Research Report
UKTRP-82-6

TRIAXIAL COMPRESSION AND PERMEABILITY TESTS ON DENSE GRADED AGGREGATE

for

Division of Materials
Kentucky Department of Transportation

by

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INTRODUCTION

Fifty-six dense-graded aggregate samples of crushed limestone were received from the Division of Materials. Triaxial tests and permeability tests were to be performed.

The samples were obtained from seven sources with four gradations (fine, medium, coarse, and gap) from each source and two samples of each gradation. One of the samples of each gradation was to be compacted by standard compactive effort (AASHTO T-99) and the other at modified compactive effort (AASHTO T-180). The seven sources and their identification codes are as follows:

1. Martin - Marietta (59)
2. Hopkinsville Stone (150)
3. Nally - Hayden (112)
4. Harrod - Carter (51)
5. Reed Crushed Stone (3)
6. Madusa Aggregate - Butler (64)
7. Maudsa Aggregate - Bardstown (41)

In addition to the original 56 samples, six blended samples were later received. Four were identical blends of gravel and crushed limestone from Maysville Dredging (33) and Dravo Limestone (162). The remaining two samples were limestone blends from Lexington Quarry (73) and Dravo Limestone (162).

No information was received concerning the percent of the various size fractions in the different gradations. The optimum moisture content for each gradation was supplied by the Division of Materials.

METHODOLOGY

The samples were compacted at optimum conditions in a split mold to make a test specimen 8.0 inches in height and 4.0 inches in diameter. The specimens were placed in the triaxial chamber and saturated prior to performing a constant-head permeability test. An unconsolidated-undrained triaxial test was then performed using an isotropic confining pressure of 10 psi.

RESULTS

The effect of compactive effort on maximum shear strength is shown in Figure 1. With most of the points falling above the line of equality, it is clear that increased compactive effort and, consequently, density is significantly beneficial to increased shear strength. The average maximum stress for all of the fine gradations was calculated regardless of source or compactive effort. This value is compared with the corresponding value from the other three gradations in Figure 2. The fine gradation provided greatest stress, which was almost 40 percent higher than the coarse gradation.

Figure 3 compares the average maximum stress values for all tests according to source. Martin - Marietta (59) and Hopkinsville stone (150) provided the highest values. The lowest, Madusa Aggregate - Butler (64), was 55 percent of that for Martin - Marietta (59).

Compactive effort also had a significant effect on permeability. Figure 4 shows that, in most cases, as compactive effort increased, permeability was greatly reduced. Table 1 shows the average permeability of each gradation for the two compactive efforts. As expected, the fine gradation was the least permeable. However, the most permeable gradation depended upon the compactive effort. At standard compaction, the coarse gradation was most permeable; but at modified compaction, the gap grading was more permeable.

The effect of increased compactive effort on permeability was more pronounced in the medium and coarse gradations. Permeability was reduced by 96 and 83 percent, respectively, in those two gradations, while reductions of only 59 and 30 percent, respectively, were noted in the fine and gap gradations.

