

SECTION 400

PAVEMENT

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SECTION 401 SUBGRADE PREPARATION

401.1 DESCRIPTION

This work shall result in bringing the subgrade under pavement to the proper distance below the grade of the finished pavement by excavating or filling as necessary and in preparing the subgrade material to support the proposed pavement. All excavation, preparation and completion of the roadway subgrade, water and material furnished, mixing, blading, rolling, cleaning, and furnishing tools and labor to complete this work is included.

401.2 TESTING PROCEDURES

Tests used to determine optimum moisture content and standard density of the various soils shall conform to the methods set out in the latest revision of ASTM D-698 unless indicated otherwise on the plans. Tests used to determine optimum moisture content and standard density of the various soils shall conform to the methods set out in the latest revision of ASTM D-1557 (modified proctor) when specified by the plans.

Laboratory determination of moisture content of the various soils shall conform to the latest revisions of ASTM D-2216. Field determination of the density of the various soils shall conform to any one of the methods specified in the latest revisions of ASTM D-1556, or D-2922. Field determination of the moisture content of the various soils shall conform to any one of the methods specified in the latest revisions of ASTM D-2216 or D-3017.

Unless otherwise shown on the plans, compaction and moisture test frequency will be a minimum of one (1) test per 1,000 SY, and one (1) per structure (each side) for each 8" loose lift.

An Independent Testing Laboratory on behalf of the Contractor will complete all testing, and is subsidiary to other earthwork bid items. Copies of all test results will be made available immediately to the City and Engineer.

401.3 CONSTRUCTION REQUIREMENTS

Cut Sections:

The earth below the finished pavement grade in cut sections shall be scarified, broken up and uniformly mixed for a minimum depth of six inches (6") and for a minimum distance of twelve inches (12") beyond the back of curb lines, adjusted to a uniform moisture content as described in moisture control requirements (this section), and compacted to a density equal to or greater than ninety-five percent (95%) of standard density of the soil. The top of the finished and compacted subgrade shall be slightly higher than the bottom elevation of the proposed pavement.

Fill Sections:

Compacted fill shall be constructed as necessary to bring the subgrade to the proper elevation to support the pavement, including curb and gutter, by using excavated material for that purpose. The Contractor shall remove all sod and vegetable matter, all unstable material, and any other unsuitable material from the surface upon which compacted fill is to be placed. The surface upon which compacted fill is then to be constructed shall be scarified and broken up to minimum depth of six inches (6"), adjusted to a moisture content of not less than five percentage points below the optimum moisture content of the soil involved, and then compacted to the density requirement to which the subsequently placed compacted fill is to be constructed. Compacted fill shall be constructed of earth free from animal and vegetable matter and shall be deposited in layers of not more than six inches (6") in compacted thickness. Each layer shall be thoroughly leveled with a motor grader or bulldozer and completely compacted to the required density using a sheep's foot roller before the succeeding layer is placed.

Compacted fill shall be constructed to the line established by the bottom of the proposed pavement to a width of one foot (1') beyond the right-of-way line and then on a one-to-one

slope down to the existing ground, unless otherwise shown on plans. The process of placing six inch (6") compacted layers of earth, adjusting moisture content, and compacting the layers is to be continued until the surface of the fill is slightly above the bottom grade of the proposed pavement and to the width previously specified. The top six inch (6") layer of compacted fill upon which the pavement is to be placed for a width of twelve inches (12") wider on each side of the proposed pavement shall be brought to the previously specified uniform moisture content and then compacted to a density equal to or greater than ninety-five percent (95%) of standard density of the soil.

Final Compaction and Grading:

When cut or fill operations are complete, the subgrade shall be graded to approximately the bottom of the proposed pavement. Prior to application of any stabilizing agent (if used), the entire subgrade must be rolled with a flat steel roller weighing not less than eight (8) tons or more than fifteen (15) tons, after which all unstable areas must be removed and replaced with suitable material, and all other areas that give under the weight of the roller shall be re-compacted or otherwise secured from settlement. All work required to stabilize the subgrade prior to the application of any stabilizing agent (if used) shall be at the contractor's expense. All earthwork must be completed to approximately the proper distance below the finished grade of the pavement and to the minimum widths specified prior to proceeding with the next phase of construction on the subgrade. The subgrade must then be brought to a true grade immediately in advance of paving operations, using procedures previously described in this section.

Trenches and Excavation:

It shall be the responsibility of the Contractor to insure that all trenches or excavations made in the subgrade are backfilled properly, adjusted to the required uniform moisture content, and compacted to the specified density. The top two-foot layer of all trenches that have been sand filled and flushed shall consist of material identical to the surrounding subgrade and shall be compacted in the same manner as previously specified to the required density.

Moisture Control Requirements:

The moisture content of the soil being compacted shall be considered as being too high to insure compaction when after repeated rolling with the sheepsfoot roller, the roller continues to pick up excessive amounts of soil and refuses to "build up" so that the tamping feet eventually ride the compacted surface. When heavy clay soils are encountered actual moisture content of the soil shall be no more than two percentage points above the optimum moisture of that soil during compaction.

When other types of rollers are used, the moisture content of the soil shall be considered as excessive when "bridging" or "building up" of the soil occurs in front of, or behind the wheels of such rollers, and/or when earth-hauling equipment produces excessive ruts in the rolled surfaces.

Frozen Soil:

When frozen soil exists in either the surface of the original ground or the surface of a partially constructed fill, work shall not proceed until such time that the frozen soil has completely thawed or been removed. Frozen soil shall not be used in constructing compacted fill.

SECTION 402 LIME TREATED SUBGRADE

402.1 DESCRIPTION

This work consists of incorporating Carbide lime sludge, Hydrated lime or Pebble quicklime, as a stabilizing agent, into prepared roadway subgrades. Only one type of lime shall be used on each individual project. All subgrade preparation and completion of the subgrade, water and material furnished, mixing, blading, rolling, testing, equipment and labor necessary to complete this work is included at the contract unit price bid per square yard, S.Y. All testing will be in accordance with Section 401.2.

402.2 MATERIALS

General:

The available lime index expressed as a percentage by weight of calcium and magnesium oxides (non-volatile basis), shall be determined by the "Rapid Sugar" test as set out in ASTM C-25. The lime supplier shall certify, in writing that the lime furnished meets the requirements specified below.

Hydrated Lime:

Hydrated lime shall have a chemical composition such that the minimum available lime index shall not be less than ninety percent (90%). The fineness of the hydrated lime shall be such that not more than five percent (5%) will be retained on a No. 30 sieve or more than twenty percent (20%) will be retained on a No. 200 sieve.

Pebble Quicklime:

Pebble quicklime shall have a chemical composition such that the minimum available lime index shall not be less than ninety percent (90%). The fineness of the pebble quicklime shall be such that one hundred percent (100%) will pass a 5/8-inch sieve and not less than eighty percent (80%) will be retained on a 1/4-inch sieve.

402.3 TESTING PROCEDURES

Tests used to determine optimum moisture content and standard density of the various soils shall conform to the methods set out in the latest revision of ASTM D-698 unless indicated otherwise on the plans. Tests used to determine optimum moisture content and standard density of the various soils shall conform to the methods set out in the latest revision of ASTM D-1557 (modified proctor) when specified by the plans.

Laboratory determination of moisture content of the various soils shall conform to the latest revisions of ASTM D-2216. Field determination of the density of the various soils shall conform to any one of the methods specified in the latest revisions of ASTM D-1556, or D-2922. Field determination of the moisture content of the various soils shall conform to any one of the methods specified in the latest revisions of ASTM D-2216 or D-3017.

Unless otherwise shown on the plans, compaction and moisture test frequency will be a minimum of one (1) test per 1,000 SY.

An Independent Testing Laboratory on behalf of the Contractor will complete all testing, and is subsidiary to other earthwork bid items. Copies of all test results will be made available immediately to the City and Engineer.

402.4 SUBGRADE PREPARATION

Prior to the application of the lime, the subgrade shall be prepared as described in Section 401.

402.5 APPLICATION

General:

No lime shall be applied unless the temperature is at least forty (40) degrees F. in the shade, away from artificial heat, and rising. Lime shall be spread on the subgrade in the specified manner and in such a quantity that the required amount of lime can be incorporated into the subgrade soil. The soil, lime, and water shall be mixed by approved road mixers or other approved equipment until a uniform mixture is obtained and all clods and lumps are reduced to a maximum of two and one-half inches (2 ½") diameter in size. This mixture shall extend to a depth of six inches (6") and for a distance of twelve inches (12") beyond the back of the curb lines of the pavement, unless indicated otherwise by the plans or contract.

Hydrated Lime:

Hydrated lime shall be mixed with water and applied using approved pressure distributing equipment. The slurry shall consist of a mixture of approximately one ton of lime to each five hundred (500) gallons of water but shall not contain more than forty percent (40%) lime. Agitation of the slurry mixture shall be accomplished by using paddles, recirculating pumps, or a combination of these devices. Constant agitation of the slurry mixture will be required to keep the lime and water in a uniform mixture. The use of compressed air to aid in the mixing of the slurry will not be permitted. Lime to be applied as a slurry shall be spread the same day that the slurry is mixed in order to avoid carbonation (reaction with CO₂ in the air).

Pebble Quicklime:

Quicklime shall be spread on the subgrade dry, using approved equipment that has demonstrated its ability to distribute the lime in controlled and uniform amounts. Water shall not be added to the quicklime until it is thoroughly mixed into the subgrade soil.

Dry lime shall not be applied when the wind conditions are such that blowing lime will be objectionable to traffic or adjacent property owners.

The quantity of water necessary for the first mixing operation will vary with the nature of the soil and normally will be three to five percent (3-5%) above the optimum moisture content of the treated soil mixture. Sufficient water shall be added during the first mixing process to insure proper chemical reaction between the lime and soil, and to completely dissolve all lime solids and allow the solution to penetrate the soil clods.

402.6 INITIAL CURING

When proper first mixing has been accomplished, the mixture shall be placed in a windrow or spread over the roadbed and the surface sealed by lightly rolling with a flat steel wheel or pneumatic roller to retard the loss of moisture and aged for a period of not less than forty-eight (48) hours. The aging process may be shortened, depending upon the type of soil involved. The mixed material shall be maintained in a moist condition of not less than two percent (2%) below optimum moisture during the aging process.

402.7 RE-MIXING AND COMPACTION

After the required initial curing time, the soil-lime material shall be re-mixed and pulverized by approved methods until one hundred percent (100%) of the mixed material by dry weight passes a one and one-half inch (1 ½") sieve and at least sixty percent (60%) by dry weight will pass a No. 4 sieve, exclusive of stone and gravel. The moisture content of the mixed material shall be adjusted during the final mixing process so that the moisture at the time of compaction will be within two percentage (2%) points above or below the optimum moisture of the mixed material.

Compaction and finishing operations shall proceed immediately upon completion of the final mixing. Sheepsfoot rollers shall be used in compaction operations so that the compaction of the mixture will begin at the bottom and shall continue until the entire depth of mixture is uniformly compacted to the specified density. The moisture content shall be maintained within two percentage (2%) points of the optimum moisture during compaction operations. The mixture shall

be laid and compacted to a density of at least ninety-five percent (95%) of the standard density of the soil-lime mixture. Light sprinkling may be required during laying and compacting operations to maintain the specified moisture content. Compaction shall be accomplished with sufficient blading to eliminate all irregularities. The surface shall be lightly scarified during finishing operations and bladed to eliminate any imprints left by the equipment. Final rolling of the completed surface shall be accomplished with a flat steel roller. The subgrade shall be brought to a true grade immediately in advance of placing pavement. The surface of the roadbed shall then be adjusted by cutting off the high areas and filling in the low areas as indicated by the screed or template. The fill in low areas is to be compacted to the same density requirement as previously specified.

402.8 FINAL CURING

Upon completion of the compaction and finishing of the treated subgrade no vehicles or equipment other than sprinkling equipment shall be permitted upon the treated subgrade for a period of seven days; however, the seven-day curing may be reduced to whatever period of time is required for the treated subgrade to gain sufficient stability to support the construction equipment if the construction of the pavement on the treated subgrade takes place in less than the seven-day period after the completion of the lime treatment. Any damage to treated subgrade due to other phases of construction shall be repaired at the Contractor's expense. The treated subgrade shall be cured by lightly sprinkling the surface with water at frequent intervals to prevent drying during the seven-day curing period or until the pavement is constructed.

SECTION 403 PORTLAND CEMENT/FLY ASH TREATED SUBGRADE

403.1 DESCRIPTION

This work consists of incorporating Portland Cement or Fly Ash, as stabilizing agents, into prepared roadway subgrades. All subgrade preparation and completion of the subgrade, water and material furnished, mixing, balding, rolling, testing, equipment and labor necessary to complete this work is included at the contract unit price bid per square yard, S.Y. All testing will be in accordance with Section 401.2.

403.2 MATERIALS

Fly Ash:

Fly ash shall meet requirements of ASTM C-618, Class C, and shall come from an approved source.

Portland Cement:

Portland cement shall be Type I/II and shall meet the requirements of ASTM C-150.

403.3 TESTING PROCEDURES

Tests used to determine optimum moisture content and standard density of the various soils shall conform to the methods set out in the latest revision of ASTM D-698 unless indicated otherwise on the plans. Tests used to determine optimum moisture content and standard density of the various soils shall conform to the methods set out in the latest revision of ASTM D-1557 (modified proctor) when specified by the plans.

Laboratory determination of moisture content of the various soils shall conform to the latest revisions of ASTM D-2216. Field determination of the density of the various soils shall conform to any one of the methods specified in the latest revisions of ASTM D-1556, or D-2922. Field determination of the moisture content of the various soils shall conform to any one of the methods specified in the latest revisions of ASTM D-2216 or D-3017.

Unless otherwise shown on the plans, compaction and moisture test frequency will be a minimum of one (1) test per 1,000 SY.

An Independent Testing Laboratory on behalf of the Contractor will complete all testing, and is subsidiary to other earthwork bid items. Copies of all test results will be made available immediately to the City and Engineer.

403.4 SUBGRADE PREPARATION

Prior to the application of cement or fly ash, the subgrade shall be brought to the proper elevation, removing all soft spots as described in Section 401.

