

TABLE 4.8 CLIMATE LIMITATIONS		
Mat Thickness Wind of 5 MPH or less	Minimum Air and Surface Temperature	
	F	C
3 inches or greater	40°	4°
Greater than 2 inches, but less than 3 inches	45°	7°
2 inches or less	50°	10°
Open graded asphalt mix	70°	21°

4.5.21 SPREADING AND FINISHING. The asphalt mix shall be placed upon an approved surface, by a self-propelled paver meeting the requirements in Section 4.5.18. The travel rate of the paving machine shall be regulated to a speed dependent upon the capacity of the mixing plant and/or trucking service to supply the mixture. The paving machine shall be operated so that material does not accumulate and cool below 250° F (121°C) along the sides of the receiving hopper.

Where unavoidable obstacles make the use of mechanical spreading and finishing equipment impracticable, the mixture may be spread, raked with hand tools, and mechanically compacted. For such areas, the mixture shall conform to the required mix design, density, compacted thickness, grade and cross section.

The asphalt mix may be windrowed in front of the self-propelled paver properly equipped to transfer the asphalt mix directly into the hopper, provided that the following conditions and requirements are strictly adhered to.

4.5.21.1 The windrow is properly sized, thereby insuring the delivery of the correct amount of material to the paving machine at all times.

4.5.21.2 The asphalt mixture shall be transferred from the windrow to the paving machine in such a manner that the materials in the paver will be a uniform mixture. The base, upon which the windrow was formed, shall not be disturbed. There shall be a minimum amount of asphalt mixture remaining on the base between the pickup device and the paving machine.

4.5.21.3 The material in the hopper of the paving machine shall meet with the temperature requirements. Asphalt mixture that does not meet the minimum specified temperatures shall not be used, and shall be properly disposed of.

When it is determined by the City Representative that the asphalt course being placed by use of a windrow is inferior to that being placed by direct transfer of the asphalt from the hauling vehicle to the spreading machine, the use of the windrow method shall be discontinued.

The asphalt mixture placed by the use of a paving machine during one day's operation shall come from a single plant manufacturer. Intermixing from more than one source shall not be allowed. Intermixing is defined as when more than one plant is used as a routine supply source to a single operation.

The asphalt mixture shall have a temperature not less than 270°F (132°C) nor more than 325°F (163°C), at the time the paving machine places the asphalt mixture on grade. Depending on environmental conditions and compaction requirements, the City's Representative may specify more strict temperature requirements.

Asphalt pavement courses of more than three inches in total compacted thickness shall be placed in two or more courses. One course shall not be placed over another course until the compaction requirements have been met and the mat temperature has cooled to 160°F (71°C) at mid-depth.

Placing of the asphalt pavement shall be as continuous as possible. Rollers should not pass over the unprotected edge of the freshly laid asphalt mixture. Transverse joints shall be formed by cutting back on the previous run to expose the full depth and proper grade of that course. A tack coat meeting Section 4.5.9 of these specifications shall be applied on the contact surface of the prepared transverse joints just before the new asphalt mixture is placed.

Longitudinal joints shall be spaced in such a manner that joints in succeeding courses will be offset at least twelve inches horizontally from joints in any preceding course. Lanes will be evened up each day to minimize cold longitudinal joints and to provide proper transverse joints. Where possible, the top course longitudinal joints shall be placed a minimum of one foot either side of the lane line.

Transverse joints shall be spaced in such a manner that joints in succeeding passes will be a minimum of five feet horizontally from joints in any adjacent pass.

Existing roadway pavements to be widened shall be sawcut far enough into the roadway to provide the proper grade, cross-section and thickness with a straight vertical longitudinal or transverse joint. These joints shall have a tack coat meeting Section 4.5.9 of these specifications applied on the contact surface immediately prior to paving.