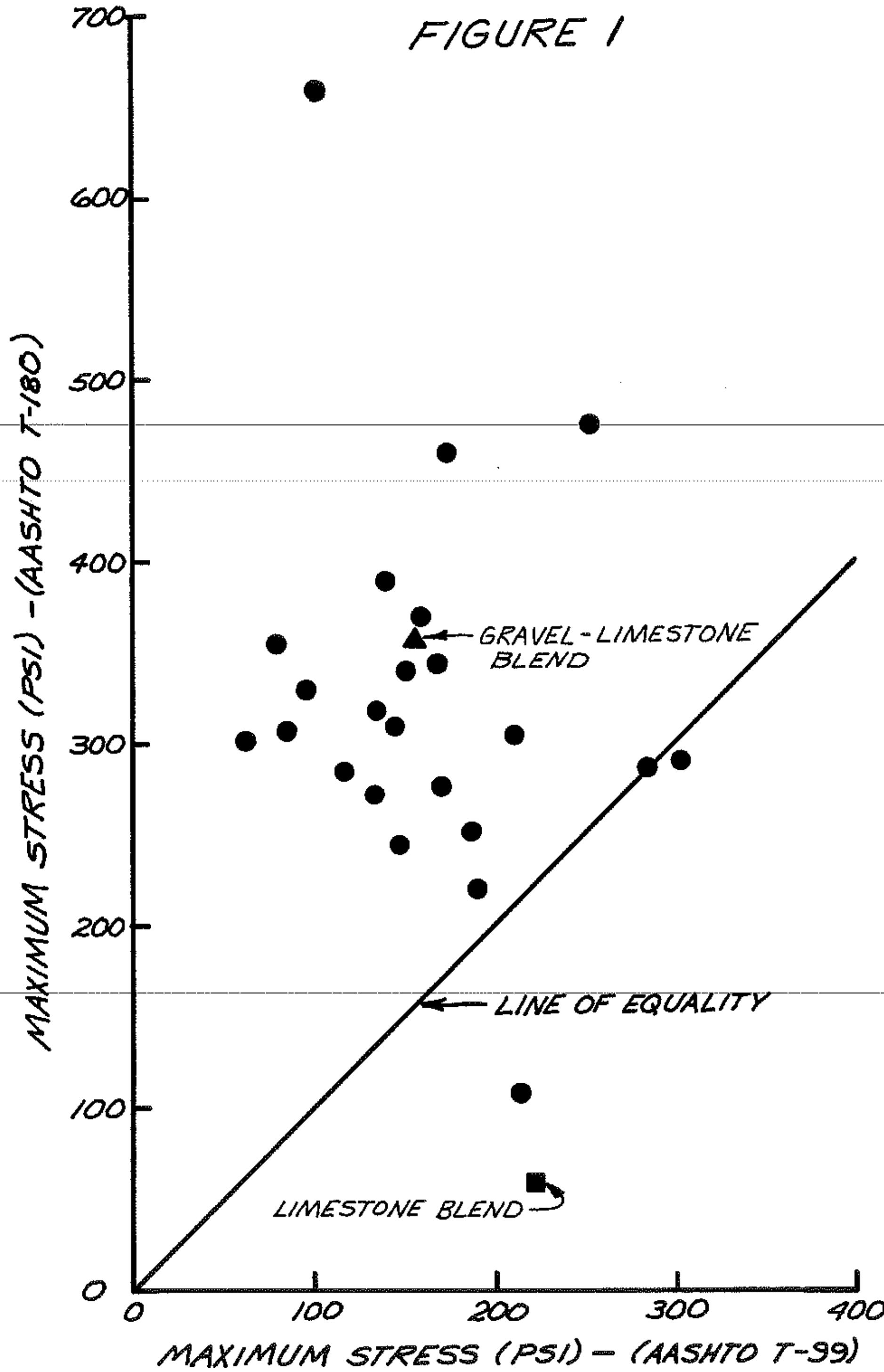
Table 2 lists average permeabilities by soruce. The Nally - Hayden (112) material yielded the most permeable specimens and the most impermeable was the Madusa Aggregate - Bardstown (41).

The four blended gravel and limestone specimens were prepared and tested in the same manner as all the other specimens. Tests on the first two specimens were aborted due to equipment malfunction. The last two tests provided stress values comparable to a medium gradation.

The specimen of blended limestones compacted with standard compactive effort yielded stress results comparable to all other specimens (222 psi). However, the specimen with modified compaction gave a stress value that appeared to be much too low (58 psi). No anomalies in the sample or data could be detected and an explanation is not offered.

It was intended to perform the triaxial test on three of the (150) series tests at degrees of saturation less than 100 percent. However, this could not be done because the permeability test must be performed on the specimen before the triaxial test, and in order to run the permeability test the sample must be 100 percent saturated.

A summary of all test data is listed in Table 3.



700
600
500
400
300
200
100
0
MAXIMUM STRESS (PSI) -(AASHTO T-180)
GRAVEL-LIMESTONE BLEND
LINE OF EQUALITY
LIMESTONE BLEND
0
100
200
300
400
MAXIMUM STRESS (PSI) - (AASHTO T-99)

