



SECTION 502

PORTLAND CEMENT CONCRETE PAVEMENT

502.1 Description. This work shall consist of a pavement composed of portland cement concrete, with or without reinforcement as specified, constructed on a prepared subgrade in accordance with these specifications and in conformity with the lines, grades, thicknesses and typical cross sections shown on the plans or established by the engineer.

502.2 Material. All material shall conform to Division 1000, Materials Details, and specifically as follows:

Item	Section
Steel Wire Fabric for Concrete Pavement	1036.2
Concrete Curing Material	1055
Material for Joints	1057.1

All material, proportioning, air-entrainment, mixing, slump and transporting for portland cement concrete shall be in accordance with [Sec 501](#).

502.3 Equipment. Equipment and tools necessary for handling material and performing all parts of the work shall be satisfactory to the engineer as to design, capacity and mechanical condition. The equipment shall be at the job site sufficiently ahead of the start of construction operations to be examined thoroughly by the engineer and shall comply with the following requirements.

502.3.1 Batching Plant and Mixer. The mixer, water measuring equipment and weighing (mass determination) and batching equipment shall conform to the requirements of [Sec 501](#).

502.3.2 Hauling. Trucks for transporting mixed concrete shall meet the requirements of [Sec 501](#). Consideration will be given for the use of an approved type of non-agitating equipment for transporting central mixed concrete provided the discharge of the concrete is completed within 30 minutes after the introduction of the mixing water to the cement and aggregates. Bodies of non-agitating hauling equipment shall be smooth, mortar-tight metal containers capable of discharging the concrete at a satisfactory, controlled rate without segregation.

502.3.3 Forms. Side forms, except as otherwise permitted, shall be of metal, with a base width sufficient to support the finishing equipment to be used. The height shall be equal to the edge thickness of the pavement. Each form section shall be straight and free from bends and warps. No section shall show a variation greater than 1/8 inch (3 mm) in 10 feet (3 m) from the true plane surface on the top, and 1/4 inch (6 mm) in 10 feet (3 m) along the face of the form. The method of connecting form sections shall ensure a tight, neat joint. Forms shall be clean and coated with a form release agent before concrete placement.

502.3.3.1 Forms for curved form lines shall comply with the grade and alignment requirements of [Sec 502.5.1](#), except that straight steel form sections 10 feet (3 m) or less in length may be used for form lines having a radius greater than 200 feet (60 m). Special forms of wood or steel will be permitted for curved form lines having a radius of 200 feet (60 m) or less, and may be permitted if approved by the engineer in other special cases where it is not

practicable to use standard pavement forms. Straight steel form sections 5 feet (1.5 m) long will be acceptable for curved form lines having a radius of not less than 100 feet (30 m). Forms shall be of sufficient rigidity to prevent distortion in edge alignment due to pressure of the concrete. Wood forms shall not be used as a track for operating paving and finishing equipment.

502.3.4 Vibrators. Vibrators used for full width vibration of the concrete shall be of the internal type. They shall not come in contact with the reinforcement, load transfer devices, subgrade or side forms. Vibrating equipment shall be operated in accordance with the manufacturer's recommendation at a frequency to provide satisfactory results, but shall not be less than 4500 impulses per minute. Hand vibrators shall have a frequency of not less than 4500 impulses per minute. The contractor shall have a satisfactory tachometer available at all times for checking the vibration frequency.

502.3.5 Surface Finishing Equipment.

502.3.5.1 Wire Comb. A wire comb shall not be less than 10 feet (3 m) long with a single line of wires exposed to a length of approximately 4 inches (100 mm). The wire shall be blue tempered and polished spring steel with nominal dimensions of 0.028 inch (0.71 mm) thick and 0.100 to 0.125 inch (2.54 to 3.175 mm) wide. The wires shall be spaced to provide 1/2 inch (13 mm) clear space between wires and securely mounted in a rigid head with the width of each wire parallel to the longitudinal centerline of the head. Except for pavements finished by hand methods, the wire comb shall be mechanically operated with the length of the comb parallel to the pavement centerline and capable of traversing the full width of pavement in a single pass, at a uniform speed and at a uniform depth. Final approval of the wire comb will be based on satisfactory performance during actual use. Texturing equipment, other than a wire comb, may be approved provided it produces a texture equivalent to that produced by a wire comb and upon satisfactory performance during actual use.

502.3.5.2 Fabric Drag. If the contract specifies concrete to be tinted, a fabric drag consisting of a seamless strip of burlap or cotton of not less than the width of the pavement shall be provided. To obtain a satisfactory finish, it may be necessary to ravel out the cross threads of the trailing 2 or 3 inches (50 or 75 mm) of the drag. Brooms of an approved type may be provided in lieu of the fabric drag. The brooms shall not be less than 18 inches (450 mm) wide, made from good quality bass or bassine fiber not more than 5 inches (125 mm) long.

502.3.6 Concrete Saw. If sawed joints are required, equipment shall be provided complete with either an abrasive wheel or a diamond-edge water-cooled blade, capable of providing a groove of the specified dimensions in the hardened concrete.

502.3.7 Equipment for Sealing Joints. An approved double boiler-type heating kettle equipped with a mechanical agitator and a satisfactory temperature indicating device will be required. The equipment shall be capable of heating the joint sealing material uniformly without damage.

502.3.8 Auxiliary equipment shall be available at all times as follows:

(a) Two footbridges so designed that they can be readily transported from place to place and which have no part in contact with the pavement.

(b) Long-handled floats, each having a blade at least 3 feet (900 mm) long and 6 inches (150 mm) wide.

