

**REINFORCING FIBERGLASS GRIDS
FOR
ASPHALT OVERLAY**

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Development of Analysis Method

1. Beam on Elastic Foundation Formulation

Consider a beam of unlimited length in both directions with a concentrated loading (Figure 1-1).

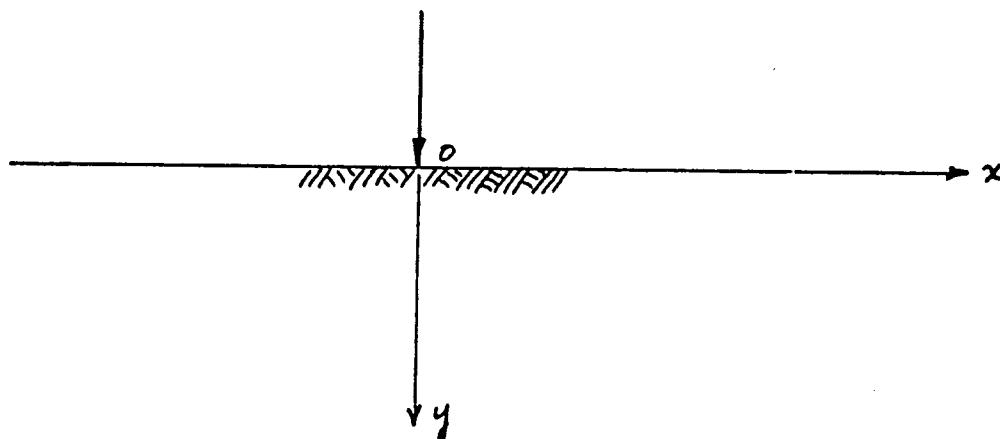


Figure 1-1.

General solution for the deflection curve of a beam subjected to transverse loading is

$$y = e^{\beta x} (C_1 \cos \beta x + C_2 \sin \beta x) + e^{-\beta x} (C_3 \cos \beta x + C_4 \sin \beta x) \quad (1-1)$$

where

$$\beta = \left(\frac{k}{4EI} \right)^{\frac{1}{4}}$$

k = modulus of foundation, support stiffness

E = modulus of elasticity of beam

I = moment of inertia of beam

From boundary conditions

if x approaches infinity, y approaches zero

From this condition and Equation (1-1),

$$C_1 = C_2 = 0$$

Therefore, the deflection curve is reduced to

$$y = e^{-\beta x} (C_3 \cos \beta x + C_4 \sin \beta x) \quad (1-2)$$

From the symmetry condition about the y-axis

$$\left[\frac{dy}{dx} \right]_{x=0} = 0$$

That is, $-(C_3 - C_4) = 0$. From this,

$$C_3 = C_4 = \text{Constant}$$

Finally, the deflection curve is,

$$y = Ce^{-\beta x} (\cos \beta x + \sin \beta x) \quad (1-3)$$

From the equilibrium condition,

$$P = 2 \int_0^{\infty} k y \, dx$$

Substituting Equation (1-3) into above equilibrium condition,

$$C = \frac{P\beta}{2k}$$

So, the final deflection curve with a concentrated loading is,

$$y = \frac{P\beta}{2k} e^{-\beta x} (\cos \beta x + \sin \beta x) \quad (1-4)$$

In our case, because of tire pressure, there is a uniform loading distributed over an A-B portion of the infinitely long beam as in Figure 1-2.

The distributed loading can be regarded as the sum of infinitely small concentrated forces, $q \, dx$.

Therefore,

$$dy = \frac{q \beta \, dx}{2k} e^{-\beta x} (\cos \beta x + \sin \beta x) \quad (1-5)$$

There are three types of distributed loading

CASE 1 (FIGURE 1-2A) - When Point C is under the loading
Deflection at point C

Fig. 1-2a

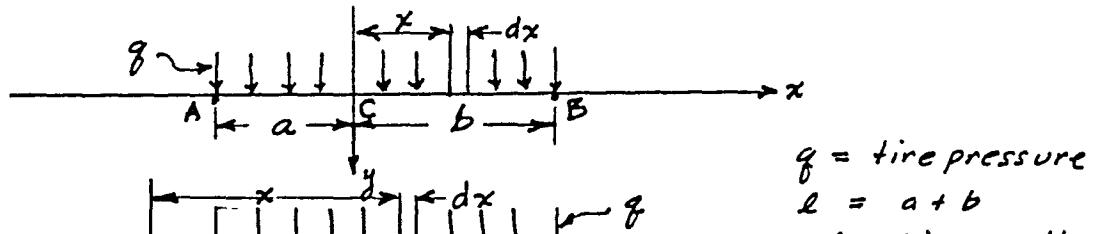


Fig. 1-2b

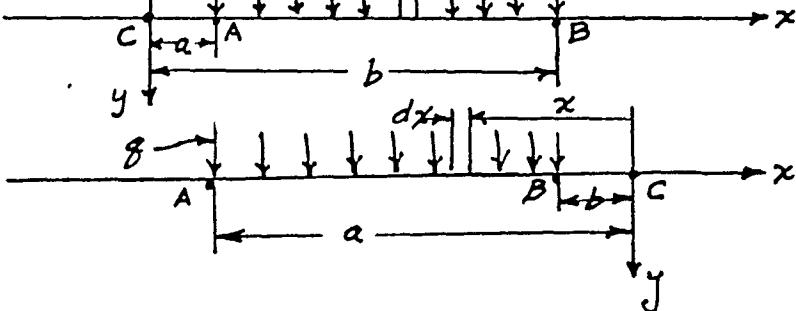


Fig. 1-2c

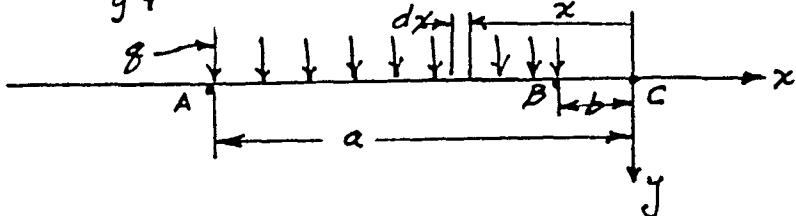


Figure 1-2.

$$y_c = \frac{q}{2k} (2 - D_{\beta a} - D_{\beta b}) \quad (1-6)$$

where

$$D_{\beta x} = e^{-\beta x} \cos \beta x$$

Moment at point C

$$M_c = -EI \left| \frac{d^2y}{dx^2} \right|_{x=c} = \frac{q}{4\beta^2} (B_{\beta a} + B_{\beta b}) \quad (1-7)$$

where

$$B_{\beta x} = e^{-\beta x} x \sin \beta x$$

If $a = b = \frac{\ell}{2}$, for symmetric loading,

$$y_c = \frac{q}{K} \left(1 - D_{\beta \frac{\ell}{2}}\right) \quad (1-8)$$

$$M_c = \frac{q}{2\beta^2} B_{\beta \frac{\ell}{2}} \quad (1-9)$$

CASE 2 (FIGURE 1-2B) - When Point C is to the left of the loading

Deflection at point C

$$y_c = \frac{q}{2k} (D_{\beta a} - D_{\beta b}) \quad (1-10)$$

Moment at point C

$$M_c = -\frac{q}{4\beta^2} (B_{\beta a} - B_{\beta b}) \quad (1-11)$$

If $a = 0, b = \ell$ for unsymmetric loading, the shearing case:

$$y_c = \frac{q}{2k} (1 - D_{\beta \ell}) \quad (1-12)$$

$$M_c = \frac{q}{4\beta^2} B_{\beta \ell} \quad (1-13)$$

CASE 3 (FIGURE 1-2C) - When Point C is to the right of the loading

Deflection at point C

$$y_c = -\frac{q}{2k} (D_{\beta a} - D_{\beta b}) \quad (1-14)$$

Moment at point C

$$M_c = \frac{q}{4\beta^2} (B_{\beta a} - B_{\beta b}) \quad (1-15)$$

If $b = 0$, $a = \ell$ for unsymmetric loading, the shearing case:

$$y_c = \frac{q}{2k} (1 - D_{\beta} \ell) \quad (1-16)$$

$$M_c = \frac{q}{4\beta^2} B_{\beta} \ell \quad (1-17)$$

Equation (1-16) and Equation (1-12) are the same, and Equation (1-17) and Equation (1-13) are also the same.

In summary, the moment at point C is expressed as follows:

$$M = \frac{q}{\beta^2} K (K_I, K_{II}, \text{ or } K_{III}) \quad (1-18)$$

where

$$\begin{aligned} K_I &= \frac{1}{2} e^{-\frac{\beta \ell}{2}} \sin \frac{\beta \ell}{2} && (\text{symmetric loading}) \\ K_{II} &= K_{III} = \frac{1}{4} e^{-\beta \ell} \sin \beta \ell && (\text{unsymmetric loading}) \end{aligned} \quad (1-19)$$

2. Stress Distribution in Overlay

Stress distribution in a beam with a vertical crack is assumed as in Figure 2-1.

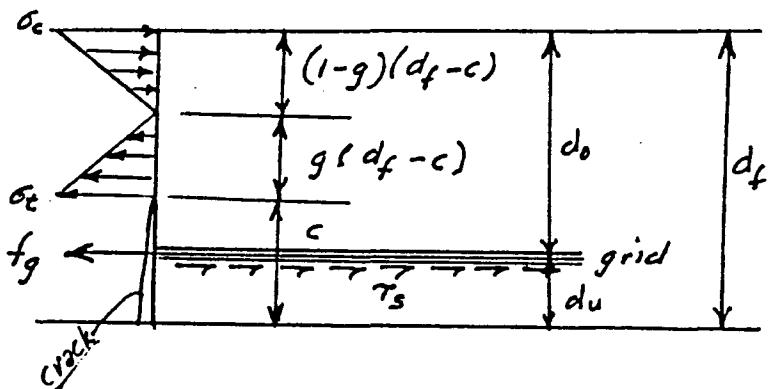


Figure 2-1.

d_f = depth of overlay ($= d_o + d_u$)
 d_o = depth of overlay above the grid
 d_u = depth of overlay below the grid
 c = crack length
 σ_t = tensile stress in overlay
 σ_c = compressive stress in overlay
 τ_s = friction below grid
 f_g = total force in grid

Total force in grid (f_g)

Total grid force is calculated as follows using E_g and M_g

$$M_g = \frac{n \pi t_g}{4s} E_g \quad (2-1)$$

where

n = number of strands in each grid spacing
 t_g = thickness of the grid
 s = spacing of strands
 E_g = modulus of elasticity of the grid material

M_g , the equivalent modulus of elasticity of the grid is calculated as in Equation (2-1).

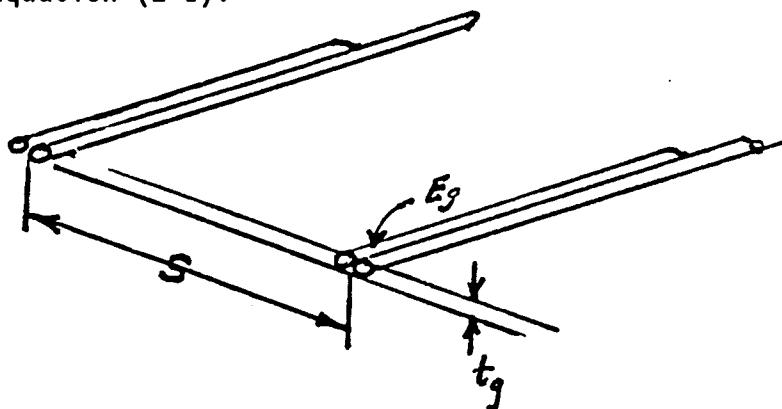


Figure 2-2.

For example, material 8502 (F2) has following dimensions

$$n = 4, \quad s = 1.0 \text{ inch}, \quad t_g = 0.033 \text{ inch}, \quad E_g = 10^7 \text{ psi}$$

Therefore,

$$M_g = \frac{n \pi t_g}{4s} E_g = \frac{4 \cdot \pi \cdot 0.033}{4 \cdot 1} \cdot 10^7 \text{ psi} = 10^6 \text{ psi}$$

Friction in Grid (τ_o)

There are three kinds of failure modes in an overlay test (Figure 2-3).

Mode I and mode III failures are called the bonding modes, and mode II failure is called the debonding mode. In the bonding modes and debonding mode, the shear stress distribution is different.

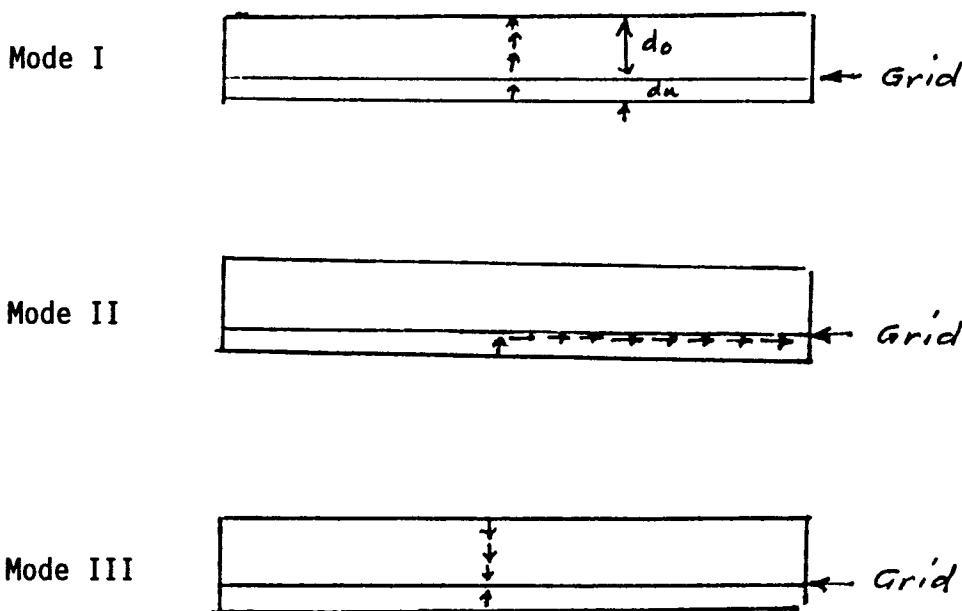


Figure 2-3.

In each case, the shear stress distribution is assumed as follows (Figure 2-4).

Bonded case

$$\tau_s = \frac{k_o}{\beta_f \sin h(\frac{\beta_f w}{2})} \left[\cos h(\frac{\beta_f w}{2}) - 1 \right]$$

where,

$$\beta_f = \left[\frac{k_o}{E_u d_u} \right]^{\frac{1}{2}} \quad \text{and}$$

E_u = modulus of the material below the grid

k_o = initial slope of the shear stress versus shear displacement curve

d_u = depth of the material below the grid

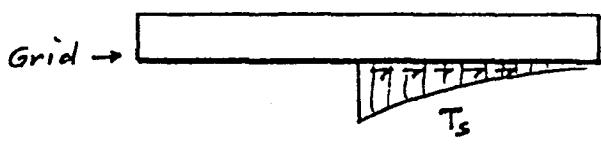
Debonded case

$$\tau_s = \tau_{min} \cdot \frac{w}{2}$$

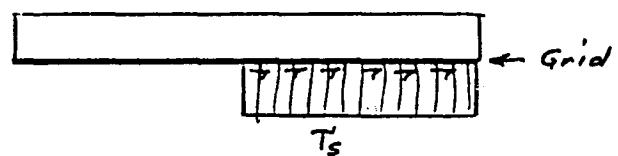
where,

w = length of the overlay test sample

The variables E_u , k_o , and τ_{min} are determined from overlay tester data.



Bonding



Debonding

Figure 2-4. Shear Stress Distributions.

All of these variables are functions of air temperature (T), in °F.

FOR MATERIAL TYPE 8501 (F1)

$$\tau_{min} = 6.220 - 0.02191 (T - 34) \quad (\text{psi})$$

$$E_u = 15542 - 567.4 (T - 34) \quad (\text{psi})$$

$$k_o = 43312 - 100.4 (T - 34) \quad (\text{lb/in}^3)$$

FOR MATERIAL TYPE 8502 (F2)

$$\tau_{min} = 9.325 - 0.08056 (T - 34) \quad (\text{psi})$$

$$E_u = 35810 - 401.4 (T - 34) \quad (\text{psi})$$

$$k_o = 52581 - 530.4 (T - 34) \quad (\text{lb/in}^3)$$

Table 2-1 shows test sample descriptions for the overlay test. Table 2-2 is the summary of the overlay test results. Figure 2-1 to Figure 2-3 show the previous results graphically.

3. Equilibrium Conditions

From the force equilibrium condition for a unit width overlay (Figure 2-1).

$$M_g t_g \varepsilon_g + \frac{\sigma_t}{2} g (d_f - c) - \frac{\sigma c}{2} (1-g) (d_f - c) - \tau_s t_g u = 0 \quad (3-1)$$

$$\sigma_c = \sigma_t \frac{(1-g)}{g} \quad (3-2)$$

where,

u - Crack spacing $\times \alpha \times \bar{\Delta T}$

α - Coefficient of thermal expansion of the overlay

$\bar{\Delta T}$ - Average temperature variation in the pavement

Table 2-1. Test Samples for Overlay Test.

Sample No.	Sample Description	T (°F)	Sample Size (D x W x L)	Crack Opening	Number of Opening to Failure
80C	No Fabric	34	3.1 x 6.0 x 20.0	0.02	8 (3.1 in)
724C	No Fabric	34	3.1 x 6.0 x 20.0	0.02	1 (3.1 in)
F13**	Fabric	122	3.2 x 6.0 x 20.0	0.03	300 (1.15 in)
F14**	Fabric	122	3.2 x 6.0 x 20.0	0.03	1000 (2.1 in)
F12	Fabric	34	3.1 x 6.0 x 20.0	0.02	10 (1.0 in)*
F11	Fabric	34	3.1 x 6.0 x 20.0	0.02	9 (1.0 in)*
F15	Fabric	0	3.2 x 6.0 x 20.0	0.01	9 (1.0 in)*
F16	Fabric	0	3.2 x 6.0 x 20.0	0.01	5 (1.0 in)*
F23A	Fabric	122	3.2 x 6.0 x 20.0	0.03	134 (1.05 in)*
F24	Fabric	122	3.1 x 6.0 x 20.0	0.03	200 (1.15 in)*
F22	Fabric	34	3.1 x 6.0 x 20.0	0.02	4 (1.0 in)*
F23	Fabric	34	3.2 x 6.0 x 20.0	0.02	3 (1.0 in)*
F26	Fabric	0	3.2 x 6.0 x 20.0	0.01	10 (1.0 in)*
F25	Fabric	0	3.2 x 6.0 x 20.0	0.01	10 (1.0 in)*

* means the final crack length up to this load cycles is almost same as that of the first load cycle. That is crack propagates horizontally at this depth of the beam.

**Samples F13 and F14 which were run at 122°F - had the test stopped after the number of cycles noted. At that time, the cracks had propagated to a length of 1.15 and 2.1 inches.

Table 2-2. Overlay Test Results.

Sample No.	Parameters		T_{min}	E_u	k_o	Failure Mode
	A	n				
80C	0.1783E+01	- 0.286	-	-	-	I
724C	-	-	-	-	-	I
F13	0.100E-03	0.933	-	-	-	I
F14	0.409E-14	9.210	-	-	-	I
F12	-	-	6.02	15401.67	75197.91	II
F11	-	-	6.42	16041.67	11426.66	II
F15	-	-	3.95	19750.00	69466.44	II
F16	-	-	9.98	49916.67	23983.68	II
F23A	-	-	3.12	5194.44	783.00	II
F24	-	-	0.78	1305.56	1878.45	II
F22	-	-	5.92	14791.67	99972.95	II
F23	-	-	14.78	36958.34	37998.36	II
F26	-	-	5.45	27250.88	99620.88	II
F25	-	-	17.20	86000.00	17943.63	II

TAUMIN vs. TEMP.

(MATERIAL TYPE F1 & F2)

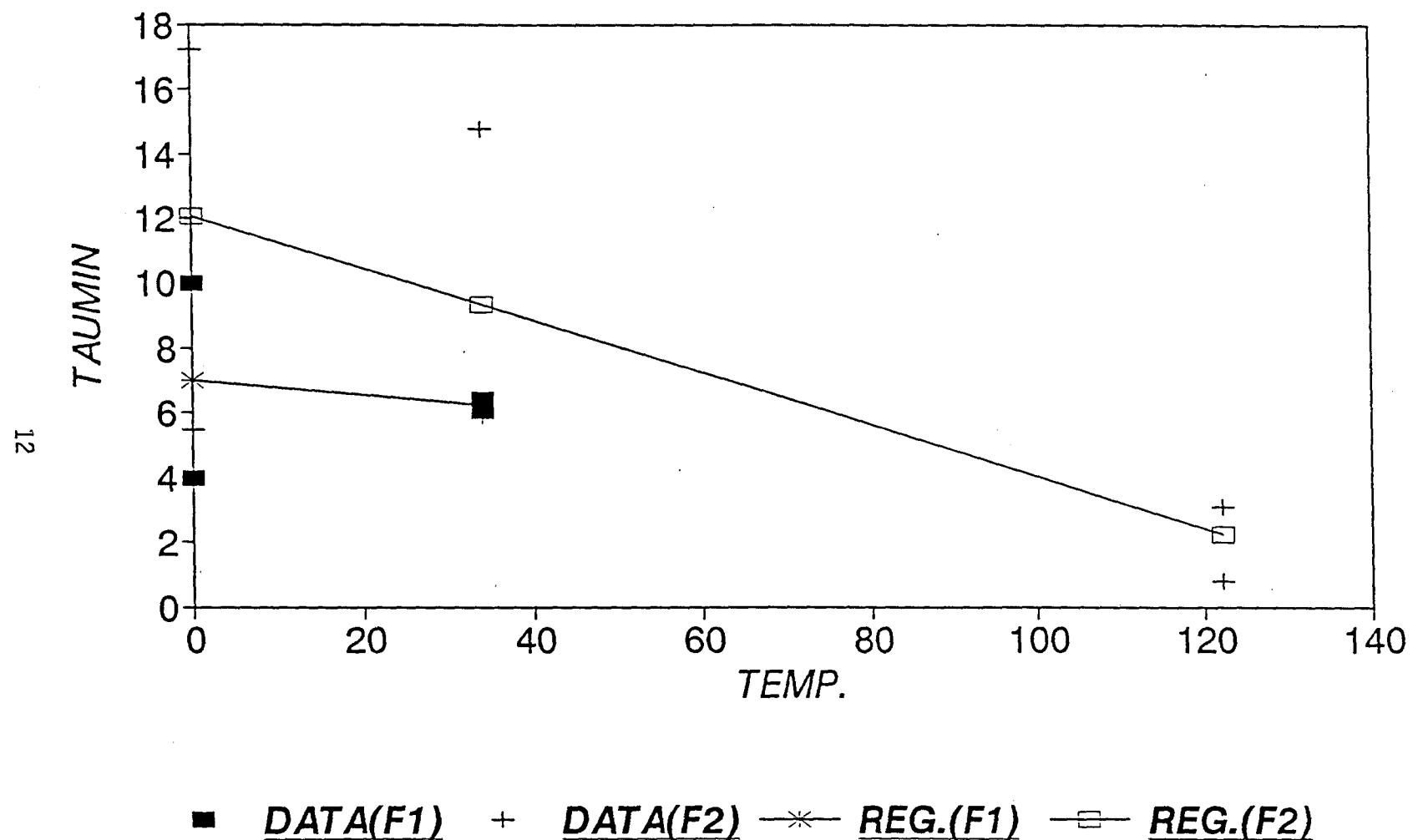


Figure 2-1. τ_{\min} vs. Temp.

