

PROJECT : CONSTRUCTION OF FARM TO MARKET ROAD

LOCATION : SITIO PAPATAHAN, PAETE, LAGUNA

TECHNICAL SPECIFICATIONS

EARTHWORK

ITEM 100 - CLEARING AND GRUBBING

100.1 Description

This item shall consist of clearing, grubbing, removing and disposing all vegetable and debris as designated in the Contract, except those objects that are designated to remain in place or are to be removed in consonance with other provisions of this Specification. The work shall also include the preservation from injury or defacement of all objects designated to remain.

100.2 Construction Requirements

The Engineering will establish the limits of work and designate all trees, shrubs, plants and other things to remain. The Contractor shall preserve all objects designated to remain. Paint required for cut or seared surface of trees or shrubs selected for retention shall be an approved asphaltum base paint prepared especially for tree pruning.

100.2.2 Clearing and Grubbing

All surface objects and all trees, roots and other protruding obstructions, not designated to remain, shall be cleared and/or grubbed, including mowing as required, except as provided below:

- (1) Removal of undisturbed stumps and roots and non-breakable solid objects with a minimum of 900mm (36 inches) below sub grade or slope of embankments will not be required.
- (2) In areas outside of the grading limits of cut and embankment area, stumps and non-breakable solid objects shall be cut off not more than 150mm (6 inches) above the ground line or low water level.
- (3) In areas to be rounded at the top of cut slopes, stumps shall be cut off flush with or below the surface of the final slope line.
- (4) Grubbing of pits, channel changes and ditches will be required only to the depth necessitated by the proposed excavation within such areas.

Except in areas to be excavated, stumps holes and other holes from which obstructions were removed shall be backfilled with suitable material and compacted to the required density.

Low hanging branches and unsound or unsightly branches on trees or shrubs designated to remain shall be trimmed as directed. Branches of trees extending over the roadbed shall be trimmed to give a clear height of 6m (20 feet) above the roadbed surface. All trimming shall be done by skilled workmen and in accordance with good tree pruning practices.

Timber cut inside the area staked for clearing shall be felled within the area to be cleared.

100.2.3 Individual Removal of Trees or Stumps

Individual trees or stumps designated by the Engineer for removal and located in areas other than those established for clearing and grubbing and roadside cleanup shall be removed and disposed of as specified under Subsection 100.2.2 except trees removed shall be cut as nearly-flush with the ground as practicable without removing stumps.

100.3 Method of Measurement

Measurement will be by one or more of the following alternate methods:

1. Area Basis – The work to be paid for shall be the number of hectares and fractions thereof acceptably cleared and grubbed within the limits indicated on the Plans or as may be adjusted in field staking by the Engineer. Areas not within the clearing and grubbing limits shown on the Plans or not staked for clearing and grubbing will not be measured for payment.
2. Lump-Sum Basis – When the Bill of Quantities contains a Clearing and Grubbing Lump Sum Item; no measurement of area will be made for such item.
3. Individual Unit Basis (Selective Clearing) The diameter of trees will be measured at a height of 1.4m (54 inches) above the ground. Trees less than 150mm (6 inches) in diameter will not be measured for payment.

When Bill of Quantities indicated measurement of trees by individual unit basis, the units will be designated and measured in accordance with the following schedule of sizes.

<u>Diameter at height of 1.4m</u>	<u>Pay Item Description</u>
Over 150mm to 900mm	Small
Over 900mm	Large

ITEM 102 - EXCAVATION, BACKFILLING AND DISPOSAL

102.1 Description

The Contractor shall perform all earthworks both for roadway, structures, drainage and borrow excavation and the disposal of material in accordance with this Specification and in conformity with the lines, grades and dimensions shown on the Plans or established by the Engineer.

102.2 Construction Requirements

102.2.1 General

When there is evidence of discrepancies on the actual elevations and that shown on the Plans, a pre-construction survey referred to the datum plane used in the approved Plan shall be undertaken by the Contractor under the control of the Engineer to serve as basis for the computation of the actual volume of the excavated materials.

All excavations shall be finished to reasonably smooth and uniform surface. No materials shall be wasted without authority of the Engineer. Excavation operation shall be conducted so that material outside of the limits of slopes will not be disturbed. Prior to excavation, all necessary clearing and grubbing in the area shall have been performed in accordance with Item 100, Clearing and Grubbing.

The Contractor shall furnish, place and maintain all supports and shoring that may be required for the sides of the excavations, and all pumping, ditching or other approved measures for the removal or exclusion of water, including taking care of storm water and waste water reaching the site of the work from any source so as to prevent damage to the work or adjoining property.

102.2.2 Conservation of Topsoil

Where provided for on the Plans or in Special provisions, suitable topsoil encountered in the excavation and on areas where embankment is to be placed shall be removed to such extent and to such depth as the Engineer may direct. The removed topsoil shall be transported and deposited in storage piles at locations approved by the Engineer. The topsoil shall be completely removed to the required depth from any designated area prior to the beginning of excavation or embankment work in the area and shall be kept separate from other excavated materials for later use.

102.2.3 Utilization of Excavated Materials

All suitable material removed from the excavation shall be used in the formation of the embankment, subgrade, shoulders, slopes, bedding and backfill for structures, and for other purposes shown on the Plans or as directed.

The Engineer will designate as unsuitable those soils that can not be properly compacted in the embankments. All suitable materials shall be disposed off as shown on the Plans or as directed without delay to the Contractor.

Only approved materials shall be used in the construction of embankments and backfills. All excess material, including rock and boulders that can not be used in embankments shall be disposed off as directed. Materials encountered in the excavation and determined by the Engineer as suitable for topping, road finishing, slope protection, or other purposes shall be conserved and utilized as directed by the Engineer.

102.2.4 Removal of Unsuitable Materials

Where the Plans show the bottom portion of the disposal cell bed to be selected, all unsuitable materials shall be excavated to the depth necessary for replacement of the selected clay liner to the required compacted thickness.

102.3 Method of Measurement

The cost of excavation of material which is incorporated in the works or other areas of fill shall be deemed to be included in the Items of work where the material is used.

For measurement purposes, surplus suitable material shall be calculated as the difference between the net volume of suitable material required to be used in embankment or cover material corrected by applying a shrinkage factor or swell factor in case of rock excavation, determined by laboratory tests to get its original volume measurement, and the net volume of suitable material from excavation in the original position. Separate pay items shall be provided for surplus common, unclassified and rock material.

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

SUB-BASE AND BASE COURSE

ITEM 200 - AGGREGATE SUB-BASE COURSE

200.1 Description

This item shall consist of furnishing, placing, and compacting an aggregate sub-base course on a prepared sub-grade in accordance with this specification and the lines, grades and cross sections shown on the Plans, or as directed by the Engineer.

200.2 Material Requirements

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

The sub-base material shall conform to Table 200.1

Table 200.1 Grading Requirements

Sieve Designation Standard mm	Alternative US Standard	Mass Percent Passing
50	2"	100
25	1"	55 - 85
9.65	3/8	40 - 75
0.075	No. 200	0 - 12

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

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

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

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

200.3 Construction Requirements

200.3.1 Preparation of Existing Surface

The existing surface shall be graded and finished as provided under Subsection 12.2, Sub-grade Preparation, before placing the sub-base material.

200.3.2 Placing

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

SURFACE COURSES

ITEM 311 - PORTLAND CEMENT CONCRETE PAVEMENT

311.1 Description

Thickness of the PCCP shall be 0.20m and width shall be 5.00m. This item shall consist of Portland Cement Concrete, with or without reinforcement, constructed on the prepared base in accordance with this Specification and in conformity with the lines, grades, thickness and typical cross-section shown on the Plans.

311.2 Material Requirements

311.2.1 Portland Cement

It shall conform to the applicable requirements of item 700 of ASTM, Hydraulic Cement. Only Type 1 Portland Cement shall be used unless otherwise provided for in the Special Provisions. Different brands or the same brands from different mills shall not be mixed nor shall they be used alternately unless the mix is approved by the Engineer.

Cement, which for any reason, has become partially set or which contain lumps of caked cement will be rejected. Cement salvaged from discarded or used bags shall not be used.

Samples of cement shall be obtained in accordance with AASHTO T 127.

311.2.2 Fine Aggregates

It shall consist of natural sand, stone screenings or other inert materials with similar characteristic, or combinations thereof, having hard, strong and durable particles approved by

the Engineer. Fine aggregate from different sources of supply shall not be mixed or stored in the same pile or used alternately in the same class of concrete without the approval of the Engineer.

It shall not contain more than three mass percent of material passing the 0.075mm (No. 200 sieve) by washing nor more than one mass percent each of clay lumps or shale. The use of beach sand will not be allowed without the approval of the Engineer.

If the fine aggregate is subjected to five cycles of the sodium sulfate soundness test, the weighted loss shall not exceed 10 mass percent.

The fine aggregate shall be free from injurious amounts of organic impurities and if a color darker than the standard is produced, it shall be rejected. However, when tested for the effect of organic impurities of strength of mortar by AASHTO T 71, the fine aggregate may be used if the relative strength at 7 and 28 days is not less than 95 mass percent.

The fine aggregate shall be well graded from coarse to fine and shall conform to Table 311.1

Table 311.1 Grading Requirements for fine Aggregates

Sieve Designation	Mass Percent Passing
9.5 mm (3/8 in)	100
4.75 mm (No. 4)	95 - 100
1.18 mm (No. 16)	45 - 80
0.300 mm (No. 50)	5 - 30
0.150 mm (No. 100)	0.10

311.2.3 Coarse Aggregate

It shall consist of crushed stone, gravel, blast furnace slag, or other approved inert materials of similar characteristics, or combinations thereof, having hard, strong, durable pieces and free from any adherent coatings.

It shall contain no more than one mass percent of material passing the 0.075mm (No. 200) sieve, not more than 0.25 mass percent of clay lumps, nor more than 3.5 mass percent of soft

fragments. If the coarse aggregates is subjected to five cycles of the sodium sulfate soundness test, the weighted loss shall not exceed 12 mass percent.

It shall have a mass percent of wear not exceeding 40 when tested by AASHTO T 96.

If slag is used, its density shall not be less than 1120kg/m³ (70 lb/cu.ft.). The gradation of the coarse aggregate shall confirm to Table 311.2 Only one grading specification shall be used from any source.