(c) Metal dyes with beveled face numerals not less than 3 inches (75 mm) nor more than 5 inches (125 mm) high and thick enough to make an indentation of 1/4 inch (6 mm). A satisfactory dye shall be used for marking the point designated by the station number.

(d) Sufficient burlap, waterproof paper or plastic film for the protection of the pavement in case of rain or breakdown of the curing equipment.

(e) A manually operated long handle wire comb approximately 2 feet (600 mm) wide with wire size and spacing in accordance with the requirements of [Sec 502.3.5.1](#).

502.3.9 Field Laboratory. The contractor shall provide a Type 4 Field Laboratory meeting the requirements of [Sec 601](#). No direct payment will be made for providing the laboratory.

Construction Requirements

502.4 Weather Limitations. Unless otherwise authorized in writing by the engineer, mixing and concreting operations shall be discontinued when a descending ambient temperature away from artificial heat reaches 40 F (5 C) and not resumed until an ascending ambient temperature away from artificial heat reaches 35 F (2 C). If approval has been granted for the contractor to place the concrete while the ambient temperature is at or lower than 40 F (5 C), the contractor shall take precautionary measures to prevent damage by freezing, such as heating mixing water, heating aggregates or applying heat directly to the contents of the mixer. Aggregates shall not be heated higher than 150 F (65 C), and the temperature of the aggregates and mixing water combined shall not be higher than 100 F (40 C), when the cement is added. Unless otherwise authorized, the temperature of the mixed concrete when heating is employed shall not be less than 50 F (10 C) and not more than 80 F (30 C) at the time of placement. Cement or fine aggregate containing lumps or crusts of hardened material or frost shall not be used. Concrete shall not be placed upon a frozen subgrade except with written approval of the engineer.

502.4.1 Protection. All concrete shall be effectively protected from freezing for a period of at least 5 days after it has been placed or until a minimum compressive strength of 3000 pounds per square inch (21 MPa) has been attained. Protection will be required for not more than 10 days. Regardless of precautions taken, the contractor shall assume all risks, and all frozen concrete shall be replaced at the contractor's expense.

502.5 Setting Forms. Forms shall be set so that they rest firmly throughout their length upon the thoroughly compacted subgrade. Any subgrade which is more than 1/2 inch (13 mm) below the established grade at the form line shall be brought to grade for a sufficient width, outside the area required by the pavement, to support the forms adequately, and shall be thoroughly rolled. Any variations, whether below or above grade, shall be brought to true grade.

502.5.1 Paving forms shall be sufficiently supported to avoid displacement during paving operations. Both straight and curved forms shall be supported in such position that the face of the form shall be vertical on tangents and perpendicular to the superelevated section on curves. The top of the form shall not vary more than 1/8 inch (3 mm) from the true grade line during placing, compacting and finishing operations. The form alignment shall not vary more than 1/4 inch (6 mm) from the true alignment.

502.5.2 Forms shall be set ahead of concrete placement a sufficient distance to provide time to check their line and grade and provide continuous paving operation.

502.6 Conditioning of Subgrade. When forms have been securely set to grade, the subgrade shall be brought to proper cross section in accordance with [Sec 209](#). The final checking for

proper crown and elevation of the subgrade shall be performed in the presence of the engineer after all equipment traffic on the subgrade has ceased and as close as is practicable to the area of concrete placement.

502.6.1 Low areas of treated bases shall be filled only with concrete integral with the pavement. No direct payment will be made for the concrete used to fill these low areas.

502.7 Proportioning and Mixing Concrete. Concrete shall be proportioned and mixed by truck or central mixers in accordance with [Sec 501](#). This shall consist of batching all aggregate, cement and water by means of automatic weighing (mass determination) or metering, with all additives dispensed automatically and interlocked with the automatic weighing (mass determination) or metering controls. For central mixed concrete, the mixing cycle shall be timed and interlocked with the weight (mass) batch cycle. The weight (mass determination) setting controls shall be equipped so that they may be locked when directed by the engineer. The automatic batching equipment shall be capable of conversion to manual operation if necessary. Manual operation will not be permitted beyond 24 hours after breakdown in the automatic equipment, except by written approval of the engineer. Where a project includes paving that cannot be performed in a normal sequence, the contractor will be permitted to place up to a maximum of 7000 square yards (5800 m²) using manual batching methods.

502.7.1 For all contracts having a total of not more than 20,000 square yards (16700 m²) of concrete base course and concrete pavement combined, manual batching methods will be permitted.

502.7.2 For all contracts having a total of more than 20,000 square yards (16700 m²) of concrete base course and concrete pavement combined, automatic, fully interlocked batching control approved by the engineer will be required.

502.8 Placing Concrete. The concrete shall be deposited over the entire width of the subgrade between forms in such manner as to prevent segregation and to require as little rehandling as practicable. Mixers used for pavement construction, including truck mixers and trucks used for transporting concrete, will not be permitted to discharge concrete by chute or by dumping directly on the subgrade, prepared base or previously placed concrete except for areas to be hand finished or for isolated pavement lanes less than 2000 feet (600 m) long. Concrete shall be thoroughly vibrated along the forms or sides and along expansion and key type longitudinal joints. Attachments on finishing machines to vibrate the concrete adjacent to forms and longitudinal joints will be permitted provided satisfactory results are attained. Care shall be taken that the vibrator does not penetrate the subgrade or dislodge or move the joints. The vibrating shall be sufficient to produce a smooth pavement edge. Honeycomb in the edge may be cause for rejection of the pavement.

