450 RIGID PAVEMENT

ITEM 451 REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT

451.01 Description. This work consists of constructing a pavement composed of reinforced portland cement concrete on a prepared surface.

451.02 Materials. Furnish materials conforming to:

Concrete, Class C	499
Joint sealer	705.04
Preformed filler	705.03
Curing materials	705.05, 705.06, 705.07 Type 2
Tiebar steel, epoxy coated	709.00
Reinforcing steel	709.09, 709.10, 709.12
Dowel bars and basket assemblies	709.13

451.03 Equipment. Furnish self-propelled spreading and finishing machines capable of consolidating and finishing the concrete and producing a finished surface meeting the requirements specified.

Construct pavement using either fixed forms or slip form paving equipment that conforms to the following:

A. Fixed Form Construction. Spread, screed, and consolidate concrete using one or more machines between previously set side forms. Furnish an adequate number and capacity of machines to perform the work at a rate equal to the concrete delivery rate. Furnish machines capable of uniformly distributing and consolidating the concrete without segregation.

Provide machines capable of operating on two side forms, on adjacent lanes of pavement and one side form or on two adjacent lanes as necessary. When placing concrete adjacent to an existing pavement lane, take measures to protect the adjacent pavement from damage. Remove from the work any machine that causes displacement of the side forms from the line or grade or causes undue delay, as determined by the Engineer, due to mechanical difficulties.

Finish small or irregular areas that are inaccessible to finishing equipment using other methods as approved by the Engineer. Accomplish vibration of these areas using hand held or machine mounted internal vibrators. Continue vibration to achieve adequate consolidation, without segregation, for the full depth and width of the area placed.

Use straight edge side forms made of steel and of a depth equal to the specified pavement thickness. Do not use bent or damaged side forms or forms with damaged joint locks or pin pockets. Clean and oil all forms each time they are used. Provide forms in sections not less than 10 feet (3 m) in length, with horizontal joint and base width equal to the depth of the forms. If the radius of the circular pavement edge is 100 feet (30 m) or less, use flexible or curved forms of a design acceptable to the Engineer. Provide adequate devices to securely set forms and withstand operation of the paving equipment. Do not use built-up forms except to construct pavement of a specified thickness whose total area for the project is less than 2000 square yards (1650 m^2). Provide forms with adequate joint locks to tightly join ends of abutting form sections together.

B. Slip Form Construction. Place concrete using a slip form paver or combination of pavers designed to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine and with a minimum of hand finishing to provide a dense and homogeneous pavement.

Consolidate the full width and depth of concrete pavement placed by a single pass of a series of approved internal vibrators operating at a frequency range of 7000 to 11,000 impulses per minute. Attach vibrators to either the spreading or finishing equipment in such a manner that they do not come in contact with preset dowel basket assemblies, the subgrade, reinforcing mesh or side forms. Do not operate vibrators in a manner to cause a separation of the mix ingredients (segregation); i.e., either a downward displacement of large aggregate particles or an accumulation of laitance on the surface of the concrete. Avoidance of segregation of the concrete mix may require reduction in the vibration frequency within the range specified when forward motion of the paver is reduced. Connect the power to all vibrators so that they cease when the machine motion is stopped. Stop paving operations if any vibrator fails to operate within the above specified range.

Provide an electronic monitoring device that displays the operating frequency of each internal vibrator on all paving machines used on mainline and ramp paving. The monitoring device shall have a readout display near the paver operator's controls that is visible to the operator and the Engineer. Operate the monitoring device continuously while paving and display all vibrator frequencies with manual or automatic sequencing among individual vibrators. Using the monitoring system record the following minimum information: time of day, station location, paver track speed, and the frequency of each individual vibrator. Make recordings after each 25 feet (8 m) of

paving or after 5-minute intervals of time. If not using a monitoring system with a recorder, make and record readings every 30 minutes. If requested by the Engineer, provide a record of the data.

Electronic vibration monitoring devices are not required for paving machines used to construct shoulders and gores or for any construction project with a total of less than 10,000 square yards (8000 m^2) of pavement. When electronic monitoring devices are not required, use a tachometer or similar device to demonstrate to the Engineer the paving equipment vibration meets specification.

