	-	-	-	4.5

1 Slump shall be determined in accordance with AASHTO T119 or JIS A1101.

2 Concrete compressive tests shall conform to the requirements of AASHTO T22 and 23
In the event of any dispute regarding conformance with this Specification, the results obtained by the cylinder test shall be taken as conclusive, unless the Engineer has previously agreed in writing to the use of cube tests for control purposes.

3 Flexural strength shall be tested by the third point loading method in accordance with AASHTO T97.

The weights of aggregate per cubic meter of concrete in the above table are based on the use of aggregates which have a bulk specific gravity of 2.65 when in a saturated surface-dry condition, the use of a uniformly graded natural sand having a fineness modulus of 2.75, and the use of a uniformly graded coarse aggregate of the size indicated.

For aggregates having other specific gravities the weights shall be corrected by multiplying the weights shown in the table by the specific gravity and dividing by 2.65.

When angular, manufactured sand or sand having a fineness modulus greater than 2.75 is used, the amount of fine aggregate shall be increased and the amount of coarse aggregate decreased. When using sand having a fineness modulus less than 2.75, the amount of fine aggregate shall be decreased and the amount of coarse aggregate increased. For each change in fineness modulus of 0.10 as compared to 2.70, the percentage of sand shall be changed by 1 percent in relation to the total weight of combined fine and coarse aggregates. The fineness modulus of fine

aggregate shall be determined by adding the cumulative percentage, by weight, of material retained on each of ASTM Standard sieves 9.5, 4.75, 2.36, 1.18, 0.600, 0.300 and 0.150 mm, and dividing by 100.

The correction for fineness modulus shall be made prior to making a correction in the weights of the above table for variations from 2.65 in specific gravity.

The Contractor may, subject to prior approval by the Engineer, use alternative sizes of coarse aggregate to those in the above table.

Requiring additional cement above that specified, no compensation shall be made to the Contractor for the additional cement. Designated sizes of coarse aggregate need not be separated into component sizes. However, two sizes are preferred when the maximum size exceeds 2.5 cm. If one or more of the component sizes used fails to meet the specified grading for its respective size, but a combination of the sizes can be used to meet the specified grading for the combined size, they may be used with the written permission of the Engineer.

8.6 Proportions and Batch Weights

The Engineer will designate the weight in kilograms of fine and coarse aggregate (in a saturated surface-dry condition) per cubic meter of concrete for the specified class of concrete and these proportions shall not be changed except as provided in the paragraphs immediately following. In addition, the Engineer will also designate the batch weights of aggregate after he has made moisture determinations and corrected the saturated surface-dry weights for free moisture.

In batching aggregate for structures containing less than 25 cubic meters of concrete, the Contractor may substitute approved volumetric measuring devices in lieu of weighing devices. In such event, weighing shall not be required but the volumes of coarse aggregate and of fine aggregate measured into each batch shall be those designated by the Engineer.

8.7 Adjustment for Variation in Workability

If it is found impossible to obtain concrete of the desired placeability and workability with the proportions originally designated by the Engineer, he will make such changes in aggregate weights as are necessary, provided that in no case shall the cement content originally designated be changed.

8.7.1 Adjustment for Variation in Yield

If the cement content of the concrete, determined by means of the yield test, AASHTO T21, varies more than plus or minus two (2) percent from the designated value in the above table, the proportions will be adjusted by the Engineer to maintain a cement content within these limits. The water content shall in no case exceed the specified amount.

8.7.2 Adjustment for Excess Water Content

If, when using the designated cement content, it is impossible to produce concrete having the required consistency without exceeding the maximum allowable water

content specified in the above table, the cement shall be increased by the Engineer so that the maximum water content will not be exceeded.

Adjustment for new materials - No change in the source or character of the materials shall be made without due notice to the Engineer and no new materials shall be used until the Engineer has accepted such materials and has designated new proportions based on tests or trial mixes as provided herein. Should the changes due to the new materials require an increase in the amount of cement, no additional payment shall be made to the Contractor for the cost of such additional cement.

8.8 Sampling of Concrete

In order to assess compliance of the concrete during construction, the Contractor shall prepare test specimens which shall be cured and tested at 7 days or 28 days as determined by the Engineer, or at any other interval that may be deemed necessary to determine the strength of the concrete. (Site working strength).

Specimens shall be made in pairs and there shall not be less than eight pairs made for every 100 cubic meters of concrete or fraction thereof placed during one day's work or as deemed necessary by the Engineer. One specimen from each pair shall be tested at 7 days and one specimen at 28 days.

If concrete is placed by means of individual transit mixer batches then each batch shall be considered to be a sample from which 2 pairs of specimens shall be prepared and tested as for bulk concrete above.

Irrespective of the quantity, every day's production of concrete shall be tested both for strength and for slump and every structure and every component of every structure shall likewise be so tested for strength and slump. The checking and testing of the concrete shall be the prerogative of the Engineer, and he may increase the specified strength and condition as required for the project.

The concrete test specimens shall be tested by the Contractor at a conveniently located and properly equipped laboratory.

The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling, transporting and storing.

8.9 Specimen Preparation

The ultimate compressive strength of the concrete shall be determined on specimens obtained and prepared in accordance with AASHTO T141 (ASTM C172) and AASHTO T23 (ASTM C31). Test cylinders made in the laboratory shall conform to AASHTO T126 (ASTM C192).

