5D-1 HMA Pavement Mixture Selection

A. Scope

This section is intended for the engineers and technicians who specify asphalt paving material criteria for urban projects, generally ranging from low to medium volume, up to 10M ESALs (3,300 trucks per day). Vehicle volumes exceeding 10M $ESAL_{20}$, or projects outside of these design standards, may require more detailed design and/or expert consultation. The section provides a step-by-step process for determining the appropriate mixture criteria and gives the designer additional background information on specific mixture criteria. The section is intended to assist in selecting the mixture criteria that best satisfy the project demands and limitations. Statewide use of this section will improve the standard application of current accepted gyratory mix design technology.

B. Definitions

Gyratory mix design: A laboratory process for achieving desired pavement performance by determining the optimum proportions of aggregates and asphalt binder for hot mix asphalt using a SHRP Superpave gyratory compactor.

Equivalent Single Axle Load (ESAL): A standard unit of pavement damage created by a single pass of a vehicle axle.

Car axle = 0.0002 ESAL   18kip truck axle = 1.0 ESAL   24kip truck axle = 3.0 ESAL

$ESAL_{20}$: Estimated cumulative ESALs over a 20 year period.

N: The number of gyratory compaction revolutions at which HMA mixture properties are measured.

- N_{ini} represents initial field compaction.
- N_{des} represents 20 years of traffic loading.
- N_{max} represents a factor of safety against excessive vehicle loads.

Nominal Maximum Aggregate Size (NMAS): The mixture size designation used for the combined aggregate gradation. Defined as one sieve size larger than the first sieve to retain more than 10%.

Lift Designation (Surface, Intermediate, Base): The terms for the lifts of mixture in the hot mix asphalt pavement structure. The surface lift is the top lift, generally 1 to 2 inches thick. The intermediate lift(s) is one or more lifts placed under the surface lift, generally 2 to 4 inches thick. The base lift(s) is all mixture placed below the intermediate lift, generally limited to full depth construction.

Performance Graded (PG): National asphalt binder grading system, developed by AASHTO, based on high and low pavement operating temperatures (°C).

"Rule of 90": The "rule of 90" adds the binder grade numbers. For example, PG 58 -28 would have a value of 86 (58+28). If the "rule of 90" value for a binder grade is above 90, it may be a modified binder with an additional cost.

C. Design checklist

Designers should follow the steps below to ensure that the material criteria selected will best meet the needs of the project and the constraints of the owner agency.

1. **Determine the level of traffic forecasted for the next 20 years.** Both current and future traffic levels are needed to determine the appropriate Hot Mix Asphalt (HMA) mixture for the project. Even if the project is not expected to remain in place for 20 years, the material selection levels are based on 20-year values. Common values are average daily traffic (ADT) for the current year, ADT for the 20-year forecast, and percent trucks. In addition to these annualized daily values, the designer should consider potential seasonal high truck volumes, and give particular attention to point sources and future development areas that may generate heavy truck volumes, like quarries, industrial parks, and bus lanes. Seasonal truck volumes may reflect a rate of pavement loading well in excess of the annualized values.

2. **Understand the pavement section design or rehabilitation strategy.** In order to make the proper mixture selection, the designer must have knowledge of the proposed pavement construction or rehabilitation and intended pavement performance. The thickness of the pavement will also affect the material and mixture selection. For example, mixture selection for new construction or reconstruction may be different from mixture selection to correct a rutting problem. Particular parameters include required structural thickness, existing pavement cross section and condition (dominant distress patterns), traffic patterns and speed, and past maintenance.

3. **Determine the regional climate conditions.** Iowa's 1-day low pavement temperature ranges approximately 5 °C from north to south. Adjusted for 98% reliability, the values range from -29 °C to -24 °C. The 7-day high pavement temperature across the state only varies by 3 °C. These values are computed from daily high air temperatures. Adjusted for 98% reliability, the pavement temperature values range from 56 °C to 59 °C. Climate details for a specific location can be obtained from the LTPPBind software package available on the FHWA website (www.tfhrc.gov/pavement/ltpp/bind/dwnload.htm). See Subsection H, Figures 1 and 2.

