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FIELD AND LABORATORY EVALUATION OF DEBONDING TEST PROCEDURES

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FIELD AND LABORATORY EVALUATION

OF

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16. Abstract

The method of testing for debonding susceptible asphaltic concrete mixes by the double punch method is examined. The procedure and apparatus for testing is presented. Data comparing the double punch method to the immersion compression method is documented and evaluated for relationships between the two methods. It was concluded that the double punch method is easy to use, saves time and can readily test field cores. With suggested minor modifications it is recommended that this mix design method be incorporated into ADOT testing practice.

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ABSTRACT

Identifying asphaltic concrete mixes that may be susceptible to debonding has and continues to be an important part of the design procedures of the Arizona Department of Transportation. For this reason, a study was conducted to correlate the double punch test to the immersion compression test. The time efficiency and debonding predictability was studied. Correlation was accomplished and the double punch test is being considered for incorporation into the mix design procedure as a replacement for the immersion compression test now being used.

ACKNOWLEDGEMENTS

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Finally, the dedicated work of many individuals at Materials Services of the Arizona Department of Transportation in laboratory testing, data collection, data reduction and clerical work is appreciated.

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INTRODUCTION

1.1 General

Debonding of the asphalt cement from its aggregate interface has been of great interest to highway officials for some time and is a serious problem. The handiwork of this "stripping" phenomenon is a weakening of the strength of the structure, bleeding and/or raveling of the surface. Naturally the interest to highway officials is generated by the expense of time and money necessary for rebuilding, repairing and/or resurfacing.

For this reason, identifying asphaltic concrete mixes that may be susceptible to debonding becomes significant during the design phase. The "state of the art" of predicting stripping has developed several different techniques, procedures and tests. These tests are based on the different theories of the mechanisms of debonding. Two theories of the mechanisms of debonding are based on failure stresses resulting from two (2) modes; a) water pressure and erosion, and b) thermal cycles on wet pavements.[1] The immersion-compression test (ARIZ 802), a modification of (AASHTO T165-55), employs the thermal cycle principle of conditioning and unconfined compression strength as the measurement gauge. Currently the Arizona Department of Transportation is employing this test for identifying stripping susceptible mix designs. In 1973, a final report was issued on research project Arizona HPR 1-10 (123) titled "Testing for Debonding of Asphalt from Aggregate".

[1]Dr. R. A. Jimenez, "Testing for Debonding of Asphalt from Aggregate"

The author, Dr. R. A. Jimenez, recommended a new test procedure using the water pressure theory in the conditioning portion of the test. This test procedure is commonly known as the double punch.

The overall objective of this investigation was to provide confidence in the double punch procedure (DP) and to determine whether this procedure would provide an improved test over the immersion-compression test (IMC). Following is the approach to the investigation, and the testing program.

1.2 Research Approach

A. To develop a testing capability for the debonding test procedure in the Central Laboratory.

B. To study the time efficiency of the new test procedure.

C. To relate the new test to existing immersion-compression tests, and debonding predictions from both to newly constructed pavement conditions.

The test procedure was studied also to the degree and type of compaction.

1.3 Test Program

The first part of the test program was to acquire equipment capable of testing by the double punch method. The apparatus necessary to apply a sinusoidal stressing pattern through a pore water pressure medium was built and calibrated. Stressing cylinders were also fabricated. A water bath was purchased exclusively for this study. Punch attachments were fabricated to fit our hydraulic press.

The second part of the testing was to study the time efficiency of the new test. The time required for preparation and for testing was studied.

Thirdly, relating the new test procedure to the existing immersion-compression procedure was routinely accomplished in the lab by incorporating the new test into the mix design procedure and by sampling and testing field specimens. A copy of the immersion-compression test method is included in Appendix B, p.36.

Following is the double punch procedure.

DOUBLE PUNCH
TEST METHOD

The test method consisted of preparing, conditioning and testing specimens for strength. The preparation of the test specimens was accomplished by grading aggregates and mixing the optimum asphalt quantity with the aggregate. The weight of the mix was approximately 1150 grams or the weight necessary to mold a 2.5 in. (63.5mm) high by 4 in. (101.6mm) diameter specimen. Nine specimens were to be prepared. Five of the nine specimens were mixed with an AR grade asphalt. Two specimens were mixed with an AR grade asphalt that had a liquid antistrip additive added to the asphalt (1.0% by weight of the asphalt). Two specimens were prepared by deleting 2% of the -#200 mineral aggregate and replacing with 2% cement.

Several methods of compacting these mixes were tried. The first 5 sets of samples were compacted by static means. A pressure of 3000 psi was applied and held for 2 minutes. This is similar to the immersion-compression (IMC) compaction method. The next 11 sets of samples were compacted by means of the vibratory compactor. The compactive effort was produced by two 2 in. (50.8mm) weights on each end of two counter rotating shafts developing approximately 400 lb. force @ 1000 rpm. A dead load of 225 lb. force also bears on the specimen through a compaction foot that is angled at 1^{o} which allows orientation of particles through the resultatnt kneading action. The last 4 sets of samples were compacted by the Hveem method. A Triaxial Institute (T.I.) compactor was used to apply the 500 psi force with 150 tamping blows.

Conditioning was accomplished on all but 3 of the specimens in each set. These 3 specimens, which have no treatment added, were tested unconditioned and are referred to as "dry" specimens. Conditioning consists of saturating and stressing. Following is the procedure for conditioning.

CONDITIONING

SATURATION

1. The specimens to be conditioned are each placed in a stressing chamber. See Figure 1 below.

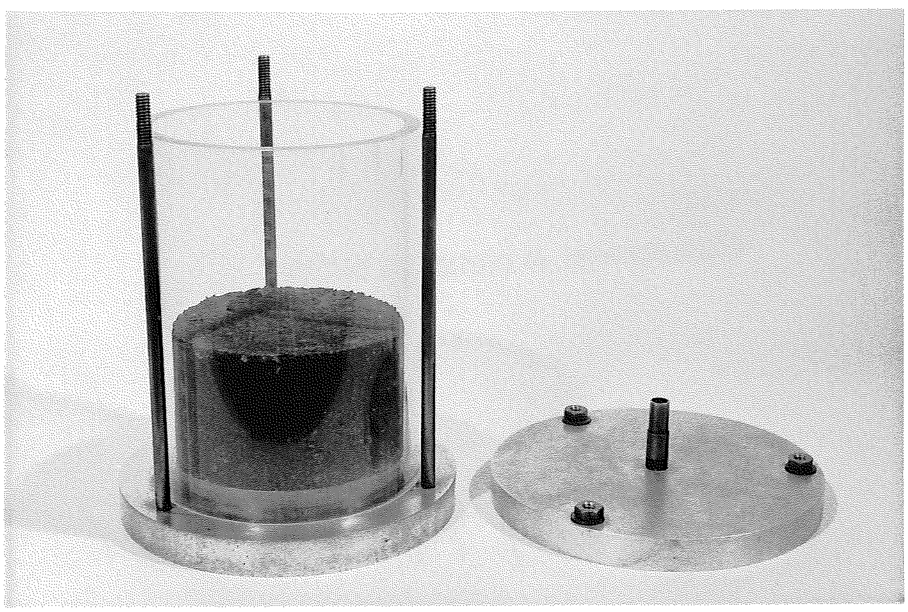


Figure 1 Specimen Placed in Stressing Chamber Prior to Vacuum Saturation

2. The chamber is placed in the 50^{o}C (122^{o}F) water bath. The specimen is covered with about 2 in. (50mm) of 122^{o}F water and a lid is secured on the chamber. See Figure 2 next page.