Eu vs. TEMP. (MATERIAL TYPE F1 & F2)

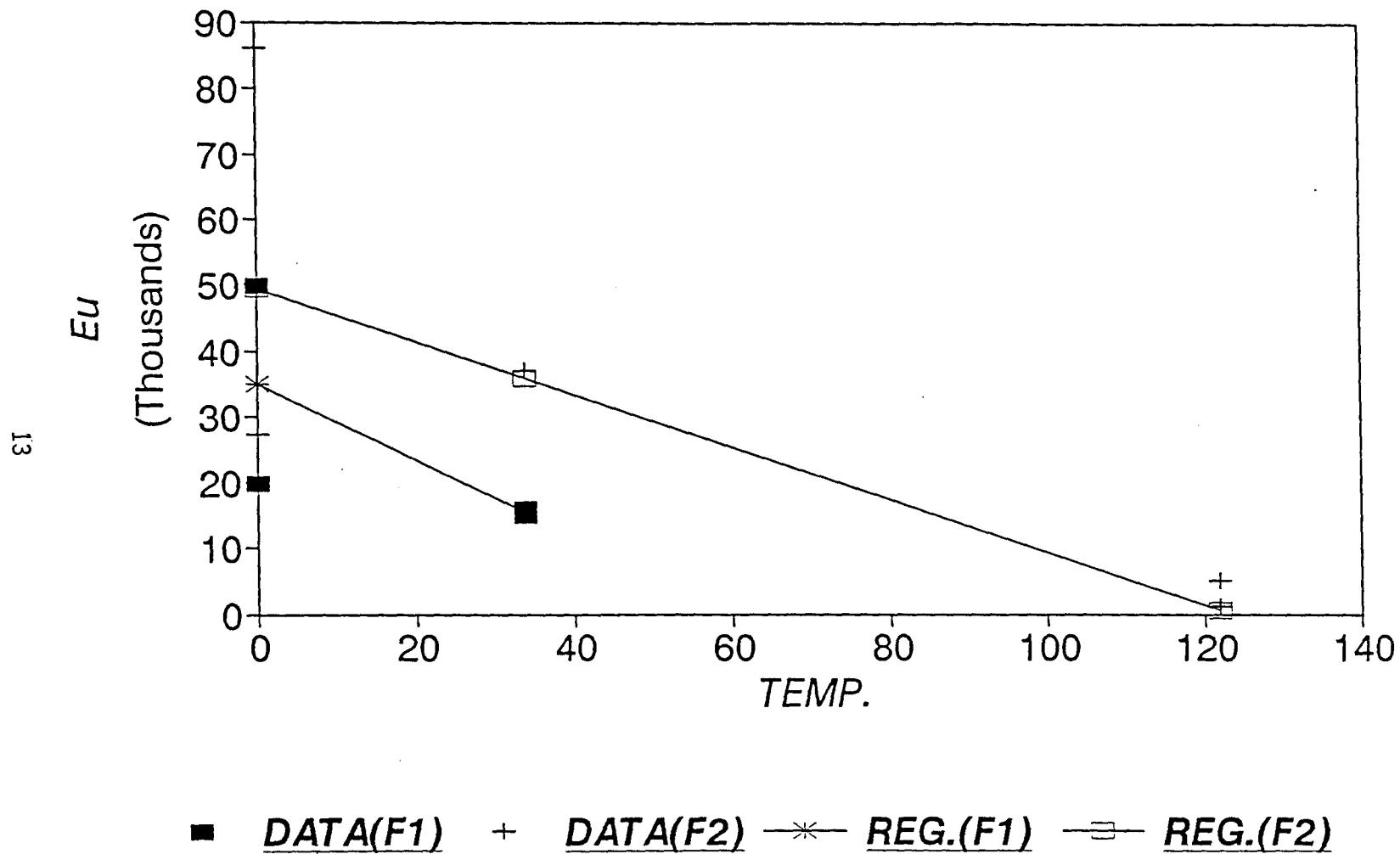
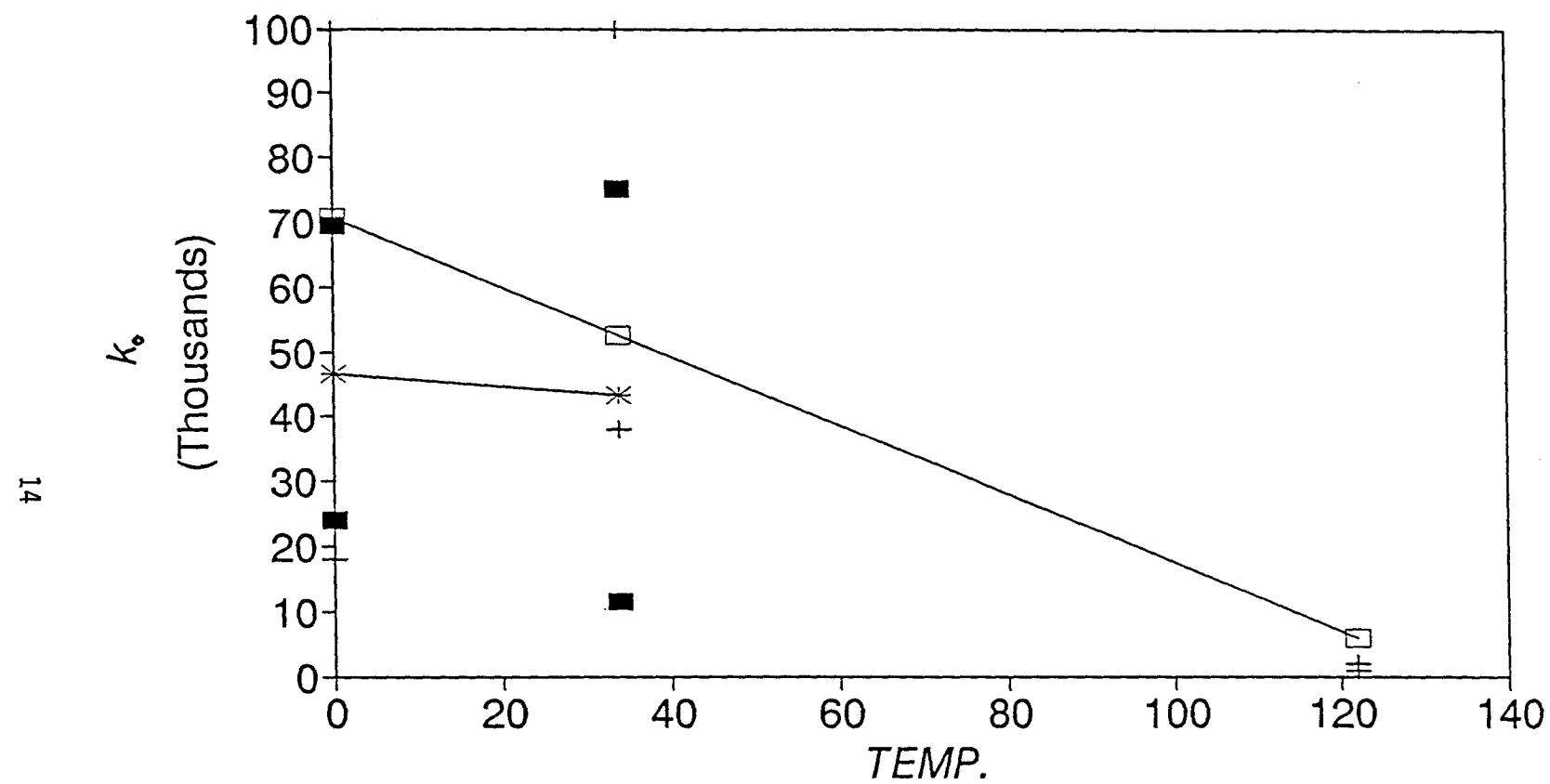


Figure 2-2. E_u vs. Temp.

k_0 vs. TEMP. (MATERIAL TYPE F1 & F2)



■ DATA(F1) + DATA(F2) —*— REG.(F1) —□— REG.(F2)

Figure 2-3. k_0 vs. Temp.

From the moment equilibrium condition,

$$\begin{aligned} M_g t_g \epsilon_g \{g(d_f - c) + (c - d_u)\} + \frac{\sigma_t}{2} g(d_f - c) \cdot \frac{2}{3} g(d_f - c) \\ + \frac{\sigma_c}{2} (1-g) (d_f - c) \cdot \frac{2}{3} (1-g) (d_f - c) - \tau_s t_g l \{g(d_f - c) + (c - d_u)\} = 0 \end{aligned} \quad (3-3)$$

solving for σ_t using Equations (3-1) and (3-2) gives

$$\sigma_t = \frac{g}{1-2g} \cdot \frac{2}{d_f - c} \cdot (M_g t_g \epsilon_g - \tau_s t_g u) \quad (3-4)$$

and using Equations (3-3) and (3-2), σ_t is found to be

$$\sigma_t = \frac{-g}{1-3g + 3g^2} \cdot \frac{3}{d_f - c^2} \cdot (M_g t_g \epsilon_g - \tau_s t_g l) \times \{g(d_f - c) + (c - d_u)\} \quad (3-5)$$

Now solve for g from Equation (3-4) and Equation (3-5). The two solutions are:

$$g=0 \quad \text{and} \quad (3-6)$$

$$g = \frac{2 + \frac{c}{d_f} - 3 \frac{d_u}{d_f}}{3 \left[1 + \frac{c}{d_f} - 2 \frac{d_u}{d_f} \right]} \quad (3-7)$$

Equation (3-6) means that the overlay always has a compressive stress at any crack length, but this is not the actual case. Equation (3-7) is used for later calculations. Because g is function of c/d_f and d_u/d_f , it is obvious that g has a different value for every crack length. The strain in the grid location is calculated as follows:

$$\epsilon_g = \left[\frac{d^2y}{dz^2} \right]_{x=0} z = \left[\frac{M}{EI} \right]_{x=0} \{g(d_f - c) + (c - d_u)\} \quad (3-8)$$

Substituting Equation (1-18) into Equation (3-8) produces

$$\varepsilon_g = \frac{q}{EI\beta^2} K \{g(d_f - c) + (c - d_u)\} \quad (3-9)$$

The moment of Inertia of a cross section with a crack in it is

$$I = \frac{1}{12}(d_f - c)^3 = \frac{d_f^3}{12} \left(1 - \frac{c}{d_f}\right)^3 \quad (3-10)$$

Substituting Equation (1.1) and Equation (3-10) into Equation (3-9) gives

$$\varepsilon_g = \frac{12qd_f^{1/2}}{3^{1/2} E^{1/2} \left(1 - \frac{c}{d_f}\right)^{3/2}} \frac{\left\{g \left(1 - \frac{c}{d_f}\right) + \left(\frac{c}{d_f} - \frac{d_u}{d_f}\right)\right\} K}{k^{1/2}} \quad (3-11)$$

here,

The K value is calculated from Equation (1-19) for traffic loading.

The temperature variation in the pavement is calculated using Barber's equation as modified by Shahin and McCullough. This equation is

$$T = T_v \frac{H e^{-xc}}{[(H + C)^2 + C^2]^{1/2}} \quad (3-12)$$

where,

T = temperature at depth x, °F

T_v = maximum air temperature variation, °F

x = depth below the surface, ft

H = h/k'

h = surface coefficient, BTU per square feet per hr, °F

h = 1.3 + 0.62 v^{3/4}, v = wind velocity, mph

k' = thermal conductivity, BTU per square feet per hr, °F per foot

$$C = \left(\frac{0.131}{c} \right)^{\frac{1}{2}}$$

c = diffusivity $\left(-\frac{k'}{S \cdot W} \right)$, per square feet per hr

S = specific heat, BTU per pound

W = density, pound per cubic foot

So, the average temperature variation is calculated as Equation (3-13)

$$\bar{\Delta T} = \frac{1}{d} \int_{d_1}^{d_2} \frac{H e^{-xc}}{[(H + C)^2 + C^2]^{\frac{1}{2}}} dx \quad (3-13)$$

where,

d_1 = depth of overlay above the grid, ft

d_2 = depth of overlay plus the existing old pavements depth, ft

d = depth of overlay below the grid plus the existing old pavement depth, ft

4. Fracture Mechanics Analysis for Reflection Cracking

The reflection cracking life of an asphalt overlay can be predicted by Paris' power law.

$$\frac{dc}{dN} = A(K)^n \quad (4-1)$$

A, n = fracture parameters of the material

K = stress intensity factor (K_b , K_s or K_t)

N = number of load cycles

c = crack length

A and n are determined from overlay beam test data. The relationship between log A and n for thermal reflection cracking is

$$\log A = -1.32421 - 1.43707 \times n \quad (4-2)$$

This relationship is shown in Figure 4-1.

The stress intensity factor (K) for in service pavements was determined using the finite element technique by P. W. Jayawickrama and R. L. Lytton for bending, shearing and thermal reflection cracking. These values are affected by the aggregate interlocking factor for traffic loading.

Tables 4-1, 4-2 and 4-3 show the nondimensional stress intensity factor vs. nondimensional overlay depth ratio for bending, shearing and the thermal reflection loading cases, respectively.

In the traffic loading case, the fracture parameter A was modified by a shifting factor to convert laboratory data to field data. For each loading case, the stress intensity factor at a given crack length is determined by regression analysis. Different regression models were used for each loading case.

Bending Case

$$\left[\frac{K_b}{\sigma \sqrt{d_f}} \right]^3 = a \left[\frac{c}{d_f} \right]^3 + r \quad (4-3)$$

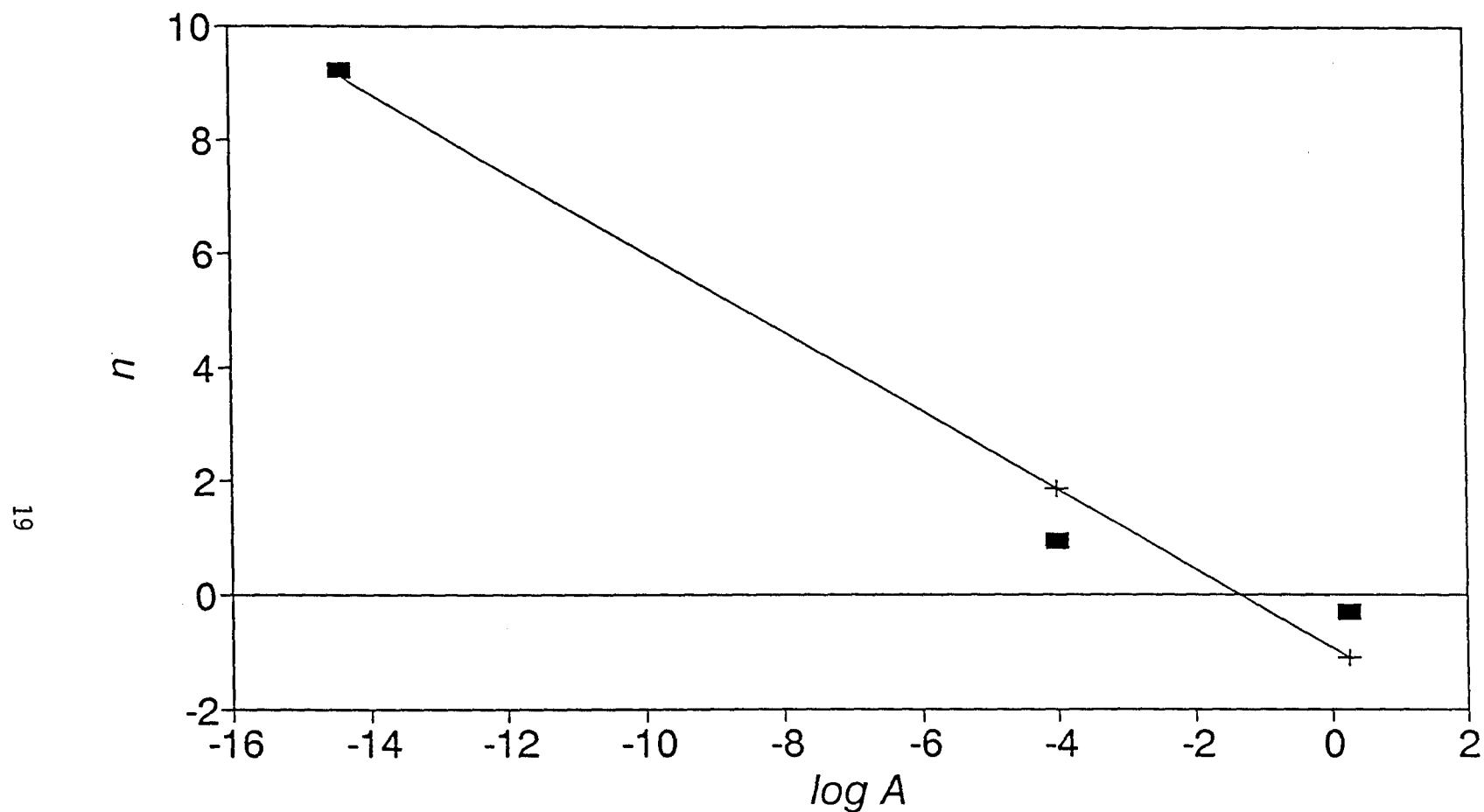
Shearing Case

$$\log \left[\frac{K_s}{\sigma \sqrt{d_f}} \right] = a \left[\frac{c}{d_f} \right]^2 + r \quad (4-4)$$

Thermal Case

$$\left[\frac{2K_t \sqrt{d_f}}{E_u} \right] = a \log \left[\frac{c}{d_f} \right] + r \quad (4-5)$$

$\log A$ vs. n



■ DATA —+— REG.EQ.

Figure 4-1. $\log A$ vs. n .

Table 4-1.

$$\frac{K_b}{\sigma\sqrt{d_f}} \text{ vs. } \frac{c}{d_f}$$

d_f	2 in			5 in.			8 in.		
inter-locking	low	med	high	low	med	high	low	med	high
c/d _f									
0.05	1.0660	1.0394	1.0156	0.6742	0.6574	0.6423	0.5330	0.5197	0.5078
0.15	1.3895	1.3073	1.1437	0.8788	0.8268	0.7234	0.6947	0.6536	0.5719
0.25	1.4470	1.2931	0.9820	0.9151	0.8178	0.6211	0.7235	0.6466	0.4910
0.35	1.3214	1.0969	0.6735	0.8357	0.6937	0.4260	0.6607	0.5484	0.3368
0.45	1.0483	0.7752	0.2943	0.6630	0.4903	0.1862	0.5241	0.3876	0.1472
0.55	0.6408	0.3403	-	0.4053	0.2152	-	0.3204	0.1701	-

Table 4-2.

$$\frac{K_s}{\sigma \sqrt{d_f}} \text{ vs. } \frac{c}{d_f}$$

d_f	2 in			5 in.			8 in.		
	inter-locking	low	med	high	low	med	high	low	med
c/d_f									
0.05	0.3217	0.2749	0.1892	0.2035	0.1739	0.1196	0.1609	0.1374	0.0946
0.15	0.4429	0.3924	0.3032	0.2801	0.2482	0.1917	0.2214	0.1962	0.1516
0.25	0.6019	0.5427	0.4305	0.3807	0.3432	0.2722	0.3010	0.2714	0.2152
0.35	0.7946	0.6903	0.5471	0.5026	0.4366	0.3460	0.3973	0.3452	0.2736
0.45	0.8971	0.8122	0.6249	0.5674	0.5137	0.3952	0.4486	0.4061	0.3125
0.55	1.0624	0.9599	0.7540	0.6719	0.6071	0.4768	0.5312	0.4999	0.3770
0.65	1.2896	1.1623	0.8848	0.8156	0.7351	0.5596	0.6448	0.5812	0.4424
0.75	1.5609	1.3948	1.0439	0.9872	0.8821	0.6602	0.7805	0.6974	0.5219
0.85	1.9048	1.6794	1.1968	1.2047	1.0621	0.7569	0.9524	0.8397	0.5984
0.95	2.2230	1.9216	1.3479	1.4059	1.2153	0.8525	1.1115	0.9608	0.6740

Table 4-3.

$$\frac{K_t}{E_u} \text{ vs. } \frac{c}{d_f}$$

$$\frac{2\sqrt{d_f}}{}$$

d_f c/d_f	2 in.	5 in.	8 in.
0.05	0.0346	0.0547	0.0692
0.15	0.0502	0.0793	0.1003
0.25	0.0646	0.1022	0.1293
0.35	0.0808	0.1278	0.1617
0.45	0.0888	0.1405	0.1777
0.55	0.0956	0.1512	0.1912
0.65	0.0997	0.1577	0.1994
0.75	0.1052	0.1663	0.21032

In Equation (4-3), (4-4) and (4-5), the coefficients a and r are regression coefficients for each loading case from which the stress intensity factors can be calculated. These a and r coefficients have different values for different overlay depth and aggregate interlocking factor. Table 4-4 shows these values for each case.

In this failure analysis, three different damage levels were used. Damage levels of 0.33, 0.40 and 0.50 are used to represent low, medium, and high levels of severity of transverse cracking, respectively.

Equation (4-1) can be modified as Equations (4-6) to take into account the damage level

$$\frac{dc}{dN} = A (K)^n f(\alpha) \quad (4-6)$$

Table 4-4. Regression coefficients a and r.

d _f	inter-locking	Coefficients								
		bending			shearing			thermal		
		a	r	R-square	a	r	R-square	a	r	R-square
2 in.	low	2.19	-11.2	0.58	-0.722	1.88	0.88	0.011	0.0038	0.91
	med.	1.65	-10.4	0.73	-0.843	1.88	0.86	0.011	0.0038	0.91
	high	1.08	-12.8	0.83	-0.970	1.59	0.81	0.011	0.0038	0.91
5 in.	low	1.12	-5.73	0.58	-1.07	1.88	0.88	0.028	0.0095	0.91
	med.	0.85	-5.32	0.73	-1.19	1.88	0.86	0.028	0.0095	0.91
	high	0.55	-6.57	0.83	-1.32	1.59	0.81	0.028	0.0152	0.91
8 in.	low	0.053	-0.27	0.58	-1.42	1.88	0.88	0.044	0.152	0.91
	med.	0.040	-0.25	0.73	-1.54	1.88	0.86	0.044	0.152	0.91
	high	0.026	-0.31	0.83	-1.66	1.59	0.81	0.044	0.152	0.91

where,

$$f(\alpha) = f(\alpha_1, \alpha_2, \alpha_3, \alpha_4, \alpha_5) \quad \text{and the}$$

α_i ($i = 1, 2, 3, 4, 5$): regression coefficients for damage levels 0.33, 0.40 and 0.50. The values of α_i are presented in Table 4.5.

Table 4-5. Regression coefficients for damage levels 0.33, 0.40 and 0.50.

α_i	0.33	0.40	0.50
α_1	2.92371	3.91662	5.44858
α_2	0.26246	0.40307	0.59267
α_3	7.61638	9.79696	13.02140
α_4	2.21993	2.75224	3.43166
α_5	2.82208	3.64735	4.48650

Therefore, Equation (4-6) is calculated as follows for each loading case.

Case 1:

Traffic loading during the day

for shearing loading

$$\frac{dc}{dN} = A(K_s)^n \frac{\alpha_3}{\alpha_1} \quad (4-8)$$

for bending loading

$$\frac{dc}{dN} = A(K_b)^n \frac{\alpha_2}{\alpha_1} \quad (4-9)$$

for shearing loading

$$\frac{dc}{dN} = A(K_s)^n \frac{\alpha_3}{\alpha_1} \quad (4-10)$$

Thermal loading during night

$$\frac{dc}{dN} = A_3(K_t)^{n_3} \frac{1}{\alpha_1} \quad (4-11)$$

and

Case 2: where $(\frac{c}{d_f})_o < \frac{c}{d_f} < 1$

Traffic loading during day

for bending loading not applicable for this c/d_f range

for shearing loading

$$\frac{dc}{dN} = 2A(K_s)^n \frac{\alpha_s}{\alpha_4} \quad (4-12)$$

Thermal loading during night

$$= A_3(K_t)^{n_3} \frac{1}{\alpha_4} \quad (4-13)$$

where,

$$(\frac{c}{d_f})_o = 0.55 \quad \text{for low and medium aggregate interlocking}$$

$$(\frac{c}{d_f})_o = 0.45 \quad \text{for high aggregate interlocking}$$

and

A, n = regression coefficients for traffic loading case.

A_3, n_3 = regression coefficients for thermal loading case.

Finally, Equations (4-8) - (4-13) are calculated using Equation (3-11) for ϵ_{grid} , Equation (3-7) for g , and Equation (3-4) for σ_t . The stress intensity factor is calculated from Equations (4-3) - (4-5) at different crack lengths.

In addition to the overlay beam test, the beam fatigue test has also been carried out. Table 4-6 is the summary of the beam fatigue test results. The constants K_1 and K_2 are regression coefficients of the number of load cycles to failure, N_f vs. the initial bending strain, ϵ_i .

The regression equation has the following form.

$$N_f = K_1 \left(\frac{1}{\epsilon_i} \right)^{K_2} \quad (4-14)$$

Table 4-6. Beam Fatigue Test Results.

Sample No.	Sample Description	T (°F)	K_1	K_2
C1, C2, C3	Control Sample	34	4.5010E-12	4.5292
F1-6, F1-5, F1-7	F1 (8501)	34	2.1820E-7	3.1334
F1-4, F1-3, F1-1	F1 (8501)	68	1.1372E-8	3.6844
F1-4, F1-2, F1-9	F1 (8501)	104	0.2943	1.6190
F2-1, F2-4, F2-8	F2 (8502)	34	2.0034E-8	3.4603
F2-3, F2-5, F2-2	F2 (8502)	68	2.1753E-4	2.3811
F2-9, F2-7, F2-6	F2 (8502)	104	9.3108E-5	2.8862

where,

K_1 and K_2 are regression coefficients.

Figures 4-2 - 4-8 show the relationship between the number of load cycles to failure, $\log N_f$ vs. the initial bending strain, $\log \epsilon_i$ for each sample.

Figure 4-9 shows the temperature vs. K_2 value for each material. Figure 4-10 shows $\log K_1$ vs. K_2 values at different temperatures for each material.

