

Research Report
KTC-89-37

PAVEMENT EVALUATION
ELKHORN DRIVE

by

R. Clark Graves
Research Engineer

Gary W. Sharpe
Former Chief Research Engineer

Kentucky Transportation Center
College of Engineering
University of Kentucky
Lexington, Kentucky

in cooperation with

Lexington-Fayette Urban County Government

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the University of Kentucky. This report does not constitute a standard, specification, or regulation. The inclusion of manufacturer names and tradenames are for identification purposes and are not to be considered as endorsements.

June 1989

PAVEMENT EVALUATION
ELKHORN DRIVE

The Lexington-Fayette Urban County Government requested that the Kentucky Transportation Center perform a pavement evaluation and overlay design for Elkhorn Drive. This pavement section consisted of 3 inches of asphaltic concrete and 8 inches of dense graded aggregate. A visual inspection during testing revealed several areas of severe alligator cracking along with some areas of transverse cracking.

Deflection measurements were performed using the Model 400B Road Rater. The testing procedure consisted of nine tests in each lane at load levels of 600 and 1200 pounds. The raw deflection results of these tests are listed given in Table 1. Deflections adjusted to a standard temperature of 70 degrees are listed given in Table 2.

A traffic analysis was conducted from data provided by Urban County Government officials. This analysis is contained in Appendix A. Results of this analysis (assuming a constant distribution of vehicles over a 24-hour period) yield an ADT of 5,333 with 5.97 percent trucks. If the number of vehicles is assumed constant for 12 hours and if 1/4 of the computed vehicles is assumed for the remaining 12 hours, this results in an ADT of 3,333.

The estimation of equivalent single axleloads (ESAL's) was achieved by using both the 1981 Kentucky method and the 1986 AASHTO Design Guide method. Since the truck data provided did not include truck classifications, a uniform distribution of trucks was assumed. Estimation of the design ESAL's is contained Appendix A.

Based on the ESAL analysis and assuming a 15 year design life, the following design ESAL's are calculated.

Kentucky Method

<u>5,333 ADT</u>	<u>3,333 ADT</u>
3.55×10^6	2.22×10^6

1986 AASHTO Method

3.2×10^6	2.0×10^6
-------------------	-------------------

These design ESAL's appear to be high for a city street application. However, a field inspection on February 20, 1989 indicated a significant number of trucks using the facility. Based on the analysis and observation, a high ESAL design level is recommended. It is recommended that designs be based on ESAL levels of 1,2, and 3 million ESAL's.

From the analysis of the deflection data, the following minimum DGA and subgrade moduli were calculated for a given elastic modulus of asphaltic concrete. Tables (3) through (10) include a complete listing of the back calculated moduli.

AC Modulus (assumed)	DGA Modulus (calculated)	Subgrade Modulus (calculated)	Subgrade CBR
750,000	16,362	5,190	3.46
1,000,000	16,240	5,146	3.43
2,000,000	15,834	5,000	3.33
3,000,000	15,514	4,886	3.26

Based on these minimum subgrade modulus values, a design CBR of three was used for the overlay analysis.

The total pavement thickness requirements have been computed based on the 1981 Kentucky procedures. The total pavement thicknesses based on a design CBR of 3 for each design ESAL level is shown below. The total pavement thicknesses required for a given percent asphalt for DGA thicknesses of 8 and 11 inches are also given.

Percent AC	Design ESAL's (millions)			DGA Thickness	
	1	2	3	8"	11"
33	23.00	25.00	26.00	11.94	16.42
50	18.00	20.00	21.00	16.00	22.00
75	14.00	15.50	16.00	32.00	44.00
100	11.25	12.5	13.0		

The percent asphaltic concrete versus total pavement thickness is plotted in Figure 1. The intersection of the these curves generated using a constant DGA thickness, and the curves

generated by the 1981 Kentucky procedure are the total pavement thicknesses required for each ESAL level.

The following overlays are calculated assuming no deterioration of the asphaltic concrete and 8 inches of DGA.

ESAL's	Total Pavement	AC	Thicknesses (inches)	
			DGA	Overlay
1,000,000	17.6	3	8	6.60
2,000,000	19.0	3	8	8.00
3,000,000	19.75	3	8	8.75

If the AC is assumed to be totally deteriorated, then an effective DGA thickness of 11 inches may be assumed. Using this assumption, the following overlay thicknesses were determined.

ESAL's	Total Pavement	AC	Thicknesses (inches)	
			DGA	Overlay
1,000,000	20.0	0	11	9.0
2,000,000	21.0	0	11	10.0
3,000,000	21.5	0	11	10.5

By plotting logarithm of overlay verses logarithm of ESAL , a straight line relation may be developed and the overlay for a range of ESAL's may be calculated. The relation between overlay thickness and ESAL's is shown in Figure 2.

The minimum overlay resulting from this analysis was 3.6 inches of asphaltic concrete. This thickness of overlay is considered prohibitive given the existing curb and gutter section. Therefore the following rehabilitation strategy is proposed:

1. Allow the pavement to deteriorate to a terminal condition.
2. When the terminal pavement condition is reached,

reconstruct the pavement.

3. Alternate pavement designs are:

- a. 7.5 inches Asphaltic Concrete
15.5 inches Dense Graded Aggregate
- b. 9 inches Asphaltic Concrete
9 inches Dense Graded Aggregate
- c. 10 inches Asphaltic Concrete
4 inches Dense Graded Aggregate
- d. 11 inches Full Depth Asphaltic Concrete

The designs are base on a CBR 3 subgrade and 1,000,000 ESAL's.