3. The chamber with specimen is allowed to stand in the bath for approximately 15 minutes.

4. A vacuum pressure of 20 in (508mm) Hg is applied to the chamber for 5 minutes. See Figure 3 on next page.

5. The vacuum is then released and the chamber is left standing for 30 minutes to bring specimen to bath temperature.

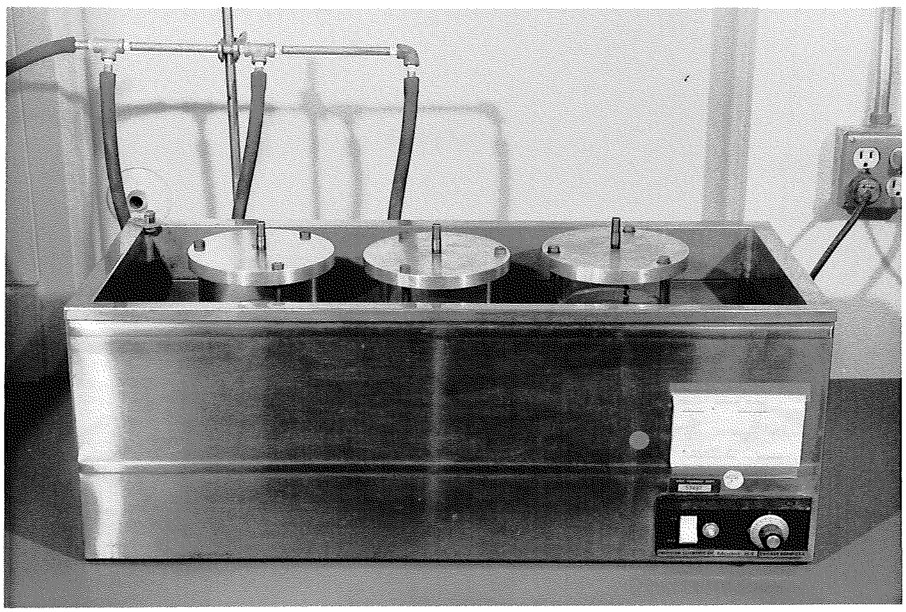


Figure 2 Stressing Chamber in 122°F Bath in Position for Vacuum Saturation

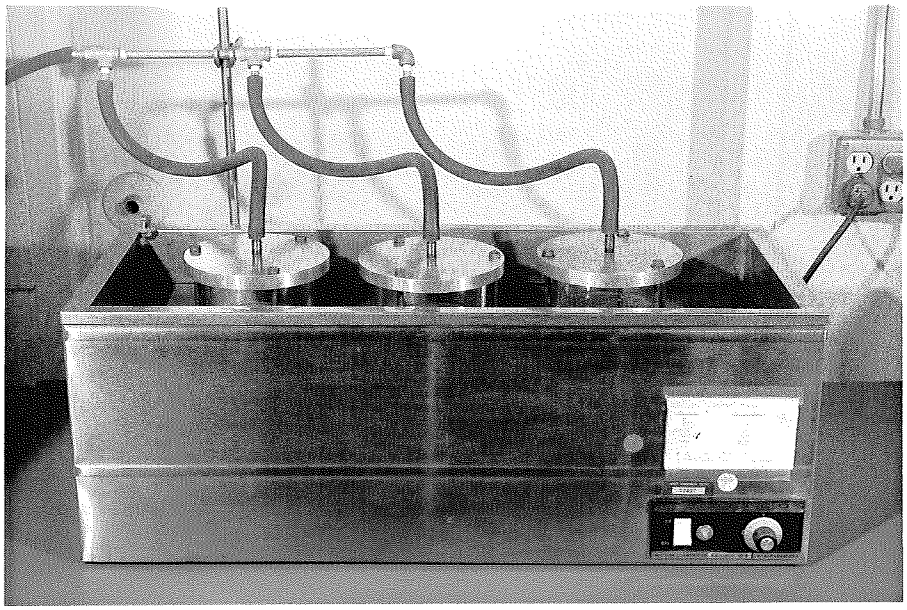
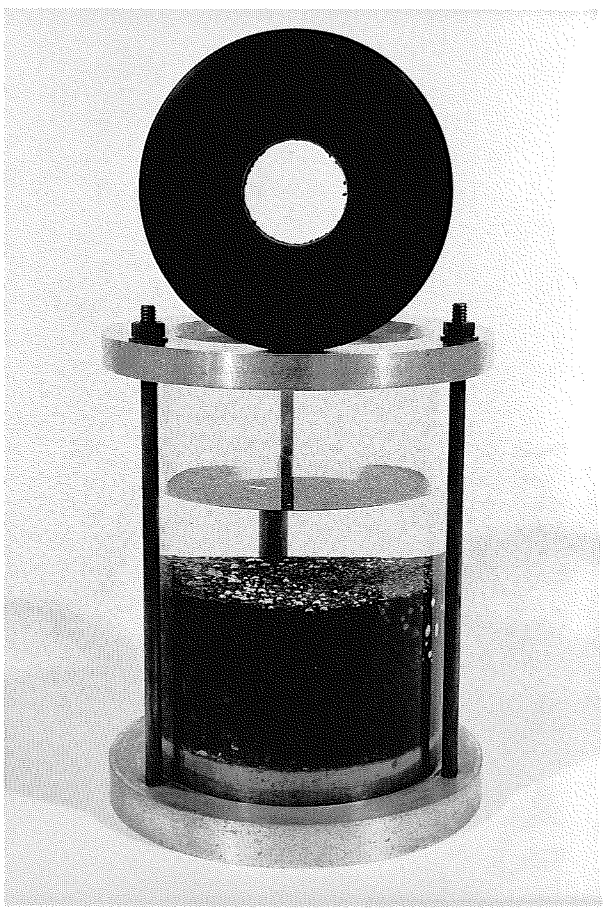


Figure 3 Stressing Chamber with Vacuum Attached

STRESSING

6. With the chamber and specimen still in the hot water bath, the lid is removed and replaced with a stressing-ring. The ring is secured tightly.
7. A 1 in. (25.4mm) thick Flexane rubber annulus is placed into the chamber beneath the water. All entrapped air beneath the annulus is released by tipping the chamber from side to side. See Figure 4 and 5 next page.

8. The annulus is then adjusted until it is perpendicular to the cylindrical axis of the chamber and approximately 1/4 in. (6.3mm) to 1/2 in (12.7mm) above the top surface of the specimen.



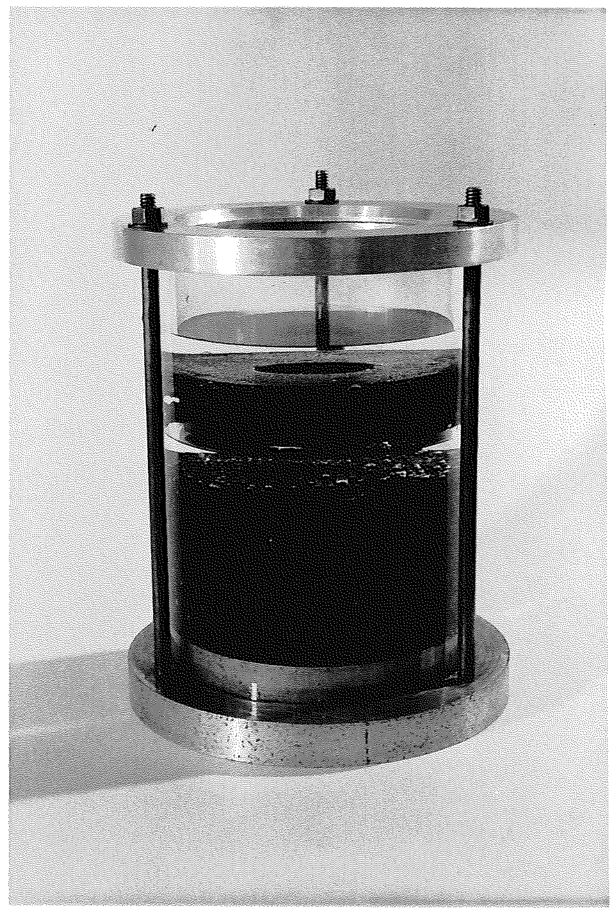


Figure 4 Stressing Chamber with Annulus

Figure 5 Stressing Chamber with Annulus in Place

9. The chamber is removed from the hot water bath and quickly placed in position on the stressing apparatus table.

10. The stressing apparatus is lowered until the 4 in. (101.6mm) diameter foot makes contact with the top of the annulus. Lowering is continued until water and annulus support the weight. See Figure 6 below.

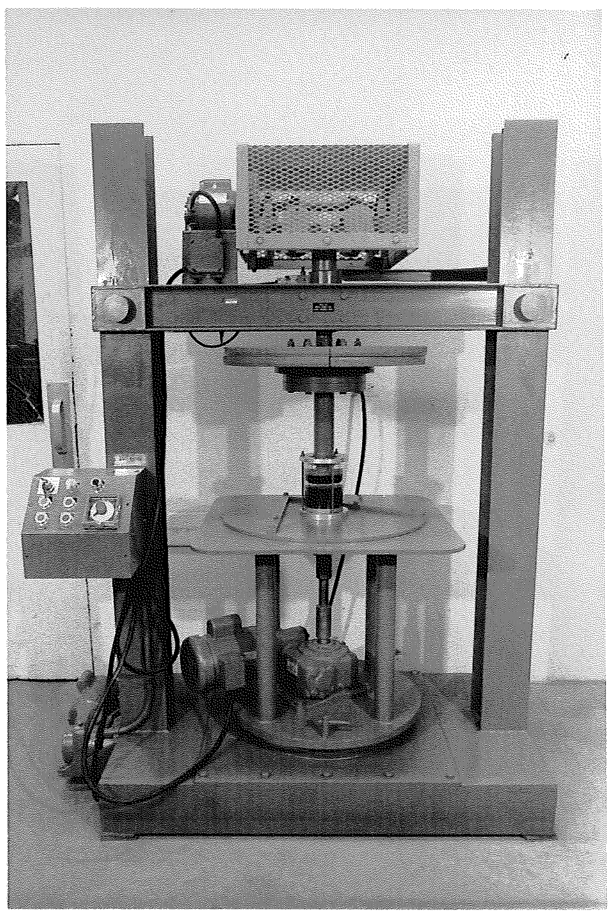


Figure 6 Stressing Chamber in Position to be Stressed

11. The timer is set to the time period required (5,800 cycles).

12. The electric motor is activated.

13. After the stressing time has elapsed, the chamber is removed and the specimen removed and placed in a 25°C (77°F) water bath for a minimum of 45 minutes.