Operate the slip form paver with as nearly a continuous forward movement as possible, and coordinate all operations of mixing, delivering, and spreading concrete to provide uniform progress with minimal stopping and starting of the paver. If for any reason it is necessary to stop the forward movement of the paver, immediately stop the tamping elements. Unless controlled from the machine, do not apply any other tractive force to the machine.

Accurately control the finish grade of the pavement from a pre-set grade line parallel to the finish grade using equipment with controls that will trace the grade line and automatically adjust the grade of the screeds or extension meters.

In areas where adjoining concrete pavement is to be constructed, ensure that the surface at the edge of the pavement on either side of the longitudinal joint does not vary more than 1/4 inch (6 mm) below the typical section. Ensure that the outside edges of the pavement does not vary more than 1/2 inch (13 mm) below the typical section. Ensure that all pavement edges are nearly vertical with no projections or keyways exceeding 1/2 inch (13 mm).

In the area of construction joints placed at the end of the days run, the Engineer will allow a reduction of approximately 2 inches (50 mm) in overall width.

451.04 Setting Forms. Set all forms in conformance to the required grade and alignment and support the entire length of forms on thoroughly compacted material during the entire operation of placing and finishing of the concrete. Set side forms with the top face of the form varying not more than 1/8 inch in 10 feet (3 mm in 3 m) from true plane, and the vertical face varying not more than 1/4 inch in 10 feet (6 mm in 3 m) from true plane. Test the forms for variations from the above requirements and reset the forms as necessary. Do not use loose earth, pebbles, etc., to shim the forms. Immediately before placing concrete, the Engineer will approve the alignment and grade of all forms set.

451.05 Fine Grading of Subgrade or Subbase.

A. Fixed Form Construction. After side forms have been set to line and grade and securely fastened, use a subbase or subgrade planer to remove a slight amount of material and bring the subgrade or subbase to final grade and to a smooth dense condition. Check the subgrade or subbase using a multiple pin template operated on the forms or other methods approved by the Engineer. Correct and retest all high or low spots.

Instead of the above operation, the Contractor may place forms on subbase or subgrade prepared according to 451.05.B.

B. Slip Form Construction. After the subgrade or base is placed and compacted to the required density, use an automatic subgrading machine to cut the areas for pavement and the areas that will support the paving machine to the plan elevation. Construct the grade sufficiently in advance of placing the concrete to permit the Engineer to check the grade.

451.06 Placing Concrete. When constructing on subbase or subgrade, immediately before placing concrete, bring the subgrade or subbase to a thoroughly moistened condition by sprinkling with water at such times and in such manner as directed by the Engineer.

When constructing on asphalt concrete, coat the asphalt concrete with curing membrane at least one day prior to placing concrete. Apply the curing membrane at a minimum rate of 1 gallon (1 L) for each 150 square feet (3.7 m^2) of surface treated using an approved self-propelled mechanical sprayer. Provide an adequate shield to protect the fog spray from the wind. Thoroughly agitate the curing material before use.

Deposit concrete on the grade in a manner that requires as little rehandling as possible. Do not allow workers to walk in the freshly mixed concrete unless wearing clean boots or shoes free of earth or any foreign material.

At expansion and contraction joints, deposit concrete near the joints to ensure the dowel basket assemblies are not disturbed. Do not allow concrete to discharge onto any dowel basket assembly unless the hopper is well centered on the assembly. Use a separate internal vibrator to consolidate concrete around dowel basket assemblies.

Provided the curing compound damage caused by sawing is repaired according to 451.10 and to the Engineer's satisfaction, the Contractor may operate the sawing equipment necessary to saw joints on the newly constructed pavement. Do not operate other mechanical equipment upon existing lane of pavement for seven days or until test cylinders attain a split tensile strength of 450 pounds per square inch (3.1 MPa), as tested per ASTM C496. If only finishing equipment is carried on an existing lane, paving may be permitted after that lane has been in place for at least 3 days and after test cylinders have attained a split tensile strength of 350 pounds per square inch (2.4 MPa), as tested per ASTM C496.