4. The pavement designs presented are somewhat greater than typically associated with pavement designs for local streets and roads. Traffic data supplied by the Lexington Fayette Urban County Government did indicate a large number of trucks using Elkhorn Drive. Since there were no truck classifications given, final design ESAL's should be verified and design calculations made before reconstruction.

OVERLAY THICKNESS COMPUTATIONS

KENTUCKY PROCEDURE

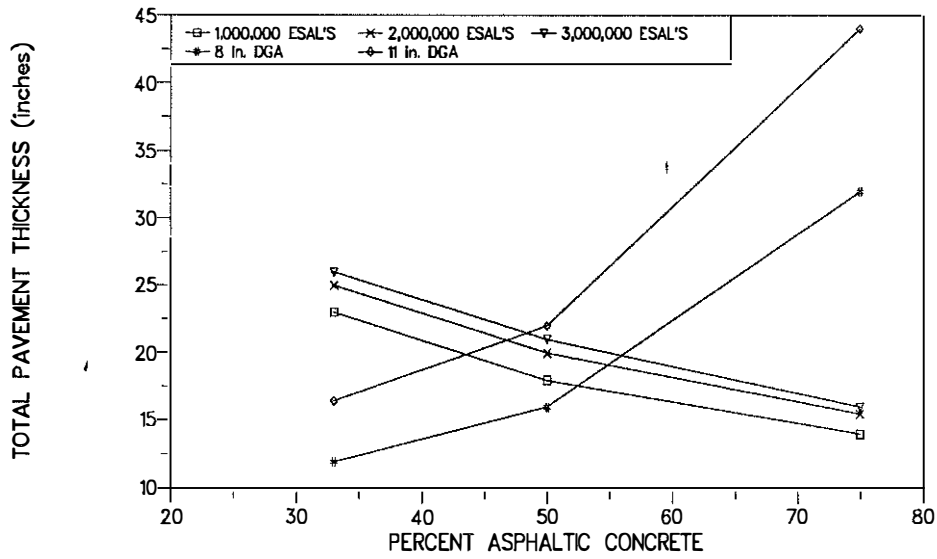


Figure 1. Total Pavement Thicknesses

ELKHORN DRIVE -- LEXINGTON, KENTUCKY

OVERLAY THICKNESS REQUIREMENTS

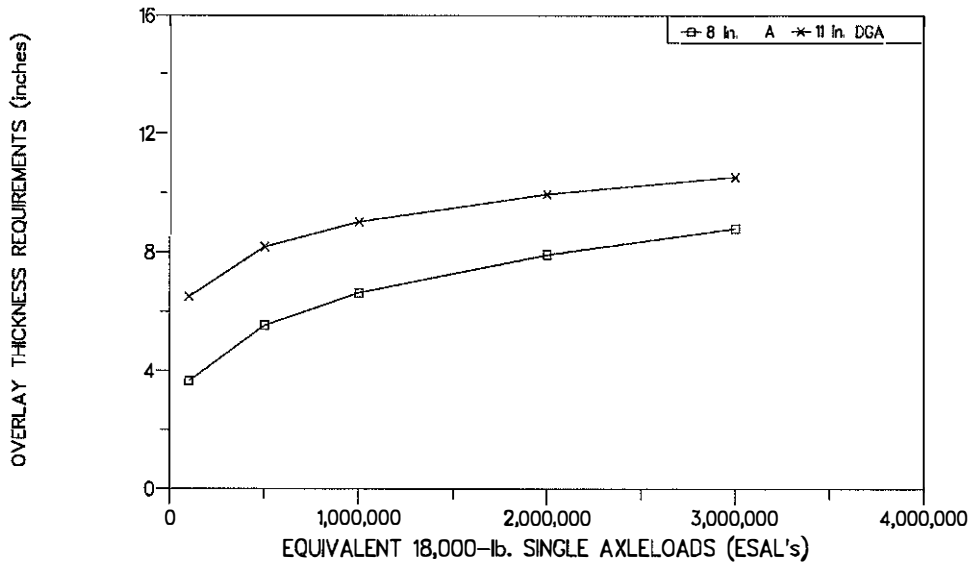


Figure 2. Overlay Thicknesses

TABLE 1. RAW ROAD RATER DATA

STA	LOAD	TEMP	FREQ	DEFL 1	DEFL 2	DEFL 3	DEFL 4
	(kips)	(°F)	(Hz)	(in x 10 ⁻³)			
ELKHORN DRIVE EASTBOUND							
0	0.60	124	25.0	1.52	0.96	0.35	0.20
0	1.21	124	25.2	3.96	2.44	0.94	1.20
100	0.59	124	25.0	1.21	0.67	0.24	0.05
100	1.22	124	25.1	3.29	1.82	0.52	0.11
200	0.61	124	25.1	1.89	1.29	0.71	0.34
200	1.22	124	25.1	5.28	3.54	1.80	0.85
300	0.61	124	25.1	1.75	1.25	0.66	0.32
300	1.22	124	25.1	5.15	3.57	1.85	0.86
400	0.58	124	25.0	0.84	0.56	0.25	0.34
400	1.21	124	25.1	2.73	1.63	0.72	0.63
500	0.59	124	25.0	1.22	0.68	0.29	0.00
500	1.21	124	25.1	4.15	2.21	0.55	0.02
600	0.59	124	25.0	1.67	1.22	0.64	0.29
600	1.22	124	25.1	5.41	3.96	1.79	0.85
700	0.60	124	25.1	1.01	0.71	0.48	0.25
700	1.19	124	25.1	2.54	1.79	1.15	0.62
800	0.59	124	25.0	1.27	0.82	0.45	0.27
800	1.19	124	25.0	3.55	2.21	1.06	0.65
ELKHORN DRIVE WESTBOUND							
800	0.59	124	25.0	0.98	0.74	0.55	0.27
800	1.19	124	25.0	2.64	2.07	3.71	0.68
700	0.59	124	25.0	1.53	1.08	0.65	0.37
700	1.19	124	25.1	4.59	3.12	1.80	1.00
600	0.58	124	25.0	1.54	0.93	0.44	0.11
600	1.19	124	25.1	4.98	2.89	1.00	0.25
500	0.59	124	25.0	0.74	0.35	0.14	0.00
500	1.19	124	25.0	2.38	1.13	0.58	0.02