Table 311.2 Grading Requirements for Coarse Aggregate

<i>SIEVE</i> <i>Standard</i> <i>mm</i>	<i>DESIGNATION</i> <i>Alternate US</i> <i>Standard</i>	<i>MASS</i> <i>Grading A</i>	<i>PERCENT</i> <i>Grading B</i>	<i>PASSING</i> <i>Grading C</i>
75.0	3 in	100	-	-
63.0	2 ½ in	90 – 100	100	100
50.0	2 in	-	90 – 100	95 – 100
37.5	1 ½ in	25 – 60	35 – 70	-
25.0	1 in	-	0 – 15	35 – 70
19.0	¾ in	0 – 10	-	-
2.5	½ in	0 – 5	0 – 5	10 – 30
4.75	No. 4	-	-	0 – 5

Water used in mixing, curing, or other designated applications shall be reasonably clean and free of oil, salt, acid, alkali, grass or other substances injurious to the finished product. Water will be tested in accordance with and shall meet the requirements of Item 714. Water which is drinkable may be used without test. Where the source of water is shallow, the intake shall be so enclosed as to exclude silt, mud, grass, or other foreign materials.

311.2.5 Reinforcing Steel

It shall conform to the requirements of Item 404, Reinforcing Steel. Dowel and tie bars shall conform to the requirements of AASHTO M 31 or M 42, except that rail steel shall not be used for tie bars that are not to be bent and re-straightened during construction. Tie bars shall be deformed bars. Dowels shall be plain round bars. Before delivery to the Site of work, one-half of the length of each dowel shall be painted with one coat of approved lead or tar paint.

311.2.6 Joint Fillers

Poured joint fillers shall be mixed asphalt and mineral or rubber filler conforming to the applicable requirements of Item 705, Joint Materials.

Performed joint filler shall conform to the applicable requirements of Item 705 of ASTM. It shall be punched to admit the dowels where called for in the Plans. The filler for each joint shall be furnished in a single place for full depth and width required for the joint.

311.2.7 Admixtures

Air-entraining admixtures shall conform to the requirements of AASHTO M 154. Admixture should be added only to the concrete mix to produce some desired modifications to the properties of concrete where necessary, but not as partial replacement of cement.

311.2.8 Curing Materials

Cotton mats, burlap clothe, waterproof paper, liquid membrane forming compounds, or sheeting (film) materials shall conform to the applicable requirements of Item 708, Concrete Curing Materials and Admixtures.

311.2.9 Calcium Chloride

It shall conform to AASHTO M 144, if specified or permitted by the Engineer.

311.2.10 Storage of Cement and Aggregate

All cements shall be stored, immediately upon delivery at the Site, in weatherproof building, which will protect the cement from dampness. The floor shall be raised from the ground. The buildings shall be placed in locations approved by the Engineer. Provisions for storage shall be ample,

And the shipments of cement as received shall be separately stored in such a manner as to allow the earliest deliveries to be used first and to provide easy access for identification and inspection of each shipment. Storage buildings shall have capacity for storage of a sufficient quantity of cement to allow sampling at least twelve days before the cement is to be used. Bulk cement, if used, shall be transferred to elevated air tight and weatherproof bins. Stored cement shall meet the test requirements at any time after shortage when wrested is ordered by the Engineer. At the time of use, all cements shall be free of lumps.

The handling and storing of concrete aggregates shall be such as to prevent segregation or the inclusion of foreign materials. The Engineer may require that aggregates to be stored on separate platforms at satisfactory locations.

In order to secure greater uniformity of concrete mix, the Engineer may require that the coarse aggregate be separated into two or more sizes. Different sizes of aggregates shall be stored in separate bins or in separate stockpiles sufficiently remote from each other to prevent the material at the edges of the piles from becoming intermixed.

311.2.11 Proportioning, Consistency and Strength of Concrete

The Contractor shall prepare the design mix based on the absolute volume method as outlined in the American Concrete Institute (ACI) Standard 211.1 "Recommended Practice for Selecting Proportions for Normal and Heavy Weight Concrete".

It is the intent of this Specification to require approximately 9.0 bags of cement per cubic meter of concrete based on a 40 kg per bag of cement. However, richer mixes may be used in order to meet the minimum strength requirements. The Engineer shall determine from laboratory test of the materials to be used, the cement content and the proportions of aggregate and water that will produce a workable concrete having a slump between 40 and 75mm (1- ½ and 3 inches) if not vibrated or between 10 and 40mm (1/2 and 1 ½ inches if vibrated, and a flexural strength of not less than 3.8 MPa (550 psi) when tested by the third point method or 4.5 MPa (650 psi) when tested by the midpoint method; or a compressive strength of 24.1 MPa (3500 psi) when tested at fourteen days in accordance with AASHTO T 97, T 177 or 22, respectively.

Slump shall be determine using AASHTO T 199.

The Designer shall consider the use of lean concrete (econcrete) mixtures using local materials or specifically modified conventional concrete mixes in base course and in the lower course of composite, monolithic concrete pavements using a minimum of 75mm (3 inches) of conventional concrete as the surface course.

The mix design shall be submitted to the Engineer for approval and shall be accompanied with certified test data from an approved laboratory demonstrating the adequacy of the mix design. A change in the source of materials during the progress work may necessitate a new design mix.

311.3 Construction Requirements

311.3.1 Quality Control of Concrete

1. General

The Contractor shall be responsible for the quality control of all materials during the handling, blending, mixing and placement operations.

2. Quality Control Plan

The Contractor shall furnish the Engineer a Quality Control Plan detailing his production control procedures and the type and frequency of sampling and testing to ensure that the concrete he produces complies with the specification. The Engineer shall be provided free access to recent plant production records, and if requested, informational copies of mixing design, material certifications and sampling and testing reports.

3. Qualification of Workmen

Experienced and qualified personnel shall perform all batching or mixing operations for the concrete mix, and shall be present at the plant and job site to control the concrete productions whenever the plant is in operation. They shall be identified and duties as follows:

a. Concrete Batcher – The person performing the batching or mixing operation shall be capable of accurately conducting aggregate surface moisture determinations and establishing correct scale weight for concrete materials. He shall be capable of assuring that the proportioned batch weight of materials is in accordance with the mix design.

b. Concrete Technician – The person responsible for concrete production control and sampling and testing for quality control shall be proficient in concrete technology and shall have a sound knowledge of the specifications as they relate to concrete production. He shall be capable of conducting test on concrete and on concrete materials in accordance with these specifications. He shall be capable of adjusting concrete mix design for improving workability and specification compliance and preparing trial mix design. He shall be qualified to act as the concrete batcher in the batcher's absence.

4. Quality Control Testing

The Contractor shall perform all sampling, testing and inspection necessary to assure quality control of the component materials and the concrete.

The Contractor shall be responsible for determining the gradation of fine and coarse aggregates and for testing the concrete mixture for slump, air content, water-cement ratio and temperature. He shall conduct his operations so as to produce a mix conforming to the approved mix design.

5. Documentation

The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of observations made, the number and type of deficiency found, the quantities approved and nature of any corrective action taken.

The Engineer may take independent assurance samples at random location for acceptance purposes, as he deems necessary.

311.3.2 Equipment

Equipment and tools necessary for handling and performing all parts of the work shall be approved by the Engineer as to design, capacity, and mechanical condition. The equipment

shall be at the jobsite sufficiently ahead of the start of construction operations to be examined thoroughly and approved.

1. Batching Plant and Equipment

- a. General – the batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and for each size of coarse aggregate. If cement is used in bulk, a bin, a hopper, and separate scale for cement shall be included. The weighing hopper shall be properly sealed and vented to preclude dusting operation. The batch plant shall be equipped with a suitable non-resettable batch counter, which will correctly indicate the number of batches proportioned.
- b. Bins and Hoppers – Bins with adequate separate compartments for fine aggregate and for each size of coarse aggregate shall be provided in the batching plant.
- c. Scales – Scales for weighing aggregates and cement shall be of either the beam type or the sprinkles-dial type. They shall be accurate within one-half percent throughout the range of use. Poises shall be designed to be locked in any position and to prevent unauthorized change.
Scale shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy.
- d. Automatic Weighing Devices – Unless otherwise allowed on the contract, batching plants shall be equipped with automatic weighing devices of an approved type to proportion aggregates and bulk cement.

2. Mixer

- a. General – Concrete may be mixed at the site of construction or at a central plant or wholly or in part in truck mixers. Each mixer shall have a manufacturer's plate attached in a prominent place showing the capacity of the drum in terms of

volume of mixed concrete and the speed of rotation of the mixing drum or blades.

- b. Mixers at Site of Construction – Mixing shall be done in an approved mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing and discharging and distributing the mixture without segregation on the prepared grade. The mixer shall be equipped with an approved timing device, which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. In case of failure of the timing device, the mixer may be used for the balance of the day while it is being repaired, provided that each batch is mixed 90 seconds. The mixer shall be equipped with a suitable non-resettable batch counter, which shall correctly indicate the number of batches mixed.
- c. Truck mixer and Truck Agitators – Truck mixes used for mixing and hauling concrete, and truck agitator is used for hauling central-mixed concrete shall conform to the requirements of AASHTO M 157.
- d. Non-Agitator Trucks – Bodies of non-agitating hauling equipment for concrete shall be smooth, mortar-tight metal containers and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation.

3. Paving and Finishing Equipment

The concrete shall be placed with an approved paver designed to spread, consolidate, screed and float finish the freshly placed concrete in one complete pass of the machine in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogenous pavement in conformance with the plans and specifications.

The finishing machine shall be equipped with at least two oscillating type transverse screed.

Vibrators shall operate at a frequency of 8,300 to 9,600 impulses per minute under load at a maximum spacing of 60 cm.

4. Concrete Saw

The contractor shall provide sawing equipment in adequate number of units and power to complete the sawing with a water-cooled diamond edge blade or an abrasive wheel to the required dimensions and at required rate. He shall provide at least one stand-by saw in good working condition and with an ample supply of saw blades.

5. Forms

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

311.3.3 Preparation of Grade

After the sub-grade or base has been placed and compacted to the required density, the areas which will support the paving machine and the grade on which the pavements are to be constructed shall be trimmed to the proper elevation by means of a property designed machine extending the work at least 60 cm beyond each edge of the proposed concrete pavement. If loss of density results from the trimming operations, it shall be restored by additional compaction before concrete is placed. If any traffic is allowed to use the prepared sub-grade or base, the surface shall be checked and corrected immediately ahead of the placing concrete.

The sub-grade or base shall be uniformly moist when the concrete is placed.