When the width of pavement being placed in one operation is 12 feet (3.6 m) or more and the total area of any given width of pavement on the project exceeds 10,000 square yards (8300 m^2) and at the direction of the Engineer, use a separate standard manufacture, self-propelled concrete placer/spreader that receives concrete into a hopper adjacent to the area to be paved and delivers the concrete in front of the slipform paver and uniformly spreads the concrete at the proper thickness for the full width being paved. When a slipform paver is equipped with a dowel bar inserter the separate placer/spreader requirement may be waived provided the concrete is delivered in front of the slipform paver at a consistent and uniform thickness for the full width being paved and the slipform paver is capable of spreading, consolidating, screeding, and float finishing the freshly placed concrete. Provide the Engineer documentation that the slipform paver will meet this specification.

Do not mix, place, or finish concrete after dark without operating an adequate and approved lighting system.

When the air temperature is 35 °F (2 °C) or below, assure the concrete has a temperature of between 50 and 80 °F (10 and 27 °C) at the point of placement.

When the air temperature is greater than 35 °F (2 °C) before placing, maintain a concrete temperature of not more than 90 °F (32 °C).

Do not place concrete on any surface that is frozen or has frost.

Make one set of 4 test cylinders for each 100 cubic yards (76 m^3) for miscellaneous concrete including but not limited to walls, curbs, and steps, and 250 cubic yards (191 m^3) for residential and arterial bases and pavements.

451.061 Depositing and Curing Concrete During Cold Weather. When an atmospheric temperature of 35° F (1.6º C) or less exists at the time concrete is placed, or is predicted by weather forecasts to occur during the curing period, the following procedures shall apply:

1. Heat the water or aggregate or both as necessary to make the temperature of the concrete not less than 50° F (10º C) nor more than 80° F (27ºC) when placed.
2. Once placed, cover the entire surface of the top and the sides of the newly placed concrete and protect from freezing for seven days, unless beam specimens have attained the required minimum strength specified. Accomplish protection as directed in Item 511.12 with insulated blankets or with a combination of loose straw 12 inches (0.3 m) thick covered with a securely fastened exterior cover of waterproof material.
3. During the initial 24 hours of protection for base concrete only (Item 305 and 306), the Contractor may use a layer of waterproof material provided the atmospheric temperature is not expected to fall below 25° F (-4ºC) and is expected to rise above 35° F (2º C) during that period. If the temperature falls below 25° F (-4º C) in the initial 24 hours, use full protection as described above.
4. Cure the concrete by maintaining the surface temperature between 50° F (10º C) and 100° F (37 º C) for a period of not less than 5 days, except as modified below for concrete flooded with water. At the end of this curing period, reduce the temperature at a rate not to exceed 20° F (11ºC) in 24 hours until it is within 20° F (11º C) at atmospheric temperatures.
5. If High-Early Strength concrete is desired and approved for the placement, the Contractor may use, at no expense to the City, additional cement in combination with calcium chloride in lieu of High-Early Strength Cement, Type III.
6. Furnish and install sufficient thermometers in such a manner that the surface temperature of the concrete may be readily determined. The Engineer will read and record the thermometers.

451.07 Placing Reinforcement. Place pavement mesh of the size and at the locations within the concrete slab shown on the standard construction drawings. When placing reinforced concrete pavement in two layers, strike off the entire width of the bottom layer to a length and depth that allows laying the mat of reinforcement on the

concrete and in its final position without further manipulation. After installing reinforcement directly upon the concrete, place, strike off, and screed the top layer of concrete. When reinforced concrete pavement is placed in one layer and in advance of placing concrete, position and securely anchor the reinforcement to the underlying base or pavement. As an alternative, after spreading the concrete and while it is in a plastic condition, use mechanical or vibratory means to place reinforcement in the concrete.

Where reinforcement is overlapped, securely fasten mats of reinforcement together at the edges of the sheets and at two additional points along the lap. Use reinforcing steel free from dirt, oil, paint, and grease.