400	0.59	124	25.0	0.95	0.48	0.12	0.16
400	1.19	124	25.1	3.33	1.64	0.45	0.64
300	0.59	124	25.0	1.46	0.97	0.53	0.22
300	1.18	124	25.1	4.65	2.96	1.43	0.67
200	0.59	124	25.0	2.18	1.56	0.89	0.48
200	1.18	124	25.0	7.11	4.84	2.57	1.31
100	0.60	124	25.0	0.97	0.54	0.23	0.79
100	1.19	124	25.1	2.97	1.56	0.65	1.93
0	0.60	124	25.0	1.26	0.71	0.32	0.97
0	1.19	124	25.1	4.02	2.10	0.79	2.45

TABLE 2. ROAD RATER DEFLECTIONS ADJUSTED TO 70 F
MEAN PAVEMENT TEMPERATURE

STA	LOAD (kips)	Sensor 1	Sensor 2 (in x 10 ⁻⁵)	Sensor 3	Sensor 4
ELKHORN DRIVE EASTBOUND					
0	0.60	110.42	64.54	24.93	14.24
0	1.21	287.79	164.09	66.96	85.48
100	0.59	87.90	45.04	17.09	3.56
100	1.22	239.05	122.37	37.04	7.83
200	0.61	137.33	86.74	50.57	24.22
200	1.22	383.65	238.02	128.21	60.54
300	0.61	127.16	84.05	47.01	22.79
300	1.22	374.20	240.04	131.77	61.25
400	0.58	61.02	37.65	17.80	24.21
400	1.21	198.36	109.60	51.28	44.87
500	0.59	88.63	45.71	20.65	0.00
500	1.21	301.54	148.60	39.17	1.42
600	0.59	121.32	82.02	45.58	20.65
600	1.22	393.09	266.26	127.49	60.54
700	0.60	73.39	47.74	34.19	17.81
700	1.19	184.56	120.36	81.91	44.16
800	0.59	92.26	55.13	32.05	19.23
800	1.19	257.90	148.57	75.49	46.29
ELKHORN DRIVE WESTBOUND					
800	0.59	71.19	49.75	39.17	19.23
800	1.19	191.79	139.16	264.21	48.43
700	0.59	111.15	72.61	46.29	26.35
700	1.19	333.51	209.78	128.21	71.23
600	0.58	111.88	62.52	31.34	7.83
600	1.19	361.85	194.32	71.23	17.81
500	0.59	53.76	23.53	9.97	0.00
500	1.19	172.90	75.97	41.31	1.42
400	0.59	69.01	32.27	8.55	11.39
400	1.19	241.96	110.27	32.05	45.58
300	0.59	106.07	65.21	37.74	15.67
300	1.18	337.87	199.02	101.85	47.72
200	0.59	158.37	104.87	63.38	34.18
200	1.18	516.52	325.38	183.03	93.29
100	0.60	70.47	36.30	16.38	56.26
100	1.19	215.80	104.89	46.30	137.46
0	0.60	91.54	47.73	22.79	69.08
0	1.19	292.09	141.20	56.27	174.50