The compression test performed on cylinders shall be according to specifications AASHTO T22 (ASTM C39).

8.10 Compressive and Flexural Strength

The average site working strength value of any 4 consecutive results of the 28 day tests shall not be less than the minimum strength specified in Table 10-1-1 for the

respective class of concrete. In the event of failure to comply with this requirement all of the concrete in all the batches represented by such specimens, including any batches within the sequence which were not sampled shall be deemed not to comply with the strength requirement of this clause. If at any time the average of any 4 consecutive results of 7 day tests falls below 70% of the prescribed minimum value at 28 days for compressive strength or below 80% of the prescribed minimum value at 28 days for flexural strength the cement content of the concrete shall be increased by at least 20 kg per cubic meter of compacted concrete, without extra payment, until any necessary mix modifications have been agreed following examination of 28 day tests.

8.10.1 Characteristic Strength

The characteristic strength of the various classes of concrete shall be determined as soon as the first 30 test results of each class become available.

The characteristic strength shall be calculated by the equation.

$$X_o = X_m - \overline{KS}$$

Where: X_o: characteristic strength.
X_m: mean or average of the series of results
K: a factor depending upon the percentage of results that fall below the characteristic strength
S: standard deviation given by the equation
$S = [X - X_m^2]^{½}/(N - 1)$

Where: X: the individual result
N: the total number of results

The values for the factor K are:

Percentage of results falling below the minimum	Value of K
0.1	3.09
0.6	2.50
1.0	2.33
2.5	1.96
5.0	1.64

If the characteristic strength so determined falls below the minimum site working strength the Contractor shall increase the cement content in the same manner as described in Item (ii) above until such time as adjustments shall be made in the mix proportions or improvements made in the quality control measures to raise the average strength or reduce variation to the satisfaction of the Engineer.

8.10.2 Failure to Comply with Compressive Strength Requirements

In the event of compressive strength results not complying with the strength requirements of this clause or in the event of doubtful results, the Engineer will proceed to check the sample compressive strength by means of crushing tests performed on test specimens taken with a rotary core borer at suitable points indicated by the Engineer on the structure already constructed.

Such tests shall be carried out by an agreed authority having suitable test facilities. If such tests show strength in compliance with the requirements herein specified, the concrete shall be considered satisfactory. If such tests do not comply with the requirements, the Engineer may direct the Contractor to cut out and make good the defective work at the Contractor's expense.

Repairs to concrete shall not be carried out without the authorisation of the Engineer.

8.10.3 Care of Specimens

The cost of taking specimens and performing the tests including the cost of providing stout, substantial packing cases and the cost of shipping or transporting the test specimens from the site to the laboratory shall be included as part of the price tender for Portland cement concrete, The Contractor shall take, on his own responsibility, every precaution to prevent injury to the test specimens during handling and transporting.

8.10.4 Records

The records of all tests shall be kept by the Engineer but results shall be available at all times to the Contractor. The Contractor shall be responsible for making such adjustments as may be necessary to produce specification concrete and the test results shall include whether or not the concrete is satisfactory.

8.11 Material

8.11.1 Cement

The Contractor shall use only one brand of any one type of cement having uniform quality for one project.

The cement used in the work shall be ordinary Portland. Cement conforming to the minimum requirements of Vietnam Standard TCVN 2682 - 1992 "Portland Cement" except that when otherwise shown on the Drawings, or directed by the Engineer, cement shall conform to the requirements of JIS R5210 "Portland Cement" or AASHTO - M85 (Type 1).

8.11.2 Admixtures

Admixtures shall not be used without the written approval of the Engineer. The Contractor shall submit samples of any proposed admixtures to the Engineer at least 28 days prior to the date of commencement of construction of the particular structure or portion of structure on which he intends to use such admixtures.

8.11.3 Water

All water used in concrete shall be subject to the Engineer's approval. Water used in mixing, curing, or other designated applications shall as a general rule be potable, otherwise reasonably clean and free from oil, salt, acid, alkali, sugar, vegetable, or any other substance injurious to the finished product. If required by the Engineer, water shall be tested by comparison with distilled water.

Comparison shall be made by means of standard cement test for soundness, time of setting and mortar strength. Indication of unsoundness, change in time of setting of plus or minus 30 minutes or more, or decrease of mortar strength more than 10 percent compared with distilled water shall be sufficient cause for rejection of the water that is being tested.

Where the source of water is relatively shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

8.11.4 Fine Aggregate

The fine aggregate for concrete shall consist of natural sand or, subject to approval of the Engineer, other inert materials with similar characteristics, having clean, hard and durable particles and it shall be free from objectionable quantities of dust, silt, clay, organic matter, and other impurities.

The fine aggregate shall be uniformly graded and shall meet the following grading requirements:

Grading of Fine Aggregate

I Sieve Size (mm)	Cumulative Passing Percentage by Weight
9.5	100
4.75	95-100
2.36	80-100
1.18	50-85
0.600	25-60
0.150	10

Sieve analysis of fine aggregate shall be made in accordance with JIS A1102 (Method of Test for Sieve Analysis of Aggregate) or AASHTO - T27.

The gradation requirements given above are the extreme limits to be used in determining the suitability of material from all possible sources of supply. The gradation of materials from any one source shall not vary in composition beyond the range of values that govern the selection of a source of supply. For the purpose of determining the degree of uniformity, a fineness modulus determination shall be made upon representative samples, submitted by the Contractor, from such sources as he proposes to use. If fineness modulus of fine aggregate varies more than 0.2 from the value used in selecting concrete proportions, the fine aggregate shall be rejected unless suitable adjustment of the mix proportions are made with the approval of the Engineer.

