B.2 柔性鋪面之結構評估

CE 421
FLEXIBLE PAVEMENT STRUCTURAL EVALUATON
USING BACKCALCULATED MODULI

1. Measure deflection basins at representative locations along the project (e.g., 100 ft. intervals or less for projects less than one mile, and 300 to 500 ft. intervals for longer projects). Set FWD loading as close as possible to wheel load of design or critical vehicle. For highways, use 9-kips. For airports use maximum (normally 24-kips). Also, run lighter and heavier loads (if possible) so that the extent of load or stress sensitivity can be determined.

Do not normally place the load plate on cracks. However, it may be desirable to obtain some deflections on alligator cracks or other prominent cracks to later determine the extent of deterioration at those locations.

2. Measure AC surface temperature hourly throughout the testing period by drilling a 2 inch deep hole, filling with oil or water, and inserting a thermometer. Measure deflections at one or more points each hour for use as reference points to adjust other deflections if temperature changes significantly.

3. Plot a maximum deflection profile along the project and examine the profile for uniformity (adjust the maximum deflection for uniform temperature). If there exists obvious variation along the project, it may be desirable to divide the project length into different design or evaluation sections. The reason for differences in deflections for the different sections should be determined (e.g., change in pavement thickness or soil type).

4. Back-calculate modulus of layers and subgrade for each test location using an elastic layered based computer program (ELSDEF OR BISDEF).

Do not average deflection basins back-calculate for the average basin. Look for a few points of erronous data where something may of happened to the deflection reading and delete if too far out (bad data always exists for some reason).

Determine the mean AC stiffness modulus for each design section at the field measurement temperature.

5. Estimate each pavement layer modulus value for each season (or month) under consideration.

AC stiffness varies greatly with temperature and must be adjusted for each seasonal period. Adjust the mean backcalculated AC stiffness modulus (at the field temperature) to the estimated pavement temperature for each major season (or month) over the year. Mean monthly air temperatures for the Champaign area are given in Figure 1 and an approximate relationship between mean monthly air temperature and AC layer temperature is given in Figure 2. Use the general shape of the graph in Figure 3 to adjust the stiffness modulus measured in the field at a given temperature to the mean pavement layer temperature for each month obtained from Figure 2. Assume that the slope of the stiffness modulus versus temperature is constant to make this adjustment.