4. **Compute the anticipated 20-year pavement loading.** The design pavement loading is the starting point for selecting the material and mixture selection criteria. The design pavement loading is measured in Equivalent Single Axle Loads (ESAL), not ADT. To determine the design ESALs on the project, use the traffic conditions from Step 1 and compute the $ESAL_{20}$ use the methods outlined in Section 5D-1, G, Method 1, for two-lane, two-way traffic; use Method 2 for urban multi-lane situations. Design ESAL levels for HMA criteria selection are divided into relatively large brackets. The high value of each bracket is three times the minimum value. While a firm understanding of the traffic and pavement loading is important, good approximations of truck traffic are normally sufficient to determine the design $ESAL_{20}$.

5. **Identify any special conditions that impact the pavement.** The standard selection process is based on high-speed traffic with a broad distribution of vehicle types. There are numerous special conditions that may, through engineering judgement, require changes in the standard pavement materials/mixture selection. These special conditions are outlined below.

    a. **Heavy trucks.** If the pavement's history has regularly been impacted by heavy trucks, the designer may consider increasing either the binder high temperature grade, the mix designation (ESAL level), or both. Typical examples of this condition are routes adjacent to quarries, grain elevators, or regional commercial freight distribution centers.

    b. **Slow/stop/turning.** Urban roadways normally require slower running speeds and often include signed or signaled intersections. The pavement loading condition significantly increases at slower speeds (less than 45 MPH) and stopped vehicles at intersections. The designer may consider increasing the high temperature binder grade and/or the percent of crushed aggregate to account for this condition. Economics will determine if the higher grade of binder can be applied to the whole project, or just the impacted length of pavement (i.e. intersection and approaches).

    c. **Durability.** Many low-volume asphalt pavements are more susceptible to failure due to long-term aging than to rutting or fatigue. For pavements with good maintenance histories and more than 15 years between overlays, the designer may want to ensure that the mixture selection will provide adequate durability and, if economically necessary, sacrifice some reliability against rutting or fatigue. This can be accomplished through the selection of a lower compaction level and/or the selection of a softer grade of binder.

    d. **Urban vs. rural.** Separate from the issue of traffic speed, rural projects that pass through urban locations should consider mix sizes (NMAS) that will appeal to the pedestrian traffic. In general, smaller mix sizes will have a better surface appearance than larger mix sizes. The designer can specify smaller mix sizes than those provided in the material selection guide table, but should also consider the availability of the aggregates when making that decision. Similarly, the designer may choose to use a larger mix size on rural sections for the purpose of reducing the asphalt binder content in the mixture.

    e. **New construction vs. overlay.** The design guide takes into account the major pavement performance parameters (rutting, fatigue, and low temperature cracking). When an overlay is placed, there are existing pavement distresses that influence the performance of the overlay. Generally, low temperature cracking will be less of a factor because reflective cracking from the existing pavement will minimize the stresses that cause low temperature cracking. If the existing pavement is cold-in-place rehabilitated (or a stress relief layer is placed) below the overlay, then low temperature cracking should be considered in the design.

    f. **Seasonal traffic.** Seasonal traffic occurs over a relatively short period of time and may create pavement damage in excess of the normal traffic. For example, grain harvest, Iowa State Fair, festivals, etc. may generate higher volumes (in terms of ESALs) of traffic for a short period of time. This does not only take into account traffic volumes, but also pavement loads.

    g. **Mixture workability.** Smaller mixture sizes are easier to use for hand work.

6. **Select the HMA mixture criteria for each pavement layer.** Using the information developed in steps 1 through 5, select the PG binder grade, mixture size, mix design level, and aggregate properties.

   a. **PG asphalt binder grade.** The designer should select a binder that nominally satisfies 98% temperature reliability for both the 7-day high pavement temperature and the 1-day low pavement temperature (see 5D-1, C, 3). The designer should select a conventional binder that best satisfies the project conditions. The standard conventional binders in Iowa are PG 58 -28 and PG 64 -22. Typically in urban areas, residential and collectors will normally use PG 58 -28. For arterials, a PG 64 -22 should be considered. If the designer selects other binder grades to address special considerations, they should recognize the cost impact of specifying non-standard binders. The "rule of 90" (see definitions) can be applied to determine if a binder may require a modifier to achieve the specified properties. "Rule of 90" values above 90 may be modified binders and will increase the binder cost by 15 to 50%.

