Research Report
KTC-96-24

VISUAL INSPECTION OF NEW RAMP PAVEMENT AT BLUEGRASS AIRPORT LEXINGTON, KENTUCKY

by

David L. Allen
Chief Research Engineer

Kentucky Transportation Center
College of Engineering
University of Kentucky

October 25, 1996

INTRODUCTION

Personnel from the Kentucky Transportation Center performed a visual inspection of newly constructed ramp pavement at the Bluegrass Airport in Lexington, Kentucky. The inspection was conducted in May, 1996 at the request of airport engineers. The inspection revealed a number of concrete apron slabs that had cracked. Attempts had been made (apparently by the contractor) to seal the cracks by epoxy injection. The visual inspection indicated that the epoxy may not have been performing as hoped, and that some of the cracks did not appear to be sealed. As a result, it was decided to obtain cores of the cracked slabs in the area of the cracks in an attempt to determine if the epoxy was performing as it should have been.

During the inspection, other concrete damage was noted along and associated with two drainage trenches constructed as a part of the new ramp. This damage will be described in detail later in this report.

ANALYSIS OF PAVEMENT CORES

Condition

Five two-inch diameter cores were obtained on June 3, 1996. The locations are noted on Figure 1. Four of the five cores were cut where the panels were cracked and had been sealed with epoxy. Core 2 was taken in a location where there was no crack. Figures 2 through 5 show the condition of the extracted cores. Cores 1, 3, 4 and 5 were in very poor conditions. Core 2 was in good condition, with one horizontal crack that was apparently caused by the coring process.

All of the cores that had vertical cracks and had been sealed with epoxy fell apart except Core 5. However, it came apart along two horizontal cracks. Figures 2 and 3 show that the epoxy apparently did not provide much adhesion or tensile strength across the cracks. From Figure 2, it appears the epoxy did not completely fill all of the cracks, leaving portions of the surface area of the crack without side-to-side bonding and without an effective seal against water.

Permeability Tests

To test the effectiveness of the epoxy seal against water, a series of laboratory permeability tests was performed on two of the cores. The test procedure used was in general accordance with ASTM Method D 5084. A portion of Core 2, which had no vertical crack, was tested and was determined to be impermeable. Because Core 5 was the only core that was epoxy-sealed that did not fall apart, it was used in the permeability tests. The epoxy-sealed crack in Core 5 allowed such a large volume of water through the crack that an accurate determination of the permeability was not possible. This clearly indicates the apparent ineffectiveness of the epoxy seal against water.

Tensile Tests

Project and Airport engineers indicated that cores taken earlier by the contractor had been tested in compression and were found to be within strength specifications. However, the most appropriate method of testing the cores is in tension. Testing in tension should help to determine the effectiveness of the bond strength of the epoxy. Two splitting tensile tests were performed on a short portion of Core 2 (intact core) and a short portion of Core 5 (an epoxy-sealed crack that had stayed together). The two test specimens were of equal length. The tests were performed in general agreement with ASTM Method D 3967. However, there was one modification in the procedure. The core specimens were of insufficient length to meet the length requirements of that method. Therefore, the actual strength values are not reported but only the relative values between the two cores. The relative tensile strength of the intact core (Core 2) was approximately twice the tensile strength of the epoxyed core (Core 5).

DRAINAGE TRENCHES

Temperature Expansion of Steel Grating

As shown in Figure 1, there are two concrete drainage trenches located on the south and southeast sides of the apron. Both trenches are covered with steel grating as shown in Figure 5. The steel grating rests on a steel angle frame that was cast in place in the concrete wall of the trench (noted in Figure 7). It appeared that all or most of the 2-foot by 2-foot sections of steel grating were wedged extremely tightly into the steel angle frame. Some of the individual sections of the steel grating had spot welds at the corners in an apparent attempt to make the grating fit more tightly into the steel frame. It appears the grating has little or no room for temperature expansion because of the tight fit in the steel angle frame.

Figure 6 is an infrared thermogram of one of the drainage trenches and the adjacent concrete. Because of the dark color of the steel grating, it absorbs more solar energy and heats more quickly and to a higher temperature than the lighter-colored, surrounding concrete. The bottom portion of Figure 6 is a temperature profile across the grating and the adjacent concrete. The day this was taken was mostly sunny, and from the temperature profile it appears the steel grating was approximately 10° F warmer than the surrounding concrete. The coefficient of thermal expansion for steel is approximately 7.2 x $10^{-6}/^{O}$ F, and the average coefficient of thermal expansion of concrete is approximately 5.5 x $10^{-6}/^{O}$ F. Therefore, it appears the steel grating would be trying to expand more than10 times an equivalent width of concrete. Because of the tight fit of the steel grating in the steel angle frame, it appears that there is insufficient room in the frame for the steel grating to expand. This would put considerable compressive stresses on the top portion of the concrete wall of the trench.