311.3.4 Setting Forms

1. Base Support

The foundation under the forms shall be hard and true to grade so that the form when set will be firmly in contact for its whole length and at the specified grade. Any

roadbed, which at the form line is found below established grade, shall be filled with approved granular materials to grade in lifts of 3 cm or less, and thoroughly rerolled or tamped. Imperfections variations above grade shall be corrected by tamping or by cutting as necessary.

2. Form Setting

Forms shall be set sufficiently in advance at the point where concrete is being placed. After the forms have been set to correct grade, the base shall be thoroughly tamped, mechanically or by hand, at both the inside and outside edges of the base of the forms. The forms shall not deviate from true line by more the 1 cm at any point.

3. Grade and Alignment

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete. Testing as to crown and elevation, prior to placing of concrete can be made by means of holding an approved template in a vertical position and moved backward and forward on the forms.

When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

311.3.5 Conditioning of Sub-grade or Base Course

When side forms have been securely set to grade, the sub-grade or base course shall be brought to proper cross-section. High areas shall be trimmed to proper elevation. Low areas shall be filled and properly compacted. The finished grade shall be maintained in a smooth and compacted until the pavement is placed.

Unless waterproof sub-grade or base course cover material is specified, the sub-grade or base course shall be uniformly moist when the concrete is placed. If it subsequently becomes too dirty, the sub-grade or base course shall be sprinkled, but the method of sprinkling shall not be such as to form mud or pools of water.

311.3.6 Handling, Measuring and Batching Materials

The batch plan site, layout, equipment and provisions for transporting material shall be such as to assure a continuous supply of material to the work. Stockpiles shall be built up in layers of not more than one meter in thickness. Each layer shall be completely in place before beginning the next, which shall not be allowed to “cone” down over the next lower layer. Aggregates from different sources and of different grading shall not be stockpiled together.

All washed aggregate and aggregates produced or handled by hydraulic methods, shall be stockpiled or binned for draining at least twelve hours before being batched.

When mixing is done at the site of the work, aggregates shall be transported from the batching plant to the mixer in batch boxes, vehicle bodies, or other containers of adequate capacity and construction to properly carry the volume required. Partitions separating batches shall be adequate and effective to prevent spilling from one compartment to another while in transit or being dumped. When bulk cement is used, the contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, while chute, boot or other approved device. This is to prevent loss of cement, and to provide positive assurance of the actual presence in each batch of the entire cement content specified.

Bulk cement shall be transported to the mixer in tight compartments carrying the full amount of cement required of the batch. However, if allowed in the Special Provisions, it may be transported between the fine and coarse aggregate. When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1 - 1 ½ hours of such contact. Cement in original shipping packages may be transported on top of the aggregates, each batch containing the number of sacks required by the job mix.

The mixer shall be charged without loss of cement. Batching shall be so as to result in the weight to each material required within a tolerance of once percent for cement and two percent for aggregates.

Water may be measured either by volume or by weight. The accuracy of measuring the water shall be within a range of error of not over one percent. Unless the water is to be weighed, the

water measuring equipment tank shall be equipped with an outside tap and valve to provide for checking the setting, unless other means are provided for readily and accurately determining the amount of water in the tank. The volume of the auxiliary tank shall be at least equal to that of the measuring tank.

311.3.7 Mixing Concrete

The concrete may be mixed at the site in a central mix plant, or in a truck mixers. The mixer shall be of an approved type and capacity. Mixing time will be measured from the time all materials, except water are in the drum. Ready mixed concrete shall be mixed and delivered in accordance with requirement of AASHTO M 157, except that the minimum required revolutions at the mixing speed for transit mixed concrete may be reduced to not less than that recommended by the mixer manufacturer. The number of revolutions recommended by the mixer manufacturer shall be indicated on the manufacturer's serial plate attached to the mixer. The contractor shall furnish test data acceptable to engineer verifying that the make and model of the mixer will produce uniform concrete conforming to the provisions of AASHTO M 157 at the reduced number of revolutions shown on the serial plate.

When mixed at the Site or in a central mixing plant, the mixing time shall not be less than fifty seconds nor more than ninety seconds, unless mixer performance tests prove adequate, mixing of the concrete is a shorter time period.

Four seconds shall be added to the specified mixing time if timing starts at the instant the skip reaches its maximum raise position. Mixing time ends when discharge chute opens. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

The mixer shall be operated at the drum speed as shown on the manufacturer's nameplate attached on the mixer. Any concrete mixed less than the specified expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic meter, as shown on the manufacturer's standard rating plate on the mixer, except that an overload up to ten percent above the mixer's nominal capacity may be permitted provided concrete test

data for strength, segregation, and uniform consistency are satisfactory, and provided no spillage of concrete takes place.

The batches shall be so charged into the drum that a portion of the mixing water shall enter in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first 15 seconds of the mixing period. The throat of the drum shall be kept free of such accumulations as it may restrict the free flow of material into the drum.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators or non-agitating trucks specified in Subsection 4.5.2, Equipment. The time elapsed from the time water is added to the mix until the concrete is deposited in place at the site shall not exceed 45 minutes when the concrete is hauled in non-agitating trucks, nor 90 minutes when hauled in truck mixers or truck agitators, except that in hot weather or under other conditions contributing to quick hardening of the concrete, the maximum allowable time may be reduced by the Engineer.

Retempering concrete by adding water or by other means shall not be permitted, except that when concrete is delivered in truck mixers, additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements, if permitted by the Engineer, provided all these operations are performed within 45 minutes after initial mixing operation and the water cement ratio is not exceeded. 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 setting of the concrete will be permitted only when specifically approved by the Engineer.

311.3.8 Limitation of Mixing

No concrete shall be mixed, placed or finished when natural light is insufficient, unless an adequate and approved artificial lighting system is operated. During hot weather, the Engineer may require that steps be taken to prevent the temperature of mixed concrete from exceeding a specified maximum temperature of 90°F (32°C). Concrete is not place within 90 minutes from the time the ingredients were charged into the mixing drum or that has developed initial set

shall not be used. Retempering of concrete or mortar, which has partially hardened, that is remixing with or without additional cement, aggregate, or water shall not be permitted.

In order that the concrete may be properly protected against the effects of rain before the concrete is sufficiently hardened, the contractor will be required to have available at all times materials for the protection of the edges and surface of the unhardened concrete.

311.3.9 Placing Concrete

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

Where concrete is to be placed adjoining a previously constructed lane and mechanical equipment will be operated upon the existing lane, the previously constructed lane shall have attained the strength for 14-day concrete. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after three days.

Concrete shall thoroughly be consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies, by means of vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 15 seconds in any one location.

Concrete shall be deposited as near as possible to the expansion and contraction joints without disturbing them, but shall not be dumped from the discharge bucket or hopper into a joint assembly unless the hopper is well centered on the joint assembly. Should any concrete material fall on or be worked into the surface of a complete slab, it shall be removed immediately.

311.3.10 Test Specimens

As work progresses, at least one set consisting of three concrete beam test specimens, 150 mm x 150 mm x 525 or 900 mm shall be taken from 330 sq.mm of pavement, 230 mm depth, or fraction thereof placed each day. Test specimens shall be made under the supervision of the Engineer, and the contractor shall provide all concrete and other facilities necessary in making the test specimens and shall protect them from damage by construction operations.

The beam shall be made, cured, and tested in accordance with AASHTO T 23 and T 97.

311.3.11 Strike-Off of Concrete and Placement of Reinforcement

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

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

311.3.12 Joints

Joints shall be constructed of the type and dimensions, and at the locations require by the plans or special provision. All joints shall be protected from the intrusion of injurious foreign material until sealed.

1. Longitudinal Joint

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

Longitudinal formed joints shall consist of a groove cleft, extending downward from and normal to, the surface of the pavement. These joints shall be affected or formed by an approved mechanical or manually operated device of the dimensions and line indicated on the manually operated device is in a plastic state. The groove or cleft shall be filled with either a pre-molded strip or poured material as required.

The longitudinal joint shall be continuous; there shall be no gaps in either transverse or longitudinal joints at the intersection of the joints.

Longitudinal sawed joints shall be cut by means of approved concrete saw to the depth, width and line shown on the plans. Suitable guidelines or devices shall be used to assure cutting the longitude joint on the true line. The longitudinal joint shall be sawed before the end of the curing period or shortly thereafter and before any equipment or vehicles are allowed on the pavement.

The sawed area shall be thoroughly cleaned and if required, the joint shall immediately be filled with sealer.

Longitudinal pavement insert type joints shall be formed by placing a continuous strip of plastic material, which will not react adversely with the chemical constituent of the concrete.

2. Transverse Expansion joint

The expansion joint filler shall be continuous from form to form shaped to the sub-grade and to the keyway along the form. Preformed joint filler shall be furnished in length equal to the pavement width or equal to the width of one lane. Damaged or repaired joint filler shall not be used.

The expansion joint filler shall be held in a vertical position. An approved installing bar, or other device, shall be used if required to secure preformed expansion joint filler at the proper grade and alignment during placing and finishing of the concrete. Finished joint shall not deviate more than 6 mm from a straight line.

If joint fillers are assembled in sections, there shall be no offsets between adjacent units. No plugs of concrete shall be permitted anywhere within the expansion space.

3. Transverse Contraction Joint

When shown on the Plans, it shall consist of planes of weakness created by forming or cutting grooves in the surface of the pavement and shall include loaded transfer assemblies.

a. Transverse Strip Contraction Joint

It shall be formed by installing a parting strip to be left in place as shown on the plans.

b. Formed Groove

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

c. Sawed Contract Joint

It shall be created by sawing grooves in the surface of the pavement of the width, depth, and the spacing and lines shown on the plans, with an approved concrete saw. After each joint is sawed, it shall be thoroughly cleaned including the adjacent concrete surface.

Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling, usually within 24 hours. All joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary the sawing operations shall be carried on during the day or night, regardless of weather condition. The sawing of any joint shall be omitted if crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. In general, all joints should be sawed in sequence. If extreme conditions exist which make it impractical to prevent erratic cracking by early sawing, the contraction joint groove shall be formed prior to initial set of concrete as provided above.

4. Transverse Construction Joint

It shall be constructed when there is an interruption of more the 30 minutes in the concerning operation. No transverse joint shall be constructed within 1.50 m of an expansion joint, contraction joint, or plane of weakness. If sufficient concrete has been mixed at the time of interruption to form a slab of at least 1.50 m long, the excess concrete form the last preceding joint shall be removed and disposed of as directed.