The surface of the subgrade shall be scarified to a depth necessary to provide the quantity of material, which when combined with the cement/fly ash, will produce a compacted subgrade of the thickness designated on the plans. The scarified soil shall be processed with approved graders, discs, harrows, or rotary mixers until 75 percent (75%) of the soil, by dry weight, exclusive of gravel or stone, shall pass a No. 4 sieve. The requirement of 75 percent (75%) passing the No. 4 sieve may be waived at the direction of the Engineer for predominately coarse sandy soils, but the Contractor shall still pulverize the soil to the extent that homogenous mixture of soil and cement/fly ash can be obtained. The use of gang plows or blades will be required in this operation to insure that the full depth of material will be loosened from the subgrade and pulverized. The length of roadway scarified and pulverized at any time shall not exceed the length, which can be completed in accordance with these specifications in two working days. The soil shall be manipulated and brought to a moisture content of not greater than three percentage (3%) points below the optimum moisture of the soil involved before application of the cement/fly ash.

403.5 APPLICATION

Application rates for cement/fly ash will be consistent with the various types of subgrade soils. Application shall not be performed when the subgrade is frozen, the temperature in the shade is less than 50 degrees Fahrenheit for cement or 40 degrees Fahrenheit for fly ash, or when wind conditions are such that blowing material becomes objectionable to traffic or adjacent property owners. The soil and cement/fly ash mixture shall extend to a depth of six inches (6") and for a distance of twelve inches (12") beyond the back of the curb lines of the pavement unless indicated otherwise by the plans or contract.

Either bagged or bulk cement may be used. When bulk cement is used, approved spreading and weighing equipment shall be provided by the Contractor. When bagged cement is used, the manufacturer's bagged weights shall be accepted to determine the rate of application. Bags shall be placed in a uniform and regular pattern on the subgrade and the frequency of placing shall be determined by rate of application. The bags shall then be opened and the cement spread evenly over the subgrade using a motor grader or other approved method.

Fly ash shall not be applied by the slurry method. The fly ash shall not be placed on wet subgrade or otherwise allowed to become wet during application.

403.6 MIXING AND COMPACTION – CEMENT

Cement shall be added as previously specified upon completion of the soil preparation. The cement and soil shall be thoroughly mixed prior to addition of any water. The equipment used in all mixing shall be such that a uniform mix for the full depth of the material will be assured. Any mixture of soil and cement that has not been compacted shall not remain undisturbed for more than thirty minutes. Water shall be added to the soil-cement mixture upon completion of the dry mixing by the use of pressure distributors. Each application of water shall be partially mixed to avoid a concentration of water near the surface. The addition of water shall be controlled so that the moisture content of the completed mixture falls inside a range from optimum to five percent (5%) above optimum moisture of the soil- cement mixture. Sufficient water distribution equipment shall be used to insure the continuous application of all water required on the section of roadway being processed within a two-hour period. The mixing of the soil-cement mixture and water shall be done with discs, harrows, blades, plows, and tillers until the full thickness of the material is thoroughly and uniformly mixed.

Compaction shall begin within thirty, (30) minutes after the material has been mixed and spread. The full thickness of the material shall be compacted to a density of not less than 95 percent (95%) of standard compaction of the soil-cement mixture. The compaction operation shall be sufficient to compact the section of roadway being processed within a period of two (2) hours after compacting operations begin. Sufficient light blading shall be done during the compaction operations to blade out all irregularities and to insure a smooth finished surface conforming to the plan cross-section. Enough sprinkling shall be done during the compaction operation to insure that the moisture content of the mixture will stay in the required range.

Cement shall be applied only to such an area that all operations from the application of the cement to the final compaction can be continuous, and all compaction and finishing completed within a period of six (6) hours after the beginning of the water application to the mixed soil-cement. When any of the operations after application of the cement are interrupted for a period of more than two (2) hours for any reason, or when the uncompacted soil cement mixture is wetted by rain so that the average moisture content at the time of completing compaction is greater than five percentage (5%) points above the optimum moisture content, the entire section affected shall be reconstructed in accordance with these specifications by the Contractor at his expense.

The surface of the cement-treated base shall be trimmed to the required line and grade by means of equipment that is automatically controlled with regard to both longitudinal and transverse slopes.

The City may waive the use of automatically controlled equipment on narrow widths or areas of irregular dimensions where operation of the automated equipment is impractical.

When required, the surface shall be lightly scarified to loosen any imprints left by the compacting and shaping equipment. The resulting surface then shall be thoroughly rolled with steel-wheel or pneumatic-tired rollers or both.

The surface of the material shall be kept moist during all finishing operations. Surface compaction and finishing of the section being processed shall be done in such a manner as to produce a relatively smooth, dense surface, essentially free of surface compaction planes, cracks, ridges or loose material. The completed base course shall conform to the grades, lines and typical cross section shown on the plans with compacted and dressed edge slopes and all evidence of laps between the various sections eliminated. With the approval of the Engineer, surface finishing operations may be varied, provided the quality of the work is as outlined above.

Sufficient equipment shall be in operation on the project so that all operations can be carried on in their proper sequence without delay and so that final compaction, rolling and finishing can be completed during daylight hours.

At the end of each day's operations, or in case of construction delays that will cause operations to cease, and at a point where satisfactory construction has been completed, a straight transverse construction joint shall be formed by cutting back into the completed work to form a true vertical face. A protective covering of earth shall be placed on the newly constructed base course for a distance back of the joint required for the turning of equipment used on the following day's work. The thickness of the covering shall be such that the equipment will not mar or damage completed work.

403.7 MIXING AND COMPACTION - FLY ASH

Mixing:

Mixing of the fly ash with the subgrade soil shall follow application and spreading as a continuous construction operation. Mixing lifts shall not exceed plan lift thickness unless previously approved. Work areas for mixing shall not exceed 5,000 square yards.

The mixing procedure shall be as hereinafter described:

- a.) First Mixing.** The moisture content of the subgrade soil shall not exceed eighty percent (80%) of optimum at the time of first mixing. The soil and fly ash shall be mixed until a uniform mixture is obtained in which all clods and non-aggregate lumps are reduced to a maximum of two and one-half inches (2.5") diameter size. The addition of water will not be permitted during first mixing. First mixing operations shall begin no later than four (4) hours after application of the fly ash.

When deemed necessary, any portion of the work area shall be re-scarified and additional fly ash added to insure adequate soil modification.

The fly ash and soil shall be thoroughly mixed to the satisfaction of the Engineer prior to the beginning of final mixing operations.

- b.) Final Mixing.** After the dry soil and fly ash have been satisfactorily mixed, additions of water shall be made in the final mixing operations to initiate soil-fly ash reaction. The method of mixing shall be an approved procedure utilizing a traveling rotary mixing plant, which demonstrates uniform dispersion of fly ash and water throughout the soil materials. The quantity of water necessary for the final mixing operations will vary with the nature of the materials, normally two to five percentage (2-5%) points above the optimum moisture content of the compacted modified soil. Sufficient water in any case shall be added in the final mixing process to insure chemical reaction between the fly ash and soil.

All clods shall be reduced in size by mixing until the soil-fly ash mixture meets the following size requirements when tested with laboratory sieves:

<u>Sieve Size</u>	<u>Percent Passing</u>
1 ½ inch	100
¾ inch	50-100

c.) **Optional.** The following alternate mixing procedure may be used at the option of the Contractor and with the approval of the Engineer in lieu of the procedure described in the above paragraphs. The moisture content of the soil shall be adjusted to between two (2) and five (5) percentage points above optimum prior to application of any fly ash. Fly ash shall then be applied and mixing shall begin immediately. The soil and fly ash shall be mixed until a uniform mixture is obtained in which all clods and non-aggregate lumps are reduced to a size such that one hundred percent (100%) will pass a one and one-half inch (1 ½") screen and fifty percent (50%) to one hundred percent (100%) will pass a three quarters inch (¾") screen. Sufficient water shall be added in this mixing process to insure chemical reaction between the fly ash and water throughout the soil materials. Compaction shall begin immediately after the mixing is completed when this prescribed procedure is used.

Compaction:

Compaction of the soil-fly ash mixture shall be performed immediately after final mixing, wherein the compaction operation shall be a continuation of the final mixing operation. Each lift of mixed fly ash-soil material shall be compacted full depth to a density of not less than ninety-five percent (95%) of standard compaction of the fly-ash soil material.

The soil-fly ash mixture shall be compacted without delay and before any appreciable loss of mixing moisture occurs. Mixing and compaction operations shall be performed in such a manner that the mixture will be compacted within plus or minus three percentage (3%) points of optimum moisture content. However, when deemed necessary during the course of construction, changes or adjustments in the specified moisture requirements to meet field conditions may be authorized.

Compaction shall continue until the entire depth of the mixture is uniformly compacted. The rate of operation and the number of rollers shall be sufficient to compact uniformly the section of roadway being processed within two (2) hours after introduction of water.

During the early stages of subgrade construction, the Contractor will report compaction test results promptly for each stage of fly ash modified subgrade construction to establish a construction procedure that will attain the required density within the prescribed two (2) hours.

The material shall be sprinkled and rolled. All irregularities, depressions or weak spots which develop shall be corrected immediately by scarifying the areas affected, adding or removing material as required, and reshaping and recompacting by sprinkling and rolling.

In addition to the requirements specified for density, the full depth of the material shown on the Plans shall be uniformly compacted to the extent necessary to remain firm and stable under construction equipment. After each section is completed, density tests as necessary will be made by the Contractor. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. Rework shall include the addition of more fly ash. at a rate. Throughout this entire operation the shape of the course shall be maintained and the surface upon completion shall be smooth and in conformity with the typical sections shown on the Plans and to the established lines and grades. Should the material, due to any reason or cause, lose the required stability, density or finish before the next course is placed or the work is accepted it shall be recompacted and refinished at the sole expense of the Contractor.

403.8 CURING AND PROTECTION

The completed cement/fly ash treated subgrade shall be protected against loss of moisture for a period of seven (7) days. The curing time may be reduced to a minimum period of three (3) days only when approved by the Engineer and as further determined by individual project conditions. The completed cement/fly ash treated subgrade shall be protected against loss of moisture by covering with an approved moisture barrier such as moist burlap or polyethylene sheet, or at the option of the Contractor and at his own expense, an application of emulsified asphalt may be applied, using approved pressure-distributing equipment immediately after the completion of the finishing operations. The asphalt emulsion shall contain not less than forty percent (40%) of asphalt and shall preferably be of the quick-breaking type of emulsion.

Immediately prior to the application of the bituminous curing membrane, however, the surface shall be thoroughly wetted by means of approved pressure-distributing equipment. No free water shall remain on the surface when the bituminous material is applied. The Contractor shall keep all traffic off the cement/fly ash-treated subgrade after the curing medium has been applied and until the base has cured for the specified length of time.

The Contractor shall be required to maintain, at his own expense, the entire roadway within the limits of the improvement, in good condition from the time he first starts work until all work has been completed. Maintenance shall include immediate repair of any defects that may occur either before or after the cement/fly ash is applied to the subgrade soil.

Cement/fly ash treated subgrades shall be constructed to elevations such that it will not be necessary to cut or trim in excess of one inch (1") of material off the subgrade.

**SECTION 404
GEOGRID REINFORCED AGGREGATE BASE**

404.1 MATERIALS

General:

Materials to be used for geogrid reinforced base construction shall consist of virgin crushed stone, recycled Portland cement concrete, or a blend of recycled Portland cement concrete and Reclaimed Asphalt Pavement (RAP). This blend is not to exceed 50% RAP and shall be tested by use of an asphalt burn off oven to ensure compliance. All materials shall meet the following gradation specification.

Stone/Concrete/Blended Aggregate:

1) Gradation

Sieve Size	% Retained (by dry weight)
2-1/2"	0
3/4"	20-60
#4	50-80
#40	80-94
#200	90-98

2) Durability

Virgin base material quality shall conform to the requirements specified by KDOT Subsection 1102 for Durability Class 1.

3) Absorption

All virgin base material shall have a maximum absorption of four percent (4%).

Biaxial Geogrid:

The geogrid shall be a regular grid structure formed to provide tensile strength biaxially, both in the machine and cross machine directions of the grid, and shall have aperture geometry and rib and junction cross-sections sufficient to permit significant mechanical interlock with material being reinforced. The geogrid shall maintain its reinforcement and interlock capabilities under repeated dynamic loads while in service and shall also be resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced.

The geogrid shall be a single layer, non-bonded mat. The same product shall be used throughout a project, unless approved by the Engineer prior to installation. The geogrid shall be: Checkmate BX 1515, MacGrid EG 11, MacGrid EG 12, MacGrid EG 41, Mirafi Base XGrid 11, Mirafi Base XGrid 12, Mirafi BXG 110, Mirafi BXG 120, Syntec SBX 11, Syntec SBX 12, Tensar BX 1100, Tensar BX 1200, Tensar BX 4100, Tenax MS 220 B, or approved equal.

Standard Biaxial Geogrid

Property	Test Method	Units	Value	
			MD ¹	CMD ¹
<u>Interlock</u>				
Open Area	COE Method ²	% (min)	70	
<u>Reinforcement</u>				
Tensile Modulus Initial (@ 1% strain)	ASTM D 6637	lb/ft (min)	14,000	20,000
Tensile strength Initial (@1% strain)	ASTM D 6637	lb/ft (min)	200	250
@ 2% strain	ASTM D 6637	lb/ft (min)	280	330
@ 5% strain	ASTM D 6637	lb/ft (min)	580	630
Ultimate	ASTM D 6637	lb/ft (min)	860	910
Junction strength Ultimate	GRI-GG2 ³	lb/junction (min)		30
Ultimate	GRI-GG2 ³	lb/ft (min)	360	360
<u>Material</u>				
UV Resistance (@ 500 hours)	ASTM D 4355	% Strength Retained (min)	60	

Notes:

1. Machine Direction (MD) is along roll length and Cross Machine Direction (CMD) is across roll width.
2. Percent open area measured without magnification by Corps of Engineers method as specified in CW 02215 Civil Works Construction Guide, November 1977.
3. Revised July, 2000.