   b. **HMA mixture size.** Each mixture size (NMAS) is a function of the available aggregates, project conditions, and lift thickness. Minimum lift thickness is a function of density and mixture constructability. The following table shows the minimum lift thickness for the following mix sizes:

Mix Size	Minimum Lift Thickness
3/8"	1"
1/2"	1-1/2"
3/4"	2"
1"	3"

   c. **Mix design level.** Based on the projected $ESAL_{20}$ value, seasonal traffic loading and current pavement distress, the designer must select a mix design level. The boundaries of the design levels are not absolute, so the designer should take into consideration the assumptions used to compute the ESAL value. A conservative $ESAL_{20}$ value of 400,000 may justify the selection of a 300,000 ESAL mixture instead of a 1,000,000 ESAL mixture. Conversely, a project that computes 900,000 $ESAL_{20}$ in a developing area may consider a 3,000,000 ESAL mixture.

   d. **Aggregate properties.** The mixture design criteria (Table 2) is derived from Iowa DOT Materials I.M. 510. Table 2 specifies a 15% increase in percent crushed aggregate for surface and intermediate mixes 1 M ESALs and less to account for slow, stop, and turning conditions. Table 2 also changes the aggregate source type for the 100K ESAL and 300K ESAL surface and intermediate mixtures from Type B to Type A.

      The specifications allow the designer to specify the minimum percent crushed and aggregate source type (Type A or Type B). This will be a local decision based on past performance and available aggregates. The actual percent crushed needed to achieve the mix design gyratory compaction volumetrics will vary with the quality of the aggregates used. Both the specified percent crushed and the gyratory compaction volumetrics must be satisfied by the HMA mixture.

7. **Check for availability of materials to meet the mix design criteria.** Review the mix design criteria selected in step 6 and determine if the binder and aggregates required to meet the mix design criteria are readily available or accessible at a reasonable cost. Contact local producers and/or district materials engineers, if the designer plans to use non-standard criteria. Imported aggregates and modified binders generally cause higher costs. The designer should be ready to justify the mix selection decision.

8. **Place mix criteria in the project plans and proposal.** The following information should be placed in the plans and proposal:

   a. **Traffic and $ESAL_{20}$ projections.** The traffic and $ESAL_{20}$ projections should be listed on the title sheet of the plans. The $ESAL_{20}$ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the $ESAL_{20}$ value is based on seasonal loading.

Example 1: Title Sheet

Traffic	
Current ADT	________
Future ADT	________
Present Trucks	________
$ESAL_{20}$	________

   b. **HMA mixture.** Each HMA mixture bid item is defined by the ESAL level, lift designation, and aggregate size. The mixture properties for each mixture level are specified in the specifications and Table 2. If the designer specifies a different percent crushed aggregate, this should be identified in the bid item note on the plans. The designer should avoid placing the mix size in additional sections of the plans to minimize errors associated with duplication. The exception to this guide would be a bid item note or tabulation intended to identify locations of different mix sizes for the same lift.

   c. **Asphalt binder grade PG XX –XX.** The asphalt binder grade should be specified in the bid item. The designer should avoid placing the binder grade in additional sections of the plans to minimize errors associated with duplication. The exception to this guide would be a bid item note or tabulation intended to identify binder use when multiple binders are specified.

Example 2: Bid Item

Mix Design Level	Lift Designation	Mix Size	Binder Grade
↘	↘	↓	↓

HMA (1M ESAL) Surface, 3/8”, PG 58 -28

D. Material properties

1. **Typical PG grades and their application**. Two grades (PG 58 -28 and PG 64 -22) are common conventional binders used in Iowa. A PG 58 -28 asphalt binder will cover the climate range for a majority of projects in Iowa with 98% reliability. Some locations along northern tier counties may desire a PG 52 -34 for better low temperature protection but will lose protection against rutting. Southern counties may consider a PG 64 -22 binder for better high temperature properties but will lose protection against low temperature cracking.