Longitudinal joints on previously compacted passes should have an overlap of new asphalt mixture one to one and one-half inches over the existing mat. Raking should be merely to "bump" the joint, pushing the asphalt mixture off the previous pass and onto the new pass directly over the joint. If the adjacent mat is overlapped too far and too much asphalt mixture is deposited on the existing mat, the excess material shall be pulled away from the new mat rather than being pushed onto the new mat. Excess mix shall never be broadcast across the newly laid asphalt. The excess mix shall be picked up and recycled.

4.5.22 ROLLING AND COMPACTING. Compaction equipment shall meet the requirements of Section 4.5.19 of these specifications, unless otherwise approved or required by the City's Representative.

A pass shall be one movement of a roller in either direction. A coverage shall be as many passes as are necessary to cover the entire width being paved. Overlap of passes during any coverage, made to ensure compaction without displacement of material shall be in accordance with good rolling practice.

The breakdown rolling shall consist of one or more complete coverages of the asphalt mat with a vibratory steel-wheeled roller. Initial rolling shall commence at the lowest edge and shall progress toward the highest portion of the asphalt mat. Initial rolling shall not commence on the interior portion of any mat.

The breakdown rolling shall be followed immediately by additional rolling with a pneumatic-tired roller that will provide uniform density throughout the depth of the course being compacted. A minimum of two rollers, one steel-wheeled, and one pneumatic-tired, shall be used. However, the total number of rollers used beyond the minimum of two shall be sufficient to obtain the required compaction while the asphalt mixture is above 175°F (80°C).

The final rolling of the asphalt mixture shall be performed by a steel wheel roller of sufficient size to remove all roller marks caused during the compaction of the asphalt mixture. The vibratory roller used for breakdown rolling may be used as the finish roller provided it is operated with the vibratory unit turned off.

The rollers shall be kept in continuous motion while rolling so that all parts of the asphalt mixture will receive as close to equal compaction as possible. The roller speed shall be slow enough at all times to avoid displacement of the pavement. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected immediately by use of rakes and fresh asphalt mixture when required.

To prevent adhesion of the asphalt mixture to the rollers, the wheels/tires, bars, pads and release agent pumps shall be kept properly maintained. The use of diesel oil on pneumatic-tired rollers shall be kept to a minimum and used only in conjunction with coca pads to prevent the asphalt mixture from adhering until the tires heat enough to prevent mix adherence.

The completed surface shall be thoroughly compacted, smooth and free from ruts, humps, depressions, or irregularities. Any ridges, indentations or other objectionable marks left in the surface of the finished pavement shall be eliminated by rolling or other means. The use of any equipment that leaves ridges, indentations, or other objectionable marks in the asphalt surface shall be discontinued, and acceptable equipment shall be furnished.

Compacting the longitudinal joint shall be performed by placing the roller on the hot uncompact mat and overlapping the joint by a distance of approximately six inches over the cold compacted mat. For proper compaction, the level of the uncompact mix at the longitudinal joint must be above the elevation of the compacted mix by an amount equal to one-quarter inch for each one inch of compacted pavement. This ratio is "rule of thumb" and may vary slightly depending on the type of asphalt mix and the supplier. A test strip is advisable.

A good source of information for rolling asphalt is a document by AASHTO, FAA, Federal Highway Administration and the National Asphalt Pavement Association entitled "AC 150/5370-14, Appendix 1, July 31, 1991". The following information is taken from that document.

1. Rolling From The Cold Side - It was common practice in the past to do the initial rolling of the longitudinal joint from the cold (previously placed mat) side of the joint. The major portion of the weight of the roller was supported by the cold, compacted mat. Only six inches or so of the width of the roller hung over the fresh mat, compressing the mix along the joint. The majority of the compactive effort was wasted because the roller essentially was applying its compactive effort to an already-compacted asphalt material.

During the time that the roller was operating on the cold side of the longitudinal joint, the mix on the hot side of the joint, and the rest of the mix in the course being laid, was cooling. Depending on the environmental conditions and the thickness of the mix

being placed, the process of compacting the joint from the cold side often proved to be detrimental to the ability to obtain density on the whole pavement layer.

