

SECTION 40

PORTLAND CEMENT CONCRETE PAVEMENT

40.1 DESCRIPTION

A. General:

This work consists of constructing Portland Cement Concrete Pavement with or without reinforcement on a prepared surface.

B. Related Work:

Section 100 - Portland Cement
Section 101 - Air-Entraining Admixtures
Section 102 - Chemical Admixtures for Concrete
Section 104 - Water for Use in Portland Cement Concrete
Section 105 - Fine Aggregate for Use in Portland Cement Concrete
Section 107 - Coarse Aggregate for Use in Portland Cement Concrete
Section 108 - Concrete Curing Materials
Section 113 - Preformed Expansion Joint Filler for Concrete
Section 114 - Concrete Joint Sealer
Section 123 - Reinforcement

40.2 MATERIALS

A. Cement:

Cement shall conform to the requirements of Section 100. Type II cement shall be used for all concrete pavement.

B. Admixtures:

Admixtures shall conform to the requirements of Sections 101 and 102.

C. Water:

Water shall conform to the requirements of Section 104.

D. Fine Aggregate:

Fine aggregate shall conform to the requirements of Section 105.

E. Coarse Aggregate

Coarse aggregate shall conform to the requirements of Section 107.

F. Reinforcing Steel:

Reinforcing steel shall conform to the requirements of Section 123.

G. Joint Filler:

Joint filler shall conform to the requirements of Section 113.

H. Joint Sealer:

Joint sealer shall conform to the requirements of Section 114.

I. Backer Rod:

Backer Rod shall conform to the requirements of Section 114.

J. Curing Materials:

Curing materials shall conform to the requirements of Section 108, white pigmented Linseed Oil Base Emulsion Compound.

40.3 CONSTRUCTION REQUIREMENTS

A. Quality of Concrete, Proportioning and Mix Design:

When the Contractor proposes to use materials for Portland Cement Concrete pavement from sources not previously accepted by the City, the Contractor shall obtain independent, certified laboratory tests that verify that the materials meet the requirements of the applicable sections listed in Section 40.2. Minimum number of tests is once each year per source unless otherwise ordered by the Engineer.

When the Contractor proposes to use a mix design not previously accepted by the City, the Contractor shall obtain independent, certified laboratory tests that verify that the mix design meets a minimum flexural strength of 650 psi at 28 days. Minimum number of tests is once each year unless otherwise ordered by the Engineer. Test results shall include three each of: 7, 14, & 28 day compressive strength; 7, 14, & 28 day flexural strength; water-cement ratios; slump (to be consistent with proposed placement method); and air content. These results shall be obtained from separate mix design batches.

These mix design results will be used to monitor and adjust, if necessary, the PCC Pavement placed on the project.

In case satisfactory plasticity, workability, or strength is not secured using the design mix designated, the Engineer may alter proportions as necessary. Adjustment will not be made in the compensation due the Contractor because of design mix alterations.

For the Stationary Side Form Method, the slump of the concrete at the time of placement shall be maintained between one (1) and three (3) inches.

For the Slip-Form Method, the concrete shall be held at a uniform consistency, having a slump of not more than two (2) inches.

The concrete shall contain six (6) plus or minus one and five-tenths (± 1.5) percent-entrained air. Air shall be entrained by an approved air-entraining admixture.

B. Equipment:

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

1. Batching Equipment:

Batching Equipment shall be automatic. Manual operation will be permitted when automatic controls fail, however, the Contractor shall restore automatic operation before work may commence the day following the failure.

The Engineer may permit the use of manually controlled batching equipment when relatively small quantities of concrete are required at one or more locations.

The Contractor shall provide safe and satisfactory means for obtaining necessary material samples from the batching plant.

Batching plant structures shall be maintained properly leveled within the accuracy required by the design of the weighing mechanism.

Hoppers shall be constructed to fully discharge without excessively jarring the scales.

Clearances between scale parts, hoppers and bin structure shall be such as to avoid displacement of, or friction between parts due to accumulations, vibration or other cause. Pivot mountings shall be designed so the parts will not jar loose and so constructed to assure unchanging spacing of knife-edges under all circumstances. Scales shall be so designed that exposed fulcrums, clevises and similar working parts may readily be kept clean.

Weighing hoppers and other parts upon which wind action may cause inaccuracy in weighing shall be protected by shelters or wind breaks.

The dials of scales shall be completely enclosed in weatherproof cases and provided with a glass opening to permit observation and reading.

Dial scales shall be provided with markers, which indicate the position of the dial indicator for predetermined loads.

Beam scales shall be equipped with an over and under indicator, which will show the beam setting. The indicator shall have an over and under travel equal to not more than five (5%) percent of the capacity of the beam.

The scales for weighing aggregates, cement, water, sand, and admixtures shall be of the beam or spring less dial type designed as an integral part of the batching equipment. The scales shall be accurate within one-half percent (1/2%) at any point throughout the range of use of the scale. Scale graduations shall be not greater than one-tenth percent (0.1%) of the capacity of the scale. The scales shall be sensitive to the weight indicated by one graduation. The Contractor shall provide the necessary equipment and assistance for checking the scales at least once for every (6) days' operation.

The following controls shall apply to the aggregate batching equipment where each aggregate is weighed separately:

The hopper inlet mechanism shall be interlocked against opening when the discharge gate is open.

The hopper discharge mechanism shall be interlocked against opening while the hopper is being filled.

The hopper discharge mechanism shall be interlocked against opening if the material in the hopper is either overweight or underweight by more than two percent (2%) of the specified weight of the material being weighed.

The following controls shall apply to the aggregate batching equipment where aggregates are weighed accumulatively into one hopper:

Hopper inlet mechanisms shall be interlocked against opening when the hopper discharge gate is open.

The hopper inlet mechanism for any ingredient shall be interlocked against opening if the previous ingredients already in the hopper are overweight or underweight by more than one-half of one percent (1/2 of 1%) of the net weight of the total aggregate batch.

The hopper discharge mechanism shall be interlocked against opening while the hopper is being filled or if the batch in the hopper is overweight or underweight by more than one-half of one percent (1/2 of 1%) of the net weight of the total aggregate batch.