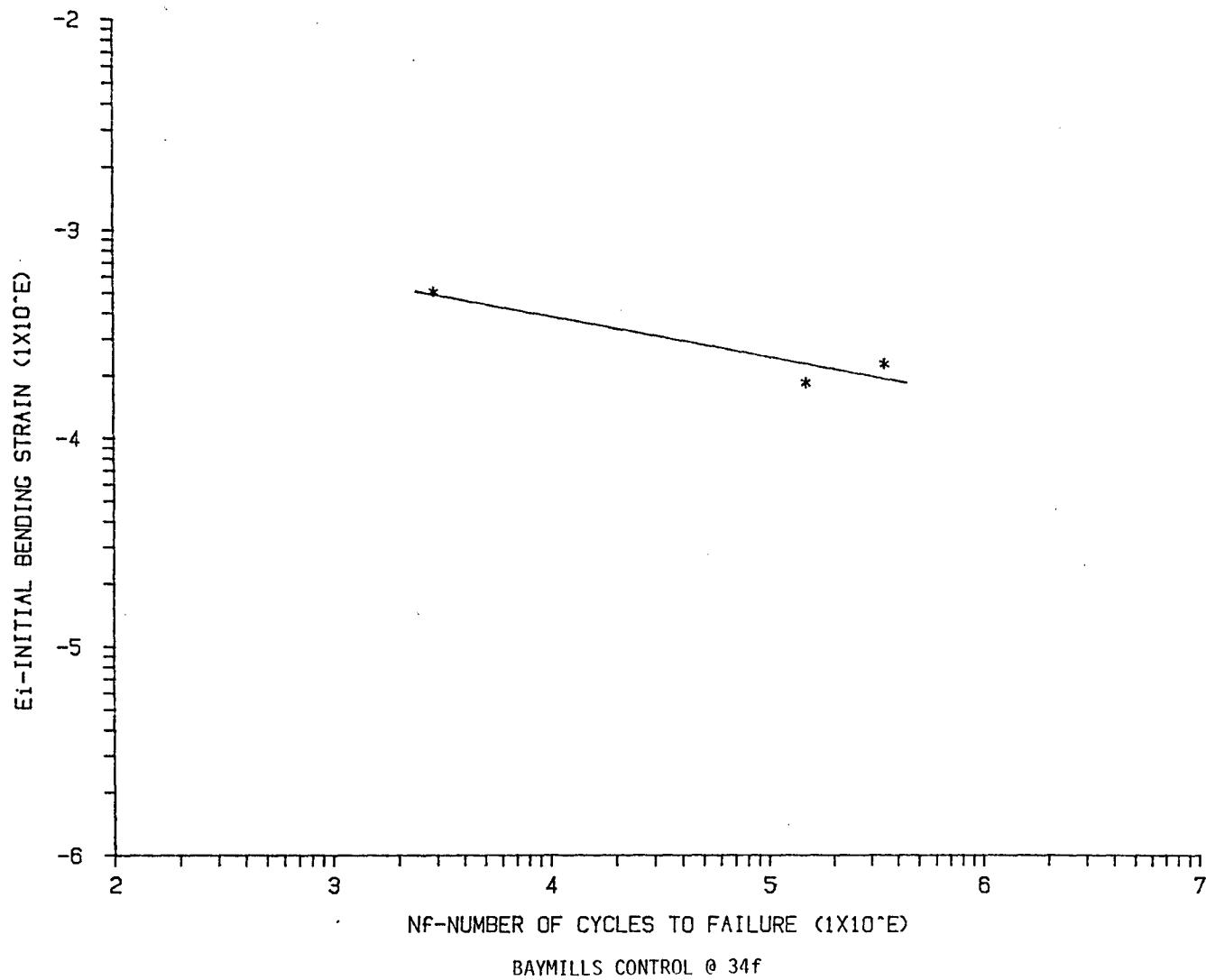


Figure 4-2. Beam Fatigue Relation for Control Samples C1, C2, and C3 at 34°F.

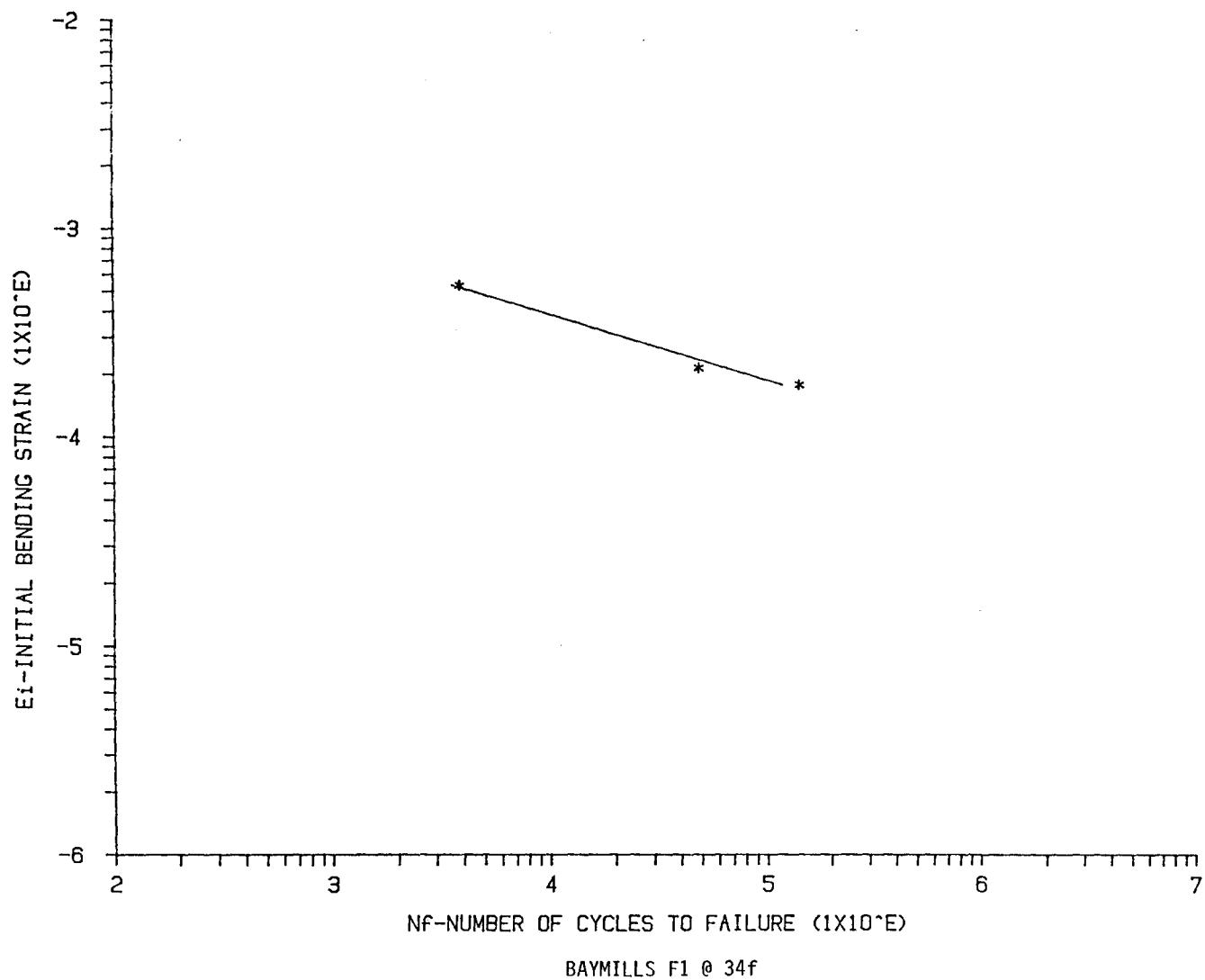


Figure 4-3. Beam Fatigue Relation Using Bayex Grid 8501 at 34°F.

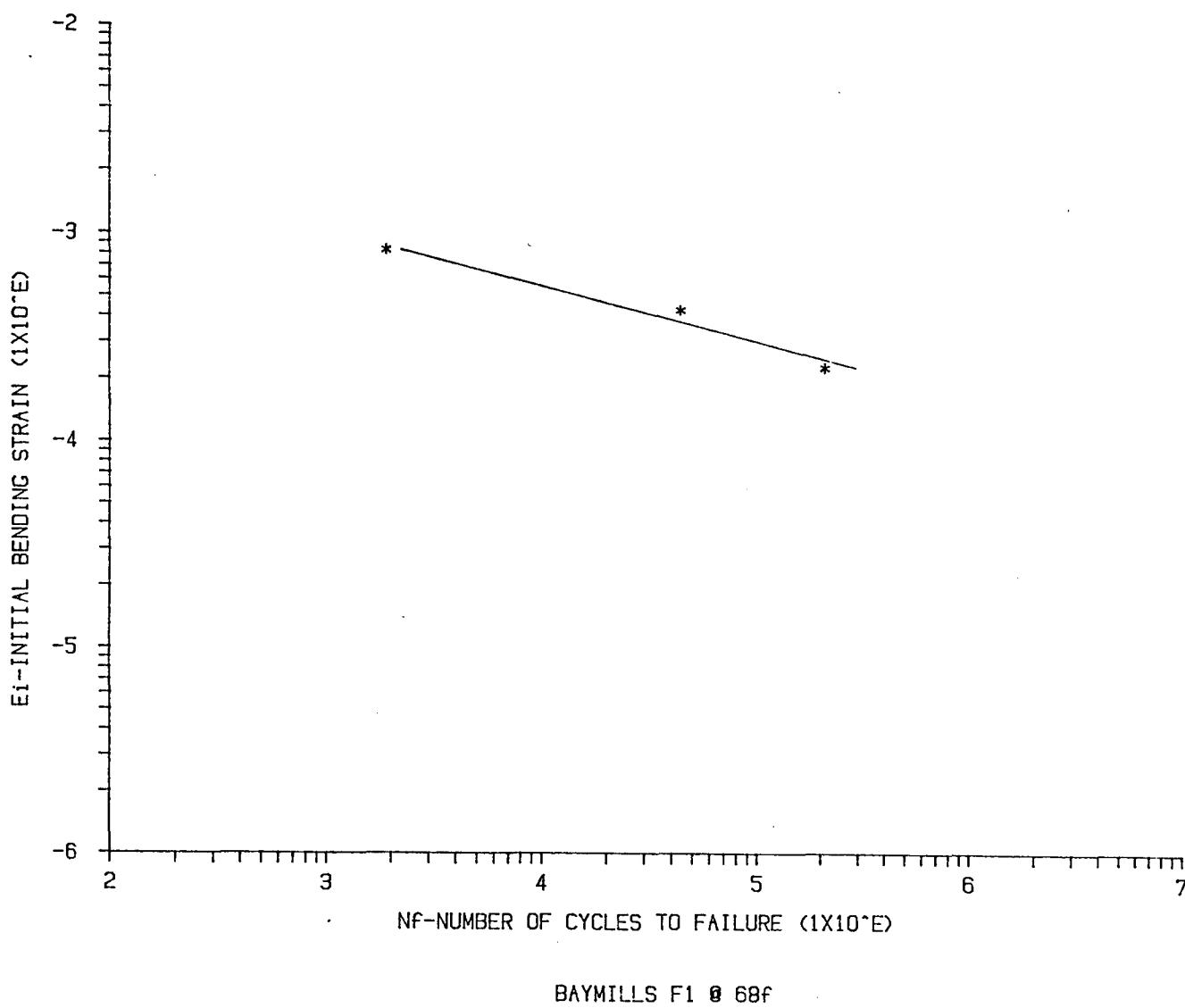


Figure 4-4. Beam Fatigue Relation Using Bayex Grid 8501 at 68°F.

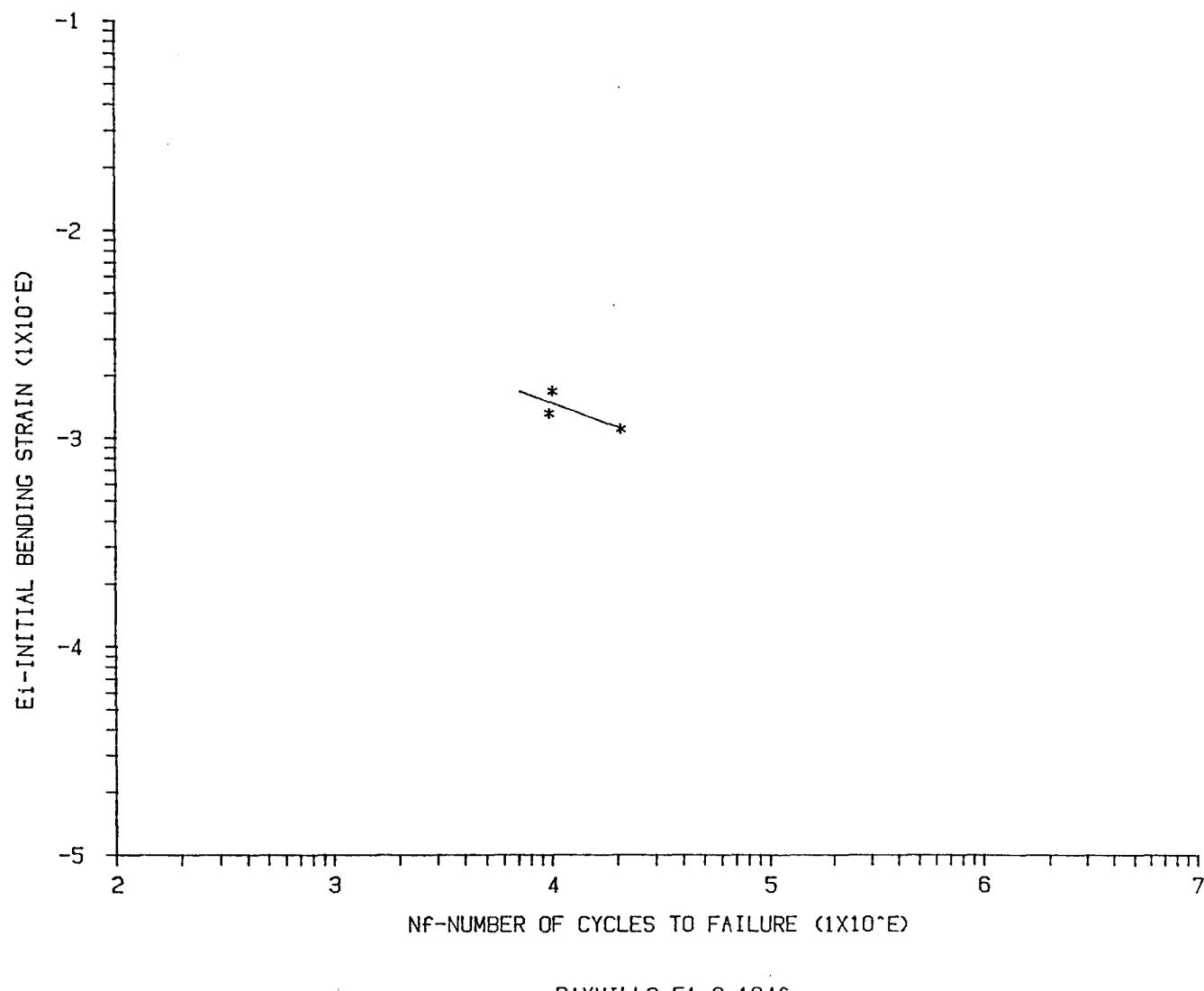


Figure 4-5. Beam Fatigue Relation Using Bayex Grid 8501 at 104°F.

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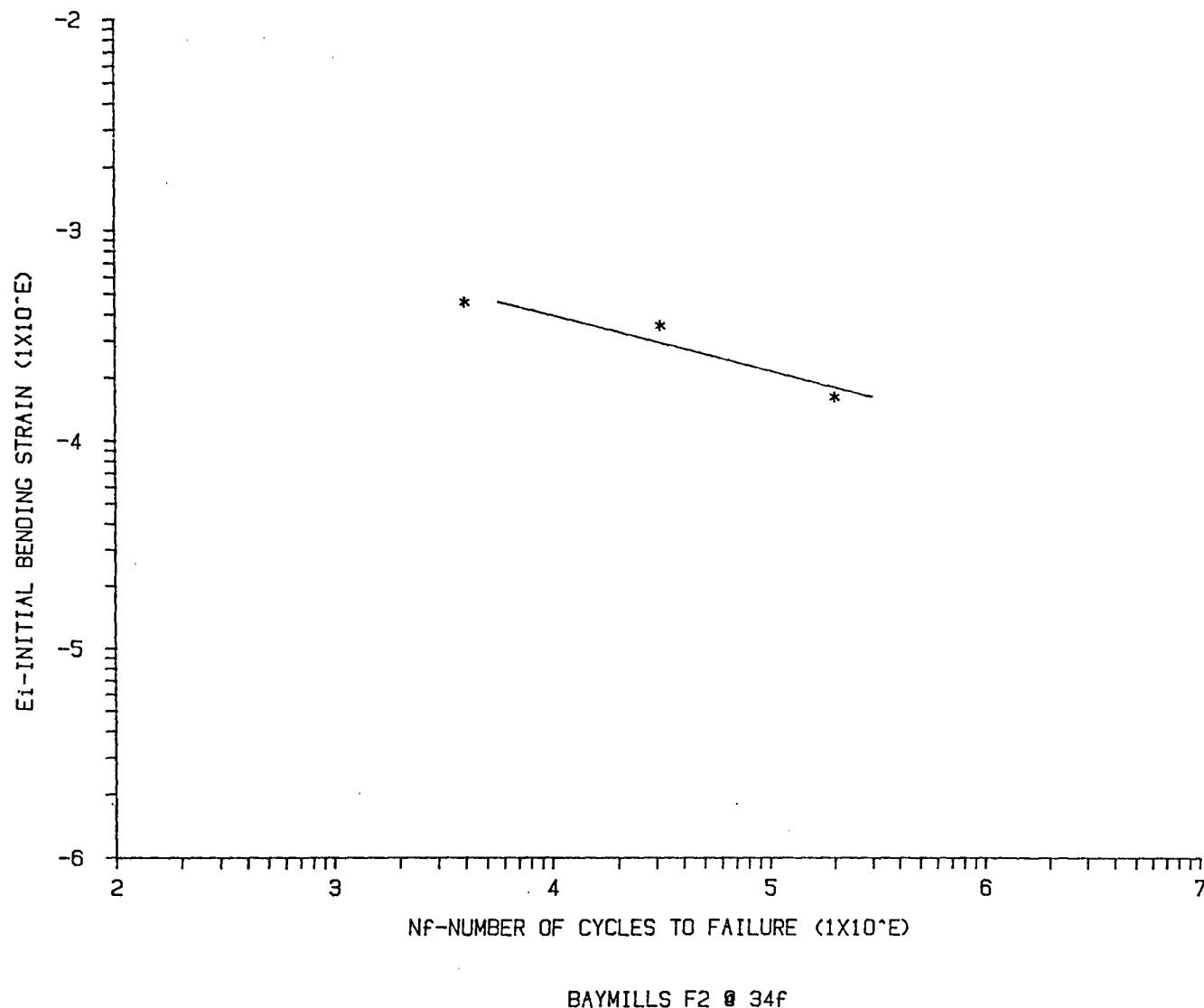


Figure 4-6. Beam Fatigue Relation Using Bayex Grid 8502 at 34°F.

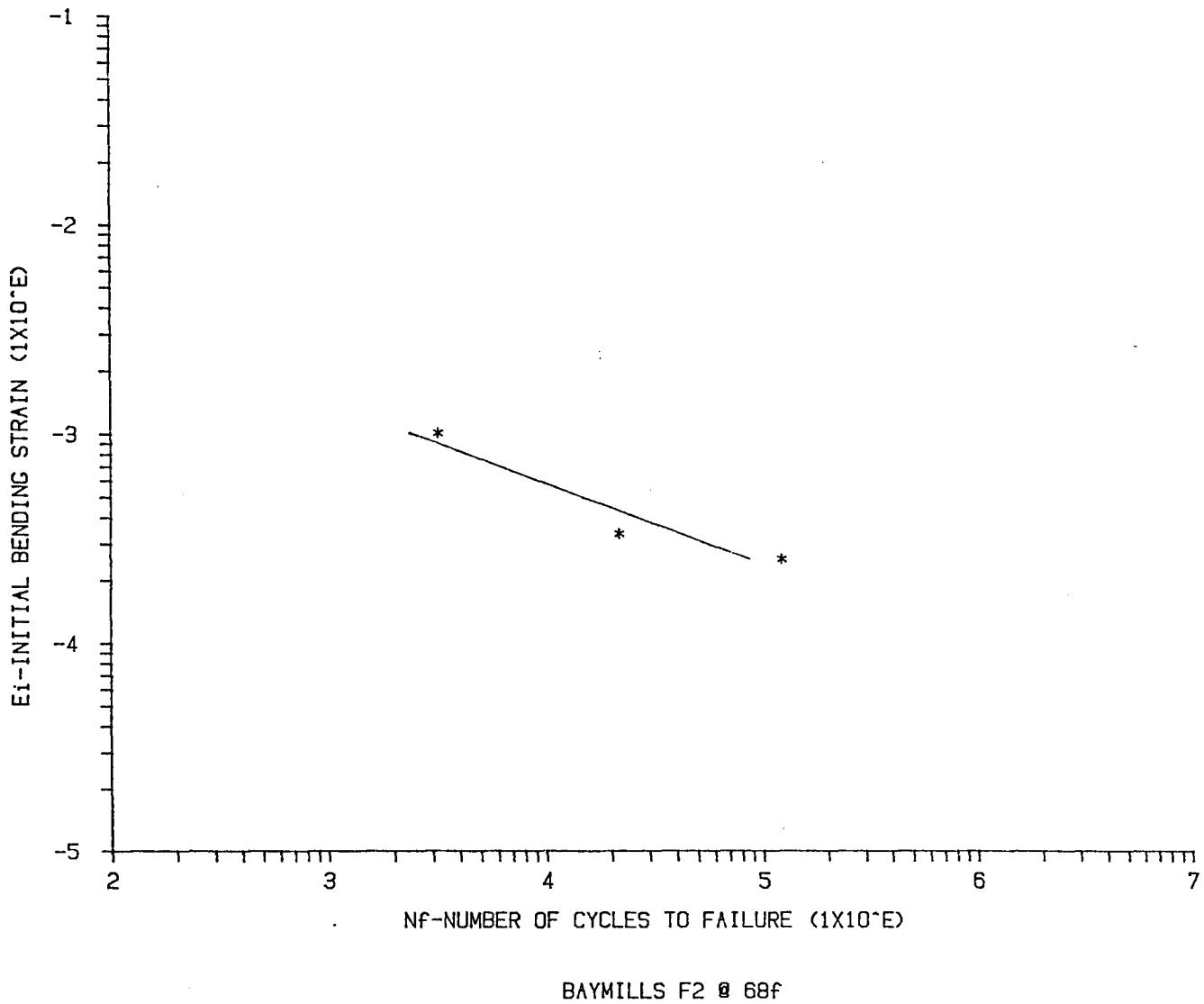


Figure 4-7. Beam Fatigue Relation Using Bayex Grid 8502 at 68°F.

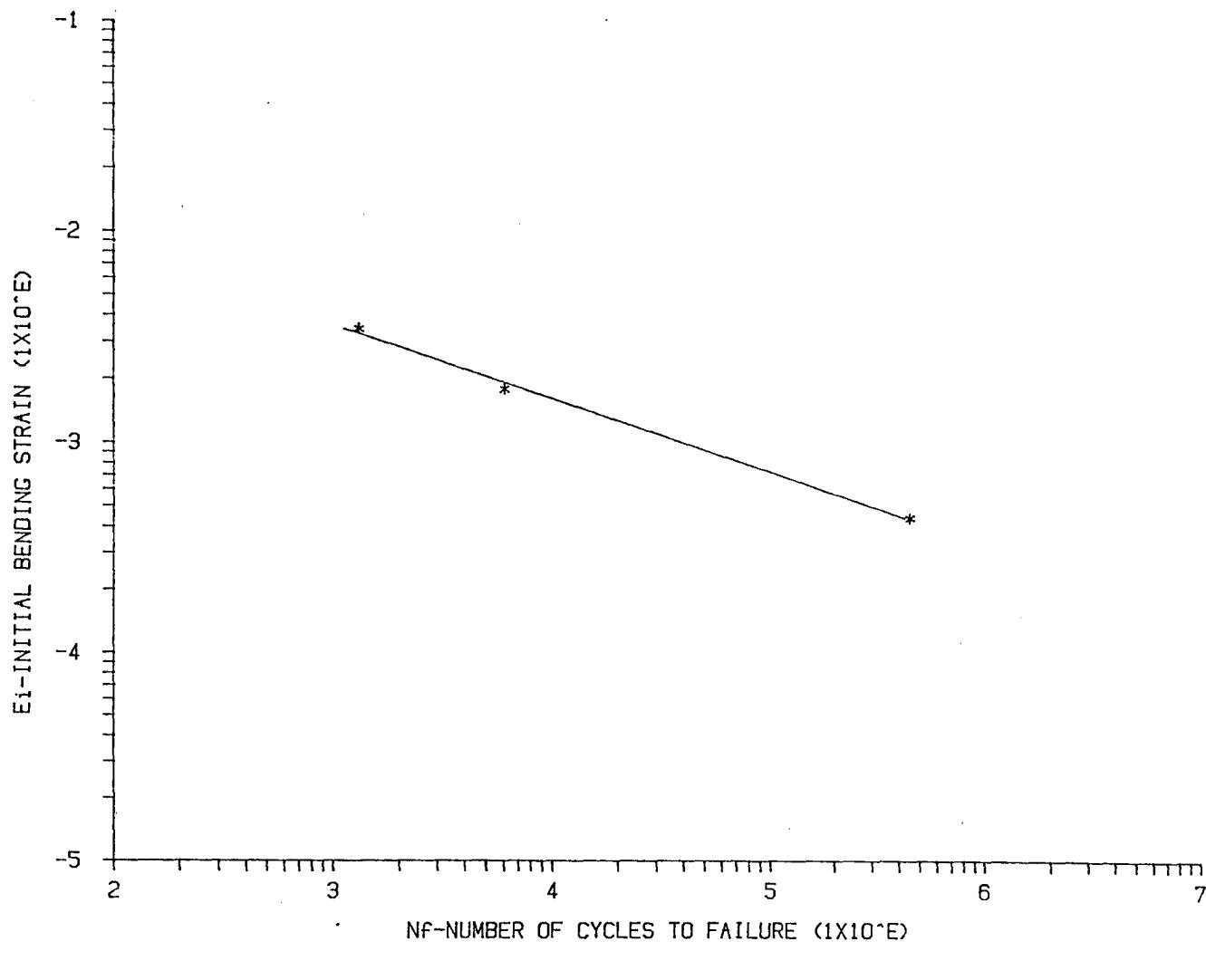


Figure 4-8. Beam Fatigue Relation Using Bayex Grid 8502 at 104°F.