High Strength Biaxial Geogrid

Property	Test Method	Units	Value	
			MD ¹	CMD ¹
<u>Interlock</u>				
Open Area	COE Method ²	% (min)	70	
<u>Reinforcement</u>				
Tensile Modulus Initial (@ 1% strain)	ASTM D 6637	lb/ft (min)	27,500	45,000
Tensile strength Initial (@1% strain)	ASTM D 6637	lb/ft (min)	275	450
@ 2% strain	ASTM D 6637	lb/ft (min)	410	620
@ 5% strain	ASTM D 6637	lb/ft (min)	810	1340
Ultimate	ASTM D 6637	lb/ft (min)	1310	1970
Junction strength Ultimate	GRI-GG2 ³	lb/junction (min)		30
Ultimate	GRI-GG2 ³	lb/ft (min)	360	360
<u>Material</u>				
UV Resistance (@ 500 hours)	ASTM D 4355	% Strength Retained (min)	70	

Notes:

1. Machine Direction (MD) is along roll length and Cross Machine Direction (CMD) is across roll width.
2. Percent open area measured without magnification by Corps of Engineers method as specified in CW 02215 Civil Works Construction Guide, November 1977.
3. Revised July, 2000.

Geotextile Fabric:

The fabric shall consist of high tenacity monofilament and fibrillated polypropylene yarns. The fabric shall maintain its reinforcement, filtration, and separation capabilities under repeated

dynamic loads while in service and shall also be resistant to ultraviolet degradation, to damage under normal construction practices and to all forms of biological or chemical degradation normally encountered in the material being reinforced.

The fabric shall be a single layer, non-bonded material. The same product shall be used throughout a project unless approved by the Engineer prior to installation. The geotextile shall be Mirafi HP 370 Woven Fabric, Mirafi HP 570 Woven Fabric, or approved equal.

Standard Geotextile Fabric

Property	Test Method	Units	Value
<u>Characteristics</u>			
Coefficient of Interaction Ci (Sand)	ASTM D 5321		0.8
Flow Rate	ASTM D 4491	gal/min/ft	40
Permeability	ASTM D 4491	cm/sec	0.050
Permittivity	ASTM D 4491	1/sec	0.0152
AOS	ASTM D 4751	US Sieve #	30
<u>Reinforcement</u>			
Tensile Strength			
@ 2% strain	ASTM D 4595	lb/ft (min)	540
@ 5% strain	ASTM D 4595	lb/ft (min)	1350
Ultimate	ASTM D 4595	lb/ft (min)	2700
<u>Material</u>			
UV Resistance (@ 500 hours)	ASTM D 4355	% Strength Retained (min)	70

High Strength Geotextile Fabric

Property	Test Method	Units	Value
<u>Characteristics</u>			
Coefficient of Interaction Ci (Sand)	ASTM D 5321		0.8
Flow Rate	ASTM D 4491	gal/min/ft	30
Permeability	ASTM D 4491	cm/sec	0.050
Permittivity	ASTM D 4491	1/sec	0.050
AOS	ASTM D 4751	US Sieve #	30
<u>Reinforcement</u>			
Tensile Strength			
@ 2% strain	ASTM D 4595	lb/ft (min)	960
@ 5% strain	ASTM D 4595	lb/ft (min)	2400
Ultimate	ASTM D 4595	lb/ft (min)	4800
<u>Material</u>			
UV Resistance (@ 500 hours)	ASTM D 4355	% Strength Retained (min)	70

404.3 CONSTRUCTION REQUIREMENTS

Subgrade Preparation:

Prior to placement of the geogrid, the subgrade shall be prepared as described in Section 401.

Placing and Overlapping Geogrids:

Place geogrid/fabric in position and roll out over the prepared subgrade. Geogrid/fabric should be cut to conform to manhole covers or other protrusions. Geogrid/fabric should be cut and overlapped as necessary to accommodate curves. Unless otherwise indicated in the plans or project provisions, all geogrids and fabrics shall be overlapped one foot (1') in both the longitudinal and transverse directions. Pin overlaps to secure against separation and to provide anchorage. Over very soft ground, wire, plastic ties or hog rings can be used on five to twenty-foot spacings as necessary to secure overlaps.

Tensioning and Pinning:

Pin beginning of roll to ground with six-inch (6") "U" staples or other approved fastener. Pin at edges, overlaps, and center of roll width. Over soft ground it may only be necessary to secure the end with stakes, rocks, or fill.

Pull geogrids tight by hand to take up all slack.

- a) **Firm Ground:** Anchor geogrid to the ground at edges, including overlaps, and in center of roll on thirty foot (30') intervals along the roll length.
- b) **Soft Ground:** Anchor only the roll ends. The geogrids will conform to the ground surface as the fill material is dumped.

Anchor the terminal ends of the roll. If the overlap is required for advancing rolls, overlap as noted previously and anchor at the overlap.

Dumping and Spreading:

- a) **Soft Subgrade:** Back Dump or End Dump and Spread. Thin fill lifts over very soft subgrades may not be sufficient to support loads of fill and heavy equipment. Low ground pressure tractors and low tire pressures (less than 4 psi) are recommended for hauling and spreading fill over these conditions. Do not operate equipment directly on the grid. Insure at least four inches (4") of fill is between the grid and vehicle.

Back dump specified fill onto the geogrid where subgrade is most stable. Spread the fill material over the geogrid out toward the softer subgrade.

Grade fill to the specified thickness. Raise the blade gradually as the fill is pushed out over the grid. This causes much of the fill to roll out onto the grid and reduce stresses on the subgrade.

Back dump subsequent loads on to the leveled fill and advance forward by spreading with a dozer.

- b) **Firm Subgrade:**
Dump while driving over. Adequate anchoring is required in this case to prevent haul traffic from pushing or shifting the grid out of position on the ground.

Rubber tire tracks (end and belly dumps) can drive over the grid at very slow speeds, less than 5 mph, and dump fill as they do. Avoid turning and sudden stops. Do not drive tracked vehicles directly on the grid. Ensure at least four inches (4") of fill is between the grid and tracks.

Back Dumping can be employed over firm ground as described for soft ground conditions.

Grade fill material to desired thickness. Raise the blade while leveling fill.

Crown fill during the grading process to assure rainfall runoff and prevent fill saturation.

Compaction:

Compact fill to project specifications after it is graded smooth and before it is open to truck traffic. Inadequate compaction will result in surface rutting under wheel loads. This reduces the total thickness of the fill and increases stress on the subgrade. Note: Compaction equipment should be the type appropriate for fill and subgrade conditions that exist. Do not use vibratory compactor on fill over very soft saturated subgrades. It may cause a "quick" condition resulting in rapid subgrade strength loss.

Repairs:

Should the geogrid be damaged during or after installation, repair by patching.

Remove fill from the surface of the grid at the damaged area and three feet (3') around in all direction.

Place a geogrid patch of appropriate dimensions to cover the damaged area and extending three feet (3') beyond in all directions.

Replace fill and compact.

Finish:

Rock base is to be compacted and smoothed with a steel faced roller prior to placement of asphalt or concrete pavement. Tack coat will not be applied to rock base.

SECTION 405 ASPHALTIC CONCRETE PAVEMENT

405.1 DESCRIPTION

This item shall consist of leveling, surface and/or base courses and curbs placed upon the previously prepared base or subgrade in accordance with these specifications to the compacted thickness and design shown on the plans is incidental to the work, and measured in-place by the ton.

All new asphalt Marshall job mix submittals with aggregate quality reports and gradations will be tested and certified for compliance on behalf of the Contractor by an Independent Testing Laboratory at no cost to the City, and is subsidiary to the asphalt paving items. Proven asphalt Marshall mix designs and aggregates approved by KDOT (within 1-year of construction) may be used providing there is no change in material(s), or source of material(s). All materials (aggregate and asphalt cement) must comply with these specifications.

405.2 MATERIALS AND MANUFACTURE

Aggregate:

Approved sources of supply for stone, gravel, sand, and mineral filler supplement will be used in asphaltic mixtures. All test procedures shall be conducted in accordance with the latest standards or tentative standards of the American Society for Testing and Materials. Individual aggregates having more than ten percent (10%) retained on the No. 8 sieve shall have a percent of wear of not more than forty percent (40%) when tested by the Los Angeles Abrasion Test Method. Individual aggregates having more than ten percent (10%) retained on the No. 8 sieve shall have a loss of not more than fifteen percent (15%) when tested by the Sodium Sulfate Method as specified in the latest revision of ASTM C-88. That portion of individual aggregates retained on No. 30 sieve shall have a maximum absorption of four percent (4%). Individual aggregates used in surface course mixes which have more than ten percent (10%) retained on the No. 8 sieve shall have a loss of not more than eighteen percent (18%) when tested by the Magnesium Sulfate Method as specified in ASTM C-88.

All aggregates and mineral filler supplements to be used in asphaltic mixtures shall be free from alkali, acids, organic matter, or injurious quantities of other foreign substances. Other deleterious substances in each individual aggregate or mineral filler supplement shall not exceed the following percentages by weight:

<u>Substance</u>	<u>Max. %</u>
Sticks (wet)	0.1%
Shale, shale like, or soft friable material, singly or in combination	1.0%
Coal	0.5%

a.) Crushed Rock

Crushed rock shall be produced from durable rock. The crushed rock shall have a percent of wear of not more than forty percent (40%) when tested by the Los Angeles Abrasion Test Method. Crushed rock shall be of uniform quality throughout, without an excess of flat or elongated pieces and it shall be clean and free from dust such that not more than four percent (4%) of the material will pass the No. 200 sieve.

b.) Crushed Gravel

Crushed gravel shall be produced by crushing siliceous or calcareous gravel. At least ninety percent (90%) of the particles retained on the No. 4 sieve shall have one or more fractured faces to be considered as crushed gravel. The screenings resulting from the crushing of gravel will not be considered as crushed aggregate. Crushed

gravel shall be clean and free from dust such that not more than four percent (4%) of the material will pass the No. 200 sieve. Crushed gravel having more than ten percent (10%) retained on the No. 8 sieve shall have a percent of wear of not more than forty (40%) when tested by the Los Angeles Abrasion Test Method.

c.) Sand-gravel

Sand-gravel shall be a mixture of natural sand and gravel formed by the disintegration of siliceous and/or calcareous rocks. Natural sand shall consist of particles of aggregate resulting from the natural disintegration of siliceous and/or calcareous rocks. Manufactured sand shall be produced by crushing predominately siliceous sand and gravel. Sand-gravel having more than ten percent (10%) retained on the No. 8 sieve shall have a percent of wear of not more than forty (40%) when tested by the Los Angeles Abrasion Test Method. That portion of sand-gravel passing the No. 40 sieve shall have a plasticity index of not more than 6. Sand-gravel shall be graded such that not more than twenty percent (20%) will pass a No. 200 sieve.

d.) Chat

Chat shall consist of mine run or screened tailings produced during the milling of lead and zinc ores in the mining district of Southeast Kansas, Southwest Missouri, and Northeast Oklahoma. Chat shall be graded such that when mixed with the other aggregates the combined gradation will conform to the specified requirements.

e.) Screenings

Screenings shall be produced by crushing aggregates that meet the quality requirements for crushed rock. The gradation shall be such that not more than two percent (2%) will be retained on the three-eighths inch (3/8") sieve and not more than forty percent (40%) will pass the No. 200 sieve. That portion of screenings passing the No. 40 sieve shall have a plasticity index of not greater than 6.

f.) Mineral Filler

Mineral filler is defined as that portion in the final combined mix that is finer than the No. 200 sieve. Material to supplement the mineral filler in the coarser aggregates, when required, shall consist of Portland cement, pulverized limestone, hydrated lime, or processed and dewatered chat sludge. All mineral filler supplements shall be approved by the City. Mineral filler supplements shall be free from cemented lumps and must be easily pulverized. The blending of two or more materials to produce a mineral filler supplement will not be permitted. Material to be used as a mineral filler supplement shall have a plasticity index of not greater than 6. Hydrated lime or Portland cement to be used as a mineral filler supplement shall conform to the same requirements as specified for these materials in the specifications for treated subgrade, Sections 402 and 403. Pulverized limestone and processed chat sludge shall be graded such that not more than forty percent (40%) of the material will be retained on the No. 200 sieve when used as a mineral filler supplement. Silt will have a minimum of fifty percent (50%) passing the 200 sieve.

Asphalt Cement:

Asphalt cement shall be of uniform consistency, free from water to the extent that it will not foam when heated to three hundred fifty degrees (350°) F., and it shall meet the following requirements for physical and chemical properties:

Polymer Modified Performance Grade Asphalt Cement

Original Binder:

- Flash Point (°C), 230
- Rotational Viscosity at 135°C (Pa's), 3 max
- Dynamic Shear at grade temperature (kPa), 1.00 min.
- Separation (°C max), 1.00 max.

Rolling Thin Film Oven Residue:

- Mass Loss (%), 1.00 max

Dynamic Shear at grade temperature (kPa), 2.20 min.
Elastic Recovery at 25°C, 10 cm Elongation (% min), 65 min
Pressure Aging Vessel Residue:
Dynamic Shear at test temperature (kPa), 5,000 max.
Creep stiffness at test temperature, stiffness 300 max MPA & m Value 0.300 min.

Non-Polymer Modified Performance Grade Asphalt Cement

Original Binder:
Flash Point (°C), 230
Rotational Viscosity at 135°C (Pa's), 3 max
Dynamic Shear at grade temperature (kPa), 1.00 min
Rolling Thin Film Oven Residue:
Mass Loss (%), 1.00 max
Dynamic Shear at grade temperature (kPa), 2.20 max.
Pressure Aging Vessel Residue:
Dynamic Shear at test temperature (kPa), 5,000 max.
Creep stiffness at test temperature, stiffness 300 max MPa & m Value 0.300 min.

Unless otherwise shown on the plans, all asphaltic concrete pavement placed on city projects shall use PG 64-22 asphalt cement for non-arterial streets; and PG 70-28 for arterial streets. Mill & overlay projects using BM1-B surface mixes shall also use PG 70-28 graded oil. The Contractor may substitute an alternate grade of asphalt that complies with or exceeds the upper and lower grade designations for the grade specified. Such substitutions require advanced approval by the Engineer and any additional cost will be the responsibility of the Contractor.

