MICHIGAN DEPARTMENT OF TRANSPORTATION
BUREAU OF AERONAUTICS - STANDARD SPECIFICATION
P-501
Portland Cement
Concrete Pavement

DESCRIPTION

1.1 This work shall consist of pavement composed of portland cement concrete without reinforcement constructed on a prepared subgrade or subbase course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans.

MATERIALS

2.1 **Fine Aggregate.** Fine aggregate for concrete shall conform to the requirements of ASTM C33 and shall meet the requirements of Table 1. Fineness modules shall be from 2.5 to 3.35 with a maximum variation of ± 0.2. Loss of wash shall be 0-3%.

TABLE I
GRADATION FOR FINE AGGREGATE

Sieve Designation (Square Openings)	Percentage by Weight Passing Sieves
3/8 in.	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 30	25-60
No. 50	10-30
No. 100	2-10

2.2 **Coarse Aggregate.** Coarse aggregate shall conform to the requirements of ASTM C33. Gradation shall be in accordance with Table 2.

TABLE 2
GRADATION FOR COURSE AGGREGATE

Sieve Designation (Square Openings - inches)	Percentage by Weight Passing Sieves
2 ½	--
2	--
1-1/2	100
1	95-100
3/4	--
1/2	30-60
3/8	--
No. 4	0-8
No. 8	--

% Loss by Wash - 0.8%. Loss of wash of 1.5% is permitted for material produced entirely by crushing ledge rock, trap rock, or boulders.

The percentage of wear shall be no more than 40% when tested in accordance with ASTM C131.

Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, crushed slag, or natural sand. The aggregate shall be composed of sound, tough, durable particles and shall meet the requirements for deleterious substances given in ASTM C33. The aggregate in any size group shall not contain more than 8 percent by weight of flat or elongated pieces. A flat or elongated particle is one having a ratio between the maximum and the minimum dimensions of a circumscribing rectangular prism exceeding 5 to 1.

2.3 **Cement.** Cement shall conform to the requirements of ASTM C150 Type 1, 1A, or 1P.

If, for any reason, cement becomes partially set or

contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.

2.4 Premolded Joint Filler. Premolded joint filler for expansion joint shall conform to the requirements of ASTM D1751 and shall be punched to admit the dowels where called for on the plans. For contraction joints, the filler shall be a resin-impregnated fiberboard conforming to the physical requirements of ASTM D1752. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is authorized for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

2.5 Joint Sealer. The joint sealer for the joints in the concrete pavement shall meet the requirements of Item P-605 and shall be of the type(s) specified in the plans.

2.6 Dowel Bars, Hook Bolts, and Tie Bars. The bars shall be deformed steel bars and conform to the requirements of ASTM A615 or ASTM A616, except that rail steel bars, Grade 50 or 60, shall not be used for tie bars that are to be bent or re-straightened during construction. Tie bars designated as Grade 40 in ASTM A615 can be used for construction requiring bent bars.

Dowel bars shall be plain steel bars conforming to ASTM A615, or A617 and shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the construction site, a minimum of two-thirds of the length of each dowel bar shall be painted with one coat of paint. If plastic or epoxy-coated steel dowels are used, no paint coating is required, except when specified for a particular situation on the contract plans. Coated dowels shall conform to the requirements given in AASHTO M254.

The sleeves for dowel bar used in expansion joint shall be metal, of an approved design to cover 2 to 3 inches of the dowel, with a closed end and with a suitable stop to hold the end of the bar at least 1 inch from the closed end of the sleeve. Sleeves shall be of such design that they will not collapse during construction.

Hook bolts shall be 3/4" minimum diameter and an 8" minimum length. The hook bolt shall have a 2-1/4" threaded coupling and a tensile strength of 36,000 pounds.

2.8 Water. Water used in mixing or curing shall be as clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product as possible. Water will be tested in accordance with the requirements of AASHTO T26. Water known to be of potable quality may be used without testing.

2.9 Cover Material for Curing. Curing materials shall conform to one of the following specifications:

(a) Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309, Type 2.

(b) White polyethylene film for curing concrete shall conform to the requirements of ASTM C171.

(c) White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C171.

(d) Waterproof paper for curing concrete shall conform to the requirements of ASTM C171.

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

a) **Pozzolanic Admixtures.** Pozzolanic admixtures shall be fly ash or raw or calcined material pozzolans meeting the requirements of ASTM C618 with the exception of loss of ignition,

where the maximum should be less than 6 percent. The use of fly ash as a partial replacement for cement, at the rate specified in paragraph 3.6, will be allowed at the Contractor's option.

(b) **Air-Entraining Admixtures.** Air-entraining admixtures shall meet the requirements of ASTM C260 and shall be added to the mixer in the amount necessary to produce the specified air content. The air-entrainment agent and the water reducer admixtures shall be compatible.

(c) **Water-Reducing Admixtures.** Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C494, Type A, water-reducing or Type D, water-reducing and retarding. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions.

CONSTRUCTION METHODS

3.1 Equipment. Equipment and tools necessary for handling materials 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 job site before the start of construction operations for examination and approval.

(a) **Batching Plant and Equipment.**

(1) ***General.*** The batching plant shall include bins, weighing hoppers, and scales for the fine aggregate and coarse aggregate. If bulk cement is used, a bin, hopper, and separate scale for cement shall be included. The weighing hoppers shall be properly sealed and vented to preclude dusting during operation.

(2) ***Bins and hopper.*** Bins with adequate separate compartments for fine aggregate and coarse aggregate shall be provided in the batching plant. Each compartment shall discharge efficiently and freely into the weighing hopper. Means of control shall be provided so that, as the quantity desired in the weighing hopper is approached, the material may be added slowly and shut off with precision. A port or other opening for removing shall be provided. Weighing hoppers shall be constructed to eliminate accumulations of materials and to discharge fully.