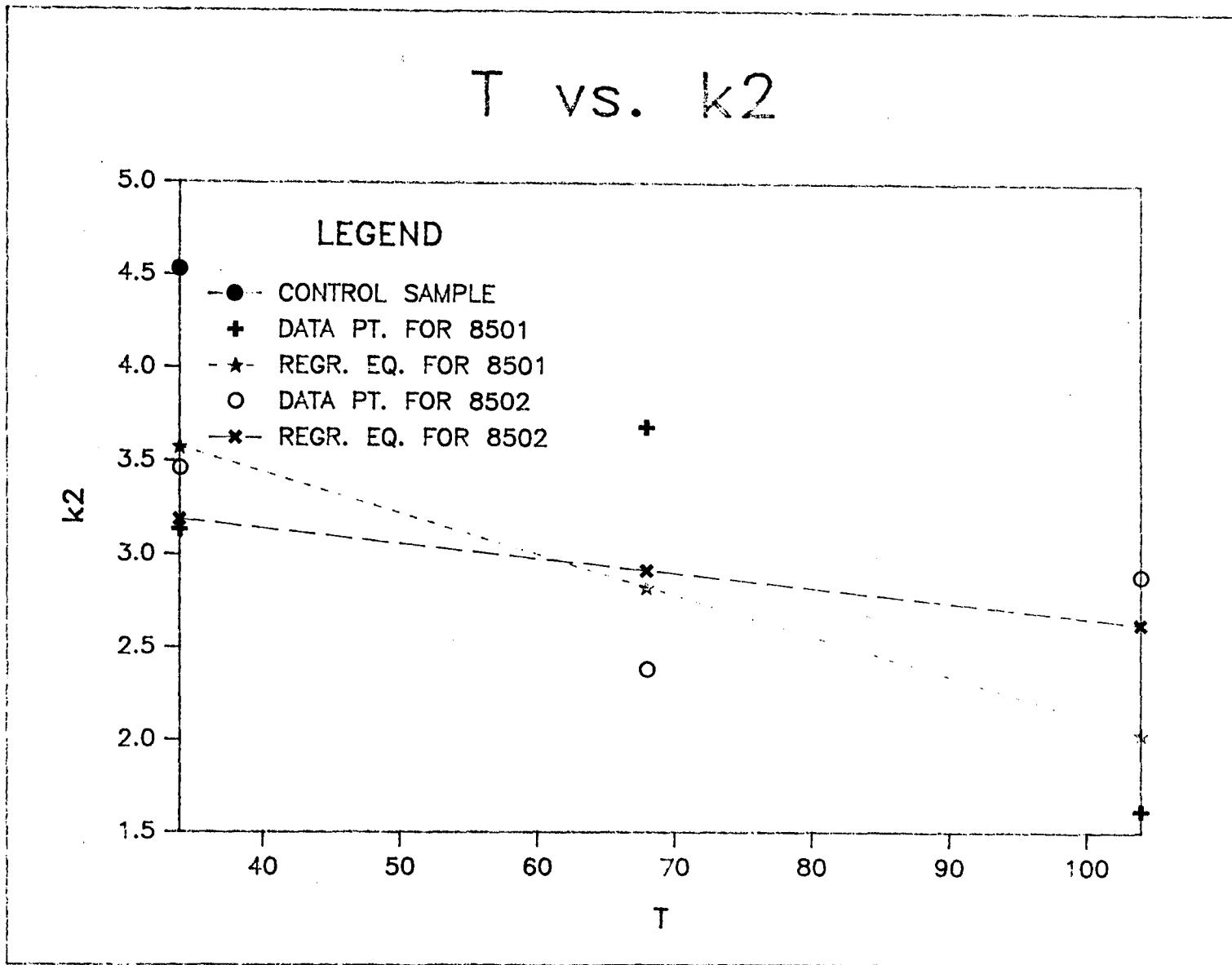


Figure 4-9. Relations Between Fatigue Exponent k_2 and Temperature Using Grids 8501 and 8502.

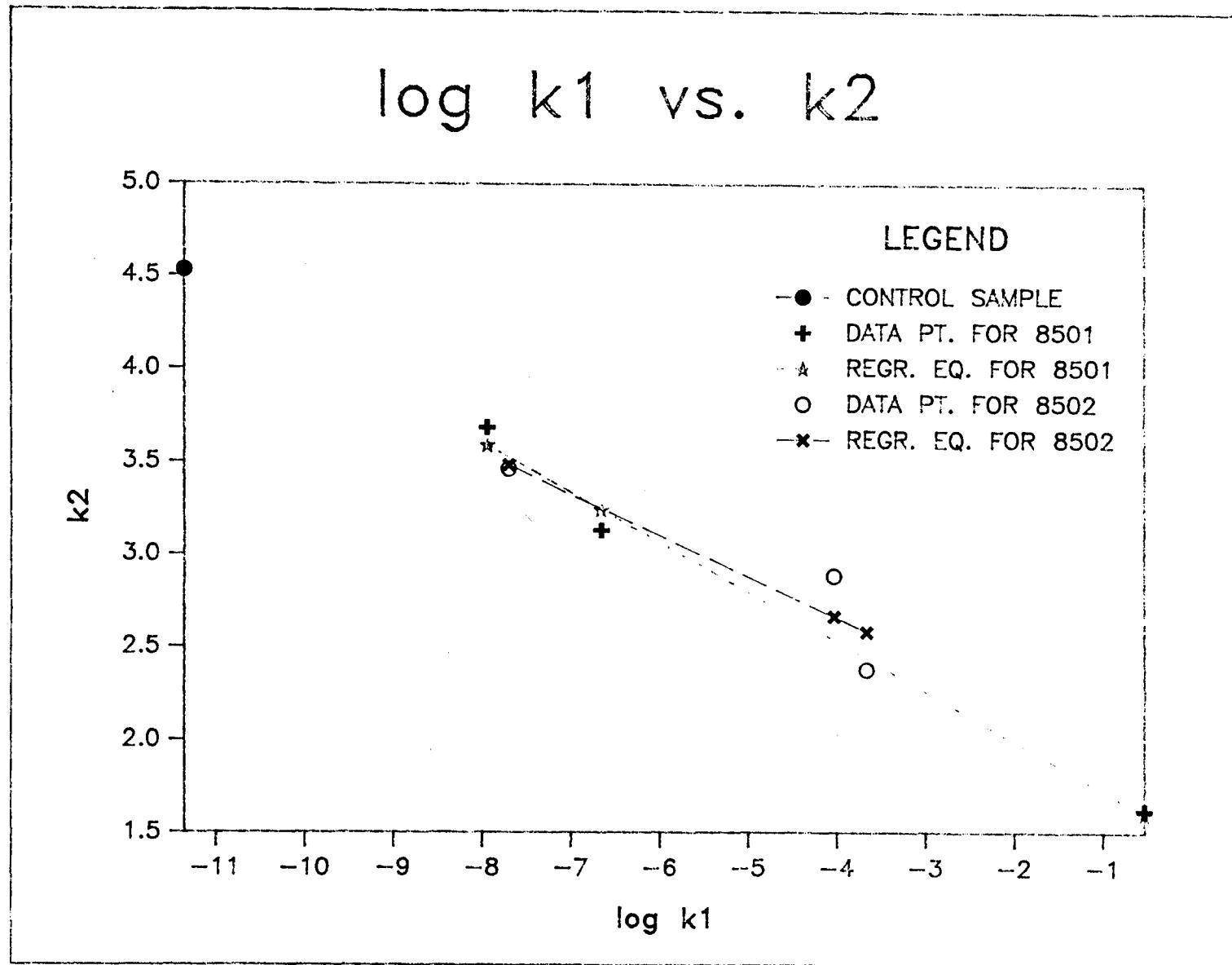


Figure 4-10. Relations Between $\log k_1$ and k_2 Using Grids 8501 and 8502.

5. Discussions and Results

Fatigue life is calculated by the following procedure at the current crack length, c each day.

1. Calculate g
 - Equation (3-7)
2. Calculate ϵ_{grid}
 - Equation (3-11)
3. Calculate σ_t
 - Equation (3-4)
4. Calculate K_i (stress intensity factor)
 - ($i =$ bending, shearing and thermal case)
 - Equation (4-3) - (4-5)
5. Calculate dc/dN
 - Equation (4-8) - (4-13)

A new crack length, c_1 and the number of days until the cracking of the pavement has reached the designated level of severity, NTL, are calculated after item 5. If the new crack length, C_1 , is less than the depth of the overlay, d_f , or the number of days, NTL is less than the maximum number of days, ND, then repeat the above procedure. Otherwise, print out a new crack length, C_1 , that is a final crack length and the number of days, NTL.

Based on the previous analysis procedure, a computer program was written (Appendix A). An input data guide and an example problem are given in Appendix B. Using this computer program, 16 different cases were analyzed.

Table 5.1 shows each case. In these cases, typical variables are bonded or debonded, material type, air temperature, temperature variation, existing old pavement thickness, thickness of overlay, crack spacing, support stiffness and modulus of elasticity of the grid. In all cases, a traffic level of 1,000 18k ESALs per day was used.

In each case, the result is summarized (Appendix C). In the case without the grid, the bonding type of failure is dominant, but in the case with the grid, two types of failure occur which depend on several of the variables mentioned above.

Case 1 (Case 1-1 - 1-4); same as case 2-1 - 2-4

except the bonding adhesive is changed from 8502 to 8501

Case 4 (Case 4-1 - 4-4); same as case 2-1 - 2-4

except air temp. is changed from 50°F to 40°F

Case 3 (Case 3-1 - 3-4); same as case 4-1 - 4-4

except the bonding adhesive is changed from 8502 to 8501

Case 5 (Case 5-1 - 5-4); same as case 2-1 - 2-4

except the grid material type is changed from 8502 to 8501

Case 6 (Case 6-1 - 6-4); same as case 2-1 - 2-4

except the grid material type is changed from 8502 to a low modulus material such as a polyester fabric.

Case 7 (Case 7-1 - 704); same as case 4-1 - 4-4

except the grid material is changed from 8502 to 8501

Case 8 (Case 8-1 - 8-4); same as case 4-1 - 4-4

except the grid material is changed from 8502 to a low modulus material such as a polyester fabric

Table 5-1. Computer Simulated Conditions for Overlay Cases 2-1 to 2-4.

Case 2	2-1	2-2	2-3	2-4
damage level	low	low	low	low
aggregate interlocking	1. m. h.	1. m. h.	1. m. h.	1. m. h.
material type	8502	8502	8502	8502
grid modulus (Ksi)	1000, 10000	1000, 10000	1000, 10000	1000, 10000
crack spacing (in)	120	240	120	240
air temp. (°F)	50	50	50	50
temp. difference (°F)	30	30	30	30
bonded, debonded	both	both	both	both
overlay depth (in)	2, 3.2, 5, 8	2, 3.2, 5, 8	2, 3.2, 5, 8	2, 3.2, 5.8
old pavement depth (in)	5.0	5.0	2.0	2.0
support stiffness (pci)	100, 500, 1000	100, 500, 1000	100, 500, 1000	100, 500, 1000
overlay depth below grid ($\frac{in}{in}$)	$\frac{0.0}{1.0}$	$\frac{0.0}{1.0}$	$\frac{0.0}{1.0}$	$\frac{0.0}{1.0}$

Table 5-2 provides further assistance in visualizing the different combinations that were simulated in Cases 1 through 8. The number of days an overlay is predicted to last is tabulated in Appendix C.

The tabulation of these computed results does not present any immediately perceived patterns whereby the reinforcing grid improves or extends the life of the overlay. In order to visualize the results, six graphs were prepared plotting a calculated "improvement ratio" versus the depth of the overlay. The "improvement ratio" is defined as the ratio of the life of the overlay with the reinforcing grid divided by the life of the same overlay with no grid.

In each case, two conditions were simulated: the life of the overlay with and without a 1 inch (2.5 cm) level-up course placed on the surface of the old pavement.

Graphs of the "improvement ratio" versus the thickness of the overlay are shown in Figure 5-1 through 5-5. The overlays were predicted to fail in two different ways: "debonding" and "bonding." The "debonding" failure occurs when the crack grows upward to the bottom of the fiberglass grid, turns and grows horizontally in the adhesive which attaches the grid to the layer beneath it, and then restarts above the grid and grows upward to the top of the overlay. The "bonding" failure occurs when the reflecting crack grows upward to the bottom of the grid, restarts above it without breaking the grid, and grows upward to the top of the overlay. The number of days required for each type of crack to reach the top of the overlay was calculated and the figure that was used to calculate the "improvement ratio" was the smaller of the two. In every case, each point on each graph is labeled with either a "d" for

Table 5-2. Experiment Design for Simulated Cases 1-8.

		Material 8501		Material 8502		Material 8502 with 8501 Bonding		Low Modulus Fabric		
		120	240	120	240	120	240	120	240	
Ø	2 ⁱⁿ	40	7-3	7-4	4-3	4-4	3-3	3-4	8-3	8-4
		50	5-3	5-4	2-3	2-4	1-3	1-4	6-3	6-4
	5 ⁱⁿ	40	7-1	7-2	4-1	4-2	3-1	3-2	8-1	8-2
		50	5-1	5-2	2-1	2-2	1-1	1-2	6-1	6-2
grid properties		$E_f = 10,000 \text{ ksi}$ $n_s = 2$		$E_f = 10,000 \text{ ksi}$ $n_s = 4$		$E_f = 10,000 \text{ ksi}$ $n_s = 4$		$E_f = 500 \text{ ksi}$ $n_s = 4$ Fabric Modulus = 50 ksi		
Debonded Adhesive Material Properties		8501		8502		8501		8501		

* n_s = number of strands in each grid

"debonding" or a "b" for a bonding crack, indicating which one took a smaller number of days to propagate through the overlay.

In general, the grids which were first placed on a 1-inch level-up course before an overlay was placed on them improved the overlay life much more than those grids placed directly on the old pavement surface. Also, overlays placed on old pavements with stiff supporting layers which are well-drained with a good cross-slope, sealed cracks, and in a dry climate will last longer than overlays placed on old pavements with soft supporting layers. Soft support comes from poor drainage, low cross-slope, unsealed cracks, and wet climates.

Another general observation is that overlays placed in climates with a higher mean annual temperature will have higher improvement ratios than those placed where lower mean annual temperatures prevail.

Observations about the failure modes indicate that debonding prevails with the grids placed on the 1-inch level-up course whereas bonding failures are the usual mode with grids and overlays placed directly on the old pavement surface. In most cases with overlays less than 5-inches thick on soft supporting layers, placing a grid directly on the old pavement results in a reduced life of the overlay below what can be achieved with the same overlay without grid reinforcing. On stiff support, no improvement in overlay life is found for overlays thinner than 3.2 inches.

The grid material 8501 consistently outperformed the 8502 grid when they were placed on a 1-inch level-up course. Their roles were reversed, however, when no level-up was used and bonding failure was more common.

Figures 5-1 through 5-3 are for different thickness of overlay placed on an old pavement with a 5-inch thick surface layer and an average crack spacing of 20-feet (240 inches). The following are the ways in which these figures differ.

<u>Figure No</u>	<u>Stiffness of Supporting Layer</u>	<u>Mean Annual Temperature</u>
5-1	Soft	50°F
5-2	Soft	40°F
5-3	Stiff	50°F

All of the "improvement ratios" for the 1-inch level-up decrease as the overlay thickness increases. This was the expected result since the grid constitutes a smaller percentage of the strength of the overlay as the overlay becomes thicker. The unexpected pattern occurred with those cases in which the grid was placed directly on the old pavement. Typically, the grid increases the life of the overlay for overlay thicknesses greater than 4-inches. The improvement ratio is rarely as large as is achieved using the 1-inch level-up course.

Figures 5-4 and 5-5 are for overlays on a 2-inch thick surface layer and an average crack spacing of 20-feet (240 inches). The ways in which they differ are as follows:

<u>Figure No</u>	<u>Stiffness of Supporting Layer</u>	<u>Mean Annual Temperature</u>
5-4	Soft	40°F
5-5	Stiff	40°F

In all of the figures, two extra curves are shown. These curves are for a combination that was never tested but simply computed. The 8502

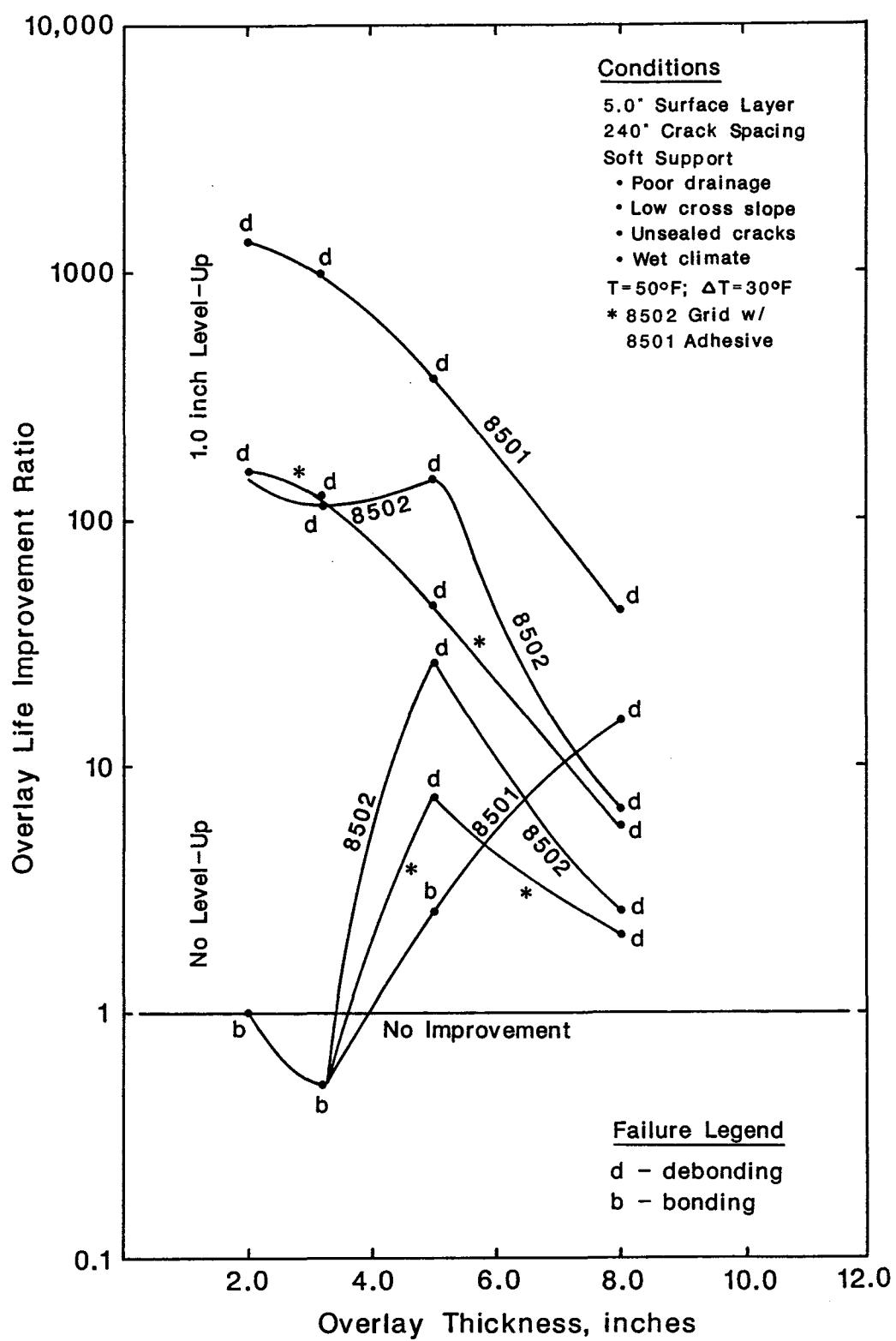


Figure 5-1.

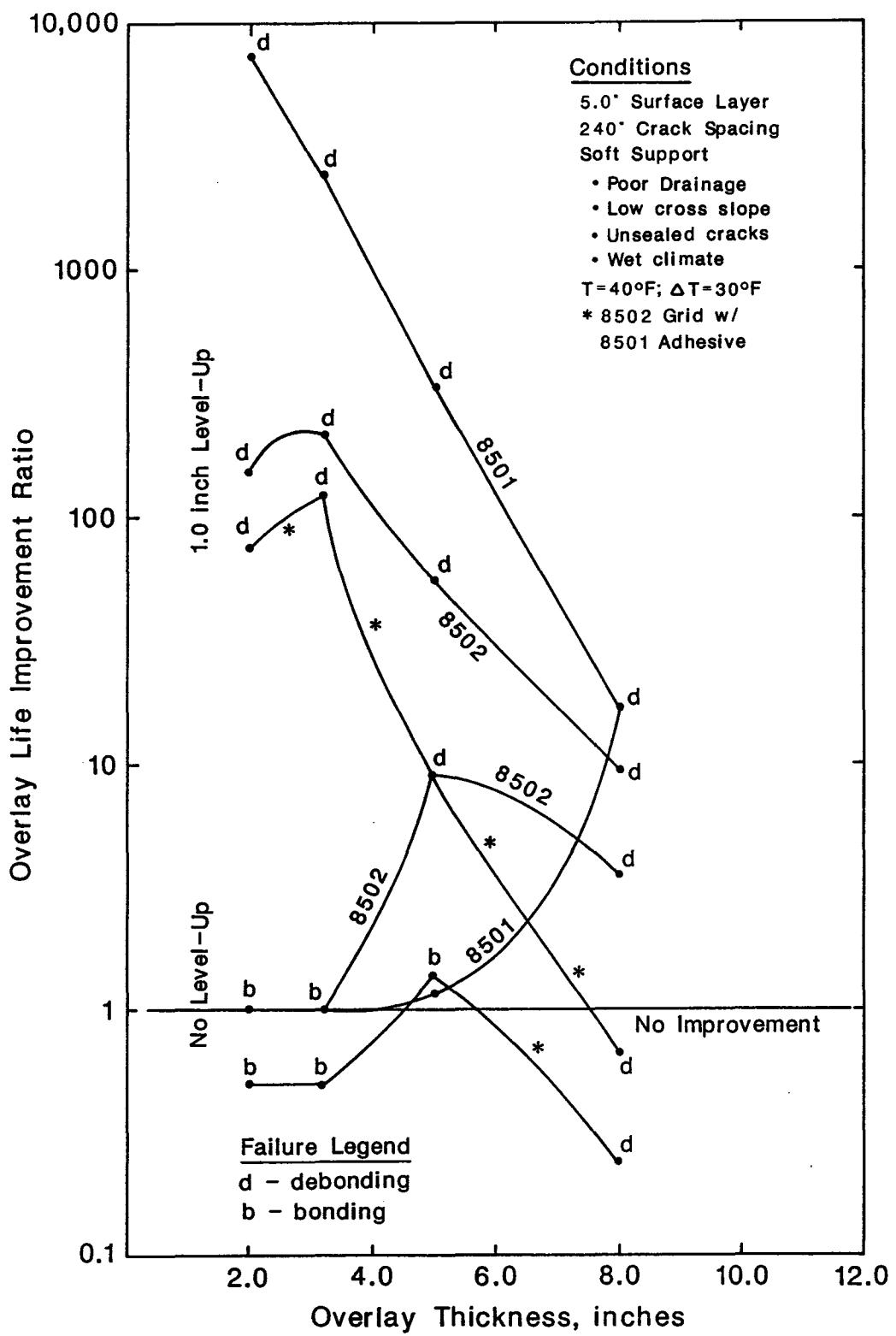


Figure 5-2.