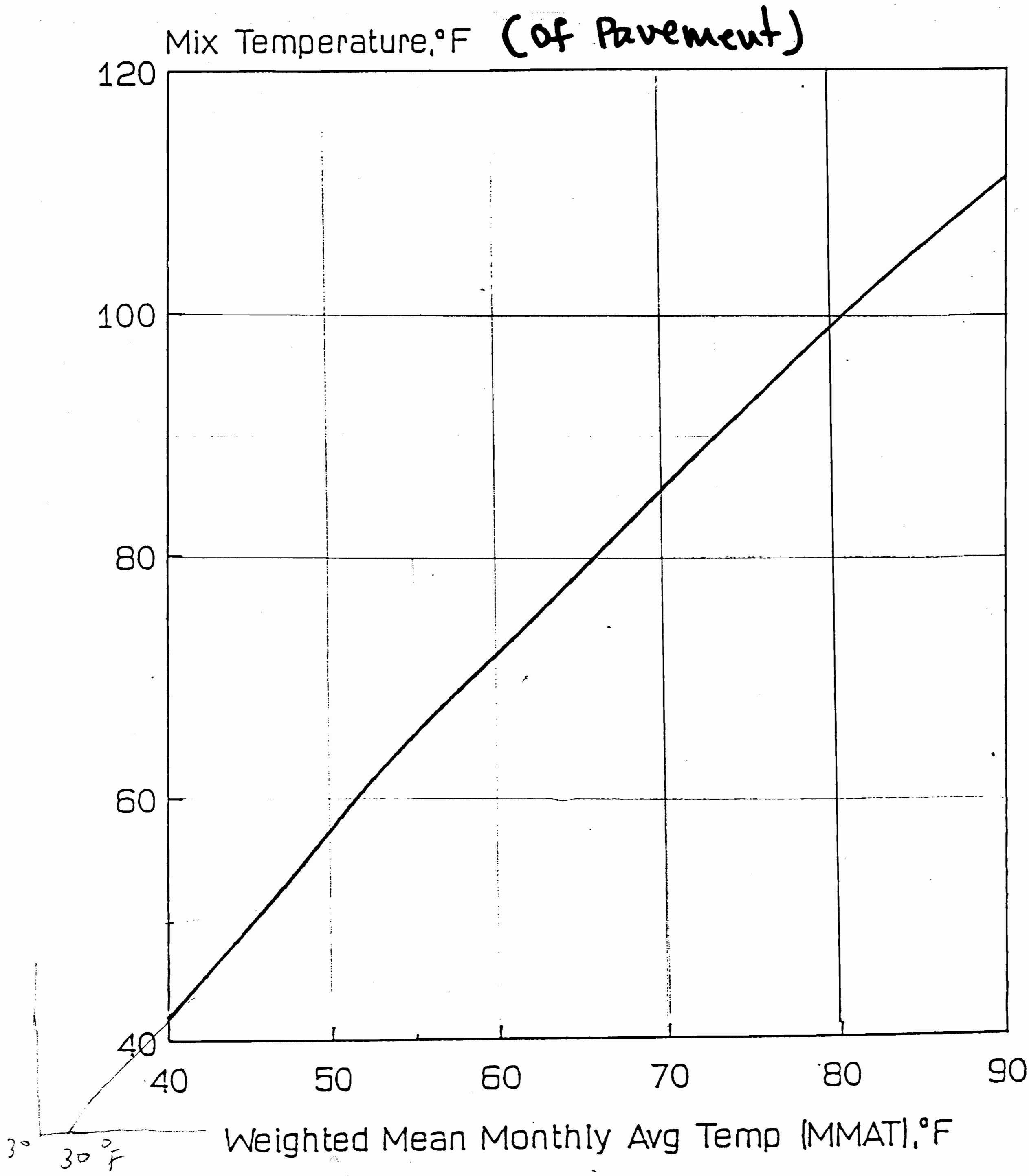
Unstabilized granular base and subbase and fine grained subgrade soil modului may also need to be adjusted for seasonal conditions based upon expected frost and moisture conditions. An example of this is shown in Figure 4 for the central Illinois area.

Fig. 1.--TEMPERATURE AND PRECIPITATION

[Data were recorded in the period 1951-73 at Urbana, Illinois]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days*	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	33.2	18.0	25.6	60	-11	18	1.56	.63	2.35	4	5.3
February---	37.4	21.0	29.3	62	-8	18	1.87	.89	2.70	5	5.7
March------	47.9	30.5	39.2	78	9	172	3.24	1.43	4.78	7	5.2
April------	62.2	41.7	52.0	84	25	364	3.79	2.00	5.34	8	.8
May--------	73.0	51.6	62.3	91	35	691	3.57	2.07	4.90	7	.0
June-------	82.7	61.0	71.8	97	46	954	4.40	2.42	6.14	7	.0
July-------	85.0	64.8	74.9	96	51	1,082	4.81	2.72	6.65	6	.0
August-----	83.8	62.7	73.2	94	47	1,029	3.06	1.44	4.44	4	.0
September--	78.7	55.7	67.2	95	38	816	2.99	.87	4.70	5	.0
October----	66.4	44.6	55.6	87	26	484	2.79	.93	4.31	5	.0
November---	50.1	33.3	41.7	74	10	125	2.45	1.27	3.48	5	1.9
December---	38.4	24.3	31.4	65	-3	33	2.40	.73	3.76	5	3.8
Yearly:											
Average--	61.6	42.4	52.0	---	---	---	---	---	---	---	---
Extreme--	---	---	---	100	-12	---	---	---	---	---	---
Total----	---	---	---	---	---	5,786	36.93	30.76	44.37	68	22.7

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (40° F).



if MMAT < 30°F ⇒ choose Mix Temperature = 30°F

Figure 2. Determination of Seasonal Pavement Temperature.