(3) ***Scales.*** The scales for weighing aggregates and cement shall be of either the beam or the springless dial type. They shall be accurate within 0.5 percent throughout their range of use. When beam-type scales are used, provisions such as a "telltale" dial shall be made for indicating to the operator that the required load in the weighing hopper is being approached. A device on the weighing beams shall clearly indicate critical position. Poises shall be designed to be locked in any position and to prevent unauthorized change. The weight beam and "telltale" device shall be in full view of the operator while charging the hopper, and the operator shall have convenient access to all controls. Scales shall be inspected and sealed as often as the Engineer may deem necessary to assure their continued accuracy. The Contractor shall have on hand not less than 50-pound weights for testing of all scales when directed by the Engineer.

(b) **Mixers.**

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

A device accurate within 3 percent and satisfactory to the Engineer shall be provided at the mixer for determining the amount of air-entraining agent or other admixture to be added to each batch requiring such admixtures.

Mixers shall be examined daily for the accumulation of hard concrete or mortar and the wear of blades.

(2) ***Central plant mixer.*** Mixing shall be in an approved mixer capable of combining the aggregates, cement, and water into a thoroughly mixed and uniform mass within the specified mixing period, and of discharging the mixture shall be equipped with an acceptable timing device that will not permit the batch to be discharged until the specified mixing time has elapsed. The water system for a central mixer shall be either a calibrated measuring tank or a meter and shall not necessarily be an integral part of the mixer.

The mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throw over blades shall be replaced when they have worn down 3/4 inch or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

(3) ***Truck mixers and truck agitators.*** Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C94.

(4) ***Non-agitator trucks.*** Non-agitating hauling equipment shall conform to the requirements of ASTM C94.

(c) **Finishing Equipment.**

(1) ***Finishing machine.*** The finishing machine shall be power driven of an approved type which will strike off and compact the concrete with a screeding and troweling action. The machine shall be capable of finishing the concrete in the manner specified herein and shall provide a minimum or two oscillating screeds. The finishing machine shall be capable of reversing under its own power to re-screed areas needing additional finishing.

(2) ***Vibrators.*** For side-form construction, vibrators may be either the surface pan type for pavements less than 8 inches thick or the internal type with either immersed tube or multiple spuds, for the full width of the concrete slab. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. They shall not come in contact with the joint, load-transfer devices, subgrade, or side forms. The frequency of the surface vibrators shall not be less than 3,500 vibrations per minute, and the frequency of the internal type shall not be less than 7,000 vibrations per minute for spud vibrators. When spud-type internal vibrators are used adjacent to the side forms, they shall have a frequency of not less than 3,500 vibrations per minute. Hand vibrators should be used to consolidate the concrete along forms and other isolated areas.

For slip-form construction, the paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators with a frequency range variable between 7,000 and 12,000 vibrations per minute. The amplitude of vibration shall be between 0.025 and 0.06 inches.

The number, spacing, frequency, and eccentric weights shall be provided as necessary to achieve an acceptable concrete density and finishing quality. Adequate power to operate all vibrators at the weight and frequency required for a satisfactory finish shall be available on the paver. The internal vibrators may be supplemented by vibrating screeds operating on the surface of the concrete. The frequency of surface vibrations shall not be less than 3,500 vibrations per minute. The Contractor shall furnish a tachometer or other suitable device for measuring the frequency of the vibrators. The vibrators and tamping elements shall be automatically controlled so that they shall be stopped as forward motion ceases. Any override switch shall be of the spring-loaded, momentary contact type.

(d) **Concrete Saw.** When sawing of joints is specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The Contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All of this equipment shall be on the job both before and at all times during concrete placement.

(e) **Forms.** Straight side forms shall be made of steel having a thickness of not less than 7/32 inch and shall be furnished in sections not less than 10 feet in length. Forms shall have a depth equal to the prescribed edge thickness of the concrete without horizontal joint, and a base width equal to the depth of the forms. Flexible or curved forms of proper radius shall be used for curves of 100-foot radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the

impact and vibration of the consolidating and finishing equipment. Flange braces shall extend outward of the base not less than two-thirds the height of the form. Forms with battered top surfaces and bent, twisted, or broken forms shall be removed from the work. Repaired forms shall not be used until inspected and approved. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch in 10 feet, and the upstanding leg shall not vary more than 1/4 inch. The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting.

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

3.2 Form Setting. Forms shall be set sufficiently in advance of the concrete placement to insure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than 3 pins for each 10-foot section. A pin shall be placed at each side of every joint.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of concrete.

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

3.3 Conditioning of Underlying Course, Slip-Form Construction. The compacted subgrade or subbase on which the pavement will be placed shall be widened approximately 3 feet to extend beyond the paving machine track to support the paver without any noticeable displacement. After the subgrade or subbase has been placed and compacted to the required density, the areas which will support the paving machine and the area to be paved shall be trimmed to the proper elevation and profile by means of a properly designed machine. The grade of the substance on which the concrete pavement is to be place shall be controlled automatically by steel guide wires erected and maintained by the Contractor. If the density of the base is disturbed by the trimming operations, it shall be corrected by additional compaction before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected by additional compaction before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the Contractor or the damaged areas filled with concrete integral with the pavement. The grading operations should be delayed as long as possible and immediately precede paving insofar as practical, particularly if the base course is subjected to haul traffic. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be well moistened with water, without saturation, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. In cold weather the underlying subbase shall be protected so that it will be entirely free of frost when concrete is placed.