The amount of deleterious substances in fine aggregate shall not exceed the limits specified in Table 10-1-2. Treatment of other deleterious substances which are not shown in the above table shall be determined by the direction of the Engineer.

Tests for material finer than 0.075 mm sieve shall be made in accordance with JIS A1103 (Method of Test for Amount of Material Passing Standard Sieve 0.074 mm. in Aggregates) or AASHTO - T11.

Limits for Deleterious Substances in Fine Aggregates

Item	Maximum % by Weight
Clay lumps	1.0
Material finer than 0.075 mm sieve:	
Concrete subject to abrasion	3.0 [1]
All other concrete	5.0 [1]
Material coarser than 0.300 mm sieve floating on a liquid having a specific gravity of 1.95	0.5 [2]

Note: [1]In the case of crushed aggregate, if the material finer than 0.075 mm sieve consists of the dust of fracture essentially free from clay or shale, these percentages may be increased to 5 and 7 percent respectively.
[2]This requirement does not apply to manufactured sand produced from blast furnace slag.

All fine aggregate shall be free from injurious amounts of organic impurities. Approximate determination of the presence of injurious organic impurities in natural sand shall be in accordance with JIS A1105 (Method of Test for Organic Impurities in Sands) or AASHTO T21. Aggregate subjected to the colourimetric test for organic impurities, and producing a colour darker than the standard, shall be rejected.

However, any sand that fails to meet the above requirement may be used provided that the compressive strength of mortar specimens using such sand is more than 95% of that of mortar specimens using the same sand which is washed by 3% solution of sodium hydroxide and then by water, and approved by the Engineer. Testing age of mortar specimens shall be 7 and 28 days for normal Portland cement.

Compressive strength of mortar specimens shall be determined by AASHTO – T71, "Effect of Organic Impurities in Fine Aggregate on Strength of Mortar".

8.11.5 Coarse Aggregate

The coarse aggregate shall consist of one or more of the following: crushed stone, gravel, blast-furnace slag, or other approved inert materials of similar characteristics having clean, hard, durable pieces. It shall be free from objectionable quantities of flat or elongated particles, organic matter or other deleterious matter.

The coarse aggregate shall be uniformly graded and shall meet the following grading requirements:

Size of Coarse Agg. (mm)	Amounts Finer than Each Standard Sieve Percentage by Weight (JIS A1102)										
	100 mm	80 mm	60 mm	50 mm	40 mm	25 mm	20 mm	15 mm	10 mm	5 mm	2.5 mm
50 –5	-	-	100	95- 100	-	37- 70	-	10- 35	-	0- 5	-
40 –5	-	-	-	100	95- 100	-	35- 70	-	10- 30	0- 5	-
25 – 5	-	-	-	-	100	95-	-	30- 70	-	0- 10	0- 5
20- 5	-	-	-	-	-	100	90- 100	-	20- 55	0- 10	0- 5
15- 5	-	-	-	-	-	100	100	90-	40- 70	0- 15	0- 5
80- 40	100	90- 100	45- 70	-	0- 15	-	0- 5	100	-	-	-
60- 40	-	100	90- 100	35- 70	0- 15	-	0- 5	-	-	-	-
50- 25	-	-	100	90- 100	35- 70	-	-	-	-	-	-
40- 20	-	-	-	100	90- 100	0- 15 20- 55	0- 15	0- 5 -	0- 5	-	-

Sieve analysis of coarse aggregate shall be made in accordance with JIS A1102 (Method of Test for Sieve Analysis of Aggregate) or AASHTO -T27.

The amount of deleterious substance in coarse aggregate shall not exceed the limits prescribed in the table below Treatment of the other deleterious substances which arc not shown in the table shall be determined by the direction of the Engineer.

Limits of Deleterious Substance in Coarse Aggregate

Item	Maximum % byWeight
Clay lumps	0.25
Soft particles	5.0
Material finer than 0.075 mm. sieve	1.0 [1]
Material floating on a liquid having a specific gravity of 1.95	1.0 [2]

Note : [1]In the case of crushed aggregate, if the material finer than 0.075 mm. sieve consists of the dust of fracture essentially free from clay or shale, this percentage may be increased to 1.5.
[2]This requirement does not apply to manufactured sand produced from blast furnace slag.

Test for material finer than 0.075 mm sieve shall be made in accordance with JIS A1103) (Method of Test for Amount of Material Passing Standard Sieve 0.075 mm in Aggregates), or AASHTO - T11. Test for soft particles shall be made in accordance with JIS A1126 (Method of Test for Soft Particles in Coarse Aggregate by Use of Scratch Tester), or AASHTO - T12.

8.12 Test of Aggregate

Before use, results of the foregoing tests of aggregate from each source shall be submitted to and approved by the Engineer. Tests for aggregate in use shall be made when required by the Engineer.

Expansion Joint Filler (Asphaltic Joint Filler)

Expansion joint filler shall conform to the requirements of AASHTO - M33.

The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint unless otherwise authorized by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely, and held accurately to shape by stapling or other positive fastening satisfactory to the Engineer.