The cement batching equipment shall operate within a delivery tolerance of one percent (1%) of the net weight of the cement per batch.

Water may be measured by volume or by weight. The measuring equipment shall operate within a delivery tolerance of one percent (1%) of the net weight or volume of water per batch.

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

Air-entraining or other admixtures may be measured by volume or by weight. The measuring equipment shall operate within a delivery tolerance of three percent (3%) of the net weight or volume per batch.

2. Mixing and Hauling Equipment:

Mixers and agitators shall have attached in a prominent place, the manufacturer's plate showing the various uses for which the equipment is designed and the capacity of the drum in terms of volume of mixed concrete.

The pick-up and throw-over blades in the drum shall be restored or replaced when any part or section is worn three-fourths (3/4) inch or more below the original height of the manufacturer's design.

The Contractor shall have available a copy of the manufacturer's design, showing dimensions and arrangement of blades in reference to the original height and depth. Mixers that have an accumulation of hard concrete or mortar in them shall not be used.

Mixers, except truck mixers, shall be equipped with an approved timing device, which will automatically lock the discharge lever when the drum has been charged and release it at the end of the mixing period. The timing device shall be equipped with a bell or other suitable warning device adjusted to give a signal each time the lock is released.

Truck mixers shall be equipped with counters by which the number of revolutions of the drum or blades may readily be verified. The counters shall be automatically actuated at the time of starting mixing at mixing speed.

Mixers shall be capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and discharging the concrete with a satisfactory degree of uniformity.

The hauling bodies of non-agitating equipment shall be smooth, mortar-tight metal containers equipped with gates that will permit control of the discharge of the concrete.

3. Spreading and Finishing Equipment:

The equipment shall consist of a mechanized spreading device, a strike-off, an oscillating transverse screed and a final float. Slip-form paving equipment shall have the direction of forward motion controlled by an electronic sensing device following a taut string line. The equipment shall be designed to spread, consolidate, screed and float-finish the freshly placed concrete in such a manner that a minimum of hand finishing will be necessary to provide a dense and homogeneous pavement.

4. Vibrators:

Vibrators, for full width vibration of concrete paving slabs, may be either the surface pan type or the internal type. They may be attached to the spreader, the finishing machine or mounted on a separate carriage. The frequency of the surface vibrators shall not be less than three thousand five hundred (3,500) impulses per minute. The frequency of the internal vibrators shall not be less than seven thousand (7,000) impulses per minute, unless modified by the Engineer. When spud type internal vibrators are used adjacent to forms, they shall have a frequency of not less than three thousand five hundred (3,500) impulses per minute. Vibrators shall be interlocked with the machine's travel mechanism so vibration is stopped when the forward motion stops.

5. Concrete Saw:

When sawing joints is elected or specified, the Contractor shall provide sawing equipment adequate in number of joints and power to complete the sawing to the required dimensions and at the required rate. The Contractor may be required to provide at least one (1) standby saw in good working order.

6. Forms:

Forms shall have a depth not less than the prescribed edge thickness of the pavement. Built up forms with horizontal joints shall not be used unless specifically approved by the Engineer. Forms shall have sufficient rigidity and shall be provided with adequate devices for secure setting so, when staked in place, they will withstand the pressure of the concrete and the impact and vibration of any equipment they are required to support, without significant springing, settlement or lateral displacement. Bent, twisted or broken forms and those with battered top surfaces shall be removed from the work. Repaired forms shall not be used until inspected and approved. The top face of any form shall not vary from a true plane by more than one-eighth (1/8) inch in ten (10) feet.

Straight forms shall be made of metal having a thickness of not less than seven-thirty seconds ($7/32$) of an inch and shall be furnished in sections not less than ten (10) feet in length, with each section having provisions for locking together the ends of abutting sections. Straight forms shall have a base width of at least eight (8) inches with flange braces extending outward on the base at least two-thirds ($2/3$) the height of the form.

Flexible or curved forms of proper radius shall be used for curves of one hundred (100) foot radius or less. Flexible or curved forms shall be of a design acceptable to the Engineer.

C. Preparation:

1. Stationary Side Form Method:

Forms shall be set to line and grade. The surface to receive concrete shall be final graded and dowel assemblies if required, placed sufficiently in advance of concrete placement.

The foundation under the forms shall be compacted and true to grade so the form will be firmly in contact for its whole length. Forms shall be staked into place with not less than three (3) pins for each ten (10) foot section. A pin shall be placed at each side of every joint. Form sections shall be tightly locked and free from play or movement. The forms shall not deviate from true line by more than one-fourth ($1/4$) inch at any point. Excessive settlement or springing of forms under the finishing machine will not be tolerated. Forms shall be cleaned and oiled prior to the placing of concrete.

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

After side forms have been set to line and grade and securely fastened, the surface on which the concrete paving is to be placed, excluding asphalt concrete and cement treated base, shall be brought to final grade by a sub grade machine or sub grade planner. High areas shall be trimmed to proper elevation. Low areas may be filled and compacted to a condition similar to that of surrounding grade, or filled with concrete integral with the pavement.

In lieu of the above operation, an automatic sub grade trimmer operating from a preset grade line may be used prior to setting of the side forms. The machine shall cover in one (1) pass, a width at least equal to the out to out dimensions of the forms. After the grade has been made by the automatic sub grade trimmer, the forms shall be set, the surface checked, and high and low, areas corrected as specified above.

The finished sub grade surface shall be maintained in a smooth and compacted condition until the pavement is placed.

2. Slip Form Method:

The surface on which the concrete is to be placed, excluding asphalt concrete and cement treated base, shall be brought to final grade by an automatic sub grade trimmer operating from a preset grade line. The machine shall cover in one (1) pass, a width at least equal to the out to out dimensions of the slip form paver tracks. Grade control for the paving operation shall be off of the final trimmed surface or from a preset string line.

If the density of the surface is disturbed by the trimming operations, it shall be corrected by additional compaction before concrete is placed. If any traffic is allowed to use the prepared sub grade, the grade shall be checked and corrected immediately ahead of concrete placement.

D. Handling, Measuring, and Batching Materials:

The separate aggregate components shall not become intermixed prior to being weighted. The weigh hopper or hoppers shall be charged in such manner as to result in batched weights within the tolerances specified.