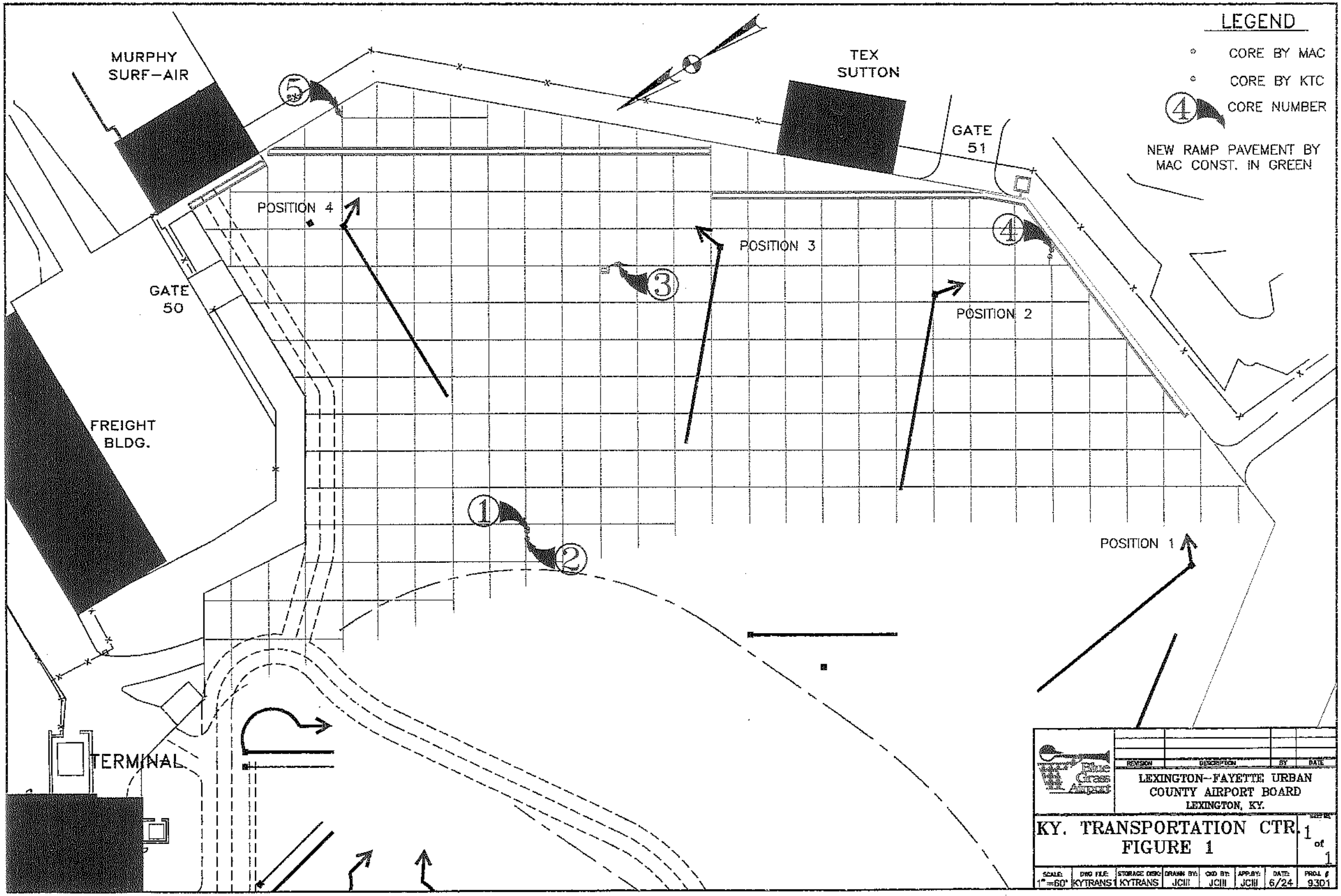
It appears the compressive strength of the concrete has been exceeded at several places along the trenches, because of the temperature expansion of the steel grating. Figure 5 shows two of these locations. The half-moon-shaped cracks should be noted in those photographs and they are, in all probability, the result of the failure of the concrete caused by the attempted expansion of the steel grating. Those half-moon cracks exit the concrete wall of the trench (on the inside of the trench) approximately one to two inches below the bottom of the steel angle frame.

RECOMMENDATIONS

1. All apron slabs that have cracked (including those that attempts have been made to seal with epoxy) should be replaced or partial slab replacement should be performed. If partial slab replacement is chosen, there should be straight saw cuts through the entire width of the slab ("dog leg" cuts should not be permitted). The portion of the slab to be replaced should not have a length-to-width ratio of greater than 2:1.

2. If an entire slab is to be replaced, dowel bars should be used on all four edges of the slab. If a partial slab is to be replaced, the saw-cut edge should be fitted with reinforcing steel bars grouted into the original portion of the slab, and should be of sufficient length to develop full bond. This is an attempt to make the new replacement portion of the slab act as a unit with the original part of the slab. The remaining three edges of the new replacement portion of the slab should be doweled with the adjacent slabs.

3. The half-moon cracks along the edges of the drainage trenches should be repaired. The steel grating should be removed and the top portion of the wall of the trenches should be jack hammered down to the top level of the reinforcement steel of the wall. Vertical reinforcement steel should be drilled and grouted into the remaining portion of the trench wall. The wall should then be repoured up to the original grade elevation. This would include recasting the steel angle frame in place as the concrete is being repoured. A sufficient gap should be allowed between the steel angle frame and the steel grating to permit temperature expansion of the steel grating in the future.



LEGEND
CORE BY MAC
CORE BY KTC
4 CORE NUMBER
NEW RAMP PAVEMENT BY MAC CONST. IN GREEN
MURPHY SURF-AIR
TEX SUTTON
GATE 51
GATE 50
FREIGHT BLDG.
TERMINAL
POSITION 1
POSITION 2
POSITION 3
POSITION 4
1
2
3
4
5
LEXINGTON-FAYETTE URBAN COUNTY AIRPORT BOARD
LEXINGTON, KY.
Blue Grass Airport
REVISION
DESCRIPTION
BY
DATE
KY. TRANSPORTATION CTR.
FIGURE 1
1 of 1
SCALE: 1"=60'
DWG FILE: KYTRANS1
STORAGE DISK: KYTRANS
DRAWN BY: JCIII
CKD BY: JCIII
APP.BY: JCIII
DATE: 6/24
PROJ. # 9301