3.4 Conditioning of Underlying course, Side-Form Construction. The prepared grade shall be well moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Ruts or depressions in the subgrade or subbase caused by hauling or usage of other equipment shall be filled as they develop with suitable material (not with concrete or concrete aggregates) and thoroughly compacted by rolling. If damage occurs to a

stabilized subbase, it shall be corrected full depth by the Contractor, or the damage occurs to the a stabilized subbase, it shall be corrected full depth by the Contractor, or the damaged areas filled with concrete integral with the pavement. A multiple-pin templet weighing not less than 1,000 pounds per 20 feet or other approved templet shall be provided and operated on the forms immediately in advance of the placing of the concrete. The templet shall be propelled only by hand and not attached to a tractor or other power unit. Templets shall be adjustable so that they may be set and maintained at the correct contour of the underlying course. The adjustment and operation of the templet shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed. Low areas may be filled and compacted to a condition similar to that of the surrounding grade, or filled with concrete integral with the pavement. In cold weather, the underlying subbase shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying material will not be permitted. The templet shall be maintained in accurate adjustment, at all times by the Contractor, and should be checked daily. The work described under the foregoing paragraphs does not constitute a regular subgrading operation, but rather a final accurate check of the underlying course.

3.5 Handling, Measuring, and Batching Material. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be built up in layers of not more than 3 feet in thickness. Each layer shall be completely in place before beginning the next layer and 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. Improperly placed stockpiles will not be accepted by the Engineer.

Aggregates shall be handled from stockpiles or other sources to the batching plant in such a manner to secure the specified grading of the material. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage. The fine aggregate and course aggregate shall be separately weighed into hoppers in the respective amounts set by the Engineer in the job mix. Cement shall be measured by weight. Separate scales and hopper, with a device to positively indicate the complete discharge of the batch of cement into the batch box or container, shall be used for weighing the cement.

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

When cement is placed in contact with the aggregates, batches may be rejected unless mixed within 1.5 hours of such contact. Batching shall be conducted so that eh results in the weights of each material required will be within a tolerance of 1 percent for cement and 2 percent for aggregates.

Water may be measured either by volume or by weight. the accuracy of measuring the water shall be within plus or minus 1 percent of required amounts. Unless the water is to be weighed, the water-measuring equipment shall include an auxiliary tank from which the measuring tank shall be filled. The measuring 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.

Methods and equipment for adding air-entraining agent or other admixtures to the batch, when required, shall be approved by the Engineer. All admixtures shall be measured into the mixer with an accuracy of ± 3 %.

3.6 Proportions. Proportioning requirements for concrete shall be designed for a minimum flexural strength as shown in Table 3.

Prior to the start of paving operations and after approval of all material to be used in the concrete, the Contractor shall submit test data showing the proportions and actual flexural strength obtained from the concrete. Flexural strength shall be as specified at 28 days using test specimens prepared in accordance with ASTM C31 and tested in accordance with ASTM C78. The mix determined shall be workable concrete having a slump for side-form concrete between 1 and 2 inches as determined by ASTM C143. For vibrated slip-form concrete, the slump shall be between ½ inch and 1-1/2 inches.

The minimum cement content shall be maintained to produce concrete of suitable durability and workability. The maximum water-cement ratio specified for concrete shall not be exceeded. Entrained air shall be required to increase durability and provide workability.

Concrete Class	Cement Type	Cement Content (Lbs./C.Y.)	Fly Ash	Water Reducer	Strengths	
					7-Day Flexural	28-Day Flexural
AA	1, 1A, 1S	611	0	Optional	600	700
	1P, 1S-A, 1P-A	564	0	Required		
	1, 1A	564	78	Optional		
A	1, 1S, 1P 1A, 1S-A	564	0	Optional	550	650
	1P-A	526	0	Required		
	1, 1A	517	78	Optional		
B	1, 1S, 1P 1A, 1S-A	517	0	Optional	500	600
	1P-A	489	0	Required		
	1, 1A	470	71	Optional		

For slip-form construction, a high degree of uniformity in the plastic concrete is required. Caution should be exercised in establishing the air-entrainment percentage, as excessive air entrainment will aggravate edge slumping and insufficient air entrainment will result in poor concrete durability. Batches with slump in excess of 1-1/2 inches shall be wasted. Some edge slump of the wet concrete behind the side form on the paving machine will occur, even with low slump concrete. This may continue, though very slowly, until initial set has taken place. Provision for adequate compensating adjustment in the side form and in the final screed must be incorporated in the paver.

The cement content shall not be less than 5.2 sacks per cubic yard nor shall the water-cement ratio, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates, be more than 6 gallons per sack of cement. The cement content shall be determined in accordance with ASTM C138.

Air-entraining admixture shall be added in such a

manner that will insure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrailed concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air entrainment in the mix shall be 5.5 percent ± 1-1/2 percentage points. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

3.7 Field Test Specimens. Concrete samples shall be furnished by the Contractor and shall be taken in the field to determine the consistency, air content, and strength of the concrete. Flexural test beams shall be made each day that the concrete is placed. Each group of test beams shall be molded from the same batch of concrete and shall consist of a sufficient number of specimens to provide two flexural strength tests at each test age. One group of specimens will be made during the first half of each shift, and the other during the last portion of the shift. The specimens shall be made in accordance with ASTM C31. However, at the start of paving operations and when the aggregate source, aggregate characteristics, or mix design is changed, additional groups of test beams may be required until the Engineer is satisfied that the concrete mixture being used complies with the strength requirements of these specifications. Test ages will be 7 days and 28 days.