FIGURE I

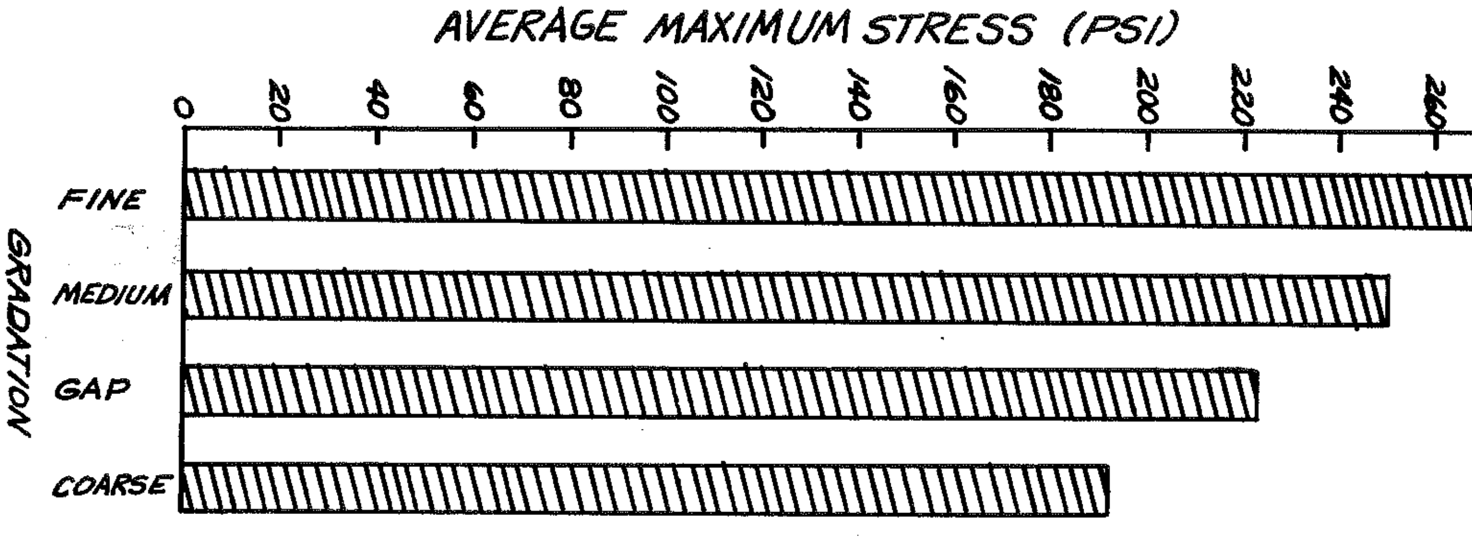


FIGURE 2

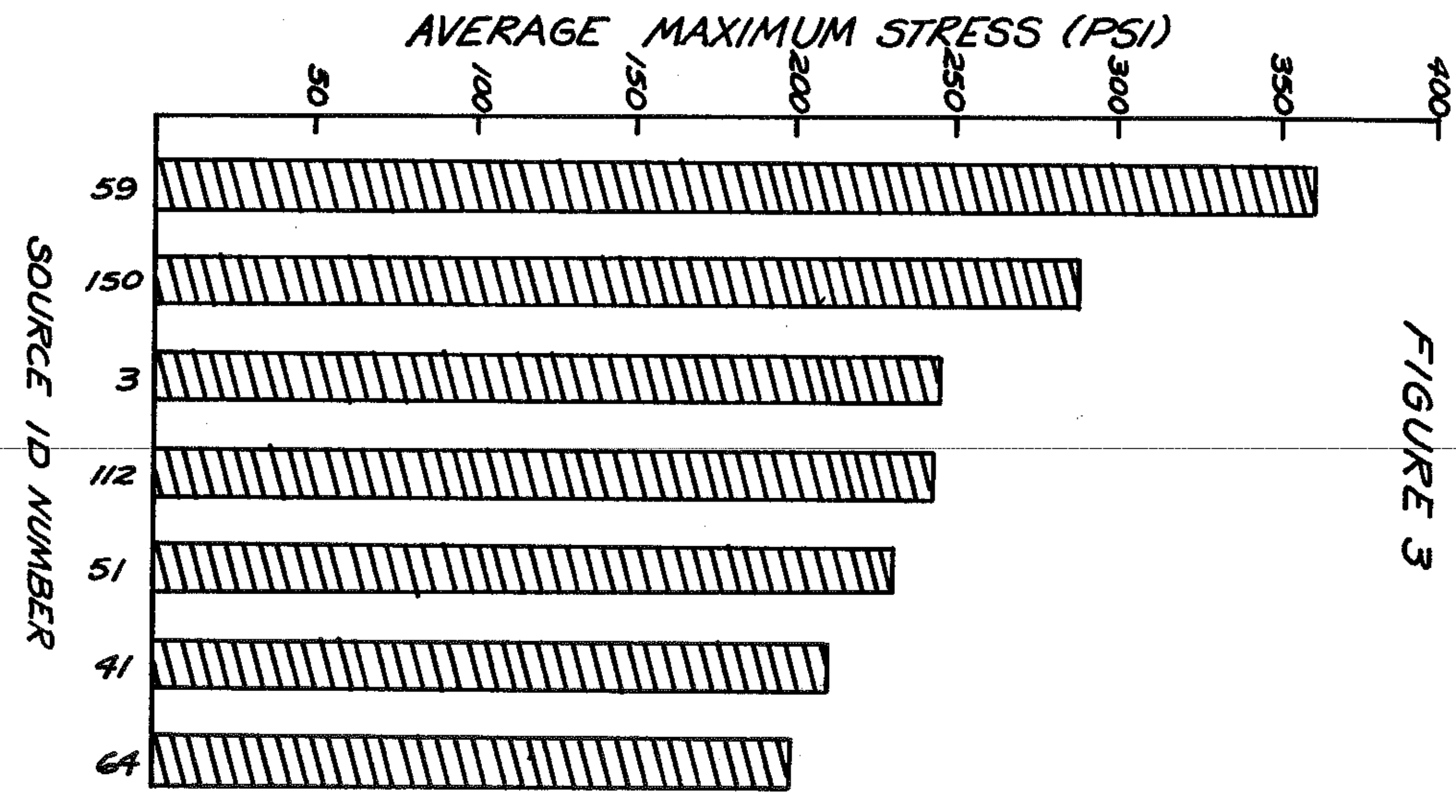


FIGURE 3

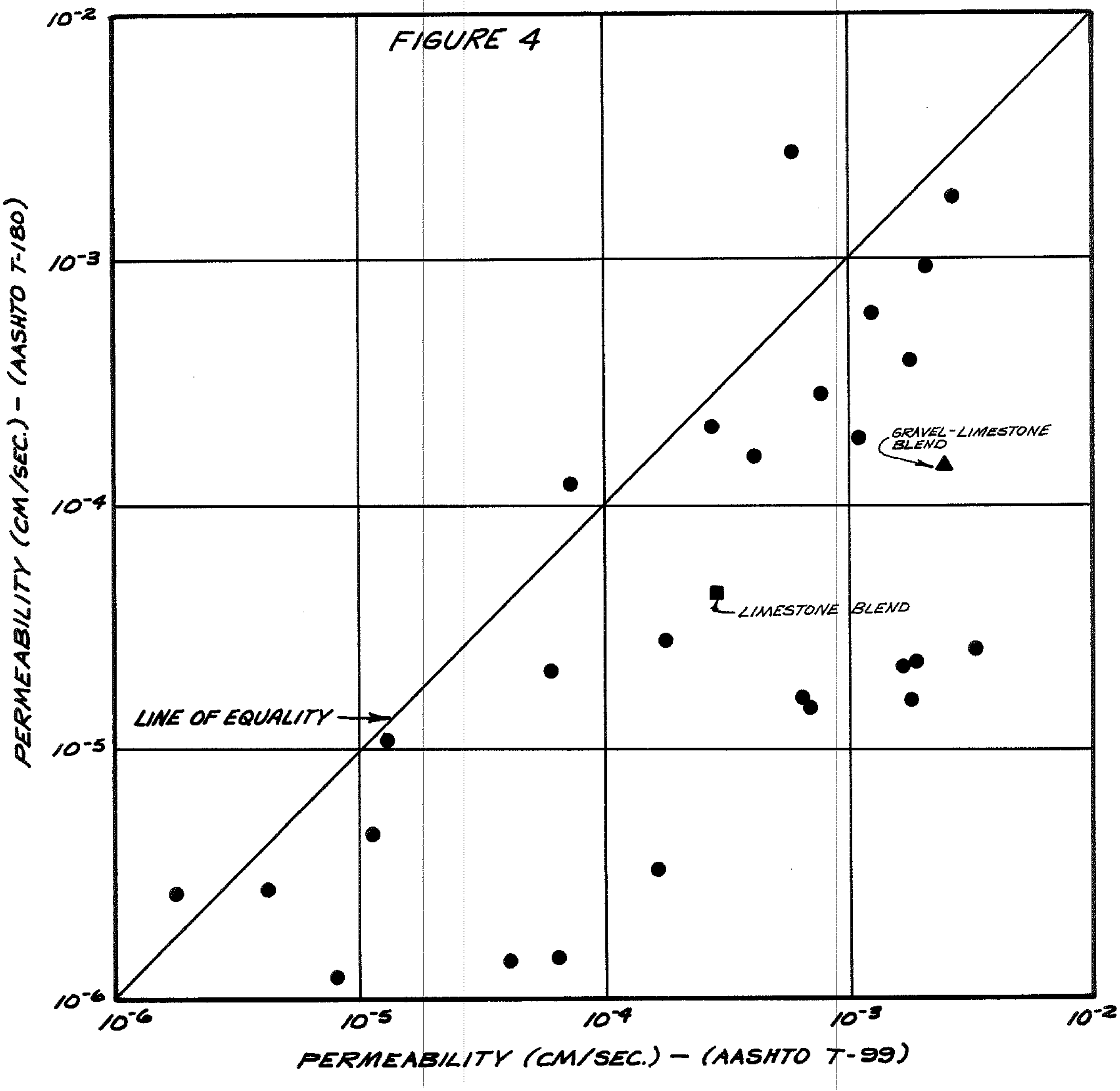


FIGURE 4
LINE OF EQUALITY
LIMESTONE BLEND
GRAVEL-LIMESTONE BLEND
PERMEABILITY (CM/SEC.) - (AASHTO T-180)
PERMEABILITY (CM/SEC.) - (AASHTO T-99)
10^{-6}
10^{-5}
10^{-4}
10^{-3}