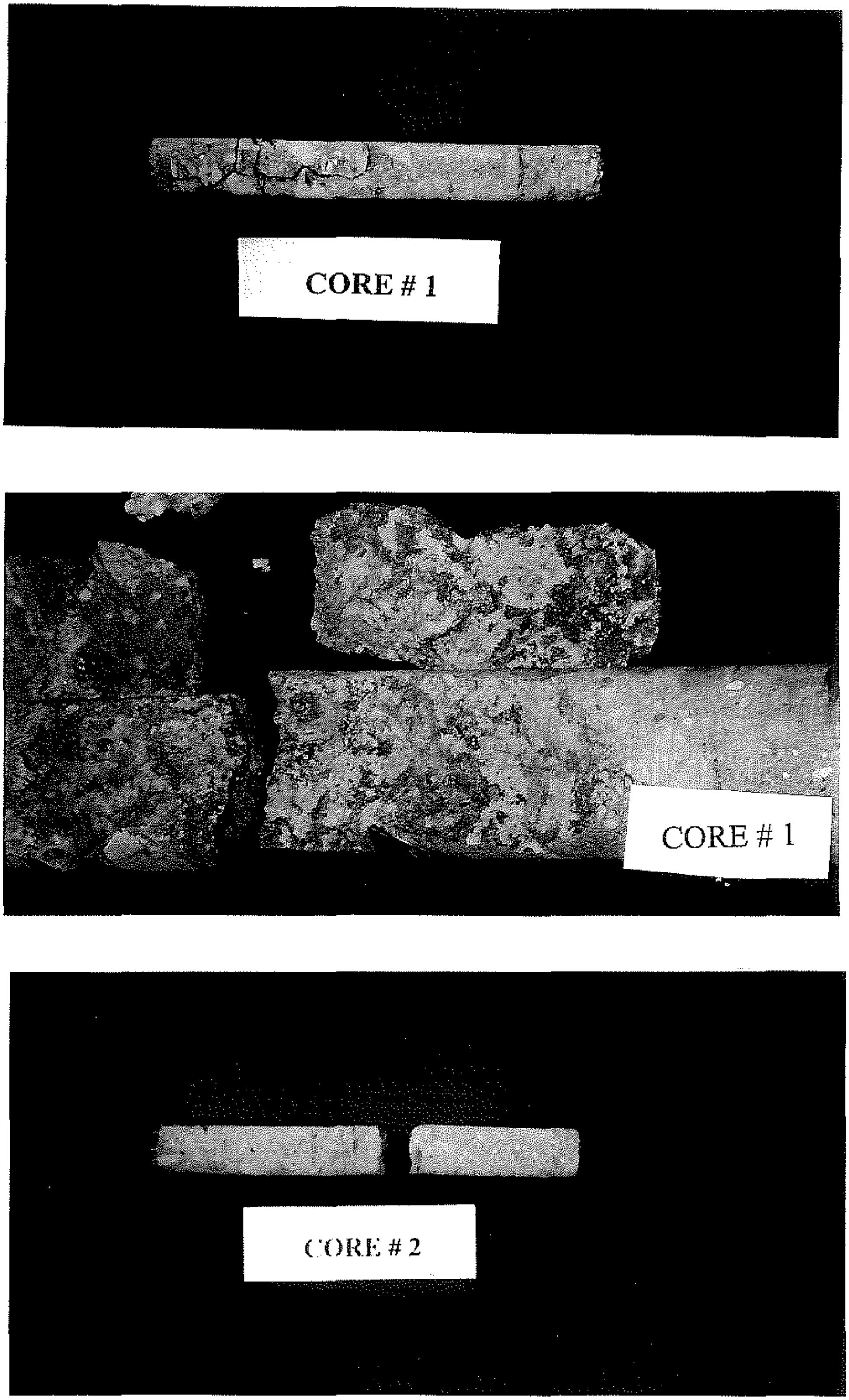
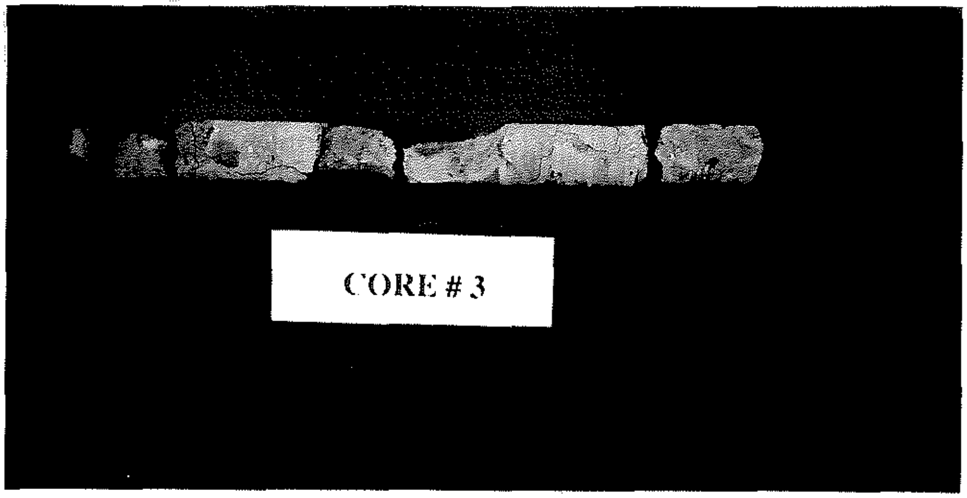
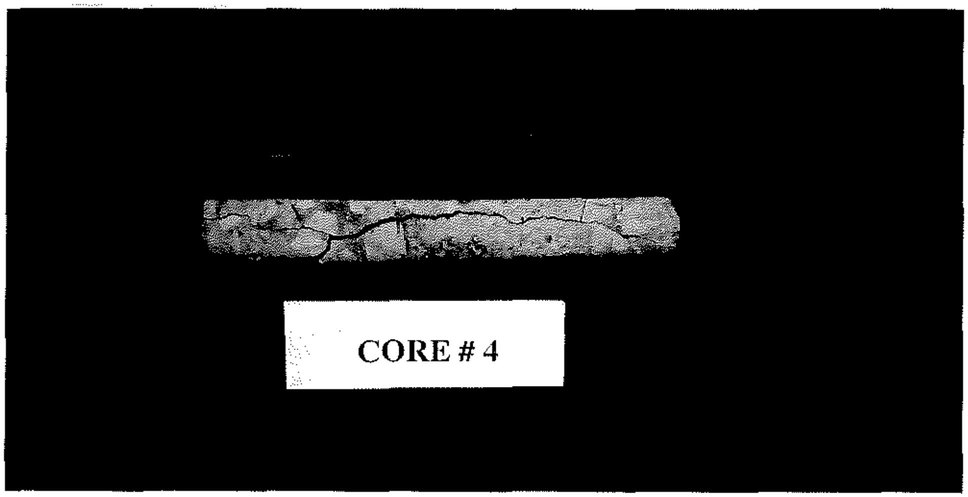