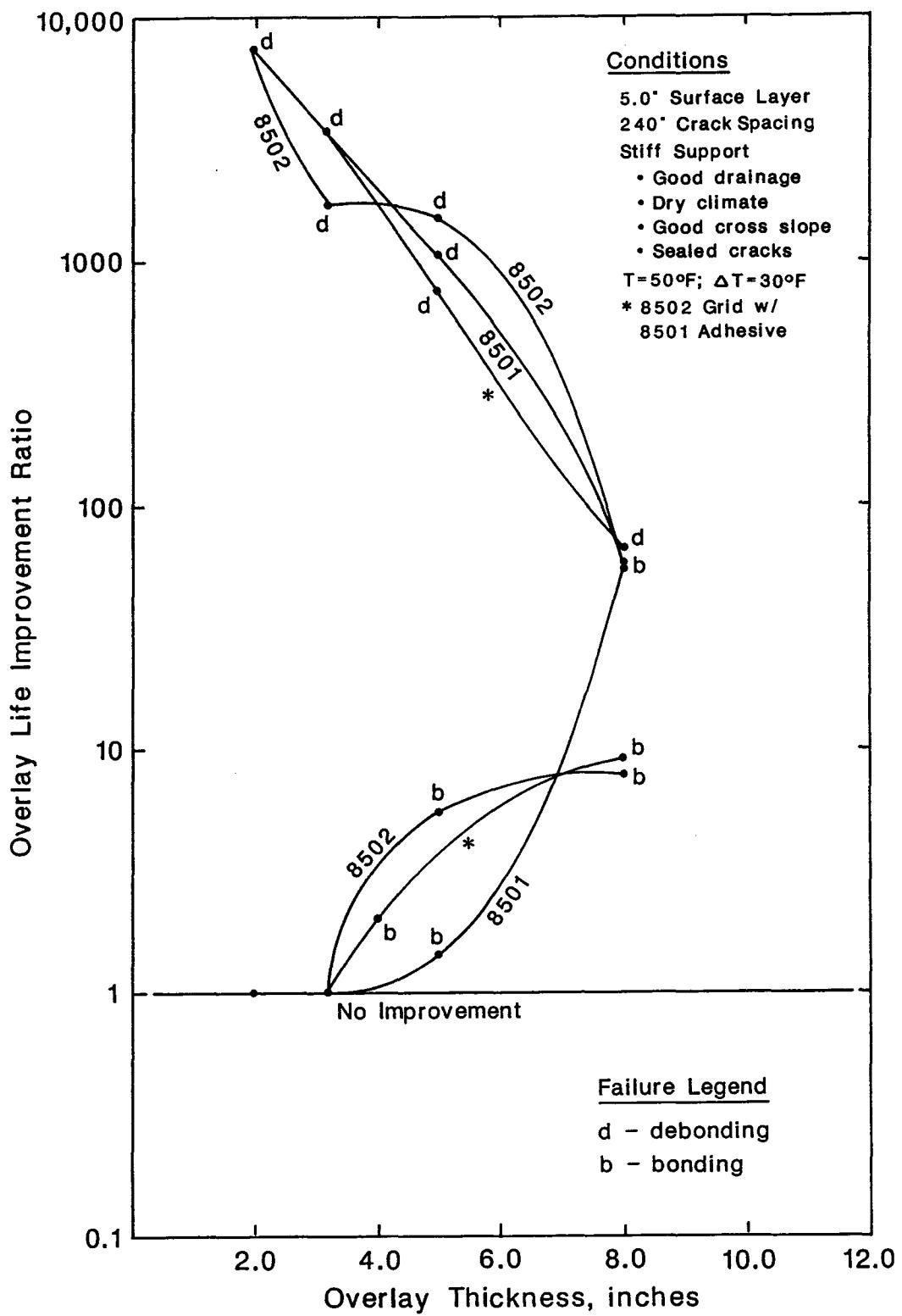


Figure 5-3.

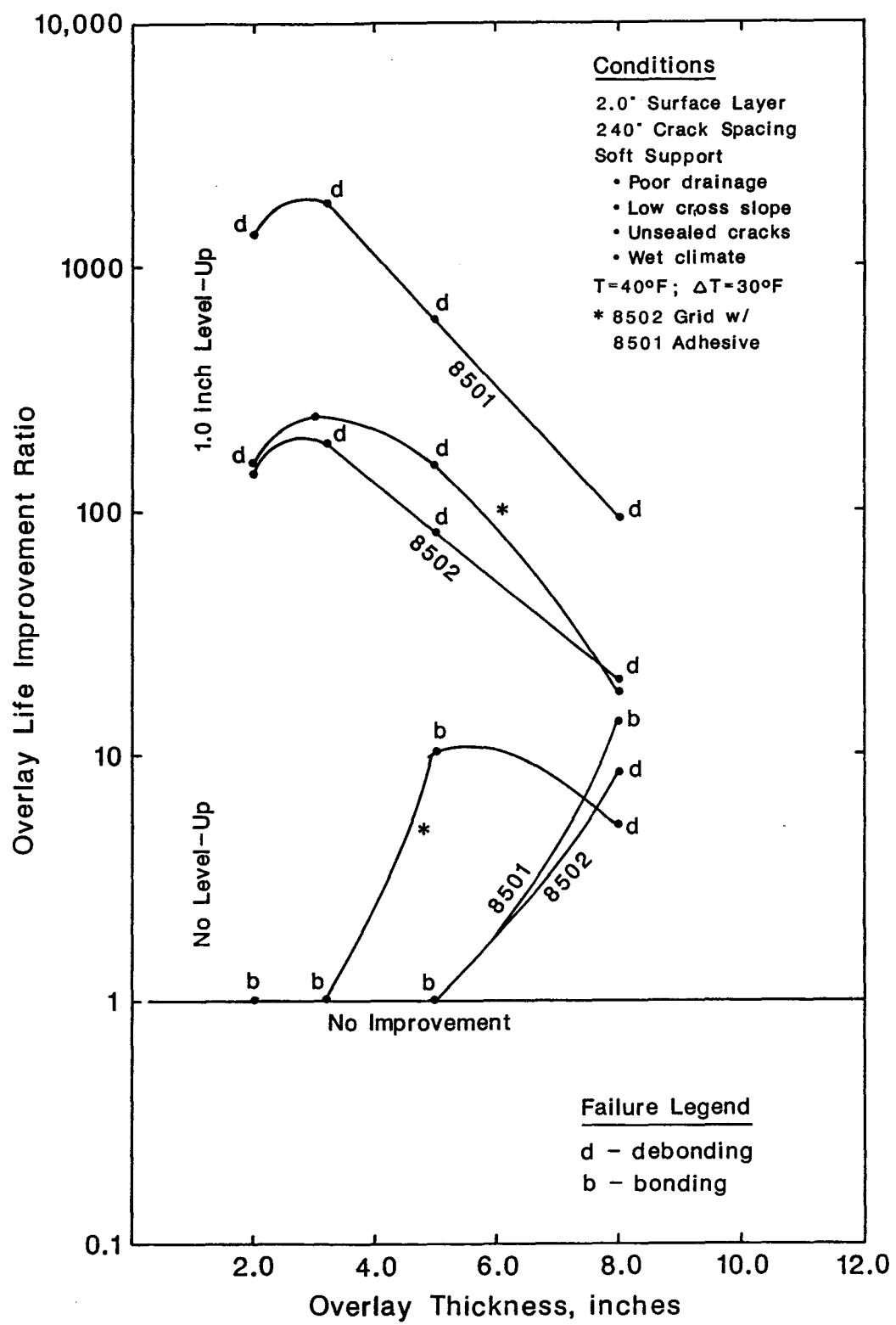


Figure 5-4.

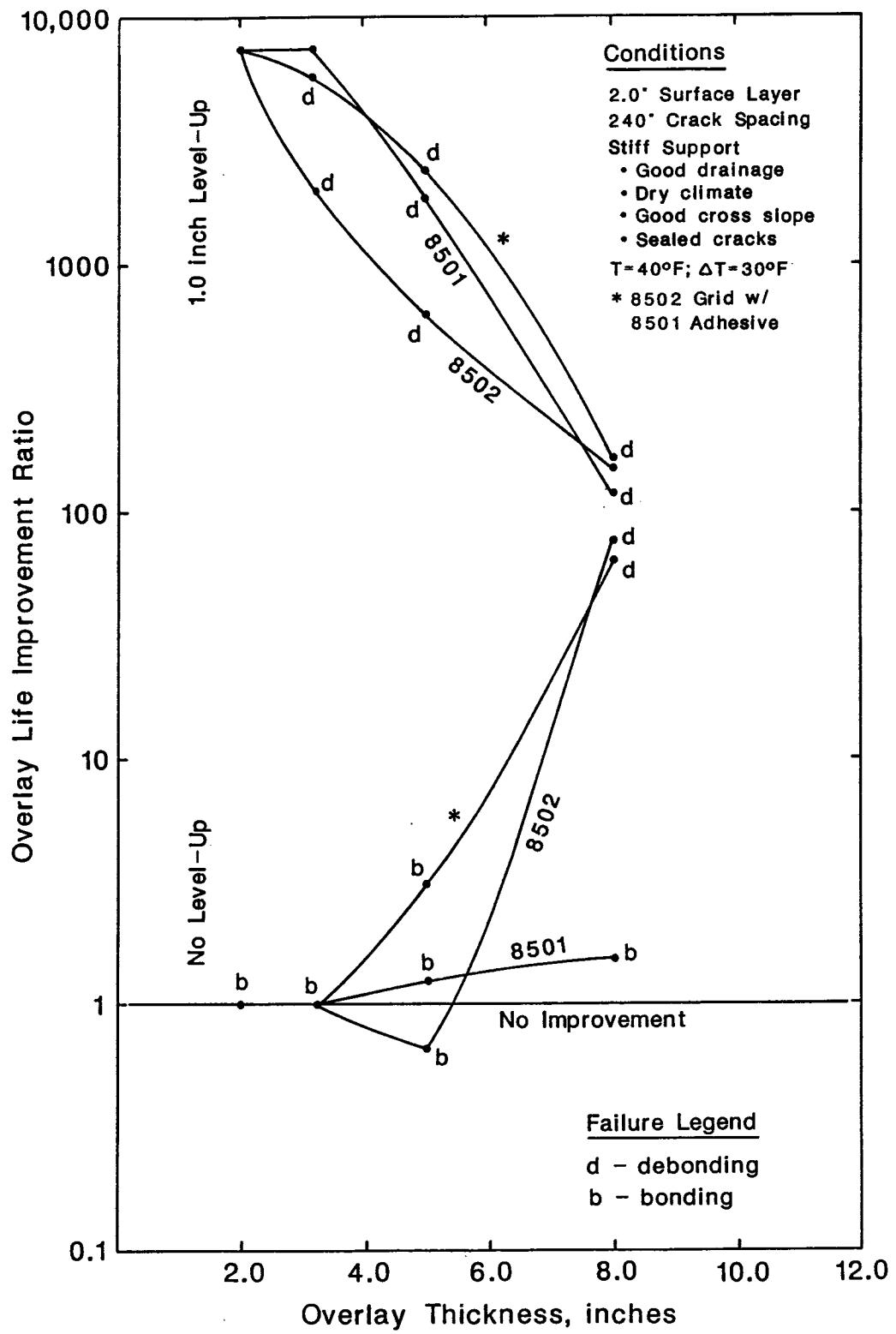


Figure 5-5.

grid was paired with the equations for the adhesive normally used with the 8501 grid. This combination did not work as well as the 8501 grid when a 1-inch level-up was used but was frequently the best combination when placed directly on the old pavement surface. Whether this hypothetical combination is a practical one or not is a practical question that can not be answered here. It does illustrate, however, the fact that such investigations can be made with the program of materials that have not been fabricated as yet but are being considered as candidates for manufacture.

An example of such a study is illustrated in Figure 5-6, where a low modulus fabric was placed on the surface of the old pavement and on a one-inch level-up course. The reflection cracking life of various thicknesses of overlay were predicted and compared with the life of the same thickness of overlay without the fabric layer, resulting in an overlay life improvement ratio, as before.

The fabric layer placed directly on the old pavement surface adds practically no life to the overlay except in the odd case of soft support and lower mean annual air temperature ($T = 40^{\circ}\text{F}$).

The fabric layer placed on a one-inch level-up produced an overlay reflection cracking life of over 20 years in all cases. All crack growth computations were cut off at the 20-year mark. Thus, the reason that the "overlay life improvement ratio" decreases with increasing overlay thickness is because the thicker control overlays without the fabric lasted longer than the thinner ones. The longer life of the thicker overlay divided into a constant 7300 days (20 years) for the overlays

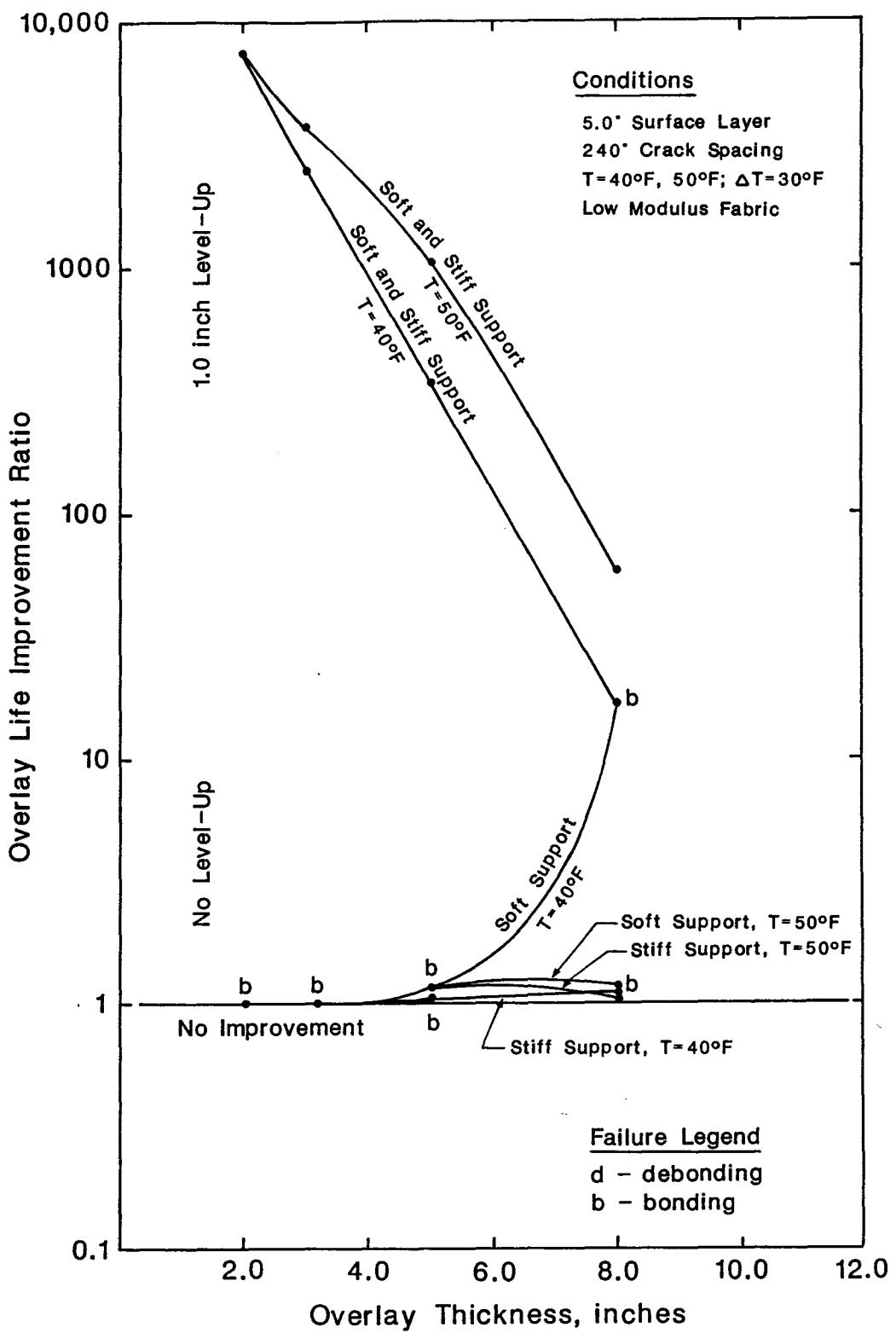


Figure 5-6.

with a one-inch level-up gives a smaller "life improvement ratio" than with the thinner overlays.

In this case, the low modulus fabric does not reinforce the overlay as is evident with the fabric placed directly on the old pavement. The fabric placed on a one-inch level-up was represented in the computer program by a fabric modulus together with the equations for the 8501 adhesive. It is believed that the one-inch level-up and the adhesive are the principal reasons for the predicted extended life of the overlay.

6. Conclusions

The conclusions to this study of the use of fiberglass grids as reinforcing layers in overlays to prevent or retard reflection cracking has produced a number of positive results. Reflection cracking is produced by a combination of thermal contraction and traffic stresses, both of which are represented in the computer program that was used in this study to extend and extrapolate the results of the laboratory tests.

Numerous runs were made with the program encompassing a wide variety of pavement conditions: traffic, temperature and daily temperature change, subgrade support, old pavement surface thickness, average crack spacing, new overlay thickness, with and without a one-inch level-up course, and with and without a reinforcing grid or fabric.

It was found clearly that the one-inch level-up course is very important in extending the life of the overlay. The fiberglass grid and its adhesive also contribute to extended life. The best grid tested was the combination of grid and adhesive number 8501 under all conditions.

The best conditions for prolonged reflection cracking life are a small crack spacing, a one-inch leveling course, stiff subgrade support,

and good drainage, with good cross slope, and sealed cracks in the old pavement surface. Because the grid can not resist traffic shearing forces well, a pavement with voids beneath the joints or cracks will reflect cracks rapidly. Fiberglass grids which are placed on pavements with poor load transfer across the joints or cracks will not work well and will probably be blamed for the poor reflection cracking performance that is, in any case, inevitable. It is best not to place an overlay, with or without a fiberglass grid for reinforcing, until the voids are filled and good load transfer is restored.

It is recommended that the 8501 grid and adhesive are the best combination to use to retard reflection cracking. These should be placed on a one-inch leveling course which is placed on the surface of a cracked or jointed pavement. Voids beneath the cracks or joints should be under-sealed and load transfer should be restored before placing the overlay. The computer program provided with this report can be used to determine the thickness of the overlay that is needed to provide the desired reflection cracking life of the pavements for specific traffic, weather, and support conditions.

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APPENDIX A

Program List

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*      THIS PROGRAM WAS PREPARED FOR THE BAY MILLS LIMITED *
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REFLECTION CRACKING ANALYSIS BY FRACTURE MECHANICS

THIS PROGRAM COMPUTES THE NUMBER OF DAYS(NTL) TO CRACK THE
OVERLAYER OF THE PAVEMENT FROM AN INITIAL CRACK
LENGTH(CO) TO A FINAL CRACK LENGTH(DF)

DEFINITION OF INPUT VARIABLES

```

NFLG      = 0, CALCULATE NTL WHEN ND IS PRESET
           1, CALCULATE NTL WHEN ND IS NOT PRESET
           (ND IS INFINITE. IN THIS PROGRAM, ND=7300)
IFLG      = 0, IF FRACTURE PARAMETERS AND E ARE READ INTO
           DIRECTLY
           = 1, IF FRACTURE PARAMETERS AND E ARE CALCULATED
           FROM FW, AT,T, AND IT
INDEX     = CONTROLLING FACTOR FOR REGRESSION BETWEEN FRACTURE
           PARAMETERS
           1, INTERCEPT.NE.0
           2, INTERCEPT.EQ.0
NCASE     = 0, WITHOUT FABRIC CASE
           1, WITH FABRIC CASE
TITL      = TITLE OF THE PROBLEM
ND        = MAXIMUM NUMBER OF DAYS THAT CALCULATIONS WILL BE
           CARRIED OUT
NL        = NUMBER OF LOADS PER DAY( 18 KIPS EQUIVALENT LOAD)
G         = RATIO OF TENSILE STRAIN DEPTH TO EFFECTIVE DEPTH(DF-C)
NTL       = NUMBER OF DAYS WHEN THE FRACTURE MECHANICS ANALYSIS
           IS TERMINATED BY NORMAL ROUTINE OR BY
           SOME OTHER REASONS
NSF       = SHIFTING FACTOR TO CONVERT LABORATORY DATA TO
           FIELD DATA(HERE,NSF=13)
CO        = INITIAL CRACK LENGTH(INCH)
C         = CRACK LENGTH AT CERTAIN LOAD APPLICATIONS(IN)
CS        = EXISTING CRACK SPACING IN THE OLD SURFACE COURSES
           (INCHES)
DELT      = TEMPERATURE DIFFERENCE BELOW STRESS FREE TEMPERATURE
           (DEGREE FAHRENHEIT)
ADELT    = AVERAGE TEMPERATURE DIFFERENCE BETWEEN THE DEPTH
           (DEGREE FAHRENHEIT)
DF        = DEPTH OF OVERLAY(DO + DU)
DO        = DEPTH OF OVERLAY ABOVE THE FABRIC
DU        = DEPTH OF OVERLAY BELOW THE FABRIC
DS        = DEPTH OF OLD PAVEMENT
CA , SN  = FRACTURE PARAMETERS OF THE OVERLAY FOR BENDING AND
           SHEARING REFLECTION CRACKING(ASSUMED THAT BENDING
           CASE AND SHEAR CASE ARE SAME)
CA3,SN3  = FRACTURE PARAMETERS OF THE OVERLAY FOR THERMAL
           REFLECTION CRACKING
RA,RQ   = REGRESSION COEFFICIENTS BETWEEN THE NONDIMENSIONAL
           STRESS INTENSITY FACTORS AND (C/DF) VALUES
           (RA1,RQ1 : FOR BENDING FATIGUE CASE)
           (RA2,RQ2 : FOR SHEARING FATIGUE CASE)
           (RA3,RQ3 : FOR THERMAL FATIGUE CASE)
SIGMA    = SURFACE TRACTION DUE TO THE TRAFFIC LOAD(PSI)
ALPHA    = COEFFICIENT OF THERMAL EXPANSION OF THE OLD SURFACE
           COURSES(PER DEGREE FAHRENHEIT)
EF        = MODULUS OF ELASTICITY OF THE FABRIC(PSI)
EMF      = EQUIVALENT MODULUS OF ELASTICITY OF THE FABRIC(PSI)
           THIS VALUE IS CALCULATED AS FOLLOWS:
           EMF=((N × PI × TF)/(4 × FS)) × EF
           WHERE,
NS       = NO. OF STRANDS AT SPACING
E        = TENSILE RELAXATION MODULUS OF THE COMPOSITE OVERLAY
           MATERIAL(PSI). E AT THE FABRIC LEVEL WHEN CRACK
           REACHES AT THE FABRIC LEVEL FOR THERMAL CRACKING
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C      EO      = MODULUS OF ELASTICITY OF OVERLAY
C      ATL     = TRAFFIC LOAD LENGTH(IN)
C      ASL     = OVERLAY SLAB LENGTH(IN)
C      AWL    = LENGTH WITHIN WHICH THE SHEARING STRESS DISTRIBUTION
C                  BECOMES NEGLIGIBLE(ASSUMED TO BE THE SPACING BETWEEN
C                  CRACKS)
C      AK      = MODULUS OF OLD SURFACE REACTION(PCI)
C      AW      = FABRIC WIDTH(IN)
C      TF      = FABRIC THICKNESS(IN)
C      FS      = STRAND SPACING(IN)
C      AKO     = SHEAR STIFFNESS OF TACK COAT
C      TAUMIN  = MINIMUM SHEAR STRENGTH OF THE FABRIC(OR TACKCOAT)
C      TAUS    = SHEAR STRENGTH OF THE FABRIC(OR TACKCOAT)
C      NTAU    = O, BONDED CASE
C                  = 1, DEBONDED CASE
C      MTYPE   = 1, FABRIC WITHOUT SEAL COAT(MATERIAL ID = 8501)
C                  2, FABRIC WITH SEAL COAT(MATERIAL ID = 8502)
C      S       = SPECIFIC HEAT OF THE OVERLAY MATERIAL
C                  (BTU PER POUND , DEGREE FAHRENHEIT)
C      W       = DENSITY OF THE MATERIAL(PCF)
C      SK      = THERMAL CONDUCTIVITY OF THE OVERLAY MATERIAL
C                  (BTU PER SQ. FT PER HOUR , DEGREE FAHRENHEIT PER FT)
C      V       = WIND VELOCITY(MPH)
C      IAIF    = AGGREGATE INTERLOCKING FACTOR
C                  1, FOR LOW INTERLOCKING
C                  2, FOR MEDIUM INTERLOCKING
C                  3, FOR HIGH INTERLOCKING
C      FW      = UNIT WEIGHT OF THE FABRIC(OZ PER SQ. YARD)
C      AT      = ACTUAL TACK COAT RATE USED DURING FABRIC INSTALLATION
C                  (GAL. PER SQ. YARD)
C      T       = AIR TEMPERATURE(DEGREE FAHRENHEIT)
C      IT      = O, FOR FABRIC WITHOUT TACK COAT DURING INSTALLATION
C                  1, FOR FABRIC WITH TACK COAT DURING INSTALLATION
C      A1 - A5  = MODIFICATION FACTORS BY DAMAGE LEVEL
C
C -----
C
C      INPUT DATA PREPARATION
C -----