STRENGTH TEST

1. The specimen is centered on the 1 in. (25.4mm) diameter bottom punch. See Figure 7 and 8 next page.

2. The upper punch, same diameter, is lowered until it just touches the upper surface of the specimen.

3. The specimen is loaded at 1.0 in. (25.4mm) per minute.

4. The maximum load is recorded.

5. The tensile stress is calculated from the equation below.

$$\sigma + = P/\ \pi(1.2bH - a^2) \qquad [2]$$

$\sigma+$ = tensile stress, psi (Pa)

P = maximum load, lb. (N)

a = radius of punch, in. (mm)

b = radius of specimen, in. (mm)

H = Height of specimen, in. (mm)

[2] Dr. R. A. Jimenez, "Testing for Debonding of Asphalt from Aggregate"

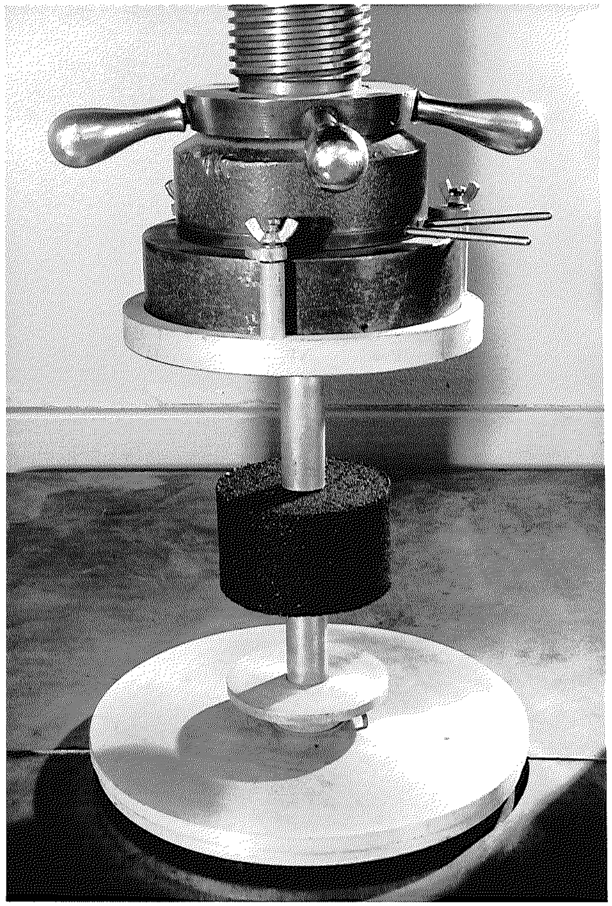


Figure 7 Specimen in Position for Double Punch Tensile Test

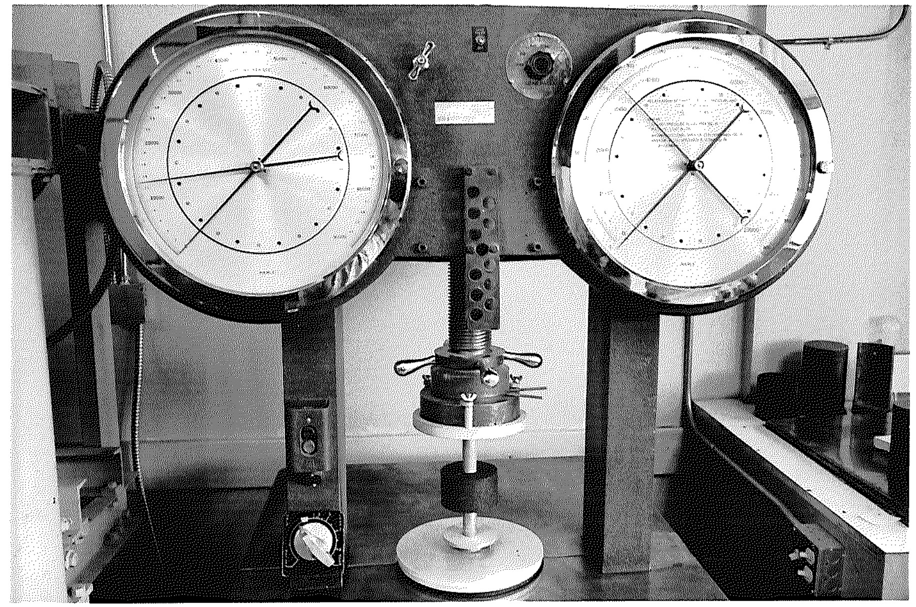


Figure 8 Specimen in Position for Double Punch Tensile Test

CHAPTER 2

FINDINGS

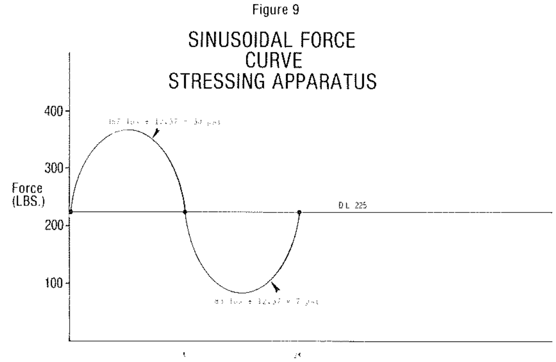
The following findings are based upon 20 laboratory sample sets and 8 field sample sets.

2.1 Testing Capability

The capability to test by the double punch procedure was accomplished by a stressing apparatus, a water bath, stressing chambers, and punch attachments. In the course of testing, it became necessary to add a bath for the stressing chamber to be immersed in, so that temperature loss during stressing would be minimal. This was accomplished by pumping water from the conditioning bath into coiled copper tubing that encircled the chamber. This kept the chamber bath water at $122^{o}F \pm 4^{o}$. An aluminum pot was used for the bath. See Figure 10 next page.

The stressing apparatus was calibrated by adjusting pulley sizes for speed variation, and by balancing the counterweights more accurately. The 1/4 hp electric motor had to be replaced by a 1/3 hp, because of over-heating and fluctuating speed. The dead load of 225 lb. in combination with the sinusoidal generated loading results in a loading diagram as shown in Figure 9 below. The peak load divided by the area of the foot results in approximately 30 psi pressure.

Figure 9



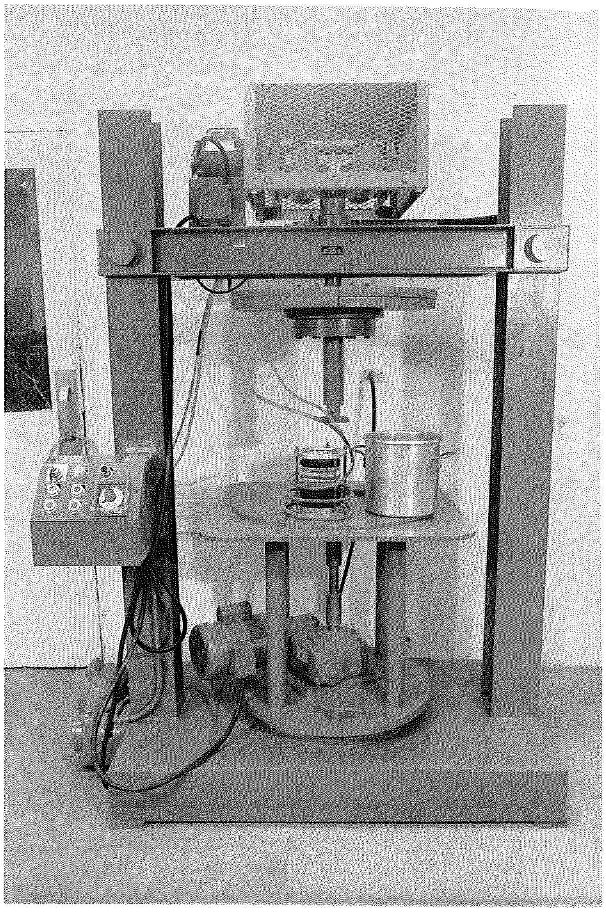


Figure 10 Aluminum Pot with Copper Heating Coil used for Chamber Bath during Stressing

2.2 Time Efficiency

The time efficiency for the 3 phases (preparation, conditioning, and testing) was examined. The time in preparation of specimens for both test methods is approximately equal. The time needed for the conditioning of one complete set of IMC specimens is 26 hours. The time needed for the conditioning of one complete set of DP specimens is 3-1/2 hours. The time needed for testing is approximately equal for both test methods. Using the optimum timing for beginning both tests, the DP will give results 24 hours sooner than IMC.

2.3 Correlation

Aggregate Type

The types of aggregates used in this testing program were cinders, basalts, limestones, granites and even one recycled aggregate. The aggregate types are listed in Table 6. There was no indication that aggregate type had any notable effect on the results of the IMC test versus the DP test.

Compaction Method

The effect of compaction on the specimens was not clearly shown in the results obtained. However, it became evident that density control was best obtained by the Hveem method, then the static method and lastly the vibratory method(See Tables 1, 2, 3 and Figures 11, 12, 13).

Retention and Strength Results

The correlation coefficients were calculated for the laboratory prepared sample sets. Following is the ranking of the correlation.

	N	Correlation (R^2)
Without Treatment	19	.6373
Anti-strip	20	.5262
Compression vs Tension	77	.3145
Cement	18	.2859

The lines of best fit are plotted on Figures 14, 15, 16 and 17 (p. 32, 33, 34 and 35 respectively).