Fig. 2





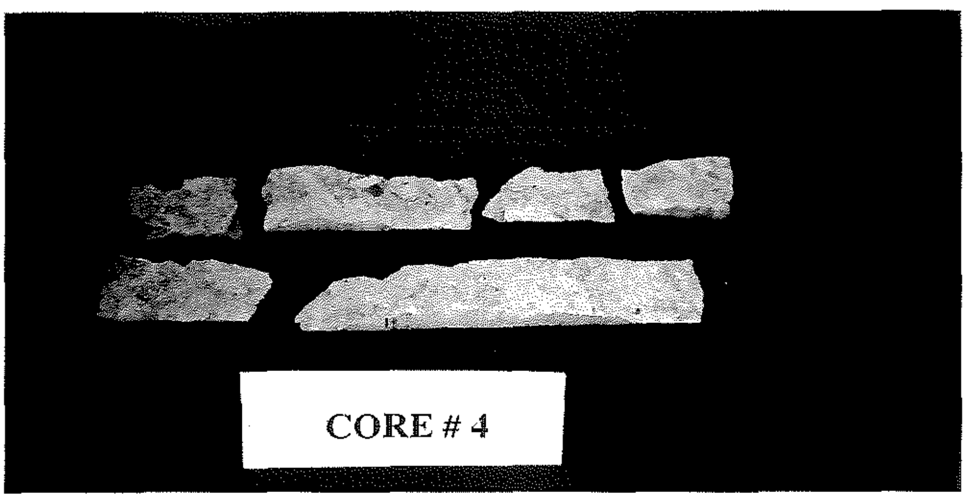


Fig. 3

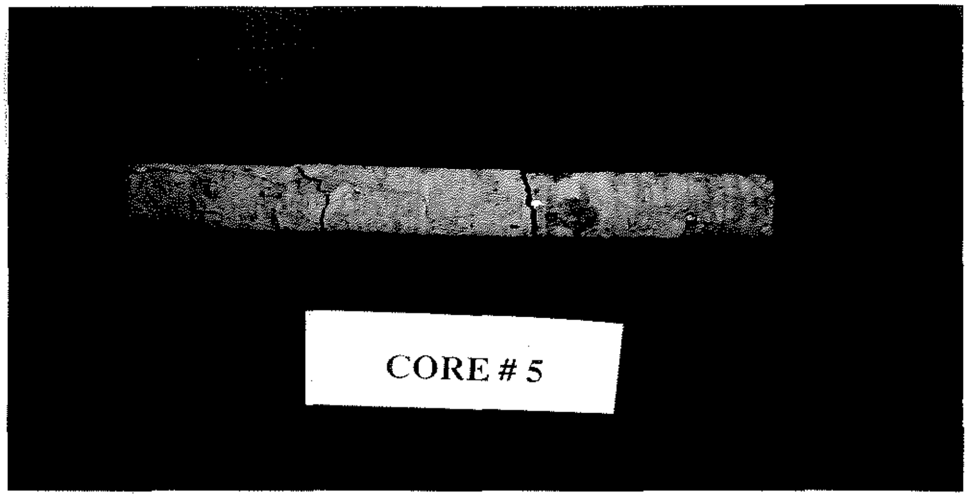


Fig 4.