The reason often given for rolling the joint from the cold side of the joint was that this compaction method allowed the rollers to "pinch" the joint and obtain a higher degree of density. There is no evidence that this is true.

2. **Rolling From The Hot Side** - The most efficient way to compact the longitudinal joint is to put the roller on the hot mat and overlap the joint by a distance of approximately six inches over the cold mat. This places the majority of the weight of the compaction equipment where it is needed. The mix at the joint is still pushed into the joint area by the roller as long as the elevation of the new mix at the joint is proper. The longitudinal joint can be compacted effectively by keeping the roller on the new mix, instead of on the previously compacted mix. Any type of roller used for the breakdown rolling of the mix can be employed to compact the longitudinal joint as long as the elevation of the mix at the joint is above the level of the cold mat and the mix is still hot.

Sometimes the first pass of the roller is completed with the edge of the machine about six inches inside of the longitudinal joint. The theory behind this method of compaction is that the mix will be shoved toward the joint by the roller, and better compaction will be obtained. If the mix being placed is stable enough, the roller should not be able to move the material laterally to any significant degree. If the mix design is proper, this method of compacting the joint does not provide any advantage over moving the first pass of the roller outward one foot (from six inches inside the joint to six inches outside the joint). Rolling the mat by lapping the roller over the adjacent old pavement typically is the more efficient way to provide roller coverage for the whole pavement width.

4.5.23 OPEN-GRADED WEARING COURSE.

4.5.23.1 WEARING COURSE. An open-graded wearing course shall be placed over a dense-graded asphalt course. The dense-graded asphalt shall be true to line and grade, cleaned and tacked.

The following specifications shall be complied with:

<u>Item</u>	<u>Section</u>
Dense-graded asphalt	4.5.10
Tack Coat	4.5.9
Asphalt Cement for (existing road) Overlays	Table 4.10
Asphalt Cement for New Construction	4.5.10.2
Hydrated Lime	4.5.11
Other related requirements	

Aggregate gradation shall conform to Table 4.9 when tested under AASHTO T-30.

The percent passing the No. 200 (.075 mm) sieve will be determined by using AASHTO T-11, test procedures.

That portion of aggregate retained on the No. 4 (4.75 mm) sieve shall have no more than ten percent rounded particles when tested in accordance with UDOT Test Procedure 8-929.

TABLE 4.9 OPEN-GRADED ASPHALT AGGREGATE GRADATION			
SIEVE SIZE		IDEAL GRADATION PERCENT PASSING	IDEAL GRADATION TOLERANCE
AMERICAN	METRIC		
½ inch	12.5 mm	100	0
3/8 inch	9.5 mm	96	93-100
No. 4	4.75 mm	40	35-45
No. 8	2.36 mm	17	13-21
No. 200	.075 mm	3	1.3-4.7

**TABLE 4.10
RUBBERIZED LIQUID ASPHALT REQUIREMENTS**

AC-20R:

Property	ASTM	Specification	
		Min.	Max.
Viscosity @ 140°F, poise	D-2171	1,600	2,400
Viscosity @ 275°F, cs	D-2170	325	
Pen @ 77°F (100 g, 5 sec)	D-5	70	
Flash Point, °F, C.O.C.	D-92	450	
Duct. @ 39.2°F, (5 cm/min)	D-113	50	
cm		2.0	
Rubber, weight %	*	110	
Toughness, in-lb	*	75	
Tenacity, in-lb	D-2872		
Rolling Thin-Film Oven Test	**		
Tests on Residue:		8,000	
Viscosity @ 140°F, poise	D-2171	25	
Duct. 39.2°F, (5 cm/min)	D-113		
cm			
<p>* Benson Method of Toughness and Tenacity: Scott Tester, inch-pounds @ 77°F, 20 inches per minute pull. Tension head 7/8-inch diameter.</p> <p>** TFOT ASTM D-1754 may be used. The Rolling Thin-Film Circulating Oven Test is the preferred method.</p>			

4.5.23.2 SUITABILITY OF AGGREGATE. The following requirements shall be used to determine the suitability of the aggregate during the mix design:

- Wear shall not exceed thirty percent when tested in accordance with AASHTO T-96.
- The weighted loss shall not exceed twelve percent by weight when subjected to five cycles of sodium sulfate tested in accordance with AASHTO T-104.
- Aggregates consisting mainly of carbonate type rocks shall not be used unless approved by UDOT as satisfactory long-term friction values for comparable traffic volumes when tested in accordance with AASHTO T-242 or ASTM E-274-79.