Composition of Asphaltic Mixtures:

Aggregates, mineral filler and asphalt shall comply with the requirements, as stated previously in this subsection. The Contractor shall submit to the Engineer prior to the start of paving operations a complete listing of Individual Aggregate Sieve Analysis, Mix Combination Sieve Analysis and any other pertinent data on the mixes to be used in the project. The Engineer may use the submitted design in whole, or in part, at their discretion. The mix design shall be adjusted as necessary when a change in the source of materials is approved. Any mix design that proves to be unsatisfactory shall be adjusted by the Engineer. There shall not be less than three percent (3%) or more than twenty-five (25%) percent of material between any two successive sieves in the following series: No. 4, 8, 16, 30 and 50. The requirements for the percent retained on the No. 200 sieve (dry screen) will be waived, provided the plasticity index of the mineral filler is four (4) or less.

Salvaged hot mix asphaltic materials may be recycled and combined with new materials to produce asphaltic base course and surface mixtures for use in construction of such base courses and surface courses as required by plans. The combination of salvaged hot mix asphaltic material with new materials shall not exceed thirty-five percent (35%) for base course mixtures or fifteen percent (15%) for surface course mixtures. Recycled materials will not be allowed in the BM-IB surface mixture. All base course mixtures containing recycled asphaltic material shall conform to the standard specification requirements for the base mix used on the project. All surface course mixtures containing recycled asphaltic material shall conform to the standard specification requirements for the surface course mix used in the project.

Gradation Requirements:

Mineral Aggregate Percentages by Weight Retained

Base Sieve Size	Surface Course BC-I	Surface Course SC-I	Surface Course BM-2	Course BM-IB
2-1/2"				
1-1/2"				
1"0	0			
3/4"	0-12		0	0
1/2"		0-8		0-10
3/8"	2-35	0-18	8-30	12-26
#4		18-39		39-56
#8	30-66	35-53	42-72	60-76
#10				
#16		50-68		72-87
#20				
#30	60-82	60-80	64-88	79-92
#40				
#50		70-88		84-95
#80				
#100		80-93		88-98
#200	89-96	90-95	90-97	92-98
P-200	4-11	5-10	3-10	2-8

The combined material for asphalt surface course, SC-I, shall contain not less than 47 percent crushed material, including the material passing the No. 200 sieve.

The combined material for asphalt surface course, BM-IB, shall contain not less than 75 percent crushed material, including the material passing the No. 200 sieve. In addition, course aggregate (#4+) used in BM-IB shall have a maximum absorption of two percent.

Design Requirements:

All asphalt mixtures shall conform to the following Marshall requirements when tested in accordance with the latest revision of ASTM D-1559.

Mix Type	BC-I	SC-I	BM-2	BM-IB
Min Stability (lbs)	1000	1600	1600	1800
Voids (%)	3-7	3-5	3-5	3-5
VFA (%)	70 min.	70 min.	70 min.	68-78

BM-IB requirements shall be for a 75-blow Marshall.

405.3 PAVING PLANT

All plants used by the Contractor for the preparation of asphalt paving mixtures shall conform to the applicable sections of the KDOT Standard Specifications unless specified otherwise. All bins used in storing mixed asphalt material shall be completely enclosed. All elevators used to handle mixed asphalt materials during periods of adverse weather conditions shall be completely enclosed. Adverse weather conditions shall be defined either as rainy or foggy weather, prevailing temperatures of less than sixty degrees (60°) F., or gusting and prevailing winds over twenty (20) miles per hour.

All methods of plant operation shall conform to applicable sections of the latest edition of the KDOT Standard Specifications, unless noted otherwise in these specifications.

Asphalt paving mixtures may be prepared by using a drum mix type asphalt plant when approved by the Engineer. The approval of and continued use of a drum mix type asphalt plant shall be contingent upon its ability to proportion and mix satisfactorily the required materials in accordance with the specifications such that the finished work will be equal to the work produced as if accepted standard methods had been used.

405.4 PAVING PLANT OPERATION

Sand and Stone Storage. The different kinds of sand and stone used shall be kept separate, using such provisions as deemed necessary to keep them from becoming mixed.

All aggregates for surface mixture shall be delivered to a revolving drier. The aggregates shall be heated to a temperature of between 275 degrees F. and 350 degrees F. The aggregate shall then be weighed in accordance with the approved mix. Each batch shall be mixed by first charging the mixer with the coarse and fine aggregate along with the mineral filler and thoroughly mixed, then the asphalt cement shall be added and the mixing continued for at least 45 seconds or longer if necessary to produce a homogenous mixture in which all particles of the aggregate are uniformly coated.

The asphalt cement shall be delivered to the surface mixture at a temperature of 275 degrees F. to 350 degrees F.

The Contractor shall provide notice of intent to mix and place asphalt materials as far in advance as is possible and the minimum time for such notification shall be 24-hours. Mixed asphalt material that has been stored over night will not be used.

405.5 CONSTRUCTION REQUIREMENTS

Equipment used in the construction of asphalt pavements such as hauling equipment, bituminous pavers, heating equipment, bitumen distributors, compacting equipment, and weighing equipment shall conform to the applicable sections of the latest edition of the KDOT Standard Specifications. Equipment that performs unsatisfactorily shall be removed from the job.

405.6 PREPARATION OF THE BASE

Prepared Subgrade or Geogrid Aggregate Base:

After the roadbed has been prepared, as described in Sections 403, it shall be maintained during asphalt placement until completely covered. It shall be the Contractor's sole responsibility to maintain the subgrade as prepared, and any defect, which may develop, shall be corrected at his expense prior to paving.

Existing Bituminous Surface:

When the surface is constructed on an existing bituminous surface, the surface shall be cleaned of all foreign material and broomed free of dust. In addition, any loose, broken or shattered bituminous material along the edges of the existing surface shall be removed and the exposed subgrade and a sufficient width of the shoulder adjacent to the edge of the existing surface to receive the new bituminous mixture shall be shaped, bladed and broomed to provide a uniform trim subgrade for the new surface course.

The existing mat, base, or subgrade shall be removed through broken, shattered, or unstable areas as shown on the Plans or designated by the City. The areas shall be excavated 'Full, and refilled with compacted bituminous base mixture is incidental to the work, and measured in-place by the square yard, S.Y.

Tack Coat:

Prior to the placing of the mixture a tack coat shall be applied to the existing surface. The type of asphalt used shall be emulsified asphalt (CSS-1h), or (SS-1h), and the rate of application shall be as shown on the plans except as set forth below.

Tack coat shall be diluted in the proportion of 50 percent water and 50 percent emulsion and applied at the rate of 0.05 to 0.10 gallons per square yard.

Tack coat shall be applied by distributor trucks designed, equipped, and maintained to provide uniform coverage at the designated application rate. Hand spray by means of hose or bar through a gear pump or air tank shall be acceptable for resurface work, corners or tacking or vertical edges. Care shall be taken to provide uniform coverage. Equipment that performs unsatisfactorily shall be removed from the job.

405.7 PLACING REQUIREMENTS

General:

The bituminous mixture shall be spread and finished reasonably true to crown and grade by the automatically controlled bituminous paver. Bituminous mixtures may be spread and finished by hand methods only where machine methods are impractical.

The automatically controlled paver shall spread the bituminous mixtures without tearing the surface and shall strike a finish that is smooth, true to cross section, uniform in density and texture, and free from hollows, transverse corrugations and other irregularities.

The paver shall be operated at a speed which will give the best results for the type of paver being used and which coordinates satisfactorily with the rate of delivery of the mixture to the paver so as to provide a uniform rate of placement without undue intermittent operation of the paver.

All mixed material shall be delivered to the paver in time to permit completion of spreading, finishing and compaction of the mixture during daylight hours. Nighttime work on projects not open to traffic may be permitted when ample lighting and other satisfactory measures are provided.

The longitudinal joints in successive courses shall be offset not less 6-inches (6") nor more than twelve inches (12"). The width of the surface of the top course placements shall conform to traffic lane edges.

Bituminous mixtures, except on leveling courses, shall be spread in a placement thickness so that after rolling the nominal thickness of the compacted mat will not in general exceed the following:

<u>Surface Course</u>	<u>Intermediate</u>	<u>On fresh subgrade</u>
2"	4"	4"

The maximum thickness for lifts may be increased when such increase is more adaptable to total pavement thickness and when approved, it is not detrimental to placement and rolling conditions. The Contractor may request a change in the lift thickness in order to obtain the most efficient combination of aggregate type, lay down equipment, mixture characteristics, temperatures and rolling equipment to produce the required density and surface characteristics.

Established Grade:

The Contractor will make the survey required for the reference grade as shown on the plans. The Contractor shall erect and maintain a reference string line and operate the paver to conform to the string line for the initial lift, and/or any lift if specified.

If automatic profile road building type equipment is used to prepare the subgrade, the requirements for an erected reference string line may be waived.

The Contractor shall furnish and maintain an approved mobile string line for all lifts not laid with the erected string line, and operate the paver to conform to that string line. The erected string line shall be erected parallel to the reference grade, and the bituminous mixture shall be spread at a constant elevation above, below or at the string line elevation.

The use of the automatically controlled bituminous paver to provide both longitudinal and transverse control shall include the furnishing and maintaining of a string line, whether it be erected or mobile, by the Contractor. The longitudinal and transverse controls shall operate independent of each other to the extent that the surface of the bituminous mixture will reasonably conform to the string line and will be reasonably uniform in cross-section or crown.

Machine Spreading:

On the initial traffic lane paving operation, the asphaltic mixture shall be spread with the bituminous paver to grade line constant to the Reference String Line as required.

The erection and maintenance of the Reference String Line shall be so coordinated that the string will be taut and free from sags at the time it is in use as a guide for the paver.

On second and subsequent lay-downs, the asphaltic mixture shall be spread as described for the initial lay-down except that the spreading of the asphalt shall conform to the motion of the Mobile String Line.

The Mobile String Line or equivalent shall be used as the reference guide on all paving operations except when the Reference String Line is used or other approved provisions are made.

On the new construction where paving starts on fresh earth subgrade, the survey may be delayed to the surface of the first course and the use of the Reference Grade Line may be delayed to the first lay-down operation of the second course.

If the existing surface is of acceptable centerline grade as determined from the profile survey, the Engineer may permit the use of the mobile string line for all lifts.

The use of the automatically controlled paver may be waived on irregular sections or other sections as designated.

Spreading and Surface Tolerances:

The Contractor shall make checks and adjustments as indicated to maintain the rate of spreading within the required calculated weight per unit of area so as to produce a compacted lift thickness in substantial conformity to the design or specified thickness.

Where leveling courses or variable depth courses are specified, the rate of spreading shall be at rates in accordance with the intent of the Plans or as directed by the Engineer.

The surface will be tested by the Contractor using a ten-foot (10') straight edge at selected locations at the Engineer's discretion. The variation of the surface from the testing edge of the straight edge between any two (2) contacts with the surface shall not exceed one-fourth inch (1/4"). All necessary corrections will be at the expense of the Contractor.

Placing Temperature:

All asphaltic surface course mixtures shall be delivered to the place of construction within a temperature range of between two hundred sixty degrees (260°) F. and three hundred thirty-five degrees (335°) F. Asphaltic base mixtures shall be delivered to the place of construction within a temperature range of between two hundred twenty degrees (220°) F. and three hundred thirty-five degrees (335°) F. The temperature of the asphaltic mixtures shall be regulated within these limits in accordance with the workability of the mix and the weather conditions. The temperature of the asphaltic materials shall be maintained at the above indicated maximum temperature when hand spreading and raking of the material is required.

For polymer modified asphalt mixtures with a Performance Grade of 70-28 or greater, and whether for base or surface course, the mixture shall be delivered to the place of construction

within a temperature range of between two hundred seventy-five degrees (275°) F and three hundred thirty-five degrees (335°) F.

Weather Limitations for Placing Asphaltic Mixtures:

Asphaltic mixtures shall not be placed on any wet or frozen surface or when the weather conditions otherwise are detrimental to the proper handling or finishing of such mixtures. Asphaltic mixtures shall not be placed when the air temperature as measured in the shade is less than 40°F. Asphaltic base course material with thicknesses of three inches (3") or more may be placed when the air temperature, as measured in the shade, is 30°F or above with the approval of the Engineer if density and Marshall requirements can be obtained.

For polymer modified asphalt mixtures with a Performance Grade of 70-28 or greater, base mixtures may be placed when the air temperature, as measured in the shade, is 45°F or above, and surface mixtures may be placed when the temperature, as measured in the shade, is 50°F or above, with the approval of the Engineer and if density and Marshall requirements can be obtained. In addition, asphalt surface temperature for all subsequent placement after first base lift shall be 50°F or above.

405.8 COMPACTION OF MIXTURES

Equipment:

After spreading and strike-off and as soon as the temperature and mix conditions permit the compacting to be performed without excess shoving or tearing, the mixture shall be thoroughly and uniformly compacted.

Rollers shall be self-propelled and shall be in good condition, capable of reversing without backlash, and shall be operated at speeds slow enough to avoid displacement of the bituminous mixture. The number and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition. The use of equipment which results in excessive crushing of the aggregate will not be permitted. A minimum of two (2) rollers, one (1) steel wheel and one (1) pneumatic tire type, shall be used with each spreading operation unless otherwise specified by the Engineer.

The frequency, amplitude and forward speed of the vibratory roller shall be coordinated to achieve satisfactory compaction without objectionable undulations.

The selection of the type of roller to be used on the breakdown rolling may be varied to suit mix characteristics. The final rolling of the top or surface course shall be accomplished with a steel roller unless otherwise designated. When the specified density is not obtained, changes in size and/or number of rollers or compactive device shall be made as corrective measures to satisfy the density requirement.

Rollers or other compactive devices shall be operated by competent and experienced roller men and shall be kept in operation continuously if necessary so that all parts of the pavement will receive substantially equal compaction at the time desired. The Contractor will cease operations at any time proper compacting is not being performed.

Density Requirements:

Any mixture that becomes loose, broken, mixed with foreign material, or which is in any way defective in finish or density, or which does not comply in all other respects with the requirements of the Specifications shall be removed, replaced with suitable material, and finished in accordance with these Specifications.