TABLE 3. CALCULATED SUBGRADE MODULUS

=====					
ASSUMED AC MODULUS = 750,000 psi					
PREDICTED SUBGRADE MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	11619.95	12132.67	18795.41	22111.10	16164.78
0	8426.07	9438.61	14001.89	7493.09	9839.92
100	15329.07	17675.01	27389.11	86589.87	36745.77
100	10555.56	12828.15	25285.23	78834.84	31875.94
200		8905.26	9277.39	13110.81	10052.47
200	5942.77	6396.16	7322.27	10524.46	7546.42
300	9790.06	9203.59	9978.75	13917.33	10722.43
300	6125.44	6339.94	7124.75	10403.93	7498.52
400	23879.75	21322.59	26295.71	13112.46	21152.63
400	13240.11	14396.40	18273.11	14135.12	15011.18
500	15176.59	17403.18	22675.51		18418.43
500	7961.64	10470.27	23908.64		14113.52
600	10364.82	9442.03	10291.27	15335.89	11358.50
600	5769.80	5688.32	7363.10	10524.46	7336.42
700	19086.20	16631.95	13711.97	17747.08	16794.30
700	14452.36	13053.14	11450.97	14359.61	13329.02
800	14453.99	14307.78	14626.07	16453.90	14960.44
800	9626.32	10471.98	12422.85	13708.44	11557.40
ELKHORN DRIVE WESTBOUND					
800	19802.47	15929.84	11971.63	16453.90	16039.46
800	13793.27	11214.00	3558.04	13112.65	10419.49
700	11527.77	10726.15	10133.25	12064.87	11113.01
700	7044.55	7299.53	7322.27	8967.93	7658.57
600	11436.92	12542.41	14957.80	39836.28	19693.35
600	6380.31	7908.32	13165.04	35123.22	15644.22
500	27854.03	34864.05	46901.73		36539.94
500	15644.07	21123.48	22677.23		19814.92
400	20564.53	25053.92	54701.67	27544.76	31966.22
400	10401.78	14304.59	29210.28	13917.59	16958.56
300	12202.47	12001.85	12422.46	20130.31	14189.27
300	6934.31	7712.79	9212.73	13303.68	9290.88
200	7498.76	7300.87	7405.39	9337.08	7885.52
200	4141.28	4612.00	5132.65	6874.79	5190.18
100	20050.69	22149.45	28577.49	5716.54	19123.54
100	11952.27	15072.85	20236.96	4693.30	12988.85
0	14593.44	16634.67	20553.76	4670.37	14113.06
0	8275.39	11044.66	16656.98	3710.61	9921.91
mean	12244.87	13155.62	17083.09	18556.88	15361.92
max	27854.03	34864.05	54701.67	86589.87	36745.77
min	4141.28	4612.00	3558.04	3710.61	5190.18

TABLE 4. CALCULATED SUBGRADE MODULUS

=====					
ASSUMED AC MODULUS = 1,000,000 psi					
PREDICTED SUBGRADE MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	11166.55	12100.46	18819.91	22153.09	16060.00
0	8081.38	9407.95	14025.44	7511.83	9756.65
100	14756.16	17644.87	27411.29	86699.74	36628.02
100	10137.96	12796.47	25307.27	78869.39	31777.77
200	8554.51	8874.67	9298.08	13138.86	9966.53
200	5687.31	6369.06	7341.10	10547.65	7486.28
300	9398.11	9172.75	10000.05	13946.73	10629.41
300	5863.23	6312.95	7143.34	10426.96	7436.62
400	23050.27	21296.33	26318.41	13140.52	20951.39
400	12734.22	14365.08	18297.17	14162.61	14889.77
500	14608.48	17372.82	22699.49		18226.93
500	7633.25	10439.01	23931.31		14001.19
600	9953.37	9410.99	10312.81	15367.60	11261.20
600	5520.75	5662.53	7381.97	10547.65	7278.23
700	18397.76	16601.03	13735.51	17782.58	16629.22
700	13907.73	13021.48	11473.39	14387.34	13197.48
800	13908.74	14275.75	14649.94	16487.39	14830.46
800	9240.18	10440.73	12445.78	13735.47	11465.54
ELKHORN DRIVE WESTBOUND					
800	19092.54	15898.50	11994.32	16487.39	15868.19
800	13269.62	11182.48	3570.71	13139.01	10290.46
700	11077.42	10694.34	10154.68	12091.15	11004.40
700	6748.85	7271.06	7341.10	8988.95	7587.49
600	10989.58	12510.16	14981.78	39901.10	19595.66
600	6108.73	7879.08	13188.29	35163.49	15584.90
500	26912.07	34864.44	46906.65		36227.72
500	15061.95	21098.10	22700.37		19620.14
400	19831.90	25033.27	54696.38	27594.27	31788.96
400	9989.34	14273.23	29229.96	13944.85	16859.34
300	11729.88	11969.66	12445.40	20169.40	14078.59
300	6642.59	7683.78	9233.51	13330.26	9222.54
200	7186.71	7272.14	7424.09	9358.53	7810.37
200	3954.37	4588.64	5148.35	6892.51	5145.97
100	19333.35	22124.30	28599.04	5730.96	18946.91
100	11488.28	15041.81	20260.77	4706.97	12874.46
0	14043.76	16603.75	20578.14	4682.59	13977.06
0	7935.97	11013.19	16681.02	3722.19	9838.09
mean	11777.69	13126.86	17103.52	18587.78	15244.28
max	26912.07	34864.44	54696.38	86699.74	36628.02
min	3954.37	4588.64	3570.71	3722.19	5145.97