502.9 Strike-off of Concrete and Placement of Reinforcement. Following the placing of the concrete, it shall be struck-off so that when the concrete is properly consolidated and finished, the surface of the pavement will be at the proper elevation and cross section. Reinforced concrete pavement shall be placed in two layers. The entire width of the bottom layer shall be struck-off to such length and depth that the sheet of wire fabric may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall be placed directly upon the concrete, and the top layer of the concrete placed, struck-off and screeded. Any portion of the bottom layer of concrete which has been placed more than 30 minutes without being covered with the top layer shall be removed and replaced with freshly mixed concrete at the contractor's expense.

502.9.1 Tie bars shall be supported in the proper position by chairs driven into the subgrade, or may be placed by approved mechanical methods prior to the consolidation of the concrete after it has been struck-off.

502.9.2 Wire fabric and tie bars shall be free from dirt, oil, paint, grease, loose mill scale and thick rust which could impair bond of the steel with the concrete. Thin, powdery rust need not be removed.

502.10 Final Strike-off, Consolidation and Finishing. Machine finishing by extrusion methods or by vibrating and screeding processes will be required for all pavement except as permitted by [Sec 502.10.7](#). After the final course of the concrete has been placed, it shall be struck-off and thoroughly vibrated until concrete of a uniform and satisfactory density is attained. The surface of the pavement shall be of uniform texture and to the proper grade and typical section. Excessive screeding over a given area shall be avoided. Finishing machines shall be kept in satisfactory repair and adjustment and shall be operated without lift, wobbling, or other variation tending to affect a precision finish. While operating, a roll of concrete shall be maintained in front of the full length of all screeds so that the vibrating and screeding work will be fully effective.

502.10.1 Consolidation. Concrete shall be consolidated by vibrating the mixture promptly following placement. Vibrating tubes shall extend into the concrete the distance necessary to provide adequate consolidation. Vibrators shall be operated only when the machine to which they are attached is moving.

502.10.2 Added Finishing Water. Moisture shall not be applied to the surface of the pavement in any form except for emergency conditions. When emergency conditions exist and it becomes necessary to apply additional moisture to the surface of the pavement in order to complete the final finishing operation, water may be applied but only in the form of a fine pressure spray. Under such conditions, placement of additional concrete on the subgrade shall be discontinued until the emergency conditions cease to exist.

502.10.3 Surface Finish. After surface irregularities have been removed, the concrete shall be given a uniformly roughened surface finish by use of a wire comb or other approved texturing device which produces a texture similar to that produced by a wire comb. Successive passes of the comb or other approved device shall be overlapped the minimum necessary to attain a continuously textured surface. The surface texture produced shall have the characteristics of a texture produced using a wire comb as specified in [Sec 502.3.5.1](#), and which has an average texture depth of approximately 0.125 inch (3 mm). Small or irregular areas, or areas not suitable for machine texturing when adjacent surrounding concrete is ready for texturing, may be textured with a hand operated device producing a textured surface equivalent to that required for machine combing.

502.10.4 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 form line, and on each side of transverse expansion joints and construction joints shall be worked with an edging tool having a radius of approximately 3/8 inch (10 mm). A well-defined and continuous radius having a smooth, dense finish shall be produced. The surface of the pavement shall not be unduly disturbed by tilting of the tool during use. Tool marks on the pavement shall be eliminated by brooming or dragging the surface. In doing this, the rounding of the corner of the pavement 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 side of the joint is higher than the other.

502.10.5 Station Numbers. The contractor shall indent station numbers into all pavement immediately following the final finishing operations and before the concrete takes its final set.

The numbers shall be placed at alternating full stations as ascertained by measurements determined by the engineer. Equations in stationing shall also be marked in the pavement. On undivided pavement, the station numbers shall be on the left side of the pavement with respect to the ascending stationing and shall be on the pavement edge unless an integral curb is involved, in which case the numbers shall be placed on the face of the curb. On divided pavement, station numbers shall be placed on the median side of each pavement. The numbers shall be placed facing the centerline of the pavement, or the centerline of each pavement in the case of divided pavements. The numbers shall be placed on a troweled area of the finished surface. No direct payment will be made for marking station numbers.

502.10.6 Modified Machine Finishing. For isolated pavement lanes over 200 feet (60 m) long but less than 2000 feet (600 m) long, all machine finishing equipment will be required except that a mechanical spreader will not be required. The final surface texture may be applied manually with a wire comb meeting the requirements of [Sec 502.3.8](#).

502.10.7 Hand Finishing. Compacting and finishing pavement by hand methods will be permitted:

(a) For all curves having a form line radius of less than 200 feet (60 m) or where wood forms are used.

(b) For all irregular shaped areas.

(c) For pavement lanes less than 200 (60 m) feet long.

(d) For pavement lanes less than 10 (3 m) feet wide.

(e) For bridge approach and pavement to first expansion joint.

(f) When a breakdown of the mechanical compacting and finishing equipment occurs or in the event of some other emergency. After a breakdown, only material which has already been proportioned and which may become unsatisfactory for use may be finished by hand.

502.10.7.1 Hand finishing shall consist of all operations required under [Sec 502.10](#) except mechanical finishing equipment will not be required. The final surface texture may be applied manually with a wire comb meeting the requirements of [Sec 502.3.8](#).

502.11 Joints. Joints shall be of the specified type and dimensions, and constructed at the locations shown on the plans or as approved by the engineer. Where joints are preformed, the form or joint shall be set and securely fastened to ensure the joint being in the required position when the concrete is finished. Dowels and tie bars in their final position shall be parallel to the subgrade and perpendicular to the line of the joint. Dowel supporting assemblies shall conform to one of the types shown on the plans. The concrete shall be placed so that it will not displace or disarrange the joint installations.