Aggregates shall be handled from stockpiles or other sources to the batching plant in such manner as to secure a uniform grading of the material. The use of track-type dozing equipment will not be permitted in handling coarse aggregates from stockpiles. Aggregates that have become segregated or mixed with earth or foreign material shall not be used. If the aggregates contain non-uniform moisture, storage or stockpile periods may be required by the Engineer to equalize the moisture content.

The separate aggregate components for each batch may be weighed cumulatively in a single hopper or weighed separately in individual hoppers. Separate scales and hoppers shall be used for weighing cement.

E. Mixing Concrete:

Concrete shall be mixed at a central stationary plant. Truck mixing will be permitted only when shown on the plans or authorized by the Engineer.

Mixing and agitating speeds shall be as designated by the manufacturer of the equipment.

Manual operation of the central plant will be permitted only in case of failure of the automatic control. Automatic operation must be restored before work may commence the day following the failure.

Batches for the central plant shall be charged into a drum so a portion of the mixing water enters in advance of the cement and aggregates. The flow of water shall be uniform and all water shall be in the drum by the end of the first fifteen (15) seconds of the mixing period.

Concrete mixed less than the specified time shall be disposed of at the Contractor's expense.

Mixers may not be charged in excess of their rated capacity.

When a concrete batch is to be transported in a truck mixer or agitator and the batch is smaller than sixty percent (60%) of the rated capacity of the truck mixer or agitator, the following percentage of additional cement shall be added to the batch:

40% to 60% rated cap	5%
20% to 40% rated cap	10%
10% to 20% rated cap	15%
0% to 10% rated cap	20%

The above provisions regarding extra cement shall also apply to the mixing of small batches in central plants as well as to the transporting.

1. Central Plant Mixing:

Concrete shall be mixed for a period of not less than one (1) minute after all materials, excluding water, are in the mixer.

2. Truck Mixing:

Mixing time for truck mixed concrete shall be not less than seventy (70) nor more than one hundred (100) revolutions of the drum or blades at mixing speed, after all ingredients, including water, are in the drum. Additional mixing beyond one hundred (100) revolutions, if any, shall be done at agitating speed. Unless otherwise permitted by the Engineer, the mixing water shall be added at the time of batching. The Engineer may order additional water or cement added to the batch after completion of the original mixing, in which case the batch shall be mixed an additional thirty (30) revolutions at mixing speed. The Contractor shall provide means to accurately measure the amount of water added.

F. Limitations of Mixing:

Concrete shall be mixed in such quantities as required for immediate use and shall be finished before initial set has occurred. Concrete in which initial set has begun shall be wasted. Retempering of concrete will not be allowed. Concrete shall not be mixed, placed, or finished when the natural light is insufficient, unless otherwise shown on the plans.

Mixing water shall not be heated above one hundred sixty (160°) degrees F. Aggregates shall not be heated above one hundred (100°) degrees F. and shall be free of frozen lumps, ice, and snow.

G. Delivery requirements:

The rate of delivery of concrete shall be uniform.

When concrete is continuously agitated in the hauling unit, it shall be discharged within ninety (90) minutes after the cement has been placed in contact with the aggregates, except when the concrete temperature is eighty five (85°) degrees F. or above, the time limitation shall be forty-five (45) minutes.

When concrete is not continuously agitated in the hauling unit, it shall be discharged within forty-five (45) minutes after the cement has been placed in contact with the aggregates, except when the concrete temperature is eighty (80°) degrees F. or above, the time limitation shall be thirty (30) minutes.

The compartment in which concrete is transported to the worksite shall be thoroughly cleaned and flushed with water at such intervals as necessary to insure hardened concrete will not accumulate in the compartment.

H. Placing Concrete:

Placement of concrete on a frozen surface will not be permitted. The surface of forms and steel, which will come into contact with the concrete, shall be raised to a temperature above freezing prior to concrete placement.

The temperature of concrete at the time of placing shall not be less than fifty (50°) degrees F, or more than ninety (90°) degrees F.

The subgrade surface shall be uniformly moist when the concrete is placed. Sprinkling shall be such as to avoid forming pools of water.

The concrete shall be deposited on the grade so as to require as little rehandling as possible. Unless truck mixers, truck agitators or non-agitating hauling equipment are equipped to discharge concrete without segregation of the materials, the concrete shall be unloaded into an approved spreading device and mechanically spread on the grade without segregation of the materials.

Necessary hand spreading shall be done with shovels, not rakes or vibrators. Workers shall not be allowed to walk in the freshly mixed concrete with boots or shoes coated with earth or foreign substances.

Vehicles will not be allowed to drive through or back into fresh mixed concrete if they are tracking earth or foreign substances. Equipment that has earth or foreign substances dropping from the unit will not be allowed over the fresh mixed concrete.

Where concrete is to be placed adjoining a previously constructed lane of pavement, and heavy mechanical spreaders or finishers will be operated upon the existing lane of pavement, that lane shall have attained a compressive strength of at least three thousand five hundred (3500) psi. Spreaders and finishers or other vehicles or equipment having less than 2000 psi ground load will be permitted on the existing lane when it has attained a compressive strength of two thousand five hundred (2500) psi. Compressive strength will be determined in accordance with Test No. SD 409.

Concrete shall be thoroughly consolidated against and along the faces of all forms by vibrators inserted in the concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade or a side form. The vibrator shall not be operated longer than ten(10) seconds in any one location.

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

Concrete material, which falls on or is worked into the surface of a completed slab, shall be removed immediately by approved methods without damage to the slab.

I. Protection of Concrete:

The Contractor shall protect the pavement with sufficient covering so the concrete surface temperature is maintained above thirty-two (32°) degrees F. until the concrete has attained a compressive strength of one thousand five hundred (1500) psi. Compressive strength will be determined in accordance with Test No. SD 409. This protection shall be in addition to one of the curing methods specified in this section.

Any concrete placed between November 1 and April 15, shall be covered by insulated blankets or equivalent heat retention methods unless, such requirements are waived by the Engineer.

