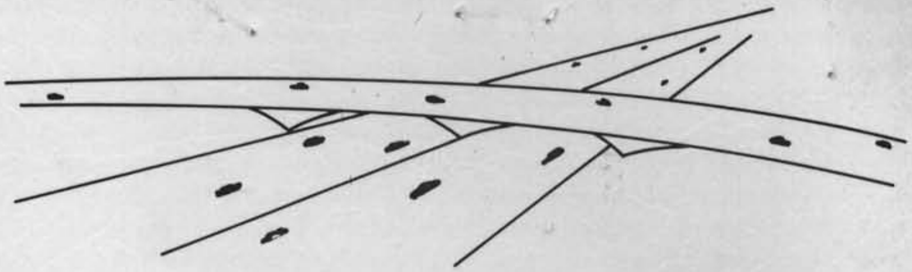

DEPARTMENTAL RESEARCH

Report Number SS 3.1

INVESTIGATION OF PAVEMENT FAILURES

ON I.H. 10

DISTRICT 20

TEXAS HIGHWAY DEPARTMENT

INVESTIGATION OF PAVEMENT FAILURES

ON IH10 IN DISTRICT 20

By

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Report Number SS 3.1

Conducted by
The Research Section of
The Highway Design Division
Texas Highway Department
April 1966

Report On

INVESTIGATION OF PAVEMENT FAILURES ON IH 10 IN DISTRICT 20

I. INTRODUCTION

There has been considerable concern for the many distressed areas showing up on concrete pavements which are only a few years old. In most cases the surface condition is of the same general nature in all of the distressed areas. The pavements are showing various degrees of distress.

The pavement problem in District 20 shows itself in the form of severe cracking with very close spacing between the cracks. The distressed areas are on IH 10 in Jefferson County between Beaumont and Winnie. The sections which were studied are briefly described in Table 1. Basically there are six sections of which four are performing satisfactorily and two may be classified as failures. (Sections 2 and 3) One of the satisfactory sections (#6) had crushed limestone for a coarse aggregate, whereas all others were siliceous river gravel. Another interesting feature of this section was that during construction considerable vibration was applied to the concrete mix during paving. Section #4 was a 30 year old pavement that was selected for comparing density variations with thickness on old and new pavements.

TABLE I

DESCRIPTION OF TEST SECTIONS

Section	Highway	Station & Lane	Pavement Thickness	Coarse Aggregate Type	Pavement Condition	Remarks
1	IH 10	528+00RML	8 in.	Siliceous River Gravel	Good	
2	IH 10	550+50LML	8 in.	Siliceous River Gravel	Failure	
3	IH 10	528+00LML	8 in.	Siliceous River Gravel	Failure	
4	SH105	25+00EBL	6 in.	Siliceous River Gravel	Good	Pavement 30 years old
5	IH 10	431+00RML	8 in.	Siliceous River Gravel	Good	
6	IH 10	903+00RML	8 in.	Crushed Limestone	Good	Slip-form paver used

NOTE:

1. All sections except Section 4 are CRCP
2. All CRCP sections have a cement factor of 4.5 sacks/cy.

II. INVESTIGATION

The distressed areas together with some other pavements in the Beaumont area that were in excellent condition were investigated in an attempt to ascertain the possible causes. Cores taken from the selected areas were submitted by the District personnel for testing and examination by the Austin Office. Prior to testing, the cores were photographed. Typical photographs of the cores from each of the sections are shown in the Appendix.

After close examination of the cores, it was decided that two of the four cores from each of six sets would be tested in compression. One core from each set was to be saved for visual inspection and one from each set was to be tested for density or unit weight. The cores for unit weight determination were sliced into three sections with a masonry saw, top, middle and bottom. The unit weight of each of the three slices from each core was determined by two methods: (1) by volume calculation and weighing and (2) by immersion in water and weighing.

The final portion of the testing was the split cylinder test on each of the core slices to determine if the tensile strength of the concrete varied with depth.