```

```

C      CARD SET 1 : NFLG,NCASE
C                  (2I2)
C
C      CARD SET 2 : IFLG,INDEX,NTAU,MTYPE,TITL
C                  (4I2,6O1)
C
C      CARD SET 3 : ND,NL,CO,CS,DELT,DF,DS(,SN,SN3)
C                  (2I10,7F8.0)
C                  - IF IFLG.EQ.O, DATA SN,SN3 ARE NOT NEEDED
C
C      CARD SET 4 : SIGMA,EF,ALPHA(,E,CA,CA3)
C                  (2F10.0,4E14.7)
C                  - IF IFLG.EQ.O, DATA E,CA,CA3 ARE NOT NEEDED
C
C      CARD SET 5 : NSF,NS,FS,ATL,AK,AW,TF,ASL,DU,AWL
C                  (2I2,8F8.0)
C
C      CARD SET 6 : S,W,SK,T,V,IAIF
C                  (5F10.0,I2)
C
C      CARD SET 7 : FW,AT,IT
C                  (2F10.0,I5)
C                  - IF IFLG.EQ.O, CARD SET 7 IS NOT NEEDED
C
C      CARD SET 8 : A1,A2,A3,A4,A5
C                  (5F10.5)
C
C -----

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```

IMPLICIT REAL*8(A-H,O-Z)
CHARACTER *1 TITL
COMMON/COEF/DD(5),RA(5),RQ(5),R(5)
COMMON/INTGR/MTYPE
COMMON/XX/XX1(6),XX2(10),XX3(8)
COMMON/YY/YY1(6,3,3),YY2(10,3,3),YY3(8,3)
COMMON/XY/X(11),Y(11)
DIMENSION TITL(60)
OPEN(UNIT=5,FILE='BAY.DAT',STATUS='OLD')

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```

      OPEN(UNIT=6,FILE='BAY.OUT',STATUS='NEW')
1000 READ (5,500,END=2000) NFLG,NCASE
      READ (5,501) IFLG,INDEX,NTAU,MTYPE,TITL
      WRITE(6,600) TITL
C
C      DETERMINE WHICH ANALYSIS IS CARRIED OUT
C
C      IF (NFLG.EQ.0) THEN
C          WRITE(6,401) NFLG
C      ELSEIF(NFLG.EQ.1) THEN
C          WRITE(6,402) NFLG
C      ENDIF
C
C      DETERMINE IF THERE EXISTS FABRIC OR NOT
C
C      IF(NCASE.EQ.0) THEN
C          WRITE(6,601) NCASE
C          GO TO 341
C      ELSEIF(NCASE.EQ.1) THEN
C          WRITE(6,602) NCASE
C      ENDIF
C
341 READ(5,520) ND,NL,CO,CS,DELT,DF,DS,SN,SN3
      READ(5,540) SIGMA,EF,ALPHA,E,CA,CA3
      READ(5,541) NSF,NS,FS,ATL,AK,AW,TF,ASL,DU,AWL
      IF(NTAU.EQ.0) THEN
          WRITE(6,611) NTAU
      ELSE
          WRITE(6,612) NTAU
      ENDIF
C
C      DETERMINE WHICH MATERIAL USED
C
C      IF(MTYPE.EQ.1) THEN
C          WRITE(6,551) MTYPE
C      ELSE
C          WRITE(6,552) MTYPE
C      ENDIF
C
      READ(5,545) S,W,SK,T,V,IAIF
      WRITE(6,610) S,W,SK,T,V,IAIF
      IF(IFLG.EQ.1) THEN
          READ(5,550) FW,AT,IT
          WRITE(6,620) FW,AT,IT
          CALL PARMTR(FW,AT,T,IT,DF,SN,SN3,CA,CA3,E,INDEX)
      ENDIF
C
C      READ AND PRINT MODIFICATION FACTORS
C
      READ(5,549) A1,A2,A3,A4,A5
      WRITE(6,666) A1,A2,A3,A4,A5
C
C      CONVERT TRAFFIC LOAD RELATED FATIGUE PARAMETER
C
C      CA=CA/NSF
C
      IF(MTYPE.EQ.1) THEN
          TAUMIN=6.220000-0.02191*(T-34)
          AK0=43312.28-100.375*(T-34)
      ELSEIF(MTYPE.EQ.2) THEN
          TAUMIN=9.325126-0.08056*(T-34)
          AK0=52580.66-530.432*(T-34)
      ENDIF
C
C      IF NFLG.EQ.1, SET ND IS EQUAL TO INFINITE
C
C      IF(NFLG.EQ.1) ND=7300
C
C      SET N1=1(DF=2") OR N1= 2(DF=5") OR N1= 3(DF=8")
C
C          IF(DF.EQ.2.0D+00) THEN
C              N1=1
C          ELSEIF(DF.EQ.5.0D+00) THEN
C              N1=2
C          ELSEIF(DF.EQ.8.0D+00) THEN
C              N1=3
C          ENDIF
C
C      CALCULATE THE AVERAGE TEMPERATURE VARIATION BETWEEN THE

```

```

C      DEPTH(OVERLAY BELOW FABRIC PLUS OLD PAVEMENT)
C
C      DO=DF-DU
C      D=(DU+DS)/12.0
C      D1=(DF+DS)/12.0
C      DO=DO/12.0
C
C      SH=1.3+0.62*V**(.3.0/4.0)
C      RH=SH/SK
C      SC=SK/(S*W)
C      RC=(0.131/SC)**0.5
C
C      ADEN=RH*(DEXP(-DO*RC)-DEXP(-D1*RC))
C      ANOM=D*RC*((RH+RC)**2.0+RC**2.0)**0.5
C      ADELT=DELT*ADEN/ANOM
C
C      WRITE(6,630) CO,CS,DF,DS,DELT,ADELT,SN,SN3,ND,NL
C      IF(DU.EQ.0.0) DU=1.0E-10
C
C      IF(NCASE.EQ.0) EF=0.0
C
C      PI=3.1415926
C      EMF=(EF*PI*TF*NS)/(4.0*FS)
C      EO=1.5E+05
C      IF(NTAU.EQ.0) THEN
C          AWL=ASL
C          BETAFF=(AKO/EO*DU)**0.5
C          FX=BETAFF*AWL*0.5
C          TAUS=AKO*(DCOSH(FX)-1)/(BETAFF*DSINH(FX))
C      ELSE
C          AWL=ASL
C          TAUS=TAUMIN*AWL*0.5
C      ENDIF
C      WRITE(6,621) NSF,NS,ATL,AK,AW,TF,FS,AKO,ASL,TAUMIN,DU,AWL
C      WRITE(6,640) ALPHA,CA,CA3,E,SIGMA,EMF,TAUS
C
C      C1 = CO
C      NTL = O
C
C      IN CASE OF FABRIC DEPENDING ON CONTROLLING
C      FACTOR NCASE
C
C      U = CS*ALPHA*ADELT
C      DX=DF/24.00D+00
C      PX=DEXP(-((0.131D+00*S*W/SK)**0.5D+00)*DX)
C
C      CALCULATE REGRESSION COEFFICIENTS AND R SQuRE VALUE
C
C      CALL COEFF(1,DF,IAIF,DA,DQ,R2)
C          RA1=DA
C          RQ1=DQ
C          RSQ1=R2
C      CALL COEFF(2,DF,IAIF,DA,DQ,R2)
C          RA2=DA
C          RQ2=DQ
C          RSQ2=R2
C      CALL COEFF(3,DF,IAIF,DA,DQ,R2)
C          RA3=DA
C          RQ3=DQ
C          RSQ3=R2
C
C      ZU=DU/DF
C
C      DO 300 I=1,ND
C      J=I
C      NTL=NTL+NL
C
C      IF(IAIF.EQ.1.OR.IAIF.EQ.2) THEN
C          IF(Z.LE.0.55) THEN
C              GO TO 47
C              ELSE
C              GO TO 36
C          ENDIF
C      ELSEIF(IAIF.EQ.3) THEN
C          IF(Z.LE.0.45) THEN
C              GO TO 47
C              ELSE
C              GO TO 36
C          ENDIF
C      ENDIF

```

```

C
CC      IF Z IS LESS THAN THE LIMIT VALUES
C
C      COMPUTE THE CHANGE IN CRACK LENGTH DUE TO SHEARING FATIGUE MODE
C
47  Z=C1/DF
Z1=1.0-Z
IF(Z1.LT.1.0E-05) Z1=1.0E-05
BETA=(3.0*AK/(EO*DF**3.0*Z1**3.0))**0.25
BE=BETA*ATL
FF=0.25*DEXP(-BE)*DSIN(BE)
C
IF(FF.LE.0.0) GO TO 6780
C
G=(2.0+Z-3.0*ZU)/(3.0*(1+Z-2.0*ZU))
C
EYPNOM=12.0*SIGMA*DF**0.5*(G*Z1+(Z-ZU))*FF
EYPDEN=(3.0*EO*Z1**3.0*AK)**0.5
EYPSIL=EYPNOM/EYPDEN
C
A=EMF*TF*EYPSIL-TAUS*U*TF
TENSON=2.0*G*A/((1.0-2.0*G)*DF*Z1)
IF(TENSON.LT.0.0) TENSON=-TENSON
FAC=TENSON*(DEXP(RA2*Z**2+RQ2))*DF**0.5
DF1=FAC**SN*(A2/A1)
DC1=CA*DF1*N
C1=C1+DC1
IF(C1.GE.DF) GO TO 6789
C
C      COMPUTE THE CHANGE IN CRACK LENGTH DUE TO BENDING FATIGUE MODE
C
Z=C1/DF
Z1=1.0-Z
IF(Z1.LT.1.0E-05) Z1=1.0E-05
BETA=(3.0*AK/(EO*DF**3.0*Z1**3.0))**0.25
BE=BETA*ATL
FF=0.5*DEXP(-0.5*BE)*DSIN(0.5*BE)
C
IF(FF.LE.0.0) GO TO 6780
C
G=(2.0+Z-3.0*ZU)/(3.0*(1+Z-2.0*ZU))
C
EYPNOM=12.0*SIGMA*DF**0.5*(G*Z1+(Z-ZU))*FF
EYPDEN=(3.0*EO*Z1**3.0*AK)**0.5
EYPSIL=EYPNOM/EYPDEN
C
A=EMF*TF*EYPSIL-TAUS*U*TF
TENSON=2.0*G*A/((1.0-2.0*G)*DF*Z1)
IF(TENSON.LT.0.0) TENSON=-TENSON
FAC=TENSON*(RA1*Z**3+RQ1)**(1/3)*DF**0.5
DF1=FAC**SN*(A3/A1)
DC1=CA*DF1*N
C1=C1+DC1
IF(C1.GE.DF) GO TO 6789
C
C      COMPUTE THE CHANGE IN CRACK LENGTH DUE TO SHEARING FATIGUE MODE
C
Z=C1/DF
Z1=1.0-Z
IF(Z1.LT.1.0E-05) Z1=1.0E-05
BETA=(3.0*AK/(EO*DF**3.0*Z1**3.0))**0.25
BE=BETA*ATL
FF=0.25*DEXP(-BE)*DSIN(BE)
C
IF(FF.LE.0.0) GO TO 6780
C
G=(2.0+Z-3.0*ZU)/(3.0*(1+Z-2.0*ZU))
C
EYPNOM=12.0*SIGMA*DF**0.5*(G*Z1+(Z-ZU))*FF
EYPDEN=(3.0*EO*Z1**3.0*AK)**0.5
EYPSIL=EYPNOM/EYPDEN
C
A=EMF*TF*EYPSIL-TAUS*U*TF
TENSON=2.0*G*A/((1.0-2.0*G)*DF*Z1)
IF(TENSON.LT.0.0) TENSON=-TENSON
FAC=TENSON*(DEXP(RA2*Z**2+RQ2))*DF**0.5
DF1=FAC**SN*(A2/A1)
DC1=CA*DF1*N
C1=C1+DC1
IF(C1.GE.DF) GO TO 6789

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C      COMPUTE THE CHANGE IN CRACK LENGTH DUE TO THERMAL FATIGUE MODE
C
Z=C1/DF
  FAC=0.5*E*U*(RA3*(DLOG(Z))+RQ3)*DF**(-0.5)
  IF(FAC.LT.0.0) FAC=-FAC
  DF2=FAC**SN3/A1
  DC1=CA3*DF2
  C1=C1+DC1
  IF(C1.GE.DF) GO TO 6789
  GO TO 300
C
CC  IF Z IS LARGE THAN THE LIMIT VALUES
C
C      COMPUTE THE CHANGE IN CRACK LENGTH DUE TO SHEARING FATIGUE MODE
C
36 Z=C1/DF
  Z1=1.0-Z
  IF(Z1.LT.1.0E-05) Z1=1.0E-05
  BETA=(3.0*AK/(E0*DF**3.0*Z1**3.0))**0.25
  BE=BETA*ATL
  FF=0.25*DEXP(-BE)*DSIN(BE)
C
  IF(FF.LE.0.0) GO TO 6780
C
  G=(2.0+Z-3.0*ZU)/(3.0*(1+Z-2.0*ZU))
C
  EYPNOM=12.0*SIGMA*DF**0.5*(G*Z1+(Z-ZU))*FF
  EYPDEN=(3.0*E0*Z1**3.0*AK)**0.5
  EYPSIL=EYPNOM/EYPDEN
C
  A=EMF*TF*EYPSIL-TAUS*U*TF
  TENSOR=2.0*G*A/((1.0-2.0*G)*DF*Z1)
  IF(TENSOR.LT.0.0) TENSOR=-TENSOR
  FAC=TENSOR*(DEXP(RA2*Z**2+RQ2))*DF**0.5
  DF1=2*FAC**SN*(A5/A4)
  DC1=CA*DF1*NL
  C1=C1+DC1
  IF(C1.GE.DF) GO TO 6789
C
C      COMPUTE THE CHANGE IN CRACK LENGTH DUE TO THERMAL FATIGUE MODE
C
Z=C1/DF
  FAC=0.5*E*U*(RA3*(DLOG(Z))+RQ3)*DF**(-0.5)
  IF(FAC.LT.0.0) FAC=-FAC
  DF2=FAC**SN3/A4
  DC1=CA3*DF2
  C1=C1+DC1
  IF(C1.GE.DF) GO TO 6789
300 CONTINUE
6789 CONTINUE
  IF(C1.GE.DF) C1=DF
  WRITE(6,650) J,NTL,C1
  GO TO 1000
6780 CONTINUE
  WRITE(6,441)
  IF(C1.GE.DF) C1=DF
  WRITE(6,650) J,NTL,C1
  GO TO 1000
500 FORMAT(2I2)
501 FORMAT(4I2,6O1)
520 FORMAT(2I10,7F8.0)
540 FORMAT(2F10.0,4E14.7)
541 FORMAT(2I2,8F8.0)
545 FORMAT(5F10.0,I2)
549 FORMAT(5F10.5)
550 FORMAT(2F10.0,I5)
600 FORMAT(1H1,5(/), 5X, 'REFLECTION CRACKING PROGRAM',//,
  1      5X, 'TEXAS TRANSPORTATION INSTITUTE',//,
  2      5X, 'TEXAS A & M UNIVERSITY',//,
  3      5X, 'COLLEGE STATION, TEXAS 77843',//,
  4      5X, 6O1)
401 FORMAT(//,5X,'NFLG = ',2X,I5,' ( FRACTURE ANALYSIS TO CALCULATE
  1 NTL WHEN ND IS PRESET ) ')
402 FORMAT(//,5X,'NFLG = ',2X,I5,' ( FRACTURE ANALYSIS TO CALCULATE
  1 NTL WHEN ND IS INFINITE ) ')
601 FORMAT(//,5X,'NCASE= ',2X,I5,' ( WITHOUT FABRIC CASE ) ',/)
602 FORMAT(//,5X,'NCASE= ',2X,I5,' ( WITH FABRIC CASE ) ',/)
610 FORMAT(//,5X,'S   = ', F10.3,5X, 'W   = ', F10.3,
  1      5X,'SK   = ', F10.3,/, 59

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2      5X 'T    = ', F10.3,5X,   'V    = ',F10.3,
3      5X,'IAIF= ',I10)
551 FORMAT(//,5X,'MTYPE=' ,2X,I5,' ( MATERIAL TYPE 8501 )')
552 FORMAT(//,5X,'MTYPE=' ,2X,I5,' ( MATERIAL TYPE 8502 )')
611 FORMAT(//,5X,'NTAU = ',2X,I5,' ( BONDED CASE )')
612 FORMAT(//,5X,'NTAU = ',2X,I5,' ( DEBONDED CASE )')
620 FORMAT(5X,'FW  = ',F10.3,5X,'AT  = ',F10.3, 5X,'IT  = ',I10,//)
621 FORMAT(//,5X,'NSF   = ',I10,10X,   'NS   = ',I10./,
1      5X,'ATL  = ',F10.3,10X, 'AK   = ',F10.3./,
2      5X,'AW  = ',F10.3,10X, 'TF   = ',F10.3./,
3      5X,'FS  = ',F10.3,10X, 'AKO  = ',F10.3./,
4      5X,'ASL  = ',F10.3,10X, 'TAUMIN= ',F10.3./,
5      5X,'DU  = ',F10.3,10X, 'AWL  = ',F10.3,//)
630 FORMAT(//,5X,'CO  = ',F10.3,10X, 'CS  = ',F10.3./,
1      5X,'DF  = ',F10.3,10X, 'DS  = ',F10.3./,
2      5X,'DELT = ',F10.3,10X, 'ADELT = ',F10.3./,
3      5X,'SN  = ',F10.3,10X, 'SN3  = ',F10.3./,
4      5X,'ND  = ',I10, 10X, 'NL  = ',I10,//)
640 FORMAT(//,5X,'ALPHA = ',E14.7, 5X, 'CA  = ',E14.7./,
1      5X,'CA3 = ',E14.7, 5X, 'E   = ',E14.7./,
2      5X,'SIGMA = ',E14.7, 5X, 'EMF = ',E14.7./,
3      5X,'TAUS = ',E14.7,//)
666 FORMAT(//,5X,'A1  = ',E14.7, 5X, 'A2  = ',E14.7./,
1      5X,'A3  = ',E14.7, 5X, 'A4  = ',E14.7./,
2      5X,'A5  = ',E14.7,//)
441 FORMAT(//,5X,'MOMENT HAS NEGATIVE VALUE',//)
650 FORMAT(///,
1      5X,'NUMBER OF DAYS          = ',I10./,
2      5X,'NUMBER OF TOTAL LOADS   = ',I10./,
3      5X,'FINAL CRACK LENGTH     = ',F10.5//)
2000 STOP
END
SUBROUTINE PARMTR(FW,AT,T,IT,DF,SN,SN3,CA,CA3,E,INDEX)
C
C COMPUTE THE FRACTURE PARAMETERS SN,SN3,CA,CA3, AND THE
C TENSILE RELAXATION MODULUS E FROM FW,AT
C
IMPLICIT REAL*8(A-H,O-Z)
COMMON/INTGR/MTYPE
SN3=3.5
C
AIN=-0.5+(T-34)*0.018-0.18*(DF-3.0)-0.6*IT
IF(INDEX.EQ.1)THEN
DUM1=-2.834-1.255*SN3
DUM1=-1.32421-1.43707*SN3
CA3=10.0**DUM1
ELSE IF(INDEX.EQ.2)THEN
DUM1=-1.255*SN3
DUM1=-1.43707*SN3
CA3=10.0**DUM1
ENDIF
SN =0.9118D+00 + 3.6311D+00*SN3 - 0.8657D+00*SN3**2
IF(SN.LT.2.0D+00) SN=0.50D+00*SN3
DUM1 = -(SN+4.3448D+00)/0.4921D+00
CA= 10.0D+00**DUM1
E=480.5506+3399.0121*AT+58.7209*FW
IF(MTYPE.EQ.1) THEN
E=15541.67-567.401*(T-34)
ELSE
E=35809.75-401.459*(T-34)
ENDIF
RETURN
END
SUBROUTINE INTERP(N3,DK,C1,DF)
C
C INTERPOLATE THE NONDIMENSIONAL STRESS INTENSITY FACTORS
C CORRESPONDING TO THE (C/DF) VALUES FOR 2",5", AND 8"
C OVERLAYS
C
IMPLICIT REAL*8(A-H,O-Z)
COMMON/XY/X(11),Y(11)
C = C1/DF
I =1
DO 1000 I=1,N3
IF(C.LT.X(I)) GO TO 1100
1000 CONTINUE
1100 J = I-1
DK =Y(J)+(Y(I)-Y(J))*(C-X(J))/(X(I)-X(J))
RETURN
END
BLOCK DATA

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C      STORE THE NONDIMENSIONAL STRESS INTENSITY FACTORS(Y COORNATES)
C      CORRESPONDING TO (C/DF) VALUES(X COORDINATES) FOR BENDING, SHEARING,
C      AND THERMAL REFLECTION CRACKING FOR 2", 5", AND 8" OVERLAYS AS
C      BLOCK DATA
C
C      -----
C      ARRAY      ELEMENTS          DESCRIPTION          AIF
C      -----
C      XX1       1 - 6             (C/DF) VALUES        -
C
C      YY1       1 - 6             2 IN.              LOW
C                  7 - 12            2 IN.              MED.
C                  13 - 18            2 IN.              HIGH
C                  19 - 24            5 IN.              LOW
C                  25 - 30            5 IN.              MED.
C                  31 - 36            5 IN.              HIGH
C                  37 - 42            8 IN.              LOW
C                  43 - 48            8 IN.              MED.
C                  47 - 54            8 IN.              HIGH
C      XX1 AND YY1(BENDING)    - 6 ELEMENTS FOR EACH CASE
C      XX2 AND YY2(SHEARING)   - 10 ELEMENTS FOR EACH CASE
C      XX3 AND YY3(THERMAL)   - 8 ELEMENTS FOR EACH CASE
C
C*****
C      USING AGGREGATE INTERLOCKING FACTOR
C*****
IMPLICIT REAL*8(A-H,O-Z)
COMMON/XX/XX1(6),XX2(10),XX3(8)
COMMON/YY/YY1(6,3,3),YY2(10,3,3),YY3(8,3)
DATA XX1/
*0.0500DO,0.1500DO,0.2500DO,0.3500DO,0.4500DO,0.5500DO/
DATA XX2 /
*0.0500DO,0.1500DO,0.2500DO,0.3500DO,0.4500DO,0.5500DO,0.6500DO,
*0.7500DO,0.8500DO,0.9500DO/
DATA XX3 /
*0.0500DO,0.1500DO,0.2500DO,0.3500DO,0.4500DO,0.5500DO,0.6500DO,
*0.7500DO/
DATA YY1/
*1.0660DO,1.3895DO,1.4469DO,1.3214DO,1.0483DO,0.6408DO,1.0395DO,
*1.3073DO,1.2931DO,1.0970DO,0.7752DO,0.3403DO,1.0156DO,1.1438DO,
*0.9820DO,0.6735DO,0.2943DO,0.0000DO,0.6742DO,0.8788DO,0.9151DO,
*0.8357DO,0.6630DO,0.4053DO,0.6574DO,0.8268DO,0.8178DO,0.6937DO,
*0.4903DO,0.2152DO,0.6423DO,0.7234DO,0.6211DO,0.4260DO,0.1862DO,
*0.0000DO,0.5330DO,0.6947DO,0.7235DO,0.6607DO,0.5241DO,0.3204DO,
*0.5197DO,0.6536DO,0.6466DO,0.5485DO,0.3876DO,0.1702DO,0.5078DO,
*0.5719DO,0.4910DO,0.3368DO,0.1472DO,0.0000DO/
DATA YY2/
*0.3217DO,0.4428DO,0.6019DO,0.7946DO,0.8971DO,1.0624DO,1.2896DO,
*1.5609DO,1.9048DO,2.2230DO,0.2749DO,0.3925DO,0.5427DO,0.6903DO,
*0.8123DO,0.9599DO,1.1623DO,1.3948DO,1.6794DO,1.9216DO,0.1892DO,
*0.3032DO,0.4305DO,0.5471DO,0.6249DO,0.7540DO,0.8848DO,1.0439DO,
*1.1968DO,1.3479DO,0.2035DO,0.2801DO,0.3897DO,0.5026DO,0.5674DO,
*0.6720DO,0.8156DO,0.9872DO,1.2047DO,1.4059DO,0.1739DO,0.2482DO,
*0.3433DO,0.4366DO,0.5138DO,0.6071DO,0.7351DO,0.8821DO,1.0621DO,
*1.2153DO,0.1196DO,1.1918DO,0.2723DO,0.3460DO,0.3952DO,0.4769DO,
*0.5596DO,0.6602DO,0.7569DO,0.8525DO,0.1609DO,0.2214DO,0.3010DO,
*0.3973DO,0.4486DO,0.5312DO,0.6448DO,0.7805DO,0.9524DO,1.1115DO,
*0.1375DO,0.1962DO,0.2714DO,0.3452DO,0.4062DO,0.4800DO,0.5812DO,
*0.6974DO,0.8397DO,0.9608DO,0.0946DO,0.1516DO,0.2152DO,0.2736DO,
*0.3125DO,0.3770DO,0.4424DO,0.5219DO,0.5984DO,0.6740DO/
DATA YY3/
*0.0346DO,0.0502DO,0.0647DO,0.0809DO,0.0889DO,0.0956DO,0.0997DO,
*0.1052DO,0.0547DO,0.0793DO,0.1022DO,0.1278DO,0.1405DO,0.1512DO,
*0.1577DO,0.1663DO,0.0692DO,0.1003DO,0.1293DO,0.1617DO,0.1777DO,
*0.1912DO,0.1995DO,0.2103DO/
END
SUBROUTINE REGR(N3,IAIF,M,RA,RQ,R2)

C      DETERMINE THE REGRESSION COEFFICIENTS BETWEEN THE NONDIMENSIONAL
C      STRESS INTENSITY FACTORS AND (C/DF) VALUES
C
IMPLICIT REAL*8(A-H,O-Z)
COMMON/XY/X(11),Y(11)
COMMON/XX/XX1(6),XX2(10),XX3(8)
COMMON/YY/YY1(6,3,3),YY2(10,3,3),YY3(8,3)
C      ACCUMULATE DATA