The Contractor shall be responsible for the quality and strength of concrete subjected to cold weather. Any concrete injured by frost action shall be removed and replaced at the Contractor's expense.

The Contractor shall have available at all times covering materials such as burlap or cotton mats, curing paper, or plastic sheeting material for the protection of the surface of the pavement. When rain appears imminent, all paving operations shall stop, and the unhardened concrete shall be covered with the protective covering.

J. Test Specimens:

The Contractor shall furnish from the mixture in actual use sufficient concrete for the purpose of making test specimens as required in 40.3.V. herein.

K. Strike-Off of Concrete and Placement of Reinforcement:

Following placement, the concrete shall be struck-off to conform to the cross section shown on the plans, so when the concrete is properly consolidated and finished, the surface of the pavement will be at the elevation shown on the plans. Portland Cement Concrete shoulders shall not be constructed above nor more than one-fourth (1/4) inch lower than adjacent Portland Cement Concrete Pavement. In slabs reinforced with non-continuous steel fabric or bar mats, concrete may be placed in two (2) separate horizontal layers.

Each layer shall be spread and struck-off at the correct elevation to permit placement of the reinforcement in the specified position. The second layer shall be placed while the first layer of concrete is plastic and both layers shall be properly vibrated to ensure adequate consolidation and a monolithic pavement structure. In lieu of placement in two (2) layers, the full depth of concrete may be placed in one (1) layer and the steel inserted by a mesh depressor. In continuously reinforced concrete slabs, the reinforcement shall be supported on chairs and the entire slab poured in one operation. The chairs used for support shall rigidly hold the reinforcement in position during concreting operations, without displacement.

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

L. Joints:

Joints shall be constructed of the type and dimensions and at the locations required by the plans or specifications. Immediately after sawing the joints to their final configuration, the resulting slurry shall be completely removed from the joint and the immediate area by flushing with a jet of water and other tools as necessary.

1. Longitudinal Sawed Joints:

1. Deformed #4 epoxy coated steel tie bars of specified length, spacing, and material shall be placed perpendicular to the longitudinal joints by approved mechanical equipment or rigidly secured by chairs or other approved supports, to prevent displacement. Tie bars shall not be painted or coated with asphalt or other such material, other than the epoxy coating or enclosed in tubes or sleeves. Longitudinal sawed joints shall be, cut by approved concrete saws to the depth, width and line shown on the Standard Details. Suitable guidelines or devices shall be used to assure cutting the longitudinal joint on the true line as shown on the plans. The longitudinal joint shall be sawed shortly after the end of the curing period and before any equipment or vehicles are allowed on the pavement. The joint shall be sealed as required in Section 40.3Q.

2. Longitudinal Construction Joints:

When adjacent lanes of pavement are constructed separately, a keyway shall be formed along the construction joint. When deformed #4 epoxy coated steel tie bars are required, they may be bent at right angles against the form of the first lane constructed and straightened into final position before the concrete of the adjacent lane is placed. In lieu of bent tie bars, approved two-piece connectors may be used. Deformed #4 epoxy coated steel tie bars shall conform to the requirements specified in Section 40.3L.1, except that rail steel shall not be used for tie bars that are to be bent and restraightened. The longitudinal construction joint shall be sawed shortly after the end of the curing period and shall be sealed as required in Section 40.3Q.

When new PCC pavement is to be constructed adjacent to existing pavement and where a keyway is not present, deformed #10 epoxy coated bars shall be drilled and epoxied into the existing pavement. The bars shall be installed to a depth of nine (9) inches and placed eighteen (18) inches on centers.

3. Transverse Contraction Joints:

Transverse contraction joints shall consist of planes of weakness one-third (1/3) the depth of the pavement. They may be created by sawing, forming with approved inserts, or by a combination of forming and sawing.

Sawed transverse contraction joints shall be created by sawing grooves in the surface of the pavement to the dimensions and at the spacing and lines shown on the plans with an approved concrete saw. Sawing of the joints shall commence as soon as the concrete has hardened sufficiently to permit sawing without excessive raveling. Joints shall be sawed before uncontrolled shrinkage cracking takes place. If necessary, the sawing operations shall be carried on both during the day and night, regardless of weather conditions. 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.

Any procedure, which results in premature and uncontrolled cracking, shall be revised immediately by adjusting the sequence of cutting the joints or the time interval involved between the placing of the concrete or removal of curing media and the cutting of joints. Repair or correction of uncontrolled cracks shall be as directed by the Engineer and at the expense of the Contractor unless a determination is made that cracking is the result of improper design.

Formed transverse contraction joints shall be created by installing an insert, which will be removed after the concrete has hardened. The insert shall be installed immediately behind the last finishing machine and shall be placed as close to the pavement surface as finishing will permit. The insert shall be placed

by a device or by an installing machine to the depth shown on the plans. Inserts shall not be removed sooner than seventy-two (72) hours after the pavement is poured, unless the joint opening is properly cured as set forth in Section 40.30.

4. Transverse Construction Joints:

Transverse construction joints, unless other joints shown on the plans occur at the same points, shall be made at the end of each day's run. Transverse construction joints shall also be placed when the paving operation is interrupted and the in-place concrete is no longer plastic enough so a monolithic slab can be obtained.

The transverse construction joint shall be located at the middle of the paving panel. Supplemental hand vibrators shall be immediately available in the event normal equipment does not provide satisfactory consolidation at joints.

Transverse construction joints shall be made using a satisfactory header and reinforcing bars of the size, length, and spacing shown on the plans. Reinforcing bars shall be held in position parallel to the surface and centerline of the slab. Transverse construction joints shall be sawed one-fourth (1/4) inch wide by three-fourths (3/4) inch deep and sealed with joint sealer.

Paving in the area of a transverse construction joint will not be permitted for twelve (12) hours after installation.

5. Transverse Expansion Joints:

Transverse expansion joints shall consist of placement of preformed expansion joint filler at the intervals and in the manner specified.