For specified lift thickness of one and one-half inches (1 ½") or greater, the bituminous mixture shall be compacted to a Road Density equal to or greater than the percent of the Field Mold Density as set forth below.

Required Field

<u>Type Aggregate</u>	<u>Mold Density</u>
Bit. Base Course	95%
Bit. Surface Course	95%
Bit. Shoulders (All Agg. Types)	90%

When the lift thickness as specified is less than one and one-half inches (1 ½"), the bituminous mixture shall be compacted using a minimum of two (2) approved rollers and in such a manner so as to obtain the best possible consolidation. If available, non-destructive test methods may be used to establish a suitable compactive procedure.

When the area to be compacted is not intended to carry traffic, such as certain types of median areas, compaction shall be achieved by the best suitable equipment.

Contact Surfaces:

Contact surfaces of curbing, gutters, manholes and similar structures shall be painted with a thin uniform coating of emulsified asphalt (CSS-1h) or (SS-1h) material. The bituminous mixture shall be placed uniformly high near the contact surfaces so that after compaction it will be one-fourth inch (1/4") above the edge of such structures.

Joints:

Joints between old and new pavements or between successive day's work shall be made so as to insure through and continuous bond between the old and new mixtures. Transverse construction joints in previously laid material may be constructed by cutting the material back for its full depth so as to expose a fresh surface. Where a wooden header is used at a construction joint, the cutting may be omitted provided the joint conforms to the specified thickness and cross-section.

Before placing the fresh mixture against a cut joint or against old pavement, the contact surface shall be sprayed or painted with a thin uniform coat of emulsified asphalt material. Where a finishing machine is used, the longitudinal joint shall be made by overlapping the screed on the previously laid material for a width of at least one inch (1") and depositing a sufficient amount of mixture so that the joint formed will be smooth and tight.

Density Testing:

Density testing including Marshall plugs as requested, and/or established roll procedures will be completed on behalf of the Contractor by an Independent Testing Laboratory at no cost to the City, and is subsidiary to the asphalt pavement items. Copies of all test results will be available immediately to the City and Engineer. The City reserves the right to sample the aggregates and asphalt at the asphalt plant and to conduct tests to verify its compliance.

Testing shall occur at the following frequencies:

Base Course:	1 Laboratory Property Test per day 1 Field Density Test per lift per 1,000 SY
Surface Course:	1 Laboratory Property Test per day 1 Field Density Test per lift per 1,000 SY

SECTION 406 PORTLAND CEMENT CONCRETE PAVEMENT

406.1 DESCRIPTION

This item shall consist of a pavement composed of plain or reinforced jointed Portland cement concrete on a prepared subgrade. The Contractor shall furnish all labor, materials and equipment necessary for the construction of the pavement in accordance with these specifications and in reasonably close conformity to the lines, grades, thicknesses and details indicated by the plans. All mix designs and testing (aggregates and gradations, concrete field testing, cores...etc.) will be completed on behalf of the Contractor by an Independent Testing Laboratory at no cost to the City, and is subsidiary to the concrete pavement items. Copies of all test results will be available immediately to the City and Engineer. The City reserves the right to sample the aggregates and concrete at the ready-mix plant and to conduct tests to verify its compliance.

406.2 MATERIALS

Steel Reinforcement:

Reinforcing steel for concrete shall be deformed billet-steel bars conforming to the requirements for Grade 40 in the latest revision of Standard Specification for Deformed Billet Steel Bars for Concrete Reinforcement (ASTM A-615). The supplier shall certify in writing that the reinforcing steel meets the required chemical and physical properties. The City reserves the right to sample and test reinforcing bars after arrival at the construction site to verify the supplier's certification. Such test samples shall be duplicate bars not less than 36 inches in length and bars from which such samples are obtained shall be replaced at the Contractor's expense. All reinforcement bars shall be cut and bent in the fabricating shop before shipment to the project, unless otherwise authorized by the Engineer. All reinforcement bars shall be bent cold. All reinforcement bars or steel shall be free from detrimental dirt, scale, grease, oil, fins, tears, excessive rust, or any other foreign substance.

Welded steel wire fabric used as reinforcement for concrete shall conform to the latest revision of ASTM A-185. Gages, spacing and arrangement of wires and dimensions of units in flat sheet form or rolls shall conform to the requirements as specified by the plans or contract. The supplier shall certify in writing that the welded steel wire fabric meets the required chemical and physical properties. The City reserves the right to sample and test welded wire fabric after arrival at the construction site to verify the supplier's certification. All welded steel wire fabric shall be free from detrimental dirt, scale, grease, oil, fins, tears, excessive rust or any other foreign substance.

Cement:

Cement shall meet the requirements of the standard specifications for Portland cement, ASTM C150, except that the total alkalis $\% \text{Na}_2\text{O} + (0.638 \times \% \text{K}_2\text{O})$ shall not exceed 0.60 percent. Type II cement shall have a sum of tricalcium silicate and tricalcium aluminate not exceeding 58.0 percent and the percentage of tricalcium silicate shall not be less than 40 percent in addition to the preceding requirements. Type I cement may be used for all concrete work. Type II cement may be used only when approved by the Engineer. Cement of different types shall not be mixed during storage or used alternately in any one part of a structure. Cement shall be stored in railroad cars or in other suitable moisture-proof storage. Caked or reclaimed cement shall not be used. The cement supplier and the concrete producer shall certify in writing that the cement used conforms to the required chemical and physical properties. The City reserves the right to sample the cement at the concrete production site and to test it to verify the certification.

Fine Aggregate:

Fine aggregate to be used in concrete shall consist of natural sand resulting from the disintegration of siliceous and/or calcareous rocks and manufactured sand produced by crushing predominantly siliceous materials and shall be uniformly graded from coarse to fine. This type of aggregate shall be free from injurious amounts of organic impurities and from injurious amounts of alkali. Other deleterious substances shall not exceed the following percentages by weight:

Material passing No. 200 sieve	2.0
Shale, lignite, coal, soft or flaky fragments	1.0
Sticks (wet)	0.1
Clay lumps (wet, on No. 4 sieve)	0.25

Fine aggregate shall meet the following gradation requirements when tested as specified by ASTM Method C 136:

Retained on 3/8 inch sieve	0%
Retained on No. 4 sieve	0%-5%
Retained on No. 8 sieve	0%-24%
Retained on No. 16 sieve	15%-50%
Retained on No. 30 sieve	40%-75%
Retained on No. 50 sieve	70%-90%
Retained on No. 100 sieve	90%-100%

The fine aggregate shall also have a fineness modulus of not less than 2.50 or more than 3.40 and the percent retained between any two consecutive sieves shall not be more than twenty- five percent (25%).

Fine aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 24 hours prior to being used to produce concrete. The City reserves the right to sample fine aggregate at the concrete production site and to conduct tests to verify that the aggregate meets the specified requirements.

Coarse Aggregate:

Coarse aggregate to be used in concrete shall consist of gravel, crushed gravel, crushed stone or a combination thereof conforming to the requirements prescribed in ASTM C-33, or the latest revisions thereof, except that the percentage of wear shall not exceed forty percent (40%) as tested by the Los Angeles Abrasion Test Method and the loss shall not be more than eighteen percent (18%) as tested for soundness by the Magnesium Sulfate Method. Coarse aggregates used in concrete mixes shall have a maximum absorption of three and five tenths percent (3.5%).

Grading requirements shall be size No. 67, 3/4" to No. 4	
Retained on 1" mesh sieve	0%
Retained on 3/4" mesh sieve	0%-10%
Retained on 3/8" mesh sieve	45%-80%
Retained on #4 mesh sieve	90%-100%
Retained on #8 mesh sieve	95%-100%

Fly Ash:

All fly ash shall meet the requirements of ASTM C-618, Class C. Certificates shall be provided identifying the source of the fly ash for review and approval by the Engineer. Fly ash such as produced in furnace operations utilizing liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The maximum substitution of Portland Cement with fly ash in any fly ash-approved city concrete mix shall not exceed 15% by weight. All concrete mix designs, including those with fly ash, shall be approved by the Engineer prior to use.

Various Proportions:

a.) 6.6 Sack City Mix

Unless noted otherwise, concrete to be used in all construction shall contain 6.6 sacks of cement per cubic yard of concrete minimum; a maximum water content, including surface moisture; but excluding water of absorption of the aggregates of .48 water/cement ratio, maximum. Fine and coarse aggregate shall be combined in such proportions that the limits of the total aggregate retained on the No. 4 mesh sieve will be a minimum of the thirty percent (30%) and a maximum of fifty percent (50%). The maximum permissible slump shall be four inches (4"). Cement and aggregates shall be proportioned at a central mixing plant in which measurement is by weight. Water used in concrete shall be suitable for human consumption. Concrete to be used for all construction shall contain an approved air-entraining admixture in such quantity that the entrapped air will be controlled between four percent (4%) and eight percent (8%). Mixes may also include approved non-chloride accelerators, normal, mid-range and high-range water reducers. When 6.6-sack mix is used, no vehicular traffic shall be allowed on the new concrete for at least seven (7) days or until a flexural strength of 550 psi has been attained.

b.) 8 Sack Sand Mix

Wheelchair ramps and sidewalks outside of driveway approaches may consist of an approved mixture of sand only with 8 sacks of cement per cubic yard of the concrete. No vehicular traffic shall be allowed on sand mix.

c.) 733 Pound Mix

When specified for street pavement, curb and gutter, driveways, parking lots, etc., an approved mix with 733 pounds of cement per cubic yard of concrete shall be used.

Street pavement constructed with a 733-pound mix shall be opened to vehicular traffic when flexural strength reaches 550 psi.

Driveway and parking lot pavement constructed with a 733-pound mix shall be opened to vehicular traffic 96 hours after placement without a flexural strength test.

d.) High Early Strength Mixes

When specified, the Contractor shall provide a high-early (HE) concrete mix to meet the following requirements. All design mixes shall have a minimum 28-day compressive strength of 3500 psi. The use of chloride accelerators will not be permitted.

<u>Designation</u>	<u>Strength (psi)</u>	<u>Time (hrs)</u>
HE-1	3000	6
HE-2	3000	12
HE-3	3000	24
HE-4	3000	36

Design:

The Contractor shall be responsible for the design and the proper combination of aggregates, cement, and water within the limits of these specifications to produce the best possible mix. The Contractor or concrete producer shall furnish to the Engineer in writing all criteria used in the mix design for each type of concrete including, but not limited to, the saturated and surface dry specific gravity of the individual aggregates, the dry and rodded unit weights of the individual aggregates, the percent by volume of the individual aggregates, the fineness modulus of the individual aggregates, the type of mix, the water content, the design slump, the theoretical weight per cubic foot of the concrete, the gradation of the individual aggregates, the percent by volume of entrapped and/or entrained air, the design moisture condition of the individual aggregates, the quantity of air entraining admixture per cubic yard

to produce the design air entraining, the gallons of water to be added per cubic yard of mixed concrete, and the batch weights of aggregate and cement per cubic yard of mixed concrete. The batch weights of the aggregates and the quantity of water in the design mix shall be adjusted to correspond with the moisture condition of the aggregates at the time the concrete is produced. The Engineer shall require the Contractor or concrete producer to re-design any concrete mix when the fineness modulus of the aggregates varies plus or minus 0.20 from the fineness modulus of the aggregates used in the original mix design at the expense of the Contractor.

Mixing:

All proportioning shall be done at a central proportioning plant in which measurement is by weight or approved metering device.

The ingredients of the concrete shall be thoroughly mixed and the consistency of concrete shall be determined by the Standard Method of Slump Test for Consistency of Portland Cement Concrete, ASTM C-143. The concrete shall be mixed in quantities required for immediate use. Concrete shall not be used which has developed initial set or is not in place one-half (½) hour after the water has been added. Re-tempering concrete by adding water or by other means will not be permitted. The desired slump shall be three inches (3") to be used in concrete base construction, and the maximum slump permitted shall be four inches (4").

The concrete shall be mixed not less than sixty (60) seconds. When double compartment mixers are used, the minimum mixing time in the first compartment shall be thirty (30) seconds and the total mixing time, including transfer time, shall not be less than sixty-five (65) seconds.

The concrete may be mixed by a paving mixer into which the material, including the water, can be precisely and regularly proportioned, and which will produce a concrete of uniform consistency in color and the materials thoroughly and uniformly mixed.

The paving mixer shall be equipped with a batch meter and automatic locking timing device. The water tank shall be equipped with a scale graduated in gallons and fractions thereof. The water-measuring device shall be capable of accurate measurement to within one percent (1%) of the required amount. The paving mixer shall be equipped with a boom and bucket, full power controlled, which shall be so operated that the batches may be uniformly distributed on the subgrade.

All equipment used to produce, mix and transport concrete shall conform to the applicable sections of the latest edition of the Kansas State Department of Transportation Standard Specifications. Transit mixed concrete may be used for all work in lieu of a paving mixer. Concrete mixed in transit shall conform to the applicable sections of the latest edition of KDOT Standard Specifications.

Testing:

Concrete used in all construction shall develop a compressive strength of not less than four thousand (4,000) pounds per square inch in twenty-eight (28) days. Compressive strength shall be determined according to the Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens, ASTM C-39, by an Independent Testing Laboratory on behalf of the Contractor.. All testing is considered to be subsidiary to items for which direct payment is made. Copies of all test results shall be immediately made available to both the City and the Engineer.

No vehicular traffic shall be allowed on the new concrete for at least seven (7) days or until a compressive strength of 4,000 psi has been attained.

The testing frequency shall be as specified below:

Concrete Pavement:

- One (1) set of compressive testing specimens (7, 28, 28 and one spare) per 2,000 SY placed, or a minimum of one (1) set per day's work.
- One (1) slump, air and yield test per ½ day's work.

Weirs:

- One (1) set of compressive testing specimens per weir (7, 21, 28 day and spare).
- One (1) slump, air and yield per weir.

Curing Compound:

Liquid curing membrane shall conform to the requirements of the KDOT Standard Specifications, latest Edition.

Other curing methods may be used when approved by the Engineer. All curing methods shall be accomplished without additional compensation.