The concrete shall be sampled in accordance with ASTM C172. Flexural strength specimens shall be made in accordance with ASTM C31 and tested in accordance with ASTM C78.

The flexural strength of concrete shall meet the following requirements: (1) the average of any four consecutive strength tests, tested at the end of 28 days, shall have an average flexural strength equal to or greater than the specified flexural strength; (2) not more than 20 percent of the beams tested at the end of 28 days shall have a flexural strength less than the specified strength. Specimens which are obviously defective shall not be considered in the determination of the strength. When it appears that the test specimens will fail to conform to the requirements for strength, the Engineer shall have the right to order changes in the concrete sufficient to increase the strength to meet the requirements. When a satisfactory relationship between 7-day and 28-day strengths has been established and approved, the 7-day test results may be used as an indication of the 28-day strengths. However, the 7-day test results will not replace the results of the 28-day tests if the 28-day results fall below the requirements.

3.8 Mixing Concrete. The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. Ready-mixed concrete shall be mixed and delivered in accordance with the requirements of ASTM C94, except that the minimum required revolutions of 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 the Engineer verifying that the make and model of the mixer will produce uniform concrete conforming to the provisions of ASTM C94 at the reduced number of revolutions shown on the serial plate.

When mixed at the work site or in a central mixing plant, the mixing time shall not be less than 50 seconds nor more than 90 seconds. Mixing time ends when the 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 on the approved mixer. Any concrete mixed less than the specified time shall be discarded at the Contractor's expense. The volume of concrete mixed per batch shall not exceed the mixer's nominal capacity in cubic feet, as shown on the manufacturer's standard rating plate on the mixer. An overload up to 10 percent above the mixer's nominal capacity may be permitted provided concrete test data for segregation and uniform consistency are satisfactory, and provided no spillage of concrete takes place. The batch shall be charged into the drum so that a portion of the mixing water shall enter in advance of the cement 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 may restrict the free flow of materials into the drum.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or non-agitating trucks. The time elapsing from the time water is added to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 60 minutes when the concrete is hauled in truck mixers or truck agitators. Re-tempering concrete by adding water or by other means will not be permitted, except when concrete is delivered in transit mixers. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements, if permitted by the Engineer. All these operations must be performed within 45 minutes after the initial mixing operations and the water-cement ratio must not be exceeded. Admixtures for increasing the workability or for accelerating the set will be permitted only when specified for in the contract.

3.9 Limitations of Mixes. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40°F and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F at the time of placement in the forms.

If the air temperature is 35°F or less at the time of placing concrete, the Engineer may require the water and/or the aggregates to be heated to not less than 70°F nor more than 150°F. Concrete shall not be placed on frozen subgrade nor shall frozen aggregates be used in the concrete.

During the periods of warm weather when the maximum daily air temperature exceeds 85°F, the following precautions should be taken. The forms and/or the underlying material shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90°F. The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.

3.10 Placing Concrete.

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

When concrete is to be placed adjoining a previously constructed lane of pavement and when mechanical equipment will be operated upon the existing lane of pavement, the concrete shall be at least 7 days old and at flexural strength approved by the Engineer. If only finishing equipment is carried on the existing lane, paving in adjoining lanes may be permitted after 3 days, if approved by the Engineer.

Concrete shall be thoroughly consolidated against and along the faces of all forms and along the full length and on both sides of all joint assemblies by means of vibrator be operated longer than 15 seconds in any one location, nor shall the vibrators be used to move the concrete.

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

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

(b) **Slip-form Method.** For the slip-form method, the concrete shall be placed with an approved crawler-mounted, slip-form paver designed to spread, consolidate, and shape the freshly placed concrete in one complete pass of the machine so that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement in conformance with requirements of the plans and specifications. The concrete should be placed directly on top of the joint assemblies to prevent them from moving when the paver moves over them. Side forms and finishing screeds shall be adjustable to the extent required to produce the specified pavement edge and surface tolerance. The side forms shall be of dimensions, shape, and strength to support the concrete laterally for a sufficient length of time so that no appreciable edge slumping with occur. Final finishing shall be accomplished while the concrete is still in the plastic state.

It is the intent of the specification to produce a high quality, dense, long lasting, and smooth pavement suitable for the high speed operations of roughness-sensitive heavy jet aircraft. This requires that all joints, and particularly all longitudinal joints, meet the specified tolerance throughout their length. The Engineer will designate the paving lanes in an apron, taxiway, or the outer runway paving lanes to be used for the initial paving operations. In the event that slumping or sloughing occurs behind the paver, or if there are any other structural or surface defects which, in the opinion of the Engineer, cannot be corrected within permissible tolerances, the Engineer may halt paving operations until proper adjustment of the equipment or procedures have been made. In the event that satisfactory procedures and pavement are not achieved after not more than 2,000 lineal feet of single lane paving, the Contractor shall complete the balance of the work with the use of standard metal forms and the formed method of placing and curing.

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

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

3.12 Joints.

(a) **General.**

(1) ***Longitudinal and transverse joints.*** Longitudinal and transverse joints shall be constructed as indicated on the plans and in accordance with these requirements. All joints shall be constructed true to line with their face perpendicular to the surface of the pavement. Joints shall not vary more than ½ inch from a true line or from their designated position. The vertical surface of the pavement adjacent to all expansion joints shall be finished to a true plane and edged to a radius of 1/4 inch or as shown on the plans. The surface across the joints shall be tested with a 10-foot straightedge as the joints are finished and any irregularities in excess of 1/4 inch shall be corrected before the concrete has hardened. When required, keyways shall be accurately formed with a template of metal or wood. The gauge or thickness of the material in the template shall be such that the full keyway, as specified, is formed and is in the correct centerline of the pavement and shall extend the full width of the slab. The transverse joints in succeeding lanes shall be placed in line with similar joints in the first lane. All joints shall be so

prepared, finished, or cut to provide a groove of the width and depth shown on the plans.