2. **Aggregate source properties.** Aggregate source properties are classified as Type A or Type B quality. The source properties are defined in Iowa DOT Standard Specifications 4126 and 4127. The mixture criteria listed in Table 2 define the aggregate type for each mixture level specified for the project. Each individual source of aggregate is expected to meet these criteria. The designer may specify a different aggregate type in the bid item note.

3. **Aggregate consensus properties.** Aggregate consensus properties are listed in Table 2 for each mixture level. These properties include percent crushed aggregate, fine aggregate angularity, clay content (sand equivalent), and flat & elongated particles. These aggregate properties are measured on the combined aggregate, not individual aggregates.

   If the designer specifies a value different from Table 2, the value selected should be based on the local practice and desired pavement performance. The HMA mixture must satisfy both the percent crushed aggregate and laboratory compaction volumetric criteria. The percent crushed aggregate specified is interdependent on the compaction level and the quality of the aggregate.

E. Use of mixture selection guide and design criteria tables

Two tables in Subsection H are provided to assist designers with the selection of HMA materials for projects. The HMA Mixture Selection Guide (Table 1) provides the project designer with a set of standard material selections that will satisfy most projects. The HMA Mixture Design Criteria (Table 2) is derived from Iowa DOT Materials I.M. 510 and provides the mix designer with the detailed mix criteria for each mixture level. The mixture selection guide and mixture design criteria represent the current understanding of accepted HMA properties for application on urban routes.

The HMA Mixture Selection Guide (Table 1) represents commonly used mixture parameters, but does not preclude the project designer from deviating from the "recommended" values. The designer should understand the impact of any modification. The first two columns define the standard mixture levels based on traffic loading. Daily ESAL and daily truck values are given as a general comparison to the design $ESAL_{20}$ ranges. These may be used to examine seasonal traffic conditions in relation to the 20-year value. The middle columns establish lift thickness and mix size relationships. It should be noted that Table 1 does not address required pavement thickness to meet structural needs (Section 5C-2, Table 10B). The Bid Item Designation column ties the mixture levels to the bid items. The final column gives a general statewide guide for the estimated binder content. Local binder content experience may be more appropriate for project estimated quantities. This table does not address the need for special friction aggregate. In general terms, urban routes do not require special friction aggregate.

As mentioned earlier, the HMA Mixture Design Criteria (Table 2) is derived from Iowa DOT Materials I.M. 510. However, the table differs from I.M. 510. For the surface and intermediate levels in the 100K to 1M ESAL mixes, the percent of crushed aggregate was increased 15% and the aggregate type was improved from B to A. A different aggregate type and the percent crushed aggregate may be specified by the designer for the project. These values established in the table are prescribed for each mixture and care should be exercised if altered by the project designer. The designer should only change these values when familiar with the material properties and mixture performance for the local area. The bid item plan note must include these values, if it differs from the value in Table 2.

F. Example plans

1. **Title Page:** The traffic and $ESAL_{20}$ projections should be listed on the title sheet of the plans. The $ESAL_{20}$ value should coincide with the selected mix design level. If seasonal ESALs are used for design, the title sheet should note that the $ESAL_{20}$ value is based on seasonal loading.

2. **Typical Section:** Lift thickness should be shown on the typical section. The lift thickness should match or exceed the recommended lift thickness for the mixture size selected. The lift should be designated as surface, intermediate, or base. Mixture size or design $ESAL_{20}$ level should not be added to the typical section (it is specified in the bid item).

3. **Bid Items:** Unless otherwise specified, each bid item covers the mixture and binder grade selected. The corresponding bid item note must specify the minimum percent crushed aggregate, if it differs from the value in Table 2.

G. Examples for determination of traffic ESALs

Similar to pavement thickness design, the HMA mixture is designed for the frequency and size of the load applied to the pavement. While it is important to have a good understanding of the traffic, it is possible to select the asphalt paving materials based on reasonable approximations. If the designer has actual traffic data, including a distribution of truck types and loads, the current annual ESAL value can be computed from the AASHTO pavement design tables. For most projects however, the designer will determine estimated values based on a general familiarity with the route. The following methods can be used to approximate the design $ESAL_{20}$ for a project.