```

```

C
AX=0.0
BY=0.0
AA=0.0
ASX=0.0
ASY=0.0
C
NCOUNT=0
DO 10 I=1,N3
IF (X(I).EQ.0.0.OR.Y(I).EQ.0.0) THEN
  NCOUNT=NCOUNT+1
ELSE
C DETERMINE WHICH LINEAR REGRESSION MODEL WILL BE USED
C
  IF(M.EQ.1) THEN
    XX=X(I)*X(I)*X(I)
    YY=Y(I)*Y(I)*Y(I)
    GO TO 5
  ELSEIF(M.EQ.2) THEN
    XX=X(I)*X(I)
    YY=DLOG(Y(I))
    GO TO 5
  ELSE
    XX=DLOG(X(I))
    YY=Y(I)*Y(I)
    GO TO 5
  ENDIF
C
  5 AX=AX+XX
  BY=BY+YY
  AA=AA+XX*YY
  ASX=ASX+XX*XX
  ASY=ASY+YY*YY
  ENDIF
10 CONTINUE
C
  J=N3-NCOUNT
  A1=AA/J
  XM=AX/J
  YM=BY/J
  SX=ASX/J
  SY=ASY/J
C
C CALCULATE THE COEFFICIENTS AND R-SQUARE VALUES
C
  XYN=A1-XM*YM
  XN=SX-XM*XN
  YN=SY-YM*YM
  RQ=XYN/XN
  RA=YM-RQ*XN
  R=XYN/((XN*YN)**0.5)
  R2=R*R
  RETURN
  END
  SUBROUTINE LREG(DF,DA,DQ)
C
C INTERPOLATE THE COEFFICIENTS FOR CERTAIN DEPTH
C
  IMPLICIT REAL*8(A-H,O-Z)
  COMMON/COEF/DD(5),RA(5),RQ(5),R(5)
C
C ACCUMULATE DATA
C
  N=3
  AX=0.0
  BYA=0.0
  BYQ=0.0
  AAA=0.0
  AAQ=0.0
  ASXA=0.0
  ASXQ=0.0
C
  DO 10 I=1,N
  AX=AX+DD(I)
  BYA=BYA+RA(I)
  BYQ=BYQ+RQ(I)
  AAA=AAA+DD(I)*RA(I)
  AAQ=AAQ+DD(I)*RQ(I)
  ASXA=ASXA+DD(I)*DD(I)

```

```

ASXQ=ASXQ+DD(I)*DD(I)
10 CONTINUE
  AA1=AAA/N
  AQ1=AAQ/N
  XM=AX/N
  YMA=BYA/N
  YMQ=BYQ/N
  SXA=ASXA/N
  SXQ=ASXQ/N
C
  BNA=AA1-XM*YMA
  BNQ=AQ1-XM*YMQ
  DNA=SXA-XM*XM
  DNQ=SXQ-XM*XM
C
  BA=BNA/DNA
  BQ=BNQ/DNQ
  ARA=YMA-BA*XM
  ARQ=YMQ-BQ*XM
C
  DA=ARA+BA*DF
  DQ=ARQ+BQ*DF
C
  RETURN
END
SUBROUTINE COEFF(M,DF,IAIF,DA,DQ,R2)
C
C INTERPOLATE THE REGRESSION COEFFICIENTS FOR 2 TO 8 INCH THICK
C OVERLAYS. THE REGRESSION COEFFICIENTS(BENDING,SHEARING, AND
C THERMAL REFLECTION CRACKING) FOR CERTAIN DEPTH WILL BE COMPUTED
C BY THE INTERPOLATION OF THE COEFFICIENTS FOR 2",5" AND 8".
C
IMPLICIT REAL*8(A-H,O-Z)
COMMON/COEF/DD(5),RA(5),RQ(5),R(5)
COMMON/XY/X(11),Y(11)
C
C SET DATA AND CALCULATE REGRESSION COEFFICIENTS FOR 2" OVERLAY
C
CALL SETXY(1,IAIF,N3,M)
CALL REGR(N3,IAIF,M,RA2,RQ2,R2)
C
C SET DATA AND CALCULATE REGRESSION COEFFICIENTS FOR 5" OVERLAY
C
CALL SETXY(2,IAIF,N3,M)
CALL REGR(N3,IAIF,M,RA5,RQ5,R2)
C
C SET DATA AND CALCULATE REGRESSION COEFFICIENTS FOR 8" OVERLAY
C
CALL SETXY(3,IAIF,N3,M)
CALL REGR(N3,IAIF,M,RA8,RQ8,R2)
C
C ASSIGN EACH VALUE TO ARRAY
C
  DD(1)=2.0
  DD(2)=5.0
  DD(3)=8.0
  RA(1)=RA2
  RA(2)=RA5
  RA(3)=RA8
  RQ(1)=RQ2
  RQ(2)=RQ5
  RQ(3)=RQ8
C
C INTERPOLATE REGRESSION COEFFICIENTS FOR CERTAIN DEPTH
C BETWEEN 2" AND 8"
C
CALL LREG(DF,DA,DQ)
RETURN
END
SUBROUTINE SETXY(N1,IAIF,N3,M)
C
C SET UP THE DATA FROM THE DATA BLOCK
C
IMPLICIT REAL*8(A-H,O-Z)
COMMON/XX/XX1(6),XX2(10),XX3(8)
COMMON/YY/YY1(6,3,3),YY2(10,3,3),YY3(8,3)
COMMON/XY/X(11),Y(11)
C
IF(M.EQ.1) THEN
  N3=6

```

```

GO TO 1
ELSEIF(M.EQ.2) THEN
  N3=10
  GO TO 2
ELSE
  N3=8
  GO TO 3
ENDIF
C
C      FOR BENDING MODE
C
1 DO 1100 I=1,N3
  X(I)=XX1(I)
  Y(I)=YY1(I,IAIF,N1)
1100 CONTINUE
  GO TO 10
C
C      FOR SHEARING MODE
C
2 DO 1300 I=1,N3
  X(I)=XX2(I)
  Y(I)=YY2(I,IAIF,N1)
1300 CONTINUE
  GO TO 10
C
C      FOR THERMAL MODE
C
3 DO 1500 I=1,N3
  X(I)=XX3(I)
  Y(I)=YY3(I,N1)
1500 CONTINUE
10 RETURN
END

```

APPENDIX B

Guide for Input Data

and

Example Problem

(This program runs at main frame VAX and PC with MS FORTRAN)

source program name: BAY.FOR
input data file name: BAY.DAT
output file name: BAY.OUT

Guide for Input Data

CARD 1: FORMAT (I2)

CC 1-2 NFLG	0, if calculate NTL when ND is present #0, if calculate NTL when ND is infinite (in this case, ND = 7300)
CC 3-4 NCASE	0, if not considering the shear strength of fiberglass grid 1, if considering the shear strength of fiberglass grid

CARD 2: FORMAT (4I2, 60A1)

CC 1-2 IFLG	0, if fracture parameters and E are read into directly #0, if fracture parameters and E are calculated in the subroutine PARMTR
CC 3-4 INDEX	controlling parameter for regression between fracture parameters (log A vs. n) 1, intercept is not equal to zero (usually is used) 2, intercept is equal to zero
CC 4-6 NTAU	0, if bonded case 1, if unbonded case
CC 7-8 MTYPE	1, if material type is 8501 2, if material type is 8502
CC 9-68 TITL	title of the problem

CARD 3: FORMAT (2I10, 7F8.0)

CC 1-10 ND	maximum number of days that calculations will be carried out
CC 11-20 NL	number of loads per day (18 kips equivalent load)
CC 21-28 CO	initial crack length, in
CC 29-36 CS	existing crack spacing in the old surface course, in
CC 37-44 DELT	temperature difference below the stress-free temperature, °F
CC 45-52 DF	depth of overlay, in
CC 53-60 DS	depth of existing old pavement, in
CC 61-68 SN	fracture parameter, n, of the overlay for bending and shearing reflection cracking (optional-if IFLG.EQ.0)
CC 69-76 SN3	fracture parameter, n, of the overlay material for thermal reflection cracking (optional-if IFLG.EEQ.0)

CARD 4: FORMAT (2F10.0, 4E14.7)

CC 1-10 SIGMA	surface traction due to the traffic load, psi
CC 11-20 EF	modulus of elasticity of fabric, psi
CC 21-34 ALPHA	coefficient of thermal expansion of the old surface course, per °F

CC 35-48 E	tensile relaxation modulus of the composite overlay material, psi (Optional - if IFLG.EQ.0)
CC 49-62 CA	fracture parameter, A, of the overlay for bending and shearing reflection cracking (optional - if IFLG.EQ.0)
CC 63-76 CA3	fracture parameter, A, of the overlay material for thermal reflection cracking (optional - if IFLG.EQ.0)
CARD 5: FORMAT (2I2, 7F8.0)	
CC 1-2 NSF	shifting factor to convert laboratory data to field data
CC 3-4 NS	number of strands in one spacing
CC 5-12 FS	strand spacing, in
CC 13-20 ATL	surface traction length due to traffic load, in
CC 21-28 AK	stiffness of the existing old pavement, pci
CC 29-36 TF	fabric thickness, in
CC 37-44 ASL	overlay slab length, in
CC 45-52 DU	depth of overlay below the fabric, in
CC 53-60 AWL	length with which the shearing stress distribution becomes negligible (assumed to be the overlay slab length), in
CARD 6: FORMAT (5F10.0, I2)	
CC 1-10 S	specific heat of overlay material, BTU per pound, °F (typical value = 0.22)
CC 11-20 W	unit weight of overlay material, pound per cubic foot (typical value = 146)
CC 21-30 SK	thermal conductivity of overlay material, BTU/ft ₂ /hr, °F/ft (typical value = 0.8)
CC 31-40 T	air temperature, °F
CC 41-50 V	wind velocity, mph
CC 51-52 IAIF	aggregate interlocking factor 1, if low aggregate interlocking 2, if medium aggregate interlocking 3, if high aggregate interlocking
CARD 7: FORMAT (2F10.0, I5)	
CC 1-10 FW	unit weight of the fabric, 02/yd ²
CC 11-20 AT	actual tack coat rate used during fabric installation, gal/yd ²
CC 21-25 IT	controlling factor for tack coat during fabric installation 0, if not tack coat during installation 1, if tack coat during installation If IFLG.EQ.0, card set 7 is not needed
CARD 8: FORMAT (5F10.5)	
CC 1-10 A1	
CC 11-20 A2	
CC 21-30 A3	
CC 31-40 A4	
CC 41-50 A5	modification factor for damage level (See Table 4.4)

EXAMPLE PROBLEM

1. Input Data

2. Output

APPENDIX C

Sample Run Summary

Case 2-1

material type: 8502
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	1(3.2)	1(3.2)
5.0 in	-	7(5.0)
	-	27(5.0)
8.0 in	-	3043(8.0)
	-	7300(1.9)

support stiffness: 500 pci

2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	1(3.2)	1(3.2)
5.0 in	-	35(5.0)
	-	169(5.0)
8.0 in	-	7300(0.8)
	7300(0.5)	7300(0.5)

Continued Case 2-1

support stiffness: 1,000 pci

2.0 in	1(2.0)	1(2.0)
	1(3.2)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	2(3.2)	2(3.2)
5.0 in	-	86(5.0)
	-	433(5.0)
8.0 in	-	7300(0.5)
	-	7300(0.5)

Case 1-1

material type: 8501
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sksi

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	1(3.2)	1(3.2)
5.0 in	-	7(5.0)
	-	27(5.0)
8.0 in	-	3213(8.0)
	-	7300(1.1)

support stiffness: 500 pci

2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	1(3.2)	1(3.2)
5.0 in	-	35(5.0)
	-	170(5.0)
8.0 in	-	7300(0.6)
	7300(0.3)	7300(0.3)

Continued Case 1-1

support stiffness: 1,000 pci

	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	2(3.2)	2(3.2)
5.0 in	-	86(5.0)
	-	437(5.0)
8.0 in	-	7300(0.4)
	-	7300(0.3)

Case 2-2

material type: 8502
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	1(3.2)	1(3.2)
5.0 in	-	7(5.0)
	-	27(5.0)
8.0 in	-	2900(8.0)
	-	7060(8.0)

support stiffness: 500 pci

2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	-	1(3.2)
5.0 in	3(5.0)	-
	-	163(5.0)
8.0 in	-	7300(5.1)
	-	7300(1.5)

Continued Case 2-2

support stiffness: 1,000 pci

2.0 in	1(2.0)	1(2.0)
	1(2.0)	1(2.0)
3.2 in	1(3.2)	1(3.2)
	-	2(3.2)
5.0 in	2(5.0)	-
	-	396(5.0)
8.0 in	7300(2.0)	-
	7300(1.2)	7300(1.2)

Case 1-2

material type: 8501
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sksi

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	3464
	-	7300(1.1)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	8	-
	-	170
8.0 in	7300(0.7)	-
	7300(0.3)	7300(0.3)

Continued Case 1-2

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
3.2 in	1	1
5.0 in	-	2
8.0 in	2	-
	-	438
	7300(1.1)	-
	7300(0.3)	7300(0.3)

Case 2-3

material type: 8502
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 2.0 in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 ksi, 10000 sk

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	2996
	-	6583

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	15	-
	-	168
8.0 in	-	7300(1.0)
	7300(0.7)	7300(0.7)

Continued Case 2-3

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	1	1
	2	2
5.0 in	9	-
	-	428
8.0 in	-	7300(0.7)
	7300(0.6)	7300(0.6)

Case 1-3

material type: 8501
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sk*i*

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	4635
	-	7300(1.1)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	23	-
	-	170
8.0 in	-	7300(0.6)
	7300(0.3)	7300(0.3)

Continued Case 1-3

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	2	2
	66	-
5.0 in	-	438
	-	7300(0.4)
8.0 in	7300(0.3)	7300(0.3)

Case 2-4

material type: 8502
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sk*i*

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	3	-
	-	27
8.0 in	-	2889
	-	4753

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	2	-
	-	155
8.0 in	-	4569
	-	7300(5.0)

Continued Case 2-4

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	-	2
	2	-
5.0 in	915	-
	-	7300(4.7)
8.0 in	-	7300(2.0)

Case 1-4

material type: 8501
 damage level: low
 air temp.: 50°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	3	-
	-	27
8.0 in	-	5045
	-	7300(1.2)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	2	-
	-	170
8.0 in	7300(2.3)	-
	7300(0.3)	7300(5.0)

Continued Case 1-4

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	1	1
	-	2
5.0 in	2	-
	-	439
8.0 in	7300(3.2)	-
	7300(0.3)	7300(3.0)

Case 4-1

material type: 8502
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	3454
	-	7240

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	35
	-	169
8.0 in	-	7300(0.9)
	7300(0.6)	7300(0.6)

Continued Case 4-1

support stiffness: 1,000 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	2	2
5.0 in	-	86
	-	431
8.0 in	-	7300(0.6)
	-	7300(0.5)

Case 3-1

material type: 8501
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sk*i*

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	3703
	-	7300(1.1)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	35
	-	170
8.0 in	-	7300(0.9)
	7300(0.3)	7300(0.3)

Continued Case 3-1

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	1	1
	2	2
5.0 in	-	86
	-	437
8.0 in	-	7300(0.4)
	7300(0.2)	7300(0.3)

Case 4-2

material type: 8502
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sksi

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	3	-
	-	27
8.0 in	-	2221
	-	4780

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	2	-
	-	159
8.0 in	-	7300(5.1)
	-	7300(2.1)

Continued Case 4-2

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	1	1
	-	2
5.0 in	2	-
	-	379
8.0 in	7300(2.9)	-
	-	7300(1.6)

Case 3-2

material type: 8501
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 5.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sksi

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	3767
	-	7300(1.4)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	3	-
	-	170
8.0 in	7300(0.8)	-
	7300(0.4)	7300(0.4)

Continued Case 3-2

support stiffness: 1,000 pci		
2.0 in	1	1
	1	1
3.2 in	1	1
	-	2
5.0 in	2	-
	-	436
8.0 in	7300(1.3)	-
	7300(0.4)	7300(0.4)

Case 4-3

material type: 8502
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	4174
	6367	-

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	22	-
	-	167
8.0 in	-	7300(1.2)
	7300(0.8)	7300(0.8)

Continued Case 4-3

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	2	2
	4	-
5.0 in	-	422
	-	7300(0.8)
8.0 in	-	7300(0.8)

Case 3-3

material type: 8501
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 120 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 sk*i*

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	-	7
	-	27
8.0 in	-	4426
	-	7300(1.2)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	18	-
	-	170
8.0 in	-	7300(0.6)
	7300(0.3)	7300(0.3)

Continued Case 3-3

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	2	2
	15	-
5.0 in	-	437
	-	7300(0.4)
8.0 in	7300(0.3)	7300(0.3)

Case 3-4

material type: 8501
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	3	-
	-	27
8.0 in	-	4344
	-	7300(2.0)

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	2	-
	-	169
8.0 in	7300(2.5)	-
	7300(0.5)	7300(0.5)

Continued Case 3-4

support stiffness: 1,000 pci

	1	1
	1	1
3.2 in	1	1
	-	2
5.0 in	2	-
	-	434
8.0 in	7300(3.4)	-
	7300(0.5)	7300(0.5)

Case 4-4

material type: 8502
 damage level: low
 air temp.: 40°F
 temp. difference: 30°F
 old pavement surface: 2.0in crack spacing: 240 in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$ fabric modulus: 1000 Ksi, 10000 skf

support stiffness: 100 pci

case	bonded	debonded
agg. interlock	medium	medium
fab. mod.	1,0000	1,000
2.0 in	1	1
	1	1
3.2 in	1	1
	1	1
5.0 in	2	-
	-	26
8.0 in	-	1611
	3544	-

support stiffness: 500 pci

2.0 in	1	1
	1	1
3.2 in	1	1
	-	1
5.0 in	2	-
	-	148
8.0 in	-	4705
	7300(4.5)	7300(4.5)

Continued Case 4-4

support stiffness: 1,000 pci

	1	1
2.0 in	1	1
	1	1
3.2 in	-	2
	1	-
5.0 in	-	331
	-	7300(4.6)
8.0 in	-	7300(4.5)

Case 2-1

material type: 8502 traffic: 1000 18K ESALs per day
 damage level: low crack spacing: 120 in.
 air temp.: 50°F grid modulus: 1,000 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 5.0in
 depth below fabric: 0.0 in
1.0 in

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2*(1.7)	-	4	3
	-	-	215*(1.7)	152
3.2 in	2	-	118	11
	-	-	303	246
5.0 in	42		7300 (0.9)	53
	-	-	379	324
8.0 in	832		7300 (0.4)	234
	-	-	727	657

support stiffness: 500 pci

	1		1	74
2.0 in	-		7300(1.4)	7300(1.5)
3.2 in	5		6	156
	-		3442	2135
5.0 in	31		508	401
	-		2719	2048
8.0 in	832	-	7300(0.5)	1282
	-	-	4010	3465

Continued Case 2-1

support stiffness: 1000 pci

2.0 in	1		1	7300(1.4)
	-		7300(0.4)	7300(0.6)
3.2 in	5		9	495*(2.7)
	-		7300(0.6)	5885*(2.8)
5.0 in	31		7300(3.0)	1014
	-		6941	4855
8.0 in	832	-	7300(1.1)	2816
	-	-	7300(1.2)	7300(2.3)

Case 1-1

material type:	8501	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	5	3
	-	-	213	152
3.2 in	2	-	175	11
	-	-	304	248*(3.0)
5.0 in	38		7300 (0.7)	53
	-	-	381	315
8.0 in	989		7300 (0.5)	234
	-	-	730	660

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(1.4)	7300(1.5)
3.2 in	6		8	157
	-		3781	2276
5.0 in	38		717*(4.7)	404
	-		2900	2157
8.0 in	989*(7.6)	-	7300(0.3)	1290
	-	-	4129	3562

Continued Case 1-1

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
	6		11	501
3.2 in	-		7300(0.4)	6921*(2.6)
	38		7300(2.9)	1033*(4.6)
5.0 in	-		7300(1.0)	5454
	989*(7.6)	-	7300(0.8)	2860
8.0 in	-	-	7300(1.0)	7300(1.6)

Case 2-2

material type:	8502	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0in		
depth below fabric:	0.0 in 1.0 in		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	268	152*(1.7)
3.2 in	2	-	1	11
	-	-	361	229
5.0 in	2		99	53*(1.9)
	-	-	392	290
8.0 in	96		7300(1.6)	247
	-	-	744	634

support stiffness: 500 pci

2.0 in	1		1	73*(1.5)
	-		7300(1.1)	7300(1.5)
3.2 in	2		1	152
	-		3051*(2.8)	1489
5.0 in	2*(4.9)		9	375
	-		2316	1500
8.0 in	96	-	2139*(7.5)	1200
	-	-	3609	2845

Continued Case 2-2

support stiffness: 1000 pci

	1		1	277*(1.5)
2.0 in	-		7300(0.6)	7300(1.3)
	2		2	438
3.2 in	-		7300(1.2)	3372*(2.7)
	2*(4.9)		11	875
5.0 in	-		4988*	2984
	96	-	755	2481
8.0 in	-	-	7134	5410

Case 1-2

material type: 8501 traffic: 1000 18K ESALs per day
 damage level: low crack spacing: 240 in.
 air temp.: 50°F grid modulus: 1,000 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 5.0in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	281	153
3.2 in	2	-	1	11
	-	-	409	249
5.0 in	7		144	53
	-	-	438	315
8.0 in	114		7300(1.3)	235
	-	-	795	660

support stiffness: 500 pci

2.0 in	1		1	76*(1.9)
	-		7300(0.7)	7300(1.5)
3.2 in	2		2	157
	-		6841*(3.0)	2277
5.0 in	7		12	405
	-		4018	2156
8.0 in	114	-	3039	1291
	-	-	4793	3561

Continued Case 1-2

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
	2		2	503
3.2 in	-		7300(0.3)	6888*(2.8)
	7		14*(5.0)	1034
5.0 in	-		7300(0.5)	5433
	114	-	1042*(7.4)	2861
8.0 in	-	-	7300(0.7)	7300(1.6)

Case 2-3

material type:	8502	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0in		
depth below fabric:	0.0 in 1.0 in		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1*(1.8)	-	2*(1.9)	3
	-	-	281	152
3.2 in	1	-	17	11
	-	-	322	244
5.0 in	20		1925	53
	-	-	380	320
8.0 in	381		7300(0.4)	234
	-	-	738	652

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(1.3)	7300(1.5)
3.2 in	3		2	156
	-		3512*(3.0)	1986
5.0 in	11		115	397
	-		2712	1928
8.0 in	381	-	7300(1.6)	1269
	-	-	4006	3348

Continued Case 2-3

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.5)	7300(0.7)
3.2 in	3		4	487(3.2)
	-		7300(0.6)	5086*(2.7)
5.0 in	11		60*(4.4)	989
	-		6549	4334
8.0 in	381	-	7300(2.7)	2758
	-	-	7300(1.3)	6974

Case 1-3

material type:	8501	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	230	153
3.2 in	2	-	27	11
	-	-	327	248
5.0 in	14		2847	53
	-	-	387	315
8.0 in	453		7300(0.2)	234
	-	-	747	660

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(1.3)	7300(1.5)
3.2 in	3		2	157
	-		4425	2277
5.0 in	24		156	404
	-		3168	2158
8.0 in	453	-	7300(1.2)	1291
	-	-	4305	3562

Continued Case 1-3

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
3.2 in	3		5	502
	-		7300(0.3)	6923
5.0 in	24		133	1033
	-		7300(0.7)	5454*(4.7)
8.0 in	453	-	7300(2.4)	2861
	-	-	7300(0.9)	7300(1.6)

Case 2-4

material type:	8502	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0in		
depth below fabric:	0.0 in 1.0 in		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	324*(1.8)	150
3.2 in	1	-	1	11
	-	-	557	209
5.0 in	2		17	52
	-	-	377	266
8.0 in	40		6280	227
	-	-	712	586

support stiffness: 500 pci

2.0 in	1	1	72
	-	6576*(1.6)	7300(1.5)
3.2 in	1	1	144
	-	2566*(2.7)	1152
5.0 in	2	2	344
	-	1933	1191
8.0 in	40	459	1105
	-	3135	2396

Continued Case 2-4

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.7)	7300(1.3)
3.2 in	1		1	388*(2.7)
	-		7300(2.4)	7300(2.6)
5.0 in	2		2	750
	-		3954*(5.0)	2232
8.0 in	40	-	7300(4.7)	2170
	-	-	5885	4314