(2) ***Tie bars.*** Tie bars shall consist of deformed bars installed principally in longitudinal joints as shown on the plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals of 30 inches, unless otherwise specified. They shall be held in position parallel to the pavement surface and midway between the surfaces of the slab. When tie bars extend into an unpaved lane, they may be bent at right angles against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. These bars shall not be painted, greased, or enclosed in sleeves.

(3) ***Dowel bars***. Dowel bars or other load-transfer units of an approved type shall be placed across transverse or other joints in the manner as specified on the plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. A metal, or other type, dowel expansion cap or sleeve shall be furnished for each dowel bar used with expansion joints. These caps shall be substantial enough to prevent collapse and shall be placed on the ends of the dowels as shown on the plans. The caps or sleeves shall fit the dowel bar tightly and the closed end shall be watertight. The portion of each dowel painted with rust preventative paint, as required under Section 501-2.7, shall be thoroughly coated with asphalt MC-70, or an approved lubricant, to prevent the concrete from binding to that portion of the dowel. If free-sliding plastic-coated or epoxy-coated steel dowels are used, a lubrication bond breaker shall be used except when approved pullout tests indicate it is not necessary. In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by a mechanical device approved by the Engineer.

(4) ***Slip-form construction.*** For slip-form construction, the following shall apply: When keyed construction joints are called for, a sheet metal keyway liner shall be required. The liner may remain in place permanently and become part of the keyed joint and shall be galvanized, copper clad, or of similar rust-resistant material, of sufficient stiffness to support the upper keyway flange. Two-piece hook bolts may be installed in either the male or female side of the keyed joint providing the installation is made without distorting the keyed dimensions or causing edge slump. If a bent tie bar installation is used, the tie bars shall be inserted through the sheet metal keyway liner only on the female side of the joint. The bent tie bar installation may cause breaking of some small amount of laitance where the bar goes through the liner when the exposed portion of the bar is bent for extension into the adjacent lane. In no case shall a bent tie bar installation be permitted which will require chipping away of concrete to perform the straightening of the tie bar. Alternate methods of bar installation may be approved by the Engineer if the keyway can be formed to a tolerance of 1/4 inch in any dimension and without distortion or slumping of the top of the male flange. Transverse joints with dowels will require particular care to insure the dowels are accurately placed and not disturbed during concrete placement. Transverse dowels will require use of an apparatus to firmly hold the dowels perpendicular to the joint and parallel to the slab surface. During the concrete placement operation, it is advisable to place plastic concrete directly on the dowel assembly immediately prior to passage of the paver to help maintain dowel alignment. In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by a mechanical device approved by the Engineer.

(b) **Installation.** The top of an assembled joint device shall be set at the proper distance below the pavement surface and the elevation shall be checked. Such devices shall be set to the required position an line and shall be securely held in place by stakes or other means during the pouring and finishing of the concrete. The Pre-molded joint material shall be placed and held in a vertical position; if constructed in sections, there shall be no offsets between adjacent units. Dowel bars shall be checked for exact position and alignment as soon as the joint device is staked in place, and the device shall be tested to determine whether it is firmly supported. The maximum permissible tolerance on dowel bar alignment in each plane, horizontal and vertical, shall not exceed 2 percent or 1/4 inch per foot of a dowel bar. The

most effective way to obtain proper alignment is with well-fabricated dowel baskets and dowel assemblies. In lieu of using dowel assemblies at contraction joints, dowel bars may be placed in the full thickness of pavement by mechanical device approved by the Engineer.

When joints in concrete pavements are sawed, the joints shall be cut as shown on the plans. Equipment shall be as described in Section 501-3.1. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 1/8 inch wide and to the depth shown on the plans. When shown on the plans or required by the specifications; the top portion of the slot or groove shall be widened by means of a second shallower cut or by a suitable and approved beveling to provide adequate space for joint sealers. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing. Sawing shall be carried on both during the day and night as required. The joints shall be sawed at the required spacing consecutively in sequence of the concrete placement, unless otherwise approved by the Engineer.

(c) **Longitudinal Joints.**

(1) ***Construction.*** Longitudinal construction joints necessary for lane construction shall be formed against suitable side forms (usually made of steel) with or without keyways, as indicated in the plans. Wooden forms may be used under special conditions, when approved by the Engineer. When the concrete is placed using slip-form pavers, the keyway shall be formed in the plastic concrete by means of preformed metal keyway liners which are inserted during the slip-form operations to form the female side of the key and which may be left in place. The dimensions of the keyway forms shall not vary more than plus or minus 1/4 inch from the dimensions indicated and shall not deviate more than plus or minus 1/4 inch from the mid-depth of the pavement. A male keyway may be used providing the keyway and edge tolerances are met. Where butt-type joints with dowels are designated, the dowels for this type shall be painted and greased. The edges of the joint shall be finished with a grooving tool or edging tool, and a space or slot shall be formed along the joint of the dimensions, as indicated, to receive the joint sealing material. Longitudinal construction joints shall be sawed to provide a groove at the top conforming to the details and dimensions indicated on the plans. Provisions shall be made for the installation of tie bars as noted on the plans.