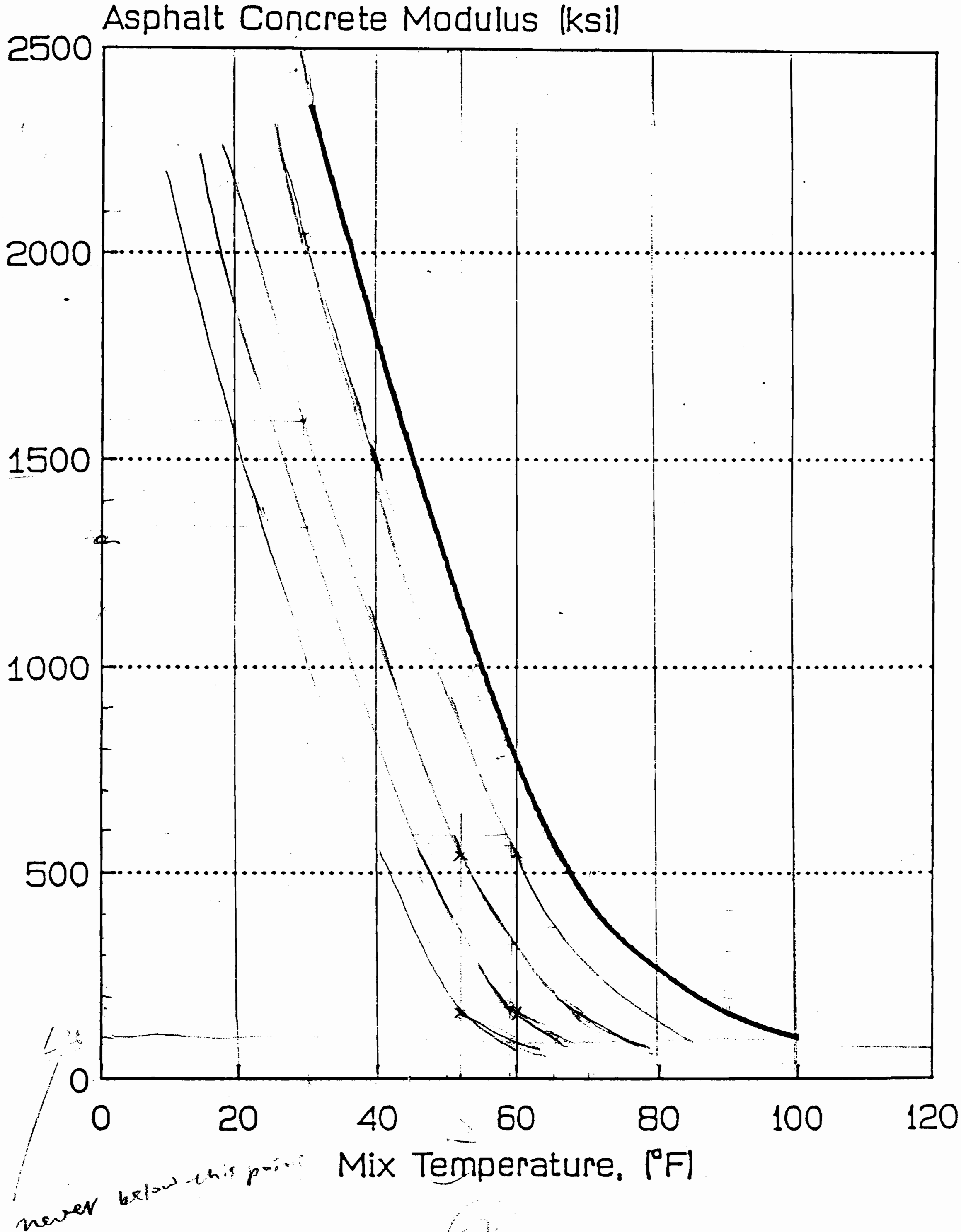


Figure 3. AC Modulus/Temperature Relationship.