406.3 CONSTRUCTION REQUIREMENTS

Thickness:

The minimum thickness of the concrete pavement shall be as shown by the Plans or as indicated in the Proposal with its upper surface constructed to finished grade without waves or other irregularities in its surface.

All holes left from taking cores by the Contractor for the Engineer to inspect the work must be immediately filled with concrete by the Contractor without additional compensation.

Prepared Subgrade:

After the roadbed has been prepared as described in Sections 401-403, it shall be maintained during concrete placement until completely covered. It shall be the Contractor's sole responsibility to maintain the subgrade as prepared and any defects which may develop shall be corrected at his expense. Dry or dusty subgrade shall receive a water spray immediately prior to placing concrete.

Placing Forms and Steel:

Straight forms shall be a metal having adequate thickness to support the equipment and shall be furnished in sections not less than ten feet in length. Forms shall have a depth equal to the prescribed edge thickness of the concrete being placed without any horizontal joints. Forms to be used as track for subgrade planers and finishing machines shall have a base width of at least eight inches wide. Flexible or curved forms of proper radius shall be used for curves of 150-foot radius or less except approved straight forms of five-foot length may be used for curves of a radius from 75-to-150 feet. Flexible or curved forms shall be of a design acceptable to the Engineer. The Engineer may approve the use of wood forms in areas requiring hand finishing. The forms shall have provisions for locking the ends of abutting form sections together tightly and for secure setting. The top face of the form shall not vary from a true plane more than one-eighth of an inch in ten feet. Forms shall be staked into place with not less than three pins for each ten-foot section and a pin shall be placed at each side of every joint. Form sections shall be tightly locked together at the joints and shall be free from play or movement in any direction. Forms with battered top surfaces, and bent, twisted, or broken forms shall not be used and shall be removed from the project. Repaired forms shall not be used until inspected and approved by the Engineer.

Forms shall be joined securely and set with exactness to the correct grade and alignment and supported firmly during the entire operation of placing and finishing so that they will not deviate more than one-eighth of an inch from a straight edge ten feet in length. A form-grading machine shall be used to excavate the subgrade in preparation for setting forms to be used as track for subgrade planers and finishing machines. The foundation under the forms shall be hard and true to grade so that the form, when set, will be firmly in contact for its entire length and at the specified grade. The building of pedestals of earth to bring the forms to the required grade will not be permitted. The foundation shall be thoroughly

tamped, either mechanically or by hand, at both the inside and outside edges of the forms after the forms have been set. No excessive settlement or springing of forms under the finishing machine will be tolerated. When any form has been disturbed or any grade has become unstable, the form shall be reset. The alignment and grade elevations of the forms shall be checked and corrections made by the contractor immediately before placing concrete. Forms shall be cleaned before setting and oiled prior to placing any concrete.

Reinforcing steel bars and fabric shall be set in proper location and position prior to placing concrete. Reinforcement for slabs shall be installed at a location midway between the top and the bottom of the slab, unless noted otherwise on the plans. Bar chairs shall be used to support the reinforcement in the specified position. Bars shall be lapped a minimum of twenty-four inches (24") when it is necessary to splice bars. Fabric shall be lapped such that the lap shall extend beyond the first wire of each sheet and securely wired at intervals not to exceed two feet and six inches (2'6") for the full width of the sheet. Bars shall be securely tied with wire ties at all crossings. Bar Chairs used to support reinforcement shall be fabricated such that they will securely anchor the reinforcement in a lateral and vertical position during the placing of concrete.

Placing and Finishing:

Slip Form Paving machines may be used, provided the machine is electronically controlled and has provisions for accurate conformation to the required grades.

Concrete shall be placed with a self-propelled finishing machine of suitable design and contour, excepting at intersections and other locations of irregular contour. The finishing machine shall be so operated and manipulated that concrete is uniformly distributed without segregation and, after final passage of the machine, is left uniform in thickness and contour and with the surface free from irregularities. Concrete shall be thoroughly spaded or otherwise manipulated to avoid honeycombing at each edge of the slab or around structures.

Concrete shall be vibrated with a vibrator having a frequency of about 3,000 revolutions per minute, excepting at intersections and other locations in the street, which do not have uniform contours. The vibrator shall be the type that will thoroughly and completely agitate concrete from top to bottom for full width of the slab.

Where conditions are such that it is not feasible to use a self-propelled finishing machine and vibrator, a screed with a vibrator attachment may be used in place of the self-propelled finishing machine. Whether the self-propelled finishing machine or screed with vibrator is used will be determined by the Engineer.

The surface of the concrete shall be hand finished to remove any irregularities or corrugations in the surface of the pavement. The finished surface shall be checked with a ten-foot (10') aluminum straight edge just before the initial set of the concrete, and any irregularities more than one-fourth inch (1/4") shall be corrected.

Expansion, Contraction, and Longitudinal Joints:

Expansion joints shall be constructed using a fiber expansion joint filler meeting the requirements of ASTM D1751.

Non-extruding expansion joints are to be constructed at locations indicated on the plans. Upon approval of the Engineer, expansion joints may be constructed by placing redwood boards meeting the requirements for Type A expansion joint material in the KDOT Standard Specifications.

The expansion joint material shall be placed such that the top of the joint material will be parallel with and 1/2 or 3/4 of an inch (1/2" or 3/4") below the finished surface of the pavement. The joint material must be securely held in place by using metal stakes, metal pins or by other approved methods so that when the pavement is completed the expansion

material will be perpendicular to the surface of the pavement. The subgrade shall be trimmed and fine-graded by hand at locations of expansion joints to permit their proper installation when necessary. A 1/2" or 3/4" filler strip having the same width as the expansion material being used shall be fastened to the top of the expansion material in such a way that it can be easily removed upon completion of the edging and finishing of the joint. The filler strip shall not be removed until the concrete has hardened sufficiently to prevent damage to the concrete. The void formed by the removal of the filler strip is to be filled and sealed with the joint sealer specified in this section. No concrete shall extend or run continuously through an expansion joint.

No excavation or trenching will be required or allowed below the top of the completed subgrade as a part of expansion joint construction except where it may be necessary to trim and fine-grade the subgrade slightly to permit proper installation of 3/4" expansion joint material in pavements having widths of 35 feet or less between back of curbs and one inch 1" expansion joint material shall be used in expansion joints in pavements having width of more than 35 feet between back of curbs.

Contraction joints shall be constructed by sawing the pavement with an approved concrete saw at right angles to the curb lines and at intervals or locations as shown by the plans. The saw cut shall be one-fourth of the pavement thickness in depth and a minimum of 3/8" in width. Load transfer bars shall be installed across contraction joints when required by the plans. Load transfer bars shall be installed such that their final position will be parallel with the centerline and surface of the pavement. Pavement reinforcement shall not extend through contraction joints.

The joints shall not be sawed until the concrete has hardened sufficiently to eliminate tearing and raveling. All joints shall be sawed during the initial curing period and before shrinking occurs and uncontrolled cracking takes place. Any procedure which results in premature and uncontrolled cracking shall be revised immediately. All pavement sections with premature and uncontrolled cracking shall be removed and replaced at the Contractors expense.

Longitudinal joints shall be constructed in conformance with the details shown on the typical section for the width of pavement being constructed. When longitudinal joints are constructed at form line joints, an approved keyed joint with tie bars shall be used. When sawed joints are specified or used, the sawing shall conform to the same requirements as specified for contraction joints. Suitable guidelines shall be used when sawing longitudinal joints to cut the joints on the true line as shown on the plans. Joints shall be sawed to a depth equal to one-third (1/3) of the pavement thickness.

Key joints shall be installed in conformance with the typical key joint detail.

Joint Sealing:

All joints shall be sealed with hot-pour type joint sealer meeting the requirements of ASTM 1190 unless noted otherwise.

In contraction and longitudinal joints, heat resistant backer rod shall be installed prior to sealing.

Joints shall be cleaned prior to filling and this cleaning may be accomplished with compressed air jets, air and water under pressure, wire brushed, or in extreme cases the joint shall be re-sawed. The joints shall be filled immediately after cleaning. An approved nozzle designed so that the joint is filled completely from bottom to top shall be used in filing the joints.

Night and Cold Weather Operations:

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

Mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40°F., and not resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F. Under no circumstances shall concreting operations continue when the air temperature is less than 20°F.

When concreting is authorized during cold weather, the aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be so arranged as to preclude the possible occurrence of overheated areas which might injure the materials. Aggregates shall not be heated directly by gas or oil flame or on sheet metal over fire. When aggregates are heated in bins, steam-coil or water-coil heating, or other methods which will not be detrimental to the aggregates, may be used. The use of live steam on or through binned aggregates will not be permitted. Unless otherwise authorized, the temperature of the mixed concrete shall not be less than 50°F. and no more than 90°F. at the time of placing it in the forms.

If the air temperature is 35°F. or less at the time of placing concrete, the Engineer may require the water and/or the aggregates to be heated to not less than 70°F. and not more than 150°F. No concrete shall be placed on frozen subgrade nor shall frozen aggregates be used in the concrete.

Time Allowance for Placement:

Maximum time allowed between batching and discharge is as follows:

air temperature < 75° F	1.5 hour
air temperature > 75° F	1.0 hour
concrete temperature > 90° F	45 minutes

Concrete Curing and Protection:

For concrete curing and protection see Section 408.

SECTION 407 CURB, GUTTER, DRIVEWAY APPROACHES, SIDEWALK AND WHEELCHAIR RAMPS

407.1 DESCRIPTION

This work shall cover preparation, construction, finishing and testing required to construct curb, gutter, driveway approaches, sidewalk and wheelchair ramps.

407.2 MATERIALS

Testing and material requirements, proportioning, and mixing of cement, fine aggregate, coarse aggregate, and reinforcement for curbs, combined curb and gutter, sidewalks and driveways, shall conform to the requirements in Subsection 406.1 and 406.2.

407.3 CONSTRUCTION REQUIREMENTS

The subgrade for curb, gutter, driveway approaches, sidewalk and wheelchair ramps shall be brought to the proper elevation by excavating or filling as may be necessary to bring the subgrade to the proper distance below the finished grade. The top six inches (6") of subgrade for combined curb and gutter or driveways in cut sections shall have a density equal to or greater than ninety-five percent (95%) of the standard density of the soil. The top six inches (6") of subgrade for sidewalk in cut sections shall have a density equal to or greater than ninety percent (90%) of the standard density of the soil. Any subgrade for curb, gutter, driveways, and sidewalk that does not meet these density requirements shall be scarified and recompactd at the expense of the Contractor. No additional payment shall be made for the necessary excavation made below the grade line across the parking as established by the top of the curb and the elevation of the back of the sidewalk. The cost of this excavation shall be included in the unit price bid for the driveways and sidewalk.

When it is necessary to bring the subgrade for curb, gutter, driveway approaches, sidewalk and wheelchair ramps to the proper elevation by filling it shall be accomplished by using suitable excavated material. Fill for combined curb and gutter or driveways shall be constructed to the same requirements as those specified for pavement in Section 401 (Preparation of Subgrade), except the use of a flat steel roller will not be required. Fill for sidewalk shall be constructed to the same requirements as specified for combined curb and gutter or driveways except that the density requirement for the top six-inch (6") layer of the subgrade shall be ninety percent (90%) of the standard density of the soil.

All costs for subgrade preparation and testing associated with the construction of driveways shall be included in the unit price bid for Driveway Construction.

All costs for subgrade preparation and testing associated with the construction of curb and gutter, sidewalk, and wheelchair ramps shall be as identified in the contract specifications and in accordance with Section 109.

The Contractor must use accurate gauges, screeds, and finishing machines for grading subgrade and finishing surfaces for the construction of all curb, gutter, driveways, and sidewalks whether constructed in conjunction with pavement or by separate contracts.

A sand cushion may be placed on the foundation prior to construction of curb, gutter, driveway approaches, sidewalks and wheelchair ramps when approved. This sand cushion shall not exceed a thickness of one inch (1"). Forms for curb, gutter, driveways, and sidewalks may be supported by wood stakes to bring the forms to the proper elevation. Undercutting the foundation in excess of one inch (1") below the required grade shall not be permitted and if done, the foundation shall be brought to the required elevation with suitable fill material compacted to the specified density by the Contractor without compensation. All form boards used must be full dimensioned for the work to be done and they shall be smooth, straight, and of sufficient strength to resist springing out of shape. Steel forms shall be required unless otherwise approved. Forms to be used for construction of combined curb and gutter or integral curb shall meet the same

requirements as specified for forms for concrete base course or pavement construction. Curb, gutter, or sidewalk may be constructed by the slip form method, using an approved concrete mix, provided the machine is electronically controlled and has provisions for accurate conformation to the required grades. Forms meeting the specified requirements will be set, and the work finished by hand methods at all discontinuities in the work to insure accurate continuity and uniform appearance of the work. Continued use of slip form type of construction shall depend on the appearance of the work and whether or not the finished work meets the specified requirements. All concrete work must be protected from injury from any source. The surface must be cured with an approved curing compound (see Section 408).

Testing:

All testing of compressive strength and concrete properties shall be performed by an Independent Laboratory. All testing shall be considered subsidiary to items for which direct payment is made. Copies of all test results shall be immediately made available to both the City and the Engineer. One (set) of compressive test specimens shall be collected and tested per project (7, 21, 28 and spare). One (1) slump, air and yield test shall be conducted per project.

407.4 MIXING AND PLACING CONCRETE

General:

Concrete shall be placed in accordance with the requirements of Subsection 406.3.

All holes left from taking cores by the Contractor for the Engineer to inspect the work must be immediately filled with concrete by the contractor without additional compensation.

Optimum moisture, standard density, field density and/or field moisture content of the various soils shall be determined by the methods as set out in Section 401.

Concrete for wheelchair ramps and sidewalk other than driveway approaches may be 6.6 sack City mix in accordance with Subsection 406.2.

Time allowance for placement of concrete shall be in accordance with Section 406.3

407.5 SIDEWALKS

All sidewalks shall be a minimum of four inches (4") in thickness with longitudinal joints and transverse contraction joints separating individual sections of walk into squares not to exceed five feet (5'). Longitudinal joints and transverse contraction joints which are cut and tooled shall be formed by inserting a metal template having a minimum thickness of one-eighth inch (1/8") into the concrete to a depth of one-third (1/3) of the thickness of the walk. The edges of all tooled contraction, construction and expansion joints shall be rounded with a one-fourth inch (1/4") radius-edging tool.