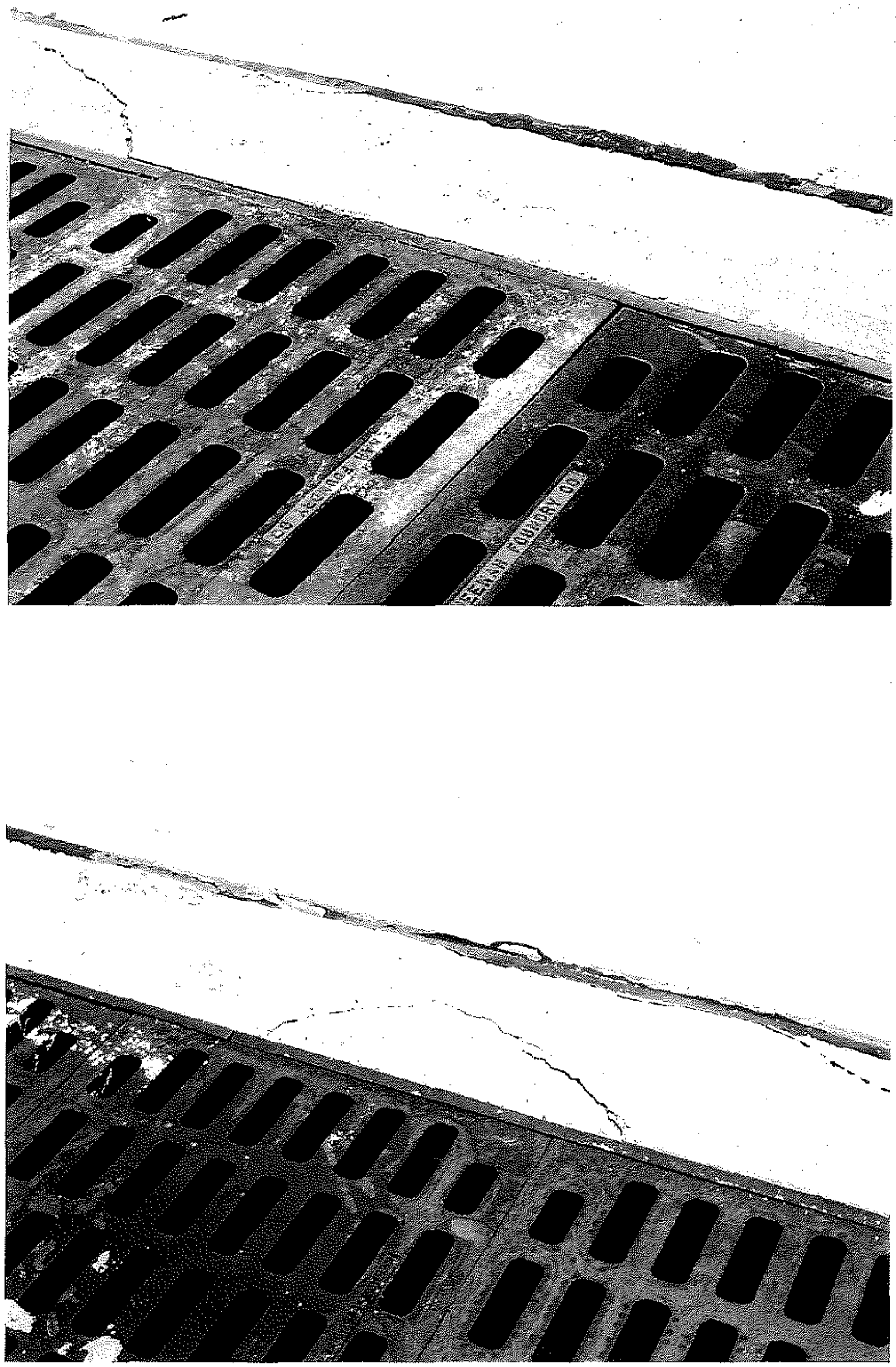
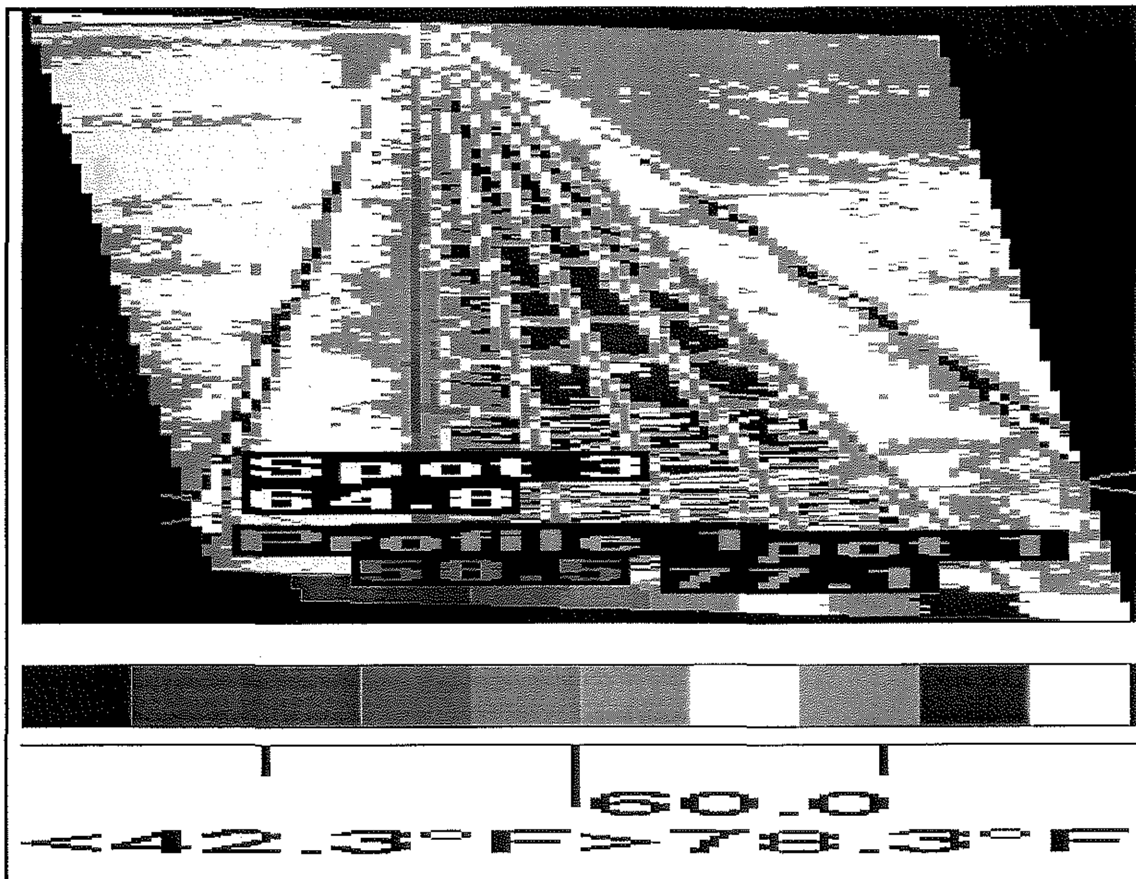
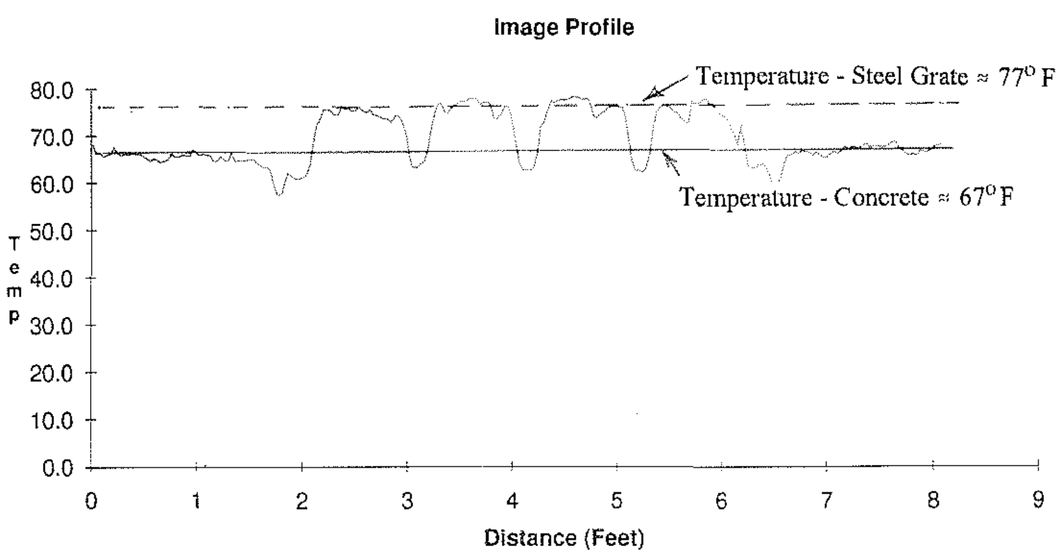


