APPENDIX

SUPPLEMENTAL VERSION OF AASHTO GUIDE, PART II, SECTION 3.2 RIGID PAVEMENT DESIGN AND SECTION 3.3 RIGID PAVEMENT JOINT DESIGN

This appendix has been prepared for consideration as a supplemental method for rigid pavement design, in the form of an addendum to the current AASHTO Guide. It contains the recommendations from NCHRP 1-30, modified based on the results of the verification study conducted using the LTPP database.

3.2 RIGID PAVEMENT DESIGN

This section describes the design for Portland cement concrete pavements, including jointed plain (JPCP), jointed reinforced (JRCP), and continuously reinforced (CRCP). As in the design for flexible pavements, it is assumed that these pavements will carry traffic levels in excess of 70,000 18-kip [80-kN] (rigid pavement) ESALs over the performance period. Examples of use of this rigid pavement design procedure are presented at the end of this appendix.

Design of Different Types of Concrete Pavement. The JPCP design concept is to provide a sufficient slab thickness and joint spacing to minimize the development of transverse cracking. The JRCP and CRCP design concepts provide sufficient slab thickness and reinforcement to hold very tight the transverse cracks that form so that aggregate interlock will be maintained. The thickness of the design model upon which this guide is based was developed and validated specifically for JPCP, for which joint spacing is one of the important required design inputs affecting thermal curling stresses and, thus, transverse cracking. A proper selection of slab thickness and joint spacing is required to control the development of transverse cracking for a given climate, base, and subgrade. JRCP has much longer joint spacing and CRCP has no joints, and the transverse cracks that eventually form in these types of pavements must be held tight by sufficient steel reinforcement.

The use of this design method to determine an appropriate slab thickness for JRCP or CRCP requires the selection of an input "hypothetical" joint spacing. Research using the LTPP database has shown that the following input values of joint spacing will result in reasonable design thicknesses using this design method.

JPCP:	Actual joint spacing, ft.
JRCP:	Actual joint spacing if less than 30 ft [9 m], or 30 ft maximum (use this value only to obtain slab design thickness).
CRCP:	15 ft [4.6 m] (use this hypothetical value only to obtain slab design thickness).

Load Transfer at Joints. The AASHTO design procedure is based on the AASHO Road Test pavement performance algorithm that was extended to include additional design features. Inherent in the use of the AASHTO procedure is the use of dowels at transverse joints. Joint faulting was not a distress manifestation at the Road Test due to the adequacy of the dowel design. A faulting design check is provided for doweled joints to ensure that the dowels are sized properly. If a significant faulting problem is expected, an increase in dowel diameter or other design change may be warranted. The non-doweled faulting check was developed using more recent measurements of field data.

If the designer wishes to consider undoweled joints, a design check for faulting is provided. If the faulting check indicates inadequate load transfer, design modifications such as the use of dowels or changes in base type, drainage, and joint spacing may be made.

In addition, if the designer wishes to consider undoweled joints, a design check is also made for critical stresses due to axle loads applied near the transverse joint, along with a negative thermal gradient, creating a corner loading situation that would lead to premature cracking. If this check shows a potential problem, design modifications such as the use of dowels, increased slab thickness, or changes in base type may be made.

3.2.1 Develop Effective Modulus of Subgrade Reaction (k-Value)

The modulus of subgrade reaction (k-value) is defined as that measured or estimated on top of the finished roadbed soil or embankment upon which the base course and/or concrete slab will eventually be constructed. The k-value represents the subgrade (and embankment, if present); it does not represent the base course. The base course is considered a structural layer of the pavement along with the concrete slab, and thus its thickness and modulus are important design inputs in determining the required slab thickness in Section 3.2.2.

The k-Value input defined. The elastic k-value on top of the subgrade or embankment is the required design input. The gross k-value incorporated in previous versions of the AASHTO Guide represents not only elastic deformation of the subgrade under a loading plate, but also substantial permanent deformation. Only the elastic component of this deformation is considered representative of the response of the subgrade to traffic loads on the pavement. The elastic k-value test was the main subgrade test conducted extensively at the AASHO Road Test. When the elastic k-value was used in structural analysis of the AASHO Road Test pavements, it was found that slab stresses computed with a three-dimensional finite element model were approximately equal to those measured in the field under full-scale truck axle loadings at creep speed, providing further justification for use of the elastic k-value in the design.

Steps in determining design k-value. The k-value input required for this design method is determined by the following steps, which are described in this section:

1. Select a subgrade k-value for each season, using any of the three following methods:
   (a) Correlations with soil type and other soil properties or tests.
   (b) Deflection testing and backcalculation (most highly recommended).
   (c) Plate bearing tests.

2. Determine a seasonally adjusted effective k-value.
3. Adjust the seasonal effective k-value for effects of a shallow rigid layer, if present, and/or an embankment above the natural subgrade.

Note that the AASHTO design methodology requires the mean k-value, not the lowest value measured or some other conservative value. Note also that no additional adjustment to the k-value is applied for loss of support. Substantial loss of support existed for many sections at the AASHO Road Test, which led to increased slab cracking and loss of serviceability. Therefore, the performance data, upon which the AASHO Road Test performance model is based, already reflect the effect of considerable loss of support.

Step 1. Select a Subgrade k-Value for Each Season. A season is defined as a period of time within a year, such as 3 months (i.e., spring, summer, fall, winter). The number of seasons and the length of each season by which a year is characterized depend on the climate of the pavement's location.

There are several ways to measure or estimate the subgrade elastic k-value. Procedures are provided for three methods described below—correlation methods, backcalculation methods, and plate testing methods.

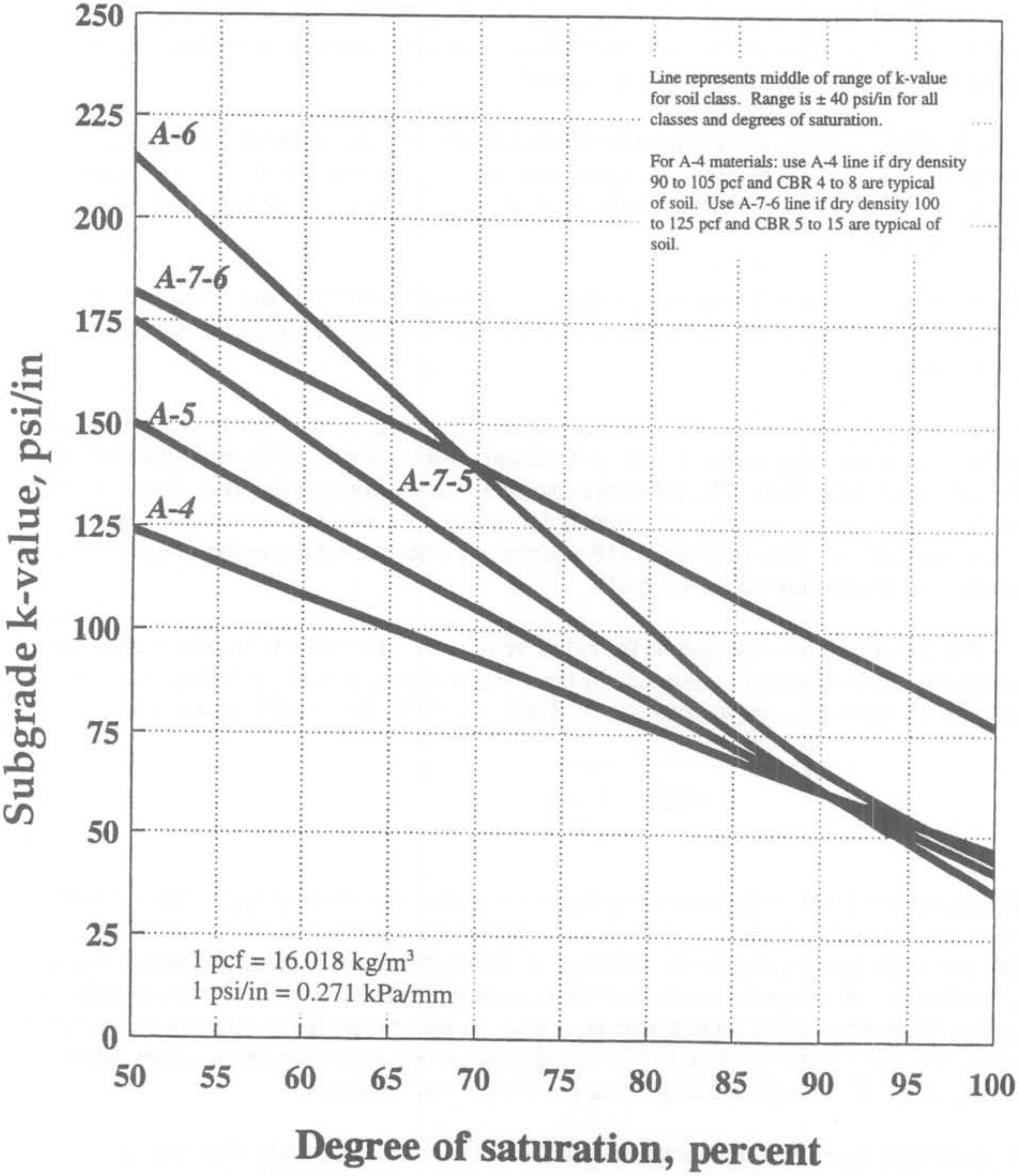
Correlation Methods. Guidelines are presented for selecting an appropriate k-value based on soil classification, moisture level, density, California Bearing Ratio (CBR), or Dynamic Cone Penetrometer (DCP) data. The CBR may also be estimated from the R-value. These correlation methods are anticipated to be used routinely for design. The k-values obtained from soil type or tests correlation methods may need to be adjusted for embankment above the subgrade or a shallow rigid layer beneath the subgrade.

The k-values and correlations for cohesive soils (A-4 through A-7). The bearing capacity of cohesive soils is strongly influenced by their degree of saturation (S_r, percent), which is a function of water content (w, percent), dry density (γ, lb/ft^3), and specific gravity (G_s):

$$S_r = \frac{w}{\left(\frac{62.4}{\gamma}\right) - \left(\frac{1}{G_s}\right)} \qquad [25]$$

Recommended k-values for each fine-grained soil type as a function of degree of saturation are shown in Figure 40. Each line represents the middle of a range of reasonable values for k. For any given soil type and degree of saturation, the range of reasonable values is about ± 40 psi/in [11 kPa/mm]. A reasonable lower limit for k at 100 percent saturation is considered to be 25 psi/in [7 kPa/mm]. Thus, for example, an A-6 soil might be expected to exhibit k-values between about 180 and 260 psi/in [49 and 70 kPa/mm] at 50 percent saturation, and k-values between about 25 and 85 psi/in [7 and 23 kPa/mm] at 100 percent saturation.

Two different types of materials can be classified as A-4: predominantly silty materials (at least 75 percent passing the #200 sieve, possibly organic), and mixtures of silt, sand, and gravel (up to 64 percent retained on #200 sieve). The former may have a density between about 90 and 105 lb/ft^3 [1442 and 1682 kg/m^3], and a CBR between about 4 and 8. The latter may have a density between about 100 and 125 lb/ft^3 [1602 and 2002 kg/m^3], and a CBR between about 5 and 15. The line labeled A-4 in Figure 40 is more representative of the former group. If the material in question is A-4, but possesses the properties of the stronger subset of materials in the A-4 class, a higher k-value at any given degree of saturation (for example, along the line labeled A-7-6 in Figure 40) is appropriate.



Line represents middle of range of k-value for soil class. Range is ± 40 psi/in for all classes and degrees of saturation.

For A-4 materials: use A-4 line if dry density 90 to 105 pcf and CBR 4 to 8 are typical of soil. Use A-7-6 line if dry density 100 to 125 pcf and CBR 5 to 15 are typical of soil.

1 pcf = 16.018 kg/m^3
1 psi/in = 0.271 kPa/mm

Figure 40. The k-value versus degree of saturation for cohesive soils.

Recommended k-value ranges for fine-grained soils, along with typical ranges of dry density and CBR for each soil type, are summarized in Table 11.

The k-values and correlations for cohesionless soils (A-1 and A-3). The bearing capacity of cohesionless materials is fairly insensitive to moisture variation and is predominantly a function of their void ratio and overall stress state. Recommended k-value ranges for cohesionless soils, along with typical ranges of dry density and CBR for each soil type, are summarized in Table 11.

The k-values and correlations for A-2 soils. Soils in the A-2 class are all granular materials falling between A-1 and A-3. Although it is difficult to predict the behavior of such a wide variety of materials, the available data indicate that in terms of bearing capacity, A-2 materials behave similarly to cohesionless materials of comparable density. Recommended k-value ranges for A-2 soils, along with typical ranges of dry density and CBR for each soil type, are summarized in Table 11.

Correlation of k-values to California Bearing Ratio. Figure 41 illustrates the approximate range of k-values that might be expected for a soil with a given California Bearing Ratio.

Correlation of k-values to penetration rate by Dynamic Cone Penetrometer. Figure 42 illustrates the range of k-values that might be expected for a soil with a given penetration rate (inches per blow) measured with a Dynamic Cone Penetrometer. This is a rapid hand-held testing device that can be used to quickly test dozens of locations along an alignment. The DCP can also penetrate AC surfaces and surface treatments to test the foundation below.

Assignment of k-values to seasons. Among the factors that should be considered in selecting seasonal k-values are the seasonal movement of the water table, seasonal precipitation levels, winter frost depths, number of freeze-thaw cycles, and the extent to which the subgrade will be protected from frost by embankment material. A "frozen" k may not be appropriate for winter, even in a cold climate, if the frost will not reach and remain in a substantial thickness of the subgrade throughout the winter. If it is anticipated that a substantial depth (e.g., a few feet) of the subgrade will be frozen, a k-value of 500 psi/in [135 kPa/mm] would be an appropriate "frozen" k.

The seasonal variation in degree of saturation is difficult to predict, but in locations where a water table is constantly present at a depth of less than about 10 ft [3 m], it is reasonable to expect that fine-grained subgrades will remain at least 70 to 90 percent saturated, and may be completely saturated for substantial periods in the spring. County soil reports can provide data on the position of the high-water table (i.e., the typical depth to the water table at the time of the year that it is at its highest). Unfortunately, county soil reports do not provide data on the variation in depth to the water table throughout the year.

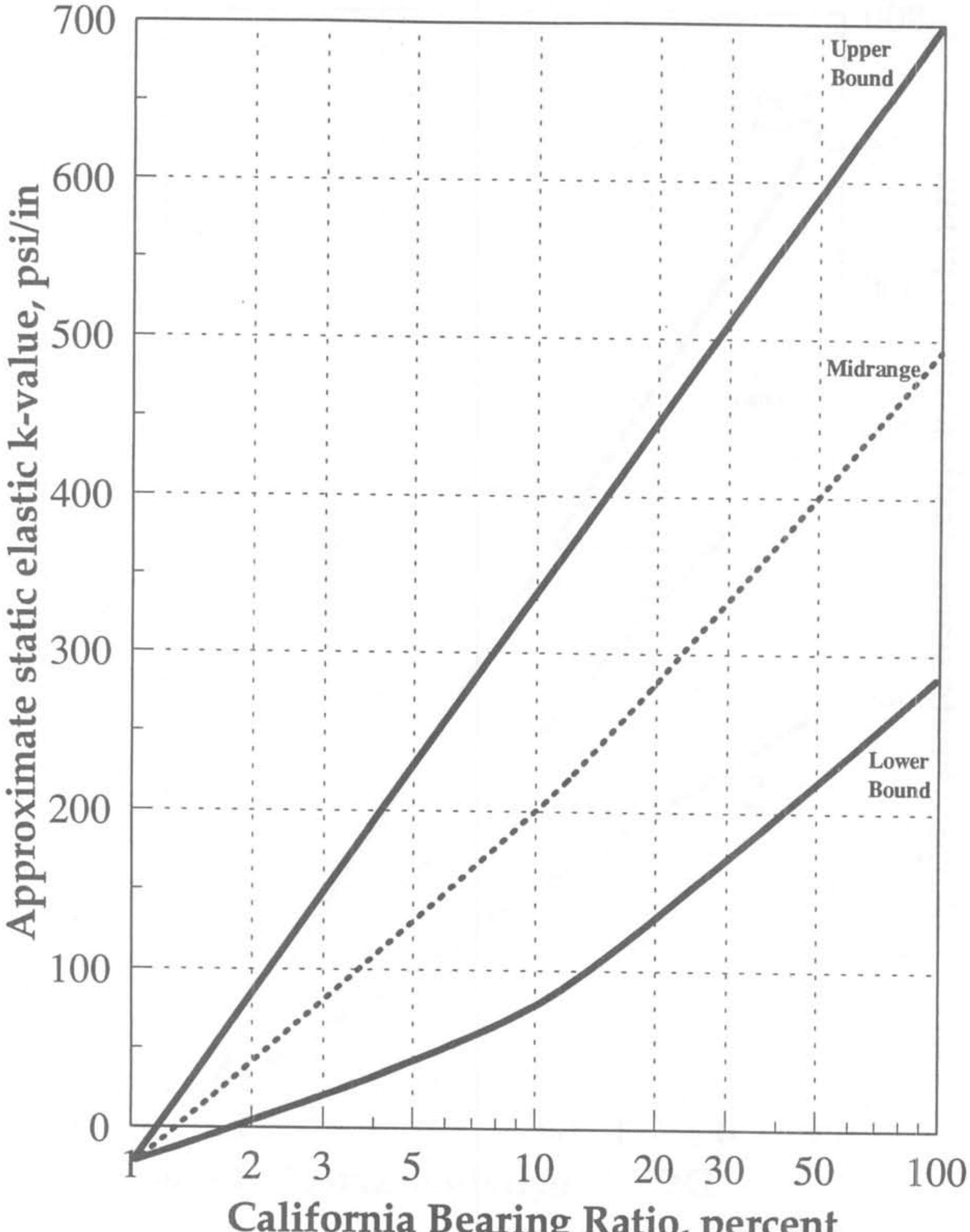
Table 11. Recommended k-value ranges for various soil types.

AASHTO class	Description	Unified class	Dry density (lb/ft^3)	CBR (percent)	k-value (psi/in)
Coarse-grained soils:					
A-1-a, well graded	gravel	GW, GP	125 - 140	60 - 80	300 - 450
A-1-a, poorly graded			120 - 130	35 - 60	300 - 400
A-1-b	coarse sand	SW	110 - 130	20 - 40	200 - 400
A-3	fine sand	SP	105 - 120	15 - 25	150 - 300
A-2 soils (granular materials with high fines):					
A-2-4, gravelly	silty gravel	GM	130 - 145	40 - 80	300 - 500
A-2-5, gravelly	silty sandy gravel				
A-2-4, sandy	silty sand	SM	120 - 135	20 - 40	300 - 400
A-2-5, sandy	silty gravelly sand				
A-2-6, gravelly	clayey gravel	GC	120 - 140	20 - 40	200 - 450
A-2-7, gravelly	clayey sandy gravel				
A-2-6, sandy	clayey sand	SC	105 - 130	10 - 20	150 - 350
A-2-7, sandy	clayey gravelly sand				
Fine-grained soils:					
A-4	silt	ML, OL	90 - 105	4 - 8	25 - 165 *
	silt/sand/ gravel mixture		100 - 125	5 - 15	40 - 220 *
A-5	poorly graded silt	MH	80 - 100	4 - 8	25 - 190 *
A-6	plastic clay	CL	100 - 125	5 - 15	25 - 255 *
A-7-5	moderately plastic elastic clay	CL, OL	90 - 125	4 - 15	25 - 215 *
A-7-6	highly plastic elastic clay	CH, OH	80 - 110	3 - 5	40 - 220 *

* k-value of fine-grained soil is highly dependent on degree of saturation. See Figure 40.

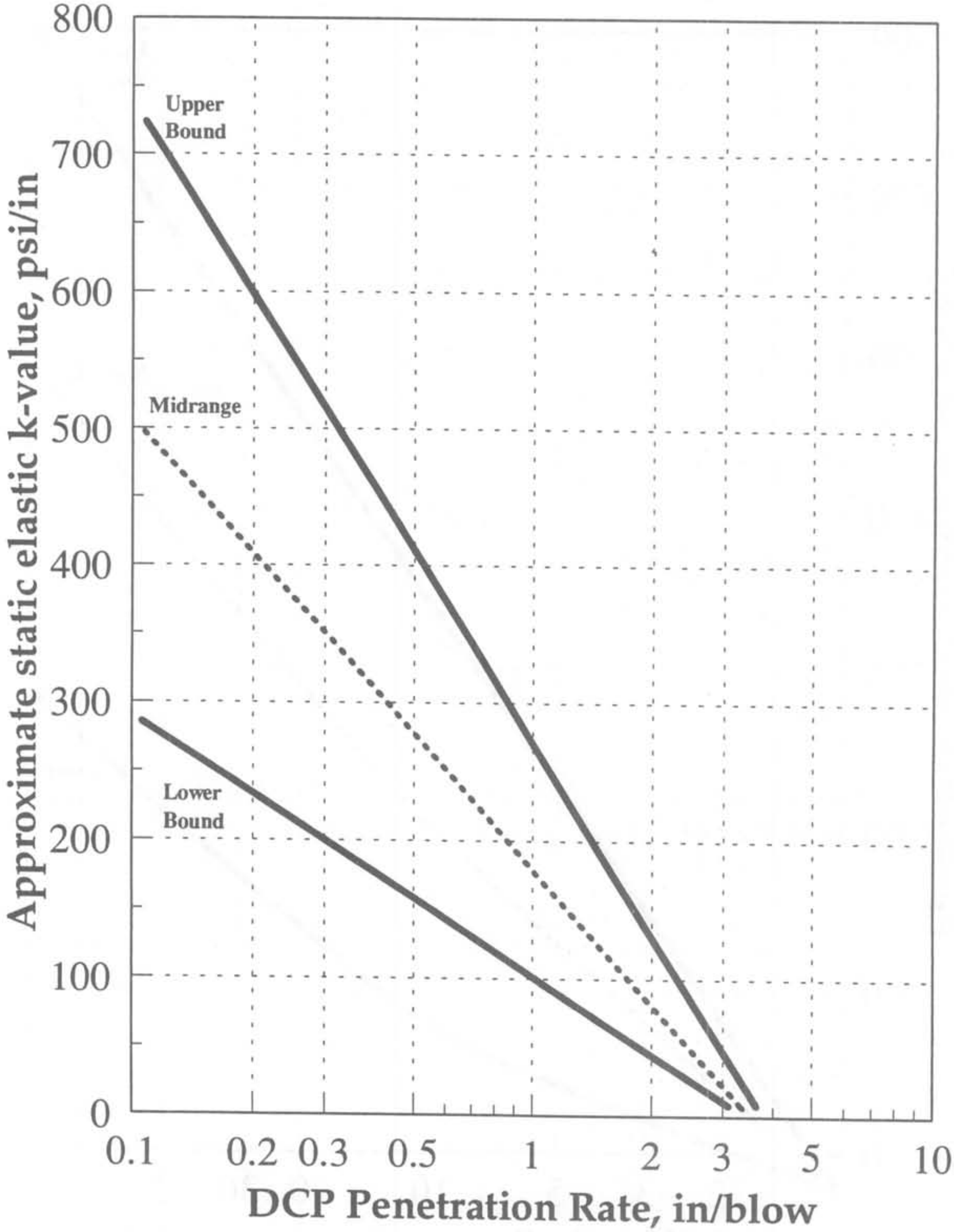
These recommended k-value ranges apply to a homogeneous soil layer at least 10 ft [3 m] thick. If an embankment layer less than 10 ft [3 m] thick exists over a softer subgrade, the k-value for the underlying soil should be estimated from this table and adjusted for the type and thickness of embankment material using Figure 43. If a layer of bedrock exists within 10 ft [3 m] of the top of the soil, the k should be adjusted using Figure 43.

1 lb/ft^3 =16.018 kg/m^3, 1 psi/in = 0.271 kPa/mm



1 psi/in = 0.271 kPa/mm

Figure 41. Approximate relationship of k-value range to CBR.



1 psi/in = 0.271 kPa/mm
1 in = 25.4 mm

Figure 42. Approximate relationship of k-value range to DCP penetration rate.

Deflection Testing and Backcalculation Methods. These methods are suitable for determining k-value for design of overlays of existing pavements, for design of a reconstructed pavement on existing alignments, or for design of similar pavements in the same general location on the same type of subgrade. An agency may also use backcalculation methods to develop correlations between nondestructive deflection testing results and subgrade types and properties. Cut and fill sections are likely to yield different k-values. No embankment or rigid layer adjustment is required for backcalculated k-values if these characteristics are similar for the pavement being tested and the pavement being designed, but backcalculated dynamic k-values do need to be reduced by a factor of approximately 2 to estimate a static elastic k-value for use in design.

An appropriate design subgrade k-value for use as an input to this design method is determined by the following steps:

1. Measure deflections on an in-service concrete or composite (AC-overlaid PCC) pavement with the same or similar subgrade as the pavement being designed.
2. Compute the appropriate AREA of each deflection basin.
3. Compute an initial estimate (assuming an infinite slab size) of the radius of relative stiffness, ℓ.
4. Compute an initial estimate (assuming an infinite slab size) of the subgrade k-value.
5. Compute adjustment factors for the maximum deflection d_0 and the initially estimated ℓ to account for the finite slab size.
6. Adjust the initially estimated k-value to account for the finite slab size.
7. Compute the mean backcalculated subgrade k-value for all of the deflection basins considered.
8. Compute the estimated mean static k-value for use in design.

These steps are described below, with the relevant equations for bare concrete and composite pavements given for each step.

Measure deflections. Measure slab deflection basins along the project at an interval sufficient to adequately assess conditions. Intervals of 100 to 1000 ft [30 to 300 m] are typical. Measure deflections with sensors located at 0, 8, 12, 18, 24, 36, and 60 in [0, 203, 305, 457, 610, 915, and 1524 mm] from the center of the load. Measure deflections in the outer wheel path. A heavy-load deflection device (e.g., Falling Weight Deflectometer) and a load magnitude of 9,000 lbf [40 kN] are recommended. ASTM D4694 and D4695 provide additional guidance on deflection testing.

Compute AREA. For a bare concrete pavement, compute the $AREA_7$ of each deflection basin using the following equation:

$$AREA_7 = 4 + 6\left(\frac{d_8}{d_0}\right) + 5\left(\frac{d_{12}}{d_0}\right) + 6\left(\frac{d_{18}}{d_0}\right) + 9\left(\frac{d_{24}}{d_0}\right) + 18\left(\frac{d_{36}}{d_0}\right) + 12\left(\frac{d_{60}}{d_0}\right) \qquad [26]$$

where d_0 = deflection in center of loading plate, inches

d_i = deflections at 0, 8, 12, 18, 24, 36, and 60 in [0, 203, 305, 457, 610, 915, and 1524 mm] from plate center, inches

For a composite pavement, compute the AREA$_5$ of each deflection basin using the following equation:

$$AREA_5 = 3 + 6\left(\frac{d_{18}}{d_{12}}\right) + 9\left(\frac{d_{24}}{d_{12}}\right) + 18\left(\frac{d_{36}}{d_{12}}\right) + 12\left(\frac{d_{60}}{d_{12}}\right) \tag{27}$$

Estimate ℓ assuming an infinite slab size. The radius of relative stiffness for a bare concrete pavement (assuming an infinite slab) may be estimated using the following equation:

$$\ell_{est} = \left[\frac{ln\left(\frac{60 - AREA_7}{289.708}\right)}{-0.698}\right]^{2.566} \tag{28}$$

The radius of relative stiffness for a composite pavement (assuming an infinite slab) may be estimated using the following equation:

$$\ell_{est} = \left[\frac{ln\left(\frac{48 - AREA_5}{158.40}\right)}{-0.476}\right]^{2.220} \tag{29}$$

Estimate k assuming an infinite slab size. For a bare concrete pavement, compute an initial estimate of the k-value using the following equation:

$$k_{est} = \frac{P\, d_0^*}{d_0\, (\ell_{est})^2} \tag{30}$$

where k = backcalculated dynamic k-value, psi/in
P = load, lb
d_0 = deflection measured at center of load plate, inch
ℓ_{est} = estimated radius of relative stiffness, inches, from previous step
d_0^* = nondimensional coefficient of deflection at center of load plate:

$$d_0^* = 0.1245\, e^{\left[-0.14707\, e^{\left(-0.07565\, \ell_{est}\right)}\right]} \tag{31}$$

For a composite pavement, compute an initial estimate of the k-value using the following equation:

$$k_{est} = \frac{P\ d_{12}^{*}}{d_{12}\ \left(\ell_{est}\right)^{2}} \tag{32}$$

d_{12} = deflection measured 12 in [305 mm] from center of load plate, inch
ℓ_{est} = estimated radius of relative stiffness, in, from previous step
d_{12}^{*} = nondimensional coefficient of deflection 12 in [305 mm] from center of load plate:

$$d_{12}^{*} = 0.12188\ e^{\left[-0.79432\ e^{\left(-0.07074\ \ell_{est}\right)}\right]} \tag{33}$$

Compute adjustment factors for d_0 and ℓ for finite slab size. For both bare concrete and composite pavements, the initial estimate of ℓ is used to compute the following adjustment factors to d_0 and ℓ to account for the finite size of the slabs tested:

$$AF_{d_0} = 1 - 1.15085\ e^{-0.71878\left(\frac{L}{\ell_{est}}\right)^{0.80151}} \tag{34}$$

$$AF_{\ell} = 1 - 0.89434\ e^{-0.61662\left(\frac{L}{\ell_{est}}\right)^{1.04831}} \tag{35}$$

where, if the slab length is less than or equal to twice the slab width, L is the square root of the product of the slab length and width, both in inches, or if the slab length is greater than twice the width, L is the product of the square root of two and the slab length in inches:

$$\begin{aligned} &\mathit{if}\ L_l \le 2 * L_w,\quad L = \sqrt{L_l\ L_w} \\ &\mathit{if}\ L_l > 2 * L_w,\quad L = \sqrt{2} * L_l \end{aligned} \tag{36}$$

Adjust k for finite slab size. For both bare concrete and composite pavements, adjust the initially estimated k-value using the following equation:

$$k = \frac{k_{est}}{AF_{\ell}^{2}\ \ AF_{d_0}} \tag{37}$$

Compute mean dynamic k-value. Exclude from the calculation of the mean k-value any unrealistic values (i.e., less than 50 psi/in [14 kPa/mm] or greater than 1500 psi/in [407 kPa/mm]), as well as any individual values that appear to be significantly out of line with the rest of the values.