8.13 Storage of cement

Cement may be shipped from pretested and approved bins at the mill. Cement shall be stored in a damp-proof warehouse with a floor raised at least 30 cm from the ground so as to permit easy access for inspection and for use in the delivered order. Bagged cement shall not be piled more than 13 sacks high. Cement which has become damp, lumpy or otherwise not in proper condition shall not be used. Cement stored by the Contractor for a period longer than 60 (sixty) days shall require the Engineer's approval before being used on the work. Subject to the Engineer's approval of their use, cement of different brands, types, or from different mills shall be stored separately. The use of cement reclaimed from discarded or used bags shall not be permitted.

Storage of aggregate - Fine and coarse aggregates shall be stored separately to prevent contamination by foreign material. Aggregate shall be stored in such a manner as to keep the moisture content as uniform as possible, and shall be handled in such a manner as to prevent segregation. Aggregate shall be stored so as to protect from the direct rays of the sun. Aggregate from different sources of supply shall not be stored in the same place without permission from the Engineer.

8.14 Adhesive

Epoxy resin adhesive shall be used for the jointing of precast concrete blocks. It shall comply with the following requirements.

	Item	Unit	Quality Standards	Testing Conditions	Curing Conditions
UNHARDENED ADHESIVE	External appearance		No foreign matter recognized as to be harmful shall be mixed in. No separation of material shall be observed.		
	Specific gravity	-	.2 – 1.6	Room temperature [1]	
	Viscosity	cp	$1 \times 10^4 - 5 \times 10^4$	Standard working temperature 2/	
	Pot life [3]	hr	2, or more	Standard working temperature [2]	
	Minimum Thickness of Slack [4]	mm	0.3, or more	Standard working temperature [2]	
HARDENED ADHESIVE	Tensile Strength	kg/ cm^2	125, or more	Age: 7 days, Room Temperature [1]	Room Temperature [1]
	Compressive strength	kg/ cm^2	700, or more	Age: 7 days, Room Temperature [1]	Room Temperature [1]
	Adhesive strength [5]	kg/ cm^2	60, or more	Age: 7 days, Room Temperature [1]	Room Temperature [1]

Note : [1]"Room temperature" refers to the Class-2, Standard Temperature Condition specified in JIS Z8703 (Standard Condition of Testing Location) i.e. 20°C ± 2°C.

[2]"Standard Working Temperature" refers to 3 categories (summer type, spring-and-autumn type and winter type) according to working temperatures and are respectively 30°C ± 2°C, 20°C +2°C and 10°C ± 2°C.

[3]"Pot life" refers to 70% of the time from mixing to the start of gelation.

[4]"Minimum slack thickness" refers to the minimum thickness of the adhesive layer formed by the application of the adhesive to a perpendicular surface to a thickness of approximately 1 mm, and measured after the adhesive has slackened downward.

[5]The adhesive strength shall be obtained from a shearing test.

8.15 Equipment and Tools Generally

Equipment and tools necessary for handling materials and performing the work, and satisfactory to the Engineer as to design, capacity, and mechanical condition, shall be at the site of the work before work is started.

If any equipment is not maintained in full working order or if the equipment as used by the Contractor proves inadequate to obtain the results prescribed, such equipment shall be improved or other satisfactory equipment substituted or added at the direction of the Engineer.

8.15.1 Batching Plant and Equipment

All material in the mix shall be proportioned wholly by weight. The batching plant shall include bins, weighing hoppers and scales for the fine aggregate and for each separated size of coarse aggregate. If cement is used in bulk, a bin, hopper and scales for the cement shall be included. The container shall be watertight.

Provision satisfactory to the Engineer shall be made for batching other components of the mix at the batching plant, which may be either stationary or mobile type. It shall be always properly levelled within the accuracy required for the proper operation of weighing mechanisms.

8.15.2 Bins and Hoppers

Bins with adequate separate compartments for fine aggregate and for each required size of coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that as the quantity desired in the weighing hopper is being approached, the material may be added slowly and shut off with precision. A port or other opening for removing any overload of the several materials from the hopper shall be provided. Weighing hopper shall be constructed so as to discharge completely.

8.15.3 Scales

The scales for weighing aggregates and cement shall be of either the beam type or the springless dial type. They shall be accurate within one-half of 1% under operating conditions throughout the range of use. Ten weights of 25 kilograms each shall be available for checking accuracy. All exposed fulcrums, clevises and similar working parts of scales shall be kept clean. When beam-type scales are used, provision shall be made for indicating to the operator that the required load in the weighing hopper is being approached. The device shall indicate at least the last 100 kilograms of load and up to 25 kilograms overload.

All weighing and indicating devices shall be in full view of the operator while charging the hopper and he shall have convenient access to all controls.

Cement may be measured by weight, or in standard sacks considered to weigh 50 kilograms net. When measured by weight a separate, satisfactory scale and hopper shall be provided together with a boot or other approved device to transfer the

cement from the weighing hopper. Satisfactory methods of handling shall be employed.

Batching shall be so conducted as to result in the weights of material required, within tolerances of 1% for cement and 2% for aggregates.

8.16 Mixers Generally

All concrete shall be mixed in batch mixers. It may be mixed at the site of construction, at a central plant, or in transit. Each mixer shall have attached to it in' a prominent place a manufacturer's plate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of mixing drum.