10^{-2}

TABLE 1. AVERAGE PERMEABILITY BY GRADATION

GRADATION	PERMEABILITY (CM/SEC) STANDARD (AASHTO T-99)	MODIFIED (AASHTO T-180)
Fine	1.07×10^{-5}	4.41×10^{-6}
Medium	3.98×10^{-4}	1.48×10^{-5}
Gap	8.36×10^{-4}	5.82×10^{-4}
Coarse	1.37×10^{-3}	2.35×10^{-4}

TABLE 2. AVERAGE PERMEABILITY BY SOURCE

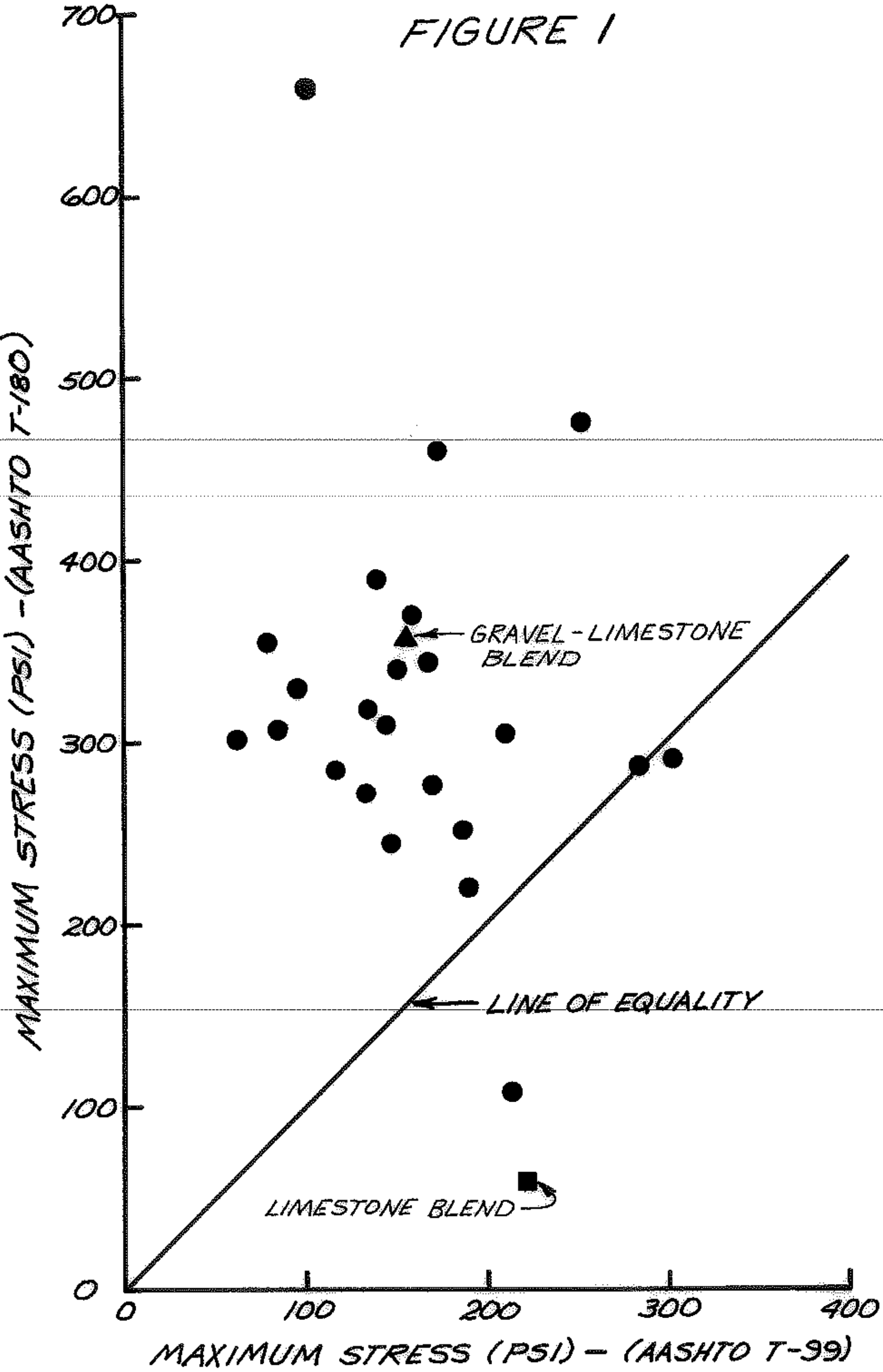
SOURCE IDENTIFICATION NUMBER	PERMEABILITY (CM/SEC) STANDARD (AASHTO T-99)	MODIFIED (AASHTO T-180)
(59)	8.64×10^{-4}	5.30×10^{-4}
(150)	9.56×10^{-4}	1.61×10^{-4}
(112)	7.84×10^{-4}	6.98×10^{-4}
(51)	7.89×10^{-4}	9.43×10^{-5}
(3)	5.76×10^{-4}	2.63×10^{-4}
(64)	9.98×10^{-4}	1.11×10^{-5}
(41)	5.35×10^{-4}	1.56×10^{-4}