TABLE 5. CALCULATED SUBGRADE MODULUS

=====					
ASSUMED AC MODULUS = 2,000,000 psi					
PREDICTED SUBGRADE MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	9880.24	11871.85	18928.90	22286.44	15741.86
0	7101.82	9190.46	14109.14	7589.12	9497.64
100	13133.10	17424.10	27562.75	86750.34	36217.57
100	8951.69	12566.99	25448.77	79000.83	31492.07
200	7526.80	8660.74	9356.56	13245.41	9697.38
200	4961.14	6180.20	7387.94	10643.00	7293.07
300	8285.43	8956.71	10062.44	14056.49	10340.27
300	5117.88	6124.81	7189.05	10521.66	7238.35
400	20708.23	21097.97	26464.59	13247.07	20379.46
400	11298.21	14135.56	18403.26	14275.29	14528.08
500	12998.92	17150.88	22827.94		17659.25
500	6699.97	10215.95	24065.98		13660.63
600	8785.54	9193.39	10376.93	15482.58	10959.61
600	4812.85	5483.51	7429.05	10643.00	7092.10
700	16450.27	16376.15	13818.12	17905.25	16137.45
700	12362.28	12791.80	11543.33	14500.97	12799.60
800	12363.51	14045.90	14737.38	16606.11	14438.22
800	8143.07	10217.66	12521.00	13846.29	11182.01
ELKHORN DRIVE WESTBOUND					
800	17084.81	15671.49	12067.60	16606.11	15357.50
800	11783.44	10956.49	3595.14	13247.17	9895.56
700	9799.73	10470.05	10217.92	12193.22	10670.23
700	5908.37	7071.55	7387.94	9075.50	7360.84
600	9720.40	12280.84	15070.96	40047.61	19279.95
600	5336.78	7673.48	13267.52	35325.96	15400.93
500	24256.51	34833.56	47148.01		35412.69
500	13410.71	20898.78	22828.88		19046.12
400	17760.61	24869.11	54971.89	27736.18	31334.45
400	8817.73	14043.63	29390.72	14056.59	16577.17
300	10389.43	11741.33	12521.12	20298.38	13737.57
300	5813.41	7480.04	9291.08	13439.29	9005.95
200	6300.20	7072.59	7471.97	9447.14	7572.97
200	3423.21	4427.52	5182.37	6965.61	4999.68
100	17304.86	21932.60	28756.20	5796.50	18447.54
100	10170.72	14813.21	20376.94	4763.51	12531.09
0	12486.06	16378.89	20696.02	4739.94	13575.23
0	6971.37	10787.79	16778.73	3770.12	9577.00
mean	10453.31	12919.10	17201.50	18690.90	14892.70
max	24256.51	34833.56	54971.89	86750.34	36217.57
min	3423.21	4427.52	3595.14	3770.12	4999.68

TABLE 6. CALCULATED SUBGRADE MODULUS

=====					
ASSUMED AC MODULUS = 3,000,000 psi					
PREDICTED SUBGRADE MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	9023.95	11595.61	19007.65	22419.31	15511.63
0	6454.19	8938.06	14154.21	7655.46	9300.48
100	12046.45	17128.43	27708.90	86965.62	35962.35
100	8163.82	12286.03	25571.21	79179.02	31300.02
200	6846.35	8414.63	9375.48	13342.06	9494.63
200	4484.40	5970.69	7398.47	10726.04	7144.90
300	7547.31	8707.09	10085.00	14156.92	10124.08
300	4628.25	5916.29	7198.75	10604.09	7086.84
400	19125.60	20806.56	26601.64	13343.73	19969.38
400	10340.06	13846.76	18475.45	14375.04	14259.33
500	11921.53	16855.38	22935.90		17237.60
500	6083.64	9952.99	24178.07		13404.90
600	8009.94	8941.09	10401.16	15589.36	10735.39
600	4348.37	5287.03	7439.75	10726.04	6950.29
700	15140.45	16081.54	13862.40	18022.05	15776.61
700	11329.25	12509.52	11573.86	14601.67	12503.58
800	11330.22	13757.78	14787.49	16717.65	14148.28
800	7415.78	9954.68	12556.90	13944.22	10967.90
ELKHORN DRIVE WESTBOUND					
800	15733.44	15378.22	12101.31	16717.65	14982.65
800	10790.97	10686.98	3593.19	13342.49	9603.41
700	8949.32	10204.91	10241.31	12284.79	10420.08
700	5354.70	6847.24	7398.47	9150.32	7187.68
600	8875.78	12001.89	15123.23	40226.20	19056.77
600	4829.25	7440.24	13307.67	35484.18	15265.34
500	22456.17	34642.25	47475.06		34857.83
500	12305.17	20606.20	22931.91		18614.42
400	16365.35	24593.28	55378.92	27885.97	31055.88
400	8039.82	13755.20	29543.72	14155.42	16373.54
300	9496.20	11466.00	12557.50	20424.26	13485.99
300	5267.34	7249.59	9310.13	13535.45	8840.63
200	5715.30	6848.32	7481.99	9524.28	7392.47
200	3076.99	4253.62	5184.73	7028.16	4885.87
100	15939.16	21643.73	28912.39	5851.12	18086.60
100	9293.44	14521.94	20462.55	4811.31	12272.31
0	11444.23	16084.27	20787.73	4787.06	13275.82
0	6333.87	10519.70	16840.29	3810.41	9376.07
mean	9569.61	12658.16	17276.23	18793.35	14636.43
max	22456.17	34642.25	55378.92	86965.62	35962.35
min	3076.99	4253.62	3593.19	3810.41	4885.87