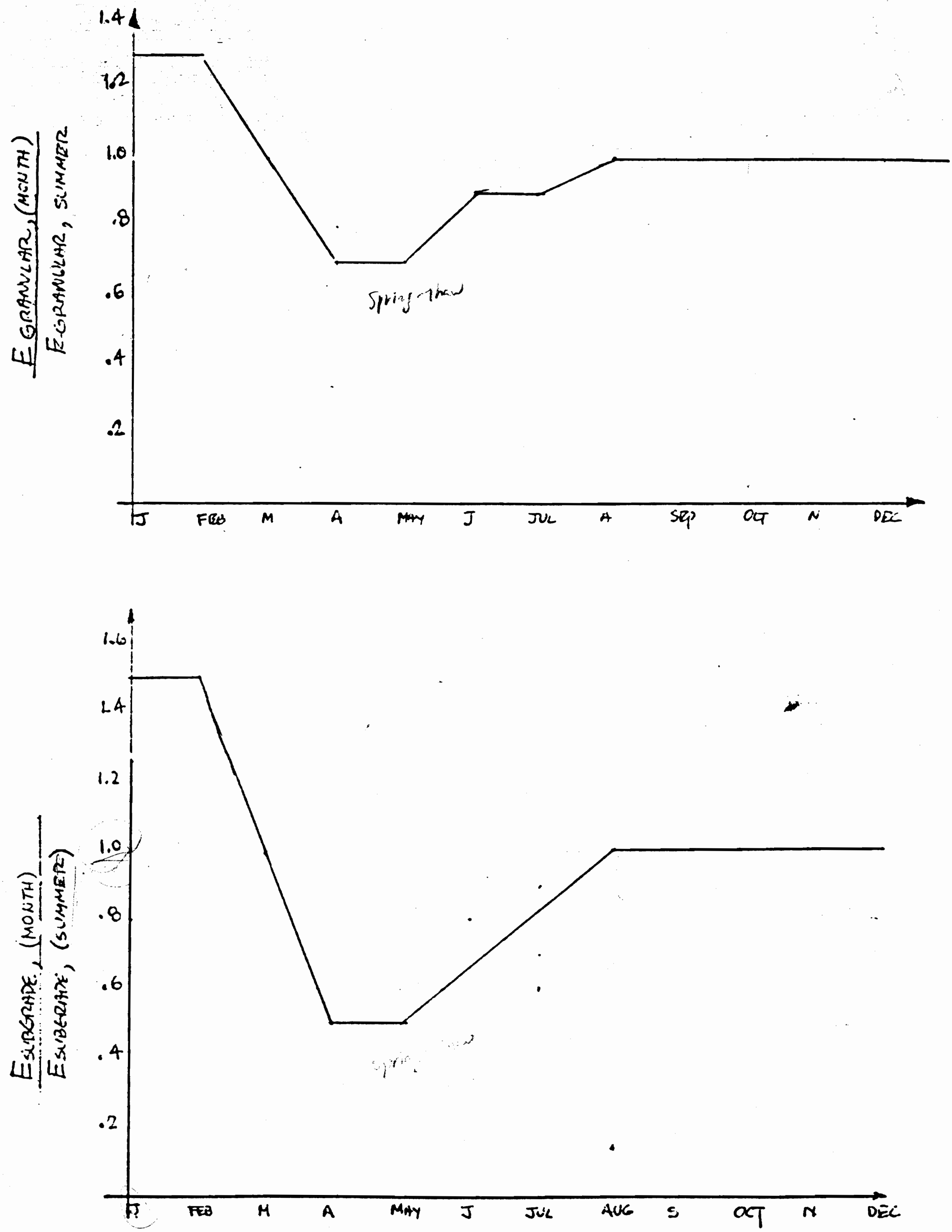


Fig. 4. Estimated variation of granular and SUBGRADE moduli values for the champaign area

base on summer Fall

6. Compute critical strains in pavement layers for each month over a year for each aircraft or truck under consideration using the elastic layered program. For highway evaluation, the 18-kip equivalent single axle load is normally used as the standard. However, the entire range of axle weights could be used, but this may require adjustment of subgrade and granular base moduli for lighter and heaver axle loads due to stress sensitivity.