Compute the estimated mean static k-value for design. Divide the mean dynamic k-value by two to estimate the mean static k-value for design.

A blank worksheet for computation of k from deflection data and example computations of k from deflection basins measured on two pavements, one bare concrete and the other composite, are given in Table 12.

Seasonal variation in backcalculated k-values. The design k-value determined from backcalculation as described above represents the k-value for the season in which the deflection testing was conducted. An agency may wish to conduct deflection testing on selected projects in different seasons of the year to assess the seasonal variation in backcalculated k-values for different types of subgrades.

Plate Bearing Test Methods. The subgrade or embankment k-value may be determined from either of two types of plate bearing tests: repetitive static plate loading (AASHTO T221, ASTM D1195) or nonrepetitive static plate loading (AASHTO T222, ASTM D1196). These test methods were developed for a variety of purposes, and do not provide explicit guidance on the determination of the required k-value input to the design procedure described here.

For the purpose of concrete pavement design, the recommended subgrade input parameter is the static elastic k-value. This may be determined from either a repetitive or nonrepetitive test on the prepared subgrade or on a prepared test embankment, provided that the embankment is at least 10 ft [3 m] thick. Otherwise, the test should be conducted on the subgrade, and the k-value obtained should be adjusted to account for the thickness and density of the embankment, using the nomograph provided in Step 3.

In a repetitive test, the elastic k-value is determined from the ratio of load to elastic deformation (the recoverable portion of the total deformation measured). In a nonrepetitive test, the load-deformation ratio at a deformation of 0.05 in [1.25 mm] is considered to represent the elastic k-value, according to extensive research by the U.S. Army Corps of Engineers.

Note also that a 30-in-diameter [762-mm-diameter] plate should be used to determine the elastic static k-value for use in design. Smaller diameter plates will yield substantially higher k-values, which are not appropriate for use in this design procedure.

Table 12. Determination of design subgrade k-value from deflection measurements.

BARE CONCRETE PAVEMENT

Step	Equation	Calculated Value	Example
d_0		________	0.00418
d_8		________	0.00398
d_{12}		________	0.00384
d_{18}		________	0.00361
d_{24}		________	0.00336
d_{36}		________	0.00288
d_{60}			0.00205
$AREA_7$	[26]		45.0
Initial estimate of ℓ	[28]		40.79
Nondimensional d_0*	[31]		0.1237
and initial estimate of k	[30]		160
AF_{d_0}	[34]		0.867
AF_{ℓ}	[35]		0.934
Adjusted k	[37]		212
Mean dynamic k			212
Mean static k for design			106

COMPOSITE PAVEMENT

Step	Equation	Calculated Value	Example
d_{12}		________	0.00349
d_{18}		________	0.00332
d_{24}		________	0.00313
d_{36}		________	0.00273
d_{60}			0.00202
$AREA_5$	[27]		37.8
Initial estimate of ℓ	[29]		48.83
Nondimensional d_{12}*	[33]		0.1189
and initial estimate of k	[32]		128
AF_{d_0}	[34]		0.823
AF_{ℓ}	[35]		0.896
Adjusted k	[37]		195
Mean dynamic k			195
Mean static k for design			97

Step 2. Determine Seasonally Adjusted Effective k-Value. The effective k-value is obtained by combining the seasonal k-values into a single "effective" value for use in concrete pavement design. The effective k-value is essentially a weighted average based on fatigue damage. The effective k-value results in the same fatigue damage over the entire year that is caused by the seasonal variation in k-value. The seasonally adjusted effective k-value is determined by the following steps:

1. Select tentative values for the slab thickness D, concrete flexural strength S'_c, concrete elastic modulus E_c, base elastic modulus E_b and friction coefficient f (both depending on base type), base thickness H_b, design temperature differential TD (for a given climatic region, as a function of the trial slab thickness D), joint spacing L, and initial and terminal serviceability P1 and P2. The tentative values selected for these parameters need only be approximate.
2. Select a k-value to represent each distinct season of the year.
3. Using each of the seasonal k-values in turn, calculate W_{18}, the allowable number of 18-kip [80-kN] ESALs for the design traffic lane, using the rigid pavement performance model given in Section 3.2.2.
4. Compute the relative damage for each season as the inverse of the calculated W_{18}.
5. Compute the total relative damage for the year and divide by the number of seasons to obtain the mean annual damage.
6. Compute a W_{18} corresponding to the mean damage as the inverse of the mean damage.
7. Use the rigid pavement performance model to determine a single k-value that produces a predicted W_{18} matching the W_{18} obtained in Step 6. This k-value is the seasonally adjusted effective k-value.

Table 13 may be used to determine the effective k-value. The example shown in Table 13 was developed using the following tentative design parameters:

D = 9 in [229 mm]
E_c = 4,200,000 psi [28,959 MPa]
S'_c = 690 psi [4758 kPa]
E_b = 25,000 psi for aggregate base [172 kPa]
H_b = 6 in [152 mm]
L = 180 in [4.57 m]
TD = +7.92°F [+4.4°C]
P1 = 4.5
P2 = 2.5

Step 3. Adjust the Effective k-Value for the Effects of Embankment and/or Shallow Rigid Layer. A nomograph is provided in Figure 43 for adjustment of the seasonally adjusted effective subgrade k-value if: (a) fill material will be placed above the natural subgrade, and/or (b) a rigid layer (e.g., bedrock or hardpan clay) is present at a depth of 10 ft [3 m] or less beneath the existing subgrade surface. Note that the rigid layer adjustment should only be applied if the subgrade k was determined on the basis of soil type or similar correlations. If the k-value was determined from nondestructive deflection testing or from plate bearing tests, the effect of a rigid layer, if present at a depth of less than 10 ft [3 m], is already represented in the k-value obtained.

Table 13. Determination of seasonally adjusted effective subgrade k-value.

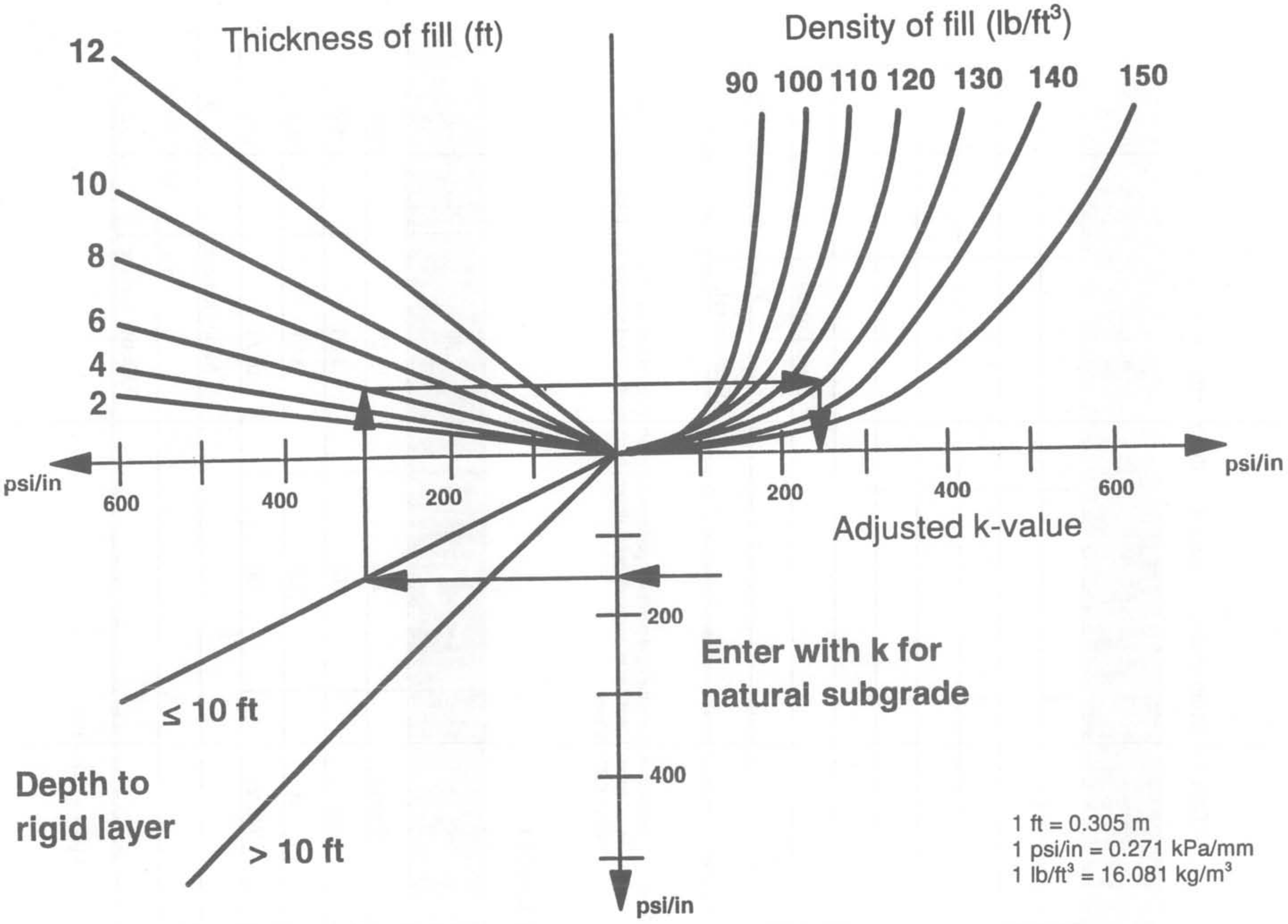
Season	k-value (psi/in)	W_{18} (millions)	Relative Damage ($1 / W_{18}$)
		Mean Damage	
		W_{18}	million
		Effective k-value	psi/in

Notes: W_{18} is computed from the rigid pavement performance model given in Section 3.2.2.
A year may be divided into as many seasons as desired to represent distinct subgrade conditions.
1 psi/in = 0.27 kPa/mm

EXAMPLE

Seasons	k-value (psi/in)	W_{18} (millions)	Relative Damage ($1 / W_{18}$)
Spring	100	13.18	0.0759
Summer	200	14.60	0.0685
Fall	300	15.71	0.0637
Winter	400	16.72	0.0598
		Mean Damage	0.0670
		W_{18}	14.92 million
		Effective k-value	229 psi/in

1 psi/in = 0.27 kPa/mm



1 ft = 0.305 m
1 psi/in = 0.271 kPa/mm
1 lb/ft^3 = 16.081 kg/m^3

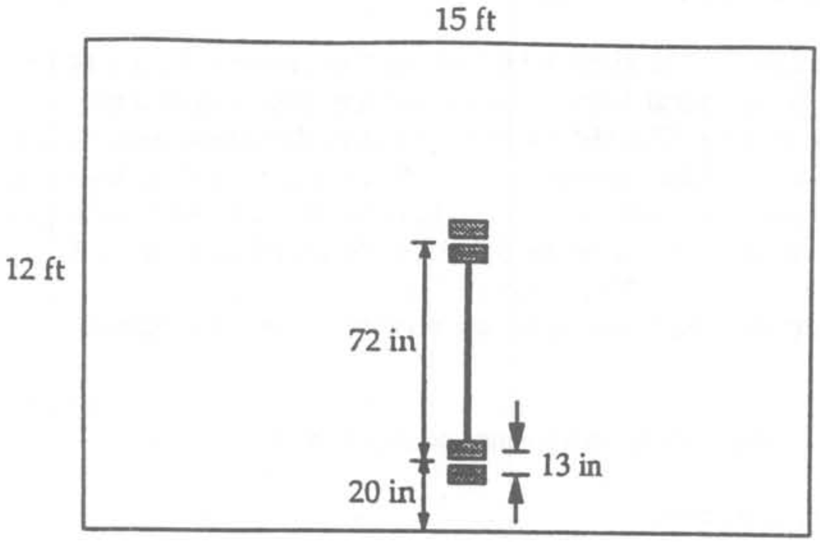
Figure 43. Adjustment to k for fill and/or rigid layer.

3.2.2 Determine Required Structural Design

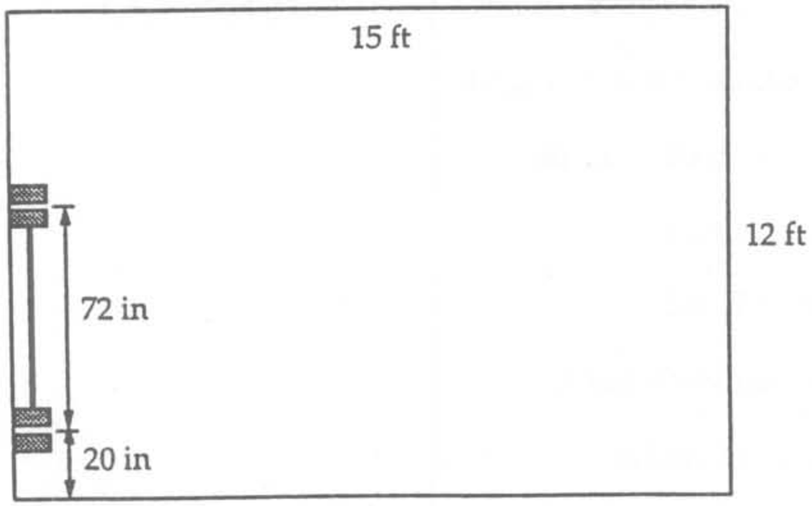
A slab thickness is determined for the midslab loading position, shown in Figure 44, because for doweled pavements this is the critical fatigue damage location. Most cracks initiate at the edge of the slab as a result of this loading. This slab thickness becomes the design thickness if the transverse joints are doweled. If the joints are not doweled, a design check is made to see if the joint loading position causes a more critical stress at the top of the slab. Also, a design check is made for joint design adequacy with respect to faulting, as described in Section 3.3.

Determine Required Inputs. The following inputs must be selected or obtained.

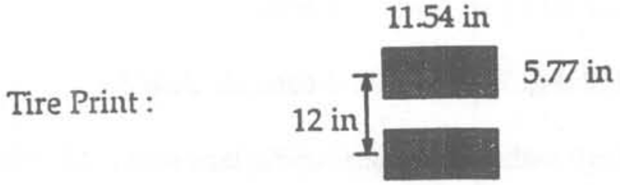
		Section of Guide
1.	Estimated ESALs, W_{18}, for the performance period in the design lane.	2.1.2
2.	Design reliability, R, percent.	2.1.3
3.	Overall standard deviation, S_o.	2.1.3
4.	Design serviceability loss, $PSI = P_1 - P_2$.	2.2.1
5.	Effective (seasonally adjusted) elastic k-value of the subgrade, psi/in.	3.2.1
6.	Concrete modulus of rupture, S'_c, psi.	2.3.4
7.	Concrete elastic modulus, E_c, psi.	2.3.3
8.	Joint spacing, L, inches.	3.3.2
9.	Base modulus, E_b, psi.	2.3.3
10.	Slab/base friction coefficient, f.	
11.	Base thickness, H_b, inches.	
12.	Effective positive temperature differential through concrete slab, TD, °F.	
13.	Lane edge support condition: a. Conventional lane width (12 ft [3.7 m]) with free edge. b. Conventional lane width (12 ft [3.7 m]) with tied concrete shoulder. c. Wide slab (e.g., 14 ft [4.3 m]) with conventional traffic lane width (12 ft [3.7 m]).	



Midslab Loading



Joint Loading



1 in = 25.4 mm, 1 ft = 0.305 m

Figure 44. Midslab and joint loading positions defined.

Design Equations for Rigid Pavement. The rigid pavement design equation for 50 percent reliability is given below:

$$\log W' = \log W + \left(5.065 - 0.03295\ P2^{2.4} \right) \left[\log \left(\frac{(S'_c)'}{\sigma_t'} \right) - \log \left(\frac{690}{\sigma_t} \right) \right] \qquad [38]$$

where W′ = number of 18-kip [80-kN] ESALs estimated for design traffic lane
W = number of 18-kip [80-kN] ESALs computed from Equation 39 below:
(Note: Logarithm is to base 10).

$$\log W = \log R + \frac{G}{Y} \qquad [39]$$

$$\log R = 5.85 + 7.35 \log (D + 1) - 4.62 \log (L1 + L2) + 3.28 \log L2 \qquad [40]$$

$$Y = 1.00 + \frac{3.63\ (L1 + L2)^{5.2}}{(D + 1)^{8.46}\ L2^{3.52}} \qquad [41]$$

$$G = \log \left(\frac{P1 - P2}{P1 - 1.5} \right) \qquad [42]$$

D = concrete slab thickness, inches
L1 = load on a single or tandem axle, kips
L2 = axle code, 1 for single axle, 2 for tandem axle
P1 = initial serviceability index
P2 = terminal serviceability index
$(S'_c)'$ = mean 28-day, third-point loading flexural strength, psi (690 psi [4758 kPa] for AASHO Road Test)
σ_t = midslab tensile stress due to load and temperature from Equation 43 with AASHO Road Test constants
σ_t' = midslab tensile stress due to load and temperature from Equation 43 with inputs for new pavement design

$$\sigma_t = \sigma_l\ E\ F \left[1.0 + 10^{(\log b)}\ TD \right] \qquad [43]$$

σ_l = midslab tensile stress due to load only, from Equation 44

$$\sigma_l = \frac{18{,}000}{D^2}\left\{4.227 - 2.381\left(\frac{180}{\ell}\right)^{0.2} - 0.0015\left[\frac{E_b\,H_b}{1.4\,k}\right]^{0.5} - 0.155\left[H_b\left(\frac{E_b}{E_c}\right)^{0.75}\right]^{0.5}\right\} \qquad [44]$$

E_c = modulus of elasticity of concrete slab, psi
(4,200,000 psi [28,959 MPa] for AASHO Road Test)

E_b = modulus of elasticity of base, psi
(25,000 psi [172 MPa] for AASHO Road Test)

H_b = thickness of base, inches (6 in [152 mm] for AASHO Road Test)

$$\ell = \sqrt[4]{\frac{E_c\,D^3}{12\,(1 - \mu^2)\,k}} \qquad [45]$$

k = effective elastic modulus of subgrade support, psi/in
(110 psi/in [29.92 kPa/mm] for AASHO Road Test)

μ = Poisson's ratio for concrete (0.20 for AASHO Road Test)

E = edge support adjustment factor (1.00 for AASHO Road Test)
= 1.00 for conventional 12-ft-wide [3.66-m-wide] traffic lane
= 0.94 for conventional 12-ft-wide [3.66-m-wide] traffic lane plus tied concrete shoulder
= 0.92 for 2-ft [0.6-m] widened slab with conventional 12-ft [3.66-m] lane width

F = ratio between slab stress at a given coefficient of friction (f)
between the slab and base and slab stress at full friction, from Equation 46

$$F = 1.177 - 4.3*10^{-8}\,D\,E_b - 0.01155542\,D + 6.27*10^{-7}\,E_b - 0.000315\,f \qquad [46]$$

f = friction coefficient between slab and base (see Table 14)

Table 14. Modulus of elasticity and coefficient of friction for various base types.

Base Type or Interface Treatment	Modulus of Elasticity (psi)	Peak Friction Coefficient low	mean	high
Fine-grained soil	3,000 - 40,000	0.5	1.3	2.0
Sand	10,000 - 25,000	0.5	0.8	1.0
Aggregate	15,000 - 45,000	0.7	1.4	2.0
Polyethylene sheeting	NA	0.5	0.6	1.0
Lime-stabilized clay	20,000 - 70,000	3.0	NA	5.3
Cement-treated gravel	(500 + CS) * 1000	8.0	34	63
Asphalt-treated gravel	300,000 - 600,000	3.7	5.8	10
Lean concrete without curing compound	(500 + CS) * 1000		> 36	
Lean concrete with single or double wax curing compound	(500 + CS) * 1000	3.5		4.5

Notes: CS = compressive strength, psi
Low, mean, and high measured peak coefficients of friction summarized from various references are shown above.
1 psi = 6.89 kPa

$$\log b = -1.944 + 2.279 \frac{D}{\ell} + 0.0917 \frac{L}{\ell} - 433{,}080 \frac{D^2}{k \ell^4} + \left(\frac{0.0614}{\ell} \right) * \left(\frac{E_b H_b^{1.5}}{1.4 k} \right)^{0.5} - 438{,}642 \frac{D^2}{k \ell^2} - 498{,}240 \frac{D^3 L}{k \ell^6} \qquad [47]$$

L = joint spacing, inches (180 in [4572 mm] for AASHO Road Test)
TD = effective positive temperature differential, top of slab minus bottom of slab, °F

$$effective\ positive\ TD = 0.962 - \frac{52.181}{D} + 0.341\ WIND + 0.184\ TEMP - 0.00836\ PRECIP \qquad [48]$$

D = slab thickness, inches
WIND = mean annual wind speed, mph
TEMP = mean annual temperature, °F
PRECIP = mean annual precipitation, inches

Contour maps for the three climatic inputs are provided in Figures 45, 46, and 47. In addition, these climatic data are provided for several U.S. cities in Table 15. Data for other locations are obtainable from local weather stations or other sources.

Required Slab Thickness. The rigid pavement design equations given above may be used to determine the required slab thickness for the design traffic. The design equations are too complex to put into nomograph form. However, the new design equations can easily be solved in a spreadsheet or computer program. In addition, for a given set of design inputs, a straight-line relationship exists between log W_{18} and slab thickness D:

$$D = A_0 + A_1 \log_{10} W_{18R} \qquad [49]$$

where D = required slab thickness, inches
A_0 and A_1 = regression constants dependent on other design features
W_{18R} = design 18-kip [80-kN] ESALs for the specified level of design reliability R

The W_{18R} for any level of design reliability and overall standard deviation is computed as follows:

$$W_{18R} = 10^{(\log W_{18} + Z S_o)} \qquad [50]$$

where W_{18R} = design 18-kip [80-kN] ESALs for a specified level of design reliability R
W_{18} = estimated 18-kip [80-kN] ESALs over the design period in the design lane
Z = standard deviate from normal distribution table for given level of reliability (e.g., 1.28 for R = 90 percent)
S_o = overall standard deviation

The required slab thickness D was computed for a range of joint spacings, concrete flexural strengths, subgrade k-values, and temperature differentials, for each of three base types and three levels of design reliability, as summarized below. Note that an appropriate friction coefficient for each base type was selected using Table 14.

Table	**Reliability**	**Base Type**	**Base Modulus, psi**
16	95	Granular	25,000
17	95	Treated	500,000
18	95	High-strength	1,000,000
19	90	Granular	25,000
20	90	Treated	500,000
21	90	High-strength	1,000,000
22	85	Granular	25,000
23	85	Treated	500,000
24	85	High-strength	1,000,000

[1 psi = 6.89 kPa]

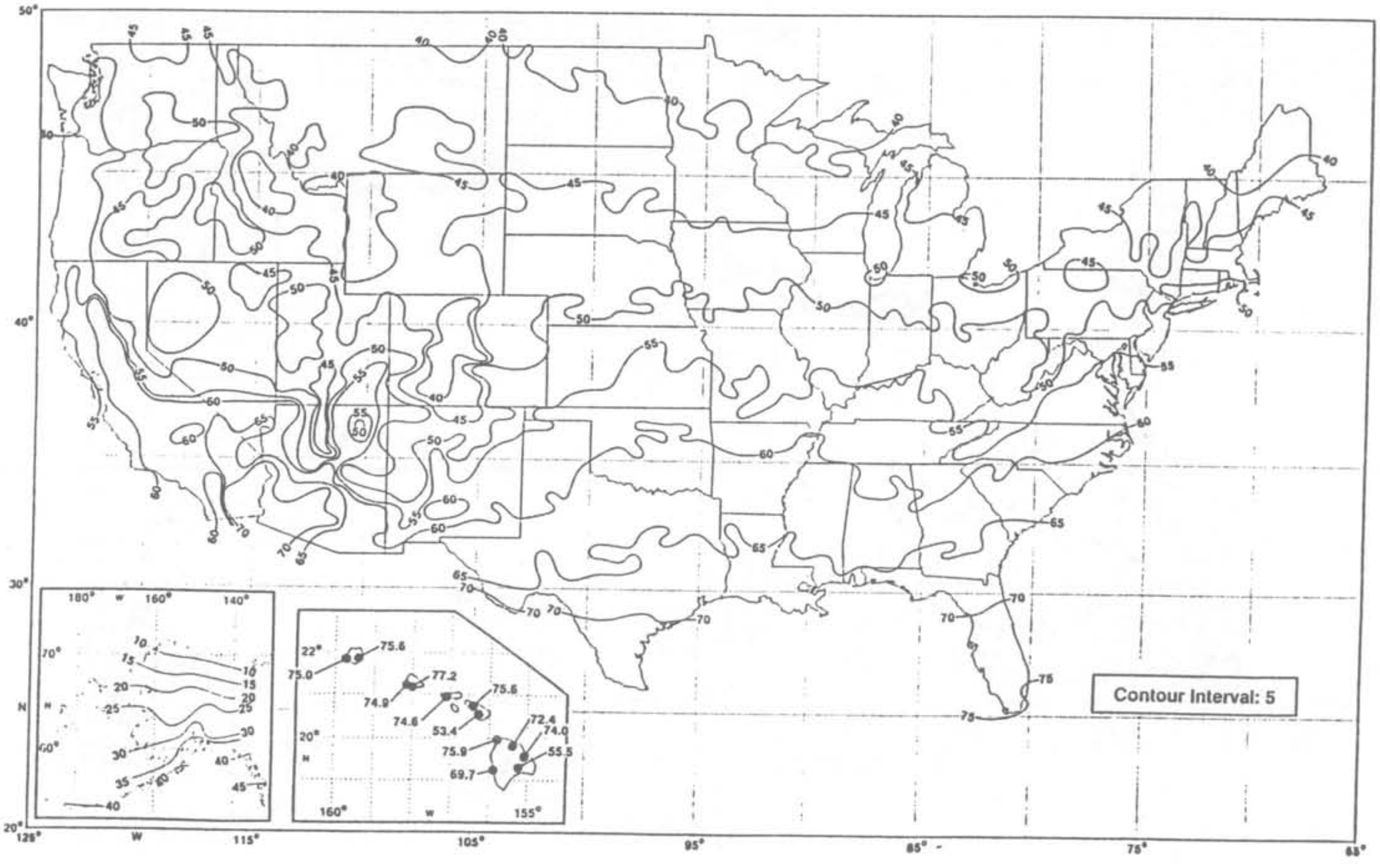
Example designs are provided at the end of this appendix.

1 mph = 1.61 km/h

Figure 45. Mean annual wind speed, mph.

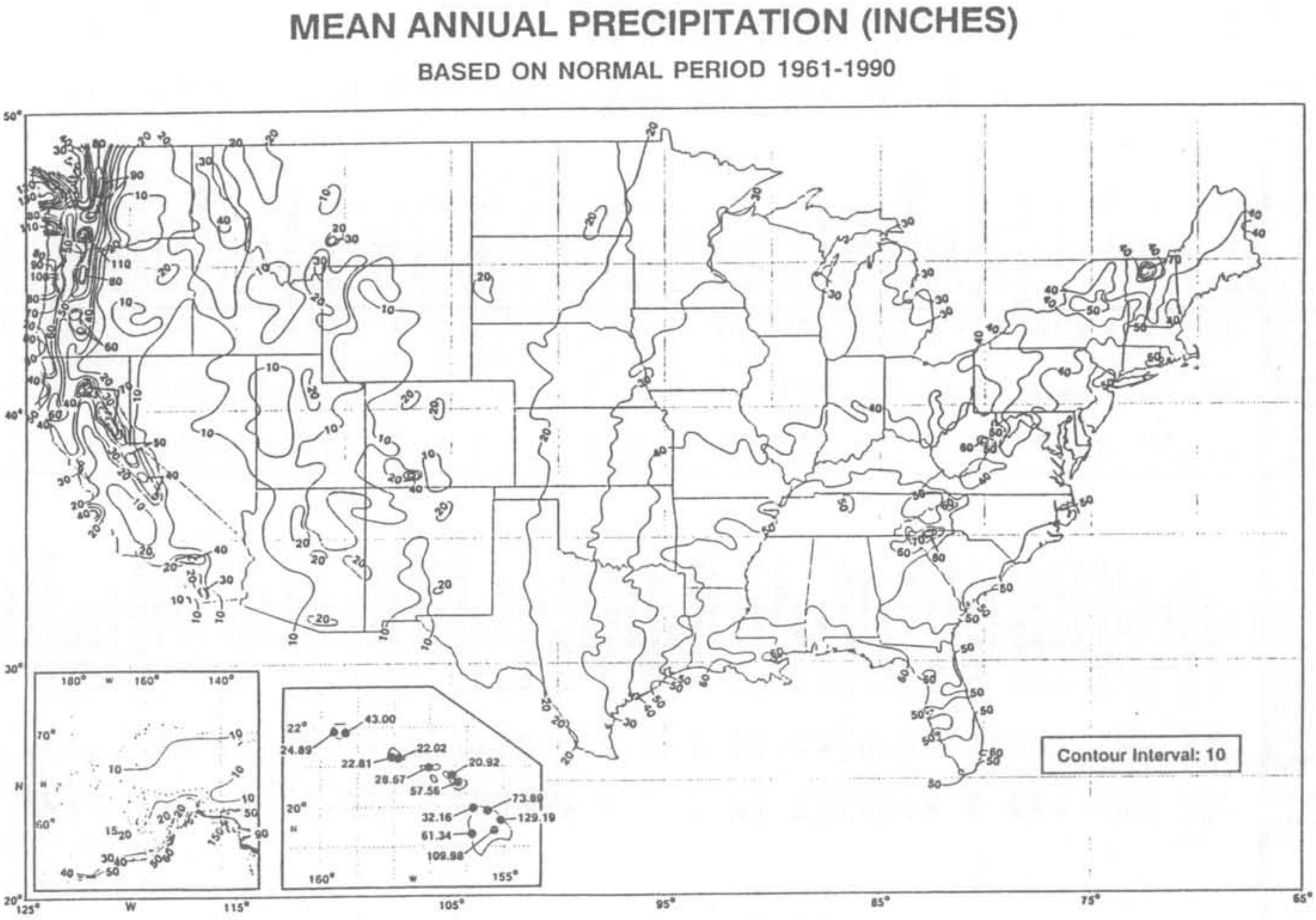
MEAN ANNUAL AIR TEMPERATURE (°F)

BASED ON NORMAL PERIOD 1961-1990



$°C = (°F - 32)/1.8$

Figure 46. Mean annual air temperature, °F.