(2) ***Contraction or weakened-plane type.*** The longitudinal groove formed or sawed in the top of the slab shall be installed where indicated on the drawings. The groove shall be formed in the plastic concrete with suitable tools or material to obtain the width and depth specified, or it shall be sawed with approved equipment in the hardened concrete to the dimensions required. When the groove is formed in plastic concrete, it shall be true to line with not more than 1/4 inch variation in 10 feet; it shall be uniform in width and depth; and the sides of the groove shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The sawed groove shall be straight and of uniform width and depth. In either case, the groove shall be clean cut so that spalling will be avoided at intersections with transverse joints. Tie bars shall be installed across these joints where indicated on the plans.

(3) ***Expansion.*** Longitudinal expansion joints shall be installed as indicated on the plans. The pre-molded filler, of the thickness as shown on the plans, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A metal cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the pre-molded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic.

(d) **Transverse Joints.**

(1) ***Expansion.*** Transverse expansion joints shall be installed at the locations and spacing as shown on the plans. The joints shall be installed at right angles to the centerline and perpendicular to the surface of the pavement. The joints shall be installed and finished to insure complete separation of the slabs. Expansion joints

shall be of a pre-molded type conforming to these specifications and with the plans and shall be the full width of the pavement strip.

All concrete shall be cleaned from the top of the joint material. Before the pavement is opened to traffic, this space shall be swept clean and filled with approved joint sealing material.

All devices used for the installation of expansion joints shall be approved by the Engineer. They shall be easily removable without disturbing the concrete and held in proper transverse and vertical alignment. Immediately after forms are removed, any concrete bridging the joint space at the ends shall be removed for the full width and depth of the joint.

When specified, expansion joints shall be equipped with dowels of the dimensions and at the spacing and location indicated on the plans. The dowels shall be firmly supported in place and accurately aligned parallel to the subgrade and the centerline of the pavement by means of a dowel assembly which will remain in the pavement and will ensure that the dowels are not displaced during construction.

Other types of load-transfer devices may be used, when approved by the Engineer.

(2) ***Contraction.*** Transverse contraction joints, weakened-plane joints, or both, shall be installed at the locations and spacing as shown on the plans. These joints will be installed by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened in the same manner as specified in Section 501-3.12(c)(2). Dowel bar assemblies shall be installed, when required, as shown on the plans.

(3) ***Construction.*** Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that concrete will obtain its initial set before fresh concrete arrives. When the installation of the joint can be planned in advance, it shall be located at a contraction or expansion joint. The joint shall not be allowed within 8 feet of a regular spaced transverse joint. If the pouring of the concrete has been stopped, causing a joint to fall within this limit, it shall not be installed, and the fresh placed concrete shall be removed back to the 8 foot limit.

3.13 Final Strike-Off, Consolidation, and Finishing.

(a) **Sequence.** The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight edging, and final surface finish. The additional of superficial water to the surface of the concrete to assist in finishing operations generally will not be permitted. If application of water to the surface is permitted, it shall be applied as a fog spray by means of approved spray equipment.

(b) **Finishing at Joints.** The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material; it shall be firmly placed without voids or segregation under and around all load-transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Section 501-3.10. After the concrete has been placed and vibrated adjacent to the joints, the finishing machine shall be operated in a manner to avoid damage or misalignment of joints. If uninterrupted operations of the finishing machine, to, over, and beyond the joints, cause segregation of concrete, damage to, or misalignment of the joints, the finishing machine shall be stopped when the screed is approximately 8 inches from the joint. Segregated concrete shall be removed from the front of and off the joint; the screed shall be lifted and set directly on top of the joint, and the forward motion of the finishing machine shall be resumed. Thereafter, the finishing machine may be run over the joint without lifting the screed, provided there is not segregated concrete immediately between the joint and the screed or on top of the joint.

(c) **Machine Finishing.** The concrete shall be spread as soon as it is placed, and it shall be struck off and screeded by an approved finishing machine. The machine shall go over each area as many times and at such intervals as necessary to give the proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided. When side forms are used, the tops of the forms shall be kept clean by an effective device attached to the machine, and the

travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish. During the first pass of the finishing machine, a uniform ridge of concrete shall be maintained ahead of the front screed for its entire length. When in operation, the screed shall be moved forward with a combined longitudinal and transverse shearing motion, always moving in the direction in which the work is progressing, and so manipulated that neither end is raised from the side forms during the striking-off process. If necessary, this shall be repeated until the surface is of uniform texture, true to grade and cross section, and free from porous areas.

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

The screed for the surface shall be at least 2 feet longer than the maximum width of the slab to be struck off. It shall be of approved design, sufficiently rigid to retain its shape, and shall be constructed either of metal or of other suitable material covered with metal. Consolidation shall be attained by the use of a suitable vibrator.

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

(1) ***Hand Method***. The hand-operated longitudinal float shall not be less than 12 feet in length and 6 inches in width, properly stiffened to prevent flexibility and warping. The longitudinal float, operated from the foot bridges resting on the side forms and spanning but not touching the concrete, shall be worked with a sawing motion, while held in floating position parallel to the pavement centerline and passing gradually from one side of the pavement to the other. Forward movement along the centerline of the pavement shall be in successive advances of not more than one-half the length of the float. Any excess water or soupy material shall be wasted over the pavement edge on each pass.

(2) ***Mechanical method.*** The Contractor may use a machine composed of a cutting and smoothing float(s), suspended from and guided by a rigid frame. The frame shall be carried by four or more visible wheels riding on, and constantly in contact with, the side forms or pavement subgrade. If necessary, long-handled floats having blades not less than 5 feet in length and 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 mechanical methods. When strike-off and consolidation are done by hand and the crown of the pavement will not permit the use of the longitudinal float, the surface shall be floated transversely by means of a long-handled float. Care shall be taken not to work the crown out of the pavement during the operation. After floating, any excess water and laitance shall be removed from the surface of the pavement by a straightedge 10 feet or more in length. Successive drags shall be lapped one-half the length of the blade.