Another phase of the investigation that was conducted by the District Laboratory to determine the soil constants for the subbase and the subgrade in each of the sections. The samples were taken from under the concrete pavement at the time the above mentioned cores were drilled.

III. PRESENTATION OF RESULTS

Compression Strength

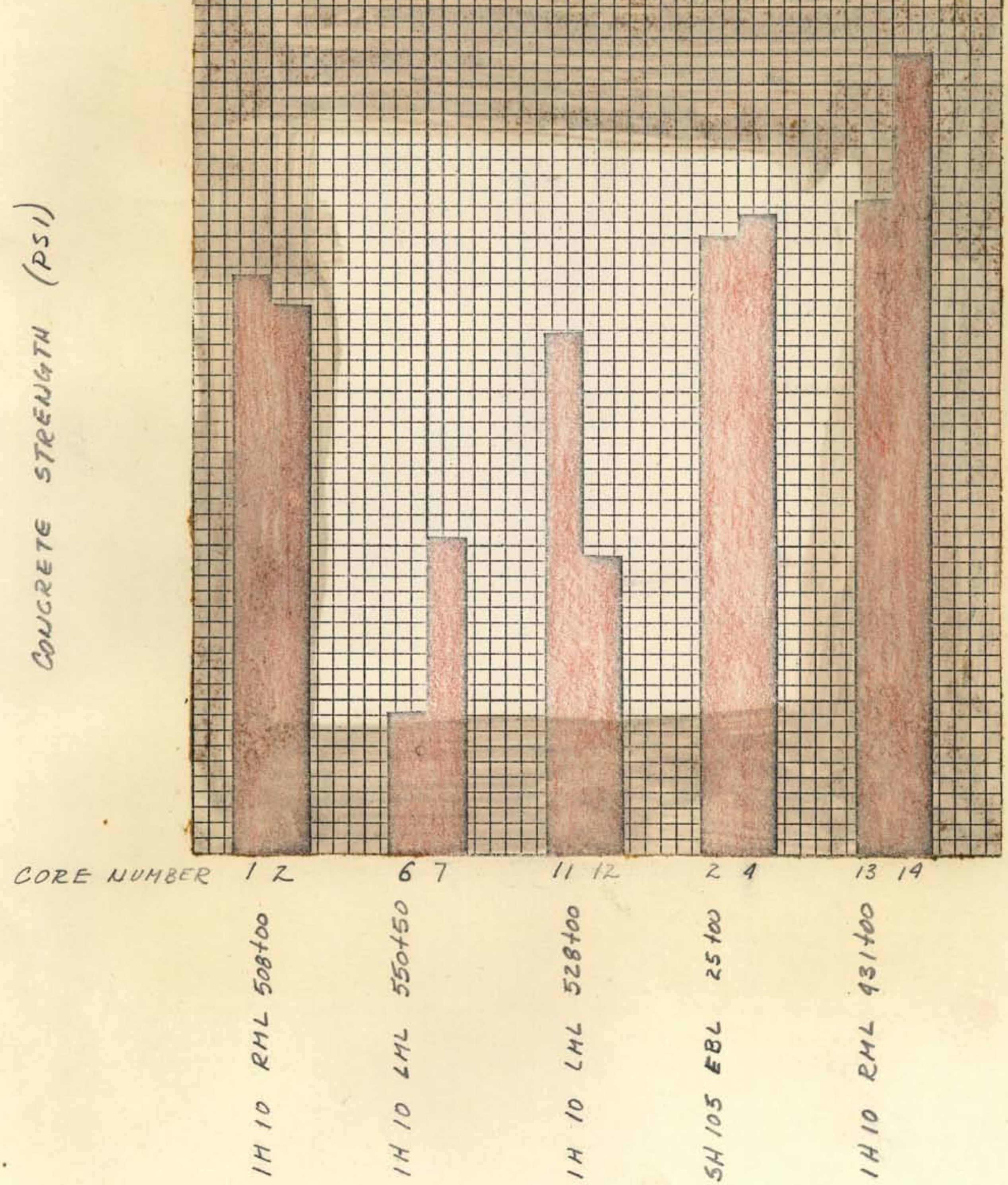
The corrected stress for the two cores tested in compression from each of the six sets is shown in Table 1A together with other pertinent information about the cores. As mentioned previously, all cores had siliceous river gravel as a coarse aggregate except the cores from Section #6 numbered 17 through 20.