Field Comparisons

Uncompacted plant mixed samples were taken from ahead of the lay-down machine in the field. Cores were taken three months later at the same location. The plant mixed samples were heated, molded, conditioned and tested by IMC and DP procedures. The specimens were made in triplicate to minimize variability. The dry or "unconditioned" strength of the "plant mix", laboratory molded, specimen versus the dry strength of the core was erratic. The core strengths averaged 68% of the laboratory molded sample strengths. The values were extremely high, or extremely low, therefore no correlation could be seen. The values are tabulated in Table 5, page 26.

CHAPTER 3

INTERPRETATION

The double punch procedure is a relatively simple test to perform. No special knowledge or skill is needed. The laboratory technician would only be occupied during the 3-1/2 hours needed for conditioning and for approximately 1/2 hour for the strength test. Using temperature and hydraulic pressure to debond the asphalt from the aggregate is an excellent simulation of the actual conditions that an asphalt pavement experiences. In explaining why better correlation exists between the groups of data as shown in Figures 14, 15, 16 and 17, several factors must be examined.

The first factor to examine is compaction or density. Naturally, the more impermeable a mix is the greater the resistance to the effects of water. The DP method would use the T.I. method of compaction which would generate densities of approximately 95% of maximum theoretical density (MTD). The static method of compaction used in the method generates densities of approximately 92% of MTD at 3000 psi. Densities greater than 92% could be achieved by increasing the pressure, but 92% is the required minimum densitity called for in the field.

The second factor to consider is the severity of the conditioning. It is the authors' feeling that dynamic stressing for a shorter time period is more severe and better simulation than a longer period of exposure at static conditions. The time in conditioning affected the cement treated samples significantly. The 24 hour immersion called for in the IMC method gives ample time for the cement to hydrate or react whereas the 60 minutes of immersion required in the DP method does not give the cement time to react. In Figure 14, this cement reaction is shown by the intercept on the IMC axis.

The third factor that should be considered is the method of test or failure mode. The IMC method induces failure by direct unconfined compression. Shear strength is perhaps the property being measured in this failure mode. In the DP method, tensile strength is being measured with the punches precipitating this failure. It is generally believed that cement, as an additive, builds strength, especially after immersion in water. This strength gain would be more significant when measured in shear than in tension. This coupled with the length of time of immersion would account for the higher results for cement IMC vs DP (See Figure 14, p. 32).

CHAPTER 4

CONCLUSION AND RECOMMENDATION

The double punch method is easy to use, saves time and can easily test field cores. It is the authors feeling that this method, with some minor modifications, should be incorporated into the mix design methods of the Arizona Department of Transportation.

The modifications that are suggested are as follows:

1. Compact the specimens to approximate the 92% level, which is the minimum required value in the field.

2. Increase the severity of the conditioning to simulate heavy truck loadings.

REFERENCES

1. Jimenez, R. A., "Testing for Debonding of Asphalts from Aggregates", Report to Arizona Department of Transportation, Final, Research Project HPR 1-10(123), University of Arizona, 1973.

2. Materials Testing Manual, Arizona Highway Department, 1969.

APPENDIX A

TABLE 1

IMMERSION COMPRESSION VS DOUBLE PUNCH (STATIC COMPACTION)

		IMMERSION COMPRESSION			DOUBLE PUNCH		
LAB #		AIR PSI	H_2O PSI	% RET	AIR PSI	H_2O PSI	% RET
1	Blank	311	223	72	103	85	83
	1% Anti-Strip		338	109		85	83
	2% Cement		371	119		107	104
2	Blank	448	209	47	106	44	42
	1% Anti-Strip		305	68		73	69
	2% Cement		416	93		74	70
3	Blank	143	104	73	73	53	73
	1% Anti-Strip		173	121		54	74
	2% Cement		208	145		54	74
4	Blank	329	253	77	103	72	60
	1% Anti-Strip		315	96		66	64
	2% Cement		378	115		74	72
5	Blank	288	183	64	113	49	44
	1% Anti-Strip		229	79		71	63
	2% Cement		305	106		75	67

TABLE 2

IMMERSION COMPRESSION RESULTS VS DOUBLE PUNCH (VIBRATORY COMPACTION)

LAB #		IMMERSION COMPRESSION			DOUBLE PUNCH		
		AIR PSI	H_2O PSI	% RET	AIR PSI	H_2O PSI	% RET
6	Blank	831	359	43	114	48	42
	1% Anti-Strip		353	42		50	44
	2% Cement						
7	Blank	308	250	81	70	55	79
	1% Anti-Strip		307	100		86	123
	2% Cement		357	116		49	70
8	Blank	300	253	84	186	168	90
	1% Anti-Strip		297	99		164	88
	2% Cement		374	125		134	72
9	Blank	255	126	49	116	62	53
	1% Anti-Strip		169	66		73	63
	2% Cement		250	98		81	70
10	Blank	207	99	48	76	47	61
	1% Anti-Strip		136	66		54	70
	2% Cement		236	114		54	70

TABLE 2 (con't)

LAB #		IMMERSION COMPRESSION			DOUBLE PUNCH		
		AIR PSI	H_2O PSI	% RET	AIR PSI	H_2O PSI	% RET
11	Blank	452	426	94	186	170	91
	1% Anti-Strip		452	100		155	83
	2% Cement		533	118		106	57
12	Blank	347			114		
	1% Anti-Strip		372	107		135	119
	2% Cement						
13	Blank	298	110	37	129	41	31
	1% Anti-Strip		241	81		85	66
	2% Cement		405	136		121	94
14	Blank	258	85	33	130	43	33
	1% Anti-Strip		119	46		83	64
	2% Cement		165	64		70	54
15	Blank	348	135	39	173	63	37
	1% Anti-Strip		151	43		57	33
	2% Cement		231	66		77	45
16	Blank	248	209	84	103	82	80
	1% Anti-Strip		245	99		86	83
	2% Cement		366	148		106	103

TABLE 3

IMMERSION COMPRESSION RESULTS VS DOUBLE PUNCH (VHEEM COMPACTION)

LAB #		IMMERSION COMPRESSION AIR PSI	IMMERSION COMPRESSION H_2O PSI	IMMERSION COMPRESSION % RET	DOUBLE PUNCH AIR PSI	DOUBLE PUNCH H_2O PSI	DOUBLE PUNCH % RET
17	Blank	205	75	37	81	49	60
	1% Anti-Strip		109	53		46	57
	2% Cement		171	83		58	72
18	Blank	247	139	56	67	48	72
	1% Anti-Strip		224	91		66	99
	2% Cement		275	111		61	91
19	Blank	411	180	44	120	46	38
	1% Anti-Strip		227	55		68	57
	2% Cement		340	83		117	98
20	Blank	262	95	31	96	60	63
	1% Anti-Strip		152	58		65	68
	2% Cement		221	84		62	65

TABLE 4

DENSITY COMPARISON
(pounds per cubic foot)

LAB #	BLANK AVERAGE	ANTI-STRIP AVERAGE	CEMENT AVERAGE	92% MAXIMUM THEORETICAL DENSITY	METHOD OF COMPACTION
5	142.4	140.6	141.3	139.0	Static
6	138.0	137.7	-----	141.4	Vibratory
7	124.4	125.8	122.9	119.3	Vibratory
9	147.9	146.7	149.4	141.9	Vibratory
10	142.7	144.2	143.5	138.4	Vibratory
14	152.8	153.4	153.4	145.5	Vibratory
15	143.0	142.3	144.2	137.0	Vibratory
16	146.2	147.8	146.6	139.8	Vibratory
17	149.3	151.1	149.7	145.8	Hveem
18	138.4	138.7	141.4	135.4	Hveem
19	143.6	144.2	146.8	139.4	Hveem
20	146.9	146.6	149.3	142.5	Hveem

TABLE 5

FIELD COMPARISON

LAB #	LOCATION	IMMERSION COMPRESSION			DOUBLE PUNCH			DOUBLE PUNCH @ 90 DAYS			$\frac{DRY_{90}}{DRY_{INITIAL}}$ %
		DRY PSI	WET PSI	%	DRY PSI	WET PSI	%	DRY PSI	WET PSI	%	
1F	I 19-1(41) Nogales-Tucson	428	367	86	140.8	126.4	90	59.4	59.1	99	42
2F	RS 453(1) Snowflake-Concho	308	250	81	46.9	41.8	89	38.2	21.4	56	81
3F	I 40-2(76) Kingman-Ash Fork	465	423	91	137.9	131.5	95	60.6	56.6	93	44
4F	U 463(5) 3rd St-Jct Hwy 80	373	252	68	139.6	91.2	65	141.0	117.6	83	101
5F	I 10-1(21) Ehrenberg-Phoenix	515	337	65	211.2	200.0	95	78.7	79.1	101	37
6F	M 600-3-501 48th St-Hohokam Expressway	489	429	88	143.8	107.1	75	80.6	65.4	81	56
7F	F 022-4-924 Globe-Safford	424	270	64	116.6	65.0	56	173.2	124.7	72	149
8F	S 207-904 Bowie Jct-Safford	846	406	48	175.0	145.4	83	119.2	66.5	56	68