Aggregates shall be separated into two or more sizes and stored separately.

Stockpiling or handling methods that cause segregation, degradation or the combining of materials of different sizes when placing the aggregate in storage or moving it from storage to the cold bins shall not be used. Any segregated or degraded material shall be re-screened.

4.5.23.3 MIX DESIGN. Annual mix designs shall be submitted in writing to the City Engineer for approval two weeks prior to the first job each calendar year, or upon selection of new aggregate sources. Any revisions to the approved mix design shall fall within the requirements listed above. Open-graded wearing courses that do not meet the tolerances shown in Section 4.5.24 shall be removed and replaced with material meeting the required gradation. The asphalt cement shall be within 0.10 percent of the mix design. At no time shall the asphalt cement content be such that asphalt slicks form on the surface of the roadway.

Based on the mix design, the open-graded wearing course shall have a tensile strength ratio of seventy (70) percent, or greater, in accordance with AASHTO T-283 UDOT modified. Hydrated lime or anti-stripping agent may be added to the asphalt mix to meet the minimum tensile strength of seventy (70) percent.

4.5.23.4 MIXING. The mixing shall be done as specified in Section 4.5.13. The mineral aggregate will be considered satisfactorily coated with asphalt when all particles are coated. During mixing the viscosity of asphalt shall be maintained between four hundred and nine hundred centistokes. The viscosity of polymer-modified asphalt, when used,

shall be maintained between one hundred fifty and three hundred (150-300) centistokes.

If a drier-drum mixing process is used, the temperature of the mixture shall not be less than 220°F (104°C), or more than 275°F (135°C), when discharged from the mixer. When using a polymer-modified asphalt the temperature of the mixture when discharged from the mixer, shall be maintained between 270°F (132°C) and 320°F (160°C). Viscosity will be determined in accordance with ASTM T-201.

4.5.23.5 SURFACE PLACEMENT. Tack coat shall be applied in accordance with Section 4.5.9.

Self-propelled asphalt paving equipment and automatic screed controls meeting the requirements of Section 4.5.18 shall be used. Rollers shall meet the requirements of Section 4.5.19 and shall be a ten-ton (9.10 tonne) vibratory operated static or a ten-ton (9.10 tonne) static steel wheeled roller for asphalt pavement finishing.

Paving operations should be planned such that all passes will be brought even "transversely" at the end of each working day. Joints between old and new pavements, or between successive days works shall ensure continuous bond between adjoining work. Construct joints to have the same texture, density, and smoothness as other sections of the bituminous pavement course. Clean contact surface and apply tack coat.

Offset longitudinal joints a minimum of 12 inches in succeeding courses and at least 6 feet transversely to avoid vertical joints through more than one course. In the top course restrict longitudinal joint to 1 foot either side of the lane line. Prevent traffic, including construction traffic, from crossing vertical joint edges.

Excessive rolling shall not be allowed. Wearing course compaction shall be completed prior to the mix temperature drop below 180°F (82°C). When using polymer-modified asphalt, compaction shall be completed prior to the mix temperature dropping below 200°F (93°C).

Asphalt slicks shall be raked immediately. Slick spots that cannot be removed by raking, shall be replaced. All humps or depressions exceeding tolerances shall be corrected. Correction methods shall be approved by the City's Representative.

All traffic shall be prevented from traveling on the completed wearing course until it has hardened sufficiently and the surface temperature has dropped below 160°F (71°C). The thickness of the compacted wearing course shall not vary more than one-quarter inch (6.35 mm) from the specified thickness. Testing and acceptance shall conform to Section 4.5.24.