451.08 Joints. Unless otherwise directed, construct all transverse joints normal to the centerline of the pavement lane and of the type, dimensions, and at locations specified.

Determine contraction and longitudinal joint sawing time limits to protect the concrete from early cracking.

A. Longitudinal Joint. Construct longitudinal joints between simultaneously placed lanes by sawing.

When a standard (water cooled diamond bladed) concrete saw is used to make the longitudinal joint between simultaneously placed lanes, saw the joint within three (3) days of placing pavement. For pavement less than or equal to 10 inches (255 mm), saw the joint to a minimum depth of one-fourth the specified pavement thickness. For pavements greater than 10 inches (255 mm) thick, saw the joint to a minimum depth of one-third the specified pavement thickness. Saw joints 1/4 ± 1/16 inch (6 ± 1.6 mm) wide measured at the time of sawing.

When using early-entry (dry cut, light weight) saws to make the longitudinal joint between simultaneously placed lanes, only use saw blades and skid plates as recommended by the saw manufacturer for the coarse aggregate type being used in the concrete. Perform the early entry sawing after initial set and before final set. Saw the joint 1/8 inch (3 mm) wide and 2 1/4 to 2 1/2 inches (56 to 63 mm) deep.

Place deformed epoxy coated steel tiebars or the epoxy coated hook bolt alternate (wiggle bolt) with epoxy coated coupling, in longitudinal joints during consolidation of the concrete. Install them at mid-depth in the slab by approved mechanical equipment. As an alternate procedure, rigidly secure them on chairs or other approved supports to prevent displacement. Provide tie bars or wiggle bolts of the size and spaced as shown on the standard construction drawings. If used, securely fasten hook bolts or wiggle bolts with couplings to the form at the longitudinal construction joint as shown on the Standard Drawings.

B. Load Transfer Devices. For all transverse joints, install round, straight, smooth, steel dowel bars of the size shown in Table 451.08-1.

TABLE 451.08-1 DOWEL SIZE

Thickness of Pavement (T)	Diameter of Steel Dowel
Less than 8 1/2 inches (215 mm)	1 inch (25 mm)
8 1/2 to 10 inches (215 to 255 mm)	1 1/4 inches (32 mm)
Over 10 inches (255 mm)	1 1/2 inches (38 mm) or as shown on the plans

Use dowel basket assemblies conforming to the standard drawings to hold the dowels in a position parallel to the surface and centerline of the slab at mid-depth of the slab thickness.

Preset all dowel basket assemblies before the day's paving unless the Engineer determines complete presetting is impractical.

Completely install dowel basket assemblies before shipping and spacer wires are removed.

Within 2 hours prior to placing concrete around the dowels, coat the full length of all preset dowels with a thin uniform coat of new light form oil as a bond-breaking material.

Immediately before paving, remove all shipping and spacer wires from the dowel basket assemblies; check the dowel basket assemblies are held firmly in place; check the dowels are parallel to the grade and parallel to centerline of pavement.

The Contractor may place dowels in the full thickness of pavement by a mechanical device (dowel bar inserter) approved by the Engineer. Immediately before inserting the dowels, coat the dowels with a thin uniform coat of new light form oil as a bond-breaking material.

When using a dowel bar inserter, initially demonstrate that the inserted dowel bars in the completed concrete pavement are parallel to the surface and centerline of the slab and are located at mid depth of the slab thickness. On each production day, re-demonstrate to the Engineer inserted dowel bars in the completed pavement are being installed parallel to the surface and centerline of the slab at mid depth of the slab thickness.

For each joint assembly used to hold dowels in position, provide a continuous assembly between longitudinal joints or between the longitudinal joint and pavement edge. Drive at least eight 1/2-inch (13 mm) diameter steel pins a minimum of 18 inches (460 mm) long at an angle to brace the assembly from lateral and vertical displacements during the placing of concrete. Drive two of these pins opposite each other at each end of the assembly, and drive the remaining pins in staggered positions on each side of the assembly. Where it is impractical to use the 18-inch (460 mm) length pins, such as where hardpan or rock is encountered, and provided the assembly is held firmly, the Engineer may authorize use of shorter pins. Where the dowel basket assembly is placed on granular material that may allow settlement or distortion, anchor the assembly with a combination of pins and steel plates, or by some other means satisfactory to the Engineer to prevent settlement.