5. Load Transfer Device

Dowels, when used, shall be held in position parallel to the surface and centerline of the slab by a metal device that is left in the pavement.

The portion of each dowel painted with on coat of lead or tar, in conformance with the requirements of Item 404 of ASTM, Reinforcing Steel, shall be thoroughly coated with approved bituminous materials, e.g., MC-70, or an approved lubricant, to prevent the concrete from binding to that portion of the dowel.

The sleeves for dowels shall be metal designed to cover 50 mm plus or minus 5 mm (1/4 inch), of the dowel with a watertight closed end and with a suitable stop to hold the end of the sleeves at least 25 mm (1 inch) from the end of the dowel.

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

311.3.13 Final Strike-off (Consolidation and Finishing)

1. Sequence

The sequence of operations shall be the strike-off and consolidation, floating and removal of Latinate, straight edging and final surface finish. Work bridges or other devices necessary to provide access to the pavement surface for the purpose of finishing straight-edging, and make correction as hereinafter specified, shall be provided by the contractor.

In general, the addition of water to the surface of the concrete to assist in finishing operations will not be permitted. If the application of water to the surface is permitted, it shall be applied as fog spray by means of approved spray equipment.

2. Finishing at Joints

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, also under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Subsection 4.5.9, Placing concrete.

After the concrete has been placed and vibrated adjacent to the joints as required in Subsection 4.5.12, the finishing machine shall be brought forward, operating in a

manner to avoid damage or misalignment of joints. If uninterrupted operation of the finishing machine, to over and beyond the joints causes segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the front screed is approximately 20 cm (8 inches) from the joint. Segregated concrete shall be removed from in front of and off the joint. The front screed shall be lifted and set directly on top of the joint and the forward motion of the finishing machine resumed. When the second screed is close enough to permit the excess mortar in front of it to flow over the joint, it shall be lifted and carried over the joint. Thereafter, the finishing machine may be run over the joint without lifting the screeds, provided there is no segregated concrete immediately between the joint and the screed or on top of the joint.

3. Machine Finishing

a. Non-vibratory Method

The concrete shall be distributed or spread as soon as placed. As soon as the concrete has been placed, it shall be struck off and screened by an approved finishing machine. The machine shall go over each area of pavement as many times and at such interval as necessary to give the proper compaction and leave a surface of uniform texture. Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine and the travel of the machines on the forms shall be maintained true without wobbling or other variation tending to affect the precision finish.

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

b. Vibratory Method

When vibration is specified, vibrators for full width vibration of concrete paving slabs shall meet the requirements in Subsection 4.5.2. Equipment. If uniform and satisfactory density of the concrete is not obtained by the vibratory method at joints, along forms,

at structure, and throughout the pavement, the contractor will be required to furnish equipment and method, which will produce pavement conforming to the specifications. All the provisions in item 1 above not in conflict with the provisions for the vibratory method shall govern.

4. Hand Finishing

Hand finishing methods may only be used under the following conditions:

- a. In the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade.
- b. In narrow widths or areas of irregular dimensions where operations of the mechanical equipment are impractical, hand methods may be used.

Concrete, as soon as placed, shall be struck off and screeded. An approved portable screed shall be used. A second screed shall be provided for striking off the bottom layer of concrete if reinforcement is used.

The screed for the surface shall be moved forward on the forms with a combined longitudinal and transverse shearing motion, moving always in the direction in which the work is progressing and so manipulated that neither end is raised from the side forms during the striking off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross-section, and free from porous areas.

5. Floating

After the concrete has been struck off and consolidated, it shall be further smoothed, trued and consolidated by means of a longitudinal float, either by hand or mechanical method.

a. Hand Method

The hand operated longitudinal float shall be not less than 265 cm (feet) in length and 15 cm (6 inches) in width, properly stiffened to prevent flexibility and warping. The longitudinal float, operated foot bridges resting on the side forms and spanning but not

touching the concrete, shall be worked with a sawing motion while held in a floating position parallel to the road center line, and moving gradually from one side of the pavement to the other. Movement ahead along the centerline of the pavement shall be successive advances of not more than one-half length of the float. Any excess water or soupy material shall be wasted over the side forms on each pass.

b. Mechanical Method

The mechanical longitudinal float shall be of a design approved by the Engineer and shall be in good working condition. The tracks from which the float operates shall be accurately adjusted to the required crown. The float shall be accurately adjusted and coordinated with the adjustment of the transverse finishing machine so that a small amount of mortar is carried ahead of the float at all times. The forward screed shall be adjusted so that the float will lap the distance specified by the Engineer on each transverse trip. The float shall pass over each area of pavement at least two times, but excessive operation over a given area will not be permitted. Any excess water or soupy material shall be wasted over the side forms on each pass.

c. Alternative Mechanical Method

As an alternative, the contractor may use a machine composed of a cutting and smoothing float or floats suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on, and constantly in contact with the side forms. If necessary, following one of the preceding methods of floating, long handled floats having blades not less than 150 cm (5 feet) in length and 15 cm (6 inches) in width may be used to smooth and fill in open-textured areas in the pavement. Long handled floats shall not be used to float the entire surface of the pavement in lieu of, or supplementing one of the preceding methods of floating. When strike off and consolidations are done by the hand method and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of the long-handled float. Care shall be taken not to work the crown out of the pavement during operation. After floating, any excess water and laitance shall be removed from the surface of the pavement by a 3-m straightedge or more in length. Successive drags shall be lapped one-half the length of the blade.

6. Straight Edge Testing and Surface Correction

After the floating has been completed and the excess water removed, but while the concrete is still plastic, the surface of the concrete shall be tested for trueness with a 300 cm long straight edge. For this purpose, the contractor shall furnish and use an accurate 300 cm straight edge swing from handles 100 cm (3 feet) longer than one-half the width of the slab. The straight edge shall be held in contact with the surface in successive positions parallel to the road centerline and the whole area gone over from one side of the slab to the other as necessary. Advances along the road shall be in successive stages of not more than one-half the length of the straight edge. Any depressions found shall be immediately filled with freshly mixed concrete, struck off, consolidated and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straight edge testing and surface correction shall be continued until the entire surface is found to be free from observable departures from the straight edge and the slab conforms to the required grade and cross-section.

7. Final Finish

If the surface texture is broom finished, it shall be applied when the water sheen has practically disappeared. The broom shall be drawn from the center to the edge of the pavement with adjacent strokes slightly overlapping. The brooming operation should be so executed that the corrugations produced in the surface shall be uniform in appearance and not more than 1.5 mm in depth. Brooming shall be completed before the concrete is in such condition that the surface will be unduly roughened by the operation. The surface thus finished shall be free from tough and porous areas, irregularities, and depressions resulting from improper handling of the broom. Brooms shall be of the quality, size and construction and be operated so as to produce a surface finish meeting the approval of the Engineer.

Subject to satisfactory results being obtained, and approval of the Engineer. The contractor will be permitted to substitute mechanical brooming in lieu of the manual brooming as herein described.

If the surface texture is belt finished, when straight-edging is complete and water sheen has practically disappeared and just before the concrete becomes non-plastic, the surface shall be belted with a 2-ply canvas belt not less than 20 cm wide and at least 100 cm longer than the pavement width. Hand belts shall have suitable handles to permit controlled, uniform manipulation. The belt shall be operated with short strokes transverse to the centerline and with a rapid advance parallel to the centerline.

If the surface texture is drag finished, a drag shall be used which consists of a seamless strip of damp burlap or cotton fabric, which shall produce a uniform gritty texture after dragging it longitudinally along the full width of pavement. For pavement 5m or more in width, the drag shall be mounted on a bridge, which travels on the forms. The dimensions of the drag shall be such that a strip of burlap or fabric at least 100 cm wide is in contact with the full width of pavement surface while drag is used. The drag shall consist of not less than two layers of burlap with the bottom layer approximately 15 cm wider than the layer. The drag shall be maintained in such condition that the resultant surface is of uniform appearance and reasonably free from grooves over 1.5 mm in depth. Drag shall be maintained clean and free from encrusted mortar. Drags that cannot be cleaned shall be discarded and new drags be substituted.

Regardless of the method used for final finish, the hardened surface of pavement shall have a coefficient of friction of 0.25 or more. Completed pavement that is found to have coefficient of friction less than 0.25 shall be grounded or scored by the contractor at his expense to provide the required coefficient of friction.

8. Edging at Forms and Joints

After the final finish, but before the concrete has taken its initial set, the edges of the pavement along each side of each slab, and on each of transverse expansion joints, formed joints, transverse construction joints, and emergency construction joints, shall be worked with an approved tool and rounded to the radius required by the plans. A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not be unduly disturbed by tilting the tool during the use.

At all joints, any tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming the surface. In doing this, the rounding of the corner of the slab shall not be disturbed. All concrete on top of the joint filler shall be completely removed.

All joints shall be tested with a straightedge before the concrete has set and correction made if one edge of the joint is higher than the other.

311.3.14 Surface Test

As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 3m straightedge or other specified device. Area showing high spots of more than 3mm but not exceeding 12 mm in 3 m shall be marked and immediately ground down with an approved grinding tool to an elevation where the area or spot will not show surface deviation in excess of 3 mm when tested with 3 m straightedge. Where the departure from correct cross-section exceeds 12 mm, the pavement shall be removed and replaced by and at the expense of the contractor.

Any section to be removed shall be not less than 1.5 m in length and not less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 1.5 m in length, shall also be removed and replaced.

311.3.15 Curing

Immediately after the finishing operations have been completed and the concrete has sufficiently set, the entire surface of the newly placed concrete shall be cured in accordance with either one of the methods described herein. Failure to provide sufficient cover material of whatever kind the contractor may elect to use, lack of water to adequately take care of both curing and other requirements, shall be a cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than ½ hour between stages of curing or during the curing period.

1. Cotton or Burlap Mats

The surface of the pavement shall be entirely covered with mats. The mats used shall be of such length (or width) that as laid extends at least twice thickness of the pavement beyond the edges of the slab. The mat shall be placed so that the entire surface and the edges of the slab are more completely covered. Prior to being placed, the mats shall be saturated thoroughly with water. The mat shall be so placed and weighed down so as to cause them to remain in intimate contact with the surface covered. The mats shall be maintained fully wetted in position for 72 hours unless otherwise specified.