502.11.1 Expansion Joints. Expansion joints shall extend for the full cross section of the concrete pavement. Filler placed prior to the placement of the concrete shall be installed with a removable cap or edging bar to serve as a guide for edging the joint and protection for the filler during the placing and finishing of the concrete. Joints constructed after the placement of concrete shall be sawed full depth and the exposed edges shall be ground to a chamfer of 3/8 inch (10 mm). The filler shall rest snugly on the subgrade from form to form. The joints shall be sealed as specified in [Sec 502.11.4](#). Upon removal of the forms, any struts or fins of concrete extending across the joint shall be removed to the full width of the joint and the full thickness of the pavement.

502.11.2 Construction Joints. Construction joints shall be made at the close of each day's work or when the work is stopped or interrupted for more than 30 minutes. No transverse construction joint shall be constructed within 10 feet (3 m) of an expansion or contraction joint. For transverse contraction joint spacing of 20 feet (6 m) or less, the transverse construction joint shall be located within the normal sequence of contraction joint spacing as shown on the plans. Construction joints shall be constructed perpendicular to the top surface and the centerline of the pavement. Construction joints may be formed with a timber header or may be sawed full depth. The final joint shall conform to the cross section of the pavement. Before paving operations are resumed, all surplus concrete and other refuse shall be removed from the subgrade.

502.11.3 Sawing. Unless otherwise provided, all transverse contraction joints and all Type L longitudinal joints in the pavement shall be sawed with the joint groove cut to the dimensions shown on the plans. If the groove for poured type transverse joints is cut prior to removal of the forms, the groove shall be cut as close as is practicable to the pavement edge, and the resulting crescent shaped plug in the groove, immediately adjacent to the form, will be acceptable. For intersections and irregular pavement, joints shall be sawed at locations as approved by the engineer. Sawing of the joints shall begin as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling. All joints shall be sawed before uncontrolled shrinkage cracking takes place. The sawing of any joint shall be omitted if a crack occurs at or near the joint location prior to the time of sawing. Sawing shall be discontinued when a crack develops ahead of the saw. The engineer reserves the right to have the contractor install preformed type joints on multiple width construction when the use of sawed joints fails to prevent random cracking. Any non-reinforced concrete pavement with random cracking not controlled by dowels or tie bars shall be removed and replaced using dowels or tie bars as appropriate to the nearest controlled joint at the contractor's expense.

502.11.4 Sealing Joints. All sawed contraction joints and sawed or formed expansion joints shall be sealed with joint sealing material before the pavement is opened to any traffic, including construction traffic. Immediately prior to sealing, the joints shall be thoroughly cleaned and dried. The sealing material shall be heated to the pouring temperature recommended by the manufacturer. Any material which has been heated above the maximum safe heating temperature will be rejected. The sealing material shall be installed in such a way as to fill the joint opening uniformly from the bottom to approximately 1/8 inch (3 mm) from the top. Any excess material shall be removed from the pavement surface.

502.11.5 Joint Filler at Railroad Crossings. Bituminous filler for use between railroad crossing approach slabs and the timber crossing shall be an approved commercial bituminous mixture meeting the requirements of [Sec 401.3.8](#). The mixture shall be tamped into a firm and compacted state.

502.12 Curing. Immediately after the finishing operations have been completed and as soon as marring of the concrete will not occur, the entire surface and exposed edges of the newly placed concrete shall be covered and cured in accordance with one of the following methods. The concrete shall not be left exposed for more than 30 minutes between stages of curing or during the curing period.

502.12.1 White Pigmented Membrane. After the free water has left the pavement surface, the entire surface shall be sealed by hand or machine spraying with a uniform application of white pigmented membrane curing material. The contractor shall provide satisfactory equipment to ensure uniform coverage of curing material, without loss, on the pavement at the rate of one gallon for each 150 square feet (0.27 L/m²). If rain falls on the newly coated pavement before the film has dried sufficiently to resist damage, or if the film is damaged in any other way, the contractor will be required to apply additional curing material to the

affected portions. All areas cut by finishing tools subsequent to the application of the curing material shall immediately be given new applications at the rate specified above. If hair-checking develops before the membrane can be applied, the concrete shall be initially cured with wet burlap as specified in [Sec 502.12.3](#) before the membrane is placed.

502.12.2 Waterproofed Paper, Polyethylene Sheeting and Polyethylene-Burlap Sheeting.

As soon as the concrete has set sufficiently to prevent marring, the top surface of the pavement shall be covered with units of waterproofed paper, white polyethylene sheeting or white polyethylene-burlap sheeting, which shall be lapped not less than 18 inches (450 mm). If polyethylene-burlap sheeting is used, the burlap shall be thoroughly dampened prior to placing and shall be placed next to the concrete. All coverings shall be so placed and weighted that they remain in contact with the pavement surface and edges for not less than 72 hours after the concrete has been placed. If hair-checking develops before the covering can be applied, the concrete shall be initially cured with wet burlap as specified in [Sec 502.12.3](#) before the covering is placed.

502.12.3 Burlap. The top surface of the pavement shall be temporarily covered with thoroughly damp burlap after the concrete has set sufficiently to prevent marring of the surface. Burlap shall be handled in such manner that contact with earth or other deleterious substances is avoided. All new or contaminated burlap and all burlap which has been used for purposes other than the curing of concrete shall be thoroughly washed before being used. The burlap shall be kept thoroughly wet until removed for application of the final curing material. Neither the top nor the edge of the pavement shall be left unprotected for more than 30 minutes. When the burlap is removed, curing shall be continued by one of the approved methods.

502.13 Removing Forms. Forms shall be removed carefully so as to avoid damage to the pavement. Honeycombed areas will be considered as defective work and shall be immediately repaired. If the forms are removed prior to 72 hours after placing concrete, the sides of the pavement shall be cured by one of the methods specified above. Any trench excavated for the forms shall be entirely backfilled so no water will stand next to the pavement.