1 in = 25.4 mm

Figure 47. Mean annual precipitation, inches.

Table 15. Mean annual temperature, precipitation, and wind speed for selected U.S. cities.

Location	Mean Annual Temperature, °F	Mean Annual Precipitation, in	Mean Annual Wind Speed, mph
ALABAMA			
Birmingham	62.2	52.2	7.2
Mobile	67.5	64.6	9.0
Montgomery	67.5	49.2	6.7
ALASKA			
Anchorage	35.3	15.2	6.9
Fairbanks	25.9	10.4	5.5
King Salmon	32.8	19.3	10.8
ARIZONA			
Flagstaff	45.4	20.9	7.1
Phoenix	71.2	7.1	6.3
Tucson	68.0	11.1	8.2
ARKANSAS			
Little Rock	61.9	49.2	7.9
CALIFORNIA			
Bakersfield	65.6	5.7	6.4
Fresno	62.5	10.5	6.4
Los Angeles	62.6	12.1	7.5
Sacramento	60.6	17.1	8.1
San Diego	63.8	9.3	6.9
San Francisco	56.6	19.7	10.5
Santa Barbara	58.9	16.2	6.1
COLORADO			
Colorado Springs	48.9	15.4	10.1
Denver	50.3	15.3	8.8
CONNECTICUT			
Hartford	49.8	44.4	9.2
DC			
Washington	57.5	39.0	9.3
DELAWARE			
Wilmington	54.0	41.4	9.2
FLORIDA			
Jacksonville	68.0	52.8	8.1
Miami	75.6	57.6	9.2
Orlando	72.4	47.8	8.6
Tallahassee	67.2	64.6	6.4
Tampa	72.0	46.7	8.5
West Palm Beach	74.6	59.7	9.4
GEORGIA			
Atlanta	61.2	48.6	9.1
Augusta	63.2	43.1	6.5
Macon	64.7	44.9	7.7
Savannah	65.9	49.7	7.9
HAWAII			
Hilo	73.6	128.2	7.1
Honolulu	77.0	23.5	11.5
IDAHO			
Boise	51.1	11.7	8.8
Pocatello	46.6	10.9	10.2
ILLINOIS			
Chicago	49.2	33.3	10.2
Peoria	50.4	34.9	10.1
Springfield	52.6	33.8	11.3
INDIANA			
Evansville	55.7	41.6	8.2
Fort Wayne	49.7	34.4	10.1
Indianapolis	52.1	39.1	9.6
South Bend	49.4	38.2	10.4
IOWA			
Des Moines	49.7	30.8	10.9
Sioux City	48.4	25.4	11.0
Waterloo	46.1	33.1	10.7
KANSAS			
Topeka	54.1	28.6	10.1
Wichita	56.4	40.1	12.3
KENTUCKY			
Lexington	54.9	45.7	7.1
Louisville	56.2	43.6	8.3
LOUISIANA			
Baton Rouge	67.5	55.8	7.7
Lake Charles	68.0	53.0	8.6
New Orleans	68.2	59.7	8.2
Shreveport	65.4	43.8	8.5
MAINE			
Caribou	38.9	36.6	11.2
Portland	45.0	43.8	8.7
MARYLAND			
Baltimore	55.1	41.8	9.2
MASSACHUSETTS			
Boston	51.5	43.8	12.4
Worcester	46.8	47.6	12.4
MICHIGAN			
Detroit	48.6	4.0	10.2
Flint	46.8	29.2	10.6
Grand Rapids	47.5	34.4	9.7
MINNESOTA			
Duluth	38.2	29.7	11.2
Minneapolis	44.7	26.4	10.6
MISSISSIPPI			
Jackson	64.6	52.8	7.4
MISSOURI			
Kansas City	56.3	35.2	10.7
MONTANA			
Great Falls	44.7	15.2	12.8
NEBRASKA			
Omaha	49.5	29.9	10.6
NEVADA			
Las Vegas	66.3	4.2	9.2
Reno	49.4	7.5	6.5
NEW JERSEY			
Atlantic City	53.1	41.9	10.1
NEW MEXICO			
Albuquerque	56.2	8.1	9.0
NEW YORK			
Albany	47.3	35.7	8.9
Buffalo	47.6	37.5	12.1
New York City	54.5	44.1	12.1
Rochester	47.9	31.3	9.7
Syracuse	47.7	39.1	9.7
NORTH CAROLINA			
Charlotte	60.0	43.2	7.5
Greensboro	57.9	42.5	7.5
Raleigh	59.0	41.8	7.8
Wilmington	63.4	53.4	8.8
NORTH DAKOTA			
Bismarck	41.3	15.4	10.3
Fargo	40.5	19.6	12.4
OHIO			
Akron-Canton	49.5	35.9	9.8
Cleveland	49.6	35.4	10.7
Columbus	51.7	37.0	8.7
Dayton	51.9	34.7	10.1
Youngstown	48.3	37.3	10.0
OKLAHOMA			
Oklahoma City	59.9	30.9	12.5
Tulsa	60.3	38.8	10.4
OREGON			
Medford	53.6	19.8	4.8
Portland	53.0	37.4	7.9
Salem	52.0	40.4	7.0
PENNSYLVANIA			
Harrisburg	53.0	39.1	7.6
Philadelphia	54.3	41.4	9.5
Pittsburgh	50.3	36.3	9.1
RHODE ISLAND			
Providence	50.3	45.3	10.6
SOUTH CAROLINA			
Charleston	64.8	51.6	8.7
Columbia	63.3	49.1	6.9
SOUTH DAKOTA			
Huron	44.7	18.7	11.6
Rapid City	46.7	16.3	11.3
TENNESSEE			
Chattanooga	59.4	52.6	6.1
Knoxville	58.9	47.3	7.1
Memphis	61.8	51.6	9.0
Nashville	59.2	48.5	8.0
TEXAS			
Amarillo	57.2	19.1	13.6
Brownsville	73.6	25.4	11.6
Corpus Christi	72.1	30.2	12.0
Dallas	66.0	29.5	10.8
El Paso	63.4	7.8	9.0
Galveston	69.6	40.2	11.0
Houston	68.3	44.8	7.8
Lubbock	59.9	17.8	12.4
Midland	63.5	13.7	11.1
San Antonio	68.7	29.2	9.4
Waco	67.0	31.0	11.3
Wichita Falls	63.5	26.7	11.7
UTAH			
Salt Lake City	51.7	15.3	8.8
VERMONT			
Burlington	44.1	33.7	8.8
VIRGINIA			
Norfolk	59.5	45.2	10.6
Richmond	57.7	44.1	7.6
Roanoke	56.1	39.2	8.2
WASHINGTON			
Olympia	49.6	51.0	6.7
Seattle	52.7	38.8	9.0
Spokane	47.2	16.7	8.8
WEST VIRGINIA			
Charleston	54.8	42.4	6.4
Huntington	55.2	40.7	6.5
WISCONSIN			
Green Bay	43.6	28.0	10.1
Madison	45.2	30.8	9.8
Milwaukee	46.1	30.9	11.6
WYOMING			
Casper	45.2	11.4	13.0
Cheyenne	45.7	13.3	12.9

°C =(°F - 32)/1.8, 1 in = 25.4 mm, 1 mph = 1.61 km/h

Source: National Climatic Data Center, 1986

Table 16. Slab thickness computed for granular base and 95 percent reliability.

E_b = 25 ksi [172.25 MPa], R = 95 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				5	10	20	30	40	50	75	100
144	600	100	5	10.7	11.8	12.9	13.6	14.0	14.4	—	—
144	600	100	7	10.6	11.7	12.8	13.5	13.9	14.3	14.9	—
144	600	100	9	10.5	11.7	12.8	13.4	13.9	14.3	14.9	—
144	600	100	11	10.5	11.6	12.7	13.4	13.8	14.2	14.9	—
144	600	100	13	10.4	11.5	12.6	13.3	13.8	14.1	14.8	—
144	600	250	5	10.1	11.4	12.7	13.4	13.9	14.4	—	—
144	600	250	7	10.2	11.5	12.8	13.6	14.1	14.6	—	—
144	600	250	9	10.3	11.7	13.0	13.8	14.4	14.8	—	—
144	600	250	11	10.4	11.8	13.1	13.9	14.5	14.9	—	—
144	600	250	13	10.5	11.9	13.3	14.1	14.7	—	—	—
144	600	500	5	9.1	10.8	12.5	13.4	14.1	14.7	—	—
144	600	500	7	9.5	11.3	13.1	14.1	14.9	—	—	—
144	600	500	9	9.9	11.8	13.7	14.8	—	—	—	—
144	600	500	11	10.3	12.3	14.3	—	—	—	—	—
144	600	500	13	10.7	12.8	14.8	—	—	—	—	—
144	700	100	5	9.7	10.8	11.8	12.4	12.9	13.2	13.8	14.3
144	700	100	7	9.6	10.7	11.7	12.3	12.8	13.1	13.7	14.2
144	700	100	9	9.6	10.7	11.7	12.4	12.8	13.1	13.8	14.2
144	700	100	11	9.5	10.6	11.7	12.3	12.7	13.1	13.7	14.1
144	700	100	13	9.5	10.5	11.6	12.2	12.7	13.0	13.6	14.1
144	700	250	5	9.0	10.2	11.4	12.2	12.7	13.1	13.8	14.3
144	700	250	7	9.2	10.4	11.7	12.4	12.9	13.3	14.0	14.5
144	700	250	9	9.3	10.6	11.8	12.6	13.1	13.5	14.2	14.7
144	700	250	11	9.4	10.7	11.9	12.7	13.2	13.6	14.3	14.8
144	700	250	13	9.5	10.8	12.1	12.8	13.4	13.8	14.5	15.1
144	700	500	5	8.1	9.6	11.1	12.0	12.6	13.1	14.0	14.6
144	700	500	7	8.5	10.0	11.6	12.6	13.2	13.7	14.7	—
144	700	500	9	8.7	10.4	12.2	13.2	13.9	14.4	—	—
144	700	500	11	9.1	10.9	12.6	13.7	14.4	15.0	—	—
144	700	500	13	9.4	11.3	13.1	14.1	14.9	—	—	—
144	800	100	5	8.9	9.9	10.9	11.5	11.9	12.2	12.8	13.2
144	800	100	7	8.9	9.9	10.8	11.4	11.8	12.1	12.7	13.1
144	800	100	9	8.8	9.8	10.8	11.4	11.8	12.1	12.6	13.0
144	800	100	11	8.8	9.8	10.7	11.3	11.7	12.0	12.6	13.0
144	800	100	13	8.8	9.7	10.7	11.3	11.7	12.0	12.5	12.9
144	800	250	5	8.2	9.3	10.5	11.1	11.6	12.0	12.6	13.1
144	800	250	7	8.3	9.5	10.7	11.3	11.8	12.2	12.9	13.4
144	800	250	9	8.5	9.6	10.8	11.5	12.0	12.4	13.1	13.6
144	800	250	11	8.6	9.8	11.0	11.7	12.2	12.6	13.3	13.8
144	800	250	13	8.7	9.9	11.1	11.9	12.4	12.8	13.5	14.0
144	800	500	5	7.2	8.6	10.0	10.8	11.4	11.9	12.7	13.3
144	800	500	7	7.6	9.1	10.5	11.4	12.0	12.5	13.4	14.0
144	800	500	9	7.9	9.5	11.0	11.9	12.6	13.0	14.0	14.6
144	800	500	11	8.2	9.8	11.4	12.3	13.0	13.5	14.4	—
144	800	500	13	8.6	10.2	11.8	12.7	13.4	13.9	14.8	—
192	600	100	5	10.8	12.0	13.1	13.8	14.2	14.6	—	—
192	600	100	7	10.8	11.9	13.1	13.7	14.2	14.5	—	—
192	600	100	9	10.8	11.9	13.0	13.7	14.1	14.5	—	—
192	600	100	11	10.7	11.9	13.0	13.6	14.1	14.5	—	—
192	600	100	13	10.7	11.8	12.9	13.6	14.1	14.4	—	—
192	600	250	5	10.4	11.7	13.0	13.7	14.3	14.7	—	—
192	600	250	7	10.6	11.9	13.2	14.0	14.6	15.0	—	—
192	600	250	9	10.8	12.2	13.5	14.3	14.9	—	—	—
192	600	250	11	10.9	12.3	13.7	14.5	—	—	—	—
192	600	250	13	11.1	12.5	14.0	14.8	—	—	—	—
192	600	500	5	9.5	11.3	13.0	14.1	—	—	—	—
192	600	500	7	10.1	12.0	13.9	15.0	—	—	—	—
192	600	500	9	10.7	12.7	14.7	—	—	—	—	—
192	600	500	11	11.3	13.4	—	—	—	—	—	—
192	600	500	13	11.8	14.0	—	—	—	—	—	—
192	700	100	5	9.9	10.9	12.0	12.6	13.1	13.4	14.0	14.5
192	700	100	7	9.9	10.9	12.0	12.6	13.0	13.4	14.0	14.4
192	700	100	9	9.8	10.9	12.0	12.6	13.0	13.4	14.0	14.4
192	700	100	11	9.8	10.9	11.9	12.6	13.0	13.3	14.0	14.4
192	700	100	13	9.8	10.9	11.9	12.5	13.0	13.3	13.9	14.4
192	700	250	5	9.4	10.6	11.8	12.5	13.0	13.4	14.1	14.6
192	700	250	7	9.6	10.8	12.0	12.8	13.3	13.7	14.4	14.9
192	700	250	9	9.8	11.1	12.3	13.1	13.6	14.0	14.8	—
192	700	250	11	10.0	11.3	12.6	13.4	13.9	14.3	—	—
192	700	250	13	10.2	11.5	12.8	13.5	14.1	14.5	—	—

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 16. Slab thickness computed for granular base and 95 percent reliability (continued).

E_b = 25 ksi [172.25 MPa], R = 95 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				5	10	20	30	40	50	75	100
192	700	500	5	8.5	10.1	11.6	12.6	13.2	13.7	—	—
192	700	500	7	9.0	10.7	12.4	13.4	14.1	14.7	—	—
192	700	500	9	9.6	11.3	13.1	14.1	14.9	—	—	—
192	700	500	11	10.1	11.9	13.7	14.8	—	—	—	—
192	700	500	13	10.6	12.4	14.3	—	—	—	—	—
192	800	100	5	9.1	10.1	11.1	11.7	12.1	12.4	13.0	13.4
192	800	100	7	9.1	10.1	11.1	11.7	12.1	12.4	13.0	13.4
192	800	100	9	9.1	10.1	11.1	11.6	12.1	12.4	13.0	13.4
192	800	100	11	9.1	10.1	11.1	11.6	12.1	12.4	12.9	13.4
192	800	100	13	9.1	10.1	11.1	11.6	12.0	12.4	12.9	13.3
192	800	250	5	8.5	9.7	10.8	11.5	12.0	12.4	13.0	13.5
192	800	250	7	8.7	9.9	11.1	11.8	12.3	12.7	13.4	13.9
192	800	250	9	8.9	10.2	11.4	12.1	12.6	13.0	13.7	14.2
192	800	250	11	9.2	10.4	11.6	12.3	12.8	13.2	13.9	14.4
192	800	250	13	9.4	10.6	11.8	12.5	13.0	13.4	14.1	14.6
192	800	500	5	7.7	9.2	10.6	11.5	12.1	12.5	13.4	14.0
192	800	500	7	8.3	9.8	11.3	12.2	12.8	13.3	14.2	14.8
192	800	500	9	8.7	10.3	11.9	12.8	13.5	14.0	14.9	—
192	800	500	11	9.2	10.8	12.5	13.4	14.1	14.6	—	—
192	800	500	13	9.6	11.3	13.0	13.9	14.6	—	—	—
240	600	100	5	11.0	12.1	13.2	13.9	14.3	14.7	—	—
240	600	100	7	11.0	12.1	13.2	13.9	14.4	14.7	—	—
240	600	100	9	11.0	12.1	13.3	13.9	14.4	14.7	—	—
240	600	100	11	11.0	12.1	13.3	13.9	14.4	14.8	—	—
240	600	100	13	11.0	12.2	13.3	13.9	14.4	14.8	—	—
240	600	250	5	10.7	12.0	13.3	14.1	14.6	15.0	—	—
240	600	250	7	11.0	12.3	13.7	14.5	15.0	—	—	—
240	600	250	9	11.3	12.7	14.1	14.9	—	—	—	—
240	600	250	11	11.6	13.0	14.5	—	—	—	—	—
240	600	250	13	11.8	13.2	14.7	—	—	—	—	—
240	600	500	5	10.0	11.9	13.7	—	—	—	—	—
240	600	500	7	10.8	12.8	14.8	—	—	—	—	—
240	600	500	9	11.7	13.8	—	—	—	—	—	—
240	600	500	11	12.4	14.6	—	—	—	—	—	—
240	600	500	13	13.2	—	—	—	—	—	—	—
240	700	100	5	10.1	11.1	12.2	12.8	13.3	13.6	14.2	14.7
240	700	100	7	10.1	11.1	12.2	12.8	13.2	13.6	14.2	14.6
240	700	100	9	10.1	11.2	12.2	12.8	13.3	13.6	14.2	14.7
240	700	100	11	10.1	11.2	12.2	12.9	13.3	13.6	14.2	14.7
240	700	100	13	10.2	11.2	12.3	12.9	13.3	13.7	14.3	14.7
240	700	250	5	9.7	10.9	12.1	12.9	13.4	13.8	14.5	15.0
240	700	250	7	10.0	11.3	12.6	13.3	13.8	14.3	15.0	—
240	700	250	9	10.3	11.6	12.9	13.7	14.2	14.6	—	—
240	700	250	11	10.6	11.9	13.2	14.0	14.5	14.9	—	—
240	700	250	13	10.9	12.2	13.5	14.3	14.9	—	—	—
240	700	500	5	9.0	10.7	12.3	13.3	14.0	—	—	—
240	700	500	7	9.8	11.6	13.3	14.3	15.0	—	—	—
240	700	500	9	10.6	12.4	14.2	—	—	—	—	—
240	700	500	11	11.2	13.1	14.9	—	—	—	—	—
240	700	500	13	11.9	13.7	—	—	—	—	—	—
240	800	100	5	9.3	10.3	11.3	11.9	12.3	12.6	13.2	13.6
240	800	100	7	9.3	10.3	11.3	11.9	12.3	12.7	13.2	13.7
240	800	100	9	9.4	10.4	11.4	12.0	12.4	12.7	13.3	13.7
240	800	100	11	9.4	10.4	11.4	12.0	12.4	12.8	13.4	13.8
240	800	100	13	9.5	10.5	11.5	12.1	12.5	12.8	13.4	13.8
240	800	250	5	8.8	10.0	11.2	11.9	12.4	12.8	13.5	14.0
240	800	250	7	9.3	10.4	11.6	12.3	12.8	13.2	13.8	14.3
240	800	250	9	9.6	10.8	12.0	12.7	13.2	13.6	14.3	14.8
240	800	250	11	9.8	11.0	12.2	13.0	13.5	13.8	14.5	15.0
240	800	250	13	10.1	11.3	12.5	13.3	13.8	14.2	14.9	15.4
240	800	500	5	8.3	9.8	11.3	12.1	12.7	13.2	14.1	14.7
240	800	500	7	9.0	10.6	12.2	13.1	13.7	14.2	—	—
240	800	500	9	9.7	11.3	12.9	13.9	14.5	15.0	—	—
240	800	500	11	10.4	12.0	13.6	14.6	—	—	—	—
240	800	500	13	10.9	12.5	14.2	—	—	—	—	—

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 17. Slab thickness computed for treated base and 95 percent reliability.

E_b = 500 ksi [3445 MPa], R = 95 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				5	10	20	30	40	50	75	100
144	600	100	5	9.2	10.3	11.3	12.0	12.4	12.7	13.4	13.8
144	600	100	7	9.4	10.4	11.4	12.1	12.5	12.8	13.4	13.9
144	600	100	9	9.5	10.5	11.5	12.1	12.6	12.9	13.5	13.9
144	600	100	11	9.6	10.6	11.6	12.2	12.6	13.0	13.6	14.0
144	600	100	13	9.6	10.7	11.7	12.3	12.7	13.0	13.6	14.1
144	600	250	5	8.6	10.0	11.3	12.1	12.6	13.0	13.8	14.3
144	600	250	7	9.1	10.4	11.7	12.5	13.0	13.4	14.2	14.7
144	600	250	9	9.4	10.7	12.1	12.8	13.4	13.8	14.6	----
144	600	250	11	9.7	11.0	12.4	13.1	13.7	14.1	14.9	----
144	600	250	13	10.0	11.3	12.6	13.4	14.0	14.4	----	----
144	600	500	5	7.5	9.2	10.9	11.9	12.6	13.1	----	----
144	600	500	7	8.4	10.1	11.8	12.8	13.5	14.0	----	----
144	600	500	9	9.1	10.8	12.5	13.5	14.2	14.8	----	----
144	600	500	11	9.4	11.3	13.2	14.3	----	----	----	----
144	600	500	13	10.1	11.9	13.8	14.9	----	----	----	----
144	700	100	5	8.5	9.5	10.4	11.0	11.4	11.8	12.3	12.7
144	700	100	7	8.6	9.6	10.6	11.1	11.5	11.9	12.4	12.8
144	700	100	9	8.8	9.7	10.7	11.2	11.6	12.0	12.5	12.9
144	700	100	11	8.9	9.8	10.8	11.3	11.7	12.0	12.6	13.0
144	700	100	13	9.0	9.9	10.9	11.4	11.8	12.1	12.7	13.0
144	700	250	5	8.0	9.2	10.3	11.0	11.5	11.9	12.6	13.1
144	700	250	7	8.3	9.5	10.7	11.5	12.0	12.4	13.1	13.6
144	700	250	9	8.7	9.9	11.1	11.8	12.3	12.7	13.4	13.9
144	700	250	11	9.0	10.2	11.4	12.1	12.6	13.0	13.7	14.2
144	700	250	13	9.2	10.4	11.7	12.4	12.9	13.3	14.0	14.5
144	700	500	5	6.6	8.2	9.8	10.8	11.4	12.0	12.9	13.6
144	700	500	7	7.6	9.1	10.7	11.6	12.3	12.8	13.7	14.3
144	700	500	9	8.3	9.8	11.4	12.3	12.9	13.4	14.4	15.0
144	700	500	11	8.6	10.3	12.0	12.9	13.6	14.2	----	----
144	700	500	13	9.2	10.9	12.5	13.4	14.1	14.6	----	----
144	800	100	5	7.9	8.8	9.7	10.3	10.7	11.0	11.5	11.9
144	800	100	7	8.0	8.9	9.9	10.4	10.8	11.1	11.6	12.0
144	800	100	9	8.2	9.1	10.0	10.5	10.9	11.2	11.7	12.1
144	800	100	11	8.3	9.2	10.1	10.6	11.0	11.3	11.8	12.1
144	800	100	13	8.4	9.3	10.2	10.7	11.1	11.3	11.8	12.2
144	800	250	5	7.3	8.5	9.6	10.2	10.7	11.1	11.7	12.2
144	800	250	7	7.7	8.9	10.0	10.6	11.1	11.4	12.1	12.6
144	800	250	9	8.1	9.2	10.3	11.0	11.4	11.8	12.5	12.9
144	800	250	11	8.4	9.5	10.6	11.3	11.7	12.1	12.7	13.2
144	800	250	13	8.6	9.7	10.9	11.5	12.0	12.3	13.0	13.5
144	800	500	5	6.4	7.7	9.1	9.9	10.5	11.0	11.8	12.4
144	800	500	7	6.9	8.4	9.8	10.7	11.3	11.7	12.6	13.2
144	800	500	9	7.6	9.1	10.5	11.3	11.9	12.4	13.2	13.8
144	800	500	11	7.9	9.5	11.0	11.9	12.5	13.0	13.9	14.5
144	800	500	13	8.5	10.0	11.5	12.4	13.0	13.5	14.3	14.9
192	600	100	5	9.5	10.5	11.6	12.2	12.6	13.0	13.6	14.0
192	600	100	7	9.7	10.7	11.7	12.3	12.8	13.1	13.7	14.2
192	600	100	9	9.8	10.9	11.9	12.5	12.9	13.3	13.9	14.3
192	600	100	11	9.9	11.0	12.0	12.6	13.0	13.3	13.9	14.3
192	600	100	13	10.1	11.1	12.1	12.7	13.1	13.4	14.0	14.4
192	600	250	5	9.1	10.4	11.7	12.5	13.0	13.4	14.2	14.7
192	600	250	7	9.6	10.9	12.2	13.0	13.5	13.9	14.7	----
192	600	250	9	10.0	11.3	12.6	13.4	14.0	14.4	15.1	----
192	600	250	11	10.4	11.7	13.0	13.8	14.3	14.8	15.5	----
192	600	250	13	10.6	12.0	13.5	14.3	15.0	15.4	16.3	----
192	600	500	5	8.1	9.8	11.5	12.5	13.2	13.8	14.8	----
192	600	500	7	9.1	10.9	12.6	13.6	14.3	14.9	----	----
192	600	500	9	9.8	11.7	13.5	14.6	----	----	----	----
192	600	500	11	10.6	12.5	14.3	----	----	----	----	----
192	600	500	13	11.3	13.2	----	----	----	----	----	----
192	700	100	5	8.7	9.7	10.7	11.3	11.7	12.0	12.5	12.9
192	700	100	7	9.0	9.9	10.9	11.4	11.8	12.2	12.7	13.1
192	700	100	9	9.1	10.1	11.0	11.6	12.0	12.3	12.9	13.2
192	700	100	11	9.3	10.2	11.2	11.7	12.1	12.4	13.0	13.4
192	700	100	13	9.4	10.4	11.3	11.9	12.2	12.5	13.1	13.5
192	700	250	5	8.3	9.5	10.8	11.5	12.0	12.4	13.1	13.6
192	700	250	7	8.9	10.1	11.3	12.0	12.5	12.9	13.6	14.1
192	700	250	9	9.3	10.5	11.7	12.4	12.9	13.3	14.0	14.5
192	700	250	11	9.7	10.9	12.1	12.8	13.3	13.7	14.4	14.9
192	700	250	13	9.9	11.2	12.4	13.1	13.6	14.0	14.8	----

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 17. Slab thickness computed for treated base and 95 percent reliability (continued).