The two cores from each of the two distressed areas exhibited a lower strength than any of the cores taken from areas of sound concrete. Figure 1 is a bar graph comparing the compressive strengths of the cores from the first five sections shown in Table 1A. Note that the compressive strengths of the four cores from the left main lane, stations 550 + 50 (Section 2) and 528 + 00 (Section 3) which were the failure areas are all lower than the remaining six cores. Only the results for the siliceous gravel are shown since coarse aggregate type will affect the strength.

Unit Weight

The unit weights of the top, middle, and bottom thirds of the cores are shown in Table 2A along with pertinent data rele-

FIGURE 1



CONCRETE STRENGTH (PSI)
CORE NUMBER
1 2
6 7
11 12
2 4
13 14
1H 10 RML 508+00
1H 10 LML 550+50
1H 10 LHL 528+00
5H 105 EBL 25+00
1H 10 RML 431+00

vant to this test. In Figure 2 the unit weight by volume calculation is plotted against relative position in the pavement slab. In most cases the unit weight was slightly less on the bottom than it was at the top. The cores from the two failure sections have a difference in unit weight of eight pounds per cubic foot between the top and the bottom of the pavement. In contrast, the older pavement along with several of the newer satisfactory sections has relatively uniform density. This indicates that with proper vibration uniformity can be achieved with the new pavement designs. Section 6 has a lower density due to the use of the lighter limestone coarse aggregate.

Splitting Tension Test

The core slices which were used for unit weight analysis were tested for tensile strength using the split-cylinder tension test. The test results were rather random as can be seen in Figure 3. The test did show that the bottom of the pavement was weaker in tension than the top in the failure area at station 528 + 00. The tensile strength was low on all three of the core slices cut from the core from station 550 + 50. Thus again the failure areas in general terms stand out from the rest.

Soil Constants

At the time the cores were drilled soil samples were taken from the subbase and the subgrade. The soil constants were determined for the subbase and the subgrade in each section.