Case 1-4

material type:	8501	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	331	153
3.2 in	1	-	1	11
	-	-	478	249
5.0 in	4		25	53
	-	-	483	315
8.0 in	48		7300(2.3)	235
	-	-	834	660

support stiffness: 500 pci

2.0 in	1		1	76*(1.8)
	-		7300(0.5)	7300(1.5)
3.2 in	1		1	158
	-		7300(0.5)	2270
5.0 in	4		9	405
	-		4857	2150
8.0 in	48	-	638	1291
	-	-	5222	3555

Continued Case 1-4

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.3)	7300(0.6)
3.2 in	1		1	505*(2.6)
	-		7300(0.3)	6804*(3.1)
5.0 in	4		6	1034
	-		7300(0.4)	5386*(4.6)
8.0 in	48	-	7300(4.6)	2860
	-	-	7300(0.7)	7300(1.7)

Case 4-1

material type:	8502	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	40°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0in		
depth below fabric:	0.0 in 1.0 in		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	3	3
	-	-	205*(1.7)	152
3.2 in	4	-	52	11
	-	-	316	245
5.0 in	20		5087	53
	-	-	369	322
8.0 in	588		7300(0.3)	234
	-	-	728	655

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(1.4)	7300(1.5)
3.2 in	4		3	156*(3.2)
	-		3369	2068
5.0 in	20		256	400
	-		2669	1994
8.0 in	588	-	7300(0.8)	1277
	-	-	3964	3414

Continued Case 4-1

support stiffness: 1000 pci

	1	-	1	7300(1.4)
2.0 in	-	-	7300(0.5)	7300(0.6)
3.2 in	4	-	7*(3.2)	492
	-	-	7300(0.6)	5501*(2.9)
5.0 in	20	-	7300(3.3)	1004
	-	-	6604*(4.9)	4611
8.0 in	588	-	7300(1.8)	2793
	-	-	7300(1.3)	7229

Case 3-1

material type: 8501 traffic: 1000 18K ESALs per day
 damage level: low crack spacing: 120 in.
 air temp.: 40°F grid modulus: 1,000 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 5.0in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	1	3
	-	-	214	152
3.2 in	2	-	148	11
	-	-	305	248
5.0 in	35		7300(0.8)	53
	-	-	382	315
8.0 in	919		7300(0.4)	234
	-	-	731	660

support stiffness: 500 pci

2.0 in	1		2	74
	-		7300(1.4)	7300(1.5)
3.2 in	6		7	157
	-		3770*(2.9)	2269
5.0 in	35		618	404
	-		2902	2152
8.0 in	919	-	7300(0.4)	1290
	-	-	4131	3558

Continued Case 3-1

support stiffness: 1000 pci

2.0 in	1		1	7300(1.4)
	-		7300(0.6)	7300(1.3)
3.2 in	1		2	415*(2.6)
	-		7300(2.5)	7300(2.6)
5.0 in	5		3	817
	-		4264	2582*(4.6)
8.0 in	65	-	586	2339
	-	-	6304	4844

Case 4-2

material type:	8502	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	40°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	288	151
3.2 in	1	-	1	11
	-	-	349	220
5.0 in	5		46	53
	-	-	378	279
8.0 in	65		7300(2.0)	230
	-	-	726	608

support stiffness: 500 pci

2.0 in	1		1	73
	-		7300(1.1)	7300(1.5)
3.2 in	1		1	148
	-		2658	1313
5.0 in	5		4	362
	-		2055	1341
8.0 in	65	-	1065	1159
	-	-	3320	2622

Continued Case 4-2

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
3.2 in	6		10	501
	-		7300(0.4)	6865*(2.8)
5.0 in	35		7300(3.0)	1032
	-		6604(1.0)	5424
8.0 in	919	-	7300(0.9)	2858
	-	-	7300(1.0)	7300(1.7)

Case 3-2

material type:	8501	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	40°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	1	3
	-	-	283*(1.8)	153
3.2 in	2	-	1	11
	-	-	409	248
5.0 in	38		123	53
	-	-	437	314
8.0 in	989		7300(1.4)	234
	-	-	794	659

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(0.7)	7300(1.5)
3.2 in	6		2	157
	-		6305	2217
5.0 in	38		9	403
	-		3851	2103
8.0 in	989*(7.6)	-	2616	1287
	-	-	4722	3515

Continued Case 3-2

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
3.2 in	6		2	500
	-		7300(0.4)	6343(2.6)
5.0 in	38		12	1025
	-		7300(0.6)	5128
8.0 in	989*(7.6)	-	913	2841
	-	-	7300(0.8)	7300(1.9)

Case 4-3

material type:	8502	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	40°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	2	3
	-	-	223*(1.7)	152
3.2 in	3	-	3	11
	-	-	333	241
5.0 in	7		886	53
	-	-	379	316
8.0 in	268		7300(0.5)	233
	-	-	737	648

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(1.7)	7300(1.5)
3.2 in	3*(2.9)		2*(2.8)	155
	-		3308*(2.7)	1871
5.0 in	7		7300(2.8)	394
	-		2583	1833
8.0 in	268*(7.7)	-	7300(2.2)	1257
	-	-	3902	3248

Continued Case 4-3

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.5)	7300(0.7)
3.2 in	3*(2.9)		3	480*(2.6)
	-		7300(0.8)	4584*(2.6)
5.0 in	7		36	968*(4.6)
	-		5791	3982
8.0 in	268*(7.7)	-	5021	2706
	-	-	7300(1.5)	6617

Case 3-3

material type: 8501 traffic: 1000 18K ESALs per day
 damage level: low crack spacing: 120 in.
 air temp.: 40°F grid modulus: 1,000 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 2.0in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	231	153
3.2 in	2*(3.0)	-	22	11
	-	-	328	248
5.0 in	13		2413	53
	-	-	399	315
8.0 in	421		7300(0.2)	234
	-	-	748	660

support stiffness: 500 pci

2.0 in	1		1	74
	-		7300(1.3)	7300(1.5)
3.2 in	3		2	157
	-		4402*(2.8)	2262
5.0 in	13		136	404
	-		3157	2146
8.0 in	421	-	7300(1.4)	1290
	-	-	4300	3553

Continued Case 3-3

support stiffness: 1000 pci

	1		1	298*(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
	3		5	501
3.2 in	-		7300(0.4)	6791*(2.7)
	13		76	1031
5.0 in	-		7300(0.8)	5383
	421	-	7300(2.5)	2856
8.0 in	-	-	7300(0.9)	7300(1.7)

Case 4-4

material type: 8502 traffic: 1000 18K ESALs per day
 damage level: low crack spacing: 240 in.
 air temp.: 40°F grid modulus: 1,000 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 2.0in
 depth below fabric: $\frac{0.0 \text{ in}}{1.0 \text{ in}}$

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	331	148
3.2 in	1	-	1	11
	-	-	331	195
5.0 in	3		3	52
	-	-	351	248
8.0 in	26		3006	223
	-	-	677	563

support stiffness: 500 pci

2.0 in	1		1	71
	-		5329*(1.5)	7300(1.5)
3.2 in	1		1	137
	-		2163	984
5.0 in	3		2	323*(5.0)
	-		1660	1030
8.0 in	26	-	239	1038
	-	-	2785	2137

Continued Case 4-4

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.8)	7300(1.3)
3.2 in	1		1	354
	-		7300(2.4)	1960
5.0 in	3		2	676
	-		3309	1882
8.0 in	26	-	7300(4.9)	1978
	-	-	5094	3750

Case 3-4

material type:	8501	traffic:	1000 18K ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	40°F	grid modulus:	1,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0in		
depth below fabric:	<u>0.0 in</u>		
	<u>1.0 in</u>		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	3
	-	-	334	153
3.2 in	1	-	1	11
	-	-	473	247
5.0 in	2		21	53
	-	-	478	312
8.0 in	45		7300(2.5)	234
	-	-	830	857

support stiffness: 500 pci

2.0 in	1		1	74*(1.5)
	-		7300(0.6)	7300(1.5)
3.2 in	1		1	157
	-		7300(0.9)	2119
5.0 in	2		7	402
	-		4310*(4.8)	2033
8.0 in	45	-	555*(7.6)	1281
	-	-	5010	3451

Continued Case 3-4

support stiffness: 1000 pci

	1		1	7300(1.4)
2.0 in	-		7300(0.4)	7300(0.6)
3.2 in	1		1	496*(2.9)
	-		7300(0.4)	5764*(2.7)
5.0 in	2		6	1013
	-		7300(0.6)	4775
8.0 in	45	-	7300(4.6)	2810
	-	-	7300(0.8)	7300(2.6)

Case 6-1

material type:	low modulus	traffic:	1000 18 ^k ESALs per day
damage level:	low	crack spacing:	120 in
air temp.:	50°F	grid modulus:	500 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	4
depth below fabric:	<u>0.0 in.</u>	debonding equations:	850 L
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	2	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	6	-	7*(3.0)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	49	-	58	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	1001	-	7300*(0.0)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

support stiffness: 500 pci

2.0 in	2	-	2	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	6	-	6*(2.8)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	49	-	53	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	1001	-	1183	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Continued Case 6-1

support stiffness: 1000 pci

	2	-	2	7300(0.2)
2.0 in	-	-	7300(0.2)	7300(0.2)
	6	-	6	7300(0.2)
3.2 in	-	-	7300(0.2)	7300(0.2)
	49	-	52	7300(0.2)
5.0 in	-	-	7300(0.2)	7300(0.2)
	1001	-	1134	7300(0.2)
8.0 in	-	-	7300(0.2)	7300(0.2)

Case 5-1

material type:	8501	traffic:	1000 18k ESAL per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	2
depth below fabric:	0.0 in. 1.0 in.	debonding equations:	8501

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	3	36
	-	-	2246	1323
3.2 in	6	-	7300(1.8)	136
	-	-	3282	1985
5.0 in	49	-	1229	492
	-	-	3607	2616
8.0 in	1001	-	7300(0.5)	1964
	-	-	6414	5411

support stiffness: 500 pci

2.0 in	2	-	1	7300(1.5)
	-	-	7300(0.3)	7300(0.4)
3.2 in	6	-	9	1341
	-	-	7300(0.2)	7300(0.3)
5.0 in	49	-	7300(3.3)	3350
	-	-	7300(0.3)	7300(0.4)
8.0 in	1001	-	7300(2.4)	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 5-1

support stiffness: 1000 pci

	2	-	2	7300(1.4)
2.0 in	-	-	7300(0.2)	7300(0.3)
	6	-	8	4057*(2.7)
3.2 in	-	-	7300(0.2)	7300(0.2)
	49	-	96	7300(0.9)
5.0 in	-	-	7300(0.2)	7300(0.3)
	1001	-	7300(3.6)	7300(0.4)
8.0 in	-	-	7300(0.3)	7300(0.3)

Case 6-2

material type:	low modulus	traffic:	1000 18k ESAL per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	500 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	4
depth below fabric:	0.0 in. 1.0 in.	bonding equations:	850

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	7300
	-	-	7300	7300
3.2 in	2	-	2	7300
	-	-	7300	7300
5.0 in	7	-	8	7300
	-	-	7300	7300
8.0 in	126	-	145	7300
	-	-	7300	7300

support stiffness: 500 pci

2.0 in	1	-	1	7300
	-	-	7300	7300
3.2 in	2	-	2	7300
	-	-	7300	7300
5.0 in	7	-	8	7300
	-	-	7300	7300
8.0 in	126	-	136	7300
	-	-	7300	7300

Continued Case 6-2

support stiffness: 1000 pci

	1	-	1	7300
2.0 in	-	-	7300	7300
3.2 in	2	-	2	7300
	-	-	7300	7300
5.0 in	7	-	8	7300
	-	-	7300	7300
8.0 in	126	-	133	7300
	-	-	7300	7300

Case 5-2

material type:	8501	traffic:	1000 18k ESAL per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	2
depth below fabric:	0.0 in. 1.0 in.	bonding equations:	8501

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	45
	-	-	4254	1328
3.2 in	2	-	1	137
	-	-	5970	1986
5.0 in	7	-	18	493
	-	-	5152	2613
8.0 in	126	-	4345	1965
	-	-	7300(1.8)	5406

support stiffness: 500 pci

2.0 in	1	-	1	7300(1.5)
	-	-	7300(0.3)	7300(0.4)
3.2 in	2	-	2	1346
	-	-	7300(0.2)	7300(0.4)
5.0 in	7	-	11	3351
	-	-	7300(0.3)	7300(0.4)
8.0 in	126	-	7300(4.7)	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 5-2

support stiffness: 1000 pci

	1	-	1	7300(1.3)
2.0 in	-	-	7300(0.2)	7300(0.3)
3.2 in	2	-	2	4060
	-	-	7300(0.2)	7300(0.3)
5.0 in	7	-	10	7300(0.9)
	-	-	7300(0.2)	7300(0.3)
8.0 in	126	-	7300(5.5)	7300(0.4)
	-	-	7300(0.2)	7300(0.3)

Case 6-3

material type:	low modulus	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	500 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	4
depth below fabric:	<u>0.0 in.</u>	debonding equations:	850
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	7300
	-	-	7300	7300
3.2 in	3	-	4	7300
	-	-	7300	7300
5.0 in	24	-	27	7300
	-	-	7300	7300
8.0 in	465	-	7300(0.2)	7300
	-	-	7300(0.3)	7300

support stiffness: 500 pci

2.0 in	1	-	1	7300
	-	-	7300	7300
3.2 in	3	-	4*(2.9)	7300
	-	-	7300	7300
5.0 in	24	-	25	7300
	-	-	7300	7300
8.0 in	465	-	428	7300
	-	-	7300	7300

Continued Case 6-3

support stiffness: 1000 pci

	1	-	1	7300
2.0 in	-	-	7300	7300
3.2 in	3	-	4* (3.2)	7300
	-	-	7300	7300
5.0 in	24	-	25	7300
	-	-	7300	7300
8.0 in	465	-	512	7300
	-	-	7300	7300

Case 5-3

material type:	8501	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	2
depth below fabric:	<u>0.0 in.</u>	debonding equations:	8501
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	2	36
	-	-	2653	1324
3.2 in	3	-	4	136
	-	-	3840	1998
5.0 in	24	-	246	493
	-	-	3972	2616
8.0 in	465	-	7300(1.7)	1965
	-	-	6734	5411

support stiffness: 500 pci

2.0 in	-	-	1	648*(1.7)
	-	-	7300(0.3)	7300(0.4)
3.2 in	-	-	5	1343
	-	-	7300(0.2)	7300(0.3)
5.0 in	-	-	1	3352
	-	-	7300(0.3)	7300(0.4)
8.0 in	-	-	5235	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 5-3

support stiffness: 1000 pci

	1	-	1	7300(1.4)
2.0 in	-	-	7300(0.2)	7300(0.3)
3.2 in	3	-	4	4058*(3.1)
	-	-	7300(0.2)	7300(0.3)
5.0 in	24	-	38	7300(0.9)
	-	-	7300(0.2)	7300(0.3)
8.0 in	465	-	7300(4.5)	7300(0.4)
	-	-	7300(0.2)	7300(0.3)

Case 6-4

material type:	low modulus	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	500 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	4
depth below fabric:	0.0 in. 1.0 in.	debonding equations:	850

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	7300
	-	-	7300	7300
3.2 in	1	-	1	7300
	-	-	7300	7300
5.0 in	4	-	4	7300
	-	-	7300	7300
8.0 in	59	-	66	7300
	-	-	7300	7300

support stiffness: 500 pci

2.0 in	1	-	1	7300
	-	-	7300	7300
3.2 in	1	-	1	7300
	-	-	7300	7300
5.0 in	4	-	4*(4.7)	7300
	-	-	7300	7300
8.0 in	59	-	63	7300
	-	-	7300	7300

Continued Case 6-4

support stiffness: 1000 pci

	1	-	1	7300
2.0 in	-	-	7300	7300
	1	-	1	7300
3.2 in	-	-	7300	7300
	4	-	4	7300
5.0 in	-	-	7300	7300
	59	-	62	7300
8.0 in	-	-	7300	7300

Case 5-4

material type:	8501	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	50°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	2
depth below fabric:	<u>0.0 in.</u>	debonding equations:	8501
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	45
	-	-	6415	1330
3.2 in	1	-	1	137
	-	-	7300(0.6)	1981
5.0 in	4	-	9	493
	-	-	6337	2602
8.0 in	59	-	887	1965
	-	-	7300(1.2)	5391

support stiffness: 500 pci

2.0 in	1	-	1	654
	-	-	7300(0.3)	7300(0.4)
3.2 in	1	-	1	1346
	-	-	7300(0.3)	7300(0.4)
5.0 in	4	-	5	3340
	-	-	7300(0.3)	7300(0.4)
8.0 in	59	-	7300(5.2)	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 5-4

support stiffness: 1000 pci

	1	-	1	7300(1.4)
2.0 in	-	-	7300(0.2)	7300(0.3)
	1	-	1	7300(2.6)
3.2 in	-	-	7300(0.2)	7300(0.3)
	4	-	5	7300(0.9)
5.0 in	-	-	7300(0.2)	7300(0.3)
	59	-	102	7300(0.4)
8.0 in	-	-	7300(0.2)	7300(0.3)

Case 8-1

material type:	low modulus	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	50°F	grid modulus:	500 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	4
depth below fabric:	<u>0.0 in.</u>	debonding equations:	8501
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	2	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	6	-	6	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	46	-	54	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	932*(7.9)	-	7300(6.0)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

support stiffness: 500 pci

2.0 in	2	-	2	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	6	-	6	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	46	-	50	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	932	-	1097	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Continued Case 8-1

support stiffness: 1000 pci

	2	-	2*(1.4)	7300(0.2)
2.0 in	-	-	7300(0.2)	7300(0.2)
3.2 in	6	-	6	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	46	-	49	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	932	-	1052	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Case 7-1

material type:	8501	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	1200 in.
air temp.:	40°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	2
depth below fabric:	<u>0.0 in.</u>	debonding equations:	8501
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	2	-	2	38
	-	-	2271	1322
3.2 in	6	-	19	136
	-	-	3228	1980
5.0 in	46	-	1054	492
	-	-	3606	2608
8.0 in	932*(7.9)	-	7300(0.6)	1964
	-	-	6412	5401

support stiffness: 500 pci

2.0 in	2	-	1	646*(1.5)
	-	-	7300(0.3)	7300(0.4)
3.2 in	6	-	9	1339
	-	-	7300(0.3)	7300(0.3)
5.0 in	46	-	7300(3.3)	3342
	-	-	7300(0.3)	7300(0.4)
8.0 in	932	-	7300(2.6)	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 7-1

support stiffness: 1000 pci

	2*(1.4)	-	2	7300(1.4)
2.0 in	-	-	7300(0.3)	7300(0.3)
3.2 in	6	-	7	4034
	-	-	7300(0.2)	7300(0.3)
5.0 in	46	-	87	7300(0.9)
	-	-	7300(0.2)	7300(0.3)
8.0 in	932	-	7300(4.2)	7300(0.4)
	-	-	7300(0.3)	7300(0.3)

Case 8-2

material type: low modulus traffic: 1000 18k ESALs per day
 damage level: low crack spacing: 240 in.
 air temp.: 40°F grid modulus: 500 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 5.0 in. number of strands: 4
 depth below fabric: 0.0 in. debonding equations: 8501
 1.0 in.

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	3	-	3	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	22	-	25	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	433	-	7300(6.3)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

support stiffness: 500 pci

2.0 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	3	-	3	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	22	-	23	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	433	-	490	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Continued Case 8-2

support stiffness: 1000 pci

	1*(1.4)	-	1*(1.4)	7300(0.2)
2.0 in	-	-	7300(0.2)	7300(0.2)
3.2 in	3	-	3	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	22	-	23	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	433	-	476	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Case 7-2

material type:	8501	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	1200 in.
air temp.:	40°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	5.0 in.	number of strands:	2
depth below fabric:	<u>0.0 in.</u>	debonding equations:	8501
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	45
	-	-	4286	1323
3.2 in	3	-	1	137
	-	-	5519	1928
5.0 in	22	-	12	491
	-	-	4857	2531
8.0 in	433	-	3737	1955
	-	-	7300(2.1)	5297

support stiffness: 500 pci

2.0 in	1	-	1	148*(1.5)
	-	-	7300(0.3)	7300(0.4)
3.2 in	3	-	2	1324
	-	-	7300(0.3)	7300(0.4)
5.0 in	22	-	10	3256
	-	-	7300(0.3)	7300(0.5)
8.0 in	433	-	7300(4.8)	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 7-2

support stiffness: 1000 pci

	1	-	1	7300(1.3)
2.0 in	-	-	7300(0.3)	7300(0.3)
3.2 in	3	-	2	3879
	-	-	7300(0.3)	7300(0.3)
5.0 in	22	-	9	7300(1.1)
	-	-	7300(0.3)	7300(0.4)
8.0 in	433	-	7300(5.5)	7300(0.5)
	-	-	7300(0.3)	7300(0.3)

Case 8-3

material type:	low modulus	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	40°F	grid modulus:	500 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	4
depth below fabric:	0.0 in. 1.0 in.	debonding equations:	8501

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	3	-	2	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	13	-	16	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	421	-	7300(6.3)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

support stiffness: 500 pci

2.0 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	3	-	2*(2.9)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	13	-	14	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	421	-	478	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Continued Case 8-3

support stiffness: 1000 pci

	1*(1.4)	-	1	7300(0.2)
2.0 in	-	-	7300(0.2)	7300(0.2)
3.2 in	3	-	2	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	13	-	14	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	421	-	463	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Case 7-3

material type:	8501	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	120 in.
air temp.:	40°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	2
depth below fabric:	0.0 in. 1.0 in.	debonding equations:	8501

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	36
	-	-	2685	1323
3.2 in	3	-	2	136
	-	-	3822	1974
5.0 in	13	-	213	492
	-	-	3948	2598
8.0 in	421	-	7300(1.8)	1963
	-	-	6713	5388

support stiffness: 500 pci

2.0 in	1	-	1	647*(1.5)
	-	-	7300(0.3)	7300(0.4)
3.2 in	3	-	4	1338
	-	-	7300(0.2)	7300(0.4)
5.0 in	13	-	45	3331
	-	-	7300(0.3)	7300(0.4)
8.0 in	421	-	4558*(7.6)	7300(0.9)
	-	-	7300(0.3)	7300(0.4)

Continued Case 7-3

support stiffness: 1000 pci

2.0 in	1*(1.4)	-	1	7300(1.4)
	-	-	7300(0.2)	7300(0.3)
3.2 in	3	-	4	4016*(2.6)
	-	-	7300(0.2)	7300(0.3)
5.0 in	13	-	35	7300(0.9)
	-	-	7300(0.2)	7300(0.3)
8.0 in	421	-	7300(4.6)	7300(0.4)
	-	-	7300(0.3)	7300(0.3)

Case 8-4

material type: low modulus traffic: 1000 18k ESALs per day
 damage level: low crack spacing: 240 in.
 air temp.: 40°F grid modulus: 500 ksi
 temp. difference: 30°F aggregate interlocking: medium
 old pavement surface: 2.0 in. number of strands: 4
 depth below fabric: 0.0 in. debonding equations: 8501
 1.0 in.

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	4	-	4*(5.0)	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	55	-	55	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

support stiffness: 500 pci

2.0 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
3.2 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	4*(5.0)	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	55	-	48	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Continued Case 8-4

support stiffness: 1000 pci

	1	-	1	7300(0.2)
2.0 in	-	-	7300(0.2)	7300(0.2)
3.2 in	1	-	1	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
5.0 in	4	-	4	7300(0.2)
	-	-	7300(0.2)	7300(0.2)
8.0 in	62	-	59	7300(0.2)
	-	-	7300(0.2)	7300(0.2)

Case 7-4

material type:	8501	traffic:	1000 18k ESALs per day
damage level:	low	crack spacing:	240 in.
air temp.:	40°F	grid modulus:	10,000 ksi
temp. difference:	30°F	aggregate interlocking:	medium
old pavement surface:	2.0 in.	number of strands:	2
depth below fabric:	<u>0.0 in.</u>	debonding equations:	8501
	1.0 in.		

*: moment changes its sign at this value

support stiffness: 100 pci

Case	w/o grid		w/ grid	
	bonded	debonded	bonded	debonded
2.0 in	1	-	1	45
	-	-	6371	1319
3.2 in	1	-	1	136
	-	-	6792	1854
5.0 in	4	-	4	488
	-	-	5398	2426
8.0 in	55	-	767	1940
	-	-	7300(1.5)	5149

support stiffness: 500 pci

2.0 in	1	-	1	644*(1.5)
	-	-	7300(0.3)	7300(0.4)
3.2 in	1	-	1	1295
	-	-	7300(0.4)	7300(0.5)
5.0 in	4*(5.0)	-	5	3128
	-	-	7300(0.4)	7300(0.6)
8.0 in	55	-	7300(5.2)	7300(1.0)
	-	-	7300(0.4)	7300(0.5)

Continued Case 7-4

support stiffness: 1000 pci

	1	-	1	7300(1.3)
2.0 in	-	-	7300(0.3)	7300(0.3)
3.2 in	1	-	1	3654*(2.7)
	-	-	7300(0.4)	7300(0.4)
5.0 in	4	-	5	7253*(4.5)
	-	-	7300(0.4)	7300(0.5)
8.0 in	62	-	95*(7.6)	7300(0.5)
	-	-	7300(0.3)	7300(0.4)