TABLE 7. CALCULATED DGA MODULUS

=====					
ASSUMED AC MODULUS = 750,000 psi					
PREDICTED DGA MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	31940.97	31726.12	47543.31	54296.98	41376.84
0	24557.41	25842.86	37368.94	22407.67	27544.22
100	40063.98	43158.75	64690.71		49304.48
100	29527.18	33210.56	60597.36		41111.70
200	25720.24	24638.78	26686.67	35409.88	28113.90
200	18456.76	18795.85	21990.14	29584.90	22206.91
300	27763.79	25311.89	28325.80	37181.80	29645.82
300	18919.51	18660.62	21503.75	29307.49	22097.84
400	57572.72	50316.91	62570.60	35413.31	51468.39
400	35539.74	36496.08	46460.24	37657.05	39038.28
500	39737.74	42615.09	55431.26		45928.03
500	23444.61	28127.42	57885.30		36485.78
600	29090.03	25843.54	29049.15	40253.72	31059.11
600	18016.17	17076.56	22090.38	29584.90	21692.00
700	47931.83	41069.57	36734.61	45360.72	42774.18
700	38179.83	33686.22	31700.54	38145.52	35428.03
800	38183.36	36307.27	38725.52	42638.48	38963.66
800	27383.41	28127.42	33884.50	36724.49	31529.96
ELKHORN DRIVE WESTBOUND					
800	49398.15	39640.67	32874.46	42638.48	41137.94
800	36749.66	29747.34	12185.91	35413.74	28524.16
700	31733.57	28684.52	28683.83	33081.80	30545.93
700	21211.46	20940.70	21990.14	25954.82	22524.28
600	31528.86	32599.81	39442.46	87880.78	47862.98
600	19560.97	22358.68	35531.75	79280.94	39183.08
500	65298.31	75226.76			70262.54
500	40736.12	49932.38	55434.72		48701.08
400	50947.66	57411.38		64987.43	57782.16
400	29174.85	36305.59	68188.67	37182.39	42712.87
300	33244.79	31446.05	33883.63	50284.83	37214.83
300	20939.58	21905.49	26534.44	35835.40	26303.73
200	22323.70	20940.98	22193.94	26825.28	23070.98
200	13735.99	14382.47	16444.30	20883.33	16361.52
100	49904.04	51907.31	66977.59	17958.16	46686.78
100	32686.22	37892.81	50505.94	15282.89	34091.96
0	38484.40	41069.57	51151.38	15221.68	36481.76
0	24197.63	29383.36	43071.25	12611.02	27315.81
mean	32885.70	33410.76	39068.62	37176.33	36459.26
std	11772.30	12478.51	15443.59	16907.09	11272.55

TABLE 8. CALCULATED DGA MODULUS

=====					
ASSUMED AC MODULUS = 1,000,000 psi					
PREDICTED DGA MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	30917.90	31653.85	47593.72	54381.18	41136.66
0	23732.62	25771.44	37420.11	22453.42	27344.40
100	38835.04	43093.96	64733.18		48887.39
100	28568.19	33139.93	60640.19		40782.77
200	24863.16	24566.94	26735.18	35471.78	27909.26
200	17805.21	18728.70	22036.24	29638.10	22052.06
300	26851.28	25239.80	28375.07	37245.96	29428.03
300	18254.44	18593.62	21549.49	29360.43	21939.50
400	55931.76	50260.87	62614.41	35475.21	51070.56
400	34425.13	36427.21	46509.99	37716.80	38769.78
500	38516.86	42549.75	55478.88		45515.16
500	22650.66	28055.73	57929.84		36212.08
600	28142.04	25771.29	29098.72	40321.70	30833.44
600	17377.57	17011.40	22136.55	29638.10	21540.91
700	46512.99	41002.77	36785.98	45434.83	42434.14
700	36998.91	33615.80	31751.10	38205.62	35142.85
800	37001.12	36236.92	38777.00	42709.36	38681.10
800	26481.64	28055.73	33935.44	36783.56	31314.10
ELKHORN DRIVE WESTBOUND					
800	47944.83	39572.65	32925.22	42709.36	40788.01
800	35604.52	29675.76	12221.33	35471.84	28243.36
700	30715.92	28611.88	28733.25	33140.66	30300.43
700	20480.38	20871.64	22036.24	26004.47	22348.18
600	30516.55	32527.78	39493.94	87997.54	47633.95
600	18877.27	22288.66	35582.86	79355.00	39025.94
500	63486.49	75219.45			69352.97
500	39492.05	49877.97	55480.66		48283.56
400	49458.19	57366.58		65082.82	57302.53
400	28225.20	36236.60	68225.84	37241.80	42482.36
300	32187.92	31373.71	33934.60	50364.60	36965.21
300	20216.25	21835.75	26583.23	35893.82	26132.26
200	21560.94	20871.33	22239.65	26875.61	22886.88
200	13226.78	14321.32	16485.33	20927.26	16240.17
100	48438.89	51853.58	67018.51	17995.18	46326.54
100	31644.63	37824.93	50554.24	15319.23	33835.76
0	37294.64	41002.77	51200.70	15254.22	36188.08
0	23382.77	29311.73	43121.84	12643.13	27114.87
mean	31850.58	33344.99	39115.84	37237.09	36179.04
std	11473.24	12487.31	15442.85	16923.81	11154.23