FIGURE 2

UNIT WEIGHT BY VOLUME CALCULATION

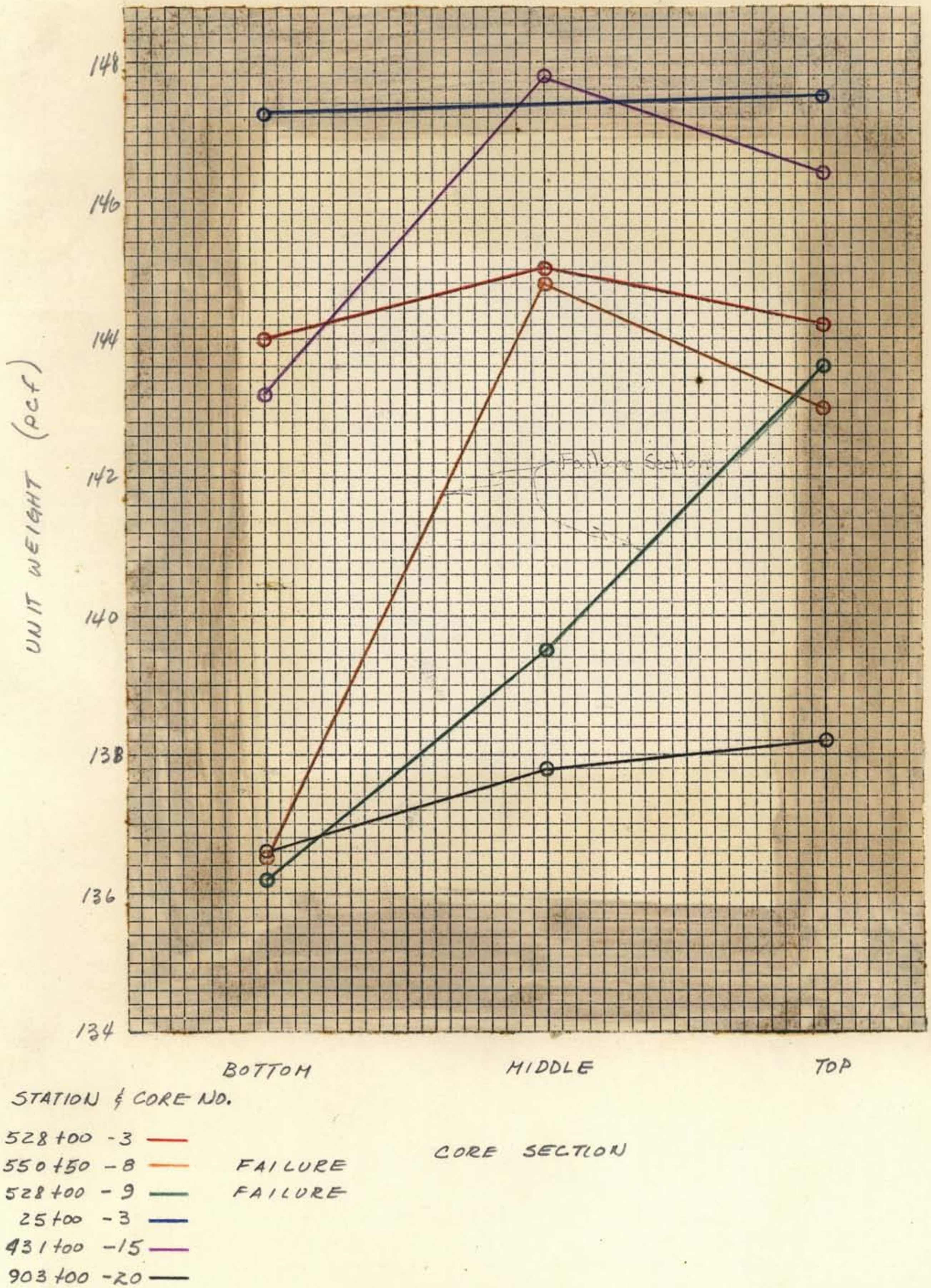
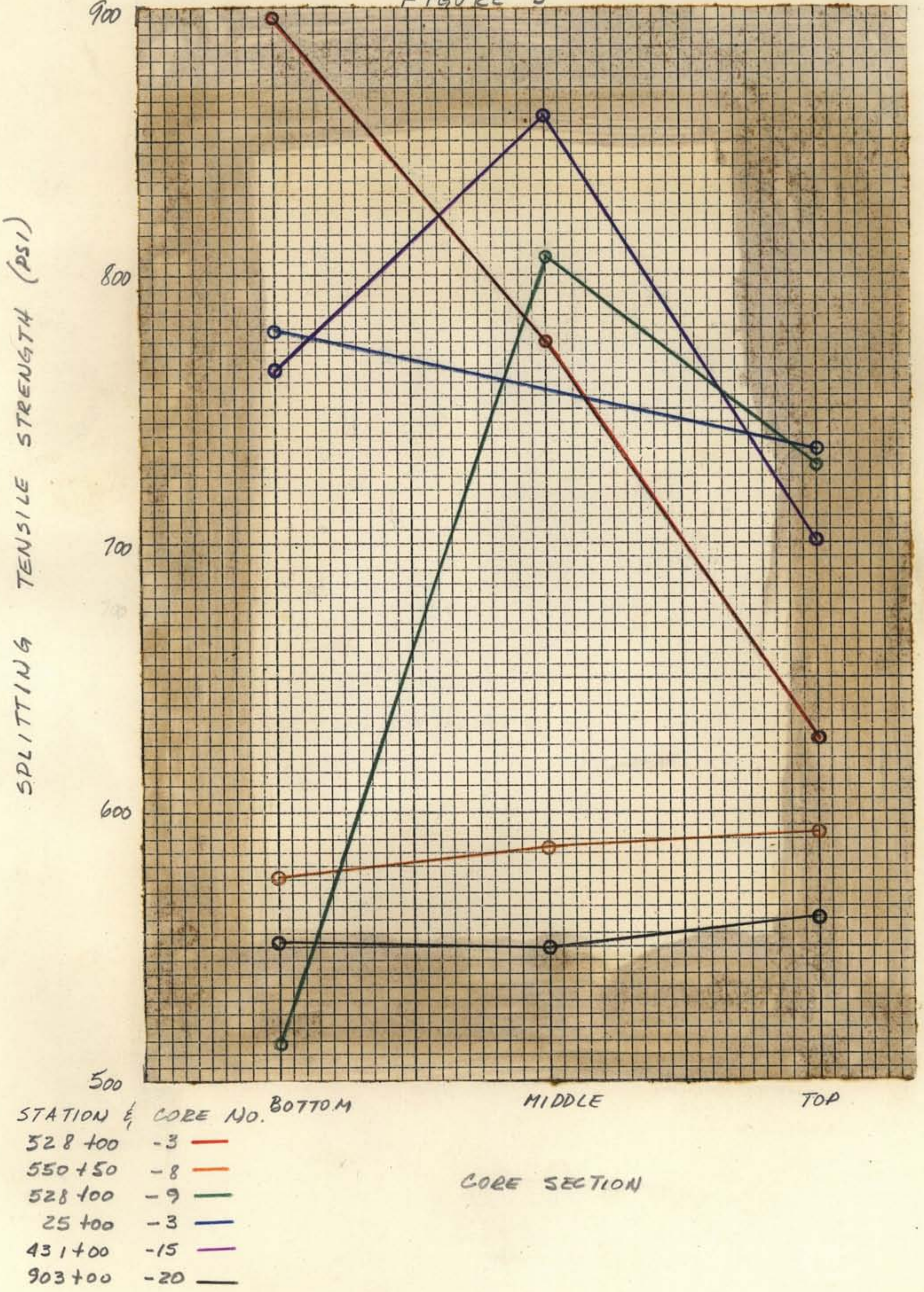