E_b = 500 ksi [3445 MPa], R = 95 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				5	10	20	30	40	50	75	100
192	700	500	5	7.5	9.0	10.6	11.5	12.1	12.6	13.5	----
192	700	500	7	8.5	10.0	11.5	12.4	13.1	13.6	14.5	----
192	700	500	9	9.1	10.7	12.3	13.3	14.0	14.5	----	----
192	700	500	11	9.9	11.5	13.1	14.0	14.7	----	----	----
192	700	500	13	10.5	12.1	13.7	14.6	----	----	----	----
192	800	100	5	8.1	9.0	10.0	10.5	10.9	11.2	11.7	12.1
192	800	100	7	8.4	9.3	10.2	10.7	11.1	11.4	11.9	12.3
192	800	100	9	8.6	9.5	10.4	10.9	11.2	11.5	12.0	12.4
192	800	100	11	8.8	9.6	10.5	11.0	11.4	11.7	12.2	12.5
192	800	100	13	8.9	9.8	10.6	11.1	11.5	11.8	12.3	12.6
192	800	250	5	7.8	8.9	10.0	10.7	11.1	11.5	12.1	12.6
192	800	250	7	8.3	9.4	10.5	11.2	11.6	12.0	12.6	13.1
192	800	250	9	8.7	9.8	10.9	11.6	12.1	12.4	13.1	13.5
192	800	250	11	9.1	10.2	11.3	12.0	12.4	12.8	13.4	13.9
192	800	250	13	9.4	10.5	11.6	12.3	12.7	13.1	13.8	14.2
192	800	500	5	6.9	8.3	9.8	10.6	11.2	11.7	12.5	13.1
192	800	500	7	7.9	9.3	10.7	11.5	12.1	12.6	13.4	14.0
192	800	500	9	8.5	10.0	11.4	12.3	12.9	13.4	14.2	14.8
192	800	500	11	9.2	10.7	12.1	13.0	13.6	14.0	14.9	----
192	800	500	13	9.6	11.1	12.7	13.6	14.2	14.7	----	----
240	600	100	5	9.7	10.8	11.8	12.4	12.9	13.2	13.8	14.2
240	600	100	7	10.0	11.0	12.0	12.6	13.1	13.4	14.0	14.4
240	600	100	9	10.2	11.2	12.2	12.8	13.3	13.6	14.2	14.6
240	600	100	11	10.4	11.4	12.4	13.0	13.4	13.7	14.3	14.8
240	600	100	13	10.5	11.5	12.5	13.1	13.5	13.8	14.4	14.8
240	600	250	5	9.5	10.8	12.1	12.9	13.4	13.9	14.6	----
240	600	250	7	10.1	11.4	12.8	13.5	14.1	14.5	----	----
240	600	250	9	10.7	12.0	13.3	14.0	14.6	15.0	----	----
240	600	250	11	11.0	12.4	13.8	14.6	----	----	----	----
240	600	250	13	11.5	12.8	14.2	15.0	----	----	----	----
240	600	500	5	8.8	10.6	12.3	13.3	14.0	----	----	----
240	600	500	7	9.8	11.7	13.6	14.7	----	----	----	----
240	600	500	9	10.9	12.8	14.6	----	----	----	----	----
240	600	500	11	11.8	13.7	----	----	----	----	----	----
240	600	500	13	12.5	14.5	----	----	----	----	----	----
240	700	100	5	9.0	10.0	11.0	11.5	11.9	12.2	12.8	13.2
240	700	100	7	9.3	10.3	11.2	11.8	12.2	12.5	13.0	13.4
240	700	100	9	9.5	10.5	11.4	12.0	12.4	12.7	13.2	13.6
240	700	100	11	9.7	10.7	11.6	12.2	12.6	12.9	13.4	13.8
240	700	100	13	9.9	10.8	11.8	12.3	12.7	13.0	13.6	14.0
240	700	250	5	8.8	10.0	11.2	11.9	12.4	12.8	13.5	14.0
240	700	250	7	9.5	10.7	11.8	12.5	13.0	13.4	14.1	14.6
240	700	250	9	9.9	11.1	12.4	13.1	13.6	14.0	14.7	----
240	700	250	11	10.4	11.6	12.8	13.5	14.0	14.4	----	----
240	700	250	13	10.8	12.0	13.2	13.9	14.4	14.7	----	----
240	700	500	5	8.3	9.8	11.3	12.2	12.9	13.4	14.3	14.9
240	700	500	7	9.2	10.8	12.5	13.4	14.1	14.6	----	----
240	700	500	9	10.3	11.8	13.4	14.3	15.0	----	----	----
240	700	500	11	11.0	12.7	14.4	----	----	----	----	----
240	700	500	13	11.7	13.4	----	----	----	----	----	----
240	800	100	5	8.5	9.4	10.3	10.8	11.1	11.4	12.0	12.3
240	800	100	7	8.8	9.6	10.5	11.0	11.4	11.7	12.2	12.6
240	800	100	9	9.0	9.9	10.8	11.3	11.6	11.9	12.4	12.8
240	800	100	11	9.2	10.1	10.9	11.5	11.8	12.1	12.6	13.0
240	800	100	13	9.4	10.2	11.1	11.6	12.0	12.3	12.8	13.1
240	800	250	5	8.3	9.4	10.5	11.1	11.6	12.0	12.6	13.1
240	800	250	7	8.9	10.0	11.1	11.8	12.2	12.6	13.2	13.7
240	800	250	9	9.4	10.5	11.6	12.3	12.7	13.1	13.7	14.2
240	800	250	11	9.8	10.9	12.0	12.7	13.1	13.5	14.1	14.6
240	800	250	13	10.2	11.3	12.4	13.0	13.5	13.8	14.4	14.9
240	800	500	5	7.8	9.2	10.6	11.4	12.0	12.4	13.2	13.8
240	800	500	7	8.8	10.2	11.6	12.5	13.1	13.5	14.4	14.9
240	800	500	9	9.7	11.1	12.5	13.3	13.9	14.4	----	----
240	800	500	11	10.4	11.8	13.2	14.1	14.7	----	----	----
240	800	500	13	11.0	12.4	13.9	14.7	----	----	----	----

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 18. Slab thickness computed for high-strength base and 95 percent reliability.

E_b = 1 million psi [6890 MPa], R = 95 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions 5	10	20	30	40	50	75	100
144	600	100	5	8.5	9.5	10.5	11.2	11.6	11.9	12.5	13.0
144	600	100	7	8.8	9.8	10.8	11.4	11.8	12.1	12.7	13.1
144	600	100	9	9.0	10.0	11.0	11.6	12.0	12.3	12.9	13.3
144	600	100	11	9.2	10.2	11.1	11.7	12.1	12.5	13.0	13.4
144	600	100	13	9.4	10.3	11.3	11.9	12.3	12.6	13.1	13.5
144	600	250	5	8.1	9.4	10.7	11.4	12.0	12.4	13.1	13.7
144	600	250	7	8.8	10.0	11.2	12.0	12.5	12.9	13.6	14.1
144	600	250	9	9.3	10.5	11.7	12.4	12.9	13.3	14.0	14.5
144	600	250	11	9.6	10.8	12.0	12.8	13.3	13.7	14.4	14.9
144	600	250	13	9.9	11.2	12.4	13.1	13.6	14.0	14.7	15.2
144	600	500	5	7.4	8.9	10.4	11.3	11.9	12.4	13.3	13.9
144	600	500	7	7.9	9.6	11.2	12.2	12.9	13.5	14.4	----
144	600	500	9	8.9	10.5	12.1	13.0	13.7	14.2	----	----
144	600	500	11	9.7	11.2	12.8	13.6	14.3	14.8	----	----
144	600	500	13	10.0	11.7	13.4	14.4	----	----	----	----
144	700	100	5	7.9	8.9	9.8	10.4	10.8	11.1	11.7	12.1
144	700	100	7	8.2	9.2	10.1	10.7	11.0	11.3	11.9	12.3
144	700	100	9	8.5	9.4	10.3	10.8	11.2	11.5	12.1	12.4
144	700	100	11	8.7	9.6	10.5	11.0	11.4	11.7	12.2	12.6
144	700	100	13	8.8	9.7	10.6	11.2	11.5	11.8	12.3	12.7
144	700	250	5	7.5	8.7	9.9	10.6	11.1	11.5	12.2	12.8
144	700	250	7	8.2	9.3	10.5	11.2	11.6	12.0	12.7	13.1
144	700	250	9	8.4	9.6	10.8	11.6	12.1	12.5	13.2	13.7
144	700	250	11	9.0	10.1	11.2	11.9	12.4	12.8	13.4	13.9
144	700	250	13	9.3	10.4	11.6	12.2	12.7	13.0	13.7	14.2
144	700	500	5	6.8	8.2	9.6	10.5	11.1	11.5	12.4	12.9
144	700	500	7	7.3	8.9	10.4	11.3	11.9	12.4	13.3	13.9
144	700	500	9	8.4	9.8	11.2	12.0	12.6	13.1	13.9	14.5
144	700	500	11	9.1	10.5	11.8	12.6	13.2	13.7	14.5	15.0
144	700	500	13	9.4	10.9	12.3	13.2	13.8	14.3	----	----
144	800	100	5	7.4	8.3	9.3	9.8	10.2	10.5	11.0	11.4
144	800	100	7	7.7	8.6	9.5	10.0	10.4	10.7	11.2	11.6
144	800	100	9	8.0	8.9	9.7	10.2	10.6	10.9	11.4	11.7
144	800	100	11	8.2	9.1	9.9	10.4	10.8	11.0	11.5	11.9
144	800	100	13	8.4	9.2	10.1	10.6	10.9	11.2	11.7	12.0
144	800	250	5	6.9	8.1	9.3	10.0	10.5	10.8	11.5	12.0
144	800	250	7	7.7	8.8	9.8	10.5	10.9	11.3	11.9	12.3
144	800	250	9	8.0	9.1	10.2	10.9	11.3	11.7	12.4	12.8
144	800	250	11	8.5	9.5	10.6	11.2	11.7	12.0	12.6	13.1
144	800	250	13	8.8	9.9	10.9	11.5	11.9	12.3	12.9	13.3
144	800	500	5	6.2	7.6	8.9	9.7	10.3	10.7	11.5	12.1
144	800	500	7	6.8	8.2	9.7	10.5	11.1	11.6	12.5	13.1
144	800	500	9	7.9	9.2	10.5	11.3	11.8	12.2	13.0	13.5
144	800	500	11	8.5	9.8	11.1	11.8	12.4	12.8	13.5	14.1
144	800	500	13	8.9	10.2	11.5	12.3	12.8	13.3	14.0	14.6
192	600	100	5	8.8	9.8	10.8	11.4	11.8	12.2	12.8	13.2
192	600	100	7	9.2	10.1	11.1	11.7	12.1	12.4	13.0	13.4
192	600	100	9	9.4	10.4	11.4	11.9	12.3	12.7	13.2	13.6
192	600	100	11	9.6	10.6	11.6	12.1	12.5	12.8	13.4	13.8
192	600	100	13	9.9	10.8	11.7	12.3	12.7	13.0	13.5	13.9
192	600	250	5	8.7	9.9	11.1	11.9	12.4	12.8	13.5	14.0
192	600	250	7	9.4	10.6	11.8	12.5	13.0	13.3	14.0	14.5
192	600	250	9	9.8	11.0	12.3	13.0	13.5	13.9	14.6	----
192	600	250	11	10.3	11.5	12.7	13.4	13.9	14.3	15.0	----
192	600	250	13	10.7	11.9	13.1	13.8	14.3	14.6	----	----
192	600	500	5	8.2	9.6	11.1	12.0	12.6	13.0	13.9	----
192	600	500	7	8.9	10.5	12.1	13.0	13.7	14.2	----	----
192	600	500	9	10.0	11.5	13.0	13.9	14.5	15.0	----	----
192	600	500	11	10.5	12.2	13.8	14.7	----	----	----	----
192	600	500	13	11.3	12.9	14.4	----	----	----	----	----
192	700	100	5	8.2	9.2	10.1	10.7	11.1	11.4	11.9	12.3
192	700	100	7	8.6	9.5	10.4	11.0	11.4	11.7	12.2	12.6
192	700	100	9	8.9	9.8	10.7	11.2	11.6	11.9	12.4	12.8
192	700	100	11	9.2	10.0	10.9	11.4	11.8	12.1	12.6	13.0
192	700	100	13	9.4	10.2	11.1	11.6	12.0	12.2	12.8	13.1
192	700	250	5	8.1	9.3	10.4	11.1	11.6	11.9	12.6	13.1
192	700	250	7	8.6	9.8	11.0	11.7	12.2	12.6	13.2	13.7
192	700	250	9	9.3	10.4	11.5	12.2	12.6	13.0	13.6	14.1
192	700	250	11	9.8	10.8	11.9	12.6	13.0	13.4	14.0	14.5
192	700	250	13	10.1	11.2	12.3	12.9	13.4	13.7	14.4	14.8

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 18. Slab thickness computed for high-strength base and 95 percent reliability (continued).

E_b = 1 million psi [6890 MPa], R = 95 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive . TD (degrees F)	Design ESALs, millions							
				5	10	20	30	40	50	75	100
192	700	500	5	7.6	9.0	10.4	11.2	11.7	12.2	13.0	13.5
192	700	500	7	8.6	9.9	11.3	12.1	12.7	13.2	14.0	14.5
192	700	500	9	9.1	10.6	12.1	13.0	13.7	14.1	15.0	----
192	700	500	11	10.0	11.4	12.8	13.6	14.2	14.7	----	----
192	700	500	13	10.7	12.0	13.4	14.2	14.8	----	----	----
192	800	100	5	7.8	8.7	9.6	10.1	10.5	10.7	11.3	11.6
192	800	100	7	8.2	9.0	9.9	10.4	10.7	11.0	11.5	11.9
192	800	100	9	8.5	9.3	10.2	10.6	11.0	11.3	11.8	12.1
192	800	100	11	8.7	9.5	10.4	10.9	11.2	11.5	11.9	12.3
192	800	100	13	8.9	9.7	10.6	11.0	11.4	11.6	12.1	12.4
192	800	250	5	7.7	8.7	9.8	10.4	10.9	11.2	11.9	12.3
192	800	250	7	8.2	9.3	10.4	11.0	11.5	11.8	12.5	12.9
192	800	250	9	8.8	9.9	10.9	11.5	11.9	12.3	12.9	13.3
192	800	250	11	9.3	10.3	11.3	11.9	12.3	12.6	13.2	13.7
192	800	250	13	9.6	10.6	11.6	12.2	12.7	13.0	13.6	14.0
192	800	500	5	7.2	8.5	9.7	10.5	11.0	11.4	12.2	12.7
192	800	500	7	8.1	9.4	10.7	11.4	12.0	12.4	13.1	13.7
192	800	500	9	8.8	10.1	11.4	12.2	12.7	13.1	13.9	14.5
192	800	500	11	9.5	10.8	12.1	12.8	13.4	13.8	14.5	15.0
192	800	500	13	9.9	11.3	12.6	13.4	14.0	14.4	----	----
240	600	100	5	9.1	10.1	11.1	11.7	12.1	12.4	13.0	13.4
240	600	100	7	9.5	10.5	11.5	12.0	12.4	12.8	13.3	13.8
240	600	100	9	9.8	10.8	11.8	12.3	12.7	13.0	13.6	14.0
240	600	100	11	10.1	11.1	12.0	12.5	12.9	13.2	13.8	14.2
240	600	100	13	10.4	11.3	12.2	12.7	13.1	13.4	14.0	14.3
240	600	250	5	9.2	10.4	11.6	12.3	12.8	13.2	13.9	14.4
240	600	250	7	9.9	11.1	12.3	13.0	13.5	13.9	14.7	----
240	600	250	9	10.5	11.7	12.9	13.6	14.1	14.5	----	----
240	600	250	11	11.0	12.2	13.4	14.1	14.5	14.9	----	----
240	600	250	13	11.4	12.6	13.9	14.6	----	----	----	----
240	600	500	5	8.4	10.1	11.7	12.6	13.3	13.8	14.8	----
240	600	500	7	9.9	11.5	13.0	13.9	14.5	----	----	----
240	600	500	9	10.8	12.4	14.1	----	----	----	----	----
240	600	500	11	11.7	13.4	15.0	----	----	----	----	----
240	600	500	13	12.4	14.2	----	----	----	----	----	----
240	700	100	5	8.6	9.5	10.4	11.0	11.4	11.7	12.2	12.6
240	700	100	7	9.0	9.9	10.8	11.3	11.7	12.0	12.5	12.9
240	700	100	9	9.4	10.2	11.1	11.6	12.0	12.3	12.8	13.2
240	700	100	11	9.6	10.5	11.4	11.9	12.2	12.5	13.0	13.4
240	700	100	13	9.9	10.7	11.6	12.1	12.4	12.7	13.2	13.6
240	700	250	5	8.7	9.8	10.9	11.6	12.0	12.4	13.0	13.5
240	700	250	7	9.4	10.5	11.6	12.3	12.7	13.1	13.7	14.2
240	700	250	9	10.0	11.1	12.2	12.8	13.3	13.6	14.2	14.7
240	700	250	11	10.4	11.5	12.7	13.3	13.8	14.1	14.8	----
240	700	250	13	10.9	12.0	13.0	13.7	14.1	14.5	15.1	----
240	700	500	5	8.2	9.6	11.0	11.9	12.4	12.9	13.7	14.3
240	700	500	7	9.2	10.7	12.2	13.1	13.7	14.2	----	----
240	700	500	9	10.4	11.8	13.1	13.9	14.5	14.9	----	----
240	700	500	11	11.0	12.5	13.9	14.8	----	----	----	----
240	700	500	13	11.8	13.2	14.6	----	----	----	----	----
240	800	100	5	8.2	9.0	9.9	10.4	10.8	11.0	11.5	11.9
240	800	100	7	8.6	9.4	10.3	10.8	11.1	11.4	11.9	12.2
240	800	100	9	8.9	9.8	10.6	11.1	11.4	11.7	12.1	12.5
240	800	100	11	9.2	10.0	10.8	11.3	11.6	11.9	12.4	12.7
240	800	100	13	9.5	10.3	11.0	11.5	11.8	12.1	12.6	12.9
240	800	250	5	8.1	9.2	10.3	11.0	11.4	11.8	12.4	12.9
240	800	250	7	9.0	10.0	11.0	11.6	12.0	12.4	13.0	13.4
240	800	250	9	9.5	10.5	11.6	12.2	12.6	12.9	13.5	14.0
240	800	250	11	10.0	11.0	12.0	12.6	13.0	13.3	13.9	14.3
240	800	250	13	10.4	11.4	12.4	13.0	13.4	13.7	14.3	14.7
240	800	500	5	7.9	9.2	10.5	11.2	11.8	12.2	12.9	13.5
240	800	500	7	9.0	10.3	11.5	12.3	12.8	13.2	14.0	14.5
240	800	500	9	10.0	11.2	12.4	13.2	13.7	14.1	14.8	----
240	800	500	11	10.6	11.9	13.1	13.9	14.4	14.8	----	----
240	800	500	13	11.2	12.5	13.7	14.4	14.9	----	----	----

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 19. Slab thickness computed for granular base and 90 percent reliability.

E_b = 25 ksi [172.25 MPa], R = 90 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	4	5	7.5	10
144	600	100	5	8.2	8.7	9.0	9.3	9.8	10.2	10.8	11.3
144	600	100	7	8.1	8.6	9.0	9.2	9.7	10.1	10.7	11.2
144	600	100	9	8.0	8.5	8.9	9.2	9.6	10.0	10.7	11.1
144	600	100	11	8.0	8.4	8.8	9.1	9.6	9.9	10.6	11.0
144	600	100	13	7.9	8.4	8.7	9.0	9.5	9.9	10.5	11.0
144	600	250	5	7.3	7.8	8.2	8.5	9.1	9.5	10.2	10.8
144	600	250	7	7.3	7.9	8.3	8.6	9.2	9.6	10.4	10.9
144	600	250	9	7.4	7.9	8.4	8.7	9.3	9.7	10.5	11.1
144	600	250	11	7.4	8.0	8.4	8.8	9.4	9.8	10.6	11.2
144	600	250	13	7.5	8.1	8.5	8.9	9.4	9.9	10.7	11.3
144	600	500	5	—	6.1	6.7	7.1	7.8	8.3	9.3	10.0
144	600	500	7	—	6.3	6.9	7.4	8.1	8.7	9.7	10.5
144	600	500	9	—	6.5	7.1	7.6	8.4	9.0	10.1	10.9
144	600	500	11	6.0	6.8	7.4	7.9	8.8	9.4	10.5	11.4
144	600	500	13	6.1	7.0	7.7	8.2	9.1	9.7	10.9	11.8
144	700	100	5	7.4	7.8	8.2	8.4	8.9	9.2	9.8	10.3
144	700	100	7	7.3	7.8	8.1	8.4	8.8	9.1	9.8	10.2
144	700	100	9	7.2	7.7	8.0	8.3	8.7	9.1	9.7	10.2
144	700	100	11	7.2	7.6	8.0	8.3	8.7	9.0	9.7	10.1
144	700	100	13	7.1	7.6	7.9	8.2	8.6	9.0	9.6	10.0
144	700	250	5	6.3	6.8	7.2	7.5	8.0	8.4	9.1	9.6
144	700	250	7	6.5	7.0	7.4	7.7	8.3	8.6	9.4	9.9
144	700	250	9	6.6	7.1	7.5	7.8	8.4	8.8	9.5	10.0
144	700	250	11	6.7	7.2	7.6	7.9	8.4	8.8	9.6	10.1
144	700	250	13	6.7	7.3	7.7	8.0	8.5	8.9	9.7	10.2
144	700	500	5	—	—	—	6.2	6.9	7.3	8.2	8.9
144	700	500	7	—	—	6.1	6.5	7.2	7.7	8.6	9.3
144	700	500	9	—	—	6.2	6.7	7.4	7.9	8.9	9.6
144	700	500	11	—	—	6.5	7.0	7.7	8.3	9.3	10.0
144	700	500	13	—	6.2	6.8	7.2	8.0	8.6	9.6	10.4
144	800	100	5	6.7	7.2	7.5	7.7	8.1	8.5	9.0	9.4
144	800	100	7	6.7	7.1	7.4	7.7	8.1	8.4	9.0	9.4
144	800	100	9	6.7	7.1	7.4	7.6	8.1	8.4	8.9	9.3
144	800	100	11	6.6	7.0	7.4	7.6	8.0	8.3	8.9	9.3
144	800	100	13	6.6	7.0	7.3	7.6	8.0	8.3	8.9	9.3
144	800	250	5	—	6.1	6.5	6.8	7.3	7.7	8.3	8.8
144	800	250	7	—	6.2	6.6	6.9	7.4	7.8	8.5	8.9
144	800	250	9	—	6.3	6.7	7.0	7.5	7.9	8.6	9.1
144	800	250	11	—	6.4	6.8	7.1	7.6	8.0	8.7	9.2
144	800	250	13	—	6.5	6.9	7.2	7.7	8.1	8.8	9.3
144	800	500	5	—	—	—	—	6.1	6.5	7.4	7.9
144	800	500	7	—	—	—	—	6.4	6.9	7.7	8.4
144	800	500	9	—	—	—	6.0	6.7	7.2	8.1	8.7
144	800	500	11	—	—	—	6.3	7.0	7.5	8.4	9.1
144	800	500	13	—	—	6.2	6.6	7.3	7.8	8.7	9.4
192	600	100	5	8.4	8.8	9.2	9.5	10.0	10.3	11.0	11.4
192	600	100	7	8.3	8.8	9.1	9.4	9.9	10.3	10.9	11.4
192	600	100	9	8.3	8.7	9.1	9.4	9.9	10.2	10.9	11.4
192	600	100	11	8.2	8.7	9.1	9.4	9.8	10.2	10.9	11.3
192	600	100	13	8.2	8.7	9.0	9.3	9.8	10.2	10.8	11.3
192	600	250	5	7.5	8.0	8.4	8.8	9.3	9.7	10.5	11.0
192	600	250	7	7.6	8.2	8.6	9.0	9.5	9.9	10.7	11.3
192	600	250	9	7.7	8.3	8.8	9.1	9.7	10.1	10.9	11.5
192	600	250	11	7.9	8.5	8.9	9.3	9.8	10.3	11.1	11.7
192	600	250	13	8.0	8.6	9.0	9.4	10.0	10.5	11.3	11.9
192	600	500	5	—	6.4	6.9	7.4	8.1	8.7	9.7	10.4
192	600	500	7	—	6.7	7.3	7.8	8.6	9.2	10.3	11.1
192	600	500	9	6.3	7.1	7.8	8.3	9.1	9.8	10.9	11.8
192	600	500	11	6.6	7.5	8.2	8.7	9.6	10.3	11.5	12.4
192	600	500	13	7.0	7.9	8.6	9.2	10.1	10.8	12.1	13.0
192	700	100	5	7.5	8.0	8.3	8.6	9.0	9.4	10.0	10.4
192	700	100	7	7.5	8.0	8.3	8.6	9.0	9.4	10.0	10.4
192	700	100	9	7.5	7.9	8.3	8.6	9.0	9.3	10.0	10.4
192	700	100	11	7.5	7.9	8.3	8.5	9.0	9.3	9.9	10.4
192	700	100	13	7.5	7.9	8.3	8.5	9.0	9.3	9.9	10.4
192	700	250	5	6.7	7.2	7.6	7.9	8.4	8.8	9.5	10.0
192	700	250	7	6.9	7.4	7.8	8.1	8.6	9.0	9.7	10.2
192	700	250	9	7.0	7.5	7.9	8.3	8.8	9.2	9.9	10.5
192	700	250	11	7.1	7.7	8.1	8.4	9.0	9.4	10.1	10.7
192	700	250	13	7.3	7.8	8.2	8.6	9.1	9.5	10.3	10.9

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 19. Slab thickness computed for granular base and 90 percent reliability (continued).

E_b = 25 ksi [172.25 MPa], R = 90 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	4	5	7.5	10
192	700	500	5	—	—	6.2	6.6	7.3	7.8	8.7	9.3
192	700	500	7	—	—	6.5	6.9	7.7	8.2	9.2	9.9
192	700	500	9	—	6.4	7.0	7.4	8.2	8.7	9.8	10.5
192	700	500	11	6.1	6.8	7.4	7.9	8.6	9.2	10.3	11.1
192	700	500	13	6.5	7.2	7.8	8.3	9.1	9.7	10.8	11.6
192	800	100	5	6.9	7.3	7.6	7.9	8.3	8.6	9.2	9.6
192	800	100	7	6.9	7.3	7.6	7.9	8.3	8.6	9.2	9.6
192	800	100	9	6.9	7.3	7.6	7.9	8.3	8.6	9.2	9.6
192	800	100	11	6.9	7.3	7.6	7.9	8.3	8.6	9.2	9.6
192	800	100	13	6.9	7.3	7.7	7.9	8.3	8.6	9.2	9.6
192	800	250	5	—	6.4	6.8	7.1	7.6	7.9	8.6	9.1
192	800	250	7	6.1	6.6	7.0	7.3	7.8	8.2	8.9	9.4
192	800	250	9	6.2	6.7	7.1	7.5	8.0	8.4	9.1	9.6
192	800	250	11	6.6	7.1	7.5	7.8	8.3	8.6	9.3	9.8
192	800	250	13	6.7	7.2	7.6	7.9	8.4	8.8	9.5	10.0
192	800	500	5	—	—	—	—	6.5	7.0	7.9	8.5
192	800	500	7	—	—	6.0	6.4	7.1	7.5	8.4	9.1
192	800	500	9	—	—	6.4	6.8	7.4	8.0	8.9	9.5
192	800	500	11	—	6.3	6.8	7.2	7.9	8.4	9.4	10.1
192	800	500	13	6.0	6.7	7.2	7.6	8.3	8.9	9.8	10.5
240	600	100	5	8.5	9.0	9.4	9.6	10.1	10.5	11.1	11.6
240	600	100	7	8.5	9.0	9.4	9.7	10.1	10.5	11.1	11.6
240	600	100	9	8.5	9.0	9.4	9.7	10.1	10.5	11.1	11.6
240	600	100	11	8.5	9.0	9.4	9.7	10.1	10.5	11.2	11.6
240	600	100	13	8.5	9.0	9.4	9.7	10.1	10.5	11.2	11.6
240	600	250	5	7.7	8.3	8.7	9.1	9.6	10.0	10.8	11.4
240	600	250	7	8.0	8.5	9.0	9.3	9.9	10.3	11.1	11.7
240	600	250	9	8.2	8.8	9.2	9.6	10.2	10.6	11.4	12.0
240	600	250	11	8.4	9.0	9.4	9.8	10.4	10.9	11.7	12.3
240	600	250	13	8.6	9.2	9.6	10.0	10.6	11.1	11.9	12.5
240	600	500	5	—	6.7	7.3	7.8	8.6	9.2	10.2	11.0
240	600	500	7	6.5	7.3	7.9	8.4	9.3	9.9	11.1	11.9
240	600	500	9	7.0	7.9	8.6	9.1	10.0	10.7	11.9	12.8
240	600	500	11	7.6	8.5	9.2	9.8	10.7	11.4	12.7	13.6
240	600	500	13	8.1	9.1	9.8	10.4	11.4	12.1	13.4	14.4
240	700	100	5	7.7	8.1	8.5	8.8	9.2	9.5	10.2	10.6
240	700	100	7	7.8	8.2	8.5	8.8	9.2	9.6	10.2	10.6
240	700	100	9	7.8	8.2	8.6	8.9	9.3	9.6	10.2	10.7
240	700	100	11	7.8	8.3	8.6	8.9	9.3	9.7	10.3	10.7
240	700	100	13	7.9	8.3	8.6	8.9	9.3	9.7	10.3	10.7
240	700	250	5	7.0	7.5	7.9	8.2	8.7	9.1	9.8	10.3
240	700	250	7	7.2	7.8	8.2	8.5	9.0	9.4	10.2	10.7
240	700	250	9	7.5	8.0	8.4	8.8	9.3	9.7	10.5	11.0
240	700	250	11	7.7	8.3	8.7	9.0	9.6	10.0	10.8	11.3
240	700	250	13	7.9	8.5	8.9	9.3	9.8	10.2	11.0	11.6
240	700	500	5	—	6.0	6.5	7.0	7.7	8.2	9.2	9.9
240	700	500	7	6.0	6.7	7.2	7.7	8.4	9.0	10.0	10.7
240	700	500	9	6.6	7.3	7.9	8.4	9.1	9.7	10.8	11.5
240	700	500	11	7.2	7.9	8.5	9.0	9.8	10.4	11.5	12.2
240	700	500	13	7.7	8.5	9.1	9.6	10.4	11.0	12.1	12.9
240	800	100	5	7.1	7.5	7.8	8.1	8.5	8.8	9.4	9.8
240	800	100	7	7.1	7.5	7.9	8.1	8.5	8.9	9.5	9.9
240	800	100	9	7.2	7.6	7.9	8.2	8.6	8.9	9.5	9.9
240	800	100	11	7.2	7.7	8.0	8.2	8.7	9.0	9.6	10.0
240	800	100	13	7.3	7.7	8.0	8.3	8.7	9.0	9.6	10.0
240	800	250	5	6.2	6.7	7.1	7.4	7.9	8.3	9.0	9.5
240	800	250	7	6.7	7.2	7.6	7.9	8.3	8.7	9.4	9.9
240	800	250	9	6.9	7.4	7.8	8.1	8.6	9.0	9.7	10.2
240	800	250	11	7.2	7.7	8.1	8.4	8.9	9.3	10.0	10.5
240	800	250	13	7.4	7.9	8.3	8.6	9.1	9.5	10.2	10.7
240	800	500	5	—	—	6.1	6.5	7.1	7.6	8.5	9.1
240	800	500	7	—	6.2	6.7	7.1	7.8	8.3	9.2	9.8
240	800	500	9	6.2	6.9	7.4	7.8	8.5	9.0	9.9	10.6
240	800	500	11	6.8	7.4	8.0	8.4	9.1	9.6	10.5	11.2
240	800	500	13	7.3	7.9	8.5	8.9	9.6	10.1	11.1	11.8

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 20. Slab thickness computed for treated base and 90 percent reliability.