TABLE 3. SUMMARY OF DATA

SOURCE	GRADATION	COMPACTION	MAXIMUM STRESS (PSI)	PERMEABILITY (CM/SEC)
59	F	T-99	312	2.19×10^{-7}
59	M	T-99	500	1.32×10^{-5}
59	C	T-99	252	7.85×10^{-4}
59	G	T-99	269	2.66×10^{-3}
59	F	T-180	-	9.30×10^{-6}
59	M	T-180	-	1.10×10^{-5}
59	C	T-180	168	2.88×10^{-4}
59	G	T-180	318	1.81×10^{-3}
150	F	T-99	173	4.10×10^{-5}
150	M	T-99	79	1.80×10^{-4}
150	C	T-99	101	1.25×10^{-3}
150	G	T-99	169	2.36×10^{-3}
150	F	T-180	465	1.39×10^{-6}
150	M	T-180	357	2.81×10^{-5}
150	C	T-180	661	5.99×10^{-4}
150	G	T-180	-	1.58×10^{-5}
112	F	T-99	304	1.11×10^{-5}
112	M	T-99	151	6.37×10^{-4}
112	C	T-99	135	1.89×10^{-3}
112	G	T-99	133	5.99×10^{-4}
112	F	T-180	291	4.57×10^{-6}
112	M	T-180	339	1.62×10^{-5}
112	C	T-180	320	2.30×10^{-5}
112	G	T-180	273	2.75×10^{-3}
51	F	T-99	285	4.17×10^{-6}
51	M	T-99	215	1.66×10^{-3}
51	C	T-99	189	1.09×10^{-3}
51	G	T-99	211	4.04×10^{-4}
51	F	T-180	286	2.72×10^{-6}
51	M	T-180	108	2.22×10^{-5}
51	C	T-180	251	1.91×10^{-4}
51	G	T-180	305	1.61×10^{-4}
3	F	T-99	152	8.73×10^{-6}
3	M	T-99	159	1.65×10^{-4}
3	C	T-99	138	7.17×10^{-5}
3	G	T-99	167	2.06×10^{-3}
3	F	T-180	-	8.98×10^{-6}
3	M	T-180	369	3.31×10^{-6}
3	C	T-180	392	1.23×10^{-4}
3	G	T-180	345	9.19×10^{-4}
64	F	T-99	170	1.73×10^{-6}
64	M	T-99	148	6.50×10^{-5}
64	C	T-99	85	3.23×10^{-3}
64	G	T-99	62	6.94×10^{-4}
64	F	T-180	277	2.65×10^{-6}
64	M	T-180	245	1.41×10^{-6}
64	C	T-180	306	2.55×10^{-5}
64	G	T-180	301	1.50×10^{-5}
41	F	T-99	188	8.17×10^{-6}