Sidewalk shall have a maximum cross slope of one-quarter inch (1/4") per foot. Expansion joints one-half inch (1/2") in width shall be constructed in sidewalks on approximately fifty-foot (50') intervals along the length of walk constructed. Slip formed sidewalk shall have expansion joints at 120 foot intervals. Expansion joints shall be made by placing precast fiber expansion joints one-half inch (1/2") thick. Additional expansion joints shall be required where the sidewalk adjoins concrete parking lots, concrete driveways, or where the width of the sidewalk is to be greater than five feet.

407.6 WHEELCHAIR RAMPS

Wheelchair ramps shall be constructed in conformance with the typical wheelchair ramp detail. Wheelchair ramps will be paid for as identified in the contract, and shall include the cost of all materials, labor, grooving, painting or coloration necessary to construct ramp. In no case shall wheelchair ramps be steeper than one inch per foot in the direction of pedestrian travel nor more than one-half inch per foot across the direction of pedestrian travel.

407.7 COMBINED CURB AND GUTTER

The cross section of the combined curb and gutter shall be as shown on the plans.

Contraction joints shall be constructed by sawing the curb and gutter at right angles to the curb line at no more than twelve-foot (12') intervals. The saw cuts shall be at least two and one-half inches (2-1/2") in depth and one-fourth inch (1/4") in width. All joints shall be sawed as soon as is practical after the concrete has hardened sufficiently to eliminate tearing and raveling. The maximum allowable time between the placing of the curb and gutter and the sawing of joints shall be twelve (12) hours; however, any procedure which results in premature and uncontrolled cracking shall be revised immediately. The joints shall be filled immediately after sawing with a joint sealer meeting the requirements for sealing concrete pavement joints (Subsection 406.3). A nozzle designed so that the joint is filled completely from top to bottom shall be used in filling the joints.

When combined curb and gutter adjoins concrete base or concrete pavement, it shall be tied to such base or pavement using tie bars. The tie bars shall be two feet (2') long and spaced on two feet (2') centers.

Expansion joints shall be constructed by placing one-inch (1") precast asphalt expansion material at maximum intervals of three hundred feet (300') along the length of the combined curb and gutter, at all radius point locations, and at quarter point locations around cul-de-sacs when the combined curb and gutter construction adjoins full depth asphalt pavement construction. Such expansion joints shall be installed at all radius points and at locations to match expansion joints in the pavement when the combined curb and gutter adjoins concrete pavement construction. Expansion joints shall extend the full depth of the curb and gutter and be trimmed to match the curb profile.

All costs associated with joint construction, keyed joint construction and tie bar installation, including the cost of the steel, shall be subsidiary to the bid price of the combined curb and gutter.

407.8 MONOLITHIC EDGE CURB

The item listed as monolithic edge curb shall include the furnishing of all materials and labor necessary to construct a curb monolithic with the concrete pavement and shall be constructed by building pavement one foot wider than the space between the face of the curbs. Curb forms shall be set on each side of the pavement as soon as possible after the last passage of the finishing machine. The curb shall then be constructed on top of the completed pavement using the concrete mix specified for curbs in these specifications. Dimensions of the monolithic edge curb shall be as indicated by the plans. Monolithic edge curb shall be cut through the pavement in uniform lengths at approximately ten-foot (10') intervals between expansion joints. Expansion joints shall be constructed in the monolithic edge curb at all locations where there is an expansion joint in the pavement, at all radius points, and at other plan locations by placing precast asphalt expansion joints the same thickness as the expansion joint in the pavement. The price bid for monolithic edge curb shall include the cost of placing and furnishing all expansion joints. The price bid for monolithic edge curb shall include only that portion above the pavement.

407.9 DRIVEWAY APPROACHES

Driveway openings shall be left at such locations as are requested by the property owners. Neither the representatives of the City nor the Contractor shall attempt to make definite location of such driveway openings. Such locations shall be designated only by the interested property owner or his representative. The Contractor will be required to provide a properly executed driveway request form for each driveway constructed with the project, regardless of whether or not such driveways are shown on the plans. All driveways shown on the plans shall be considered as tentative until validated by a properly executed driveway request form. The Contractor shall contact each individual property owner or his representative and have such individual execute a standard driveway request form for the City at least ten (10) days prior to the construction of any curb, combined curb and gutter, or driveway approaches on the project. No driveway openings shall be constructed without completing the driveway from the street curb line to the property line.

All driveways constructed on public street right-of-way shall be a minimum of six inches (6") in thickness throughout the entire width of the flat slab, including that portion of the sidewalk section within the limits of the drive. Commercial and industrial use drives shall be constructed eight inches (8") in thickness. Commercial and industrial use drives shall be reinforced with 6" x 12", W4-W4 welded wire fabric. Welded wire fabric reinforcement in drives will be paid for at the unit price bid or the unit price set in the proposal per pound as measured on the basis of forty-four hundredths (0.44) pounds per square foot of drive constructed with such reinforcement. The maximum width of any one drive will be thirty feet (30') at the right-of-way line with a maximum opening in the street curb for radius type drives of fifty-two feet (52'). Standard ramp type drives shall be constructed when the distance between the right-of-way line and the back of the street curb is twelve feet (12') or less. Radius type or radius-ramp type drives shall be constructed when the distance between the face of the walk and the back of the street curb is greater than eight feet (8'). The curb radius shall not exceed the distance between the street curb line and the front edge of the sidewalk.

All driveways constructed adjacent to combined curb and gutter which adjoins full depth asphalt pavement or concrete base pavement construction shall be tied to the combined curb and gutter using No. 4 reinforcing tie bars.

All driveways constructed adjacent to combined curb and gutter which adjoins concrete pavement shall be tied to the concrete roadway at the high edge of the curb and gutter with No. 4 tie bars.

All driveways constructed abutting concrete pavement shall be tied to the pavement one foot back of the curb using No. 4 reinforcing tie bars at 18" spacing.

That portion of the driveway between the back of the street curb line and the right-of-way line will be paid for at the unit price bid or set in the proposal per square foot for the thicknesses indicated, which price shall include the cost of all curb along the edges of the driveway, the cost of all necessary excavation and the cost of the subgrade compaction. When combined curb and gutter is constructed, that portion of the gutter and one and one-half inch (1-1/2") curb through the drive opening will be included in the price bid for combined curb and gutter. When the driveway abuts concrete pavement, the one and one-half inch (1-1/2") curb through the drive opening will be included in the price bid for curb of the same type indicated to be constructed with the pavement. Keyed joints and tie bars installed with keyed joints will not be paid for directly and this cost shall be considered as subsidiary to other work.

SECTION 408 CONCRETE CURING AND PROTECTION

408.1 DESCRIPTION

This work shall cover the curing and protection of concrete pavement, curb and gutter, sidewalk, driveway approaches and slabs. Payment for this work is subsidiary to other paving items.

408.2 CURING CONCRETE PAVEMENT

Concrete pavement shall be cured by spraying, using approved pressure distributing equipment, with an approved liquid curing membrane while the surface of the concrete is still moist.

Liquid curing membrane shall conform to the requirements of applicable sections of the KDOT Standard Specifications.

Other curing methods may be used when approved by the Engineer.

When liquid curing membrane is applied using approved self-propelled mechanical distributors, the minimum rate of application shall be one gallon per one hundred fifty square feet. When the liquid curing membrane is applied using approved hand sprays, the membrane shall be applied in two applications, the second application applied at right angles to the path of the spray of the first application, and the rate of application shall not be less than one gallon per two hundred square feet for each application. Satisfactory means shall be provided for thoroughly mixing the curing membrane compound before and during use. If from any cause the curing membrane is damaged, such as rainfall soon after its application, the Contractor shall immediately apply another application of curing membrane to the surface of the pavement. All existing expansion, contraction, and longitudinal joints that are to be filled with joint compound shall be protected from the curing membrane by filling with jute rope or by using other acceptable protective material.

408.3 COLD WEATHER PROTECTION

When concrete is being placed during the time that the air temperature may be expected to drop below 40°F. the Contractor will be required to protect the work by covering it with a suitable moisture barrier such as wet burlap or plastic sheeting and a suitable blanketing material such that will maintain a minimum temperature of 40°F. in the concrete as measured on the surface of the work. This type of curing shall be maintained for a duration of 96 hours after the concrete has been placed as long as the air temperature is expected to go below 40°F. anytime during the 96 hour period.

408.4 PHYSICAL PROTECTION

The concrete shall be protected from damage due to traffic or pedestrians by use of adequate barricades and signs. If required, the Contractor shall leave personnel to guard the concrete until set up to a point where it cannot be easily damaged. Damaged concrete shall be removed and replaced at no extra cost to the City.

SECTION 409 COLD MILLING PAVEMENT

409.1 DESCRIPTION

This work shall consist of the removal of pavement surfaces in accordance with these specifications. Payment for this milling work will be by the square yard, S.Y. Pavement surface removal area and depth shall be as indicated by the plans. Where required, milling will also be performed to remove or reduce high spots caused by rutted or channeled roadways, and to remove material to match adjacent street elevations. Cold milling of pavement surfaces will be to required grade lines in areas as noted on the plans or using approved equipment which is automatically controlled, except as otherwise noted, herein, with regard to longitudinal grade and cross slope. Contractor will not be allowed to carry traffic through construction on pavement whose surface has been milled in excess of a 72-hour time limit.

409.2 CONSTRUCTION DETAILS AND REQUIREMENTS

Curb Line Milling:

Curb line milling shall consist of milling to a depth of 1 ½ inches below the adjacent gutter or curb apron (high edge) if the curb or gutter is on grade. The milling depth shall taper to meet the existing street surface at the width indicated by the plans. Normally, the milling width will be approximately 6 feet. Milling equipment used for curb line milling shall be capable of milling a straight line parallel with the curb line.

Street Surface Milling:

Street surface milling shall be required to permit construction of the new street surface as identified by the plans. Where required, milling will also be performed on channeled street surfaces, bumps or high spots and at locations requiring milling to establish differential elevations or smooth transitions from one pavement section to the next.

Loading:

The milled material will be immediately loaded into the contractor's trucks and hauled to a site designated by the City, unless noted otherwise. The loading device shall be capable of removing and loading at least 85 percent of the milled material.

Dust Control:

The entire milling and loading operation shall be equipped with an effective dust control system.

Final Cleaning:

The milled area and adjacent areas will be swept or otherwise cleaned of all millings and debris. All debris shall be removed and disposed by the Contractor .

SECTION 410 COLD PLASTIC TRAFFIC MARKING

410.1 DESCRIPTION

This specification is intended to cover white and yellow pre-formed pavement markings for use in marking streets in compliance with the Manual on Uniform Traffic Control Devices (MUTCD). The tape is intended for use in areas subjected to high traffic volumes and severe wearing conditions where there is repeated shear action, stopping, starting, turning, etc.

The tape shall have glass beads for immediate and continuing retro-reflectivity. The tape shall have a pressure sensitive adhesive on it and shall require no paper liner to keep the material from sticking to itself (although paper liners may be required for transverse lines, legends, arrows, etc., for ease of handling). The primary application of the material will be for "inlay" on new hot asphalt surfaces, but it will also be used on existing asphalt and concrete surfaces. Material for long lines shall be furnished in rolls.

All material must be in compliance with this specification and certified accordingly. All incidental work is subsidiary to the traffic marking bid item and measured in-place by the linear foot, L.F., unless noted otherwise.

410.2 MATERIALS

General:

The pre-formed markings shall consist of white or yellow films with pigments selected and blended to conform to standard highway colors through the expected life of the film. Glass beads shall be incorporated to provide immediate and continuing retro-reflection.

The size, quality and refractive index of the glass beads shall be such that the performance requirements for the markings shall be met. The bead adhesion shall be such that beads are not easily removed when the material surface is scratched with a thumbnail.

The film shall have glass bead retention qualities such that when a 2" x 6" sample is bent over a ½" diameter mandrel, with the 2" dimension perpendicular to the mandrel axis, microscopic examination of the area on the mandrel shall show no more than 10 percent of the beads with entrapment by the binder of less than 40 percent.

The pre-formed words and symbols shall conform to the applicable shapes and sizes as outlined in the MUTCD latest edition.

The pre-formed markings shall be capable of being adhered to asphalt concrete or Portland cement concrete by a pre-coated pressure sensitive adhesive. A primer may be used to precondition the pavement surface. The pre-formed marking film shall mold itself to pavement contours by the action of traffic. The pavement marking films also shall be capable of application to new, dense and open graded asphalt concrete wearing courses during the paving operation in accordance with the manufacturer's instructions. After application, the marking shall be immediately ready for traffic. The manufacturer shall identify proper solvents and/or primers to be applied at the time of application on pavements which have been exposed to traffic, all equipment necessary for proper application, and recommendations for application that will assure an effective performance life. Such materials shall be suitable for use one year after the date of purchase from the manufacturer when properly stored.

Composition:

The retro-reflective pliant polymer pavement marking film shall consist of a mixture of high quality polymeric materials, pigments, and glass beads distributed throughout its base cross-sectional area, with a retro-reflective layer of beads bonded to the top surface.

Thickness:

The film without adhesive shall have a minimum thickness of 0.06", unless otherwise specified.

Patchability:

The pavement marking film shall be capable of use for patching worn areas of the same type film in accordance with manufacturer's instructions.

Tensile Strength and Elongation:

The film shall have a minimum tensile strength of 40 pounds per square inch of cross-section when tested according to ASTM D 638-76, except that a sample 6" x 1" shall be tested at a temperature between 70°F and 80°F using a jaw speed of 10-to-12 inches per minute. The sample shall have a minimum elongation of 75% at break when tested by this method.

Acid Resistance:

The beads shall show resistance to etching, hazing or delamination of bead surface after exposure to a one percent solution of sulfuric acid. The test shall be performed as follows:

Soak one gram of beads in 100 cc of one percent H²SO₄ solution for 100 hours. Then decant the acid solution and dry the beads at 100°C. Microscopic examination of a sample of the beads shall show no more than five percent of the beads altered by the acid.