Preformed joint filler shall be formed to the required size and location for the load transfer units as shown on the plans. The preformed joint filler shall be furnished in lengths equal to the pavement width. In cases where pavement is being placed two (2) or more traffic lanes wide, the preformed filler may be furnished in sections equal to the width of one lane. Where more than one section of joint filler is used in a joint, the sections shall be securely laced or clipped together. The bottom edge of the filler shall project to or slightly below the bottom of the slab. Unless otherwise prescribed, the top edge shall be about three-fourths (3/4) inch below the proposed surface of the pavement to facilitate the finishing operations. While the concrete is being placed, the top edge of the filler shall be protected by a metal channel cap having flanges not less than one and one-half (1 ½) inches in depth.

6. Concrete Headers:

Concrete headers, when designated on the plans, shall be placed full pavement width at the starting point, and at the end of the finished pavement. Headers

shall also be constructed at such other points as may be ordered by the Engineer. Concrete headers shall be of the design shown on the plans.

M. Final Strike-Off, Consolidation and Finishing:

1. Sequence:

The sequence of operations shall be the strike-off and consolidation, floating and removal of laitance, straight-edging, and final surface finish.

The addition of water to the surface of the concrete to assist in finishing operations will not be permitted, except under extreme conditions. In isolated areas where the Engineer determines the addition of water would be beneficial, water may be applied with an approved fog sprayer.

2. Finishing at Joints:

The concrete adjacent to joints shall be compacted or firmly placed without voids or segregation against the joint material, under and around all load transfer devices, joint assembly units, and other features designed to extend into the pavement. Concrete adjacent to joints shall be mechanically vibrated as required in Section 40.3H.

3. Machine Finishing:

Vibrators meeting the requirements of Section 40.3B.4 shall be used for full width vibration of concrete paving slabs.

Immediately after placement, the concrete shall be struck off and screeded by an approved finishing machine. The machine shall go over each area of pavement as many times and at such intervals as necessary for proper consolidation and to leave a surface of uniform texture. Excessive operation over a given area shall be avoided. The tops of the forms shall be kept clean by an effective device attached to the machine. The travel of the machine on the forms shall be maintained true without lift, wobbling, or other variation tending to affect the precision finish.

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

The finishing machine shall be operated with as nearly a continuous forward movement as possible, and all operations of mixing, delivering, spreading, and vibrating concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. Except in an emergency, no tractive force shall be applied to the machine, except that which is controlled from the machine.

The Contractor shall furnish equipment and methods, which will produce uniform and satisfactory consolidation of the concrete.

4. Hand Finishing:

Hand finishing methods will not be permitted except when areas of narrow width or irregular dimensions are encountered that cannot be finished with mechanical equipment.

In the event of mechanical equipment breakdown, the concrete already deposited on the grade shall be hand finished, and additional concrete placement shall be terminated.

Hand finishing shall be done in a manner acceptable to the Engineer.

5. Floating:

After the concrete has been struck off and consolidated, the surface shall be further smoothed, trued, and consolidated by means of an approved mechanical longitudinal float, consisting of a cutting and smoothing float or floats included as part of the finish machine or suspended from a separate rigid frame.

If necessary, long-handled floats having blades not less than five (5) feet in length and six (6) inches in width may be used to smooth and fill open-textured areas in the pavement.

Long-handled floats shall not be used to float the entire surface of the pavement. Care shall be taken not to work the crown out of the pavement during the operation.

After floating, any excess water and laitance shall be removed from the surface of the pavement by a straightedge ten (10) feet or more in length. Successive drags shall be lapped one-half (1/2) the length of the blade.

6. Final Finish:

Before the concrete has attained its initial set, it shall be given a final finish by means of a carpet drag drawn over the surface in a longitudinal direction. The drag shall be mounted on a bridge and the dimensions of the drag shall be such that a strip of the carpet at least two (2) feet wide is in contact with the pavement surface while the drag is operated, unless otherwise allowed by the Engineer.

The condition of the drag shall be maintained so the resultant surface is of uniform appearance with corrugations approximately one-sixteenth (1/16) inch in depth. Drags shall be maintained clean and free of encrusted mortar. Drags that cannot be cleaned shall be discarded and replaced

The carpet shall meet the following requirements:

- Facing Material - Molded polyethylene pile face
- Blade Length - 7/8 inch, plus or minus 1/8 inch
- Total Fabric Weight - 70 oz. per square yard minimum

The backing shall be of a strong, durable material, not subject to rot, and adequately bonded to the facing, to withstand construction requirements.

If approved by the Engineer, brooming may be used on irregular areas in lieu of the carpet drag. The broom shall be drawn transversely across the pavement with adjacent strokes slightly overlapping. The brooming operation shall be so executed that the grooves produced in the surface shall be uniform in appearance and approximately one-sixteenth (1/16) inch in depth. Texturing shall be completed while the concrete surface can be broomed without being torn or unduly roughened by the operation. The surface thus finished shall be free from rough and porous areas and irregularities and depressions resulting from improper handling of the broom. Brooms shall be of the quality, size, and construction and so operated as to produce a surface finish meeting the approval of the Engineer.

7. Edging at Forms and Joints:

After the final finish, but before the concrete has taken its initial set, the edges of the pavement along each side of transverse expansion joints and transverse construction joints shall be worked with an approved tool and rounded to the radius required by the plans. Edging will be permitted along longitudinal construction joints provided the radius does not exceed one-fourth (1/4) inch. A well-defined and continuous radius shall be produced and a smooth, dense mortar finish obtained. The surface of the slab shall not, be unduly disturbed by tilting of the tool during use. On formed contraction joints, the bond between concrete and insert shall be broken by insertion of an approved tool between the plastic concrete and the insert.

Any tool marks appearing on the slab adjacent to the joints shall be eliminated by brooming, belting, or burlap dragging the surface without disturbing the rounding of the corner of the slab. 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 or if they are higher or lower than the adjacent slabs.

N. Surface Test

The pavement surface shall be tested with a ten (10) foot straightedge or other specified device. The permissible longitudinal and transverse surface deviation shall be one-fourth (1/4) inch in ten (10) feet. The permissible transverse surface

deviation on the outer six (6) inches of the edge of pavement may be one-fourth (1/4) inch under a ten (10) foot straightedge, except where the edge will become a longitudinal joint.

Areas where the maximum deviation exceeds the permissible deviation by not more than three-eighths (3/8) inch will be subject to the following at the discretion of the Engineer:

Grind down to an elevation where the area or spot will be within the permissible deviation.