Fig. 5

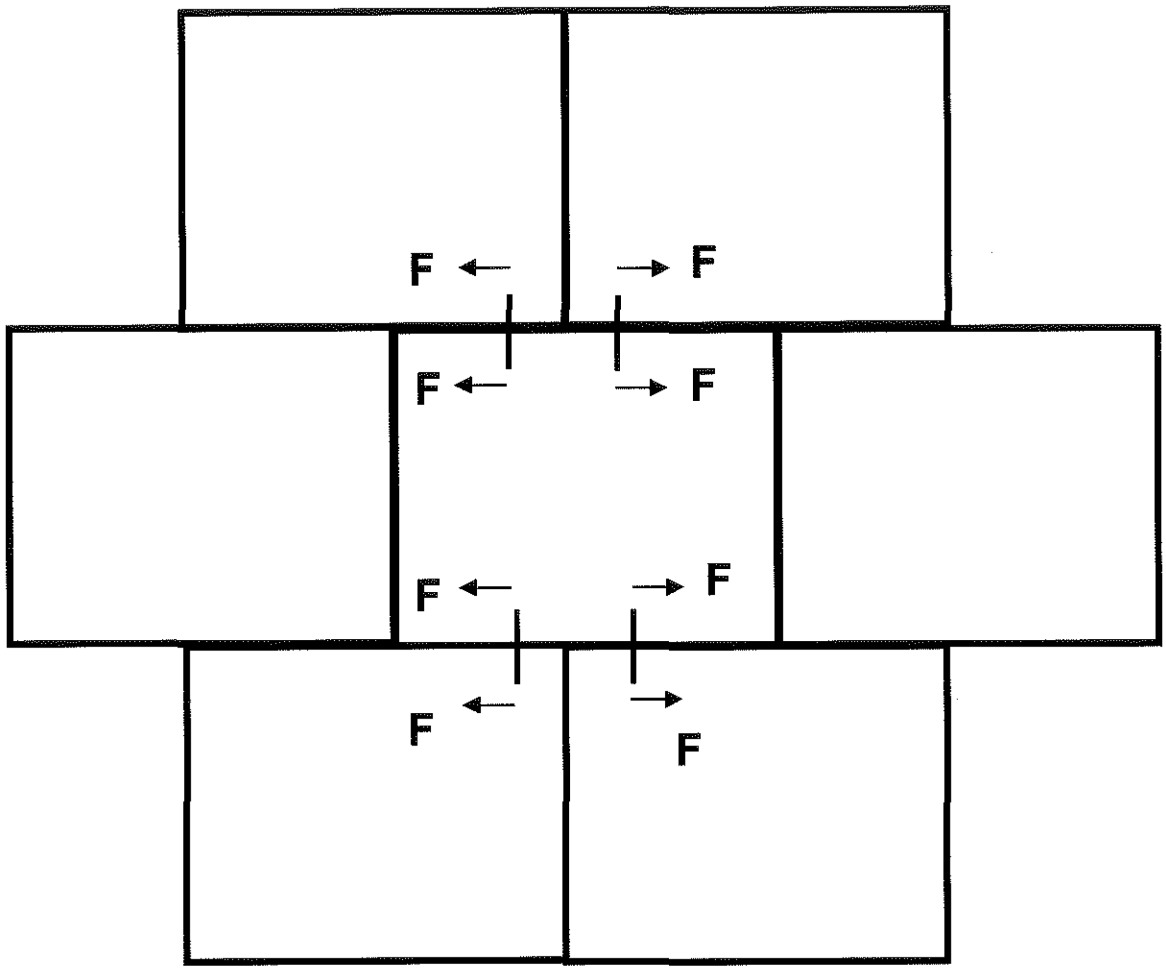


Infrared Image



Visual Image

Fig. 6


F
F
F
F
F
F
F
F

2000	72	5184	1
1800	60	3600	0.9
1400	42	1764	0.7
1000	29	841	0.5
600	18	324	0.3
400	12	144	0.2
300	6	36	0.15
150	1	1	0.075

1	0.050892	203.568	24.42816
2	0.068193	272.772	32.73264
3	0.085388	341.552	40.98624
4	0.102477	409.908	49.18896
5	0.11946	477.84	57.3408
6	0.136337	545.348	65.44176
7	0.153108	612.432	73.49184
8	0.169773	679.092	81.49104
9	0.186332	745.328	89.43936
10	0.202785	811.14	97.3368
11	0.219132	876.528	105.1834
12	0.235373	941.492	112.979
13	0.251508	1006.032	120.7238
14	0.267537	1070.148	128.4178
15	0.28346	1133.84	136.0608
16	0.299277	1197.108	143.653
17	0.314988	1259.952	151.1942
18	0.330593	1322.372	158.6846
19	0.346092	1384.368	166.1242
20	0.361485	1445.94	173.5128
21	0.376772	1507.088	180.8506
22	0.391953	1567.812	188.1374
23	0.407028	1628.112	195.3734
24	0.421997	1687.988	202.5586

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.997704
R Square	0.995413
Adjusted	0.993579
Standard	0.0284
Observati	8

ANOVA

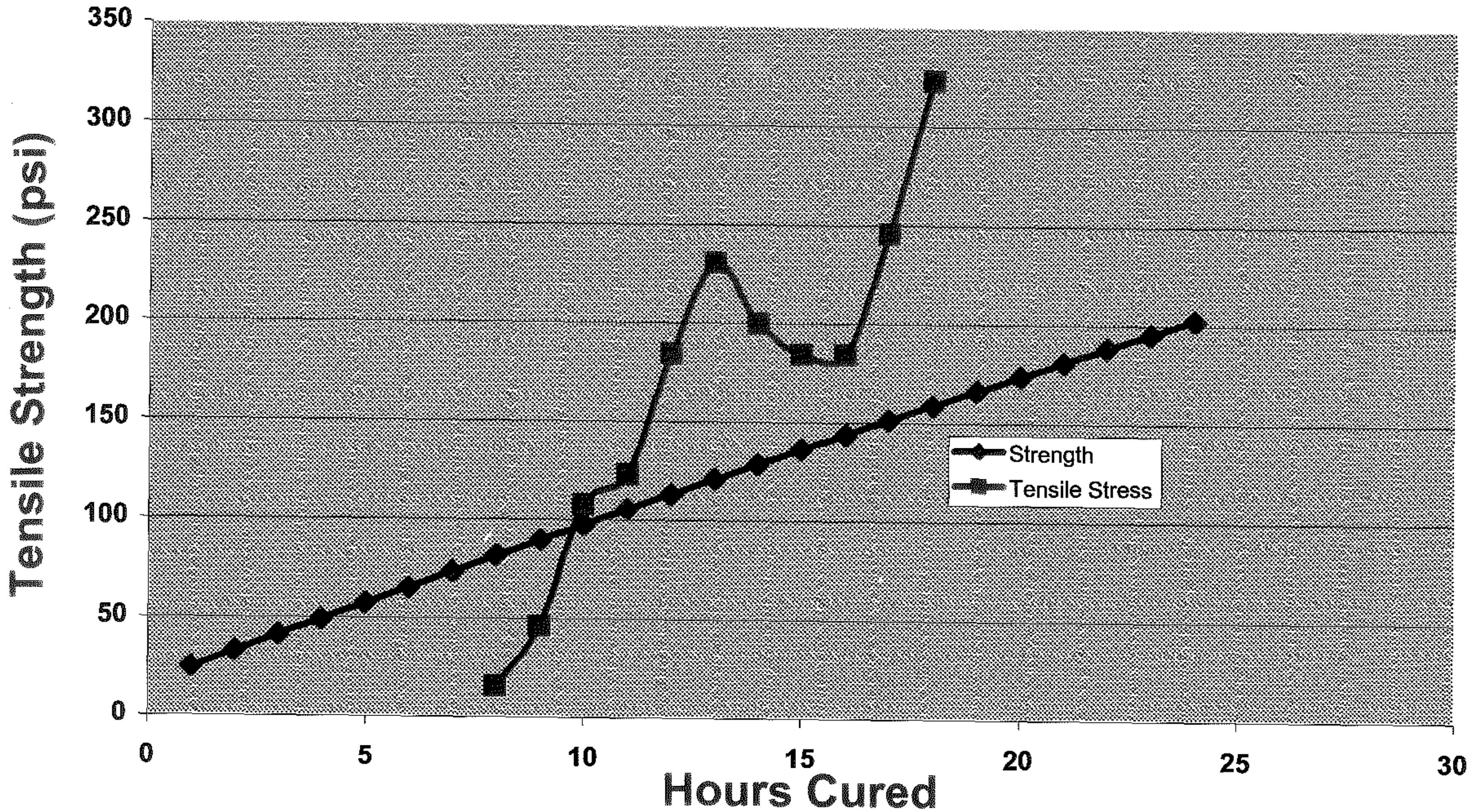
	df	*SS*	*MS*	*F*	*gnificance F*
Regressio	2	0.875264	0.437632	542.5757	1.42E-06
Residual	5	0.004033	0.000807		
Total	7	0.879297			

	Coefficient	*andard Err*	*t Stat*	*P-value*	*ower 95%*	*pper 95%*	*ower 95.0*	*pper 95.0%*
Intercept	0.033485	0.02188	1.530412	0.186472	-0.02276	0.089729	-0.02276	0.089729
X Variable	0.01746	0.001644	10.62246	0.000128	0.013235	0.021685	0.013235	0.021685
X Variable	-5.3E-05	2.2E-05	-2.41511	0.060481	-0.00011	3.43E-06	-0.00011	3.43E-06