TABLE 6

AGGREGATE TYPE

FOR TABLES 1, 2, 3

LAB #	PIT #	AGGREGATE TYPE	BLEND #	AGGREGATE TYPE
1	5781	Basalt Quarry	7470 Camp Verde	Quartzitic Sand & Gravel
2	Hospital Pit	Sand & Gravel	Wingfield Pit	Granitic Sand & Gravel
3	8528	Quartzite, Volcanics Sand & Gravel	NONE	NONE
4	964	Granitic Sand & Gravel	NONE	NONE
5	5392	Quartzitic Sand & Gravel	NONE	NONE
6	Old Cake	Crushed A.C.	Palace Yard Aggregate	Gravel
7	5153	Cinder Quarry	NONE	NONE
8	2971	Andesitic Sand & Gravel	NONE	NONE
9	7007	Schist, Granite, Basalt Sand & Gravel	NONE	NONE
10	7214	Basalt Sand & Gravel	NONE	NONE
11	5781	Basalt Quarry	NONE	NONE
12	5781	Baslat Quarry	NONE	NONE
13	8538	Basalt Quarry	5390	Basalt Sand & Gravel
14	8076	Basalt & Granite Sand & Gravel	8034	Gneiss & Granite Sand & Gravel
15	7143	Granitic Sand & Gravel	NONE	NONE
16	8519	Quartzite Quarry	5907	Granite & Quartzite Sand & Gravel
17	8537	Basalt Quarry	6906	Chert, Quartizite Sand & Gravel

TABLE 6

AGGREGATE TYPE

FOR TABLES 1, 2, 3

LAB #	PIT #	AGGREGATE TYPE	BLEND #	AGGREGATE TYPE
18	8401	Sandstone, Granite Quartzite Sand & Gravel	8520	Andesite & Sandstone Sand & Gravel
19	5216	Basalt Sand & Gravel	NONE	NONE
20	7635	Quartzitic Sand & Gravel	NONE	NONE

Figure 11

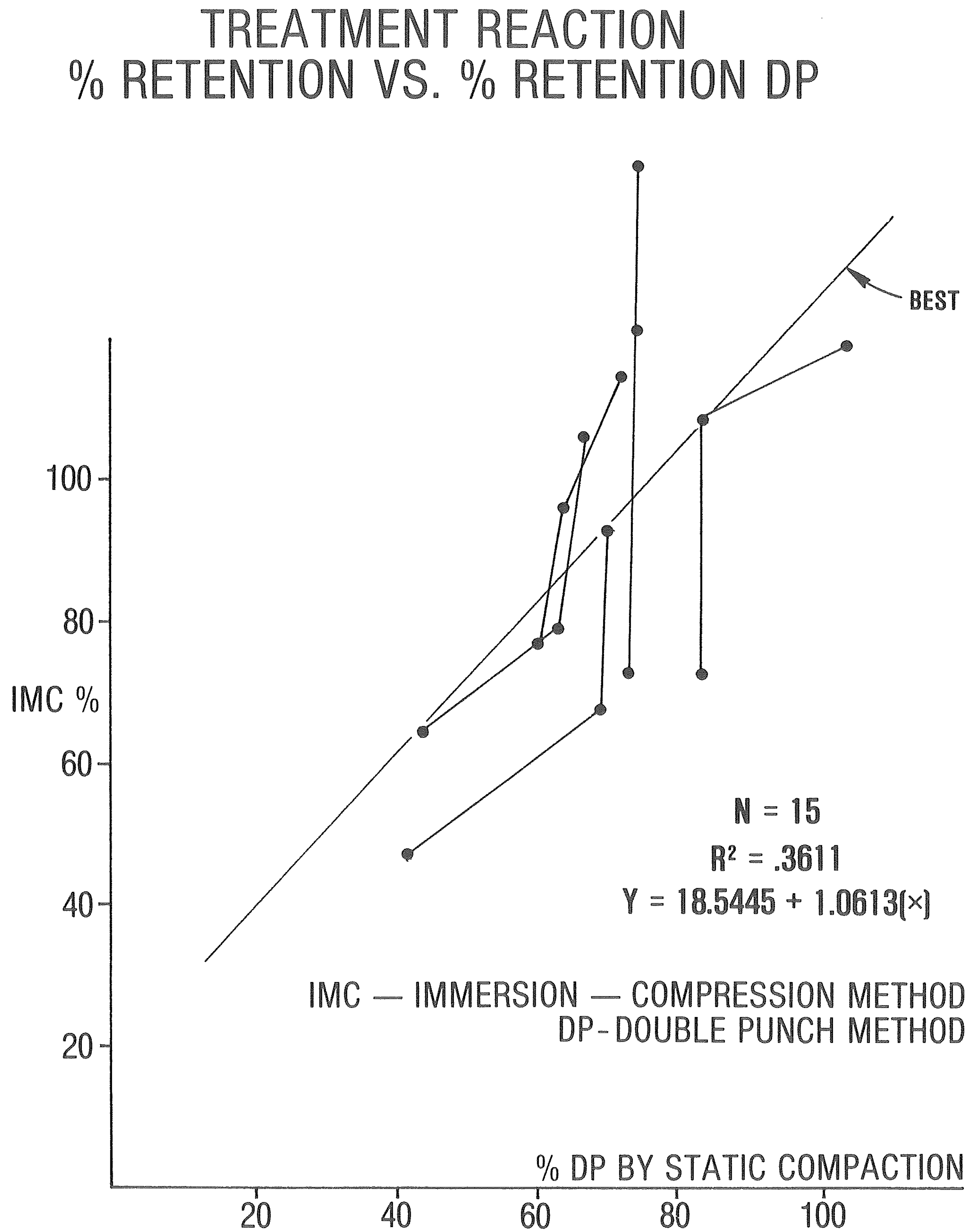

TREATMENT REACTION
% RETENTION VS. % RETENTION DP
BEST FIT
100
80
IMC %
60
40
20
N = 15
R² = .3611
Y = 18.5445 + 1.0613(×)
IMC — IMMERSION — COMPRESSION METHOD
DP-DOUBLE PUNCH METHOD
% DP BY STATIC COMPACTION
20
40
60
80
100

Figure 12

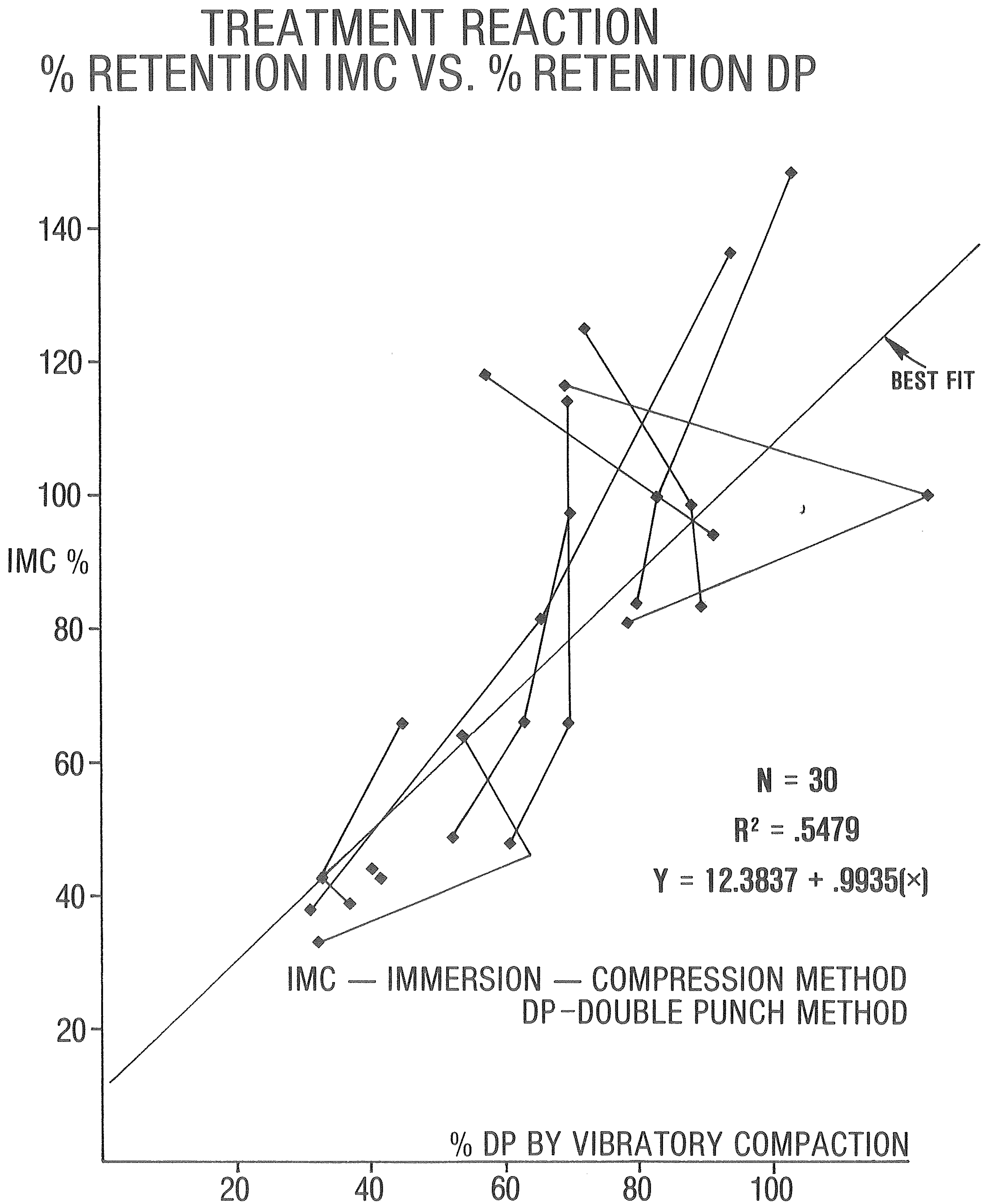

TREATMENT REACTION
% RETENTION IMC VS. % RETENTION DP
140
120
100
IMC %
80
60
40
20
BEST FIT
N = 30
R² = .5479
Y = 12.3837 + .9935(×)
IMC — IMMERSION — COMPRESSION METHOD
DP–DOUBLE PUNCH METHOD
% DP BY VIBRATORY COMPACTION
20
40
60
80
100