2. Waterproof Paper

The top surface and sides of the pavement shall be entirely covered with waterproof paper, the units shall be lapped at least 45 cm. the paper shall be so placed and weighed down so as to cause it to remain in intimate contact with the surface covered. The paper shall have such dimensions but each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement, or at pavement width and 60 cm strips of paper for the edges. If laid longitudinally, paper not manufactured in sized which will provide this width shall be surely sewed or cemented together, the joints being securely sealed in such a manner that they do not open up or separate during the curing period. Unless otherwise specified, the covering shall be maintained in place for 72 hours after the concrete has been placed. The surface of the pavement shall be thoroughly wetted prior to the placing of the paper.

3. Straw Curing

When this type of curing is used, the pavement shall be cured initially with burlap or cotton mats, until after final set of the concrete or in any case, for as hours after placing the concrete. As soon as mats are removed, the surface and sides of the pavement shall be thoroughly wetted and covered with at least 20 cm of straw or hay, thickness of which is to be measured after wetting. If the straw or hay covering becomes displaced during the curing period, it shall be replaced to the original depth and saturated. It shall be kept thoroughly saturated with water for 72 hours and thoroughly wetted down during the morning of the fourth day, and the cover shall remain in place until the concrete has attained the required strength.

4. Impervious Membrane Method

The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place, or if the pavement is cured initially with jute or cotton mats, it may be applied upon removal of the mats. The curing compound shall not be applied during rain.

Curing compound shall be applied under pressure at the rate of 4L to not more than 14 m² by mechanical sprayers. The spraying equipment shall be equipped with a wind guard. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application, the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd widths or shaped and concrete surface exposed by the removal of forms will be permitted. Curing compound shall not be applied to the inside faces of joints to be sealed, but approved means shall be used to insure proper curing at least 72 hours and to prevent the intrusion of foreign material into the joint before sealing has been completed. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film be damaged from any cause within the 72 hour curing period, the damaged portion shall be repaired immediately with additional compound.

5. White Polythene Sheet

The top surface and sides of the pavement shall be entirely covered with polythene sheeting. The units used shall be lapped at least 45 cm. The sheeting shall be so placed and weighed down so as to cause it to remain in intimate contact with the surface covered. The sheeting as prepared for use shall have such dimension that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement. Unless otherwise specified, the covering shall be maintained in place for 72 hours after the concrete has been placed.

311.3.18 Protection of Pavement

The contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by his own employees and agents. This shall include watchmen to direct

traffic and the erection of and maintenance of warning signs, lights, pavement bridges or cross-over, etc. the plans or special provisions will indicate the location and type of device or facility required to protect the work and provide adequately for traffic.

Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement be replaced.

SUPER STRUCTURES CONSTRUCTION

ITEM 403- METAL STRUCTURES

403.1 Description

This work shall consist of steel structures and the steel structure portions of composite structures, in reasonably close conformity with the lines, grades and dimensions shown on the plans.

The work will include the fabricating, hauling, erecting, welding and painting of structural metals called for in the special provision or shown on the plans. Structural metals will include structural steel, rivet, welding, special alloy steel, steel forging and casting, and iron castings. This work will also include furnishings of all plant, tools, equipment, materials and labor in the installation of metal framing, roof framing and roofing, including miscellaneous sheet metal works as required in accordance with these specifications, plans and special provisions.

403.2 Materials Requirements

Materials shall meet the requirements of Item 712, structural metal; item 409, welded structural steel and welded structural steel; and item 709, paint.

403.3 Construction Requirements

403.3.1 Inspection

The contractor shall give the Engineer at least fifteen (15) days notice prior to the beginning of work at the mill or shop, so that the mill, shop or foundry where material for the work is to be manufactured or fabricated. No material shall be rolled or fabricated until said inspection has been provided.

The contractor shall furnish the Engineer with copies of the certified mill reports of the structural steel, preferably before but not later than the delivery of the steel to the job site.

The contractor shall furnish all facilities for inspection and the Engineer shall be allowed free access to the mill or shop and premises at all times. The contractor shall furnish, without charge, all labor, machinery, material and tools necessary to prepare test specimens.

Inspection at the mill or shop is intended as a means of facilitating the work and avoiding errors and it is expressly understood that it will not relieve the contractor from any responsibility for imperfect material or workmanship and the necessity for replacing same. The acceptance of any material or finished member at the mill or shop by the Engineer shall not preclude their subsequent rejection if found defective before final acceptance of the work. Inspection of welding will be in accordance with the provision of section 5 of the "Standard code for arc and gas welding in building construction" of the American Welding Society.

403.3.2 Stock Material Control

When so specified in the contract, stock material shall be segregated into classes designated as "identified" or "unidentified". Identified material is material which can be positively identified as having been rolled from a given heat for which certified mill test can be produced. Unidentified material shall include all other general stock materials. When it is proposed to use unidentified material, the Engineer shall be notified of such intention at least fifteen (15) days in advance of commencing fabrication to permit sampling and testing. When so indicated or directed, the contractor shall select such material as he wishes to use from stock, and place it in such position that it will be accessible for inspection and sampling. The contractor shall select

identified material from as few heat numbers as possible, and furnish the certified mill test reports on each of such heat numbers. Two samples shall be taken from each heat number as directed, one for a tension test and one for a bend test.

In case of unidentified stock, the Engineer may, at his discretion, select any number of random test specimens.

Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids, or other supports, it shall be kept free from dirt, grease or other foreign matter, and shall be protected as far as practicable from corrosion.

403.3.3 Fabrication

These specifications apply to welded construction. The contractor may, however, with the approval of the Engineer, substitute high tensile strength steel bolts equivalent to the welds in any connection.

Workmanship and finish shall be in accordance with the best general practice in modern shops. Portions of the work exposed to view shall be finished neatly. Shearing, flame cutting, and chipping shall be done carefully and accurately.

Structural material, either plain or fabricated, shall be stored above the ground upon platforms, skids or other supports. Rolled material before being laid off or worked must be straight. If straightening is necessary, it shall be done by methods that will not injure the metal. Sharp kinks and bends will be cause for rejection of the material.

Preparation of material shall be in accordance with AWS D 1.1, paragraph 3.2 as modified by AASHTO standard specification for welding of structural steel highway bridges.

403.3.4 Finishing and Shaping

Finished members shall be true to line and free from twists, bends and open joints.

1. Edge Planing

Sheared edges of plates more than 15.9 mm in thickness and carrying calculated stresses shall be planed to a depth of 6.3 mm. Re-entrant cuts shall be filleted before cutting.

2. Facing of Bearing Surfaces

The surface finish of bearing and based plates and other bearing surfaces that are to come in contact with each other or with concrete shall meet the American national standards institute surface roughness requirements as defined in ANSI B-46, 1-47, Surface roughness waviness and lay, Part I:

Steel Slabs	ANSI 2,000
Heavy plates in contact in shoes to be welded	ANSI 1,000
Milled ends of compression member, stiffeners and fillers	ANSI 500
Bridge rollers and rockers	ANSI 250
Pins and pin holes	ANSI 125
Sliding bearings	ANSI 125

3. Abutting Joints

Abutting joints in compression members and girders flanges, and in tension members where so specified on the drawings, shall be faced and brought to an even bearing. Where joints are not faced, the opening shall not exceed 6.3 mm.

4. End Connection Angles

Floor beams, stringers and girders having end connection angles shall be built to plan length back to back of connection angles with a permissible tolerance of 0 mm. to minus 1.6 mm. If end connections are faced, the finished thickness of the angles shall not be less than shown on the detail drawings, but in no case less than 9.5 mm.

5. Lacing Bars

The ends of lacing bars shall be neatly rounded unless another form is required.

6. Fabrication of Members

Unless otherwise shown on the plans, steel plates for main members and splice plates for flanges and main tension members, not secondary members, shall be cut and fabricated so that the primary direction of rolling is parallel to the direction of the main tensile and/or compressive stresses.

Fabricated members shall be true to line and free from twists, bends and open joints.

403.3.5 Shop Assembly

The field connections of main members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders and rigid frames shall be assembled in the shop with milled ends of compression members in full bearing, and then shall have their sub-size holes reamed to specified size while the connections are assembled. Assembly shall be "Full Truss or Girders Assembly" Unless "Progressive Chord Assembly" or "Special Complete Structure Assembly" is specified in the Special provisions on the plans.

Check assemblies with numerically-controlled drilled fields connections shall be in accordance with the provision of 2 (f) of this subsection.

Truss, Purlins and Tank Structures

(1) Structural Steel Shapes, Plates and Bars

Unless otherwise shown or specified on the drawings, structural steel shapes plates and bars shall conform to ASTM specification A36/A36M.

(2) Hot-Formed Steel Sheet and Strip

Unless otherwise shown or specified on the drawings, hot-formed steel sheet and strip shall conform to ASTM A570.

(3) Bolts, Nuts and Washer

It shall conform to specification ASTM A370, with a minimum yield point of 33,000 psi, unless otherwise shown in the drawings. Heavy hexagonal structural bolts, heavy hexagonal nuts, and hardened washers, shall be quenched and tempered medium-carbon steel bolts, nuts and washers complying with ASTM A325.

(4) Screw and Expansion Bolts

Screws and expansion bolts shall be of standard commercial grade, and of the sizes and types indicated as approved by the Consultant.

(5) Electrodes

Electrodes for arc welding shall be E60 or E70, AWS D1.1.

(6) Pipe Columns and Hand Rails

Pipe columns and hand rails shall be zinc-coated steel pipe of standard weight conforming to ASTM A53.

(7) Galvanizing

Unless otherwise specified, galvanizing shall be of standard quality, hot-dipped process of 1.25 ounces per square foot of coating. Galvanized surfaces that are damaged prior to final acceptance shall be repaired using an approved repair compound to the satisfaction of the Engineer.

(8) Miscellaneous Metals

Miscellaneous metal including fastening, anchorages and incidentals not specifically mentioned herein or in other sections of this specifications but are required to complete the work, for which there are no detailed drawings, shall be provided and installed in accordance with standard practice of the traders as approved by the Engineer.

(9) Delivery, Storage and Handling

Fabricated materials delivered to job site shall be stored in clean and protected dry area in manufacturer's protective packaging. Structural steel materials to be stored shall be placed on skids above the ground. It shall be kept clean and properly drained. Long members, such as purlins and chords, shall be supported by skids placed near enough together to prevent injury from deflection. The contractor shall check the quantity and quality of materials turned over to him against the delivery lists and report promptly in writing any shortage or damage discovered.