Method 1: Two-Lane, Two-Way Traffic

Step	Task	Values
1	Given: Current ADT Year 20 ADT Percent trucks	500 750 10%
2	Select a "design year" ADT *[current year + 70-80% of Year 20 increase]*	500 + 80% (250) = 700
3	Convert to trucks per day *[design year ADT X % trucks]*	700 X 10% = 70 trucks/day
4	Select an appropriate ESAL factor *[0.40 for low volume to 0.45 for major collectors, 0.50 for heavy truck routes]*	0.40 ESAL factor
5	Compute ESALs per day *[trucks per day X ESAL factor]*	70 X 0.40 = 28 ESALs/day
6	Compute ESALs per year *[300 days for low volume to 365 days for high volume]*	28 X 300 = 8400 ESALs/year
7	Compute $ESAL_{20}$ *[20 years]*	8400 X 20 = 168,000 $ESAL_{20}$
8	Select HMA mixture design level *[from Table 1, HMA Mixture Selection Guide]*	**HMA 300K**

Method 2a: Urban Multi-Lane (simple approach)

Step	Task	Values
1	Given: Current ADT Year 20 ADT Percent trucks	10,000 15,000 3%
2	Select a "design year" ADT *[current year + 70-80% of Year 20 increase]*	10,000 + 80% (15,000-10,000) = 14,000
3	Compute number of design-lane trucks *[design lane is set at 80% of truck volume and 50% directional split]*	14,000 X 3% X 80% X 50%= 168 trucks/day/design-lane
4	Select an appropriate ESAL factor from the table below *[for this example, select Commercial/Arterial]*	0.24 ESAL factor
5	Compute ESALs per day *[trucks per day X ESAL factor]*	168 X 0.24 = 40 ESALs/day
6	Compute ESALs per year *[300 days for low volume to 365 days for high volume]*	40 X 300 = 12,000 ESALs/year
7	Compute $ESAL_{20}$ *[20 years]*	12,000 X 20 = 240,000 $ESAL_{20}$
8	Select HMA mixture design level *[from Table 1, HMA Mixture Selection Guide]*	**HMA 300K**

Method 2a ESAL Factor

Route Type	Truck Type			ESAL Factor[1]
	Panel 0.1 ESAL/truck	Dump 1.5 ESAL/truck	Semi 0.75 ESAL/truck	
Residential	95%	5%	0%	0.17
Collector	90%	5%	5%	0.20
Commercial/Arterial	85%	5%	10%	0.24
Light Industrial	75%	5%	20%	0.30
Heavy Industrial	65%	5%	30%	0.37

[1] Combined value of various truck type and load ESALs, taking into account all levels of loading (full to empty).

Method 2b: Urban Multi-Lane (more input required)

<table>
<tr><th>Step</th><th>Task</th><th>Values</th></tr>
<tr><td>1</td><td>Given: Current ADT
Year 20 ADT
Percent trucks
Directional Distribution (trucks only)
Lane Distribution (trucks only)
Truck Type Proportions (must equal 100%)</td><td>10,000
15,000
3%
60:40 split
70:30 split
30% panel, 10% dump, 60% semi</td></tr>
<tr><td>2</td><td>Select a “design year” ADT
[current year + 70-80% of Year 20 increase]</td><td>10,000 + 80% (15,000-10,000) = 14,000</td></tr>
<tr><td>3</td><td>Compute number of design-lane trucks
[use higher volume lane]</td><td>14,000 X 3% X 60% X 70% = 176 trucks/day/design-lane</td></tr>
<tr><td>4</td><td>Select an appropriate ESAL factor using the table below
[for this example select Panel = 0.2, Dump = 1.3, Semi = 1.0]</td><td>Panel = 0.2, Dump = 1.3, Semi = 1.0</td></tr>
<tr><td>5</td><td>Compute ESALs per day
[trucks per day X ESAL factor]
<table><tr><th>Truck Type</th><th>Design Trucks</th><th>Truck Proportion</th><th>ESAL Factor</th><th>ESAL/day</th></tr><tr><td>Panel</td><td>176</td><td>30%</td><td>0.2</td><td>11</td></tr><tr><td>Dump</td><td>176</td><td>10%</td><td>1.3</td><td>23</td></tr><tr><td>Semi</td><td>176</td><td>60%</td><td>1.0</td><td>105</td></tr></table></td><td>11 + 23 + 105 = 139 ESALs/day</td></tr>
<tr><td>6</td><td>Compute ESALs per year
[300 days for low volume to 365 days for high volume]</td><td>139 X 300 = 41,700 ESALs/year</td></tr>
<tr><td>7</td><td>Compute $ESAL_{20}$
[20 years]</td><td>41,700 X 20 = 834,000 $ESAL_{20}$</td></tr>
<tr><td>8</td><td>Select HMA mixture design level
[from Table 1, HMA Mixture Selection Guide]</td><td>HMA 1M</td></tr>
</table>