Figure 13

TREATMENT REACTION
% RETENTION IMC VS. % RETENTION DP

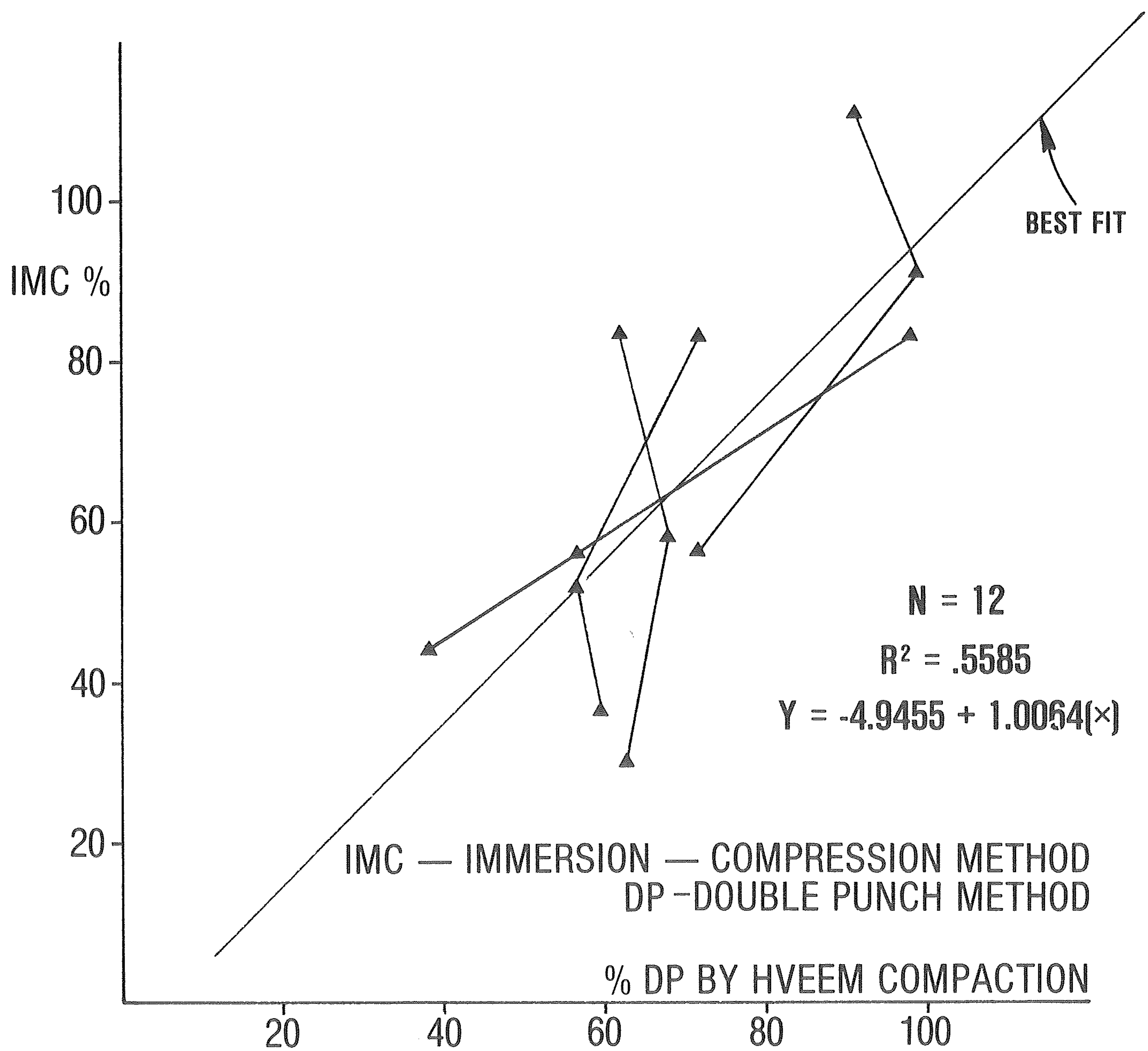


Figure 14

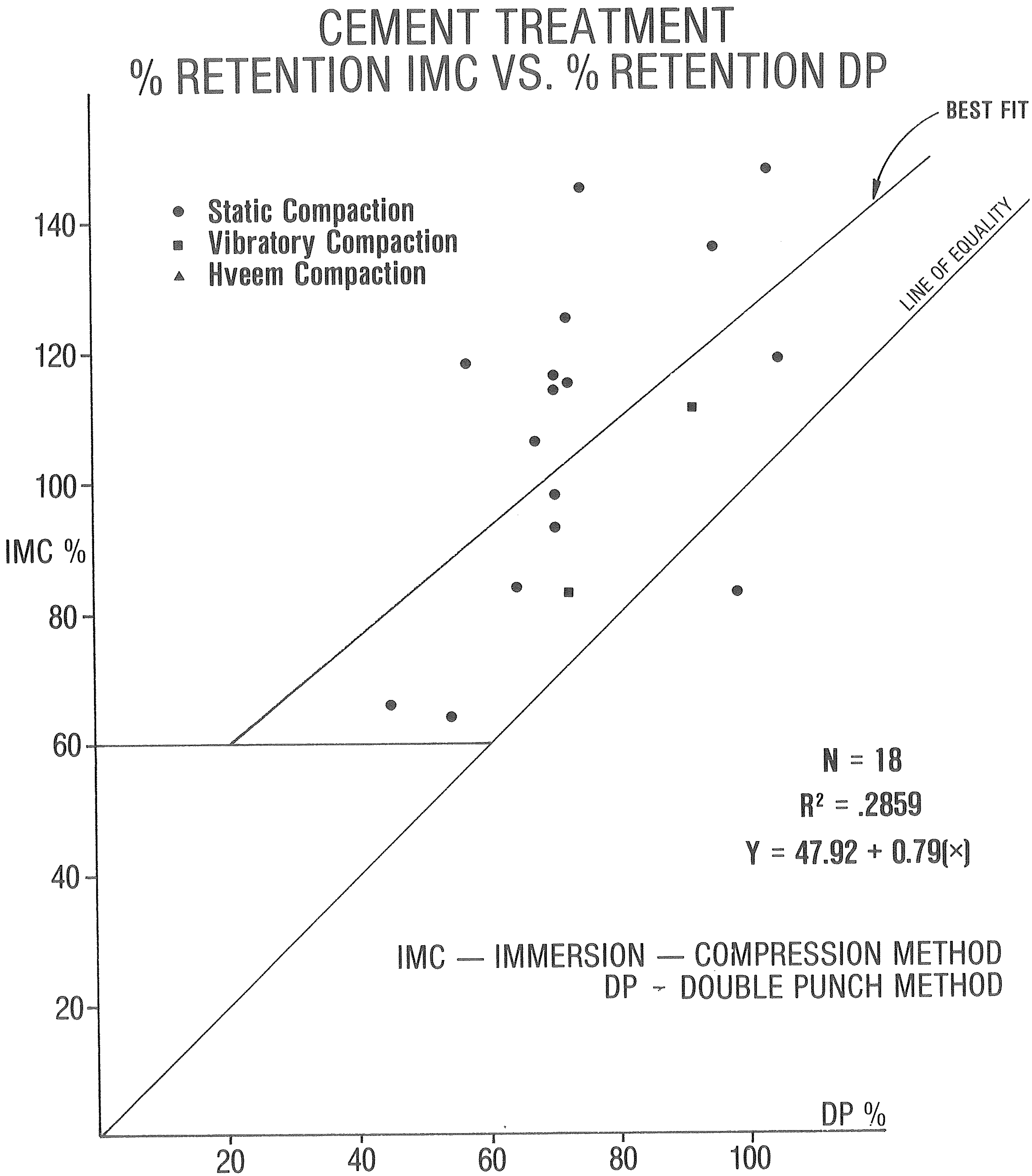

CEMENT TREATMENT
% RETENTION IMC VS. % RETENTION DP
BEST FIT
LINE OF EQUALITY
Static Compaction
Vibratory Compaction
Hveem Compaction
IMC %
DP %
140
120
100
80
60
40
20
20
40
60
80
100
N = 18
R² = .2859
Y = 47.92 + 0.79(×)
IMC — IMMERSION — COMPRESSION METHOD
DP - DOUBLE PUNCH METHOD