E_b = 500 ksi [3445 MPa], R = 90 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	4	5	7.5	10
144	600	100	5	6.9	7.4	7.7	8.0	8.4	8.7	9.4	9.8
144	600	100	7	7.1	7.5	7.8	8.1	8.5	8.9	9.5	9.9
144	600	100	9	7.2	7.6	8.0	8.2	8.7	9.0	9.6	10.0
144	600	100	11	7.3	7.7	8.1	8.3	8.8	9.1	9.7	10.1
144	600	100	13	7.4	7.8	8.1	8.4	8.8	9.2	9.8	10.2
144	600	250	5	—	6.3	6.7	7.0	7.6	8.0	8.8	9.3
144	600	250	7	6.2	6.7	7.1	7.5	8.0	8.5	9.2	9.8
144	600	250	9	6.5	7.1	7.5	7.8	8.4	8.8	9.6	10.1
144	600	250	11	6.8	7.4	7.8	8.1	8.7	9.1	9.9	10.4
144	600	250	13	7.1	7.6	8.1	8.4	9.0	9.4	10.2	10.7
144	600	500	5	—	—	—	—	6.2	6.7	7.7	8.4
144	600	500	7	—	—	—	6.3	7.0	7.5	8.5	9.3
144	600	500	9	—	6.0	6.6	7.0	7.7	8.3	9.3	10.0
144	600	500	11	—	6.0	6.6	7.1	7.9	8.5	9.7	10.4
144	600	500	13	6.0	6.8	7.4	7.9	8.6	9.2	10.3	11.1
144	700	100	5	6.3	6.7	7.0	7.3	7.7	8.0	8.6	9.0
144	700	100	7	6.5	6.9	7.2	7.5	7.9	8.2	8.8	9.2
144	700	100	9	6.7	7.1	7.4	7.6	8.0	8.3	8.9	9.3
144	700	100	11	6.8	7.2	7.5	7.7	8.1	8.4	9.0	9.4
144	700	100	13	6.9	7.3	7.6	7.8	8.2	8.5	9.1	9.5
144	700	250	5	—	—	6.2	6.5	7.0	7.4	8.1	8.6
144	700	250	7	—	6.1	6.5	6.8	7.3	7.7	8.4	8.9
144	700	250	9	6.0	6.5	6.9	7.2	7.7	8.1	8.8	9.3
144	700	250	11	6.3	6.8	7.2	7.5	8.0	8.4	9.1	9.6
144	700	250	13	6.5	7.0	7.4	7.8	8.3	8.7	9.4	9.9
144	700	500	5	—	—	—	—	—	—	6.8	7.5
144	700	500	7	—	—	—	5.7	6.4	6.9	7.8	8.4
144	700	500	9	—	—	6.0	6.4	7.0	7.5	8.4	9.1
144	700	500	11	—	—	6.1	6.6	7.3	7.8	8.8	9.5
144	700	500	13	—	6.3	6.8	7.2	7.9	8.4	9.4	10.1
144	800	100	5	—	6.2	6.5	6.7	7.1	7.4	8.0	8.4
144	800	100	7	6.0	6.4	6.7	6.9	7.3	7.6	8.1	8.5
144	800	100	9	6.2	6.5	6.8	7.1	7.4	7.7	8.3	8.6
144	800	100	11	6.4	6.8	7.0	7.3	7.6	7.9	8.4	8.8
144	800	100	13	6.5	6.9	7.2	7.4	7.7	8.0	8.5	8.9
144	800	250	5	—	—	—	6.0	6.4	6.8	7.5	7.9
144	800	250	7	—	—	6.1	6.4	6.8	7.2	7.9	8.3
144	800	250	9	—	6.0	6.4	6.7	7.2	7.5	8.2	8.7
144	800	250	11	—	6.3	6.7	7.0	7.5	7.8	8.5	8.9
144	800	250	13	6.1	6.6	7.0	7.3	7.7	8.1	8.7	9.2
144	800	500	5	—	—	—	—	—	—	6.5	7.1
144	800	500	7	—	—	—	—	—	6.2	7.1	7.7
144	800	500	9	—	—	—	—	6.5	6.9	7.8	8.4
144	800	500	11	—	—	—	6.1	6.7	7.2	8.1	8.7
144	800	500	13	—	—	6.3	6.7	7.3	7.8	8.7	9.3
192	600	100	5	7.1	7.6	7.9	8.2	8.6	9.0	9.6	10.0
192	600	100	7	7.4	7.8	8.1	8.4	8.8	9.2	9.8	10.2
192	600	100	9	7.5	8.0	8.3	8.6	9.0	9.3	9.9	10.4
192	600	100	11	7.7	8.1	8.5	8.7	9.1	9.5	10.1	10.5
192	600	100	13	7.8	8.3	8.6	8.8	9.3	9.6	10.2	10.6
192	600	250	5	6.2	6.7	7.1	7.5	8.0	8.4	9.2	9.7
192	600	250	7	6.7	7.2	7.6	8.0	8.5	9.0	9.7	10.3
192	600	250	9	7.1	7.7	8.1	8.4	9.0	9.4	10.2	10.7
192	600	250	11	7.5	8.0	8.5	8.8	9.4	9.8	10.5	11.1
192	600	250	13	7.4	8.0	8.4	8.8	9.4	9.9	10.7	11.4
192	600	500	5	—	—	—	6.1	6.8	7.3	8.3	9.0
192	600	500	7	—	6.1	6.6	7.1	7.8	8.3	9.3	10.1
192	600	500	9	—	6.4	7.0	7.5	8.3	8.9	10.0	10.8
192	600	500	11	6.5	7.3	7.9	8.4	9.1	9.7	10.8	11.6
192	600	500	13	7.1	7.9	8.5	9.0	9.8	10.4	11.5	12.3
192	700	100	5	6.6	7.0	7.3	7.6	8.0	8.3	8.9	9.3
192	700	100	7	6.8	7.2	7.5	7.8	8.2	8.5	9.1	9.5
192	700	100	9	7.0	7.4	7.7	8.0	8.4	8.7	9.2	9.6
192	700	100	11	7.2	7.6	7.9	8.2	8.5	8.9	9.4	9.8
192	700	100	13	7.4	7.7	8.0	8.3	8.7	9.0	9.5	9.9
192	700	250	5	—	6.1	6.5	6.8	7.4	7.7	8.5	9.0
192	700	250	7	6.2	6.7	7.1	7.4	7.9	8.3	9.0	9.5
192	700	250	9	6.7	7.2	7.5	7.9	8.4	8.7	9.4	9.9
192	700	250	11	7.0	7.5	7.9	8.2	8.7	9.1	9.8	10.3
192	700	250	13	7.2	7.7	8.1	8.4	8.9	9.3	10.1	10.6

Table 20. Slab thickness computed for treated base and 90 percent reliability (continued).

E_b = 500 ksi [3445 MPa], R = 90 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	4	5	7.5	10
192	700	500	5	—	—	—	—	6.3	6.8	7.7	8.3
192	700	500	7	—	—	6.2	6.6	7.3	7.7	8.6	9.3
192	700	500	9	—	6.2	6.7	7.1	7.8	8.3	9.3	10.0
192	700	500	11	6.3	7.0	7.5	7.9	8.6	9.1	10.0	10.7
192	700	500	13	6.9	7.6	8.1	8.5	9.2	9.7	10.7	11.3
192	800	100	5	6.1	6.5	6.8	7.0	7.4	7.7	8.2	8.6
192	800	100	7	6.4	6.8	7.1	7.3	7.7	8.0	8.5	8.9
192	800	100	9	6.6	7.0	7.3	7.5	7.9	8.2	8.7	9.1
192	800	100	11	6.8	7.2	7.5	7.7	8.1	8.3	8.9	9.2
192	800	100	13	7.0	7.3	7.6	7.8	8.2	8.5	9.0	9.3
192	800	250	5	—	—	6.2	6.5	6.9	7.3	7.9	8.4
192	800	250	7	—	6.3	6.6	6.9	7.4	7.8	8.4	8.9
192	800	250	9	6.3	6.7	7.1	7.4	7.8	8.2	8.8	9.3
192	800	250	11	6.6	7.1	7.4	7.7	8.2	8.6	9.2	9.7
192	800	250	13	6.9	7.3	7.7	8.0	8.5	8.8	9.5	10.0
192	800	500	5	—	—	—	—	—	6.2	7.1	7.7
192	800	500	7	—	—	—	6.2	6.8	7.2	8.1	8.6
192	800	500	9	—	—	6.4	6.8	7.4	7.8	8.7	9.3
192	800	500	11	6.1	6.6	7.1	7.5	8.1	8.6	9.4	10.0
192	800	500	13	6.2	6.9	7.4	7.8	8.4	8.9	9.8	10.4
240	600	100	5	7.4	7.8	8.2	8.5	8.9	9.2	9.8	10.3
240	600	100	7	7.7	8.1	8.5	8.7	9.2	9.5	10.1	10.5
240	600	100	9	7.9	8.4	8.7	9.0	9.4	9.7	10.3	10.7
240	600	100	11	8.1	8.5	8.9	9.1	9.6	9.9	10.5	10.9
240	600	100	13	8.3	8.7	9.0	9.3	9.7	10.0	10.6	11.0
240	600	250	5	6.6	7.2	7.6	7.9	8.5	8.9	9.7	10.2
240	600	250	7	7.2	7.8	8.2	8.6	9.1	9.5	10.3	10.8
240	600	250	9	7.8	8.3	8.7	9.1	9.6	10.0	10.8	11.4
240	600	250	11	8.0	8.5	9.0	9.4	9.9	10.4	11.2	11.8
240	600	250	13	8.4	9.0	9.5	9.8	10.4	10.8	11.6	12.2
240	600	500	5	—	—	6.3	6.8	7.5	8.0	9.0	9.8
240	600	500	7	—	6.4	7.0	7.5	8.3	8.9	10.0	10.8
240	600	500	9	6.9	7.6	8.2	8.7	9.5	10.1	11.1	11.9
240	600	500	11	7.7	8.5	9.1	9.6	10.4	11.0	12.0	12.8
240	600	500	13	8.1	8.9	9.6	10.1	10.9	11.6	12.8	13.6
240	700	100	5	6.9	7.3	7.6	7.9	8.3	8.6	9.1	9.5
240	700	100	7	7.2	7.6	7.9	8.2	8.5	8.9	9.4	9.8
240	700	100	9	7.4	7.8	8.1	8.4	8.8	9.1	9.6	10.0
240	700	100	11	7.7	8.0	8.3	8.6	9.0	9.3	9.8	10.2
240	700	100	13	7.8	8.2	8.5	8.8	9.2	9.5	10.0	10.4
240	700	250	5	6.2	6.7	7.1	7.4	7.9	8.3	9.0	9.5
240	700	250	7	6.8	7.3	7.7	8.0	8.5	8.9	9.6	10.1
240	700	250	9	7.2	7.7	8.1	8.4	8.9	9.3	10.0	10.5
240	700	250	11	7.7	8.2	8.6	8.9	9.4	9.8	10.5	11.0
240	700	250	13	8.1	8.6	9.0	9.3	9.8	10.2	10.9	11.4
240	700	500	5	—	—	6.0	6.4	7.1	7.6	8.5	9.1
240	700	500	7	—	6.4	6.9	7.3	8.0	8.5	9.4	10.1
240	700	500	9	6.8	7.4	8.0	8.4	9.0	9.5	10.4	11.1
240	700	500	11	7.2	7.9	8.5	8.9	9.6	10.2	11.2	11.9
240	700	500	13	8.0	8.7	9.3	9.7	10.4	10.9	11.9	12.6
240	800	100	5	6.5	6.8	7.1	7.4	7.7	8.0	8.6	8.9
240	800	100	7	6.8	7.2	7.5	7.7	8.1	8.3	8.9	9.2
240	800	100	9	7.1	7.4	7.7	7.9	8.3	8.6	9.1	9.5
240	800	100	11	7.3	7.6	7.9	8.1	8.5	8.8	9.3	9.7
240	800	100	13	7.5	7.8	8.1	8.3	8.7	9.0	9.5	9.8
240	800	250	5	—	6.3	6.6	6.9	7.4	7.8	8.4	8.9
240	800	250	7	6.5	6.9	7.3	7.6	8.0	8.4	9.0	9.5
240	800	250	9	6.9	7.4	7.7	8.0	8.5	8.9	9.5	10.0
240	800	250	11	7.4	7.9	8.2	8.5	9.0	9.3	10.0	10.4
240	800	250	13	7.8	8.2	8.6	8.9	9.3	9.7	10.3	10.8
240	800	500	5	—	—	—	6.1	6.7	7.2	8.0	8.5
240	800	500	7	—	6.2	6.7	7.1	7.6	8.1	8.9	9.5
240	800	500	9	6.6	7.2	7.6	8.0	8.6	9.0	9.9	10.4
240	800	500	11	7.2	7.8	8.2	8.6	9.2	9.7	10.5	11.1
240	800	500	13	7.9	8.5	8.9	9.3	9.9	10.3	11.2	11.8

Table 21. Slab thickness computed for high-strength base and 90 percent reliability.

E_b = 1 million psi [6890 MPa], R = 90 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	4	5	7.5	10
144	600	100	5	6.2	6.6	6.9	7.2	7.6	8.0	8.6	9.0
144	600	100	7	6.6	7.0	7.3	7.6	8.0	8.3	8.9	9.3
144	600	100	9	6.9	7.3	7.6	7.8	8.2	8.6	9.1	9.5
144	600	100	11	7.0	7.4	7.7	8.0	8.4	8.7	9.3	9.7
144	600	100	13	7.2	7.6	7.9	8.2	8.6	8.9	9.5	9.9
144	600	250	5	—	—	6.2	6.6	7.1	7.5	8.3	8.8
144	600	250	7	6.1	6.6	7.0	7.3	7.8	8.2	8.9	9.4
144	600	250	9	6.6	7.1	7.5	7.8	8.3	8.7	9.4	9.9
144	600	250	11	6.8	7.3	7.7	8.1	8.6	9.0	9.7	10.2
144	600	250	13	7.2	7.7	8.1	8.5	9.0	9.4	10.1	10.6
144	600	500	5	—	—	—	—	6.2	6.7	7.6	8.2
144	600	500	7	—	—	—	—	6.6	7.1	8.1	8.8
144	600	500	9	—	6.1	6.6	7.0	7.7	8.2	9.1	9.8
144	600	500	11	6.4	7.0	7.5	7.9	8.5	9.0	9.9	10.5
144	600	500	13	6.3	7.0	7.5	8.0	8.7	9.2	10.2	10.9
144	700	100	5	—	6.1	6.4	6.7	7.1	7.4	8.0	8.4
144	700	100	7	6.1	6.5	6.8	7.1	7.5	7.8	8.3	8.7
144	700	100	9	6.4	6.8	7.1	7.4	7.7	8.0	8.6	9.0
144	700	100	11	6.7	7.0	7.3	7.6	7.9	8.2	8.8	9.1
144	700	100	13	6.9	7.3	7.5	7.8	8.1	8.4	9.0	9.3
144	700	250	5	—	—	—	6.0	6.5	6.9	7.6	8.1
144	700	250	7	—	6.1	6.5	6.8	7.3	7.7	8.3	8.8
144	700	250	9	—	6.2	6.6	6.9	7.4	7.8	8.5	9.0
144	700	250	11	6.5	6.9	7.3	7.6	8.1	8.4	9.1	9.6
144	700	250	13	6.9	7.3	7.7	8.0	8.5	8.8	9.5	9.9
144	700	500	5	—	—	—	—	—	6.1	6.9	7.5
144	700	500	7	—	—	—	—	6.1	6.6	7.5	8.1
144	700	500	9	—	—	6.3	6.7	7.3	7.7	8.6	9.1
144	700	500	11	6.0	6.6	7.0	7.4	8.0	8.4	9.2	9.8
144	700	500	13	6.2	6.8	7.2	7.6	8.2	8.7	9.6	10.2
144	800	100	5	—	—	6.1	6.3	6.7	7.0	7.5	7.9
144	800	100	7	—	6.2	6.4	6.7	7.0	7.3	7.8	8.2
144	800	100	9	6.1	6.5	6.7	7.0	7.3	7.6	8.1	8.5
144	800	100	11	6.4	6.7	7.0	7.2	7.6	7.8	8.3	8.7
144	800	100	13	6.6	6.9	7.2	7.4	7.8	8.0	8.5	8.9
144	800	250	5	—	—	—	—	6.0	6.4	7.1	7.6
144	800	250	7	—	—	6.1	6.4	6.8	7.2	7.8	8.3
144	800	250	9	—	6.0	6.3	6.6	7.1	7.5	8.1	8.6
144	800	250	11	6.1	6.6	6.9	7.2	7.6	8.0	8.6	9.0
144	800	250	13	6.5	7.0	7.3	7.6	8.0	8.3	8.9	9.4
144	800	500	5	—	—	—	—	—	—	6.4	6.9
144	800	500	7	—	—	—	—	—	6.1	6.9	7.5
144	800	500	9	—	—	—	6.3	6.8	7.2	8.0	8.5
144	800	500	11	—	6.2	6.6	7.0	7.5	7.9	8.7	9.2
144	800	500	13	6.0	6.5	6.9	7.3	7.8	8.3	9.0	9.6
192	600	100	5	6.6	7.0	7.3	7.6	8.0	8.3	8.9	9.3
192	600	100	7	7.0	7.4	7.7	8.0	8.4	8.7	9.3	9.7
192	600	100	9	7.2	7.6	8.0	8.2	8.6	8.9	9.5	9.9
192	600	100	11	7.5	7.9	8.2	8.5	8.9	9.2	9.8	10.2
192	600	100	13	7.8	8.2	8.5	8.7	9.1	9.4	10.0	10.4
192	600	250	5	6.0	6.5	6.9	7.2	7.7	8.1	8.8	9.3
192	600	250	7	6.8	7.2	7.6	7.9	8.4	8.8	9.5	10.0
192	600	250	9	7.1	7.6	8.0	8.3	8.8	9.2	10.0	10.5
192	600	250	11	7.7	8.2	8.5	8.9	9.4	9.7	10.4	10.9
192	600	250	13	8.1	8.6	9.0	9.3	9.8	10.1	10.8	11.3
192	600	500	5	—	—	6.0	6.4	7.0	7.5	8.3	8.9
192	600	500	7	—	6.1	6.6	7.0	7.7	8.2	9.1	9.8
192	600	500	9	6.6	7.3	7.7	8.1	8.8	9.3	10.1	10.8
192	600	500	11	7.0	7.6	8.2	8.6	9.3	9.8	10.7	11.4
192	600	500	13	7.8	8.4	9.0	9.4	10.0	10.5	11.5	12.1
192	700	100	5	6.1	6.5	6.8	7.1	7.5	7.8	8.3	8.7
192	700	100	7	6.6	7.0	7.3	7.5	7.9	8.2	8.7	9.1
192	700	100	9	6.9	7.3	7.6	7.8	8.2	8.5	9.0	9.4
192	700	100	11	7.2	7.6	7.9	8.1	8.5	8.7	9.3	9.6
192	700	100	13	7.4	7.8	8.1	8.3	8.7	9.0	9.5	9.8
192	700	250	5	—	6.1	6.4	6.7	7.2	7.6	8.3	8.7
192	700	250	7	6.0	6.5	6.9	7.2	7.7	8.1	8.8	9.3
192	700	250	9	6.8	7.3	7.7	7.9	8.4	8.8	9.4	9.9
192	700	250	11	7.3	7.8	8.1	8.4	8.9	9.2	9.9	10.3
192	700	250	13	7.7	8.2	8.5	8.8	9.3	9.6	10.3	10.7

Table 21. Slab thickness computed for high-strength base and 90 percent reliability (continued).

E_b = 1 million psi [6890 MPa], R = 90 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k, (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	4	5	7.5	10
192	700	500	5	—	—	—	6.0	6.5	7.0	7.8	8.4
192	700	500	7	—	6.1	6.5	6.9	7.5	7.9	8.7	9.3
192	700	500	9	—	6.4	6.9	7.3	7.9	8.4	9.3	9.9
192	700	500	11	6.9	7.5	8.0	8.3	8.9	9.4	10.2	10.8
192	700	500	13	7.6	8.2	8.6	9.0	9.6	10.0	10.8	11.4
192	800	100	5	—	6.2	6.5	6.7	7.1	7.4	7.9	8.2
192	800	100	7	6.3	6.6	6.9	7.1	7.5	7.8	8.3	8.6
192	800	100	9	6.6	7.0	7.2	7.5	7.8	8.1	8.6	8.9
192	800	100	11	6.9	7.3	7.5	7.7	8.1	8.3	8.8	9.2
192	800	100	13	7.1	7.5	7.7	8.0	8.3	8.6	9.0	9.4
192	800	250	5	—	—	6.1	6.4	6.8	7.2	7.8	8.2
192	800	250	7	—	6.3	6.6	6.9	7.4	7.7	8.4	8.8
192	800	250	9	6.6	7.0	7.3	7.6	8.0	8.3	9.0	9.4
192	800	250	11	7.0	7.5	7.8	8.0	8.5	8.8	9.4	9.8
192	800	250	13	7.3	7.7	8.0	8.3	8.7	9.1	9.7	10.1
192	800	500	5	—	—	5.3	5.6	6.2	6.6	7.3	7.9
192	800	500	7	—	—	6.2	6.6	7.1	7.5	8.3	8.8
192	800	500	9	—	6.4	6.8	7.2	7.7	8.1	8.9	9.5
192	800	500	11	6.7	7.3	7.7	8.0	8.5	8.9	9.7	10.2
192	800	500	13	7.0	7.5	8.0	8.3	8.9	9.3	10.1	10.7
240	600	100	5	6.9	7.3	7.7	7.9	8.3	8.7	9.2	9.6
240	600	100	7	7.3	7.7	8.0	8.3	8.7	9.0	9.6	10.0
240	600	100	9	7.7	8.1	8.4	8.7	9.1	9.4	10.0	10.3
240	600	100	11	8.1	8.4	8.7	9.0	9.4	9.7	10.2	10.6
240	600	100	13	8.3	8.7	9.0	9.2	9.6	9.9	10.5	10.8
240	600	250	5	6.6	7.1	7.4	7.8	8.3	8.6	9.4	9.8
240	600	250	7	7.2	7.7	8.1	8.4	8.9	9.3	10.0	10.5
240	600	250	9	7.9	8.4	8.8	9.1	9.6	10.0	10.7	11.2
240	600	250	11	8.5	8.9	9.3	9.6	10.1	10.5	11.2	11.7
240	600	250	13	8.7	9.2	9.6	9.9	10.4	10.8	11.5	12.0
240	600	500	5	—	—	6.1	6.5	7.2	7.7	8.6	9.3
240	600	500	7	6.6	7.2	7.7	8.1	8.7	9.2	10.1	10.7
240	600	500	9	7.1	7.8	8.3	8.8	9.5	10.0	11.0	11.7
240	600	500	11	8.1	8.8	9.3	9.8	10.4	11.0	11.9	12.6
240	600	500	13	8.6	9.3	9.8	10.3	11.0	11.6	12.6	13.3
240	700	100	5	6.5	6.9	7.2	7.5	7.9	8.2	8.7	9.1
240	700	100	7	7.0	7.4	7.7	7.9	8.3	8.6	9.1	9.5
240	700	100	9	7.4	7.8	8.1	8.3	8.7	9.0	9.5	9.8
240	700	100	11	7.7	8.1	8.4	8.6	9.0	9.2	9.7	10.1
240	700	100	13	8.0	8.3	8.6	8.8	9.2	9.5	10.0	10.3
240	700	250	5	6.3	6.7	7.1	7.4	7.8	8.2	8.8	9.3
240	700	250	7	7.0	7.4	7.8	8.1	8.5	8.9	9.5	10.0
240	700	250	9	7.7	8.1	8.4	8.7	9.2	9.5	10.2	10.6
240	700	250	11	8.0	8.5	8.8	9.1	9.6	9.9	10.6	11.0
240	700	250	13	8.5	9.0	9.3	9.6	10.0	10.4	11.0	11.5
240	700	500	5	—	—	6.2	6.5	7.1	7.6	8.4	9.0
240	700	500	7	—	6.5	7.0	7.4	8.0	8.5	9.4	10.0
240	700	500	9	7.3	7.9	8.4	8.7	9.3	9.7	10.5	11.1
240	700	500	11	7.9	8.5	8.9	9.3	9.9	10.4	11.2	11.8
240	700	500	13	8.7	9.3	9.7	10.1	10.7	11.1	11.9	12.5
240	800	100	5	6.2	6.6	6.9	7.1	7.5	7.7	8.3	8.6
240	800	100	7	6.7	7.1	7.4	7.6	7.9	8.2	8.7	9.0
240	800	100	9	7.1	7.5	7.7	8.0	8.3	8.6	9.0	9.4
240	800	100	11	7.5	7.8	8.0	8.3	8.6	8.8	9.3	9.7
240	800	100	13	7.7	8.0	8.3	8.5	8.8	9.1	9.5	9.9
240	800	250	5	—	6.1	6.5	6.8	7.2	7.6	8.2	8.7
240	800	250	7	6.7	7.2	7.5	7.8	8.2	8.5	9.1	9.5
240	800	250	9	7.2	7.6	7.9	8.2	8.6	9.0	9.6	10.0
240	800	250	11	7.8	8.2	8.5	8.8	9.2	9.5	10.1	10.5
240	800	250	13	8.2	8.7	9.0	9.2	9.6	10.0	10.5	10.9
240	800	500	5	—	—	6.0	6.3	6.9	7.3	8.1	8.6
240	800	500	7	6.1	6.7	7.1	7.4	8.0	8.4	9.1	9.7
240	800	500	9	7.2	7.7	8.1	8.5	9.0	9.4	10.1	10.6
240	800	500	11	7.8	8.4	8.8	9.1	9.6	10.0	10.8	11.3
240	800	500	13	8.5	9.0	9.4	9.8	10.3	10.7	11.4	11.9

Table 22. Slab thickness computed for granular base and 85 percent reliability.