When concrete pavement is placed on an existing concrete pavement or on a stabilized base, secure dowel basket assemblies from lateral and vertical displacement during concrete placement using power-driven fasteners and appropriate clips or pins

driven in predrilled holes of a diameter slightly less than the pin diameter. Use either of the above methods or a combination of the two in sufficient numbers to adequately secure the basket assemblies.

Beginning 6 inches (150 mm) from the longitudinal joint, space dowels at 12-inch (300 mm) centers. Where widths other than 12 feet (3.6 m) are specified, the Contractor may use standard dowel basket assemblies with dowel spacings adjusted as follows. Maintain 6-inch (150 mm) dowel spacing at the longitudinal joint and increase the spacing at the outer edge of the lane up to 12 inches (300 mm). Where an odd width of lane occurs and if the standard dowel basket assembly would provide for a space exceeding 12 inches (300 m), place a dowel 6 inches (150 mm) from the outer edge of the lane). Hold such a dowel rigidly in proper position by a method satisfactory to the Engineer or cut and splice a dowel basket assembly of greater length than required to attain the required length

C. Expansion Joints. Where a pressure relief joint is not provided adjacent to a bridge structure, construct expansion joints at the first two regularly spaced joint locations adjacent to the bridge approach slab on each side of the bridge. If the pavement is constructed in two or more separately placed lanes, construct the transverse expansion joints in a continuous line for the full width of the pavement and shoulders.

Construct expansion joints according to the Standard Drawings. Install the face of the expansion joint perpendicular to the concrete surface except when expansion joint is installed at a skewed bridge approach slab.

Use round, straight, smooth, steel dowels, and within 2 hours of placing concrete, coat the dowels with a thin uniform coat of new light form oil as a bond-breaking material to provide free movement. After coating the dowel, install a sleeve of metal or other approved material approximately 3 inches (75 mm) long, with crimped end, overlapping seams fitting closely around the dowel, and a depression or interior projection to stop the dowel a sufficient distance from the crimped end to allow 1 inch (25 mm) for longitudinal dowel movement with pavement expansion on one free end of each dowel. If approved by the Engineer, use other means to allow for 1 inch (25 mm) of expansion.

Punch or drill proper size dowel holes into the preformed expansion joint filler to assure a tight fit around each dowel.

Form a 1-inch (25 mm) wide and 1-inch (25 mm) deep opening on top of the expansion joint filler and seal this opening with 705.04 joint sealers.

D. Contraction Joint. For pavement less than or equal to 10 inches (225 mm) thick, saw contraction joints with a standard (water cooled diamond bladed) concrete saw to a minimum depth of one-fourth of the specified pavement thickness. For pavement greater than 10 inches (255 mm) thick, saw contraction joints to a minimum depth of one-third the specified pavement thickness. When cutting joints using a standard (water cooled diamond blade) saw assure the joint is 1/4 ± 1/16 inch (6 ± 1.6 mm) wide when measured at the time of sawing.

When using the option of early-entry (dry cut, light weight) saws, only use saw blades and skid plates as recommended by the saw manufacturer for the coarse aggregate type being used in the concrete. Perform the early entry contraction joint sawing after initial set and before final set. Saw the contraction joint 2-1/4 to 2-1/2

inches (56 to 63 mm) deep. Ensure any early entry saw joints are approximately 1/8 inch (3 mm) wide at the time of sawing.

If the pavement is constructed in two or more separately placed lanes, install the joints continuous for the full width of the pavement. Saw the pavement with sawing equipment approved by the Engineer as soon as the saw can be operated without damaging the concrete. Provide saws with adequate guides, blade guards, and a method of controlling the depth of cut. After wet sawing, clean the joint using a jet of water. After dry sawing clean the joint using air under pressure. During sawing of contraction joints, maintain a standby saw in working condition with an adequate supply of blades.