Hour of Day	Degree Differential	Strain	Microstrain	Tensile Stress	Stress-Strain
	1	0.000006	6	15.36	0.00064
	2	0.000012	12	30.72	
	3	0.000018	18	46.08	
	4	0.000024	24	61.44	
	5	0.00003	30	76.8	
	6	0.000036	36	92.16	
	7	0.000042	42	107.52	
	8	0.000048	48	122.88	
	9	0.000054	54	138.24	
	10	0.00006	60	153.6	
	11	0.000066	66	168.96	
	12	0.000072	72	184.32	
	13	0.000078	78	199.68	
	14	0.000084	84	215.04	
	15	0.00009	90	230.4	
	16	0.000096	96	245.76	
	17	0.000102	102	261.12	
	18	0.000108	108	276.48	
	19	0.000114	114	291.84	
	20	0.00012	120	307.2	
	21	0.000126	126	322.56	

Degree Differential	Tensile Stress	Hours Cured	Time of Day		
1	15.36	1	11:00 AM	24.42816	
2	30.72	2	12:00 PM	32.73264	
3	46.08	3	1:00 PM	40.98624	
4	61.44	4	2:00 PM	49.18896	
5	76.8	5	3:00 PM	57.3408	
6	92.16	6	4:00 PM	65.44176	
7	107.52	7	5:00 PM	73.49184	
8	122.88	8	6:00 PM	81.49104	15.36
9	138.24	9	7:00 PM	89.43936	46.1
10	153.6	10	8:00 PM	97.3368	107.5
11	168.96	11	9:00 PM	105.1834	122.9
12	184.32	12	10:00 PM	112.979	184.3
13	199.68	13	11:00 PM	120.7238	230.4
14	215.04	14	12:00 AM	128.4178	199.7
15	230.4	15	1:00 AM	136.0608	184.3
16	245.76	16	2:00 AM	143.653	184.3
17	261.12	17	3:00 AM	151.1942	245.8
18	276.48	18	4:00 AM	158.6846	322.6
19	291.84	19	5:00 AM	166.1242	
20	307.2	20	6:00 AM	173.5128	
21	322.56	21	7:00 AM	180.8506	
		22	8:00 AM	188.1374	
		23	9:00 AM	195.3734	
		24	10:00 AM	202.5586	

Airport Slab



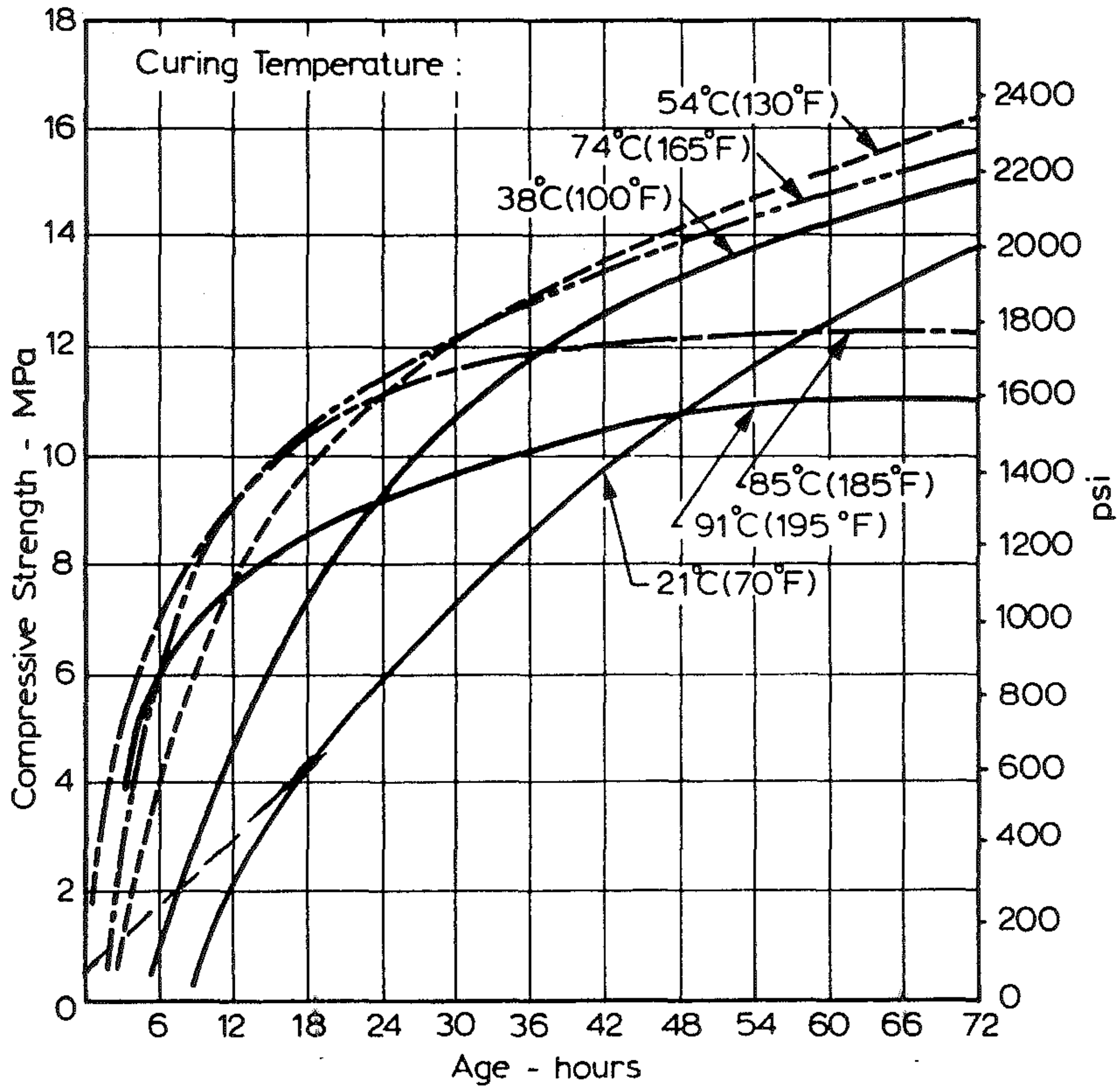


Fig. 5.50. *Strength of concrete cured in stream at different temperatures (water/cement ratio = 0·50; steam curing applied immediately after casting)*[5.47]