403.4 Method of Measurement

403.4.1 Unit Basis

The quantity of structural steel to be paid for shall be number of kilograms complete in place and accepted. For the purpose of measurement for payment components fabricated from metals listed in (1) below, such as casting alloy steels, steel plates, anchor bolts and nuts, shoes, rockers, rollers, pins and nuts, expansion dams, roadway drains and sumpers, weld metal, bolts embedded in concrete, cradles and brackets, posts, conduits and ducts, and structural shapes or expansion joints and pier protection will be considered as structural steel.

Unless otherwise provided, the mass of metal paid for shall be computed and based upon the following mass:

1. Unit Density, kg/m³

Aluminum, cast or rolled	2,771.2
Bronze or copper alloy	8,585.9
Copper sheet	8,938.3
Iron, cast	7,128.2
Iron, malleable	7,528.7

Lead, sheet	1,122.9
Steel, cast or rolled, including alloy copper bearing and stainless	7,849
Zinc	7,208.3

2. Shapes, Plates Railing and Flooring

The mass of steel shapes and plates shall be computed on the basis of their nominal mass and dimensions as shown on the approved shop drawings, deducting for copes, cuts and open holes, exclusive of rivets holes. The mass of all plates shall be computed on the basis of nominal dimensions with no additional for overrun.

The mass of railing shall be included as structural steel unless the Bill of Quantities contains as pay item for bridge railing under item 401, Railings.

The mass of steel grid flooring shall be computed separately.

3. Welds

The mass of shop and field fillet weld shall be assumed as follows:

Size of Weld (mm)	Kg. per linear meter
6.3	0.984
7.9	1.213
9.5	1.771
12.7	2.690
5.9	3.936
19.0	5.379
22.2	7.314
25.4	9.774

The mass of other welds will be computed on the basis of the theoretical volume from dimensions of the welds, with an addition of 50 mass percent as an allowance for overrun.

4. Other Items

The quantities of other contract items which enter into the completed and accepted structure shall be measured for payment in the manner prescribed in Subsection 403.5.1 (4).

403.5 Basis of Payment

403.5.1 Structural Steel

1. Furnished, fabricated and Erected

The quantity, determined as provided above, shall be paid for at the contract unit price per kilogram for “Structural Steel, furnished, fabricated and erected”, which price and payment shall constitute full compensation for furnishing, galvanizing, fabricating, radiographing, magnetic particle, inspection, delivering, erecting ready for use, and painting all steel and other metal including all labor, equipment, tools and incidentals necessary to complete the work, except as provided in Subsections 403.5.2, 403.5.3 and 403.5.4.

403.5.2 Metal Considered as Structural Steel

For the purpose of subsection 403.5.1 and unless otherwise shown on the plans, castings, forgings, special alloy steels and steel plates, wrought iron, and structural shapes of expansion joints and pier protection shall be considered as structural steel except that when quantities and unit price for certain alloy steels, forgings, castings and other specific categories of metal are called for in the bill of quantities, the mass of such selected material, determined as provided above, shall be paid for at the respective contract unit price per kilogram for “Structural Steel (Alloy steel, forgings, castings, and/or other category), furnished and fabricated, and erected” or Structural Steel (Subsection 403.4.1), furnished and fabricated as named in the Bill of Quantities.

403.5.3 other Items

The quantities of all other contract items which enter into the completed and accepted structure shall be paid for all the contract unit prices for the several pay items as prescribed for the items involved.

403.5.4 Payment as Reinforcing Steel

When the bill of quantities does not contain a pay item for structural steel, the quantities of metal drains, scuppers, conduits, ducts and structural shapes for expansion joints and pier protection, measured as provided above will be paid for as Reinforcing Steel under item 404.

Payment will be made under:

<u>Pay item no.</u>	<u>Description</u>	<u>Unit of Measurement</u>
403 (1)	Structural Steel, Furnished, fabricated and erected	Kilograms (kg)
403 (2)	Structural Steel, Furnished, fabricated and erected	Kilograms (kg)
403 (3)	Structural Steel, Furnished, fabricated and erected	Kilograms (kg)

Where separate payment is to be made for certain metals or for certain particular components, other than under the general provision for structural steel, designation of those particular cases shall be inserted in the spaces provided in the pay names for item 404 (2), 403 (4) or 403 (6), as the case may be.

ITEM 404- REINFORCING STEEL

404.1 Description

This item shall consist of furnishing, bending, fabricating and placing of steel reinforcement of the type, size, shape and grade required in accordance with this Specification and in conformity with the requirements shown on the plans or as directed by the Engineer.

404.2 Material Requirements

Reinforcing steel shall meet the requirements of item 710, Reinforcing Steel and Wire Rope.

404.3 Construction Requirements

404.3.1 Order List

Before materials are ordered, all order lists and bending diagrams shall be furnished by the contractor, for approval of the Engineer. The approved order lists and bending diagrams by the Engineer shall in no way relieve the contractor of responsibility for the correctness of such lists and diagrams. Any expense incident to the revisions of materials furnished in accordance with such lists and diagrams to make them comply with the plans shall be borne by the contractor.

404.3.2 Protection of Material

Steel reinforcement shall be stored above the surface of the ground upon platforms, skid or other support and shall be protected as far as practicable from mechanical injury and surface deterioration caused by exposure to conditions producing rust. When placed in the work, reinforcement shall be free from dirt, detrimental rust, loose scale, paint, grease, oil, or other foreign materials. Reinforcement shall be free from injurious defects such as cracks and laminations. Rust, surface seams, surface irregularities or mill scale will not be cause for rejection, provided the minimum dimension, cross sectional area and tensile properties of the material meets the physical requirements for the size and grade of steel specified.

404.3.3 Bending

All reinforcing bars requiring bending shall be cold-bent to the shapes shown on the plans or required by the Engineer. Bars shall be bent around a circular pin having the following diameter (D) in relation to the diameter of the bar (d):

Bends and Hooks

Nominal diameter, (d), mm	Pin diameter (D)
10 to 20	6d
25 to 28	8d
32 and greater	10d

Bends and hooks in stirrups or ties may be bent to the diameter of the principal bar enclosed therein.

404.3.4 Placing and Fastening

All steel reinforcement shall be accurately placed in the position shown on the plans and firmly held there during the placing and settling of the concrete. Bars shall be tied at all intersections except where spacing is less than 300 mm in each directions, in which case, alternate intersections shall be tied. Ties shall be fastened on the inside.

Distance from the forms shall be maintained by means of stays, blocks, ties, hangers, or other approved supports, so that it does not vary from the position indicated on the plans by more than 6 mm. blocks for holding reinforcement from contact with the forms shall be precast mortar blocks approved shapes and dimensions. Layers of bars shall be separated by precast blocks or by other equally suitable devices. The use of Peebles, pieces of broker stone or brick, metal pipe and wooden blocks shall not be permitted. The minimum distance between bars shall be 40 mm. reinforcement any member shall be placed, inspected and approved by the Engineer before the concrete begins. Concrete placed in violation of this provision may be rejected and removal may be required.

404.3.5 Splicing

All reinforcement shall be furnished in the full lengths indicated on the plans. Splicing of bars except where shown on the plans will not be permitted without the written approval of the Engineer. Splices shall be staggered as far as possible and with a minimum separation of not less than 40 bar diameters. Not more than one-third of the bars may be spliced in the same cross-section, except where shown on the plans.

Unless otherwise shown on the plans, bars shall be tapped a minimum distance of:

Splice	Grade 40	Grade 50	But not less than
Tension	24 bar dia.	36 bar dia.	300 mm
Compression	20 bar dia.	24 bar dia.	300 mm

In tapped splices, the bars shall be placed in contact and wired together. Lapped splices will not be permitted at locations where the concrete section is insufficient to provide minimum clear distance of one and one-third (1 1/3) the maximum size coarse aggregate between the splice and the nearest adjacent bar. Welding of reinforcing steel shall be done only if detailed on the plans or if authorized by the Engineer in writing. Spiral reinforcement shall be spliced by lapping at least one and a half turns or by butt welding unless otherwise shown on the plans.

404.4 Method of Measurement

The quantity of reinforcing steel to be paid for will be the final quantity placed and accepted in the completed structure. No allowance will be made for tie-wires, separators, wire chairs and other material used in fastening the reinforcing steel in place. No measurement or payment will be made for splices added by the contractor. When there is no item for reinforcing steel in the bill of quantities, cost will be considered as incidental to the other items. (i.e. structural concrete, masonry, etc.) in the bill of quantities.

404.5 Basis of Payment

The accepted quantity, measured as prescribed in section 404.4 shall be paid for at the contract unit price for reinforcing steel which price and payment shall be full compensation for furnishing and placing all materials, including all labor, equipment, tools, and incidentals necessary to complete the work prescribed in this item.

Payment will be made under:

<u>Pay item no.</u>	<u>Description</u>	<u>Unit of Measurement</u>
404 (1)	Reinforcing Steel (d)	Kilograms (kgs)

ITEM 405- STRUCTURAL CONCRETE

405.1 Description

405.1.1 Scope of Work

This item shall consist of furnishing, bending, placing and finishing concrete in all structures except pavements in accordance with this specification and conforming to the lines, grades, and dimensions shown on the plans. Concrete shall consist of a mixture of Portland Cement, fine aggregate, coarse aggregate, admixture when specified or approved by the Engineer.

405.1.2 Classes and Uses of Concrete

Five classes of concrete are provided for in this item, namely: A, B, C, P and Seal. Each class shall be used in that part of the as called for on the plans. The classes of concrete will generally be used as follows:

Class A – All superstructures and heavily reinforced substructures. The important parts of the structure included are slabs, beams, girders, columns, arch ribs, box culverts, reinforced abutments, retaining walls, and reinforced footings.

Class B – Footings, pedestals, massive pier shafts, pipe bedding, and gravity walls, unreinforced or with only a small amount of reinforcement.

Class C – Thin reinforcement sections, precast R.C. piles and cribbing and for filler in steel grid floors.

Class P – Prestressed concrete structures and members.

Seal – Concrete deposited in water.

405.2 Material Requirements

405.2.1 Portland Cement

It shall conform to all the requirements of Subsection 311.2.1

405.2.2 Fine Aggregate

It shall conform to all the requirements of Subsection 311.2.2

405.2.3 Coarse Aggregate

It shall conform to all the requirements of Subsection 311.2.3 except that gradation shall conform to Table 405.1

Table 405.1- Grading Requirements for Coarse Aggregate

Standard (Mm)	Alternate US Standard	Class A	Class B	Class C	Class D	Class Seal
63	2- ½"					
50	2'	100	100			
37.5	1- ½"	95-100	-			100
25	1"	-	35-70	-	100	95-100
19.0	¾"	35-70	-	100	-	25-60

12.5	½"	-	10-30	90-100	-	25-60
9.5	3/8"	10-30	-	40-70	20-55	-
4.75	No.4	0-5	0-5	0-15"	0-10"	0-10"

The measured cement content shall be within plus (+) or minus (-) 2 mass percent of the design cement content.