TABLE 9. CALCULATED DGA MODULUS

=====					
ASSUMED AC MODULUS = 2,000,000 psi					
PREDICTED DGA MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	27972.81	31141.28	47818.89	54647.85	40395.21
0	21352.41	25264.87	37602.57	22641.84	26715.42
100	35304.63	42621.55	65025.39		47650.52
100	25803.44	32629.41	60917.22		39783.36
200	22391.96	24064.08	26872.57	35706.26	27258.72
200	15922.96	18259.99	22151.13	29856.58	21547.67
300	24221.63	24734.65	28519.69	37484.90	28740.22
300	16333.25	18126.03	21662.15	29577.88	21424.83
400	51238.65	49841.49	62898.53	35709.70	49922.09
400	31215.75	35924.48	46730.32	37961.47	37958.01
500	35009.32	42074.11	55735.35		44272.93
500	20358.97	27544.49	58196.17		35366.55
600	25411.05	25264.55	29246.51	40567.59	30122.43
600	15532.58	16558.24	22251.90	29856.58	21049.83
700	42445.30	40518.63	36966.72	45690.23	41405.22
700	33600.49	33106.07	31909.24	38451.65	34266.86
800	33603.23	35733.08	38966.08	42959.99	37815.59
800	23880.70	27544.49	34103.03	37025.56	30638.44
ELKHORN DRIVE WESTBOUND					
800	43779.82	39081.54	33089.57	42959.99	39727.73
800	32308.07	29163.15	12289.64	35709.93	27367.70
700	27786.23	28099.73	28879.45	33368.74	29533.54
700	18369.32	20387.27	22151.13	26208.66	21779.10
600	27602.11	32016.05	39686.00	88260.20	46891.09
600	16902.45	21796.03	35757.50	79653.49	38527.37
500	58314.61	75110.48			66712.55
500	35913.85	49456.32	55737.26		47035.81
400	45191.23	57017.34		65355.33	55854.64
400	25487.17	35733.27	68532.40	37485.11	41809.49
300	29146.51	30860.96	34103.27	50626.99	36184.43
300	18127.47	21345.59	26718.65	36133.18	25581.22
200	19359.86	20386.92	22356.83	27083.10	22296.68
200	11754.82	13898.60	16574.33	21108.29	15834.01
100	44240.49	51448.50	67319.39	18163.02	45292.85
100	28643.70	37327.07	50791.05	15469.33	33057.79
0	33875.43	40518.63	51440.30	15406.60	35310.24
0	21031.08	28799.29	43328.20	12775.95	26483.63
mean	28873.15	32872.17	39303.78	37463.53	35322.60
std	10623.31	12536.19	15507.45	16956.33	10824.15

TABLE 10. CALCULATED DGA MODULUS

=====					
ASSUMED AC MODULUS = 3,000,000 psi					
PREDICTED DGA MODULUS					
(PSI)					
STA	Sensor 1	Sensor 2	Sensor 3	Sensor 4	mean

ELKHORN DRIVE EASTBOUND					
0	25973.69	30525.38	47982.19	54913.57	39848.71
0	19746.05	24678.31	37701.24	22803.32	26232.23
100	32896.73	41998.86	65308.14		46734.58
100	23930.47	32008.60	61157.56		39032.21
200	20722.08	23486.47	26917.36	35918.83	26761.18
200	14660.05	17739.40	22177.20	30046.62	21155.82
300	22441.84	24152.07	28572.37	37703.39	28217.42
300	15043.57	17607.09	21686.32	29766.92	21025.97
400	48012.74	49242.28	63165.68	35922.29	49085.75
400	29033.17	35297.75	46880.75	38177.85	37347.38
500	32617.43	41450.45	55951.61		43339.83
500	18813.83	26943.93	58418.49		34725.41
600	23560.88	24678.25	29302.77	40795.82	29584.43
600	14295.28	16059.86	22278.36	30046.62	20670.03
700	39660.32	39892.83	37064.08	45933.36	40637.65
700	31285.89	32484.07	31978.64	38669.45	33604.51
800	31288.07	35107.19	39074.93	43195.38	37166.39
800	22121.44	26943.93	34183.40	37239.16	30121.98
ELKHORN DRIVE WESTBOUND					
800	40926.37	38454.66	33165.60	43195.38	38935.50
800	30064.71	28554.57	12284.33	35919.52	26705.78
700	25797.85	27496.59	28933.89	33573.19	28950.38
700	16948.87	19842.59	22177.20	26384.95	21338.40
600	25624.33	31397.42	39799.07	88581.02	46350.46
600	15575.87	21237.44	35846.41	79944.22	38150.99
500	54749.84	74719.18			64734.51
500	33473.49	48854.18	55943.59		46090.42
400	42265.99	56458.97		65643.16	54789.37
400	23632.75	35106.74	68824.91	37700.09	41316.12
300	27080.28	30246.02	34184.75	50883.08	35598.53
300	16722.38	20791.28	26763.78	36344.08	25155.38
200	17876.85	19842.36	22381.64	27263.55	21841.10
200	10773.07	13440.82	16580.70	21262.94	15514.38
100	41363.54	50857.00	67619.21	18302.67	44535.60
100	26606.42	36699.40	50966.14	15596.01	32466.99
0	31545.35	39892.83	51627.37	15531.57	34649.28
0	19444.45	28192.38	43458.71	12887.35	25995.72
mean	26849.33	32288.37	39422.30	37671.51	34678.07
std	10030.14	12534.37	15595.89	17002.88	10587.55