Method 2b ESAL Factor

Truck Type	ESAL Factor (ESAL/truck)[1]
Panel	0.10 – 0.30 [fully loaded=0.5]
Dump	1.20 – 1.80 [fully loaded=4.0]
Semi	0.60 – 1.20 [fully loaded=2.5]

[1] ESAL factors take into account all levels of loading (full to empty)

H. Tables and figures

Table 1: HMA Mixture Selection Guide

Daily Trucks	Daily ESALs	Design $ESAL_{20}$ (Millions)	Layer Designation	Lift Thickness[3] min	rec	max	Mix Size[1]	Bid Item Designation	Binder Content[2]
<40	< 15	< 0.1	surface	1.5	1.5	2.5	½”	HMA 100K	6.00
			intermediate	1.5	1.5	3	½”		
			base	1.5	1.5	3	½”		
40-125	15 – 40	0.1 - 0.3	surface	1.5	1.5	2.5	½”	HMA 300K	6.00
			intermediate	1.5	1.5	3	½”		
			base	1.5	1.5	3	½”		
125-350	40 – 140	0.3 – 1.0	surface	1.5	1.5	2.5	½”	HMA 1M	6.00
			intermediate	1.5	1.5	3	½”		
			base	1.5	1.5	3	½”		
350-990	140 – 400	1.0 – 3.0	surface	1.5	2	2.5	½”	HMA 3M	6.00
			intermediate	2	3	4	¾”		5.50
			base	2	3	4	¾”		6.00
990-3300	400 – 1350	3.0 – 10.0	surface	1.5	2	2.5	½”	HMA 10M	6.00
			intermediate	2	3	4	¾”		5.50
			base	3	4	5	1"		5.25

[1] The common mix size is shown. When other mix sizes are used, the minimum lift thickness also changes (See Subsection C, 6, b).
[2] These values are for estimating quantities only. The actual asphalt binder content is established in the approved JMF.
[3] Some lift thickness values in this guide may conflict with traffic control or allowable compaction criteria.

Table 2: SUDAS HMA Mixture Design Criteria
(derived from Iowa DOT Materials I.M. 510)

Mix Designation	Gyratory Density					Friction[2]			Aggregate[3]			
	N_{ini} - N_{des} - N_{max}	Initial % G_{mm} (max) - Design % G_{mm} (target) - Maximum % G_{mm} (max)	VFA	Film Thickness	Filler: Binder	Type 4 (min)	Type 3 (min)	Type 2 (min)	Quality Type	Crush (min)	FAA (min)	Sand Equiv. (min)
HMA 100K S-I	7 - 68 - 104	92.5 - 97.0 - 98.5	75-85	8.0-13.0	0.6-1.4				A[1]	60[1]	---	40
HMA 100K B									B	45	---	
HMA 300K S-I	7 - 68 - 104	92.0 - 96.5 - 98.0	70-80	8.0-13.0	0.6-1.4				A[1]	60[1]	---	40
HMA 300K B		92.5 - 97.0 - 98.5	75-85						B	45	---	
HMA 1M S L-4	7 - 76 - 117	90.5 - 96.0 - 98.0	65-78	8.0-15.0	0.6-1.4	50			A	75[1]	40	40
HMA 1M S												
HMA 1M I									A[1]	60[1]		
HMA 1M B	7 - 68 - 104	92.0 - 96.5 - 98.0	70-80						B	45	---	
HMA 3M S L-4	7 - 86 -134	89.5 - 96.0 - 98.0	65-78	8.0-15.0	0.6-1.4	50			A	75	40	40
HMA 3M S L-3						80	45	(30)				
HMA 3M S												
HMA 3M I										60		
HMA 3M B	7 - 76 - 117	90.5 - 96.5 - 98.0	65-78						B	45		
HMA 10M S L-3	8 - 96 - 152	89.0 - 96.0 - 98.0	65-78	8.0-15.0	0.6-1.4	80	45	(30)	A	75	43	45
HMA 10M I												
HMA 10M B	7 - 86 - 134	89.5 - 96.0 - 98.0	65-78						B	75	40	