502.14 Surface Test. As soon as practicable, the pavement surface shall be thoroughly tested by profilographing or straightedging as indicated. Testing applicable to this specification, except straightedging, shall be performed by the contractor in the presence of the engineer.

502.14.1 Profilographing. Profilographing is applicable to the surface of all mainline paving, auxiliary lanes, turning lanes and ramps. Specifically excluded are:

- (a) Bridge decks and their approach slabs.
- (b) Pavement on horizontal curves with centerline radius of curve less than 1000 feet (300 m) and pavement within the superelevation transition of such curves.
- (c) Pavement on vertical curves having a "K" value less than 90 and a length less than 500 feet (150 m).
- (d) Contracts or stages of construction with less than one half mile (0.8 kilometers) of continuous concrete pavement.
- (e) Width transitions.
- (f) Fifty feet (15 m) in direction of travel on each side of utility appurtenances such as manholes and valve boxes.

(g) Fifty feet (15 m) in direction of travel on each side of intersecting routes with special grade transition.

(h) Portland cement concrete shoulders.

(i) Any portland cement concrete lane which abuts an existing lane not constructed under the same contract.

502.14.1.1 Pavement profiles shall be taken 3 feet (1 m) from and parallel to each edge of pavement for pavements 11 feet (3.5 m) wide. If pavement is placed at a greater width than 11 feet (3.5 m), the profile shall be taken 3 feet (1 m) from and parallel to each edge and 3 feet (1 m) to one side of each plan longitudinal joint as directed by the engineer.

502.14.1.2 Additional profiles shall be required only to define the limits of an area representing deviations greater than 0.40 inch (10 mm), except as required in [Sec 502.14.6.4](#).

502.14.1.3 A profilogram shall be made for each continuous section of 50 feet (15 m) or more for each days placement. A section is defined where paving begins and terminates at a days work joint, a bridge or other interruption designated by the engineer. Sections will be divided into segments of 0.1 mile (0.1 km) with the exception of the last segment which normally will be less than 0.1 mile (0.1 km).

502.14.1.4 Individual sections shorter than 50 feet (15 m) and the last 15 feet (5 m) of any section where the contractor is not responsible for the adjoining surface, will be straightedged in accordance with [Sec 502.14.2](#).

502.14.1.5 If there is a segment of 250 feet (75 m) or less in length at the end of a section, the profilogram for that segment shall be included in the evaluation of the adjacent segment in that section.

502.14.1.6 If there is an independently placed section of a length between 50 and 250 feet (15 m and 75 m), a profilogram shall be made for that section and included in the evaluation of the most recently placed adjacent segment.

502.14.1.7 The contractor shall furnish the profilogram and its evaluation to the engineer. The testing shall be done by a trained operator in the presence of the engineer. The testing procedure and the evaluation of the profilogram shall be done in accordance with this specification and MoDOT Test Method T59. The profilogram and evaluation shall be furnished to the engineer not later than the end of the next day worked following placement of the pavement and within two days after corrective grinding.

502.14.1.8 The engineer may also test the surface or re-evaluate the profilogram for comparison and assurance purposes. If these tests or re-evaluations indicate the contractor-furnished profilograms are not accurate within 3.0 inches per mile (45 mm/km), the engineer may test the entire project length. If the entire project length is tested, the contractor will be charged for this work at the rate of \$500.00 per lane mile (\$310.00 per lane kilometer). Furnishing inaccurate test results may result in disapproval of the operator.

502.14.1.9 The profilogram line drawn by the profilograph will be referred to as the profile trace in these specifications.

502.14.1.10 A profile index shall be calculated from the profilogram for pavements 50 feet (15 m) or more in length. The profile index is calculated by summing the vertical deviations of the profile trace above or below the dashed reference line on the transparent scale. The units of this measure are inches per mile (mm/km).

502.14.1.11 Bumps shall be separately identified. These appear as high points on the profile trace and correspond to high points or bumps on the pavement surface. They are identified by locating vertical deviations greater than 0.40 inch (10 mm) for a 25-foot (7.622 m) span, as indicated on the profile trace.

502.14.2 Straightedging. As soon as practicable, the engineer will straightedge all segments of the paved surface not profilographed, including shoulder areas between rumble strips, and mark any variations exceeding 1/8 inch in 10 feet (3 mm in 3 m). Areas more than 1/8 inch (3 mm) high shall be removed by an approved device as listed in [Sec 502.14.6.3](#).

502.14.3 Equipment. The profilograph shall be a California type as approved by the engineer. The equipment furnished shall be supported on multiple wheels having no common axle. The wheels shall be arranged in a staggered pattern such that no two wheels cross the same bump at the same time. The pavement profile is recorded from the vertical movement of a sensing wheel attached to the frame at midpoint and is in reference to the mean elevation of the 12 points of contact with the road surface established by the support wheels. The profilogram is recorded with a scale of one inch equals one inch (1 mm equals 1 mm) vertically and one inch equals 25 feet (1 mm equals 300 mm) longitudinally.

502.14.4 Calibration. All profilographs used shall be calibrated at least annually on a test section established by MoDOT. The contractor's calibration profile index shall not vary more than 2.0 inches per mile (30 mm/km) from a standard profile index produced by a MoDOT profilograph.

502.14.4.1 Longitudinal calibration consists of pushing the profilograph over a pre-measured test distance and determining the scale factor by dividing the premeasured test distance by the length of the paper in inches (millimeters). This factor shall be 25 (300), one inch equals 25 feet (25 mm equals 7.622 m). If not, the machine shall be adjusted until the scale factor is 25 (300) plus or minus 0.2 percent.