Accept affected area without corrective action with price reduction at a rate noted below.

Areas where the maximum deviation exceeds the permissible by more than three-eighths (3/8) inch will be subject to the following at the discretion of the Engineer:

Grind down to an elevation where the area or spot will be within the permissible deviation.

Accept affected area without corrective action with price reduction at a rate noted below.

Remove and replace deficient area to the satisfaction of the Engineer.

Grinding shall be accomplished with specially prepared circular diamond blades mounted on a horizontal shaft. Areas that have been ground shall not be left smooth or polished, but shall have a uniform texture equal in roughness to the surrounding unground concrete.

If the Engineer accepts the deficient area without correction, a price reduction at the following rates will be deducted from the contract.

Ten dollars (\$10.00) per square yard for those areas where the maximum deviation exceeds the permissible deviation by not more than one-eighth (1/8) inch.

Twenty dollars (\$20.00) per square yard for those areas where the maximum deviation exceeds the permissible deviation by more than one-eighth (1/8) inch but not more than three-eighths (3/8) inch.

Thirty dollars (\$30.00) per square yard for those areas where the maximum deviation exceeds the permissible deviation by more than three-eighths (3/8) inch.

Measurements for determining the limits of deficient areas accepted by the Engineer with applicable price reduction will be made in the following manner:

The longitudinal pavement surface test shall be completed on each wheel pass on driving lanes and on at least one pass on shoulder, etc. The length of the

deviation will be that length out of specification tolerance at the location of the surface test as checked with a ten (10) foot straightedge and a one-fourth (1/4) inch shim surface tolerance is specified. Where two (2) surface tests vary within a particular site within a driving lane or shoulder, the length used for computation of the area will be the average of the two (2) tests. The width will be the total width of the particular driving lane or shoulder. The depth of the deviation will be the maximum depth of the test(s) at a particular site, as checked with one-eighth (1/8) inch, one-fourth (1/4) inch, and three-eighths (3/8) inch shims.

Where the transverse surface test is out of specification, the maximum length and maximum width at a particular site shall be used in computation of the area.

O. Curing:

Immediately after the finishing operations have been completed, and marring of the concrete will not occur, the entire surface and the edges of the slip-form pavement shall be covered and cured in accordance with one of the following methods. The concrete shall not be left exposed for more than one-half (1/2) hour between stages of curing or during the curing period. Curing shall be maintained for at least seventy-two (72) hours after concrete has been placed.

1. Cotton or Burlap Mats and White Polyethylene Sheeting:

The surface of the concrete pavement and both pavement edges shall be covered with cotton or burlap mats. Prior to placement, the mats shall be thoroughly saturated with water and placed with the wettest side down.

Immediately after placement, the mats shall be covered with white polyethylene sheeting placed in accordance with paragraph 3 below. The mats shall be kept moist by periodic applications of water.

2. Impervious Membrane Method:

The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place, or if the pavement is cured initially with jute or cotton mats, it may be applied upon removal of the mats. The curing compound shall not be applied during or immediately after rainfall. Curing compound shall be, applied under pressure by approved self-propelled mechanical sprayers. The curing compound may be applied in either one (1) or two (2) applications in accordance with the directions of the manufacturer. If applied in two (2) coatings, the second shall be applied not later than thirty (30) minutes after the first. The rate of application shall be one (1) gallon to not more than one hundred fifty (150) square feet for carpet drag or broom finished surfaces and one (1) gallon to not more than one hundred twenty-five (125) square feet for metal tine-finished surfaces. The spraying equipment shall be equipped with a tank agitator and be fully atomizing. The spray fog shall be protected from the wind by an adequate shield. At the time of use, the

compound shall be in a thoroughly mixed condition. During application, the compound shall be stirred continuously by effective mechanical means. Hand spraying of odd width or shapes and concrete surfaces exposed by the removal of forms will be permitted. Curing compound shall not be applied to the inside faces of joints to be sealed, unless such compound will be completely removed by subsequent sawing operations. Ropes of moistened paper, fiber, or other suitable material shall be used to seal the top of the joint opening.

Should the film become damaged from any cause within the required curing period, the damaged portions shall be repaired immediately with additional compound.

Upon removal of side forms, the sides of the slab exposed shall be protected immediately to provide a curing treatment equal to that provided for the surface.

3. White Opaque Polyethylene Sheeting:

The top surface and sides of the pavement shall be entirely covered with polyethylene sheeting. The units used shall be lapped at least eighteen (18) inches. The sheeting shall be placed and weighted down to maintain intimate contact with the surface covered. The sheeting, as prepared for use, shall have such dimension that each unit as laid will extend beyond the edges of the slab at least twice the thickness of the pavement. In cold weather, the Engineer may permit the substitution of dark sheeting for white sheeting.

P. Removing Forms:

Unless otherwise provided, forms shall not be removed from freshly placed concrete until it has set for at least twelve (12) hours, except auxiliary forms used temporarily in widened areas. Forms shall be removed without damaging the pavement. After the forms have been removed, the sides of the slab shall be cured as outlined in one of the methods indicated above.

Q. Sealing Joints:

Joints shall be sealed with hot-poured elastic joint sealer or low modulus silicone sealant as specified on the plans. Joints shall be sealed before the pavement is opened to traffic and as soon after completion of the curing period as is feasible.

Joint grooves shall be inspected for spalling. Spalls greater than one-half (1/2) inch in depth, which impair the performance of the seal shall be repaired by patching with an epoxy mortar approved by the Engineer. Loose concrete shall be removed from the spalled area, and the spalled concrete surface shall be thoroughly cleaned. Construction shall be such that a vertical face is provided and the joint width is maintained. After cleaning, the spalled surface shall be primed, and an epoxy mortar of troweling consistency shall be placed in the spalled area and finished as the original pavement surface. After the epoxy mortar has cured, the forming material shall be carefully removed.

The epoxy binder components shall be mixed in the proportions and by methods recommended by the manufacturer. After the epoxy binder is, thoroughly mixed, dry silica sand shall be blended into the mixture to give an epoxy mortar of trowelable consistency.