E. Construction Joints. Install dowelled construction joints at the end of each day's work and when work is suspended for a period of more than 30 minutes.

Use dowels in transverse construction joints. Within 2 hours of placing concrete, coat the free half of all dowels with a thin uniform coat of new light form oil. Use an adequate bulkhead, with openings provided for dowel bars spaced as specified and shaped to fit the typical section of the pavement, to form a straight joint. During placing of concrete, hold dowels rigidly in position.

Locate construction joints at or between contraction joints. If located between contraction joints, construct the construction joint no closer than 10 feet (3 m) to the last contraction joint.

451.09 Finishing. Use 10-foot (3 m) straightedges to continually check the finished concrete surface for trueness. If the pavement surface is dragged with a diagonal pipe float machine, occasionally check the surface while the concrete is plastic. Do not add water or finishing agent to aid finishing.

Before the concrete initially sets, round the edges of the pavement along each side of each slab and on each side of transverse expansion joints to the radius specified using an approved edging tool. Before texturing the surface, eliminate tool marks left by the edging tool.

Texture the surface in the longitudinal or transverse direction using a broom or artificial turf drag to produce a uniform, gritty, texture.

Before the concrete finally sets, impress complete station numbers into the pavement every 100 feet (50 m), e.g., 1+00 (2+050). Mark station equations in the pavement as shown on the plans. Ensure that the numerals are 3 to 4 inches (75 to 100 mm) high and 1/4 inch (6 mm) deep. Place the station numbers parallel with and facing the right edge of the pavement, and centered 12 inches (0.30 m) in from the right edge. On divided highways, provide station numbers on both pavements. When placing concrete shoulders with the traveled lane, place station numbers 12 inches (0.30 m) in from the outside edge of the shoulder and facing the pavement.

451.10 Curing. Immediately after the finishing operations have been completed and after all free water has dissipated, spray and seal all exposed concrete surfaces with a uniform application of curing membrane in such a manner as to provide a continuous uniform film without marring the surface of the concrete. Apply a minimum of 1 gallon (1 L) of material for each 150 square feet (3.7 m^2) of surface treated using an approved mechanical sprayer. Provide an adequate shield to protect the fog spray from the wind. Before each use, thoroughly agitate the curing material.

On pavement with integral curb or small and irregular areas that are inaccessible to the mechanical spray machine, apply the curing material by a hand-held sprayer.

As soon as the forms have been removed, immediately correct all honey-comb areas and coat the edges of the pavement with the curing material.

Respray all areas of curing material film damaged during the sawing of joints.

The Contractor may water cure concrete with wet burlap cloth, waterproof paper, or polyethylene sheeting. Apply curing as soon as possible and without marring the concrete surface. Unless the test cylinders have attained a split tensile strength of 450 pounds per square inch (3.1 MPa), as tested per ASTM C496, keep the entire surface of the top and sides of the newly placed concrete covered for seven days. Protect concrete from freezing until cylinders attain a split tensile strength of 450 pounds per square inch (3.1 MPa), as tested per ASTM C496.

The above requirements for curing are minimum requirements only. Repair or replace all concrete showing injury or damage due to noncompliance to curing requirements at no additional cost to the City.

451.11 Removing Forms. Remove forms in a manner that doesn't damage the pavement.

451.12 Surface Smoothness. After final concrete curing and cleaning the pavement surface, test the pavement surface for smoothness using a 10-foot (3 m) rolling straightedge. Provide a two or four-wheeled device 10 feet (3 m) in length with an indicator wheel at the center which detects high and low areas in the pavement surface. Provide equipment which actuates a pointer scale, an audio alert, or marks the pavement with paint or dye when encountering any high or low areas in excess of a preset tolerance. Tow the 10-foot (3 m) rolling straightedge or walk the equipment over the completed pavement. Test all wheel paths in the presence of the Engineer. Locate wheel paths parallel to the pavement centerline and approximately 3 feet (1 m) measured transversely inside all lane edges. Maintain alignment of the 10-foot (3 m) rolling straightedge with reference to the pavement edge at all times.