APPENDIX A

ANALYSIS OF TRAFFIC DATA

A. EVALUATION OF TRAFFIC DATA

COUNT DATA APRIL 7, 1988 9:15 TO 11:00 AM
105 MINUTES

ELKHORN DRIVE

	NON TRUCKS	TRUCKS	PERCENT TRUCKS	VEH/MIN
LEFT TURNS	459	32	6.517	4.676
RIGHT TURNS	270	16	5.594	2.724

COUNT DATA APRIL 10, 1988 4:15 TO 6:00 PM
105 MINUTES

ELKHORN DRIVE

	NON TRUCKS	TRUCKS	PERCENT TRUCKS	VEH/MIN
LEFT TURNS	485	22	4.339	4.829
RIGHT TURNS	223	21	8.607	2.324

COUNT DATA APRIL 7, 1988 9:15 TO 11:00 AM
105 MINUTES

TURNS FROM WINCHESTER ROAD ON TO ELKHORN DRIVE

	NON TRUCKS	TRUCKS	PERCENT TRUCKS	VEH/MIN
LT FROM EB WIN	349	26	6.933	3.571
RT FROM WB WIN	456	25	5.198	4.581

COUNT DATA APRIL 10, 1988 4:15 TO 6:00 PM
 105 MINUTES

 TURNS FROM WINCHESTER ROAD ONTO ELKHORN DRIVE

	NON TRUCKS	TRUCKS	PERCENT TRUCKS	VEH/MIN
LT FROM EB WIN	361	15	3.989	3.581
RT FROM WB WIN	328	23	6.553	3.343

 CALCULATED MEANS

PERCENT TRUCKS	VEH/MIN
5.966	3.704

B. ESTIMATION OF EQUIVALENT AXLELOADS

KENTUCKY 1981 PROCEDURES

THERE WERE NO DATA AVAILABLE RELATIVE TO THE TYPES OF TRUCKS USING THE FACILITY

THE FOLLOWING TRUCKS WERE ASSUMED TO BE EQUALLY DISTRIBUTED WITHIN THE COMPUTED PERCENT TRUCKS

VEHICLE	SU-2A	SU-3A	C-3A	C-4A	C-5A
GROSS WEIGHT-	26,000	48,000	48,000	64,000	80,000
AXLE WEIGHTS					
FRONT SINGLE	8,000	12,000	12,000	12,000	12,000
REAR SINGLE	18,000		18,000		
REAR TANDEM		34,000		34,000	34,000
TRAILER SINGLE			18,000	18,000	
TRAILER TANDEM					34,000

VEHICLE	SU-2A	SU-3A	C-3A	C-4A	C-5A
GROSS WEIGHT-	26,000	48,000	48,000	64,000	80,000

LOAD EQUIVALENCY FACTORS FROM REPORT UKTRP 81-17, FIGURE 3

FRONT SINGLE	0.2	0.7	0.7	0.7	0.7
REAR SINGLE	1		1		
REAR TANDEM		0.6		0.6	0.6
TRAILER SINGLE			1	1	
TRAILER TANDEM					0.6

ESAL'S PER VEHI	1.2	1.3	2.7	2.3	1.9
-----------------	-----	-----	-----	-----	-----

AVERAGE ESAL'S PER TRUCK	1.88 ESAL'S PER TRUCK				
--------------------------	-----------------------	--	--	--	--

ESAL'S PER AUTO, PICK-UP ETC.	0.01 ESAL'S PER NON-TRUCK				
-------------------------------	---------------------------	--	--	--	--

C. COMPARATIVE ANALYSIS TO ESTIMATE ESAL'S BY AASHTO METHOD

1986 AASHTO GUIDE FOR DESIGN OF PAVEMENT STRUCTURES

THERE WERE NO DATA AVAILABLE RELATIVE TO
THE TYPES OF TRUCKS USING THE FACILITY

THE FOLLOWING TRUCKS WERE ASSUMED TO BE
EQUALLY DISTRIBUTED WITHIN THE COMPUTED PERCENT TRUCKS

VEHICLE	SU-2A	SU-3A	C-3A	C-4A	C-5A
GROSS WEIGHT-	26,000	48,000	48,000	64,000	80,000
AXLE WEIGHTS					
FRONT SINGLE	8,000	12,000	12,000	12,000	12,000
REAR SINGLE	18,000		18,000		
REAR TANDEM		34,000		34,000	34,000
TRAILER SINGLE			18,000	18,000	
TRAILER TANDEM					34,000

VEHICLE	SU-2A	SU-3A	C-3A	C-4A	C-5A
GROSS WEIGHT-	26,000	48,000	48,000	64,000	80,000

LOAD EQUIVALENCY FACTORS FROM 1986 AASHTO GUIDE (PT =2.0),
TABLES D.1 & D.2

FRONT SINGLE	0.036	0.189	0.189	0.189	0.189
REAR SINGLE	1		1		
REAR TANDEM		1.06		1.06	1.06
TRAILER SINGLE			1	1	
TRAILER TANDEM					1.06

ESAL'S PER VEHI 1.036 1.249 2.189 2.249 2.309

AVERAGE ESAL'S PER TRUCK 1.806 ESAL'S PER TRUCK

ESAL'S PER AUTO, PICK-UP ETC. 0.002 ESAL'S PER NON-TRUCK

D. ESTIMATION OF DESIGN EQUIVALENT AXLELOADS

ASSUME 15-YEAR LIFE

ESAL'S BY KENTUCKY 1981 PROCEDURE

5,333	ESIMATED ADT	
	ESAL'S FOR TRUCKS	3,280,000
	ESAL'S FOR NON-TRUCKS	275,000
	TOTAL ESAL'S	3,550,000

3,333	ESIMATED ADT	
	ESAL'S FOR TRUCKS	2,050,000
	ESAL'S FOR NON-TRUCKS	172,000
	TOTAL ESAL'S	2,220,000

ESAL'S BY 1986 AASHTO DESIGN GUIDE PROCEDURE

5,333	ESIMATED ADT	
	ESAL'S FOR TRUCKS	3,150,000
	ESAL'S FOR NON-TRUCKS	54,900
	TOTAL ESAL'S	3,200,000

3333	ESIMATED ADT	
	ESAL'S FOR TRUCKS	1,970,000
	ESAL'S FOR NON-TRUCKS	34,300
	TOTAL ESAL'S	2,000,000