8.16.1 Mixers at site of construction

Mixers at the site shall be approved drum-type capable of combining the aggregate cement and water into a thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. The mixer shall be equipped with a suitable charging hopper, water storage, and a Water measuring device, accurate within 1%. Controls shall be so arranged that the water can be applied only while the mixer is being charged. The discharge level shall lock automatically until the batch has been mixed the required time after all materials are in the mixer. Suitable equipment for discharging the concrete on the roadbed shall be provided. The mixer shall be cleaned at suitable intervals. The pick-up and throw-over blades in the drum shall be replaced when they have lost 10% of their depth.

8.16.2 Central Plant Mixers

Central plant mixers shall be of approved drum type capable, of combining the aggregate, cement and water into the thoroughly mixed and uniform mass within the specified mixing period and of discharging the mixture without segregation. Central plant mixers shall be equipped with an acceptable timing device that shall not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixers shall be cleaned at suitable intervals. They shall be examined daily for changes in interior condition. The pick-up and throw- over blades in the drum shall be replaced when they have lost 10% of their depth.

8.16.3 Truck or Transit Mixers

These shall be equipped with electrically actuated counters by which the number of revolutions of the drum or blades may readily be verified and the counters shall be actuated at the commencement of mixing operations at designated mixing speeds. The mixer when loaded shall not be filled to more than 60% of the drum gross volume. The mixer shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

Except when intended for use exclusively as agitators, truck mixers shall be provided with a -water measuring device to measure accurately the quantity of water

for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount.

8.17 Vibrators

Unless otherwise directed, the concrete shall be consolidated with approved mechanical vibrators operating within the concrete. When required, vibrating shall be supplemented by hand spading with suitable tools to assure proper and adequate compaction.

The vibrators shall be of a type approved by the Engineer, with a minimum frequency of 3500 impulses per minute and shall be capable of visibly affecting a properly designed concrete with a 2 centimeter slump over a circular area of 45 centimeters radius. The number of vibrators used shall be sufficient to consolidate the concrete properly within 10 minutes after it is deposited in the forms and in addition at least 3 spare vibrators shall be available on standby at the site of the pour to maintain immediate continuity in case of breakdown.

8.18 Forms

Forms shall be made of timber or metal, shall conform to the shape, lines and dimensions of the members shown on the Drawings, and shall be so constructed as to prevent deformation due to load, drying and wetting, vibration, and other causes.

Forms shall be properly equipped with braces, ties and other devices, so as to maintain them in the positions and the shape as shown on the Drawings.

Forms shall be so constructed that they can be removed easily and safely. Joints in linings or panels shall be either horizontal or vertical as far as possible, and shall be sufficiently tight to prevent any leakage of mortar.

Curved forms shall be of the radius called for on the Drawings and acceptable flexible forms shall be installed with that radius.

After forms have been set in the correct location, they shall be inspected and approved by the Engineer before concrete is placed.

Care shall be exercised to keep forms free from dust, grease or other foreign matter. No material or treatment that shall adhere to concrete or discolour concrete shall be used. All forms shall be treated with an approved form-release-oil prior to placing reinforcement and in addition, wood forms shall be flushed with water immediately before placing concrete.

For narrow walls, columns, etc., where the bottom of the form is inaccessible, lower form boards or parts thereof shall be left loose so that they may be removed for cleaning out extraneous material immediately before placing concrete.

Forms for exposed surfaces shall be constructed with triangular fillets not less than 25 mm x 25 mm attached so as to prevent mortar runs and to produce smooth straight chamfers at all sharp edges of the concrete.

8.19 Batching and Transporting Materials

For mixing at site of construction, aggregates shall be transported from the batching Plant to the mixer in batch boxes, vehicle bodies, or other containers adequate in design and construction to properly carry the batch required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or while being dumped.

Cement in original shipping containers may be transported on top of the aggregates. The number of sacks of cement required for each batch shall be placed on the aggregates for that batch. Sacked cement shall be emptied into the aggregates prior to dumping into mixer.

Batches shall be delivered to the mixer separately and intact. Each batch container shall be dumped cleanly into the mixer without loss of cement or mixing or spilling of material from one batch compartment into another.

8.20 Mixing Concrete Generally

Concrete shall be mixed at the construction site, at a central mixing plant, in a truck mixer, or by a combination of central plant and truck mixing. Handmixing may be used when approved by the Engineer. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

8.20.1 Mixing at Site of Concrete Construction

Concrete shall be mixed in a batch mixer of the type and capacity approved by the Engineer. Mixing time shall be determined by the Engineer in accordance with JIS A1119 (Method of Test for Variation in Unit Weight of Air Free Mortar in Freshly Mixed Concrete). When results of the above tests are not available, the mixing time shall be longer than 1 1/2 minutes after all the materials have been introduced into the mixer, but in no case shall the mixing time exceed three times the mixing time prescribed above. Charging of water into the mixer shall begin before the cement and aggregates enter the drum. During mixing the drum shall be operated at speeds specified by manufacturers. Pick-up blades in the drum of the mixer which are worn down 2 cm or more at any part must be replaced.

The volume of a batch shall not exceed the manufacturer's rated capacity of the mixer without written permission of the Engineer. No mixer whose rated capacity is less than a one bag batch shall be used.

Concrete shall be mixed only in such quantities as are required for immediate use, and concrete which is not of the required consistency at the time of placement shall not be used.