502.14.4.2 Vertical calibration consists of sliding a pre-measured calibration block, measured to the nearest 0.01 inch (0.25 mm), under the sensing wheel while the profilograph is stationary. The measurement of the vertical trace line from the base line to the peak and return shall be the same as the calibration block. The trace line must return to the base line. No tolerance will be allowed.

502.14.4.3 A profilograph equipped with automatic profile trace reduction capabilities shall be checked by comparing the machine's results with the results obtained by the engineer. This shall be done for the profile trace obtained on the MoDOT test section. The results and the profilogram shall be submitted to the engineer. The results of the comparison may not differ by more than 2.0 inches per mile (30 mm/km).

502.14.4.4 The contractor shall furnish certification that the 25-foot (7.622-meter) profilograph test and evaluation was conducted by an operator trained in the use of profilograph equipment and with sufficient experience to demonstrate the operator's competence.

502.14.5 Test Procedures. Smoothness will be tested by measurement with a profilograph. This device produces a profilogram of the surface tested.

502.14.5.1 All objects and foreign material on the pavement surface, including protective covers, if used, shall be removed by the contractor prior to testing and, if appropriate, protective covers shall be properly replaced by the contractor after testing.

502.14.5.2 The profilograph shall be propelled at walking speed in the paths indicated in [Sec 502.14.1.1](#) for each section of pavement. Propulsion may be provided by personnel pushing manually or by a suitable propulsion unit.

502.14.5.3 A location indicator for lateral placement is mandatory. More than one person may be required to hold the back end of the profilograph exactly in the required path on horizontal curves except as stated in [Sec 502.14.1\(b\)](#).

502.14.5.4 Walking speed shall be decreased if excessive spikes are encountered.

502.14.5.5 The sensing wheel shall be lifted, rotated to take slack out of the linkage, and lowered to the pavement surface at the starting point prior to testing.

502.14.5.6 The actual stationing shall be noted on the profilogram at least every 200 feet (50 m). Station referencing is used to accurately locate deviations greater than 0.40 inch (10 mm).

502.14.5.7 Both ends of the profilogram shall be labeled with the stationing, lane designation, position on the pavement and the direction the pavement was placed. A report form furnished by the engineer shall be completed and placed with the profilogram.

502.14.5.8 When operating the profilograph, all wheels shall be on the new pavement for which the contractor is responsible.

502.14.6 Surface Corrections. Bump correction or smoothness correction or both may be required.

502.14.6.1 If an average profile index of 45.0 inches per mile (711 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or 65.0 inches per mile (1026 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, is exceeded in any daily paving operation, the paving operation will be suspended and will not be allowed to resume until corrective action approved by the engineer is taken by the contractor.

502.14.6.2 All bumps greater than 0.40 inch (10 mm) in height over a 25-foot (7.622-meter) span, as indicated on the profile trace, shall be corrected. The corrected bumps will be considered satisfactory when measurements by the profilograph show that the bumps are 0.40 inch (10 mm) or less in height over a 25-foot (7.622-meter) span.

502.14.6.3 Corrective action to improve the average profile index shall be accomplished by longitudinally diamond grinding or by use of an approved device designed for that purpose. The device shall be designed to improve the profile of the riding surface. The use of a bush hammer or other impact device will not be permitted.

502.14.6.4 After removing all individual deviations greater than 0.40 inch (10 mm) in height, additional correction shall be performed if necessary to reduce the average profile index to 30.0 inches (474 mm) or less per mile (kilometer) for pavements having a final posted speed greater than 45 mph (70 km/h), or 45.0 inches (711 mm) or less per mile (kilometer) for pavements having a final posted speed of 45 mph (70 km/h) or less. All corrective work shall be completed prior to determination of pavement thickness. On pavement segments where corrections are necessary, additional profiles shall be made to verify that the corrections have produced an average profile index within the limits noted above.

502.14.6.5 If the initial average profile index of any segment is less than 30.1 inches per mile (475 mm/km) for pavements having a final posted speed greater than 45 mph (70 km/h), or

less than 45.1 inches per mile (712 mm/km) for pavements having a final posted speed of 45 mph (70 km/h) or less, only the areas with deviations greater than 0.40 inch (10 mm) in height shall be retested for correction verification.

502.14.6.6 The final surface of the corrected concrete pavement shall be such that the texture is comparable to adjacent sections that do not require correcting. Satisfactory longitudinal grinding is acceptable as the final surface of the corrected pavements.

502.15 Opening to Traffic. The concrete pavement shall not be opened for light traffic until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3000 pounds per square inch (21 MPa). The pavement shall not be opened to all types of traffic until the concrete is at least 72 hours old and has attained a minimum compressive strength of 3500 pounds per square inch (24 MPa). If high early strength concrete is used, the pavement may be opened to all types of traffic when the concrete has attained a minimum compressive strength of 3500 pounds per square inch (24 MPa). Compressive strength will be determined by tests made in accordance with MoDOT methods. Pavement shall be cleaned prior to opening to traffic.

502.16 Slip-Form Construction. At the option of the contractor, pavement may be constructed by the use of sliding form methods. All applicable provisions of [Sec 502](#) shall be followed. In addition, the following provisions shall apply.

502.16.1 Subgrade and Base. If an aggregate base course is specified for the pavement, it shall be constructed in accordance with the requirements of [Sec 304](#) and the slip-form paver shall operate on the aggregate base. After the grade or base has been placed and compacted to the specified density, the areas which will support the paving machine and the area upon which the pavement is to be placed shall be cut to the proper elevation by means of an approved machine.