E_b = 25 ksi [172.25 MPa], R = 85 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	3.5	4	4.5	5
144	600	100	5	7.9	8.3	8.7	9.0	9.2	9.4	9.6	9.8
144	600	100	7	7.8	8.2	8.6	8.9	9.1	9.4	9.5	9.7
144	600	100	9	7.7	8.1	8.5	8.8	9.1	9.3	9.5	9.6
144	600	100	11	7.6	8.1	8.4	8.7	9.0	9.2	9.4	9.6
144	600	100	13	7.5	8.0	8.4	8.7	8.9	9.1	9.3	9.5
144	600	250	5	6.9	7.4	7.8	8.1	8.4	8.7	8.9	9.1
144	600	250	7	6.9	7.5	7.9	8.2	8.5	8.8	9.0	9.2
144	600	250	9	6.9	7.5	7.9	8.3	8.6	8.9	9.1	9.3
144	600	250	11	7.0	7.6	8.0	8.4	8.7	8.9	9.2	9.4
144	600	250	13	7.0	7.6	8.1	8.4	8.7	9.0	9.2	9.4
144	600	500	5	—	—	6.1	6.6	6.9	7.3	7.6	7.8
144	600	500	7	—	—	6.3	6.8	7.2	7.6	7.9	8.1
144	600	500	9	—	—	6.5	7.0	7.5	7.8	8.1	8.4
144	600	500	11	—	6.1	6.8	7.3	7.7	8.1	8.5	8.8
144	600	500	13	—	6.4	7.0	7.6	8.0	8.4	8.8	9.1
144	700	100	5	7.1	7.5	7.8	8.1	8.3	8.5	8.7	8.9
144	700	100	7	7.0	7.4	7.8	8.0	8.3	8.5	8.7	8.8
144	700	100	9	6.9	7.3	7.7	8.0	8.2	8.4	8.6	8.8
144	700	100	11	6.8	7.3	7.6	7.9	8.1	8.4	8.5	8.7
144	700	100	13	6.8	7.2	7.6	7.9	8.1	8.3	8.5	8.6
144	700	250	5	—	6.4	6.8	7.1	7.4	7.6	7.8	8.0
144	700	250	7	6.1	6.7	7.0	7.4	7.6	7.9	8.1	8.3
144	700	250	9	6.2	6.7	7.1	7.4	7.7	8.0	8.2	8.4
144	700	250	11	6.3	6.8	7.2	7.5	7.8	8.0	8.3	8.5
144	700	250	13	6.3	6.9	7.3	7.6	7.9	8.1	8.3	8.5
144	700	500	5	—	—	—	—	6.1	6.4	6.6	6.9
144	700	500	7	—	—	—	6.0	6.4	6.7	7.0	7.2
144	700	500	9	—	—	—	6.1	6.5	6.8	7.1	7.4
144	700	500	11	—	—	—	6.4	6.8	7.1	7.4	7.7
144	700	500	13	—	—	6.2	6.7	7.1	7.4	7.7	8.0
144	800	100	5	6.4	6.8	7.2	7.4	7.6	7.8	8.0	8.1
144	800	100	7	6.4	6.8	7.1	7.4	7.6	7.8	7.9	8.1
144	800	100	9	6.4	6.8	7.1	7.3	7.6	7.7	7.9	8.1
144	800	100	11	6.3	6.7	7.1	7.3	7.5	7.7	7.9	8.0
144	800	100	13	6.3	6.7	7.0	7.3	7.5	7.7	7.8	8.0
144	800	250	5	—	—	6.2	6.5	6.7	6.9	7.1	7.3
144	800	250	7	—	—	6.2	6.5	6.8	7.0	7.2	7.4
144	800	250	9	—	—	6.3	6.6	6.9	7.1	7.3	7.5
144	800	250	11	—	6.0	6.4	6.7	7.0	7.2	7.4	7.6
144	800	250	13	—	6.1	6.5	6.8	7.1	7.3	7.5	7.7
144	800	500	5	—	—	—	—	—	—	—	6.1
144	800	500	7	—	—	—	—	—	—	6.2	6.4
144	800	500	9	—	—	—	—	—	6.2	6.4	6.7
144	800	500	11	—	—	—	—	6.2	6.5	6.8	7.0
144	800	500	13	—	—	—	6.1	6.5	6.8	7.0	7.3
192	600	100	5	8.0	8.5	8.8	9.1	9.4	9.6	9.8	10.0
192	600	100	7	8.0	8.4	8.8	9.1	9.3	9.5	9.7	9.9
192	600	100	9	7.9	8.4	8.7	9.0	9.3	9.5	9.7	9.9
192	600	100	11	7.9	8.3	8.7	9.0	9.3	9.5	9.7	9.8
192	600	100	13	7.8	8.3	8.7	9.0	9.2	9.4	9.6	9.8
192	600	250	5	7.1	7.6	8.0	8.4	8.7	8.9	9.1	9.3
192	600	250	7	7.2	7.8	8.2	8.5	8.8	9.1	9.3	9.5
192	600	250	9	7.3	7.9	8.3	8.7	9.0	9.3	9.5	9.7
192	600	250	11	7.4	8.0	8.5	8.8	9.1	9.4	9.6	9.8
192	600	250	13	7.5	8.1	8.6	8.9	9.3	9.5	9.8	10.0
192	600	500	5	—	—	6.4	6.8	7.2	7.6	7.9	8.1
192	600	500	7	—	6.1	6.7	7.2	7.7	8.0	8.3	8.6
192	600	500	9	—	6.5	7.1	7.7	8.1	8.5	8.8	9.1
192	600	500	11	6.0	6.8	7.5	8.1	8.5	8.9	9.3	9.6
192	600	500	13	6.3	7.2	7.9	8.5	9.0	9.4	9.8	10.1
192	700	100	5	7.2	7.6	8.0	8.3	8.5	8.7	8.9	9.0
192	700	100	7	7.2	7.6	8.0	8.2	8.5	8.7	8.9	9.0
192	700	100	9	7.2	7.6	7.9	8.2	8.5	8.7	8.8	9.0
192	700	100	11	7.2	7.6	7.9	8.2	8.4	8.7	8.8	9.0
192	700	100	13	7.1	7.6	7.9	8.2	8.4	8.6	8.8	9.0
192	700	250	5	6.3	6.8	7.2	7.5	7.8	8.0	8.2	8.4
192	700	250	7	6.5	7.0	7.4	7.7	8.0	8.2	8.4	8.6
192	700	250	9	6.6	7.1	7.5	7.9	8.2	8.4	8.6	8.8
192	700	250	11	6.7	7.3	7.7	8.0	8.3	8.6	8.8	9.0
192	700	250	13	6.9	7.4	7.8	8.2	8.5	8.7	8.9	9.1

Table 22. Slab thickness computed for granular base and 85 percent reliability (continued).

E_b = 25 ksi [172.25 MPa], R = 85 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	3.5	4	4.5	5
192	700	500	5	—	—	—	6.1	6.5	6.8	7.1	7.3
192	700	500	7	—	—	6.0	6.4	6.8	7.1	7.4	7.7
192	700	500	9	—	—	6.4	6.9	7.3	7.6	7.9	8.2
192	700	500	11	—	6.2	6.8	7.3	7.7	8.1	8.4	8.7
192	700	500	13	—	6.6	7.2	7.7	8.1	8.5	8.8	9.1
192	800	100	5	6.6	7.0	7.3	7.6	7.8	8.0	8.1	8.3
192	800	100	7	6.6	7.0	7.3	7.6	7.8	8.0	8.2	8.3
192	800	100	9	6.6	7.0	7.3	7.6	7.8	8.0	8.2	8.3
192	800	100	11	6.6	7.0	7.3	7.6	7.8	8.0	8.2	8.3
192	800	100	13	6.6	7.0	7.3	7.6	7.8	8.0	8.2	8.3
192	800	250	5	5.6	6.0	6.4	6.7	7.0	7.2	7.4	7.6
192	800	250	7	—	6.2	6.6	6.9	7.2	7.4	7.6	7.8
192	800	250	9	—	6.4	6.7	7.1	7.3	7.6	7.8	8.0
192	800	250	11	6.2	6.7	7.1	7.4	7.7	7.9	8.1	8.3
192	800	250	13	6.3	6.8	7.2	7.5	7.8	8.0	8.2	8.4
192	800	500	5	—	—	—	—	—	6.1	6.3	6.5
192	800	500	7	—	—	—	—	6.3	6.6	6.8	7.1
192	800	500	9	—	—	—	6.3	6.6	6.9	7.2	7.4
192	800	500	11	—	—	6.3	6.7	7.1	7.4	7.7	7.9
192	800	500	13	—	6.2	6.7	7.1	7.5	7.8	8.1	8.3
240	600	100	5	8.2	8.6	9.0	9.3	9.5	9.8	9.9	10.1
240	600	100	7	8.2	8.6	9.0	9.3	9.5	9.8	9.9	10.1
240	600	100	9	8.2	8.6	9.0	9.3	9.6	9.8	10.0	10.1
240	600	100	11	8.2	8.7	9.0	9.3	9.6	9.8	10.0	10.1
240	600	100	13	8.2	8.7	9.0	9.3	9.6	9.8	10.0	10.1
240	600	250	5	7.3	7.9	8.3	8.6	8.9	9.2	9.4	9.6
240	600	250	7	7.6	8.1	8.6	8.9	9.2	9.5	9.7	9.9
240	600	250	9	7.7	8.3	8.8	9.1	9.5	9.7	10.0	10.2
240	600	250	11	7.9	8.5	9.0	9.4	9.7	10.0	10.2	10.4
240	600	250	13	8.1	8.7	9.2	9.6	9.9	10.2	10.4	10.6
240	600	500	5	—	6.1	6.7	7.2	7.6	8.0	8.3	8.6
240	600	500	7	—	6.6	7.3	7.8	8.3	8.6	9.0	9.3
240	600	500	9	6.3	7.2	7.9	8.4	8.9	9.3	9.7	10.0
240	600	500	11	6.9	7.8	8.5	9.1	9.6	10.0	10.4	10.7
240	600	500	13	7.4	8.4	9.1	9.7	10.2	10.6	11.0	11.4
240	700	100	5	7.3	7.8	8.1	8.4	8.7	8.9	9.0	9.2
240	700	100	7	7.4	7.9	8.2	8.5	8.7	8.9	9.1	9.3
240	700	100	9	7.5	7.9	8.2	8.5	8.8	9.0	9.1	9.3
240	700	100	11	7.5	7.9	8.3	8.5	8.8	9.0	9.2	9.3
240	700	100	13	7.5	8.0	8.3	8.6	8.8	9.0	9.2	9.3
240	700	250	5	6.6	7.1	7.5	7.8	8.1	8.3	8.5	8.7
240	700	250	7	6.8	7.4	7.8	8.1	8.4	8.6	8.8	9.0
240	700	250	9	7.1	7.6	8.0	8.4	8.7	8.9	9.1	9.3
240	700	250	11	7.3	7.9	8.3	8.6	8.9	9.2	9.4	9.6
240	700	250	13	7.5	8.1	8.5	8.8	9.1	9.4	9.6	9.8
240	700	500	5	—	—	6.0	6.4	6.8	7.1	7.4	7.7
240	700	500	7	—	6.1	6.7	7.1	7.5	7.9	8.2	8.4
240	700	500	9	6.0	6.8	7.3	7.8	8.2	8.6	8.9	9.1
240	700	500	11	6.6	7.3	7.9	8.4	8.8	9.2	9.5	9.8
240	700	500	13	7.1	7.9	8.5	9.0	9.4	9.8	10.1	10.4
240	800	100	5	6.7	7.2	7.5	7.8	8.0	8.2	8.3	8.5
240	800	100	7	6.8	7.2	7.5	7.8	8.0	8.2	8.4	8.5
240	800	100	9	6.9	7.3	7.6	7.9	8.1	8.3	8.5	8.6
240	800	100	11	6.9	7.3	7.7	7.9	8.1	8.3	8.5	8.7
240	800	100	13	7.0	7.4	7.7	8.0	8.2	8.4	8.5	8.7
240	800	250	5	5.9	6.3	6.7	7.0	7.3	7.5	7.7	7.9
240	800	250	7	6.3	6.8	7.2	7.5	7.7	8.0	8.2	8.3
240	800	250	9	6.6	7.0	7.4	7.8	8.0	8.2	8.5	8.6
240	800	250	11	6.8	7.3	7.7	8.0	8.3	8.5	8.7	8.9
240	800	250	13	7.0	7.5	7.9	8.2	8.5	8.7	8.9	9.1
240	800	500	5	—	—	—	6.1	6.4	6.7	6.9	7.1
240	800	500	7	—	—	6.2	6.6	7.0	7.3	7.5	7.8
240	800	500	9	—	6.4	6.9	7.3	7.6	8.0	8.2	8.5
240	800	500	11	6.2	6.9	7.4	7.9	8.2	8.6	8.8	9.1
240	800	500	13	6.7	7.4	8.0	8.4	8.8	9.1	9.4	9.6

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 23. Slab thickness computed for treated base and 85 percent reliability.

E_b = 500 ksi [3445 MPa], R = 85 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	3.5	4	4.5	5
144	600	100	5	6.6	7.0	7.4	7.6	7.9	8.1	8.3	8.4
144	600	100	7	6.7	7.2	7.5	7.8	8.0	8.2	8.4	8.5
144	600	100	9	6.9	7.3	7.6	7.9	8.1	8.3	8.5	8.7
144	600	100	11	7.0	7.4	7.7	8.0	8.2	8.4	8.6	8.8
144	600	100	13	7.1	7.5	7.8	8.1	8.3	8.5	8.7	8.8
144	600	250	5	—	—	6.3	6.6	6.9	7.2	7.4	7.6
144	600	250	7	—	6.3	6.7	7.1	7.4	7.6	7.8	8.0
144	600	250	9	6.1	6.7	7.1	7.4	7.7	8.0	8.2	8.4
144	600	250	11	6.4	7.0	7.4	7.7	8.0	8.3	8.5	8.7
144	600	250	13	6.7	7.2	7.6	8.0	8.3	8.5	8.8	9.0
144	600	500	5	—	—	—	—	—	—	—	6.2
144	600	500	7	—	—	—	—	6.1	6.4	6.7	7.0
144	600	500	9	—	—	6.0	6.5	6.9	7.2	7.5	7.7
144	600	500	11	—	—	6.0	6.5	7.0	7.3	7.7	7.9
144	600	500	13	—	6.2	6.8	7.3	7.7	8.0	8.4	8.6
144	700	100	5	6.0	6.4	6.7	6.9	7.2	7.4	7.5	7.7
144	700	100	7	6.2	6.6	6.9	7.2	7.4	7.6	7.7	7.9
144	700	100	9	6.4	6.8	7.1	7.3	7.5	7.7	7.9	8.0
144	700	100	11	6.5	6.9	7.2	7.4	7.7	7.8	8.0	8.1
144	700	100	13	6.6	7.0	7.3	7.5	7.8	7.9	8.1	8.2
144	700	250	5	—	—	—	6.1	6.4	6.6	6.8	7.0
144	700	250	7	—	—	6.1	6.4	6.7	6.9	7.2	7.3
144	700	250	9	—	6.1	6.5	6.8	7.1	7.3	7.5	7.7
144	700	250	11	—	6.4	6.8	7.1	7.4	7.6	7.8	8.0
144	700	250	13	6.2	6.7	7.1	7.4	7.6	7.9	8.1	8.3
144	700	500	5	—	—	—	—	—	—	—	—
144	700	500	7	—	—	—	—	—	—	6.1	6.4
144	700	500	9	—	—	—	—	6.2	6.5	6.8	7.0
144	700	500	11	—	—	—	6.0	6.4	6.7	7.0	7.3
144	700	500	13	—	—	6.3	6.7	7.1	7.4	7.7	7.9
144	800	100	5	—	—	6.2	6.4	6.7	6.8	7.0	7.1
144	800	100	7	—	6.1	6.4	6.6	6.8	7.0	7.2	7.3
144	800	100	9	—	6.2	6.5	6.8	7.0	7.2	7.3	7.4
144	800	100	11	6.1	6.5	6.8	7.0	7.2	7.4	7.5	7.6
144	800	100	13	6.2	6.6	6.9	7.1	7.3	7.5	7.6	7.7
144	800	250	5	—	—	—	—	—	6.1	6.3	6.4
144	800	250	7	—	—	—	6.0	6.3	6.5	6.7	6.9
144	800	250	9	—	—	6.0	6.3	6.6	6.8	7.0	7.2
144	800	250	11	—	6.0	6.3	6.6	6.9	7.1	7.3	7.5
144	800	250	13	—	6.2	6.6	6.9	7.1	7.4	7.6	7.7
144	800	500	5	—	—	—	—	—	—	—	—
144	800	500	7	—	—	—	—	—	—	—	—
144	800	500	9	—	—	—	—	—	6.0	6.3	6.5
144	800	500	11	—	—	—	—	6.0	6.2	6.5	6.7
144	800	500	13	—	—	—	6.2	6.6	6.9	7.1	7.3
192	600	100	5	6.8	7.2	7.6	7.9	8.1	8.3	8.5	8.6
192	600	100	7	7.0	7.5	7.8	8.1	8.3	8.5	8.7	8.8
192	600	100	9	7.2	7.6	8.0	8.2	8.5	8.7	8.8	9.0
192	600	100	11	7.4	7.8	8.1	8.4	8.6	8.8	9.0	9.1
192	600	100	13	7.5	7.9	8.3	8.5	8.8	8.9	9.1	9.3
192	600	250	5	—	6.3	6.7	7.0	7.3	7.6	7.8	8.0
192	600	250	7	6.3	6.8	7.2	7.6	7.9	8.1	8.3	8.5
192	600	250	9	6.7	7.2	7.7	8.0	8.3	8.6	8.8	9.0
192	600	250	11	7.1	7.6	8.0	8.4	8.7	8.9	9.2	9.4
192	600	250	13	6.9	7.5	8.0	8.4	8.7	9.0	9.2	9.4
192	600	500	5	—	—	—	—	—	6.3	6.5	6.8
192	600	500	7	—	—	6.1	6.5	6.9	7.2	7.5	7.8
192	600	500	9	—	—	6.4	6.9	7.3	7.7	8.0	8.3
192	600	500	11	—	6.7	7.3	7.8	8.2	8.6	8.9	9.2
192	600	500	13	6.5	7.3	7.9	8.4	8.9	9.2	9.5	9.8
192	700	100	5	6.3	6.7	7.0	7.3	7.5	7.7	7.8	8.0
192	700	100	7	6.5	6.9	7.2	7.5	7.7	7.9	8.1	8.2
192	700	100	9	6.7	7.1	7.4	7.7	7.9	8.1	8.2	8.4
192	700	100	11	6.9	7.3	7.6	7.9	8.1	8.2	8.4	8.6
192	700	100	13	7.1	7.4	7.7	8.0	8.2	8.4	8.5	8.7
192	700	250	5	—	—	6.1	6.5	6.7	7.0	7.2	7.4
192	700	250	7	—	6.3	6.7	7.0	7.3	7.5	7.7	7.9
192	700	250	9	6.3	6.8	7.2	7.5	7.7	8.0	8.2	8.4
192	700	250	11	6.6	7.1	7.5	7.8	8.1	8.3	8.5	8.7
192	700	250	13	6.8	7.3	7.7	8.0	8.3	8.6	8.8	9.0

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 23. Slab thickness computed for treated base and 85 percent reliability (continued).

E_b = 500 ksi [3445 MPa], R = 85 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	3.5	4	4.5	5
192	700	500	5	—	—	—	—	—	—	6.0	6.3
192	700	500	7	—	—	—	6.1	6.5	6.8	7.0	7.3
192	700	500	9	—	—	6.2	6.6	7.0	7.3	7.6	7.8
192	700	500	11	—	6.5	7.0	7.4	7.8	8.1	8.4	8.6
192	700	500	13	6.4	7.1	7.6	8.0	8.4	8.7	9.0	9.2
192	800	100	5	—	6.2	6.5	6.7	6.9	7.1	7.3	7.4
192	800	100	7	6.1	6.5	6.8	7.0	7.2	7.4	7.6	7.7
192	800	100	9	6.4	6.7	7.0	7.2	7.4	7.6	7.8	7.9
192	800	100	11	6.5	6.9	7.2	7.4	7.6	7.8	7.9	8.1
192	800	100	13	6.7	7.1	7.3	7.6	7.8	7.9	8.1	8.2
192	800	250	5	—	—	—	6.1	6.4	6.6	6.8	6.9
192	800	250	7	—	—	6.3	6.6	6.8	7.0	7.2	7.4
192	800	250	9	—	6.4	6.7	7.0	7.3	7.5	7.7	7.8
192	800	250	11	6.3	6.7	7.1	7.4	7.6	7.8	8.0	8.2
192	800	250	13	6.5	7.0	7.4	7.6	7.9	8.1	8.3	8.5
192	800	500	5	—	—	—	—	—	—	—	—
192	800	500	7	—	—	—	—	6.1	6.3	6.6	6.8
192	800	500	9	—	—	—	6.3	6.6	6.9	7.2	7.4
192	800	500	11	—	6.2	6.7	7.0	7.4	7.6	7.9	8.1
192	800	500	13	—	6.4	6.9	7.3	7.6	7.9	8.2	8.4
240	600	100	5	7.1	7.5	7.8	8.1	8.4	8.6	8.7	8.9
240	600	100	7	7.4	7.8	8.1	8.4	8.6	8.8	9.0	9.2
240	600	100	9	7.6	8.0	8.4	8.6	8.9	9.1	9.2	9.4
240	600	100	11	7.8	8.2	8.5	8.8	9.0	9.2	9.4	9.6
240	600	100	13	8.0	8.4	8.7	9.0	9.2	9.4	9.6	9.7
240	600	250	5	6.2	6.7	7.2	7.5	7.8	8.0	8.3	8.5
240	600	250	7	6.8	7.4	7.8	8.1	8.4	8.7	8.9	9.1
240	600	250	9	7.3	7.9	8.3	8.7	8.9	9.2	9.4	9.6
240	600	250	11	7.5	8.1	8.6	8.9	9.2	9.5	9.7	9.9
240	600	250	13	8.0	8.6	9.0	9.4	9.7	9.9	10.2	10.4
240	600	500	5	—	—	—	6.2	6.6	6.9	7.2	7.5
240	600	500	7	—	—	6.4	6.9	7.3	7.7	8.0	8.3
240	600	500	9	6.3	7.0	7.6	8.1	8.5	8.9	9.2	9.5
240	600	500	11	7.2	7.9	8.5	9.0	9.4	9.8	10.1	10.4
240	600	500	13	7.5	8.3	8.9	9.5	9.9	10.3	10.7	11.0
240	700	100	5	6.6	7.0	7.3	7.5	7.8	7.9	8.1	8.3
240	700	100	7	6.9	7.3	7.6	7.8	8.1	8.2	8.4	8.6
240	700	100	9	7.1	7.5	7.8	8.1	8.3	8.5	8.6	8.8
240	700	100	11	7.4	7.7	8.0	8.3	8.5	8.7	8.8	9.0
240	700	100	13	7.5	7.9	8.2	8.5	8.7	8.9	9.0	9.2
240	700	250	5	—	6.3	6.7	7.0	7.3	7.5	7.7	7.9
240	700	250	7	6.5	6.9	7.3	7.6	7.9	8.1	8.3	8.5
240	700	250	9	6.8	7.3	7.7	8.0	8.3	8.5	8.7	8.9
240	700	250	11	7.3	7.8	8.2	8.5	8.8	9.0	9.2	9.4
240	700	250	13	7.7	8.2	8.6	8.9	9.2	9.4	9.6	9.8
240	700	500	5	—	—	—	6.0	6.3	6.6	6.9	7.1
240	700	500	7	—	—	6.4	6.8	7.2	7.5	7.7	8.0
240	700	500	9	6.3	6.9	7.5	7.9	8.2	8.5	8.8	9.0
240	700	500	11	6.7	7.4	7.9	8.4	8.8	9.1	9.4	9.6
240	700	500	13	7.5	8.2	8.7	9.2	9.6	9.9	10.2	10.4
240	800	100	5	6.2	6.6	6.8	7.1	7.3	7.5	7.6	7.7
240	800	100	7	6.5	6.9	7.2	7.4	7.6	7.8	7.9	8.1
240	800	100	9	6.8	7.1	7.4	7.7	7.9	8.0	8.2	8.3
240	800	100	11	7.0	7.4	7.6	7.9	8.1	8.2	8.4	8.5
240	800	100	13	7.2	7.5	7.8	8.0	8.2	8.4	8.6	8.7
240	800	250	5	—	—	6.3	6.6	6.8	7.0	7.2	7.4
240	800	250	7	6.1	6.6	6.9	7.2	7.5	7.7	7.9	8.0
240	800	250	9	6.6	7.0	7.4	7.7	7.9	8.1	8.3	8.5
240	800	250	11	7.1	7.5	7.9	8.2	8.4	8.6	8.8	9.0
240	800	250	13	7.4	7.9	8.3	8.5	8.8	9.0	9.2	9.3
240	800	500	5	—	—	—	—	6.0	6.3	6.5	6.7
240	800	500	7	—	—	6.2	6.6	6.9	7.2	7.4	7.7
240	800	500	9	6.2	6.7	7.2	7.6	7.9	8.1	8.4	8.6
240	800	500	11	6.7	7.3	7.8	8.2	8.5	8.8	9.0	9.2
240	800	500	13	7.4	8.0	8.5	8.8	9.2	9.4	9.7	9.9

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, °C = (°F - 32)/1.8

Table 24. Slab thickness computed for high-strength base and 85 percent reliability.

E_b = 1 million psi [6890 MPa], R = 85 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders.
Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	3.5	4	4.5	5
144	600	100	5	—	6.3	6.6	6.9	7.1	7.3	7.5	7.7
144	600	100	7	6.2	6.7	7.0	7.2	7.5	7.7	7.8	8.0
144	600	100	9	6.5	6.9	7.3	7.5	7.7	7.9	8.1	8.2
144	600	100	11	6.7	7.1	7.4	7.7	7.9	8.1	8.2	8.4
144	600	100	13	6.9	7.3	7.6	7.9	8.1	8.3	8.5	8.6
144	600	250	5	—	—	—	6.2	6.5	6.7	6.9	7.1
144	600	250	7	—	6.2	6.6	6.9	7.2	7.4	7.7	7.8
144	600	250	9	6.3	6.8	7.1	7.5	7.7	8.0	8.2	8.3
144	600	250	11	6.4	6.9	7.3	7.7	7.9	8.2	8.4	8.6
144	600	250	13	6.8	7.4	7.7	8.1	8.3	8.6	8.8	9.0
144	600	500	5	—	—	—	—	—	—	6.0	6.2
144	600	500	7	—	—	—	—	—	6.0	6.3	6.6
144	600	500	9	—	—	6.1	6.5	6.9	7.2	7.5	7.7
144	600	500	11	—	6.5	7.0	7.4	7.8	8.1	8.3	8.5
144	600	500	13	—	6.5	7.0	7.5	7.8	8.2	8.4	8.7
144	700	100	5	—	—	6.1	6.4	6.6	6.8	7.0	7.1
144	700	100	7	—	6.2	6.5	6.8	7.0	7.2	7.3	7.5
144	700	100	9	6.2	6.5	6.8	7.1	7.3	7.5	7.6	7.7
144	700	100	11	6.4	6.7	7.0	7.3	7.5	7.7	7.8	7.9
144	700	100	13	6.6	7.0	7.3	7.5	7.7	7.9	8.0	8.1
144	700	250	5	—	—	—	—	—	6.1	6.3	6.5
144	700	250	7	—	—	6.2	6.5	6.7	6.9	7.1	7.3
144	700	250	9	—	—	6.2	6.5	6.8	7.0	7.2	7.4
144	700	250	11	6.1	6.6	6.9	7.2	7.5	7.7	7.9	8.1
144	700	250	13	6.5	7.0	7.3	7.6	7.9	8.1	8.3	8.5
144	700	500	5	—	—	—	—	—	—	—	—
144	700	500	7	—	—	—	—	—	—	—	6.1
144	700	500	9	—	—	—	6.3	6.6	6.8	7.1	7.3
144	700	500	11	—	6.2	6.6	7.0	7.3	7.5	7.8	8.0
144	700	500	13	—	6.3	6.8	7.2	7.5	7.8	8.0	8.2
144	800	100	5	—	—	—	6.0	6.2	6.4	6.6	6.7
144	800	100	7	—	—	6.2	6.4	6.6	6.8	6.9	7.0
144	800	100	9	—	6.2	6.5	6.7	6.9	7.1	7.2	7.3
144	800	100	11	6.1	6.4	6.7	6.9	7.1	7.3	7.4	7.6
144	800	100	13	6.3	6.7	6.9	7.2	7.3	7.5	7.6	7.8
144	800	250	5	—	—	—	—	—	—	—	6.0
144	800	250	7	—	—	—	6.0	6.3	6.5	6.7	6.8
144	800	250	9	—	—	6.0	6.3	6.5	6.8	6.9	7.1
144	800	250	11	—	6.2	6.6	6.9	7.1	7.3	7.5	7.6
144	800	250	13	6.2	6.6	7.0	7.2	7.5	7.7	7.8	8.0
144	800	500	5	—	—	—	—	—	—	—	—
144	800	500	7	—	—	—	—	—	—	—	—
144	800	500	9	—	—	—	—	6.1	6.4	6.6	6.8
144	800	500	11	—	—	6.2	6.6	6.8	7.1	7.3	7.5
144	800	500	13	—	6.1	6.5	6.9	7.2	7.4	7.6	7.8
192	600	100	5	6.2	6.6	7.0	7.2	7.5	7.7	7.8	8.0
192	600	100	7	6.7	7.1	7.4	7.7	7.9	8.1	8.2	8.4
192	600	100	9	6.9	7.3	7.6	7.9	8.1	8.3	8.5	8.6
192	600	100	11	7.2	7.6	7.9	8.2	8.4	8.6	8.8	8.9
192	600	100	13	7.5	7.9	8.2	8.4	8.6	8.8	9.0	9.1
192	600	250	5	—	6.1	6.5	6.8	7.1	7.3	7.5	7.7
192	600	250	7	6.4	6.9	7.3	7.6	7.8	8.1	8.3	8.4
192	600	250	9	6.7	7.2	7.6	7.9	8.2	8.5	8.7	8.8
192	600	250	11	7.3	7.8	8.2	8.5	8.7	9.0	9.2	9.4
192	600	250	13	7.7	8.2	8.6	8.9	9.2	9.4	9.6	9.8
192	600	500	5	—	—	—	—	6.2	6.5	6.8	7.0
192	600	500	7	—	—	6.1	6.5	6.9	7.2	7.4	7.7
192	600	500	9	6.1	6.8	7.3	7.7	8.0	8.3	8.5	8.8
192	600	500	11	6.4	7.1	7.6	8.1	8.4	8.7	9.0	9.3
192	600	500	13	7.3	7.9	8.5	8.9	9.2	9.5	9.8	10.0
192	700	100	5	—	6.2	6.5	6.8	7.0	7.2	7.3	7.5
192	700	100	7	6.3	6.7	7.0	7.2	7.4	7.6	7.8	7.9
192	700	100	9	6.6	7.0	7.3	7.5	7.7	7.9	8.0	8.2
192	700	100	11	6.9	7.3	7.6	7.8	8.0	8.2	8.3	8.5
192	700	100	13	7.2	7.5	7.8	8.0	8.2	8.4	8.5	8.7
192	700	250	5	—	—	6.1	6.4	6.6	6.9	7.0	7.2
192	700	250	7	—	6.1	6.5	6.8	7.1	7.3	7.5	7.7
192	700	250	9	6.5	6.9	7.3	7.6	7.8	8.1	8.2	8.4
192	700	250	11	7.0	7.4	7.8	8.1	8.3	8.5	8.7	8.9
192	700	250	13	7.4	7.8	8.2	8.5	8.7	8.9	9.1	9.3

1 in = 25.4 mm, 1 psi = 6.89 kPa, 1 psi/in = 0.271 kPa/mm, "C = ("F - 32)/1.8

Table 24. Slab thickness computed for high-strength base and 85 percent reliability (continued).