FIGURE 3



900
800
700
600
500
SPLITTING TENSILE STRENGTH (PSI)
BOTTOM
MIDDLE
TOP
CORE SECTION
STATION & CORE NO.
528 +00 -3
550 +50 -8
528 +00 -9
25 +00 -3
431 +00 -15
903 +00 -20

Table 2 is tabulation of the results found. The PI's shown in Table 2 are uniform and no irregularity exists which might cause the distress. The soil constants show uniformity between the distressed and satisfactory sections consequently, it may be concluded that the problem is due to the slab.

IV. SUMMARY AND CONCLUSION

The cores taken from the six pavement sections were studied and tested by several different procedures, and the same general result was found from each analysis. In each method of investigation compressive strength, unit weight, and tensile strength the cores from the two failure areas were inferior to the cores from the good areas.

This project and others previously investigated by the D-8 Research Section show that the specifications on vibration of concrete are apparently inadequate. A better specification is needed to control vibration with different concrete types and environmental conditions in order to eliminate honey combing of the concrete below the continuous reinforcing steel.

Conclusions that might be drawn from this investigation are as follows:

1. There was a difference in the integrity of the concrete between the top and bottom as was shown by the unit weight analysis and the tensile strength analysis. Also, the failure areas were depicted by the compression tests on the drilled cores.

2. Good vibration can achieve uniform density as was the condition of the pavement at station 903 + 00.

Table 2

Soil Constants for Subbase and Subgrade

LOCATION	SUBBASE LL	SUBBASE PI	SUBGRADE LL	SUBGRADE PI
IH 10 Right Main Lane 528 + 00	21.2	4.7	56.2	31.7
*IH 10 Left Main Lane 550 + 50	20.5	4.2	62.7	33.6
*IH 10 Left Main Lane 528 + 00	22.1	4.8	55.9	35.9
S 105 East Bound Lane 25 + 00			48.8	30.6
IH 10 Right Main Lane 431 + 00	21.2	5.3	59.1	33.6
IH 10 Right Main Lane 903 + 00			38.0	9.8

*Failure Sections

NOTE:

All tests and sampling were performed by the District 20 Laboratory.