Patching of spalls shall be done only when the temperature of the air and pavement are above forty (40°) degrees F.

Joints shall not be sealed unless they are thoroughly clean and dry. All materials such as old sealant, oil, asphalt, curing compound, paint, rust, and other foreign materials shall be completely removed. Cleaning shall be accomplished by sand blasting and other tools as necessary.

Just prior to sealing, each joint shall be blown out using a jet of compressed air at a working pressure of not less than ninety (90) psi to remove all trace of dust. Air compressors used for cleaning joints shall be equipped with traps capable of removing all free water and oil from the compressed air.

Joint sealer application will not be permitted when the air temperature near the joint is less than forty (40°) degrees F. or is forty (40°) degrees F. and falling.

The sealant shall be applied so the material will not be spilled on the exposed surfaces of the concrete. Any excess material on the surface of the concrete pavement shall be removed immediately and the pavement surface cleaned.

Failure of the joint material in either adhesion or cohesion will be cause for rejection, and repair shall be made at the Contractor's expense.

1. Hot-Poured Elastic Joint Sealer:

Hot-poured elastic joint sealer shall be stirred during heating so localized overheating does not occur. All joints shall be sealed with an approved pressure sealing device equipped with a nozzle inserted into the joint so sealing material will be forced from the bottom of the joint to the top.

2. Silicone Sealant:

Silicone sealant shall be applied with an approved mechanical device suitable for the intended use and shall be equipped with a nozzle or spout shaped to fit into the joint. The sealant to fill the joint shall be applied under pressure from the inside of the joint to remove entrapped air and ensure good joint contact.

Backer rod of the required size shall be installed to the proper depth to produce the width and depth of sealant shown on the plans. Stretching the backer rod during installation will not be permitted.

The sealant surface shall be tooled to produce a slightly concaved surface approximately one-fourth (1/4) inch below the pavement surface. Tooling shall be accomplished before a skin forms on the surface. The use of soap or oil as a tooling aid will not be permitted.

R. Protection of Pavement:

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by his own employees and agents. This shall include guards to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, etc. Crossovers will not be permitted until the concrete is at least twenty-four (24) hours old.

Any damaged or defective pavement shall be repaired as directed by the Engineer. When a pavement is to be removed and replaced, the Engineer will specify the dimensions of the pavement to be removed.

Uncontrolled cracking shall be repaired at the Contractor's expense. Transverse cracks shall be repaired by pressure injection with an approved epoxy material or by an alternate method approved by the Engineer. Longitudinal cracks shall be repaired by routing and sealing with an approved white or gray joint sealing material.

S. Opening to Traffic:

The pavement shall not be opened to traffic until the concrete has attained a compressive strength of four thousand (4000) pounds per square inch. The compressive strength may be checked by means of cylinders or by using a Swiss Impact Hammer in accordance with Test No. SD 409. Prior to opening to traffic, the pavement shall be cleaned.

T. Concrete Patching:

Concrete replacement for utilities, storm sewer, or similar work shall comply with the requirements herein and as follows:

1. Joints formed by new concrete and existing concrete shall be tied by drilling and epoxy grouting #10 deformed, epoxy coated rebar eighteen (18) inches long into existing concrete at mid-depth. Rebar shall extend eighteen (18) inches into new concrete. Tie bars are to be located on eighteen (18) inch centers, but no closer than six (6) inches from corners of existing concrete. This shall include existing curb and gutter.
2. Joint sawing and sealing shall be as shown for tie-bar joint or transverse contraction joint as applicable.
3. Existing joints shall be utilized as much as possible. New joints formed by this work shall be kept to a minimum.

4. Concrete streets with asphalt overlays shall be repaired as described above, except that joints may be tooled, and sealing will be waived. Asphalt overlay shall extend (6) inches beyond new pavement edges.
5. Sound, vertically straight, fully supported, unbroken edges of existing concrete will be required prior to placing new concrete.
6. Measurement and payment for this work to be in accordance with Sections 40.4 and 40.5

U. Tolerance in Pavement Thickness:

The thickness of the pavement will be determined by average caliper measurement of cores tested in accordance with AASHTO T 148 and thickness will be reported to accuracy specified herein.

Cores may be taken in areas the Engineer has reason to believe are deficient in thickness. These core measurements will not be used to determine pavement thickness as set forth in the following:

For the purpose of establishing an adjusted unit price for pavement, units to be considered separately are defined as those lengths of pavement, as specified below, starting at the end of the pavement bearing the smaller station number. The last unit in each lane shall be the appropriate length in feet for the width involved plus the fractional part of that length in feet remaining. Width of pavement represented by cores shall be the pavement surface between adjacent longitudinal construction joints, between a longitudinal construction joint and the pavement edge, or between two (2) pavement edges where the entire width of pavement is poured in one (1) operation.

Each ramp will be considered as a unit, and small irregular areas such as intersections, entrances, crossovers, etc., may be included as part of an adjacent unit.

<u>Width of Pavement to be Represented by Cores</u>	<u>Length of Unit</u>	<u>Intervals for Additional Cores</u>
up to and including 15 ft.	1,500 ft.	400 ft.
over 15 ft. thru 30 ft.	1,000 ft.	300 ft.
over 30 ft. thru 42 ft.	750 ft.	225 ft.
over 42 ft.	500 ft.	150 ft.

One (1) core may be taken at random by the Engineer in each unit. When the measurement of the core from a unit is not deficient more than two-tenths (0.2) inch from the plan thickness, full payment will be made. When such measurement is deficient more than two-tenths (0.2) inch and not more than one (1.0) inch from the plan thickness, two (2) additional cores at intervals not less than those specified above for the width of pavement represented will be taken and used in the average

thickness for that unit. An adjusted unit price as hereinafter specified will be paid for the unit represented by the cores, if the average thickness is determined to be deficient by more than two-tenths (0.2) inch. If the average thickness is not deficient by more than two-tenths (0.2) inch, full payment will be made. The average thickness will be determined by numerically averaging measurements. Location of cores will not be a factor in determining average thickness for a unit. The average thickness will be reported to the nearest one-tenth (0.1) inch.