E_b = 1 million psi [6890 MPa], R = 85 percent, S_o = 0.39, P2 = 2.5, 12-ft-wide [3.7-m-wide] lanes with AC shoulders. Computed thicknesses less than 6.0 in [152 mm] or greater than 15.0 in [381 mm] are not shown.

Joint Spacing (in)	Flexural Strength (psi)	Subgrade k (psi/in)	Positive TD (degrees F)	Design ESALs, millions							
				1.5	2	2.5	3	3.5	4	4.5	5
192	700	500	5	—	—	—	—	—	6.1	6.3	6.6
192	700	500	7	—	—	6.1	6.4	6.7	7.0	7.2	7.5
192	700	500	9	—	—	6.4	6.8	7.1	7.4	7.7	7.9
192	700	500	11	6.5	7.1	7.5	7.9	8.2	8.5	8.7	8.9
192	700	500	13	7.2	7.7	8.2	8.6	8.9	9.1	9.4	9.6
192	800	100	5	—	—	6.2	6.4	6.6	6.8	6.9	7.1
192	800	100	7	6.0	6.3	6.6	6.8	7.0	7.2	7.4	7.5
192	800	100	9	6.4	6.7	7.0	7.2	7.4	7.5	7.7	7.8
192	800	100	11	6.7	7.0	7.3	7.5	7.7	7.8	8.0	8.1
192	800	100	13	6.9	7.2	7.5	7.7	7.9	8.0	8.2	8.3
192	800	250	5	—	—	—	6.0	6.3	6.5	6.7	6.8
192	800	250	7	—	—	6.3	6.6	6.8	7.0	7.2	7.4
192	800	250	9	6.2	6.7	7.0	7.3	7.5	7.7	7.9	8.0
192	800	250	11	6.7	7.1	7.5	7.7	8.0	8.1	8.3	8.5
192	800	250	13	6.9	7.4	7.7	8.0	8.2	8.4	8.6	8.7
192	800	500	5	—	—	—	—	—	—	—	6.2
192	800	500	7	—	—	—	6.1	6.4	6.7	6.9	7.1
192	800	500	9	—	6.0	6.4	6.8	7.1	7.3	7.5	7.7
192	800	500	11	6.3	6.9	7.3	7.6	7.9	8.1	8.4	8.5
192	800	500	13	6.6	7.1	7.6	7.9	8.2	8.5	8.7	8.9
240	600	100	5	6.6	7.0	7.3	7.6	7.8	8.0	8.2	8.3
240	600	100	7	7.0	7.4	7.7	8.0	8.2	8.4	8.6	8.7
240	600	100	9	7.4	7.8	8.1	8.4	8.6	8.8	8.9	9.1
240	600	100	11	7.8	8.1	8.5	8.7	8.9	9.1	9.2	9.4
240	600	100	13	8.0	8.4	8.7	8.9	9.2	9.3	9.5	9.6
240	600	250	5	6.2	6.7	7.1	7.4	7.7	7.9	8.1	8.3
240	600	250	7	6.8	7.3	7.7	8.0	8.3	8.5	8.7	8.9
240	600	250	9	7.5	8.0	8.4	8.7	9.0	9.2	9.4	9.6
240	600	250	11	8.1	8.6	8.9	9.3	9.5	9.7	9.9	10.1
240	600	250	13	8.3	8.8	9.2	9.5	9.8	10.0	10.2	10.4
240	600	500	5	—	—	—	6.0	6.3	6.6	6.9	7.2
240	600	500	7	6.1	6.7	7.2	7.6	7.9	8.2	8.5	8.7
240	600	500	9	6.6	7.3	7.8	8.3	8.6	8.9	9.2	9.5
240	600	500	11	7.6	8.3	8.8	9.3	9.6	9.9	10.2	10.5
240	600	500	13	8.0	8.7	9.3	9.7	10.1	10.5	10.8	11.0
240	700	100	5	6.3	6.6	6.9	7.2	7.4	7.6	7.7	7.9
240	700	100	7	6.7	7.1	7.4	7.6	7.8	8.0	8.2	8.3
240	700	100	9	7.1	7.5	7.8	8.0	8.2	8.4	8.5	8.7
240	700	100	11	7.5	7.8	8.1	8.3	8.5	8.7	8.8	9.0
240	700	100	13	7.7	8.1	8.3	8.6	8.8	8.9	9.1	9.2
240	700	250	5	—	6.4	6.7	7.0	7.3	7.5	7.7	7.8
240	700	250	7	6.6	7.1	7.4	7.7	8.0	8.2	8.4	8.5
240	700	250	9	7.3	7.8	8.1	8.4	8.6	8.8	9.0	9.2
240	700	250	11	7.6	8.1	8.5	8.7	9.0	9.2	9.4	9.6
240	700	250	13	8.2	8.6	9.0	9.2	9.5	9.7	9.9	10.0
240	700	500	5	—	—	—	6.1	6.4	6.7	6.9	7.1
240	700	500	7	—	6.0	6.5	6.9	7.2	7.5	7.8	8.0
240	700	500	9	6.9	7.5	7.9	8.3	8.6	8.9	9.1	9.3
240	700	500	11	7.4	8.0	8.5	8.8	9.2	9.4	9.7	9.9
240	700	500	13	8.3	8.8	9.3	9.7	10.0	10.2	10.5	10.7
240	800	100	5	6.0	6.3	6.6	6.8	7.0	7.2	7.3	7.5
240	800	100	7	6.5	6.8	7.1	7.3	7.5	7.7	7.8	7.9
240	800	100	9	6.9	7.2	7.5	7.7	7.9	8.0	8.2	8.3
240	800	100	11	7.2	7.5	7.8	8.0	8.2	8.3	8.5	8.6
240	800	100	13	7.4	7.8	8.0	8.2	8.4	8.6	8.7	8.8
240	800	250	5	—	—	6.1	6.4	6.7	6.9	7.1	7.2
240	800	250	7	6.4	6.8	7.2	7.4	7.7	7.9	8.0	8.2
240	800	250	9	6.8	7.3	7.6	7.9	8.1	8.3	8.5	8.6
240	800	250	11	7.5	7.9	8.2	8.5	8.7	8.9	9.1	9.2
240	800	250	13	7.9	8.3	8.7	8.9	9.1	9.3	9.5	9.6
240	800	500	5	—	—	—	—	6.2	6.5	6.7	6.9
240	800	500	7	—	6.3	6.7	7.0	7.3	7.6	7.8	8.0
240	800	500	9	6.8	7.3	7.7	8.1	8.3	8.6	8.8	9.0
240	800	500	11	7.4	8.0	8.4	8.7	9.0	9.2	9.4	9.6
240	800	500	13	8.1	8.7	9.0	9.4	9.6	9.9	10.1	10.3

Example Determination of Required Slab Thickness. Using the rigid pavement design equations presented previously, a slab thickness that is adequate to support the design ESALs must be determined by iteration. Consider, for example, the following inputs:

Input	Value
Estimated future traffic, W_{18}	20 million
Design reliability, R	95 percent
Overall standard deviation, S_o	0.39
Design serviceability loss, $\Delta PSI = P_1 - P_2$	$4.5 - 2.5 = 2.0$
Effective subgrade k-value, k	100 psi/in [27 kPa/mm]
Mean concrete modulus of rupture, S'_c	700 psi [4827 kPa]
Mean concrete elastic modulus, E_c	$26454\ S'^{0.77}_c$ = 4,100,000 psi [28,270 MPa]
Joint spacing, L	16 ft = 192 in [4.88 m]
Base modulus, E_b	1,000,000 psi [6895 MPa] (high-strength base)
Slab/base friction coefficient, f	35
Base thickness, H_b	5 in [127 mm]
Average annual wind speed	10 mph [16 km/h]
Average annual temperature	53°F [11.7°C]
Average annual precipitation	40 in [1016 mm]
Lane edge support condition	Conventional slab width (12 ft [3.66 m]) and AC shoulders

For the above climatic inputs and a trial slab thickness of 11 in [279 mm], an effective positive temperature differential TD of 9°F [5°C] was computed from Equation 48. Using the rigid pavement design equations, a slab thickness of 10.75 in [273 mm] was found to be needed for a design traffic level of 20 million ESALs and a design reliability level of 95 percent. Similarly, Table 18 indicates a required slab thickness of 10.7 in [272 mm]. These thicknesses are close to the initial estimate of 11 in [279 mm]. If the thickness obtained differs by an inch or more from the estimated thickness used to compute the effective positive temperature differential, the determination of the required slab thickness should be repeated, beginning with a new effective temperature differential for the new trial slab thickness.

Design Check for Joint Load Position Cracking. This check is not necessary if dowels are to be used at the transverse joints. Dowels reduce the stresses at the joint to levels much lower than those at the midslab load position. Cracking near adequately doweled joints is uncommon, and when it does occur, is attributable to causes other than fatigue damage.

If dowels are not used at the transverse joints, a check must be made to ensure that stresses created at the top of the slab when the axle load is at the joint are not excessive. Under certain design and climatic conditions, truck axle loadings near an undoweled transverse joint may produce higher tensile stresses at the top of the slab than the stresses produced at the bottom of the slab by midslab loading. These repeated high tensile stresses could result in the development of corner breaks or diagonal cracks. The load and climatic conditions that could potentially contribute to the critical stress being produced by joint loading are described below.

Axle load stress. When the axle load is near the transverse joint, a tensile stress occurs at the top of the slab.

Negative temperature differential stress. Negative (nighttime) temperature differentials cause corners to curl upward, which, due to the weight of the slab, produces a tensile stress at the slab surface.

Construction curling stress. If a high positive temperature differential through the slab exists in a concrete slab when it hardens (at which time the slab is flat), upward corner and edge curling may occur shortly thereafter when the temperature gradient dissipates. A high positive temperature differential occurs particularly on sunny days and when conventional curing procedures are used. This temperature differential has not been measured extensively and its typical magnitude is not well known at the present time.

Moisture gradient stress. Moisture shrinkage warping of the top of the slab occurs over time. The stress induced by this type of warping can be determined by representing the moisture warping by an equivalent temperature gradient.

It is difficult to quantify construction curling stress and moisture gradient stress separately. However, their combined effect can be thought of as the positive temperature differential required to bring the slab into a flat position in the absence of an actual temperature differential through the slab. An approximate equivalent temperature differential may be assumed that is related to the climate of the site and to conventional curing procedures (i.e., curing compound, no wet cure):

Wet climate (Annual precipitation $\geq$ 30 in [762 mm] or Thornthwaite Moisture Index > 0): 0 to 2°F per inch [0 to 0.044°C per mm] of slab thickness.

Dry climate (Annual precipitation $<$ 30 in [762 mm] or Thornthwaite Moisture Index < 0): 1 to 3°F per inch [0.022 to 0.066°C per mm] of slab thickness.

If wet curing or night construction are used, these values may be reduced significantly.

The procedure to check for critical stress for the joint loading position for pavements without mechanical load transfer devices equivalent to dowel bars consists of the following steps:

1. Determine the required slab thickness as described previously, assuming that the midslab loading position is critical.
2. Compute the midslab stress for the required slab thickness and the site's climatic conditions.
3. Estimate a total equivalent negative temperature differential that considers the contributions of the effective (weighted average annual) negative temperature differential, construction temperature differential, and moisture differential.
4. Estimate the critical stress at the top of the slab due to joint loading and the total equivalent negative temperature differential.
5. Compare the midslab loading stress (Step 2) with the joint loading stress (Step 4). If the joint loading position yields a stress equal to or higher than the midslab loading position, consideration should be given to redesign of the joints to reduce the joint loading stress.

Step 1. Determine the Required Slab Thickness assuming that the midslab loading position is critical, using the design equations or tables provided earlier. Note that the effect of slab/base friction is included in the required slab thickness obtained by either of these methods.

Step 2. Compute the Midslab Stress for the required slab thickness and the site's effective positive temperature differential. This may already have been done in Step 1 if the required slab thickness was determined using the design equations provided earlier. The midslab stress may also be estimated by the following method:

(a) Use the charts provided in Figures 48 through 53 to determine, interpolating as necessary, the midslab stress assuming full friction between the slab and base. Charts are provided for two levels of base modulus and three levels of subgrade k.
(b) Use Equation 46 to compute a friction adjustment factor.
(c) Multiply the full friction stress by the friction adjustment factor to obtain the proper estimate of the midslab stress.

Step 3. Estimate the Total Equivalent Negative Temperature Differential from the following sources.

(a) Effective negative temperature differential from the following equation:

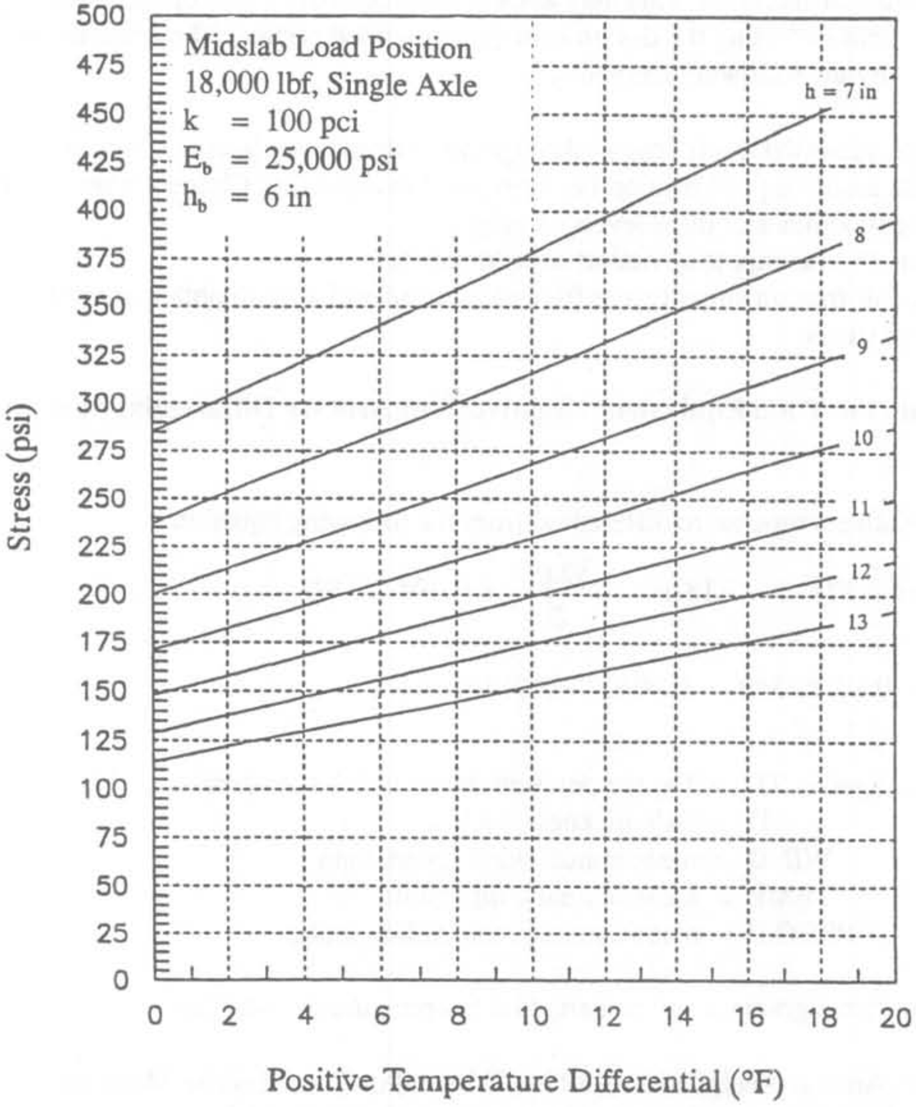
$$\begin{aligned} \mathit{effective\ negative\ TD} \;=\; & -18.14 + \frac{52.01}{D} + 0.394\,\mathit{WIND} \\ & + 0.07\,\mathit{TEMP} + 0.00407\,\mathit{PRECIP} \end{aligned} \qquad [51]$$

where effective negative TD = top temperature minus bottom temperature, °F
D = slab thickness, inches
WIND = mean annual wind speed, mph
TEMP = mean annual temperature, °F
PRECIP = mean annual precipitation, inches

(b) Combined moisture gradient and construction temperature differential:

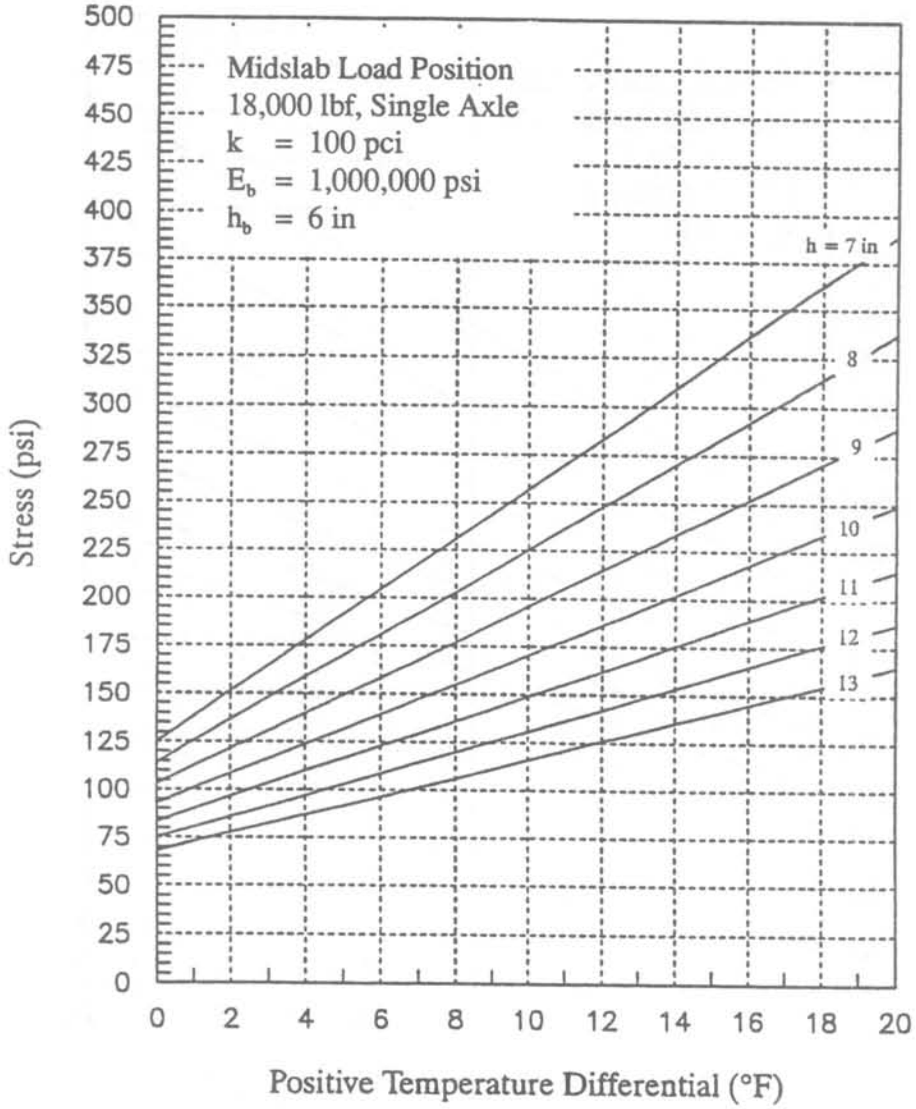
Wet climate (Annual precipitation $\geq$ 30 in [762 mm] or Thornthwaite Moisture Index > 0): 0 to 2°F per inch [0 to 0.044°C per mm] of slab thickness.

Dry climate (Annual precipitation $<$ 30 in [762 mm] or Thornthwaite Moisture Index < 0): 1 to 3°F per inch [0.022 to 0.066°C per mm] of slab thickness.



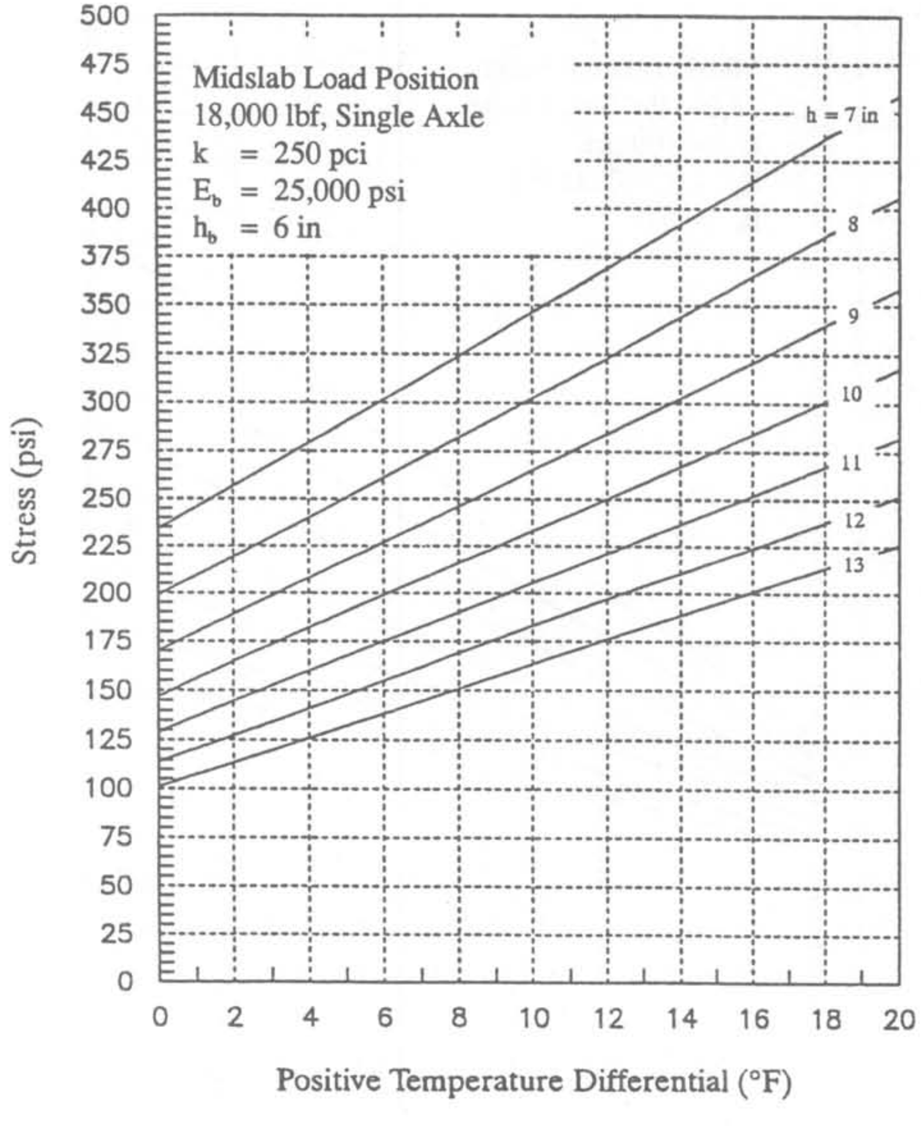
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 48. Tensile stress at bottom of slab for midslab loading position, positive temperature differential, and full friction, for aggregate base and soft subgrade.



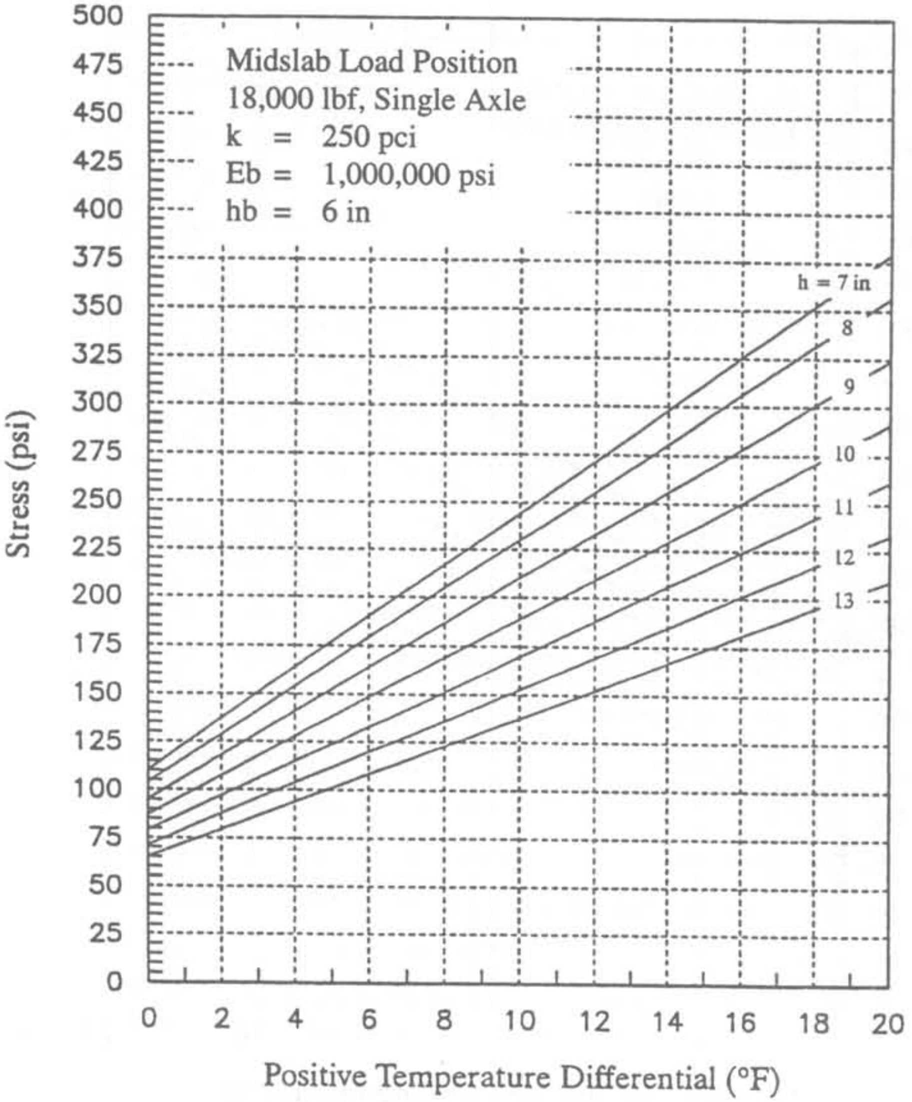
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 49. Tensile stress at bottom of slab for midslab loading position, positive temperature differential, and full friction, for high-strength base and soft subgrade.



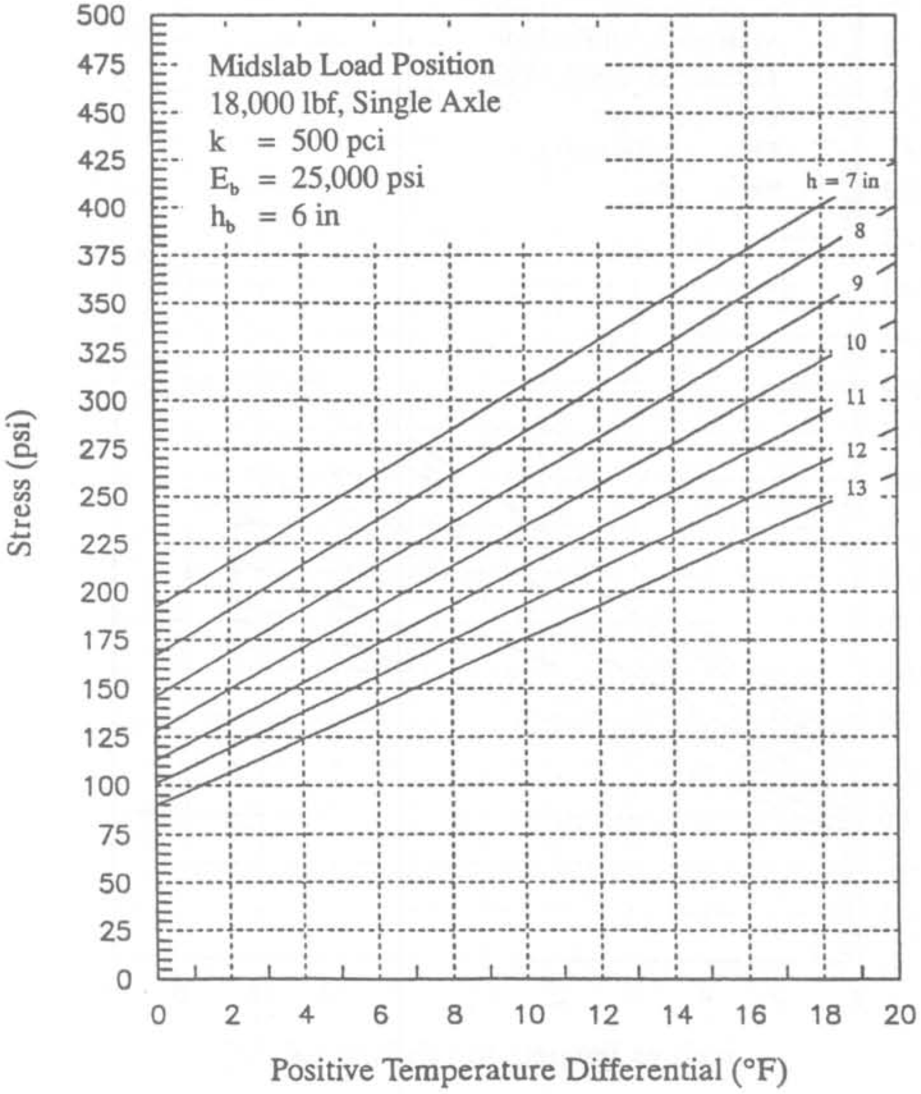
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 50. Tensile stress at bottom of slab for midslab loading position, positive temperature differential, and full friction, for aggregate base and medium subgrade.