This pavement has crushed limestone coarse aggregate, was placed with a slip-form paver and was adequately vibrated.

3. The problem of failing concrete was not due to a lack of support or discontinuity in the subbase or subgrade but due to inferior concrete within the slab itself.

APPENDIX

Figure 2A

Cores 1-4, drilled at

Station 528 + 00 RML,

IH10

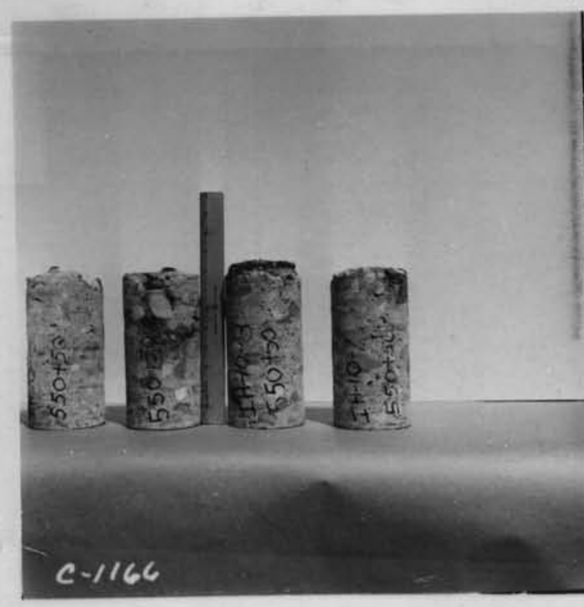


Figure 3A

Cores 5-8, drilled at

Station 550 + 50 LML,

(Failure Area) IH10

Figure 4A

Cores 9-12, drilled at

Station 528 + 00 LML

(Failure Area) IH 10

Figure 5A

Cores 1-4, drilled at Station 25 + 00 EBL, SH 105

Figure 6A

Cores 13-16, drilled at Station 431 ± 00 RML, IH10

Figure 7A

Cores 17-20, drilled at Station 903 + 00 RML, IH10

FIGURE 1A

UNIT WEIGHT BY IMMERSION

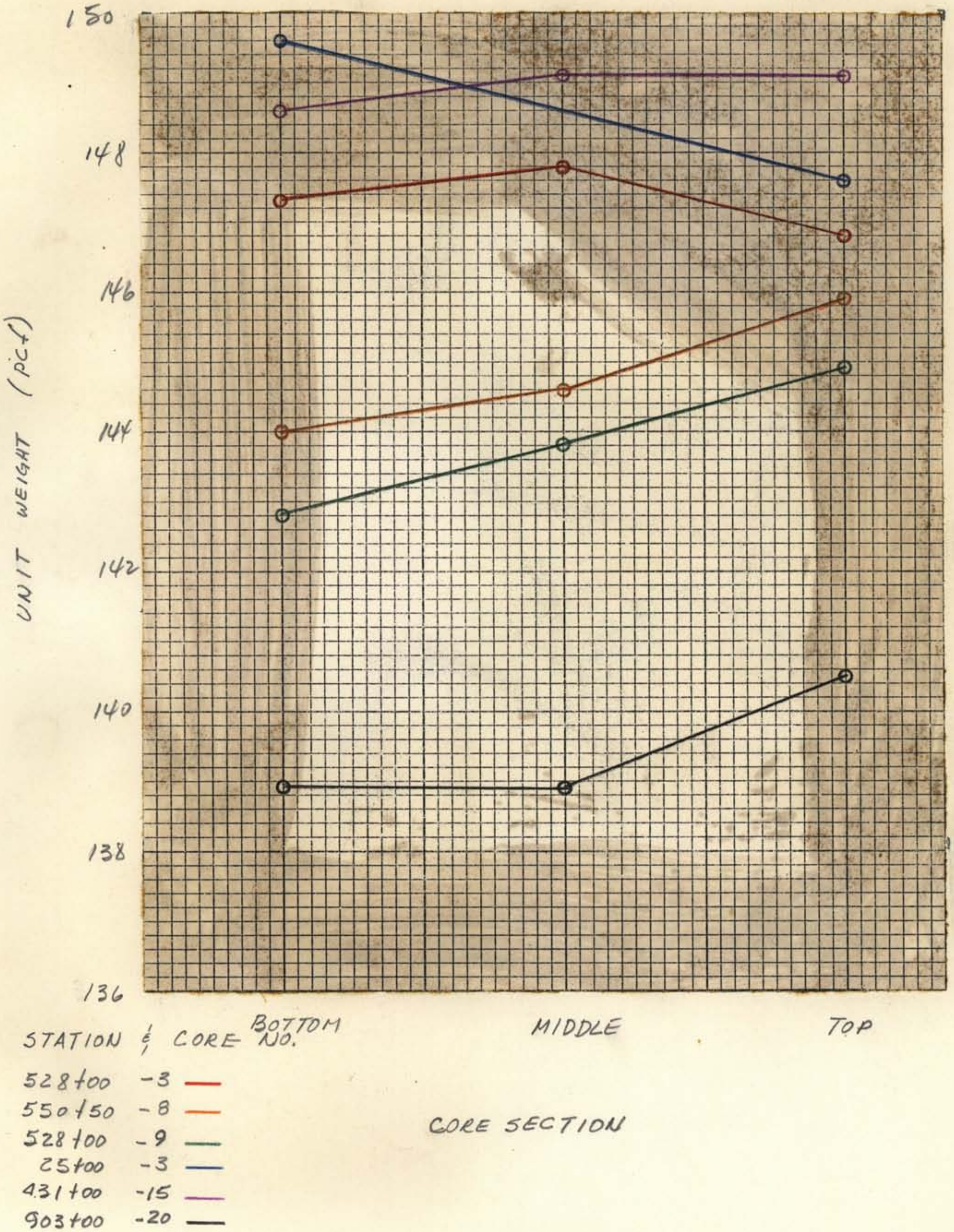


TABLE 2A

CONCRETE CORES

Sawed into 3 Parts

D-8, IPE 200

Station & Core No.		Height (in.)	Dia. (in.)	Volume by Immersion Wt. (gms.)	Vol. (c.c.)	Unit Wt. (#/c.f.)	Volume by Calculation Wt. (lbs.)	Vol. (in.^{3})	Unit Wt. (#/c.f.)