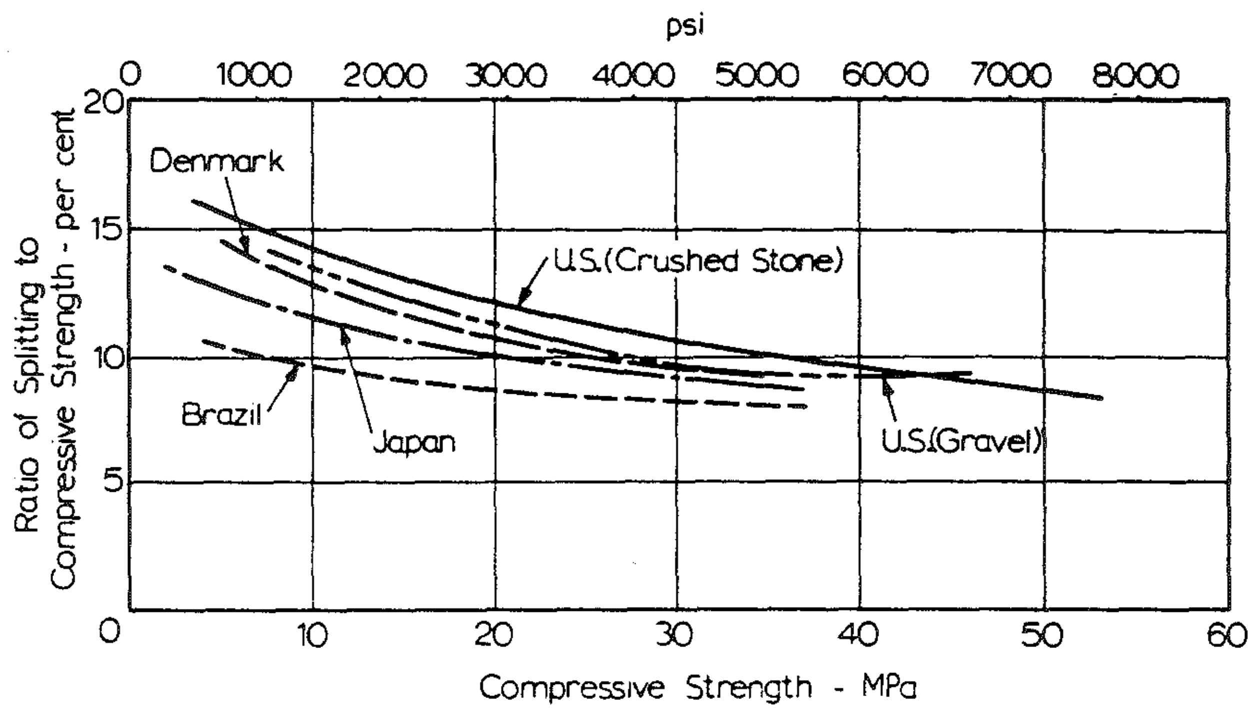


Fig. 8.13. *Tensile splitting strength of cylinders of varying compressive strength*[8.25]

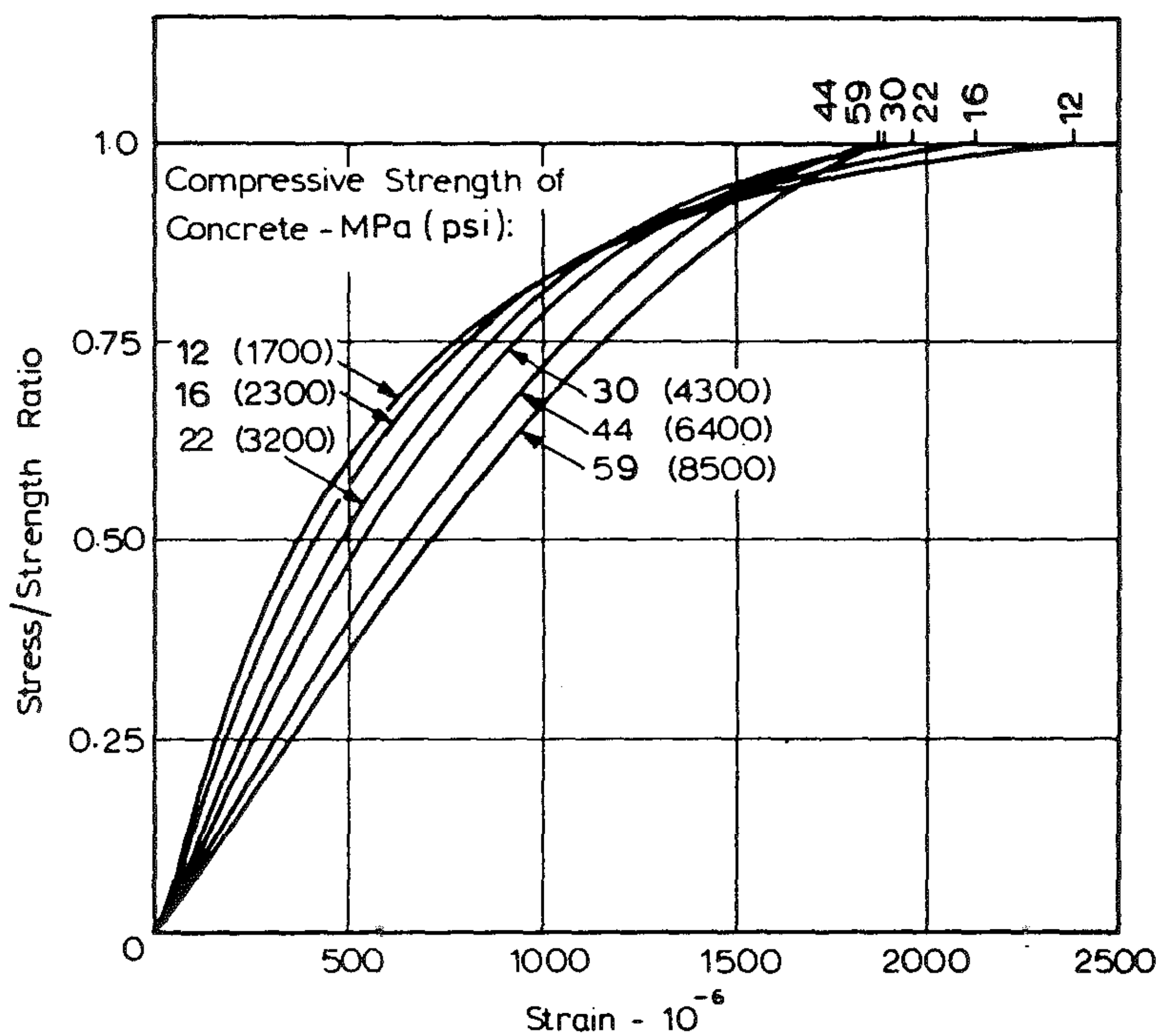


Fig. 6.2. *Relation between stress/strength ratio and strain for concretes of different strengths*[6.2]