In calculating the average thickness of the pavement measurements which are in excess of the specified thickness by more than two-tenths (0.2) inch will be considered as the specified thickness plus two-tenths (0.2) inch, and measurements which are less than the specified thickness by more than one (1.0) inch will not be included in the average. When any core is found to be deficient by more than one (1.0) inch, the length of such deficient pavement shall be determined by the procedure hereinafter described and another core shall be taken to replace the one, which was found to be deficient by more than one (1.0) inch.

When the measurement of any core is less than the specified thickness by more than one (1.0) inch, the actual thickness of the pavement in this area will be determined by taking additional cores at not less than twenty-five (25) foot intervals parallel to the centerline in each direction from the affected location, until in each direction a core is found which is not deficient by more than one (1.0) inch. The point at which the pavement is deficient by exactly one (1.0) inch will be found by assuming a straight line relationship between the core which is deficient by more than one (1.0) inch and the core which is deficient by less than one (1.0) inch. Areas found deficient in thickness by more than one (1.0) inch will not be used in averages for adjusted unit price.

**PORTLAND CEMENT CONCRETE PAVEMENT
8 INCHES AND UNDER**

Deficiency in Thickness Determined by Cores (Inches)		Proportional Part of Contract Price Allowed
From	Through	
0.00	0.20	100 per cent
0.21	0.30	80 per cent
0.31	0.40	72 per cent
0.41	0.50	68 per cent
0.51	0.70	57 per cent
0.71	1.00	50 per cent

**PORTLAND CEMENT CONCRETE PAVEMENT
OVER 8 INCHES**

Deficiency in Thickness Determined by Cores (Inches)		Proportional Part Of Contract Price Allowed
From	Through	
0.00	0.20	100 per cent
0.21	0.30	85 per cent
0.31	0.40	77 per cent
0.41	0.50	73 per cent
0.51	0.70	62 per cent
0.71	1.00	55 per cent

The foregoing provisions for tolerance in pavement thickness will apply to Portland cement concrete shoulders with the following modifications: Each shoulder will be cored separately. Unit lengths are defined as two thousand (2000) lineal feet. Full payment will be made when core deficiency is not more than three-tenths (0.3) inch from plan thickness. Additional cores in a unit will be taken at intervals of not less than six hundred (600) feet.

PORTLAND CEMENT CONCRETE SHOULDERS

Deficiency in Thickness Determined by Cores (Inches)		Proportional Part of Contract Price Allowed
From	Through	
0.00	0.30	100 per cent
0.31	0.40	80 per cent
0.41	0.50	72 per cent
0.51	0.60	68 per cent
0.61	0.80	57 per cent
0.81	1.00	50 per cent

V. Strength and Thickness Tests:

The Contractor shall submit the following test data. All sampling and testing shall be done by certified testing laboratory personnel.

Slump, air content, seven (7) and twenty-eight (28) day compressive and flexural strength.

One test per 250 lineal feet of main line paving.

One test per 250 square yards of patching.

Thickness cores per Section 40.3U.

All test results shall be submitted to the Engineer.

Failing strength tests shall be pro-rated as follows:

$$D = [(A - B) / A] * C$$

A = Specified strength

B = Average of all tests below specified strength

C = Number of failing tests divided by total number of tests times one hundred (100)

D = Percent reduction in unit price bid

If C is twenty percent (20%) or greater, the Contractor shall extend the pavement warranty period an additional two years. The City reserves the right to order additional tests. The Contractor shall pay for those additional tests that fail to meet specified strength and the City will pay for those additional tests that do meet the specified strength.

The Engineer or his representative shall be present for all field sampling and lab testing performed by/for the Contractor. Failure to notify the City of pending sampling or testing could result in rejection of submitted data and re-testing by in-place methods.

All required data shall be received by the Engineer before payment for pavement exceeds seventy-five percent (75%) of the total quantity.

40.4 METHOD OF MEASUREMENT

- A. Portland Cement Concrete Pavement, Portland Cement Concrete Shoulders, and Portland Cement Concrete Pavement - Miscellaneous:

These items will be measured by the square yard for pavement accepted, complete, in place. Pavement which is removed or for which no payment will be made, as set forth under Section 40.3U, will not be measured for payment. When an item for Portland Cement Concrete Pavement - Miscellaneous is provided in the contract, the areas of concrete pavement to be measured under this item will be described on the plans.

- B. Concrete Headers:

This item will be measured in square yards. Quantities measured under this item will not be included under the items of Concrete Pavement.

C. Admixtures:

When admixtures other than air-entraining admixtures are required by the Engineer, they will be measured in pounds, with computations based on the theoretical factor specified in the job-mix, the plan shown thickness of the concrete pavement, and the number of square yards of concrete pavement accepted for payment.

40.5 BASIS OF PAYMENT

A. Portland Cement Concrete Pavement, Portland Cement Concrete Shoulders, and Portland Cement Concrete Pavement - Miscellaneous:

These items will be paid for at the contract unit price per square yard to the nearest tenth (0.1) square yard, or the adjusted unit price as set forth in Section 40.3V.

Payment for these items will be full compensation for furnishing all materials, except admixtures specified by the Engineer, and for labor, equipment, sampling and testing and incidentals necessary to satisfactorily construct the concrete pavement. These items will also be full compensation for water used to moisten the sub grade ahead of the paver and that used for curing the concrete.

The amount bid on these items will be based on the plan shown quantity of cement per cubic yard or five hundred sixty-four (564) pounds per cubic yard for pavement and pavement - miscellaneous and five hundred twenty (520) pounds per cubic yard for shoulders, in the event no cement factor is shown on the plans.

B. Concrete Headers:

This item will be paid for at one and one-half (1 1/2) times the contract unit price per square yard of Portland Cement Concrete Pavement, which price will be full compensation for materials, labor, equipment, and incidentals necessary to satisfactorily construct the concrete headers.

C. Admixtures:

Payment for admixtures (other than air-entraining admixtures) will be made at the Contractor's cost f.o.b. jobsite material yard to the nearest whole pound, when such admixtures are specified by the Engineer. Separate payment will not be made for admixtures used at the option of the Contractor.

Compensation provided under this item will be full payment for furnishing the admixtures at the batching site.

END OF SECTION