IH-10-3	Top	2.68	3.966	1254.1	532.9	146.83	2.765	0.01917	144.24
	Middle	2.65	3.963	1245.2	525.7	147.83	2.745	0.01893	145.01
	Bottom	2.37	3.959	1103.0	467.2	147.33	2.432	0.01689	143.99
IH-10-8	Top	2.51	3.972	1167.7	499.5	145.90	2.574	0.01800	143.00
	Middle	2.20	3.965	1031.2	444.8	144.64	2.273	0.01570	144.78
	Bottom	2.69	3.966	1191.3	516.2	144.02	2.626	0.01924	136.49
IH-10-9	Top	2.46	3.942	1132.1	487.5	144.89	2.496	0.01738	143.61
	Middle	2.71	3.943	1212.1	525.9	143.83	2.672	0.01916	139.46
	Bottom	2.41	3.948	1055.1	460.9	142.83	2.326	0.01708	136.18
SH-105-3	Top	2.87	3.944	1358.6	574.3	147.64	2.995	0.0203	147.50
(2 only)	Bottom	2.86	3.944	1349.0	562.6	149.64	2.974	0.0202	147.23
IH-10-15	Top	2.55	3.954	1203.7	503.9	149.07	2.654	0.01813	146.39
	Middle	2.40	3.947	1139.5	478.8	149.14	2.512	0.01700	147.76
	Bottom	2.64	3.950	1216.4	510.8	148.57	2.682	0.01873	143.19
IH-10-20	Top	2.62	3.950	1165.5	517.8	140.46	2.569	0.01859	138.19
	Middle	2.50	3.949	1108.0	497.8	138.90	2.443	0.01773	137.79
	Bottom	2.44	3.948	1070.9	481.0	138.90	2.361	0.01729	136.55