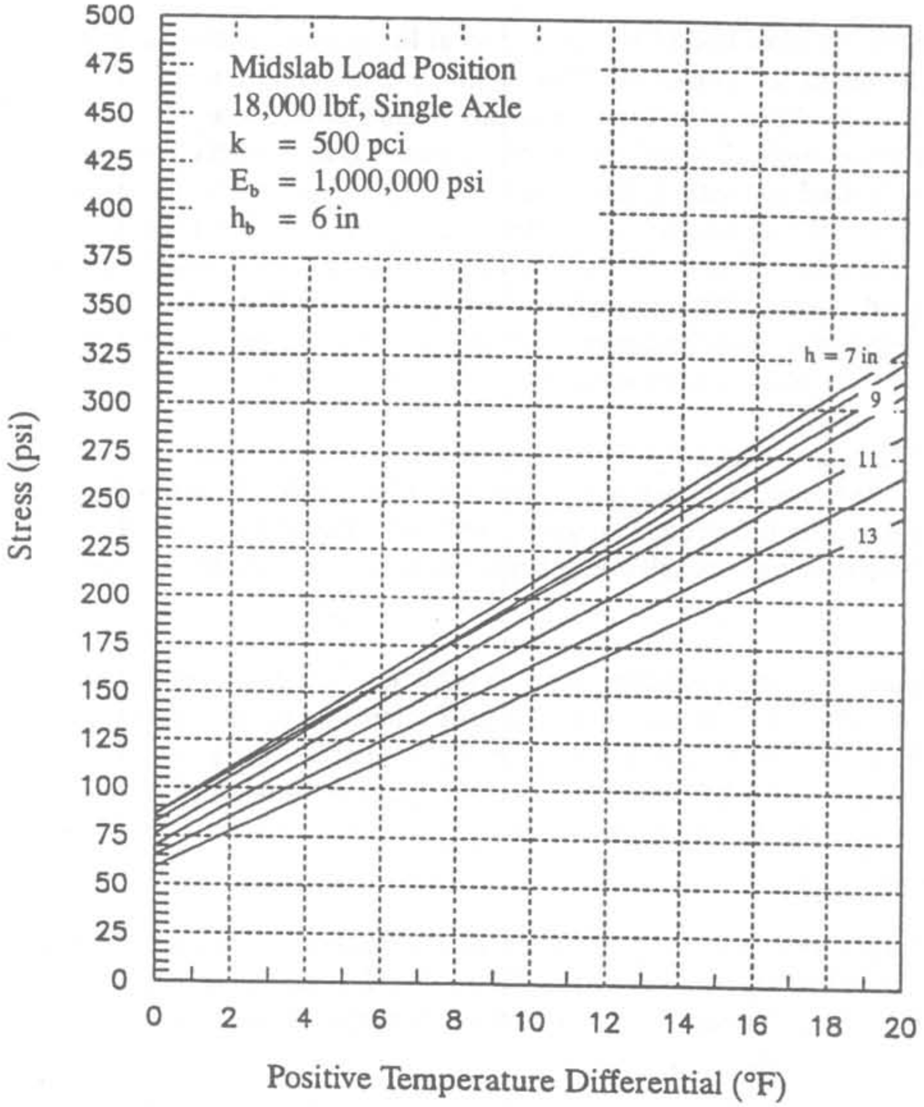
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 51. Tensile stress at bottom of slab for midslab loading position, positive temperature differential, and full friction, for high-strength base and medium subgrade.



1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 52. Tensile stress at bottom of slab for midslab loading position, positive temperature differential, and full friction, for aggregate base and stiff subgrade.



1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 53. Tensile stress at bottom of slab for midslab loading position, positive temperature differential, and full friction, for high-strength base and stiff subgrade.

Step 4. Estimate the Critical Stress at the Top of the Slab From Joint Loading and Negative Temperature Differential using Figures 54 through 60. Charts are provided in Figures 54 through 59 for two levels of base modulus and three levels of subgrade. The full friction stress from Figures 54 through 59 is multiplied by the friction adjustment factor from Figure 60 to obtain the proper joint load stress.

Step 5: Compare the Midslab Load Position Stress at the Bottom of the Slab and the Joint Loading Position Stress at the Top of the Slab. If the joint load position produces a stress equal to or greater than the stress produced by midslab loading, strong consideration should be given to a redesign of the joints. Design features that protect against critical joint load stresses are the use of properly sized and spaced dowels, and, to a lesser degree, a widened slab (i.e., slab paved wider than 12 ft [3.66 m], but with the traffic lane striped 12 ft [3.66 m] wide) or tied concrete shoulder. The other effect that good load transfer has on performance is that corner deflections are reduced. High differential deflections can lead to erosion and loss of support, resulting in even greater stresses under corner loading. Reducing the joint spacing and/or changing the base type can also reduce stresses caused by joint loading.

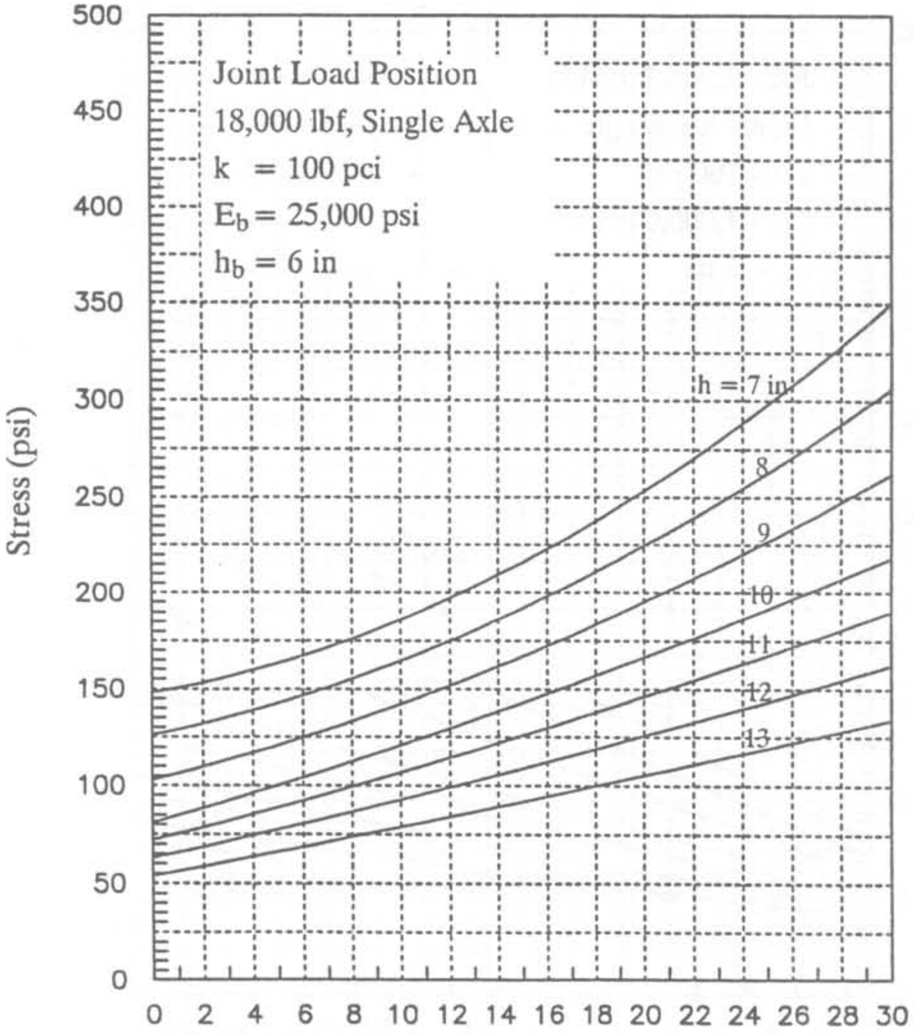
Example Design Check for Joint Load Position Cracking. The adequacy of the joint design is checked in this example for the same design parameters as used previously in the example slab thickness determination. From the equations given previously, the tensile stress at the bottom of the slab due to midslab load and a positive temperature differential is calculated to be 188 psi [1296 kPa].

The negative effective temperature gradient is -5.3°F [-2.9°C]. The combined negative construction and moisture shrinkage is assumed for this example to be the maximum for a wet climate, -2°F/in [-0.044°C/mm] of slab thickness, or -22°F [-12°C]. Thus, the total negative temperature differential is about -27°F [-15°C]. Using Figures 54 through 59, the full friction tensile stress at the top of the slab due to joint load and negative curling is about 130 psi [896 kPa].

The full friction stress, when multiplied by the joint friction factor of 1.08 obtained from Figure 60, yields a joint loading stress of 140 psi [965 kPa]. The joint load position results in a lower stress than the midslab load position, so it is not necessary to modify the joint design to reduce the chance of corner breaks.

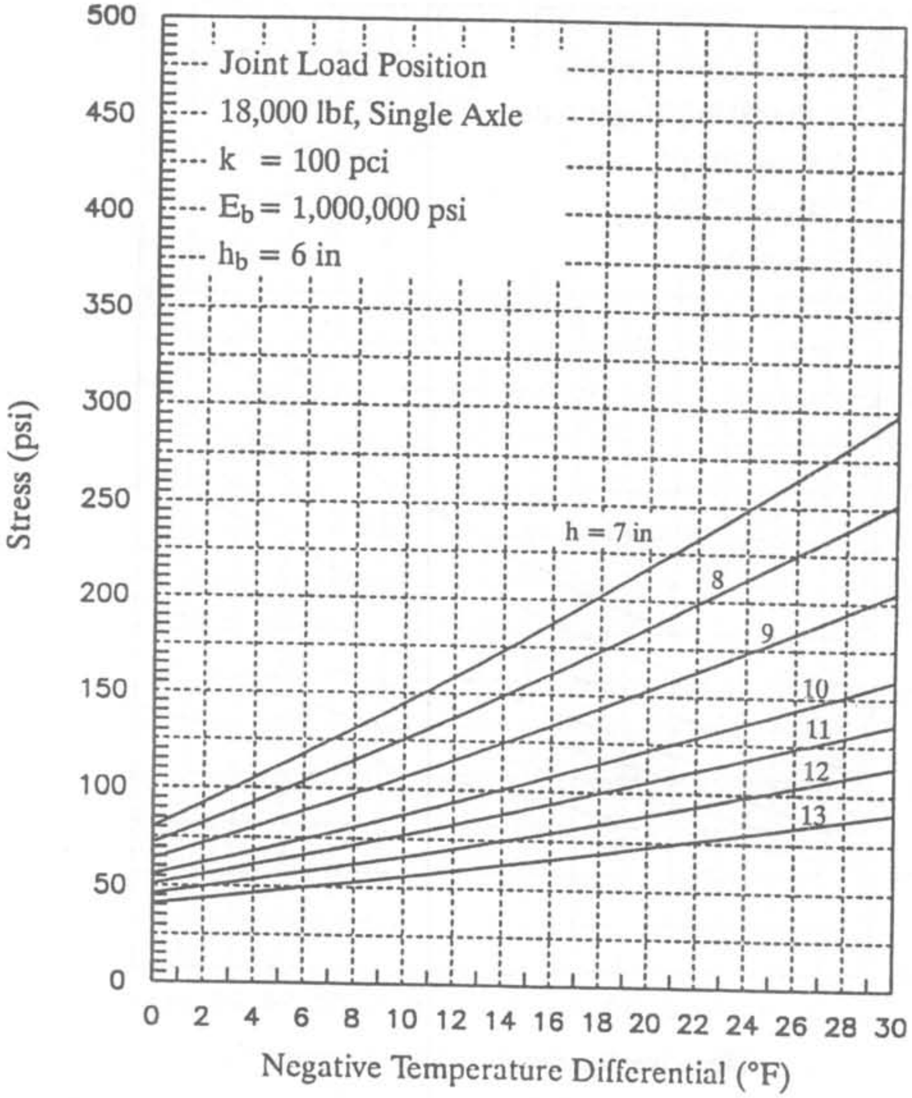
3.2.3 Stage Construction (no change)

3.2.4 Roadbed Swelling and Frost Heave (no change)



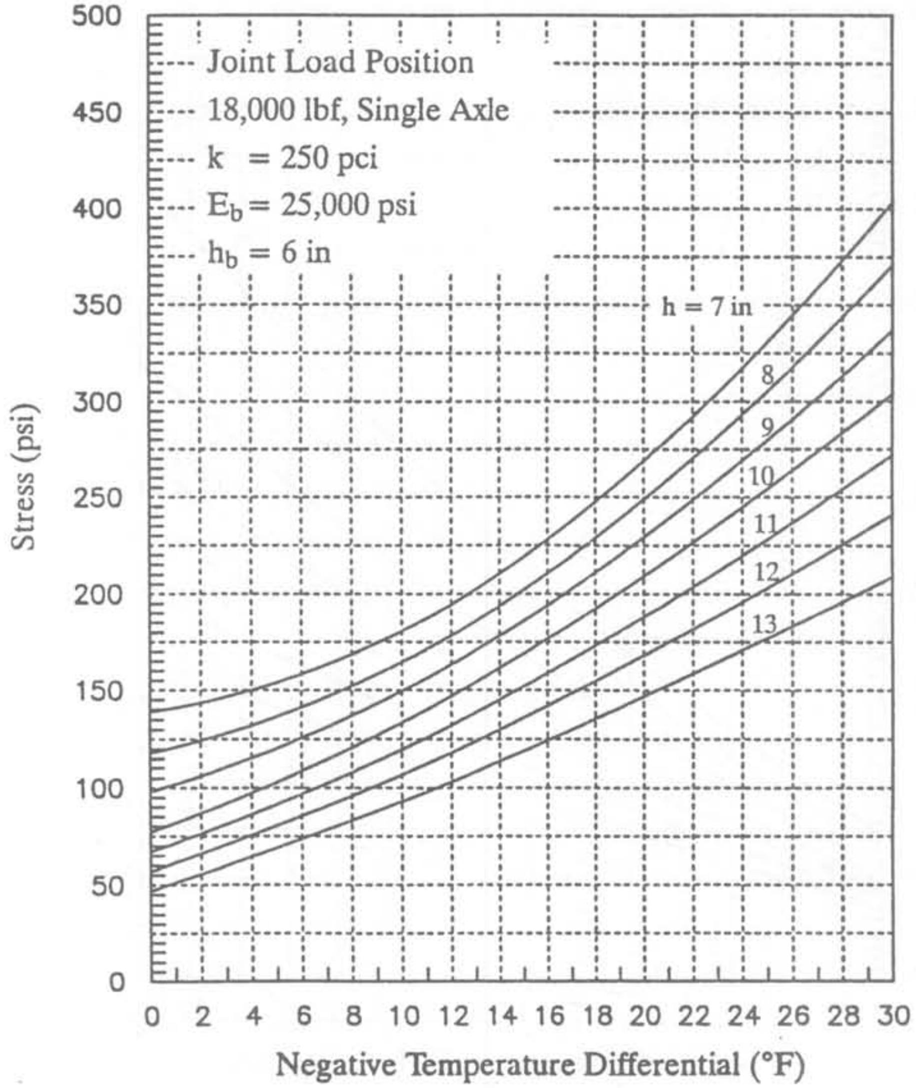
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 54. Tensile stress at top of slab for joint loading position, negative temperature differential, and full friction, for aggregate base and soft subgrade.



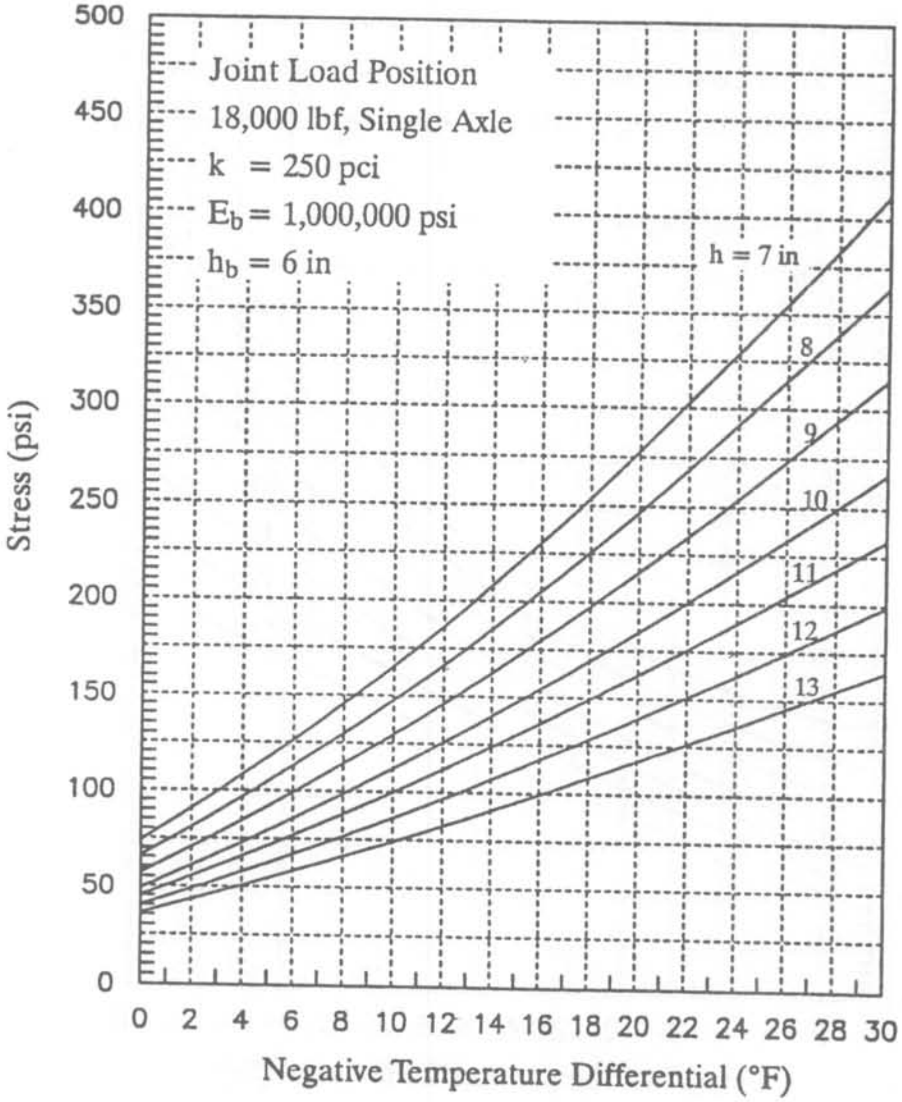
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 55. Tensile stress at top of slab for joint loading position, negative temperature differential, and full friction, for high-strength base and soft subgrade.



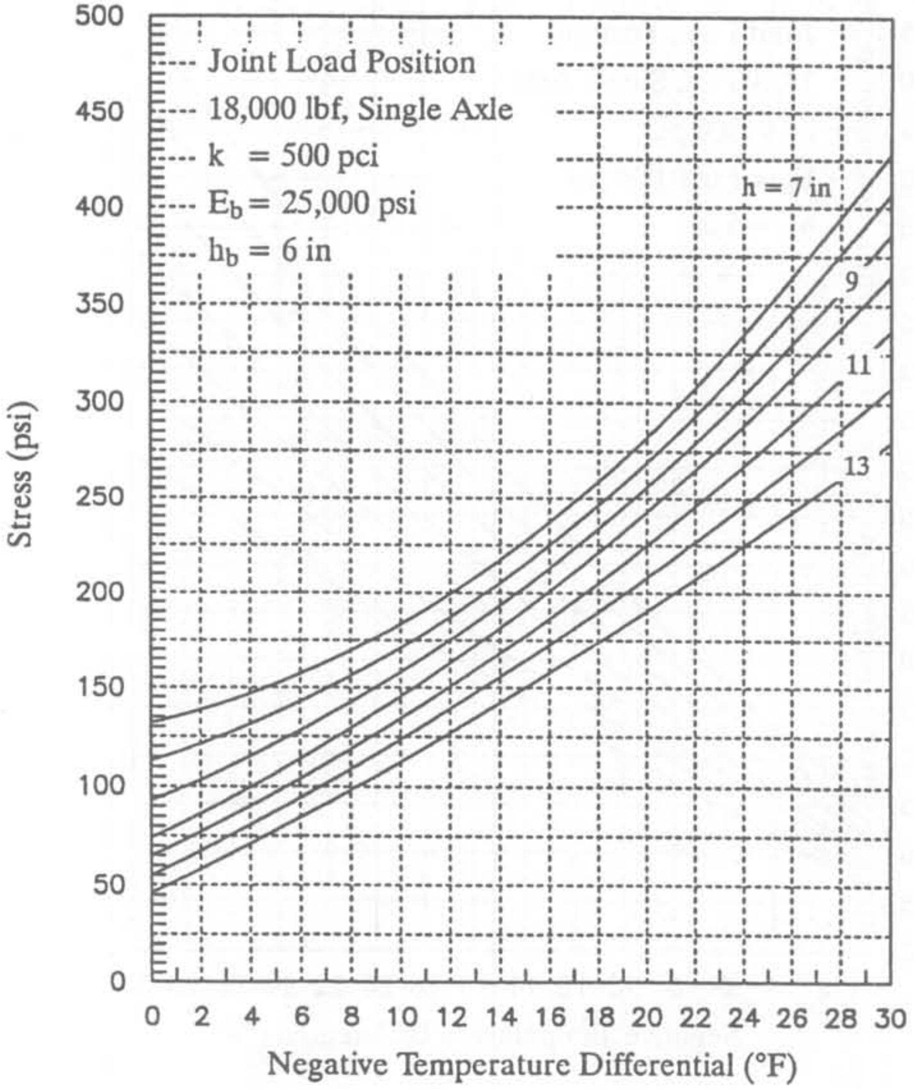
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 56. Tensile stress at top of slab for joint loading position, negative temperature differential, and full friction, for aggregate base and medium subgrade.



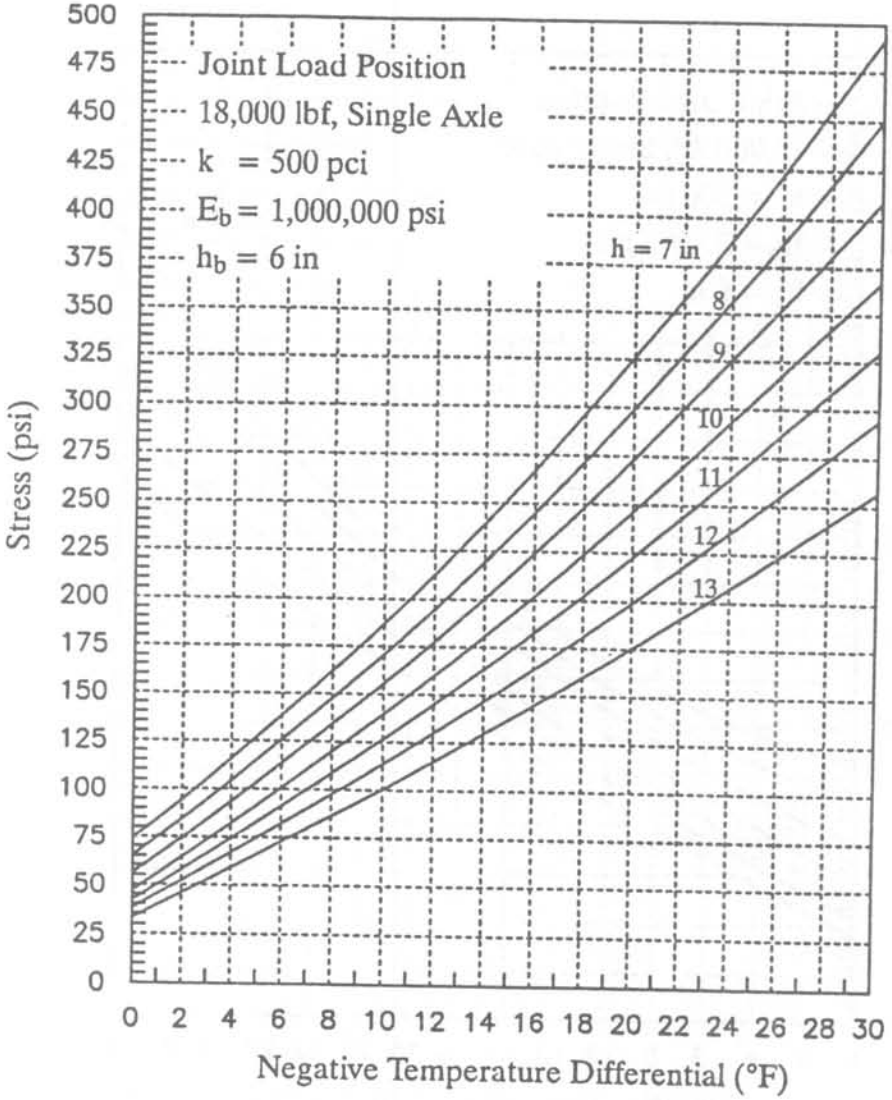
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 57. Tensile stress at top of slab for joint loading position, negative temperature differential, and full friction, for high-strength base and medium subgrade.



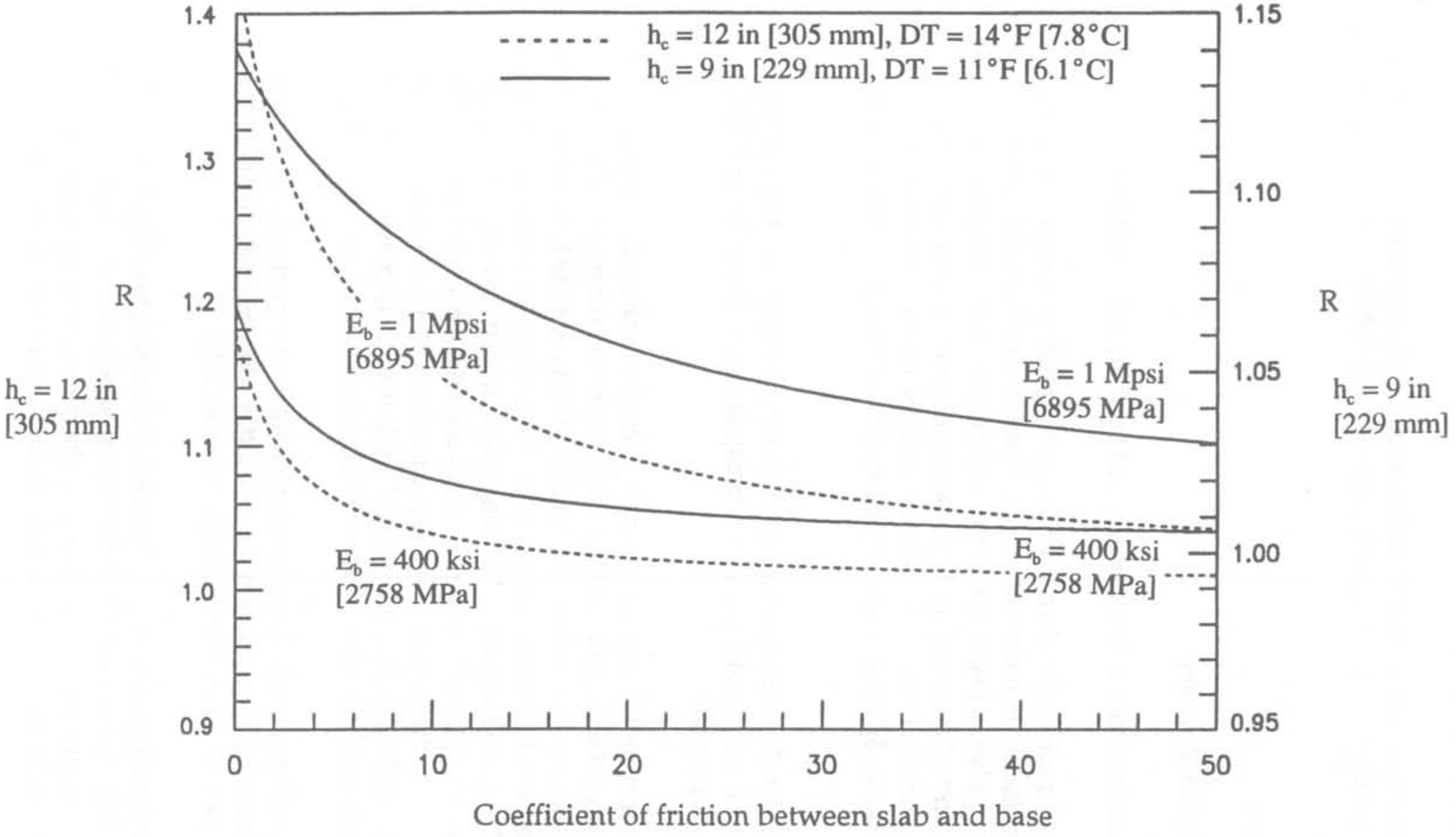
1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 58. Tensile stress at top of slab for joint loading position, negative temperature differential, and full friction, for aggregate base and stiff subgrade.



1 lbf = 4.45 N, 1 pci = 0.271 kPa/mm, 1 psi = 6.89 kPa, 1 in = 25.4 mm, °C = (°F - 32)/1.8

Figure 59. Tensile stress at top of slab for joint loading position, negative temperature differential, and full friction, for high-strength base and stiff subgrade.



Note: $R = \sigma_f / \sigma_{full\ friction}$
h_b = 5 in [127 mm], k = 200 psi/in [54 kPa/mm]
Joint loading with nighttime curling DT

Figure 60. Friction adjustment factor for stress at top of slab for joint loading.