(f) **Straight-edge Testing and Surface Correction.** After the pavement has been struck off and consolidated and while the concrete is still plastic, it shall be tested for trueness with a 16 foot straightedge. For this purpose the Contractor shall furnish and use an accurate 16 foot straightedge swung from handles 3 feet longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance shall be removed from the surface of the pavement. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the requirements for smoothness. Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from

the straightedge and until the slab conforms to the required grade and cross section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment.

3.14 Surface Texture. The surface of the pavement shall be finished with either a broom or burlap drag finish for all newly constructed concrete pavements.

(a) **Brush or Broom Finish.** If the pavement surface texture is to be a type of brush or broom finish, it shall be applied when the water sheen has practically disappeared. The equipment shall operate transversely across the pavement surface, providing corrugations that are uniform in appearance and approximately 1/16 of an inch in depth. It is important that the texturing equipment does not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected.

(b) **Burlap Drag Finish.** If a burlap drag is used to texture the pavement surface, it shall be at least 15 ounces per square yard. To obtain a rough-textured surface, the transverse threads of the burlap should be removed approximately 1 foot from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The corrugations shall be uniform in appearance and approximately 1/16 of an inch in depth.

3.15 Skid Resistant Surfaces. A skid resistant surface shall be provided by construction of grooves.

3.16 Surface Test. As soon as the concrete has hardened sufficiently, the pavement surface shall be tested with a 16 foot straightedge or other specified device. Areas in a slab showing high spots of more than 1/4 inch but not exceeding ½ inch in 16 feet shall be marked and immediately ground down with an approved grinding machine to an elevation that will fall within the tolerance of 1/4 inch or less. Where the departure from correct cross section exceeds ½ inch, the pavement shall be removed and replaced at the expense of the Contractor when so directed by the Engineer.

Any area or section so removed shall not be less than 10 feet in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to the joints that is less than 10 feet in length shall also be removed and replaced.

3.17 Curing. Immediately after the finishing operations have been completed and marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured in accordance with one of the methods below. In all cases in which curing shall have prior right to all water supply or supplies. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than ½ hour during the curing period. The following are alternate approved methods for curing concrete pavements.

(a) **Impervious Membrane Method.** The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of 1 gallon to not more than 150 square feet. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator., At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd widths or shapes and concrete surfaces 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 for 72 hours. the curing compound shall be of such character that he film will harden within 30 minutes after application. Should the film become damaged from any cause within the required curing period, the damaged portions shall be repaired immediately with additional compound. Upon removal of side forms, the sides of the exposed slabs shall be protected

immediately to provide a curing treatment equal to that provided for the surface.

(b) **Polyethylene Films.** The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units shall be lapped at least 18 inches. The sheeting shall be placed and weighed to cause it to remain in contact with the surface covered. The sheeting shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the pavement. Unless otherwise specified, the sheeting shall be maintained in place for 72 hours after the concrete has been placed.

(c) **Waterproof Paper.** The top surface and sides of the pavement shall be entirely covered with waterproof paper. The units shall be lapped at least 18 inches. the paper shall be placed and weighed to cause it to remain in contact with the surface covered. The paper shall have dimensions that will extend at least twice the thickness of the pavement beyond the edges of the slab. The surface of the pavement shall be maintained in place for 72 hours after the concrete has been placed.

(d) **White Burlap-Polyethylene Sheets.** The surface of the pavement shall be entirely covered with sheeting. The sheeting used shall be such length or width that it will extend at least twice the thickness of the pavement beyond the edges of the slab. The sheeting shall be placed so that the entire surface and both edges of the slab are completely covered.

The sheeting shall be placed and weighted to remain in contact with the surface covered, and the covering shall be maintained fully wetted and in position for 72 hours after the concrete has been placed.

(e) **Curing in Cold Weather.** When the average daily temperature is below 40°F, curing shall consist of covering the newly laid pavement with no less than 12 inches of loose, dry hay or straw, or equivalent protective curing authorized by the Engineer, which shall be retained in place for 10 days. The hay or straw shall be secured to avoid being blown away. Admixture for curing or temperature control may be used only when authorized by the Engineer.

When concrete is being placed or the air temperature may be expected to drop below 35°F, a sufficient supply of straw, hay, grass, or other suitable blanketing material such as burlap or polyethylene shall be provided along the work. Any time the temperature may be expected to reach the freezing point during the day or night, the material so provided shall be spread over the pavement to a sufficient depth to prevent freezing of the concrete. The period of time such protection shall be maintained shall not be less than 10 days. A minimum of 3 days is required when high, early strength concrete is used. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather, and any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

3.18 Removing Forms. Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has set for at least 12 hours, except where auxiliary forms are used temporarily in widened areas. Forms shall be removed carefully to avoid damage to the pavement. After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated in Section 501-3.17. Major honeycombed areas shall be considered as defective work and shall be removed and replaced. Any area or section so removed shall not be less than 10 feet in length nor less than the full width of the lane involved. When it is necessary to remove and replace a section of pavement, any remaining portion of the slab adjacent to eh joints that is less than 10 feet in length shall be also be removed and replaced.

3.19 Sealing Joints. The joints in the pavement shall be sealed in accordance with Item P-605.

3.20 Protection of Pavement. The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, or crossovers, 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 replaced at the Contractor's expense. In order that the concrete 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 surfaces of the unhardened concrete. Such protection materials shall consist of rolled polyethylene sheeting at least 4 mils thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

3.21 Opening to traffic. The Engineer shall decide when the pavement shall be opened to traffic. The pavement will not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained a flexural strength of 550 pounds per square inch when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening to traffic, the pavement shall be cleaned.