Tests performed by Materials and Tests Division

TABLE 3A

TEXAS HIGHWAY DEPARTMENT
CONCRETE CORES

SAMPLE	Nominal Diam-Inches	Average Height Inches	Load at Failure Pounds	Splitting Tensile Strength-PSI	REMARKS
3 Top	4"	2.870	13250	735	
3 Middle (SH 105)	-	-	-	-	
3 Bottom	4"	2.861	14000	779	
3 Top	4"	2.681	10570	627	ALL COARSE AGGREGATE IN BOTTOM SAMPLE
3 Middle	4"	2.630	12800	775	
3 Bottom	4"	2.379*	13400	896	
8 Top	4"	2.510	9340	592	
8 Middle	4"	2.278	8400	587	
8 Bottom	4"	2.663	9640	576	
9 Top	4"	2.480	11360	729	
9 Middle	4"	2.651	13450	807	
9 Bottom	4"	2.377	7680	514	HONEYCOMB
15 Top	4"	2.566	11300	701	
15 Middle	4"	2.400	13100	869	
15 Bottom	4"	2.583	12400	764	
20 Top	4"	2.609	9190	561	
20 Middle	4"	2.507	8650	549	
20 Bottom	4"	2.421	8400	552	

NOTE: Date Tested - 4-19-66
Average Loading Rate = 30 pounds/second
Testing Temperature = 75° C

* A questionable height

Specimens were tested by Project 3-8-66-98, Center for Highway Research, at the request of Frank McCullough of the Texas Highway Department.

TABLE 1A

No.	Loc. From C.L.	Sta. No.	Diameter (in.)	H/D	Height (in.)	Area (sq.in.)	Corrected Stress (psi)
IH-10, Right Main Lane							
IH-10-1	10'-R	528+00	3.96-3.95	2.12	8.41	12.32	5779
IH-10-2	10'-R	528+00	3.95-3.94	2.13	8.42	12.25	5565
IH-10-3	10'-R	528+00	Saved				
IH-10-4	10'-R	528+00	Cut into sections				
IH-10, Left Main Lane							
IH-10-5	10'-L	550+50	Saved				
IH-10-6	11'-L	550+50	3.97-3.97	2.05	8.15	12.38	2920
IH-10-7	10'-L	550+50	3.97-3.98	2.13	8.48	12.44	4059
IH-10-8	10'-L	550+50	Cut into sections				
IH-10, Left Main Lane							
IH-10-9	10'-L	528+00	Cut into sections				
IH-10-10	10'-L	528+00	Saved				
IH-10-11	10'-L	528+00	3.95-3.95	2.22	8.75	12.25	5402
IH-10-12	10'-L	528+00	3.95-3.95	2.22	8.75	12.25	3948
SH-105, Eastbound Lane							
S-105-1	7'-L	25+00	Saved				
S-105-2	7'-L	25+00	3.96-3.95	1.60	6.32	12.32	5996
S-105-3	7'-L	25+00	Cut into sections				
S-105-4	7'-L	25+00	3.95-3.96	1.64	6.50	12.32	6134
IH-10, Right Main Lane							
IH-10-13	9'-R	431+00	3.97-3.95	2.13	8.44	12.32	6271
IH-10-14	9'-R	431+00	3.95-3.95	2.17	8.57	12.25	7201
IH-10-15	9'-R	431+00	Cut into sections				
IH-10-16	9'-R	431+00	Saved				
IH-10, Right Main Lane							
IH-10-17	9'-R	903+00	Saved				
IH-10-18	9'-R	903+00	3.96-3.95	2.13	8.45	12.32	4673
IH-10-19	9'-R	903+00	3.98-3.95	2.11	8.38	12.38	5257
IH-10-20	9'-R	903+00	Cut into sections				

5 cores retained by Dist. 20 Lab.

Tests performed by Materials and Tests Division