Correct all surface variations so indicated to within the specified tolerance and in a manner that provides a surface texture conforming to 451.09. For corrective grinding provide equipment conforming to 451.13. Ensure pavement surface variations do not exceed 1/8 inch in a 10-foot (3 mm in a 3 m) length of pavement. For ramp pavements and for those pavements with curvature greater than 8 degrees, or with grades exceeding 6 percent, ensure the surface variations do not exceed 1/4 inch in 10 feet (6 mm in 3 m).

Repair or replace sections of pavement containing depressions that cannot be corrected by grinding as directed by the Engineer.

451.13 Profile Grinding. To correct surface variations exceeding tolerances specified in 451.12 use grinding equipment conforming to Item 257.

451.15 Sealing Expansion Joints. As soon as feasible after completing sawing, but before the pavement is open to construction equipment and traffic, seal expansion joints with material conforming to 705.04. Just before sealing, thoroughly clean each joint of all foreign material, using approved equipment. Ensure the joint faces are clean and dry when the seal is installed.

451.16 Opening to Traffic. When 7 days have elapsed, the Contractor may use the completed pavement for traffic, including construction traffic. If a split tensile strength of 450 pounds per square inch (3.1 MPa), as tested per ASTM C496, has been attained, the Contractor may open the pavement to traffic when 5 days have elapsed. If necessary to open a portion of the pavement in less than 5 days, with the proviso that the pavement will be cured for a minimum of 3 days, use high early strength concrete according to 499.03.C and obtain a split tensile strength of 450 pounds per square inch (3.1 MPa), as tested per ASTM C496.

Pavement Repairs before City Acceptance. Repair transverse or diagonally cracked full depth pavement; longitudinally cracked full depth pavement; spalled pavement surfaces and any portland cement concrete pavement panels with cement balls or mudballs; at no cost to the City.

Repair transverse or diagonally cracked PCC pavement with a full depth repair according to Item 255 and applicable Standard Drawings. Repair cracks by replacing the pavement the full width between longitudinal joints, perpendicular to the centerline and at least 6 feet (1.8 m) longitudinally. At the direction of the Engineer, install smooth dowel bars at the interface between the original pavement and the replaced pavement section. Locate and size the repairs to ensure that the repair limits are at least 7 feet (2.1 m) away from any transverse joint.

Repair longitudinal cracks within 15 inches (380 mm) of a tied longitudinal joint by routing and sealing the crack according to Item 423. For other longitudinal cracks, repair the same as for transverse or diagonal cracks stated above.

Repair spalled pavement with Item 256 Bonded Patching of Portland Cement Concrete Pavement.

Repair cement balls or mudballs by coring out the area, full depth, with a diamond core bit and replacing the removed concrete with the same concrete as in the pavement. Remove and replace any pavement panel with 5 or more cement balls or mudballs. Locate the limits of the repair along the longitudinal joints and at least 1-foot (0.3 m) past the transverse joints to remove any existing dowel bars. Install smooth dowel bars at the transverse limits of the repairs. Install Type D (Drilled Tied Longitudinal) Joint along the longitudinal limits.

451.17 Pavement Thickness.

A. General. As determined by measurement of cores cut as specified in this section, construct the concrete not more than 0.2 inch (5 mm) less than the specified thickness. Core pavement at the direction of the Engineer and at locations the Engineer determines according to City Supplement 1064. The Engineer will measure core length according to AASHTO T 148.

For the purpose of coring, the City will consider the entire pavement area of a specified thickness a unit. To determine the number of cores, each pavement unit will be divided into Lots. A Lot consists of 2000 square yards (1650 square meters) of a pavement unit or major fraction thereof.

Take one random core for each Lot but not less than 3 cores for any pavement unit cored. If a core shows a deficiency in thickness of more than 1/2 inch (13 mm) from the

specified thickness take additional cores to determine the limits of the deficiency. Follow the procedures below:

1. Take a core five (5) feet (1.5 m) longitudinally on both sides of the deficient core. If both the cores are less than 1/2-inch (13 mm) deficient in thickness the zone of deficiency has been determined.