Skid Resistance:

The surface of the retro-reflective pliant polymer film shall provide an initial minimum skid resistance of 45 BPN when tested according to ASTM E 303-74.

Reflectance:

The white and yellow films shall have the following initial minimum reflectance values at 0.2° observation angles and 86.0° entrance angle as measured in accordance with the testing procedures of Federal Test Method Standard 370. The photometric quantity to be measured shall be specific luminance (SL*), and shall be expressed as milcandelas per square foot per foot-candle (mcd.ft⁻².fc-1). The metric equivalent shall be expressed as millicandelas per square meter per lux. The test distance shall be 50 feet (15m) and the sample size shall be a 2.0 x 2.5 ft. rectangle (0.61 x 0.76m).

The angular aperture of both the photoreceptor and light projector shall be 6 minutes of arc. The reference center shall be the geometric center of the sample, and the reference axis shall be taken perpendicular to the test sample.

Observation Angle	White		Yellow	
	0.2°	0.5°	0.2°	0.5°
SL(mcd.ft ⁻² .fc-1)	550	380	410	250

Reflectivity Retention:

To have a good, effective performance life, the glass beads must be strongly bonded and not be easily removed by traffic wear.

The Taber Abraser Simulation Test: shall be employed to measure reflectivity retention. Using a Taber Abraser with an H-18 wheel and a 125-gram load, the sample shall be inspected at 200 cycles, under a microscope, to observe the extent and type of bead failure. No more than 15 percent of the beads shall be lost due to popout and the performance mode of failure shall be "wear down" of the beads.

Effective Performance Life:

The film, when applied according to the recommendations of the manufacturer, shall provide a neat, durable marking that will not flow or distort due to temperature if the pavement surface remains stable. Although reflectivity is reduced by wear, the pliant polymer shall provide a cushioned, resilient substrate that reduces bead crushing and loss. The film shall be weather resistant and, through normal traffic wear, shall show no appreciable fading, lifting or shrinkage throughout the useful life of the marking, and shall show no significant tearing, roll back, or other signs of poor adhesion.

Adhesive:

All material for lines, legends, arrows, etc. shall require no paper liner, talc, release paper, etc. to keep the marking tape from sticking to itself in a roll. (Paper liner may be required for transverse lines, legends, arrows, etc. for ease of handling.) Unless otherwise specified, all roll goods shall be burnished without paper liner. Legends and arrows must have the same pressure sensitive adhesive as the roll goods and must have a paper liner for ease of handling. Legends and arrows must conform to the standards of the MUTCD.

For "inlay" application on hot asphalt, the tape shall require no adhesive activator, primers, epoxies, etc. For application on pavement surfaces which have been exposed to traffic, the only requirement shall be for the use of a one-part primer to be sprayed on the road surface. Material requiring the mixing of a two-part primer or the application of one part to the adhesive and another part to the pavement will not be permitted. The primer shall be 3M (E-44) or equivalent and shall be for use in a spray applicator available from the manufacturer. The manufacturer shall advise on proper application techniques and required primers for installation on pavement which have been exposed to traffic.

410.3 WEATHER LIMITATIONS

When pavement marking material is applied to Portland cement or cold bituminous surfaces, the pavement temperature shall not be less than 70°F and rising.

410.4 CONSTRUCTION REQUIREMENTS

The pavement to be striped shall be broomed and cleaned prior to application as deemed necessary by the Engineer. The marking shall be supplied complete with a pre-coated, factory applied adhesive, to make possible immediate application to the pavement without the use of heat, solvent or other type adhesive or adhesive operations, unless recommended otherwise by the manufacturer due to climatic or pavement conditions. When the adhesive backing is supplemented by a solvent, or other type of adhesive or adhesive operation, the material used and application shall be in accordance with the manufacturer's recommendation. Application shall be made by placing the marker on the pavement surface, when applied to fresh laid hot mixed asphalt surfacing, with the embedment by roller during the final rolling by the asphalt contractor without twisting, stopping or turning of the roller.

When using cold plastic markings on new Portland cement concrete, sand or shot blast cleaning shall be required to remove curing compounds, laitance, debris and other foreign matter, followed by an air blast. Application of primer and pavement markings shall closely follow the cleaning procedure.

When using durable pavement marking tape, the bituminous surface (over thirty days) to be striped shall be broomed and cleaned prior to application as deemed necessary by the engineer. Application of primer and pavement markings shall closely follow the cleaning procedure.

Except when cold plastic markings are rolled into a hot bituminous surface, a minimum of three (3) passes with a tamping cart and added weights shall weigh a minimum of 250 pounds and have a roller with a deep soft rubber surface. Tamping with the tires of an automobile or truck in lieu of the tamp cart shall not be permitted.

Pavement markings shall extend to the limits of the surfacing project whether specifically detailed or not. New pavement markings shall match to the existing pavement markings.

410.5 WARRANTY

Material Replacement:

The Contractor shall provide replacement materials and install such replacement materials if the original longitudinal lines, words or symbols are later determined to be defective or inadequate traffic control devices, in less than two years if done on an "inlay" job, or one year if on an existing pavement or new concrete pavement at no additional cost to the City.

410.6 REMOVAL OF EXISTING TRAFFIC MARKINGS REQUIREMENTS

Pavement markings shall be removed to the fullest extent possible without damage to the pavement surface. Equipment used for the removal of the markings shall be any type that will not appreciably damage the surface or texture of the pavement. All material deposited on the pavement as a result of the removal operation shall be removed as the work progresses.

Any appreciable damage or different appearance from the surrounding surface shall be repaired by the Contractor, at his expense. The Contractor shall treat, at his expense, the affected areas with any permanent or lasting material to blend in and match as well as practical, the appearance of the surrounding area.

Removal of existing traffic markings using methods which require sand blasting, blocking out with asphaltic materials, and other such methods resulting in objectionable staining or marking of the pavement surface will not be permitted. Removal of existing traffic markings will conform to the following methods identified for the various material types using methods and equipment which will not result in objectionable staining or marking of the pavement surface.

Painted traffic markings shall be removed by chipping with hand operated or power operated chisels, rotary hammer mills or shot blasting.

Cold plastic traffic markings shall be removed by peeling and scraping using hand operated scrapers.

Thermoplastic traffic markings shall be removed by chipping with hand operated or power operated chisels.

Removal of existing traffic markings will not be measured and will not be paid for directly and the cost of this work will be considered as subsidiary to other pay items of work.

SECTION 411 PAVEMENT MARKING - PAINTING

411.1 DESCRIPTION

This item shall consist of the painting of numbers, markings, and stripes on the surface of Portland cement concrete or bituminous pavement applied in accordance with these specifications and at the locations shown on the plans (Refer, KDOT, special provision 90M-84-R5).

411.2 MATERIALS

Paint:

Use white or yellow paint that is specifically manufactured for use on traffic markings. The paint must comply with volatile organic compound (VOC) requirements, be lead and other toxic heavy metal free, and exhibit the following qualities:

1. **Dry-Opacity:** A contrast ratio of not less than 0.96 when the paint is applied with a 300 µm film applicator. Dry Opacity will be determined according to Method 4121, Federal Test Method Standard No. 141a. Apply the paint with the above applicator to the chart specified in Section 1.1 of Method 4121.
2. **Daylight Reflectance:** Daylight Reflectance of the white paint not less than 80% relative to magnesium oxide when tested according to Method 6121, Federal Test Standard No. 141a.
3. **Color:** Closely match the color of the yellow paint with Color no. 33538 of Federal Test Standard No. 595a.
4. **Bead Embedment:** Apply paint to a glass panel at a glass panel at a wet film thickness of 300 µm followed immediately by an application of glass beads (AASHTO M247 Type I) dropped onto the surface of the paint. After drying for at least 24-hours observe the amount of bead embedment with a 30 power microscope. At least 90% of the beads must be embedded between 40 and 60%.

Glass Beads for Traffic Line Paint:

When reflective paint is specified, this feature will be provided by the addition of glass beads to the surface of the pigmented binder. Furnish regular beads which are specifically manufactured to be compatible with the paint being used, and which comply with the requirements of AASHTO M247, Type I. Beads are to be coated with a moisture resistant coating and an adhesion promoting coating which is compatible with the paint being used

411.3 CONSTRUCTION METHODS

Weather Limitations:

The painting shall be performed only when the existing surface is dry and clean, when the atmospheric temperature is above 40° F., and when the weather is not excessively windy, dusty, or foggy. The suitability of the weather will be determined by the manufacturer representative.

Equipment:

All equipment for the work shall be pre-approved and shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, and such auxiliary hand painting equipment as may be necessary to satisfactorily complete the job.

Use self propelled or truck-mounted equipment, which is, designed for the purpose of applying painted traffic lane markings of the type, width and thickness required. Towing of the equipment will not be allowed. Equip the machine with an adjustable guide-on to assure proper placement of the line.

It shall produce an even and uniform film thickness at the required coverage and shall be designed so as to apply markings of uniform cross sections and clear-cut edges without running or spattering and within the limits for straightness set forth herein. When needed, a dispenser shall be furnished which is properly designed for attachment to the mechanical marker and suitable for dispensing the required quantity of reflective media.

Contractor's Personnel:

Assure that at least one of his employees on the project when pavement markings are being applied holds an American Traffic Safety Services Association (ATSSA) pavement marking certification and is experienced in the application of painted pavement markings.

Preparation of Existing Surface:

Immediately before application of the paint, the existing surface shall be dry and entirely free from dirt, grease, oil, acids, laitance, or other foreign matter which would reduce the bond between the coat of paint and the pavement. The surface shall be thoroughly cleaned by sweeping and blowing as required to remove all dirt, laitance, and loose materials. Areas which cannot be satisfactorily cleaned by brooming and blowing shall be scrubbed as directed with a water solution of trisodium phosphate (10% Na_3PO_4 by weight) or an approved equal solution. After scrubbing, the solution shall be rinsed off and the surface dried prior to painting.

Existing markings or stripes which are to be abandoned or removed shall be obliterated or obscured by the best methods suited for the purpose (refer. subsection 410.6).

Alignment:

All layouts required in the construction of the pavement marking are the responsibility of the Contractor. Lay out the pavement marking as detailed on the Plans. When the Plans do not provide details, submit a layout plan (conforming to the requirements of the MUTCD) for the pavement markings to the Engineer for approval. Normally locate longitudinal pavement marking stripes 2" from existing longitudinal joints. Provide adequate guide marks (approximately 2" by 12" at approximately 30 to 50 ft intervals) for the application of the pavement markings.

The Contractor shall provide an experienced technician to supervise the location, alignment, layout, dimensions, and application of the paint.

Single stripes shall be applied wholly on one side of the longitudinal pavement joints. Double or multiple stripes shall be centered over similar joints.

Application:

Markings shall be applied at the locations and to the dimensions and spacing indicated on the plans or as specified. Paint shall not be applied until the layouts, indicated alignment, and the condition of the existing surface have been approved.

The paint shall be mixed in accordance with the manufacturer's instructions before application. The paint shall be thoroughly mixed and applied to the surface of the pavement with the marking machine at its original consistency without the addition of thinner. If the paint is applied by brush, the surface shall receive two coats; the first coat shall be thoroughly dry before the second coat is applied.

When reflectorized markings are applied, the reflective media shall be distributed to the surface of the pigmented binder immediately and imbedded at the rate and depth as required to provide adhesion and reflection.

A period of several weeks shall elapse between application of the bituminous seal coat or the placement of the bituminous surface course and the marking of the pavement. The paint shall not bleed excessively, curl, or discolor when applied to bituminous surfaces.

In the application of straight stripes, any deviation in the edges exceeding ½ inch in 50-feet shall be obliterated and the marking corrected. The width of the markings shall be as designated within a tolerance of 5%. All painting shall be performed to the satisfaction of the Engineer by competent and experienced equipment operators, laborers, and artisans in a neat and workmanlike manner.

Paint shall be applied uniformly by suitable equipment at a wet film thickness of 375 µm at an approximate rate of not less than 110 nor more than 115 square feet per gallon for 4" solid line. For other widths of marking, increase the amount of paint proportionally. Glass spheres shall be applied at the rate of 10 pounds per gallon of paint. High-intensity granules shall be applied at the rate of 1.7 pounds per gallon of paint.

Use an automatic bead dispenser attached to the striping machine in such a manner that the beads are dispensed almost instantaneously upon the line as it is being installed. Equip the glass bead dispenser with an automatic cut-off control synchronized with the cut-off of the paint.

Cone off the newly applied lines to keep traffic from crossing them until they are dry to no-pick-up. The Contractor may reduce or eliminate the need for this by using fast dry paints and using traffic control.

Do not apply paint when the air temperature is below 40°F, upon damp or frosted surfaces or when in the opinion of the Engineer, conditions are not satisfactory for the work.

The Contractor shall furnish a certified report on the quality of materials ordered for the work. This report shall not be interpreted as a basis for final acceptance. When required, all emptied containers shall be returned to the paint material storage or made available for tallying by the Engineer. The containers shall not be removed from the site or destroyed without permission. The Contractor shall make an accurate accounting of the paint materials used in the accepted work.

Protection:

After application of the paint, all markings shall be protected while the paint is drying. The fresh paint shall be protected from injury or damage of any kind. The Contractor shall be directly responsible and shall erect or place suitable warning signs, flags or barricades, protective screens, or coverings as required. All surfaces shall be protected from disfiguration by spatter, splashes, spillage, drippings of paint or other materials.

Defective Workmanship or Material:

When any material not conforming to the requirements of the specifications or plans has been delivered to the project or incorporated in the work or any work performed is of inferior quality, such material or work shall be considered defective and shall be corrected at the expense of the Contractor.

Remove and replace pavement marking that has foreign covering or discolored areas; improper wet film thickness, width or length; areas that present a ragged appearance, areas that do not present clear and sharply defined edges, or areas with abrupt unintended changes in alignment.

411.4 METHOD OF MEASUREMENT:

The quantity of accepted painted pavement markings for the various widths and classes. Symbol will be measured by the unit complete in place.

411.5 BASIS OF PAYMENT:

Payment shall be made at the contract unit price per linear foot or contract lump sum for painting. This price shall be full compensation for furnishing all materials and for all preparation, layout, and application of the materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.