Retempering of concrete shall not be permitted. Entire content of the mixer shall be removed from the drum before materials for the next batch are placed therein. Upon cessation of mixing for a considerable length of time, the mixer shall be cleaned thoroughly. Upon resumption of mixing, the first batch of concrete material placed in the mixer shall contain sufficient sand, cement, and water to coat the inside surface

of the drum without diminishing the required mortar content of the mix.

8.20.2 Central plant mixing

Mixed concrete shall be transported from the central mixing plant to the site of work in agitator or non-agitator trucks approved by the Engineer.

Unless otherwise permitted in writing by the Engineer, agitator trucks shall be equipped with a water tight revolving drum and shall be capable of transporting and discharging concrete without segregation. The agitation speed of the drum shall be between 2 and 6 revolutions per minute. The volume of mixed concrete permitted in the drum shall not exceed the manufacturer's rating nor exceed 70% of the gross volume of the drum. Upon approval of the Engineer, truck mixers may be used in lieu of agitator trucks for transportation of central plant mixed concrete. Gross volume of agitator bodies, expressed in cubic meters, shall be as determined by the mixer manufacturer. The interval between introduction of water into mixer drum and final discharge time shall be a maximum of 45 minutes unless the use of additives have been approved. Depending on the type and usage of the approved additives this interval may be extended up to a maximum of 2 hours. During this interval the mixture shall be agitated continuously.

Bodies of non-agitator trucks shall be smooth and water-tight. Covers shall be provided when needed for protection against rainfall. The non-agitator trucks shall deliver concrete to the work site in a thoroughly mixed and uniform mass. Uniformity shall be deemed satisfactory if samples from the one-quarter and three-quarter points of the load do not differ more than 2.5 cm in slump. Placing of concrete shall be completed within 30 minutes after introduction of mixing water into the cement and aggregates or if admixture is used at a time to be determined by the Engineer.

8.20.3 Truck Mixing

Concrete may. be mixed in truck mixers of approved design. Truck mixing shall be in accordance with the following provisions. The truck mixer shall be either a closed, water-tight, revolving drum or an open-top revolving-blade or paddle type. It shall combine all ingredients into a thoroughly mixed and uniform mass, and shall discharge the concrete with satisfactory uniformity. A maximum difference of 2.5 cm between slumps of samples from the one-quarter and three-quarter points of the discharge load shall be deemed satisfactory.

Mixing speed for revolving drum type mixers shall not be less than 4 revolutions per minute of the drum nor greater than a speed resulting in a peripheral velocity of the drum of 1 meter per second. For the open-top type mixer, mixing speed shall be between 4 and 16 revolutions per minute of the mixing blades or paddles. Agitation speed for both the revolving drum and revolving blade type mixers shall be between 2 and 6 revolutions per minute of the drum or mixing blades or paddles.

The capacities of truck mixer shall be in accordance with the manufacturer's ratings except that they shall not exceed the limitation herein. Standard for normal rated capacity, expressed as percentage of the gross volume of the drum, shall not be more than 50% for truck mixing and 70% for agitating.

The concrete shall be delivered to the Site of the work and discharge shall be completed within 45 minutes after the introduction of the mixing water into cement and aggregates unless the use of additives have been approved by the Engineer. Depending on the type and usage of the approved additives this interval may be extended up to a maximum of 2 hours. During this interval the mixture shall be agitated continuously.

When the concrete is mixed in a truck mixer, the mixing operation shall begin within 30 minutes after the cement has been mixed with the aggregates. Except when intended for use exclusively as agitators, truck mixers shall be provided with a water measuring device which shall measure accurately the quantity of water for each batch. The delivered amount of water shall be within plus or minus 1% of the indicated amount when the tank, if mounted on the truck mixer, is satisfactorily and practically level.

8.20.4 Hand Mixing

Hand mixing shall not be permitted, except in case of emergency, without written permission from the Engineer. When permitted, it shall be performed only on water tight mixing platforms made of metal, etc. Concrete shall be turned and returned on the platform at least six times and until all particles of the coarse aggregate are covered thoroughly with mortar and the mixture is uniform.

8.21 Retempering Concrete

Retempering concrete by adding water shall not be permitted under any circumstances. Concrete that is not within the specified slump limits at the time of placement shall not be used. Admixtures for increasing the workability or for accelerating the set shall be permitted only with the written approval of the Engineer.

8.22 Consistency

Slump shall be measured in accordance with AASHTO -T119 or JIS A1101 and shall be in accordance with Clause 8.5.

8.23 Concrete Construction Generally

The Contractor shall maintain an adequate number of trained and experienced supervisors and foremen at the site to supervise and control the work. All construction, other than the concrete, shall conform to the requirements prescribed in other sections or clauses for the several items of work entering into the complete structure.

8.23.1 Preparation of Foundations

Preparation of foundations shall conform to the details as shown on the Drawings in accordance with the requirements of Clause 3.10.2. The elevations of the bottoms of footings as shown on the Drawings are approximate only and the Engineer may order further excavation as necessary to obtain satisfactory foundations.

Pile foundations shall be constructed in accordance with the provisions set out in the other relevant Clauses and as shown on the Drawings.

8.23.2 Falsework

Falsework shall be built on foundations of sufficient strength to carry the loads without appreciable settlement. Falsework that cannot be founded on solid footings must be supported by ample falsework piling provided at the Contractor's expense.

Before constructing forms or falsework the Contractor, if required, shall submit detailed drawings of proposed forms or falsework for approval by the Engineer, but such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

8.23.3 Formwork

No formwork shall be fabricated or erected until the drawings have been approved by the Engineer.