3.22 Surface Tolerance. Extreme care must be exercised in all phases of the operation to assure the pavement will pass the specified tolerances. The following tolerances are applicable:

(a) Lateral deviation from established alignment of the pavement edge shall not exceed plus or minus 0.10 foot in any lane.

(b) Vertical deviation from established grade shall not exceed plus or minus 0.04 foot at any point.

(c) Surface smoothness deviations shall not exceed 1/4 inch from a 16 foot straightedge placed in any direction, including placement along and spanning any pavement joint or edge.

3.23 Tolerance in Pavement Thickness. Concrete will be accepted for thickness on a lot basis. A lot will consist of 1200 square yards. One core shall be taken at random by the Engineer in each lot. When the measurement of the core form a lot is not deficient more than 0.2 inch from the plan thickness, full payment will be made. When such measurement is deficient more than 0.2 inch and not more than 1.0 inch from the plan thickness, two additional cores shall be taken at random and used in determining the average thickness for that lot. An adjusted unit price, as provided in Paragraph 501-5.2, will be paid for the lot. The thickness of the pavement shall be determined by an average caliper measurement of cores tested in accordance with ASTM C174.

In calculating the average thickness of the pavement, measurements which are in excess of the specified thickness by more than 0.2 inch shall be considered as specified thickness plus 0.2 inch, and measurements which are less than the specified thickness by more than 1.0 inch shall not be included in the average.

When the measurement of any core is less than the specified thickness by more than 1.0 inch, the actual thickness of the pavement in this area shall be determined by taking additional cores at not less than 10-foot intervals parallel to the centerline in each direction from the affected location, until in each direction a core is found which is not deficient by more than 1.0 inch. Areas found deficient in thickness by more than 1.0 inch shall be evaluated by the Engineer and, if the deficient areas warrant removal, they shall be removed and replaced with concrete of the thickness shown on the plans. Exploratory cores for deficient thickness will not be used in averages for adjusted unit price. Core holes shall be filled with non-shrink grout.

METHOD OF MEASUREMENT

4.2 The quantity to be paid for shall be the number of square meters of either plain or reinforced pavement as specified, in place, completed and accepted, less deductions as hereinafter required for deficient thickness.

BASIS OF PAVEMENT

5.1 General. The accepted quantities of concrete pavement will be paid for at the contract unit price per square yard which price and pavement shall be full compensation for furnishing and placing all materials, including any dowels, steel reinforcement and joint material texturing, except for saw-cut grooving, provided, however, that for any pavement found deficient in thickness by more

than 0.2 inch, but not more than 1.0 inch only the reduced price stipulated below shall be paid.

No additional pavement over the unit contract bid price shall be made for any pavement which has an average thickness in excess of that shown on the plans.

Payment will be made under the nomenclature and seven digit item number specified in the plans and proposal for each thickness or type of concrete -- per square yard. The first three digits included under this specification shall be 501, i.e. 501XXXX.

5.2 Price adjustment.

Thickness adjustment. Where the average thickness of pavement is deficient in thickness by more than 0.2 inch but not more than 1.0 inch, payment will be made at an adjusted price as specified in Table 4.

TABLE 4
PAVEMENT DEFICIENCY

Deficiency in Thickness Determined by Cores (Average 3 Tests)	Proportional Part of Contract Price Allowed (Percent)
Inches	
0.00 to 0.20	100
0.21 to 0.30	80
0.31 to 0.40	72
0.41 to 0.50	68
0.51 to 0.75	57
0.76 to 1.00	50

When the thickness of pavement is deficient by more than 1 inch and, in the judgement of the Engineer, the area of such deficiency should not be removed and replaced, there shall be no payment for the area retained.

TESTING AND MATERIAL REQUIREMENTS

ASTM C31	Making and Curing Concrete Test Specimens in the Field
ASTM C39	Compressive Strength of Cylindrical Concrete Specimens
ASTM C78	Test for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C131	Test for Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C138	Test for Unit Weight, Yield, and Air Content (Gravimetric) of Concrete
ASTM C143	Test for Slump of Portland Cement Concrete
ASTM C172	Sampling Fresh Concrete
ASTM C173	Test for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Measuring Length of Drilled Concrete Cores
ASTM C231	Test for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C311	Sampling and Testing Fly Ash for Use as an Admixture in Portland Cement Concrete
ASTM C535	Test for Resistance to Abrasion of Large Size Coarse Aggregate by Use of the Los Angeles Machine
AASHTO T26	Quality of Water to be Used in Concrete

MATERIALS

ASTM A 184	Specification for Fabricated Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A185	Specification for Welded Steel Wire Fabric for Concrete Reinforcement
ASTM A497	Specification for Welded Deformed Steel Wire Fabric for Concrete Pavement
ASTM A615	Specification for Deformed and Plain Billet-Steel Bars for Concrete Reinforcement
ASTM A616	Specification for Rail-Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A617	Specification for Axle-Steel Deformed and Plain
ASTM A704	Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM C33	Specification for Concrete Aggregates
ASTM C94	Specification for Ready-Mixed Concrete
ASTM C150	Specification for Portland Cement
ASTM C171	Specification for Sheet Materials for Curing Concrete
ASTM C260	Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Specification for Liquid Membrane-Forming Compounds
ASTM C494	Specification for Chemical Admixtures for Concrete
ASTM C595	Specification for Blended Hydraulic Cements
ASTM D1751	Specification for Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Non-extruding and Resilient Bituminous Types)
ASTM D1752	Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction
AASHTO M254	Specification for Coated Dowel Bars