405.2.4 Water

It shall conform to all the requirements of Subsection 311.2.4

405.2.5 Reinforcing Steel

(1) General

Steel reinforcement shall be provided as indicated, together with all necessary wire ties, chair, spacers, supports and other devices necessary to install and secure the reinforcement properly. All reinforcement, when placed, shall be free from loose, flaky rust and scale, oil grease, clay, and other coating and foreign substances that would reduce or destroy its bond with concrete. Reinforcement shall be placed accurately and secured in place by use of metal or concrete supports, spacers and ties. Such supports shall be of sufficient strength to maintain the reinforcement in place throughout the concreting operations. The supports shall be used in such manner that they will not be exposed or contribute in any way to the discoloration or deterioration of the concrete.

(2) Splicing

Splices shall be by lapping to develop the full strength of the bars unless otherwise indicated, the minimum splice length shall be 40 times the bar diameter or the development length shown in Subsection 404.3.5 and item 710, Reinforcing Steel-splicing.

405.2.5.2 Admixtures

Admixtures shall conform to the requirements of Subsection 311.2.7

405.2.5.3 Curing Materials

Curing materials shall conform to the requirements of Subsection 311.2.8

405.2.5.4 Storage of Cement and Aggregates

Storing of cement and aggregates shall conform to all the requirements of Subsection 311.2.10

405.3 Sampling and Testing of Structural Concrete

As work progresses, at least one (1) sample consisting of three (3) concrete cylinder test specimens, 150mm x 300mm (6"x12") shall be taken from each seventy five (75) cubic meter of each class of concrete of fraction thereof placed each day. Compliance with the requirements of this section shall be determined in accordance with the following standard methods of AASHTO:

Sampling of fresh concrete	T 141
Weight per cubic meter and air content (gravi-metric) of concrete	T 121
Sieve analysis of fine and coarse aggregates	T 27
Slump of Portland Cement Concrete	T 119
Specific gravity and absorption of fine aggregate	T 84

Test for strength shall be made in accordance with the following:

Making and curing concrete comprehensive and flexural test	
Specimens in the field	T 23
Comprehensive strength of molded concrete cylinders	T 22

405.4 Production Requirements

405.4.1 Proportioning and Strength of Structural Concrete

The concrete materials shall be proportioned in accordance with the requirements for each class of concrete as specified in Table 405.4.1, using absolute method as outlined in the American Concrete Institute (ACI) Standard 211.1. "Recommended Practice for Selecting proportions for Normal and Heavyweight Concrete". Other methods of proportioning may be employed in the mix design with prior approval of the Engineer. The mix shall either be designed or approved by the Engineer. A change in the source of materials during the progress of work may necessitate a new mix design.

The strength requirements for each class of concrete shall be specified in Table 405.4.1

Table 405.4.1 – Composition and Strength of Concrete for use in Structure

Class Of Concrete	Minimum Cement Content Per m ³ Kg (bag **)	Maximum Water Cement Ratio Kg/kg	Consistency Range in Slump Mm (inch)	Designated Size of Coarse Aggregate Square Opening Std. mm	Minimum Compressive Strength of 150 mm x 300mm Conc. Cylinder Specimen at 28 days, MN/m ³ (psi)
A	(360) (9 bags)	0.53	50-100 (2 – 4)	37.5 – 4.75 (1 – ½" – No.4)	20.7 (3000)
B	(320) (8 bags)	0.58	50 – 100 (2 – 4)	50 – 4.75 (2" – No.4)	16.5 (2400)
C	380 (9.5 bags)	0.55	50 – 100 (2 – 4)	12.5 – 4.75 (1/2" – No.4)	20.7 (3000)
P	440 (11 bags)	0.49	100 max. (4 max.)	19.0 – 4.75 (¾" – No.4)	37.7 (5000)
Seal	380 (9.5 bags)	0.58	100 – 200 (4 – 8)	25 – 4.75 (1" – No.4)	20.7 (3000)

The measured cement content shall be within plus (+) or minus (-) 2 mass percent of the design cement content. Based on 40 kg/bag.

405.4.2 Consistency

Concrete shall have a consistency such that it will be workable in the required position. It shall be of such a consistency that it will flow around reinforcing steel but individual particles of the coarse aggregate when isolated shall show a coating of mortar containing its proportionate amount of sand. The consistency of concrete shall be gauged by the ability equipment to properly place it and not by difficulty in mixing and transporting. The quantity of mixing water shall be determined by the Engineer and shall not be varied without his consent. Concrete as dry as it is practical to place with the equipment specified shall be used.

405.4.3 Mixing and Delivery

Concrete may be mixed at the site of the construction, at a central point or by a combination of central point and mixing or by a combination of central point mixing truck agitating. Mixing and delivery of concrete shall be in accordance with the appropriate requirement of AASHTO M 157 except as modified in the following paragraphs of this section, for truck mixing in combination of central point and mixing or truck agitating. Delivery of concrete shall be regulated so that placing is at a continuous rate unless delayed by placing operations. The intervals between delivery of batches shall not be so long as to allow the concrete in place to hardened partially, and in no case shall such an interval exceed 30 minutes.

In exceptional cases and volumetric measurements are authorized, for small project requiring less than 75 cubic meters per day of pouring, the weight proportions shall be converted to equivalent volumetric proportions. In such cases, suitable allowance shall be made for variations in the moisture condition of the aggregates, including the bulking effect in the aggregate. Batching and mixing shall be in accordance with ASTM C 685, Section 6 through 9.

405.4.3.1 Mixing Concrete: General

Concrete shall be thoroughly mixed in a mixer of an approved size and type that will insure a uniform distribution of the materials throughout the mass.

All concrete shall be mixed in mechanically operated mixers, mixing plant and equipment for transporting and placing concrete shall be arranged with an ample auxiliary installation to provide minimum supply of concrete in case of breakdown of machinery or in case the normal supply of concrete is disrupted. The auxiliary supply of concrete shall be sufficient to complete the casting of a section up to a construction joint that will meet the approval of the Engineer.

405.4.3.2 Mixing Concrete at Site

Concrete mixers may be of the revolving drum or the revolving blade type and the mixing drum or blades shall be operated uniformly at the mixing speed recommended by the manufacturer. The pick-up and throw-over blades of mixers shall be restored or replaced when any part or section is worn 20mm or more below the original height of the manufacturer's design. The first batch of concrete materials placed in the mixer shall contain a sufficient excess of cement, sand and water to coat inside the drum without reducing the required mortar content of the mix.

When the aggregate contains more water than the quantity necessary to produce a saturated surface dry condition, representative samples shall be taken and the moisture content determined for each kind of aggregate.

The batch shall be so charged into the mixer that some water will enter in advance of cement and aggregate. All water shall be in the drum by the end of the first quarter of the specified mixing time. Cement shall be batched and charged into the mixer so that it will not result in loss of cement due to the effect of wind, hoppers, or other conditions which reduce or vary the required quantity of cement in the concrete mixture.

The entire content of a batch mixer shall be removed from the drum before materials for a succeeding batch are placed therein, the materials composing a batch except water shall be deposited simultaneously in the mixer.

All concrete shall be mixed for a period of not less than 1 – ½ minutes after all materials, including water, are in the mixer. During the period of mixing, the mixer shall operate at the speed for which it has been designed. When mixing is to cease for a period of one hour or more, the mixer shall be thoroughly cleaned. Mixers and agitators which have an accumulation of hard concrete or mortar shall not be used.

405.5 Formwork Construction

Concrete form shall be mortar-tight, true to the dimensions, lines and grades of the structure and with sufficient strength, rigidity, shape and surface smoothness as to leave the finished works true to the dimension shown on the plans or required by the Engineer and the surface finish as specified.

The inside surface of form shall be cleaned of all dirt, mortar and foreign material. From which will later be removed shall be thoroughly coated with form oil prior to use. The form oil shall be of commercial quality form oil or other approved coating which will permit the read release of the forms and will not discolor the concrete.

Concrete shall not be deposited in the forms until work in connection with the constructing the forms has been completed, all inspected and approved said forms and materials. Such work shall include the removal of all dirt, chips, sawdust and other foreign material from the forms.

The rate of depositing concrete in forms shall be such to prevent bulging of the forms or form panels in excess of the deflections permitted by this specification. Forms shall have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete, and shall be maintained rigidly in correct position.

405.5.1 Removal of Forms and Falsework

Forms and falsework shall not be removed without the consent of the Engineer. The Engineer's consent shall not relieve the contractor of responsibility for the safety of the work. Blocks and bracing shall be removed at the time the forms are removed and in no case shall any portion of the wood forms be left in the concrete.

Falsework removal for continuous or cantilevered structures shall be as directed by the Engineer or shall be such that the structure is gradually subjected to its working stress.

When concrete strength tests are used for removal of forms and supports, such removal should not begin until the concrete has attained the percentage of the specified design strength shown in the table below;

Table 405.1 – Requirements for Removal of Forms

Element	Minimum Time	Minimum Percentage Design Strength
Centering under beams frames or arches, girders	14 days	80%
Floor slabs:	14 days	70%
Walls	1 day	70%
Columns	2 days	70%
Side of Beams and all other vertical surfaces	1 day	70%

Forms and falsework shall not be released from under concrete without first determining if the concrete has gained adequate strength without regard to the time element. In the absence of strength determination, the forms and falsework are to remain in place until removal is permitted by the Engineer.

To facilitate finishing, forms used on ornamental work, railing, parapets and exposed vertical surfaces shall be removed in not less than 12 or more than 48 hours, depending upon the

weather condition of concrete in columns, forms shall always be removed from them before the removal of shoring from beneath beams and girders.

405.5.2 Construction Joints

Construction joints shall be made only where shown on the plans or called for in the pouring schedule, unless otherwise approved by the Engineer. Shear keys or reinforcement shall be used, unless otherwise specified, to transmit shear or to bond the two sections together.

Before depositing new concrete on or against concrete which has hardened, the forms shall be retightened. The surface of the hardened concrete shall be roughened as required by the Engineer, in a manner that will not leave loose particles or aggregate or damage concrete at the surface.

The placing of concrete shall be carried continuously from joint to joint. The face edges of all joints which are exposed to view shall be carefully finished true to line and elevation.