Before concrete is placed the Engineer shall inspect all formwork and falsework and no concrete shall be placed until the Engineer has inspected and approved such formwork and falsework. Such approval shall not relieve the Contractor of any of his responsibilities under the Contract for the successful completion of the structure.

Internal formwork for hollow slab construction shall be made of plywood, thin metal plate or other materials. These materials shall have sufficient strength to resist the pressure and the buoyancy' effects of fresh concrete.

Type and structure of joint and cover for the cylindrical form shall be tight to prevent any leakage of concrete, and shall be approved by the Engineer. Nominal diameter of cylindrical forms shall be the outer diameter, or the outer diameter of projecting portion in case of thin metal plate having projection. The height of the projection shall be less than 10 mm.

Internal forms shall be fixed in the correct position such that they shall not displace or deform during placing concrete.

U-shape bolts shall be used to fix the internal forms and the method of supporting and fixing the internal forms shall be approved by the Engineer. Care shall be taken to ensure that U-shape bolts and other items can resist the buoyancy forces on the formwork.

In falsework, bridge camber shall be considered in accordance with the Working Drawings prepared by the Contractor and approved by the Engineer.

Concrete shall not be placed in any formwork until such formwork has been inspected and approved by the Engineer.

8.23.4 Reinforcement

The Engineer shall inspect and approve all reinforcement in place before concrete is placed. An experienced steel fixer shall be present while all concrete is placed to ensure that no reinforcement becomes displaced during placing and if it does to reposition reinforcement before placing continues.

The positioning and fixing of reinforcing in particular sections of the work may be required to be inspected by the Engineer prior to any concrete being poured in the section. The Engineer will advise the Contractor of these particular sections at the time the Contractor is preparing its Quality Plan, and from time to time during the progress of the works. Ample notice shall be given by the Contractor to allow time for inspection by the Engineer of such sections.

Welding shall not commence until the welding procedure has been qualified and reviewed by the Engineer.

8.24 Placing Concrete Generally

Concrete shall be placed in such a manner as to avoid segregation and the displacement of reinforcing bars and shall be spread in horizontal layers where practicable. Concrete shall be placed where necessary inside forms by hand shovels and in no instance shall vibrator be so manipulated to transport concrete inside formwork. Care shall be taken to prevent mortar from spattering forms and reinforcing steel and form drying ahead of the final covering with concrete. When spattering has occurred the forms and steel shall be cleaned with wire brushes or scrapers before concrete is placed around steel or in forms which have been spattered.

Troughs, pipes, or short chutes used as aids in placing concrete shall be positioned in such a manner that segregation of the concrete shall not occur. All chutes, troughs, and pipes shall be kept clean and free from coating of hardened concrete or mortar.

Concrete shall not be dropped freely over a vertical distance of more than 1.5 meters.

Concrete shall be placed continuously throughout each section of the structure or between indicated joints if shown on the Drawings or as directed by the Engineer.

If in an emergency it is necessary to stop placing concrete before a section is completed, bulkheads shall be placed as the Engineer may direct and the resulting joint shall be deemed a construction joint, and treated as specified herein below.

8.24.1 Placing Concrete to Concrete Columns

Concrete in columns or bents shall be placed in one continuous operation unless shown on the Drawings or permitted by the Engineer.

8.24.2 Placing Concrete to Slab and Girder Spans

Slabs and girders having spans of 10 meters or less shall be placed in one continuous operation unless otherwise stated on the Drawings. Concrete preferably shall be deposited by beginning at the centre of the span working from the centre toward the ends.

Concrete in slab spans shall be placed in one continuous operation and in one layer for each span, unless otherwise stated on the Drawings.

Concrete in girders spanning more than 10 meters may be placed in two operations, the first operation being the placing of concrete in the girder stems to the bottom of

the slab haunches or the bottom of the slab whichever is applicable. A period of at least 24 hours shall elapse between the completion of placing concrete in the girder and. the commencement of placing concrete in slab.

The construction procedure for the concrete deck slab on steel box girders shall be so arranged as to eliminate excessive stress in new or recently placed concrete.

Immediately before placing concrete, the top surface of the previously placed concrete shall be hammered with a sharp hand tool (scabbled) until the aggregate is exposed and cleaned. The Contractor shall check all falsework for shrinkage and settlement, and shall tighten all wedges to ensure minimum deflection of all formwork.

8.24.3 Placing Concrete to Walls, Piers, etc.

Where walls, piers, columns, struts, posts and other such structural members allow horizontal construction joints, concrete shall not be placed on top of other concrete which has not been allowed to set for 12 hours or more.

Work shall not be discontinued within 45 centimeters of the top of any face, unless provision has been made for a coping less than 45 centimeters thick, in which case, if permitted by the Engineer, the construction joint may be made at the underside of the coping.

8.24.4 Placing Concrete to Culverts

The slabs of box culverts shall be placed for their full depth in one mass or layer and allowed to set not less than 12 hours before any additional work is done on them.

Before concrete is placed in sidewalls, bottom slabs, shall be cleaned of all shavings, sticks, sawdust and other extraneous material.

The Contractor shall submit to the Engineer for approval his proposals for pouring culvert walls before commencing culvert construction. Concrete shall not be placed in layers more than one meter high relative to the concrete already placed. Deposition shall proceed in a systematic manner.