4.5.24 ACCEPTANCE TESTING REQUIREMENTS AND TOLERANCES. The following subsections list the requirements for testing and acceptance for subbase, roadbase, RAM, dense-graded asphalt, open graded asphalt and asphalt pavement surfaces. Testing documentation shall fully address the requirements of these standards.

4.5.24.1 SUBBASE. The following will be required for testing and acceptance of subbase:

- A. One moisture/density test per seven thousand square feet of roadway, or fraction thereof.
- B. One thickness test hole per five thousand square feet.
- C. One gradation test per fifteen thousand square feet of roadway, or fraction thereof. The allowable deviations from the approved subbase targets are as follows:

SIEVE SIZE AMERICAN (METRIC)	ALLOWABLE DEVIATION
2" (50.80 mm) to 6" (152.4 mm)	± 12.1%
½" (12.5 mm) to 1" (25.0 mm)	± 10.8%
3/8" (9.5 mm)	± 9.8%
No. 4 (4.75 mm)	± 8.8%
No. 16 (1.18 mm)	± 6.9%
No. 200 (.075 mm)	± 2.9%

C.1 One sand equivalent (SE) value for every gradation outside the allowable deviation. A CBR or R-value shall be performed on twenty five percent of all sand equivalent

test results with a minimum of one test required. Where multiple SE tests are run, the CBR or R-value shall be determined on those SE tests that exhibit the lowest values.

The Following Are the Minimum Values for Roadway Subbases.

- The minimum acceptable SE value shall be eighteen.
- The minimum acceptable R-value shall be sixty.⁽¹⁾
- The minimum acceptable CBR value shall be 8.8.⁽²⁾

Note 1: R-value test: AASHTO T-190 or ASTM-D 2844 (300 psi exudation pressure)

Note 2: CBR Value Test: AASHTO T-193, (3 point)

4.5.24.2 ROADBASE AND RECYCLED AGGREGATE MATERIALS (RAM).

- A. One moisture/density test per seven thousand square feet of roadway, or fraction thereof.
- B. One thickness test hole per five thousand square feet.
- C. One gradation test per fifteen thousand square feet of roadway, or fraction thereof. The allowable deviation from the approved roadbase and RAM targets are as follows:

SIEVE SIZE AMERICAN (METRIC)	ALLOWABLE DEVIATION
1/2" (12.5 mm) to 1" (25.0 mm)	± 10.8%
3/8" (9.5 mm)	± 9.8%
No. 4 (4.75 mm)	± 8.8%
No. 16 (1.18 mm)	± 6.9%
No. 200 (.075 mm)	± 2.9%

C.1 One sand equivalent (SE) value for every gradation outside the allowable deviation. A CBR or R-value shall be performed on twenty five percent of all sand equivalent test results with a minimum of one test required. Where multiple SE tests are run, the CBR or R-value shall be

determined on those SE tests that exhibit the lowest values.

The Following Are the Minimum Values for Roadbase and RAM.

- The minimum acceptable SE value shall be twenty-two.
- The minimum acceptable R-value shall be seventy-six.⁽¹⁾
- The minimum acceptable CBR value shall be 14.5.⁽²⁾

Note 1: R-value test: AASHTO T-190 or ASTM-D 2884 (300 psi exudation pressure)

Note 2: CBR Value Test: AASHTO T-193, (3 point)

4.5.24.3 DENSE-GRADED ASPHALT PAVEMENTS.

A. One density test per seven thousand square feet of surface area, or fraction thereof.

B. One core sample per nine thousand square feet, or fraction thereof, unless sufficient inspection has been made by the City's Representative to verify required thickness.

C. One extraction and gradation test per days work, or one for every five hundred tons or fraction thereof, whichever is greater.

In the event that the asphalt pavement fails to meet the allowable deviation for extraction or gradation tests, or shows a tendency under traffic loading to rut, tear, or distort, or in the opinion of the City's Representative is "tender" or deficient in appearance, the asphalt pavement shall be cored and tested in accordance with AASHTO T-283-89 or ASTM D 4867-92 including Note 5.