405.5.3 Concrete Surface Finishing

Surface finishing shall be classified as follows:

Class 1 – Ordinary Finish

Immediately following the removal of forms, all formwork and irregular protection shall be removed from all surfaces except from those which are not to be exposed or are not to be waterproofed. On all surfaces the cavities produced by form ties and all other holes, honeycomb sports, broken corners or edges and other defects shall be thoroughly cleaned, and having been kept saturated with water and made true with a mortar and fine aggregate mixed in the proportions used in the grade of concrete being finished. Mortar to be used shall not be more than one (1) hour old. The mortar patches shall be cured as specified under Subsection 407.3.8 All construction and expansion joints in the completed work shall be left

carefully tooled and free of all mortar and concrete. The joint filler shall be left exposed for its full length, with clean and true edges.

All concrete shall be given Class 1, Ordinary finish and additionally any further finish as specified. The resulting surfaces shall be true and uniform. All repaired surfaces, the appearance of which is not satisfactory to the Engineer, shall be “rubbed” as specified below.

Class 2 – Rubbed Finish

After removal of forms, the rubbing of concrete shall be started as soon as its condition will permit. Immediately before starting this work, the concrete shall be kept thoroughly saturated with water for a minimum period of three hours. Sufficient time shall have elapsed before the wetting down to allow the mortar used to thoroughly set. The mortar shall be composed of cement and fine sand mixed in the proportions used in the grade of concrete being finished. Rubbing shall be continued until all form marks, protections and irregularities have been removed, all voids have been filled, and a uniform surface has been obtained.

Unless otherwise specified, the following surfaces shall be given a Class 2, Rubbed Finish

- (1) The exposed faces of piers, abutments, wingwalls and retaining walls.
- (2) The outside face of girders, T-beams, slabs, columns, brackets, curbs, headwalls, railings, arch rings, spandrel walls and parapets.

405.5 Method of Measurement

The quantity of structural concrete to be paid for will be the final quantity placed and accepted in the completed structure. No deduction will be made for the volume occupied less than 100 mm (4 inches) in diameter or by reinforcing steel, anchor, conduits, weep hole or expansion joint materials.

405.6 Basis of Payment

The accepted quantities measured prescribed in Section 405.5., shall be paid for at the contract unit price for each of the pay item listed below that is included in the Bill of Quantities. Forms and accessories shall likewise be included in each item.

Payment, shall constitute full compensation for furnishing, placing and finishing concrete including all labor, equipment, tools and incidentals necessary to complete the work prescribed in the item.

Payment will be made under:

<u>Pay item No.</u>	<u>Description</u>	<u>Unit of Measurement</u>
405 (1)	Structural concrete, Class A	Cubic meter
405 (2)	Structural concrete, Class B	Cubic meter
405 (3)	Structural concrete, Class C	Cubic meter
405 (4)	Structural concrete, Class P	Cubic meter
405 (5)	Seal concrete	Cubic meter

ITEM 409- WELDED STRUCTURAL STEEL

409.1 Description

This work shall consist of the joining of structural steel members with welds of the type, dimensions, and design shown on the plans and in accordance with this Specification.

It is the intent of this specification to provide for work of a quality comparable to that required under the Standards Specifications for Welded Highway and Railway Bridges of the American Welding Society. In case of dispute of for situations not adequately provided for in this Specification, those designated Standard Specifications shall be considered as the final authority and shall govern except as amended by the Special Provisions.

Welding of structural Steel shall be done only when shown on the Plans or authorized in writing by the Engineer.

409.2 Material Requirements

Steel base metal to be welded shall be open-hearth or electric furnace steel conforming to AASHTO M 183.

All arc-welding electrodes shall conform to the requirements of American Welding Society Specifications. Electrodes shall be of classification numbers E7016, E7018 or E7028 as required for the positions, type of current and polarity, and other conditions of intended use, and to conform to any special requirements indicated on the plans.

Filler material to be used in the repair or strengthening of old structures or for joining new parts to existing steel members, shall be adopted to the material to be welded and may depart from the foregoing requirements only if agreed by the Engineer.

409.3 Construction Requirements

409.3.1 Equipment

409.3.1.1 General

All items of equipment for welding and gas cutting shall be so designed and manufactured and in such condition as to enable qualified welders to follow the procedures and attain the results prescribed in this specification

409.3.1.2 Arc-Welding Equipment

Welding generators and transformers shall be designed expressly for welding. They shall be capable of delivering steady currents adjustable through a range ample for the work requirements. They shall respond automatically and quickly to changes in power requirements due to variations in arc length and shall deliver full current promptly on striking an arc.

Welding cable shall have sufficient conductivity to avoid overheating and inadequate current at the arc and shall be effectively insulated against welding circuit voltage. Earth or ground connections and circuits shall be secured and adequate to carry the welding currents.

Electrode holders shall grip the electrode firmly and with good electrical contact. Approved automatic welding heads may be used, with suitable auxiliary handling equipment to provide automatic instead of manual control of electrode and welding arc.

409.3.1.3 Gas-Cutting Equipment

Torches and tips shall be of proper size and type of the work at hand. Suitable regulators shall afford the welder complete control over the pressure and rate of flow of each gas.

409.3.1.4 Protective Equipment

All personnel protective equipment shall conform to the American Standard Association Code for such equipment.

The contractor shall enforce the use of approved accessories necessary for the protection and convenience of the welders and for the proper and efficient execution of the work.

Suitable protection against the light of the arc shall be maintained by the contractor when arc-welding operation might be viewed within harmful range by persons other than the actual welders and inspectors.

409.3.2 Welding

409.3.2.1 General

Welding shall be performed by the metal-arc process using the electrodes specified with either direct or alternating current.

Surfaces to be welded shall be smooth, uniform and free from fins, tears and other defects which would adversely affect the quality of the weld. Edges of the material shall be trimmed by machining, chipping, grinding or machine gas-cutting to produce a satisfactory welding edge wherever such edge is thicker than: 13mm for sheared edge of material; 16mm for toes of angles or rolled shapes (other than twice flange sections); 25mm for universal mill plate or edges of flange sections.

The width of root face used, shall be not more than 1.5mm for parts less than 10mm in thickness nor more than 3mm for parts 10mm or more in thickness.

Butt welds shall be proportioned so that their surface contours will lie in gradual transition curves. For butt welded joints between base metal parts of unequal thickness, a transition shall be provided on a slope or level not greater than 1 in 2.5 to join the offset surfaces. This transition may be provided by sloping the surface of the weld material or beveling the thicker part or by combination of these two methods.

Surfaces to be welded shall be free from loose scale, slag, rust grease or other material that will prevent proper welding. Scale mill that withstands vigorous wire brushing or a light film of drying oil or rust inhibitive coating may remain.

409.3.2.2 Welders

All welding shall be done by approved competent and experienced and fully qualified welders.

409.3.2.3 Preparation of Materials for Welding

Dimensional tolerance, straightness and flatness of the structure shapes and plates shall be within the limits prescribed in the Specification.

Structural steel which is to be welded shall preferably not be painted until all welding is completed.

Preparation of edges by gas-cutting shall, wherever practicable, be done by machine gas - cutting. Machine gas-cutting edges shall be substantially as smooth and regular as those produced by edge planning and shall be left free of slag. Manual gas cutting shall be permitted only where machine gas-cutting is not practicable and with the approval of the Engineer. The edge resulting from manual gas cutting shall be inspected and smoothed with special care. All

re-entrant corners shall be filleted to a radius at least 19mm. The cut lines shall not extend beyond the fillet and all cutting shall follow closely the line prescribed.

409.3.2.4 Assembly

The parts to be joined by fillet welds shall be brought into a close contact as practicable, and no event shall be separated more than 5mm. If the separation is 1.5mm or greater, the leg of the fillet weld shall be increased by the amount of separation. The separation between faying surfaces of lap joints and of butt joints landing on a backing structure shall not exceed 1.5mm. The fits of joints which are not sealed by welds throughout their length shall be sufficiently close to exclude water after painting. Where irregularities in rolled shape or plates, after straightening, do not permit contact within the above limits, the procedure necessary to bring the material within these limits shall be subject to the approval of the Engineer.

Cutting parts to be joined by butt welds shall be carefully aligned. Where the parts are effectively restrained against bending due to eccentricity or alignment, a maximum offset of 10 percent of the thickness or the thinner part joined, but in no case more than 3mm, may be permitted as a departure from the theoretical alignment. In connecting alignment in such cases, the parts shall not be drawn into a greater slope than two (2) degrees (1 in 30). Measurement of offset shall be between centerline of parts unless otherwise shown on the plans.

When parts abutting edge to edge differ in thickness, the joint shall be of such form that the slope of either surface through the transition zone does not exceed 1 in 2.5, the thicker part being beveled, if necessary.

Members to be welded shall be brought into correct alignment and held in position by bolts, clamps, wedges, guy lines, strut and other suitable devices or tack welds until welding has been completed. The use of jigs and fixtures is recommended where applicable. Such fastening devices as may be used shall be adequate to insure safety.

Plug and slot welds may be used to transmit shear in a lap joint or to prevent the buckling or separation of lapped parts.

The diameter of the hole for a plug weld shall not be less than the thickness of the part containing it plus 8mm nor shall it be greater than 2.25 times the thickness of the weld.

The minimum center spacing of plug welds shall be four times the diameter of the hole.

The length of the slot shall be semicircular or shall have the corners rounded to a radius not less than the thickness of the part containing it plus 8mm nor shall it be greater than 2.25 times the thickness or the weld.

The end of the slot shall be semicircular or shall have the corners rounded to a radius not less than the thickness of the part containing it, except those ends which extend to the edge of the part.

The minimum spacing of lines of slot welds in a direction transverse to their length shall be 4 times the width of the slot. The minimum center to center spacing in a longitudinal direction on any line shall be 2 times the length of the slot.

The thickness of plug or slot welds in material 16mm or less in thickness shall be equal to the thickness of the material. In material over 16mm in thickness, it shall be at least one-half the thickness of the material but not less than 16mm.

Tack welds, located where the final welds will later be made, shall be subject to the same quality requirements as the final weld. Tack welds shall be as small as practicable and where encountered in the final welding, shall be cleaned and fused thoroughly with the final weld. Defective, cracked or broken tack welds shall be removed before final welding.

Members or component parts of structures shall be assembled and matchmarked prior to erection to insure accurate assembly and adjustment of position on final erection. Painted assembly marks shall be removed from any surface to be welded.