8.24.5 Depositing Concrete under Water

Concrete shall not be deposited in water except with the approval of the Engineer and with his immediate supervision, and by the method described in this paragraph.

At least four weeks prior to the proposed date for commencement of supply of the concrete for tremie operations, the Contractor shall submit to the Engineer for approval full details of its proposed methods.

To prevent segregation, the concrete shall be carefully placed in- a compact mass in its final position by means of a tremie tube or pipe and shall not be disturbed after being deposited. Special care must be exercised to maintain still water at the point of deposit. Concrete shall not be placed in running water. The method of depositing concrete shall be so regulated as to produce approximately horizontal surfaces.

Placement of tremie concrete shall not commence until full evidence of successful trials of tremie concrete placement methods and the testing of the concrete is provided to the Engineer.

Concrete seals shall be placed in one continuous operation. When a tremie tube or pipe is used, it shall consist of a tube or pipe not less than 25 centimeters in diameter, constructed in sections having flanged couplings fitted with gaskets. The means of supporting the tremie shall be such as to permit free movement of the discharge end over the entire top of the concrete and permit its being lowered rapidly when necessary to choke off or retard the flow. The tremie shall be filled by a method that shall prevent washing of the concrete. The discharge end shall be completely submerged in concrete at all times and the tremie shall contain sufficient concrete to prevent any water entry.

Dewatering shall proceed only when the concrete seal is considered strong enough to withstand any pressures to be exerted upon it. This time will be decided by the Engineer. All laitance or other unsatisfactory material shall be removed from the exposed surface by scraping, jetting, chipping or other means which shall not unduly injure the seal.

8.25 Construction Joints in Concrete

Construction, joints shall be located where shown on the Drawings or permitted or instructed by the Engineer. Construction joints shall be perpendicular to the principal lines of stress and in general shall be located at points of minimum shear.

At horizontal construction joints, details shall be as approved by the Engineer. Before placing fresh concrete, the surfaces of construction joints shall be sandblasted or washed and scrubbed with a wire brush to expose clean aggregate, drenched with water until saturated, and kept saturated until the new concrete is placed. Immediately prior to placing new concrete the forms shall be drawn tight against the concrete already in place and the old surface shall be coated thoroughly with a 1.5mm thick coating of neat cement mortar. Concrete in substructures shall be placed in such a manner that all horizontal construction joints shall be truly horizontal.

Where vertical construction joints are necessary, reinforcing bars shall extend across the joint in such a manner as to make the structure monolithic. Special care shall be taken to avoid construction joints through panelled wing walls or other large surfaces which are to have an architectural finish.

Necessary dowel, load-transfer devices, and bonding devices shall be placed as shown on the Drawings or directed by the Engineer.

8.25.1 Expansion Joints in Concrete

Expansion joints shall be filled with an asphaltic or poly-sulphide type joint filler, 20 mm thick and shall be located and formed as required on the Drawings.

Cut-off plate for water stops used for the expansion joints shall be flexible PVC to JIS K6773 and shall be placed in accordance with the Drawings.

The water stops shall be held firmly in place to prevent displacement during

concreting. If after placing concrete water stops are materially out of position or shape, the surrounding concrete shall be removed, the water stop reset, and the concrete replaced, all at the Contractor's expense.

Water stop shall be furnished full length for each straight portion of the joint, without field splices. Water stop shall be cut and spliced at changes in direction as may be necessary to avoid buckling or distortion. All field splices shall be performed by heat sealing or hot-air welding the adjacent surfaces in accordance with the manufacturer's recommendations to form continuous watertight joints.

8.25.2 Open Joints in Concrete

Open joints shall be constructed where shown on the Drawings by insertion and subsequent removal of a wooden strip, metal plate, or other approved material. The insertion and removal of the template shall be accomplished without chipping or breaking the corners of the concrete. Reinforcement shall not extend across an open joint unless so specified on the Drawings.

8.25.3 Steel Joints in Concrete

The plates, or other structural shapes shall be accurately shaped at the shop to conform to the section of the concrete floor. The fabrication and painting shall conform to the requirements of this Specification covering those items. When called for on the Drawings or in the Specifications, the material shall be galvanized in lieu of painting. Care shall be taken to ensure that the surface in the finished plane is true and free of warping. Positive methods shall be employed in placing the joints to keep them in correct position during the placing of the concrete. The opening at expansion joints shall be that designated on the Drawings at normal temperature, and care shall be taken to avoid impairment of the clearance in any manner.

8.26 Anchor Bolts in Concrete

All necessary anchor bolts in piers or abutments shall be accurately set in holes formed while the concrete is being placed. Holes may be formed by inserting in the fresh concrete oiled wooden plugs, metal pipe sleeves, or other approved devices, and withdrawing them after the concrete has partially set. Holes so formed shall be at least 10 cm in diameter. Bolts shall be set accurately and fixed with grout completely filling the holes. The grout shall be non-shrink mortar of a type approved by the Engineer.

Anchor bolts used in connection with expansion shoes, rollers, and rockers shall be located with due regard to the temperature at the time of erection. Care shall be taken that full and free movement of the superstructure at the moveable bearings is not restricted by improper setting or adjustment of bearings or anchor bolt and nuts.

8.27 Shoes and Bearing Plates in Concrete

Bridge seat bearing areas shall preferably be finished high and ground to level required. Shoes and bearing plates shall be set as provided in the drawings.