7. Compute the expected or "allowable" number of load applications to "failure" using an AC fatigue model and a subgrade permanent deformation model for each month (denoted by N_i). Two reasonable models are given that were developed by the Corps of Engineers, and have been used successfully for consulting work.

<u>Asphalt Concrete</u>:

$$\log_{10}(COV) = -\left(5.0 \log_{10}TSTRAIN + 2.665 \log_{10}(Eac/14.22) + 0.392 \right)$$

Where: COV = number of coverages to unknown amount of fatigue cracking
TSTRAIN = tensile strain in the AC layer
Eac = stiffness modulus of the AC layer, psi

<u>Fine Grained Subgrade</u>

$$COV = (0.005511 / VSTRAIN)^{6.527}$$

where: COV = number of coverages to 0.5 ins. of rutting
VSTRAIN = vertical strain on fine grained subgrade

8. Compute past damage (and future damage if desired to determine if pavement can withstand future loadings over some time period) using Miner's accumulated hypothesis:

$$DAMAGE = \sum n_i / N_i$$

where: n_i = no. of axle or gear loads for the ith month actually applied to the pavement at a given load magnitude.

N_i = no. of axle or gear loads for the ith month allowable to "failure" computed from fatigue or permanent deformation models.

If more than one axle or gear load is used, this summation must be repeated for each and the total damage summed for all axle or gear loads.

9. Develop a table of results (using a spreadsheet) for both past and future traffic such as shown below for the pavement.

Spreadsheet To Compute Past Fatigue Damage For A Given Pavement Section, Given Axle Type And Load Level.

Tensile strain micro units

MONTH	E1	E2	E3	10E-6 (με) TSTRAIN	Nallow	Since Opening To Traffic n applied	DAMAGE n/N
JAN	2,000,000	50,000	25,000	150	10,000,000	100,000	0.10
FEB	ETC.						
MAR							
APR	700,000	20,000	5,000	400	350,000	100,000	0.29
MAY							
ETC.							
DEC							
					TOTAL FATIGUE DAMAGE =		0.85

Season: Spring, Summer, Fall, Winter

10. Experience has shown that the DAMAGE values computed normally agrees with visable pavement fatigue cracking. Figure 5 shows some results for a group of highway pavements. A very general correlation between past computed Miner's Damage and field fatigue cracking is as follows:

Computed Past DAMAGE	Expected Pavement Condition
0.0 to 0.25	Fatigue cracking may not be visable, or only a small amount should be visable. Substantial life remains.
0.26 to 0.50	Fatigue cracking should definitely exist along the pavement. About half the pavements fatigue life remains. Extensive patching of fatigued areas would restore fatigue life to those areas.
0.50 to 1.50	From 25 to 75 percent of the length of the wheel path or length of the pavement should show fatigue cracking. No fatigue life exists unless extensive patching is done in the areas of fatigue cracking.
> 1.50	Fatigue cracking should be prevalent over most of the pavement length. No fatigue life exists.

When the computed DAMAGE results do not agree roughly with the visible fatigue cracking, the evaluation should be re-checked and modified. Potential problems include errors in estimating past traffic loadings, unrealistic back-calculation values for moduli, unreasistic adjustment of moduli over the year, and an inadequate fatigue curve used in the computation.

11. These evaluation results can be then used to assess remaining life of the existing pavement and also its ability to handle future traffic. The results are also very important for overlay design purposes. The greater the past damage, the thicker the overlay must be to support future traffic.

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