The asphalt pavement must possess seventy percent of the tensile strength ratio based on the approved Marshall mix design. Asphalt pavement not meeting this requirement shall be removed.

The maximum allowable deviations from the approved Marshall mix design are:

Asphalt content	+/- 0.46%
1/2" (12.5 mm) and larger	+/- 6.3%
3/8" (9.5 mm)	+/- 5.9%
No. 4 (4.75 mm)	+/- 5.7%
No. 8 (2.36 mm)	+/- 4.8%
No. 16 (1.18 mm)	+/- 4.6%
No. 50 (.300 mm)	+/- 3.8%
No. 200 (.075 mm)	+/- 2.0%

4.5.24.4 COMPACTION OF DENSE-GRADED ASPHALT PAVEMENT.

A. Acceptance of dense graded asphalt pavement shall be as follows:

- When the average of all density tests is not less than ninety six (96) percent of the maximum laboratory density (Marshall) and when no single test is lower than ninety two (92) percent of the Marshall.
- When the average of all density testing falls between ninety three (93) percent to 95.9% of the Marshall with no test lower than ninety two (92) percent of the Marshall, the asphalt pavement shall be tested to determine the percent of air voids. If the percent of air voids are between three to five (3-5) percent, the asphalt pavement will be considered acceptable. If the percent of air voids are between five to seven (5-7) percent, the asphalt pavement will require a slurry seal per these specifications.
- When the average of all density testing falls between ninety one (91) percent of the Marshall and 92.9% of the Marshall with no single test below ninety (90) percent of the Marshall, the asphalt pavement shall be overlaid with a minimum of one inch thick asphalt pavement. Prior to the overlay, the existing asphalt next to the curb, gutter, cross gutter, etc. shall be milled one inch below the top edge of the concrete to provide a finished asphalt surface that is flush with or not more than .02 foot above the concrete gutter.
- Asphalt pavements with an average density less than ninety one percent of the Marshall, or with any single test less than ninety percent of the Marshall, shall be removed and replaced.

4.5.24.5 OPEN-GRADED ASPHALT WEARING COURSE.

In the event that the extraction or gradation fails to meet the allowable deviation, the remaining sample material shall be remolded and tested in accordance with AASHTO T 283-89 or ASTM D 4867-92 including Note 5. The open-graded asphalt pavement must possess seventy percent of the tensile strength ratio based on the approved mix design. Open-graded asphalt not meeting this requirement shall be removed and replaced.

The allowable maximum deviations from the approved Marshall mix design shall be as follows:

Asphalt content	+/- 0.46%
1/2" (12.5 mm)	+/- 6.3%
3/8" (9.5 mm)	+/- 5.9%
No. 4 (4.75 mm)	+/- 5.7%
No. 8 (2.36 mm)	+/- 4.8%
No. 200 (.075 mm)	+/- 2.0%

4.5.24.6 ASPHALT PAVEMENT SURFACES.

The completed surfacing shall be thoroughly compacted, smooth and free from ruts, humps, depressions, rock pockets or slick spots. Any ridges, indentations or other objectionable marks left in the pavement's finished surface shall be corrected prior to acceptance.

The paving contractor shall provide adequate quality control during spreading and finishing procedures to meet or exceed the following longitudinal and transverse profiles:

- Longitudinal deviations shall not exceed ± 0.025 foot in 25 feet when checked by a taut string line.
- Transverse deviations shall not exceed ± 0.01 foot in 10 feet when checked with a ten foot straight edge.
- Longitudinal construction joint deviations shall not exceed ± 0.01 foot when checked with a ten foot straight edge.
- The completed pavement surfaces shall be constructed to the required grades and cross sections. When pavement surfaces contact concrete structures such as drainage structures, curbs & gutters, utility vaults, or manholes, the pavement surfaces shall be flush with or above the concrete structures by not more than 0.02 foot.

All deviations exceeding the specified profile tolerances shall be corrected prior to final rolling.