502.16.2 Placing Concrete. A self-propelled concrete spreader equipped with a power-driven device for spreading the concrete uniformly across the subgrade transversely shall be used to place the concrete. The spreader shall also be equipped with an adjustable strike-off blade capable of striking off the surface of the concrete in the longitudinal direction of the pavement at any required elevation. For isolated pavement lanes over 200 feet (60 m) long but less than 2000 feet (600 m) long, a mechanical spreader will not be required.

502.16.3 Consolidating and Finishing Equipment. The concrete shall be consolidated and finished by a slip-form paver designed to spread, consolidate and shape the concrete in one complete pass of the machine in such a manner to provide a smooth, dense and homogeneous pavement in conformance with the plans and specifications. Hand finishing is discouraged. The slip-form paver shall be fully energized, self-propelled and crawler mounted. It shall be of sufficient weight (mass) and power to construct the maximum specified concrete paving lane width as shown on the plans at an adequate forward speed, and without transverse, longitudinal or vertical instability or displacement. The slip-form paver shall produce a surface reasonably free of surface voids and tears. The machine shall satisfactorily vibrate the concrete for the full width and depth of the pavement being placed. No apparent slumping of the concrete shall occur 6 inches (150 mm) or more in from the pavement edge. All operations of mixing, delivering and spreading concrete shall be so coordinated as to provide uniform progress with stopping and starting of the paver held to a minimum. If it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately.

502.16.4 Forms. Forms shall be used where necessary to produce a pavement of plan section and shall incorporate a keyway where required.

502.16.4.1 Longitudinal tongue and groove joints of the specified type and size shall be constructed at locations shown on the plans or approved by the engineer. The groove side of the joint shall be slip-formed or formed with approved metal forms that will produce a keyway conforming to plan location and dimensions. The form shall remain in place for sufficient time to prevent slump. Metal forms may be left in place if approved by the engineer. The tongue side of the joint may be constructed without forms provided the plan section of the pavement and joint is maintained.

502.16.4.2 Where tie bars are required at longitudinal construction joints, a tongue and groove type joint shall be constructed and the tie bars shall be installed in the groove side of the joint. The bars shall be positioned before pavement consolidation.

502.16.5 Protection Against Rain. To protect against the effects of rain, the contractor shall have on location at all times material for the protection of the edges and surface of the unhardened concrete. It is the contractor's responsibility to protect the pavement from damage due to rain. Failure to properly protect unhardened concrete may constitute cause for the removal and replacement of defective pavement at the contractor's expense.

502.17 Tolerance in Pavement Thickness. It is the intent of these specifications that pavement shall be constructed strictly in accordance with the thickness shown on the plans. The thickness of the pavement will be measured, and where any pavement is found deficient in thickness, deductions for or removal of thin pavement will be made in accordance to [Sec 502.19](#).

502.17.1 Metal plates will be placed on the subgrade at points selected by the engineer in areas where the planer has cut or leveled off the subgrade or at any points where conditions are conducive to deficient pavement thickness. When the surface of the pavement has been finished to final grade, the engineer will, for informational purposes, check the thickness of the completed pavement by measuring the distance from the surface of the pavement to the metal plates by use of a calibrated rod. The surface of the pavement shall be satisfactorily restored by the contractor after thickness measurements have been made. The contractor shall, if necessary, furnish a bridge to facilitate the taking of the measurements. The engineer reserves the right to core drill the finished pavement to determine the thickness of the pavement. Cores may be drilled at the same locations as rod measurements or at any other locations. The contractor may require check cores to verify thicknesses determined by the engineer, and all costs of check core drilling shall be borne by the contractor. If the check cores requested by the contractor indicate that the engineer's measurement would have erroneously resulted in deductions for, or removal of, thin pavement, the cost of drilling the check cores will not be charged to the contractor.

502.17.2 The thickness of the pavement will be determined by average caliper measurement of cores in accordance with the procedure established by the Commission.

502.17.3 For the purpose of determining the constructed thickness of the pavement, cores will be taken at random intervals in each traffic lane at the rate of 1 core per 1000 feet (300 m) or increment thereof. In addition, cores will be taken at all locations where thickness measurements taken during construction indicate a thickness deficiency sufficient to justify a deduction from the contract unit price, or at any other locations as may be determined by the engineer. If the measurement of any core is deficient in excess of 2/10 inch (5 mm) from the plan thickness, additional cores will be taken at 30-foot (10 m) intervals parallel to centerline ahead and back of the affected location until the extent of the deficiency has been determined.

502.17.4 It will be assumed that each core is representative of the pavement thickness for a distance extending one-half the distance to the next core, measured along centerline, or in the case of a beginning or ending core, the distance will extend to the end of the pavement section.

502.17.5 The drilling of cores in irregular areas, or on projects involving less than 2500 square yards (2000 m²) of concrete pavement, may be waived by the engineer. In this case the designed thickness will be considered as the measured thickness.

502.17.6 Cores may be waived by the engineer for full depth concrete shoulders if satisfactory rod measurements are obtained. If coring of full depth concrete shoulders is performed, any treatment for deficiencies will be the same as for pavement.

502.18 Method of Measurement. Pavement areas will be computed to the nearest 1/10 square yard (0.1 m²). Final measurement of the completed pavement will not be made except for authorized changes during construction, or where appreciable errors are found in the contract quantity. The revision or correction will be computed and added to or deducted from the contract quantity.

502.19 Basis of Payment.

502.19.1 Pavement thickness determination will be made after all smoothness correction has been completed. If any core measurement of thickness is deficient, the contractor shall have the option of removing and replacing the pavement at the contractor's expense or of leaving the pavement in place and receiving the following deductions in payment.