For mix design levels exceeding 10M ESALs, see Iowa DOT I.M. 510.

[1] Requirements differing from I.M. 510; for surface and intermediate mixes, aggregate quality improved from B to A and percent crushed aggregate increased by 15%.

[2] See Iowa DOT Standard Specification 2303.02

[3] Flat & Elongated 10% maximum at a 5:1 ratio

Figure 1: High (7-day) Pavement Temperature at 98% Reliability

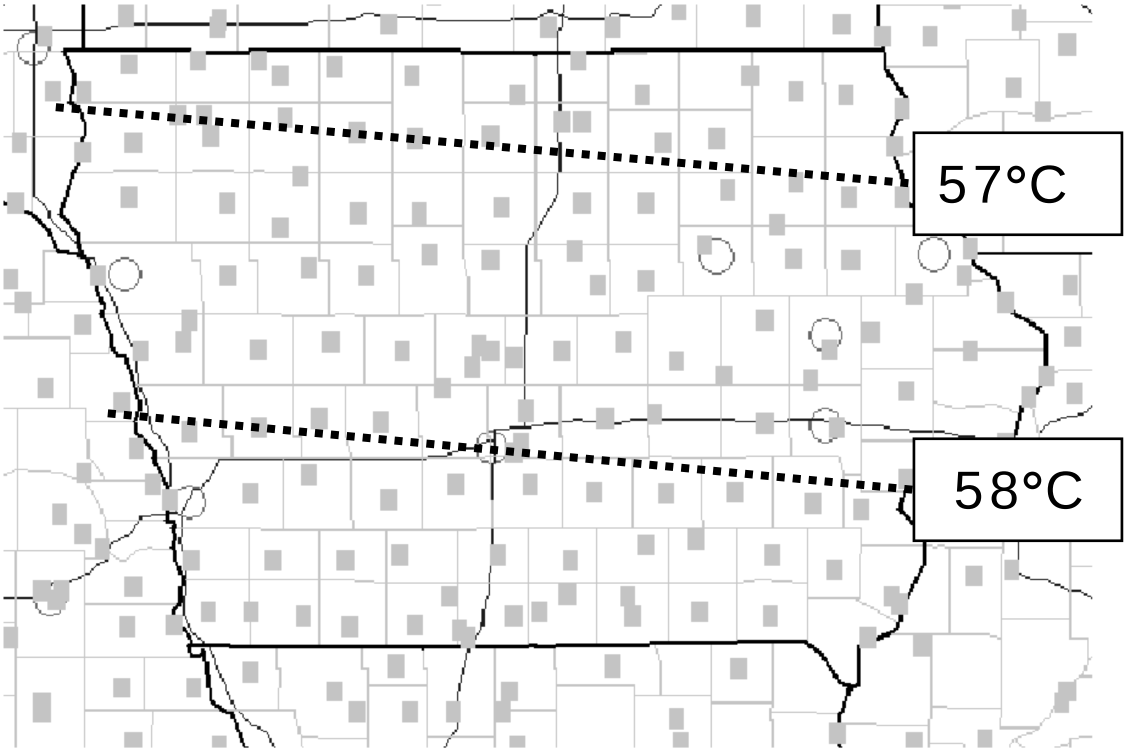

Figure 2: Low (1-day) Pavement Temperature at 98% Reliability