Figure 15

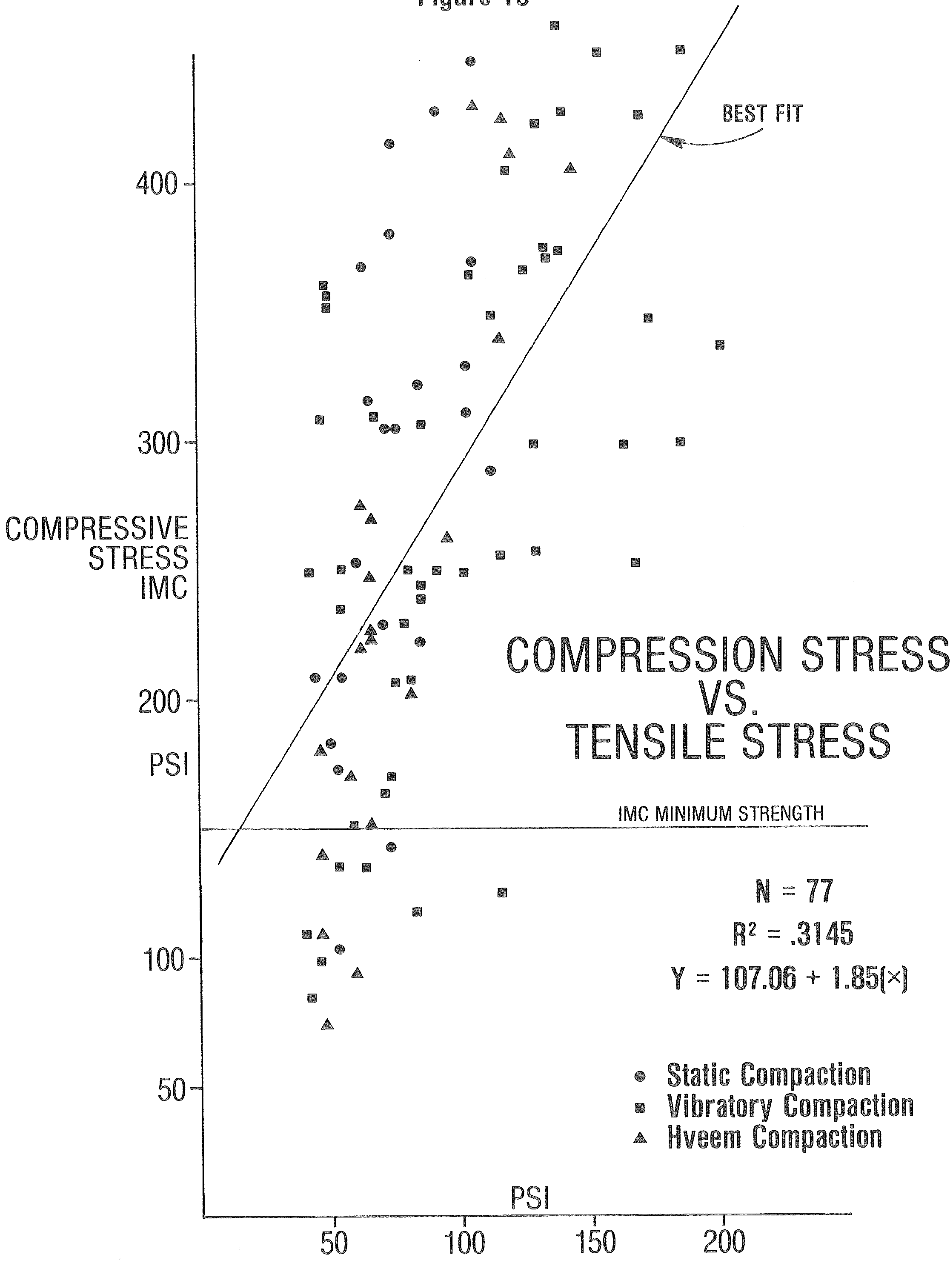

400
300
200
100
50
COMPRESSIVE
STRESS
IMC
PSI
BEST FIT
COMPRESSION STRESS
VS.
TENSILE STRESS
IMC MINIMUM STRENGTH
N = 77
R² = .3145
Y = 107.06 + 1.85(×)
Static Compaction
Vibratory Compaction
Hveem Compaction
PSI
50
100
150
200

Figure 16

ANTISTRIP TREATMENT
% RETENTION IMC VS. % RETENTION DP

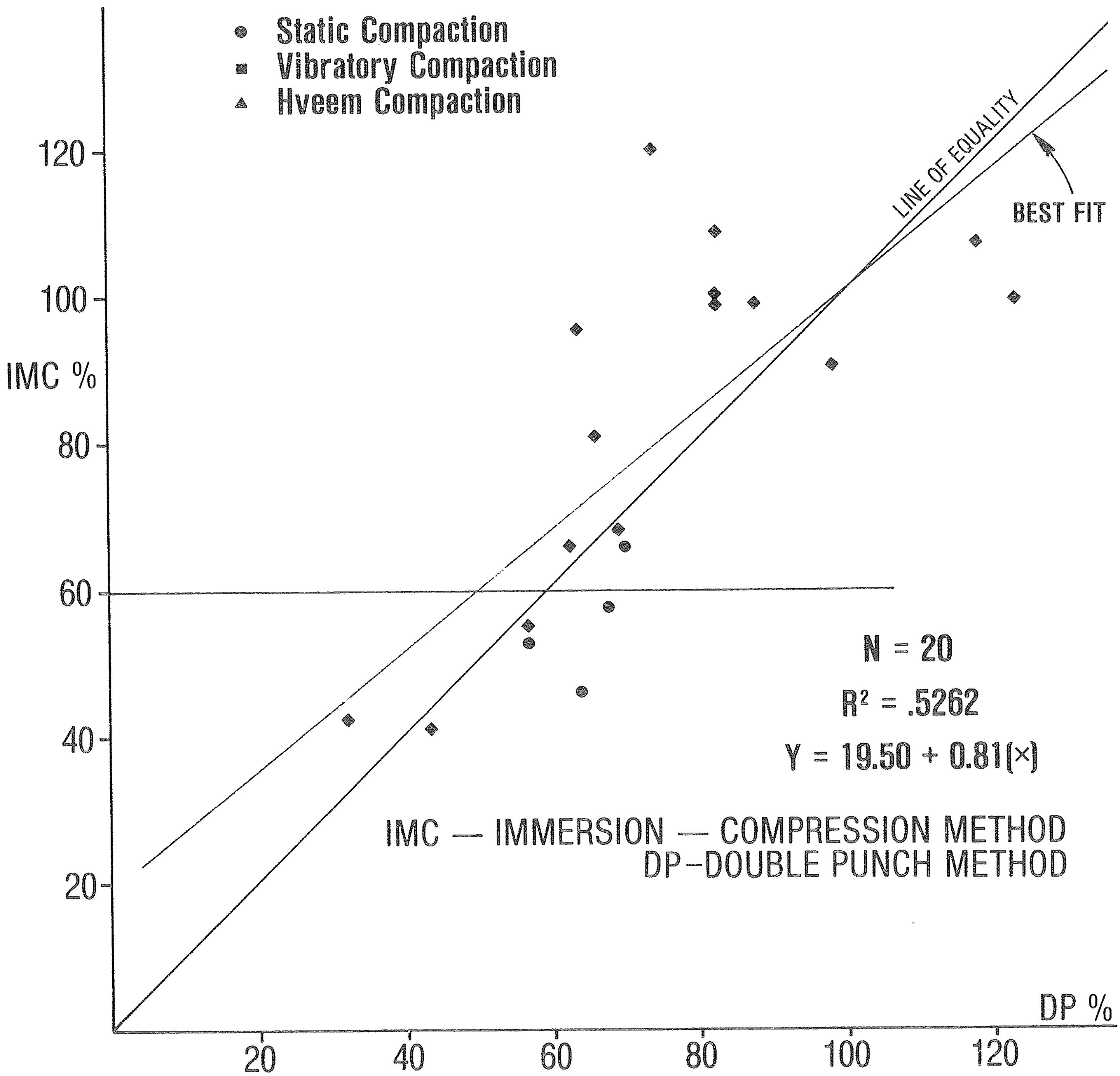
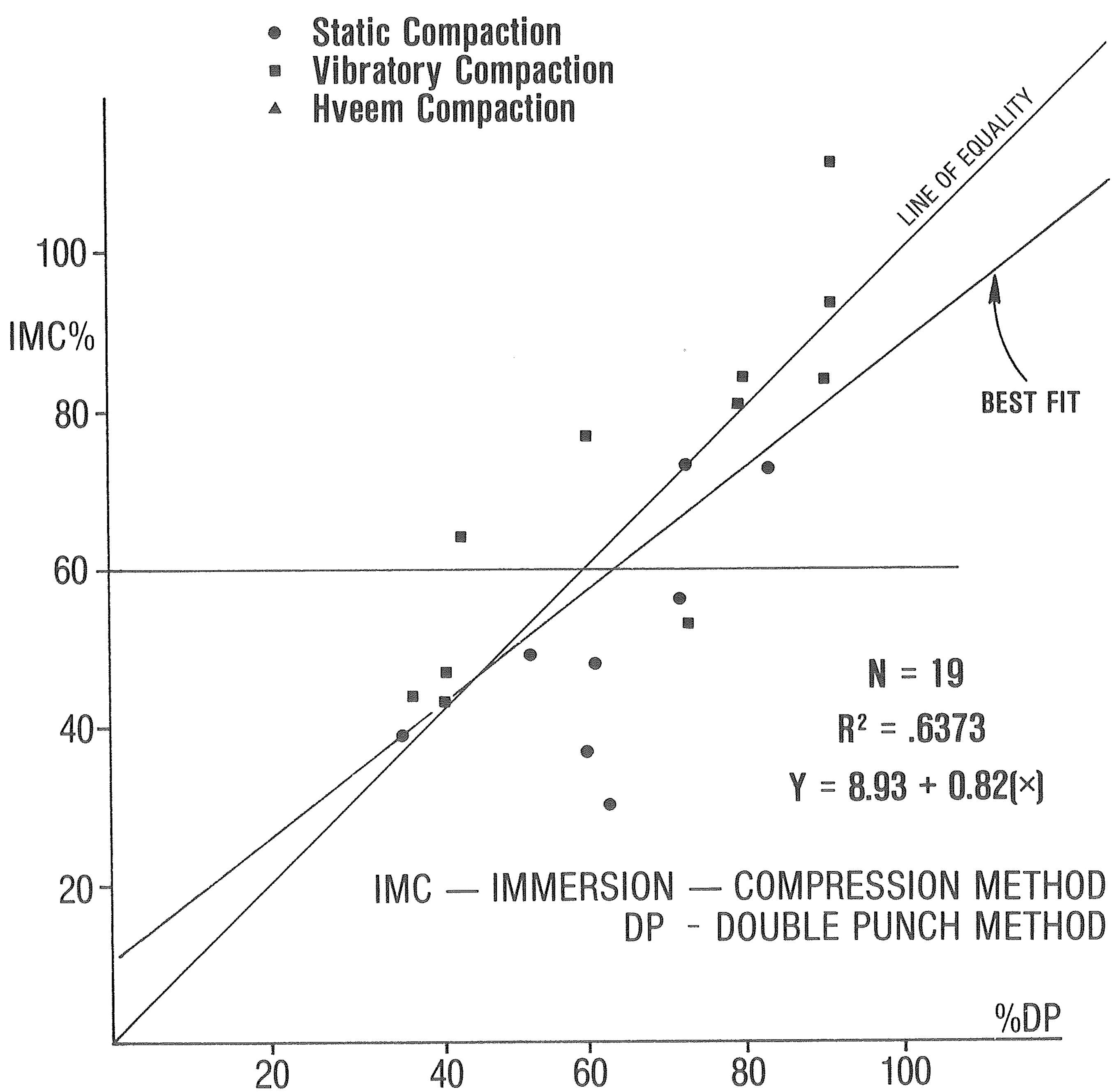