2. If either or both 451.17.A.1 cores are more than 1/2 inch (13 mm) deficient in thickness, cut a core 50 feet (15 m) longitudinally from the deficient core(s). If the 50 foot (15 m) core(s) is more than 1/2 inch (13 mm) deficient, cut additional cores at 100 foot (30 m) longitudinal intervals until a core is less than 1/2 inch (13 mm) deficient; until the pavement ends; or until overlapping an adjacent pavement Lot's core in the same lane.

3. If a pavement Lot has cores more than 1/2 inch (13 mm) deficient in thickness and the Lot's constructed width is greater than 12 feet (3.6 m) obtain cores transverse to the location of the more than 1/2 inch (13 mm) deficient cores. Obtain transverse cores at a location 1/2 the distance from the deficient core to the furthest edge of pavement. Obtain a transverse core for each core more than 1/2 inch (13 mm) deficient.

4. The Engineer will use the cores that measure less than 1/2 inch (13 mm) deficient in thickness to define the limits of the deficiency.

If any deficient core is greater than 1 inch (25 mm) deficient in thickness, determine the limits of over 1 inch (25 mm) deficiency by following 451.17.A.1 through 4 to determine the limits. Remove and replace those areas greater than 1 inch (25 mm) deficient in thickness.

The Engineer will calculate average thickness of concrete pavement placed as follows:

When zones of deficient thickness greater than 1/2 inch (13 mm) to 1 inch (25 mm) are allowed to remain in place, the Engineer will calculate two average thicknesses. A Project Average Thickness (PAT) will include all cores not more than 1/2 inch (13 mm) deficient. Cores that exceed the specified thickness by more than ½ inch (13 mm) will be considered as the specified thickness plus 1/2 inch (13 mm) when calculating the PAT. A second Deficient Zone Average (DZA) will include all cores with thickness deficiency greater than 1/2 inch (13 mm) to 1 inch (25 mm). The pavement represented by each of the two averages, PAT or DZA, will be calculated and paid separately.

The City will determine and apply deductions to each separately placed width of pavement.

For any pavement areas removed and replaced, re-core those areas replaced following this section of the specifications. Include those core values into the calculations for average pavement thickness.

Unless the Engineer requests, do not core any widening less than 5 feet (1.5 m) in width or any pavement area less than 2000 square yards (1650 square meters).

Fill all core holes with concrete of the same proportions and materials used in the pavement.

B. Price Adjustments. Based on the pavement average thickness, the City will make payment as specified in Table 451.17-1.

TABLE 451.17-1 CONCRETE PAVEMENT DEFICIENCY

Deficiency in Thickness as Determined by Cores	Proportional Part of Contract Price
0.0 to .2 inch (0.0 to 5 mm)	100 percent
0.3 to 0.5 inch (6 to 13 mm)	$\text{Ratio}\left[\frac{PAT}{PST}\right]^6$
0.6 to 1.0 inch (15 to 25 mm)*	$\text{Ratio}\left[\frac{DZA}{PST}\right]^6$
Greater than 1.0 inch (25 mm)	Remove and replace

* The Engineer will determine whether pavement areas from 0.6 inch (15 mm) up to 1 inch (25 mm) deficient in thickness will be allowed to remain in place at the reduced price or must be removed and replaced.

PAT = Project Average Thickness

PST = Plan Specified Thickness

DZA = Deficient Zone Average

451.18 Method of Measurement. The City will measure Reinforced Concrete Pavement by the number of square yards (square meters) completed and accepted in place. The width equals the pavement width shown on the typical cross-section of the plans plus additional widening as the Engineer directs in writing. The City will field measure the length along the centerline of each roadway or ramp. The City will determine the area based on the above width and length.

451.19 Basis of Payment. Payment is full compensation for furnishing and placing all materials including reinforcing steel, dowels, and joint materials; for furnishing the 10-foot (3 m) rolling straightedge; and for coring the pavement. For pavement found deficient in thickness, the City will pay a reduced price according to 451.17.

The City will not pay extra for pavement with an average thickness in excess of that shown on the plans.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
451	Square Yard (Square Meter)	Reinforced Concrete Pavement