Deficiency in Thickness	Deductions, Percent of Contract Unit Price
0 to 2/10 inch (5 mm)	None
Over 2/10 inch (5 mm) and not over 4/10 inch (10 mm)	15
Over 4/10 inch (10 mm) and not over 6/10 inch (15 mm)	60
Over 6/10 inch (15 mm)	100

The above deductions will be applied to a section of pavement 30 feet (9 m) long and extending from the edge of the pavement to a longitudinal joint or between longitudinal joints in that section of pavement in which the deficient measurement was found. Deductions for deficient thickness or damaged pavement may be entered on any estimate after the information becomes available.

502.19.2 If pavement which is deficient in thickness in excess of 6/10 inch (15 mm) may, in the judgment of the engineer, seriously impair traffic service of the pavement, the contractor will be required to remove the pavement and to replace it with one of a satisfactory quality and thickness which, when accepted, will be included in the pay quantity. No payment will be made for any costs incurred in the removal of the pavement deficient in thickness. If, in the judgment of the engineer, there is no probability of immediate failure, the engineer may allow the contractor the choice of leaving the deficient pavement in place and receiving no payment or of removing and replacing the pavement as provided herein.

502.19.3 In removing pavement, it shall be removed from the edge to a longitudinal joint, or between longitudinal joints, and on each side of the deficient measurement until no portion of the exposed cross sections is more than 2/10 inch (5 mm) deficient, except that there shall not be less than 15 linear feet (4.5 m) of pavement removed. If there remains less than 15 feet (4.5 m) of acceptable pavement between the section that has been removed and a transverse contraction, expansion or construction joint, the contractor shall remove the pavement to the joint.

502.19.4 For marred surface areas or slightly damaged concrete that remains in the completed pavement, a minimum deduction of 20 percent of the contract unit price will be made for the areas affected. The deduction will be applied to a section of pavement extending from edge of

the pavement to a longitudinal joint or between longitudinal joints in that section of pavement affected. If the length of the section affected is less than 10 feet (3 m), the deduction will be computed for 10 feet (3 m). Areas corrected for smoothness will not be considered marred surfaces.

502.19.5 Payment for smoothness shall be based on either Table I or Table II. Table I shall be used for pavements having a final posted speed greater than 45 mph (70 km/h). Table II shall be used for pavements having a final posted speed of 45 mph (70 km/h) or less and for pavements with no posted speed limits. Constant width acceleration and deceleration lanes shall be considered as mainline pavements.

Final Profile Index, Inches Per Mile (mm/km)		Percent of Contract Price
Table I	Table II	
10.0 (158) or less		107
10.1 - 15.0 (159 - 237)	15.0 (237) or less	105
15.1 - 18.0 (238 - 284)	15.1 - 25.0 (238 - 395)	103
18.1 - 30.0 (285 - 474)	25.1 - 45.0 (396 - 711)	100
30.1 - 45.0 (475 - 711)	45.1 - 65.0 (712 - 1026)	95*
45.1 (712) or greater	65.1 (1027) or greater	93*

*Correction required.

502.19.5.1 Smoothness incentive will be paid per section based on the profile index before bump correction. Within a section qualifying for incentive pay, any segment having a profile index requiring a reduction in contract price will not be included in incentive payment for that section.

502.19.5.2 Segments with a profile index of 30.1 (475) or greater (Table I), or 45.1 (712) or greater (Table II), after bump correction, shall be corrected as specified in [Sec 502.14.6](#) until the profile index is 30.0 (474) or less (Table I), or 45.0 (711) or less (Table II), or at the contractor's option, the segment may be removed and replaced with no additional payment. Under Table I, those segments with a profile index of greater than 30.0 (474) and less than 45.1 (712) after bump correction will receive 100 percent of contract price when reduced to 30.0 (474) or less, and those segments with a profile index of 45.1 (712) or greater before bump correction will receive 93 percent when reduced to 30.0 (474) or less. Under Table II, those segments with a profile index of greater than 45.0 (711) and less than 65.1 (1027) after bump correction will receive 100 percent of contract price when reduced to 45.0 (711) or less, and those segments with a profile index of 65.1 (1027) or greater before bump correction will receive 93 percent when reduced to 45.0 (711) or less.

502.19.5.3 On sections where corrections are made, the pavement will be tested by the contractor to verify that corrections have produced a profile index of 30.0 (474) or less (Table I), or 45.0 (711) or less (Table II).

502.19.5.4 The contractor will not be allowed to make corrective grinding to increase the percent of pay when the final profile index is 30.0 (474) or less (Table I), or 45.0 (711) or less (Table II).

502.19.6 If the profile index, after bump correction, is 30.1 (475) or greater (Table I), or 45.1 (712) or greater (Table II), and the contractor elects to remove and replace the segment, the contractor will be paid the percent of contract price that corresponds to the replaced segment's profile index as specified above.

502.19.7 The contract unit price for portland cement concrete pavement will be considered as full compensation for all material, including reinforcement, dowels, dowel supports, tie bars and any other items entering into the construction of the traveled way pavement or portland cement concrete shoulders, and for the cost of smoothness testing. No additional compensation will be allowed for any excess thickness.

502.19.8 The accepted quantities of portland cement concrete pavement will be paid for at the contract unit price with proper allowance made for any deductions for deficiency in thickness, smoothness or marred surface.

502.19.9 When paving widths are greater than the travel lane widths, profiling and payment for profiling will apply to the traffic lane design driving width only, normally 12 feet (3.6 m). Random lane coring for thickness or required lane replacement will include the full paved lane width to the longitudinal joints or edge of shoulder, whichever is first.