Figure 17

WITHOUT TREATMENT
% RETENTION IMC VS. % RETENTION DP



APPENDIX B

ARIZ 802c
September 1971
(2 pages)

EFFECT OF WATER ON COHESION OF COMPACTED, TREATED & UNTREATED BITUMINOUS MIXTURES

(A Modification of AASHO T 165 & T 167)

Scope

1. This method of test is intended to measure the loss of cohesion resulting from the action of water on compacted bituminous mixtures containing penetration grade asphalt. The relation of cohesion reduction between untreated and specially treated specimens and the effect the additives have on specimens is observed.

Apparatus

2. (a) Water bath. – The automatically controlled water bath shall be of sufficient size to permit total immersion of the test specimens. It shall permit accurate and uniform control of the immersion temperature within ±1.8° F (1° C). It shall be lined with a non-reactive material. The water used may be tap water, or any other potable water.

(b) A separate, manually or automatically controlled water bath for bringing immersed specimens to a temperature of 77° ±1.8° F (25° ±1.0° C) for the compression test. (Note 1.)

NOTE 1: *Any convenient pan or tank may be used, provided the specimens are totally immersed. The water bath in 2.(a) may be used, provided the warmer water is drained, and the heating controls can be adjusted to 77° ±1.8° F.*

(c) Molds. – Molding cylinders, and top and bottom molding plungers; the cylinders shall be 4.000 ±0.005 in. in inside diameter by 7 in. in height. The top and bottom plungers shall be 3.990 ±0.005 in. in diameter, shall have planed bearing surfaces, normal to their long axis.

(d) Testing Machine. – 50,000-pound capacity, minimum, and capable of a head speed of 0.2 in. per minute.

(e) Ovens. – One oven shall be capable of maintaining a temperature of 235° ±5° F, the other capable of 140° ± 5° F.

Preparation of Sample

3. (a) The percentage and grade of asphalt as determined in design tests shall be used for all specimens prepared in this test.

(b) The weight of aggregate shall be 1700 ±2 g. The aggregate shall be proportioned in that grading determined by design.

(c) The required number of samples of aggregate shall be prepared. The project may require a study of effects of certain additives added in a percentage by weight of aggregates; generally the distribution of samples in Table I shall be used unless otherwise specified:

TABLE I

No. of Samples	Type Additive	% by Wt.	Wt.	Total Wt.
4	none	——	——	1700 g.
2	Anti-stripping	See Note 3		—— g.
2	Dry Lime	2%	34 g.	1734 g.
2	Wet Lime	2% Lime	34 g.	
	(Note 2)	& 3% Water	51 g.	1734 g.

TABLE II

WEIGHT OF ASPHALT NEEDED FOR PERCENTAGE REQUIREMENTS, BASED ON 1734 G OF AGGREGATE

Percentage Required	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5
Amount Asphalt, g.	54	63	72	82	91	101	111	121
Total Wt. of Mix, g	1788	1797	1806	1816	1825	1835	1845	1855

NOTE 2: The "Wet Lime" Treatment shall be thoroughly mixed with the aggregate and allowed to cure at room temperature for 48 hours to 7 days. Then it shall be dried to constant weight at 235° ± 5° F. This curing shall be done in advance of the preparation of the other specimens in order to allow immersion of all specimens at the same time.

NOTE 3: The anti-stripping agent is added to the asphalt in a proportion of 1.0% by weight of asphalt required for a 1700 g. aggregate sample.

(d) The weight of asphalt to be added to the aggregate shall be determined on the basis of total weight of mix using Table II.

NOTE 4: For the blank specimens, use Table I in ARIZ 800, based on 1700 g. of aggregate.

(e) Mix the asphalt with the aggregate as specified in section 5 of ARIZ 800.

Compaction of Specimens

4. (a) Place the mixtures in an oven maintained at 235° ± 5° F for 2 hours or until they attain a constant temperature.

(b) Remove one heated sample from the oven and immediately place about half of it into the molding cylinder which, together with the top and bottom plunger, shall have been preheated. Paraffin-coated cardboard discs shall be used to prevent material adhering to the plungers. With the bottom plunger in place, spade the mixture vigorously with a heated spatula or a similar flat object, 15 times around the edges of the mold and 10 times at random over the mixture. Place the remaining half of the mixture into the mold and repeat the process. The spatula should penetrate the mixture as deeply as possible. The top of the mixture should be slightly rounded to aid in firm seating of the upper plunger.

(c) Place the upper plunger on the sample and compress the mixture under an initial load of 150 psi, to set it against the sides of the mold. Remove the support bars and permit full double-plunger action. Apply the load to the mixture at a rate of 0.2 inch per minute until a load of 3000 psi is reached. Hold the load at 3000 psi for 2 minutes. Remove the specimen from the mold with an ejection device that provides a smooth, uniform rate of travel for the ejection head. The specimens shall be placed in a forced draft air bath for approximately 2 hours at 77° ± 1.8° F.

(d) Place the specimen in an oven maintained at 140° ± 5° F, and cure for 16 to 20 hours.

(e) Repeat steps 4. (b) through 4. (d) for the other mixtures.

Immersion Procedure

5. (a) Remove 2 blank specimens from the 140° F oven and allow to cool in a forced draft air bath at 77° ± 1.8° F for 4 hours before breaking. Break in the testing machine as in section 6.

(b) Immediately place all other specimens into the water bath maintained at 140° ± 1.8° F for 18 to 24 hours. Make sure all specimens are completely immersed.

(c) At the end of the immersion period, transfer the specimen to a water bath maintained at 77° ± 1.8° F for 2 hours.

Compression

6. (a) Place each specimen between the bearing plates of the testing machine, and apply axial compression at a uniform rate of vertical deformation of 0.20 inch per minute. Record the pound load at which the specimen fails.

Calculation

7. (a) Record the average failure point for each pair of identically treated specimens.

(b) Record the average failure point for the two blank specimens that were not subjected to immersion.

(c) The numerical index of resistance of treated mixtures to the detrimental effect of water shall be expressed as the percentage of the original strength of the blank specimens in 7.(b). It shall be calculated as follows:

$$\text{Index of retained strength} = \frac{S_2}{S_1} \times 100$$

Where:

S_1 = Compressive strength of dry blanks, 7. (b).

S_2 = Compressive strength of immersed specimens 7. (a).

(d) The index shall be recorded to the nearest 1 percent.