SOURCE	GRADATION	COMPACTION	MAXIMUM STRESS (PSI)	PERMEABILITY (CM/SEC)
41	C	T-99	97	1.79×10^{-3}
41	G	T-99	144	2.82×10^{-4}
41	F	T-180	218	1.25×10^{-6}
41	M	T-180	286	2.12×10^{-5}
41	C	T-180	329	3.95×10^{-4}
41	G	T-180	307	2.10×10^{-4}
33-162	-	T-99	-	-
33-162	-	T-180	-	-
33-162	-	T-99	152	2.54×10^{-3}
33-162	-	T-180	359	1.50×10^{-4}
73-162	-	T-99	222	2.94×10^{-4}
73-162	-	T-180	58	4.49×10^{-5}

FIGURE 1



700
600
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MAXIMUM STRESS (PSI) - (AASHTO T-180)
MAXIMUM STRESS (PSI) — (AASHTO T-99)
GRAVEL - LIMESTONE BLEND
LINE OF EQUALITY
LIMESTONE BLEND

FIGURE 2

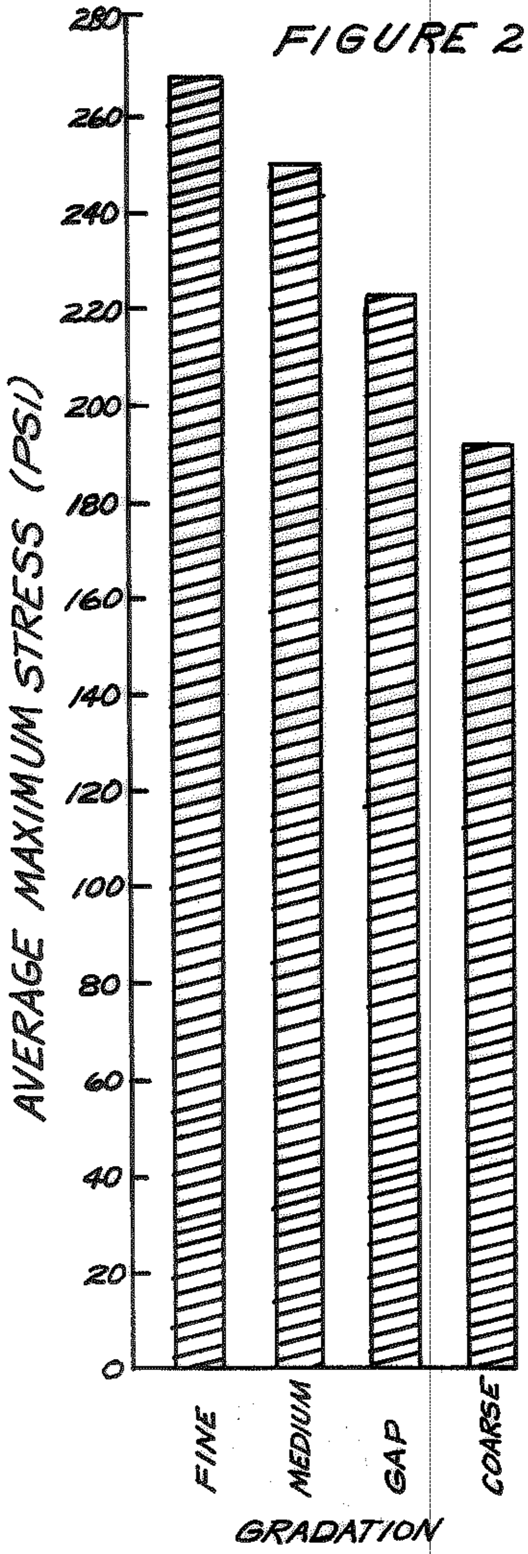
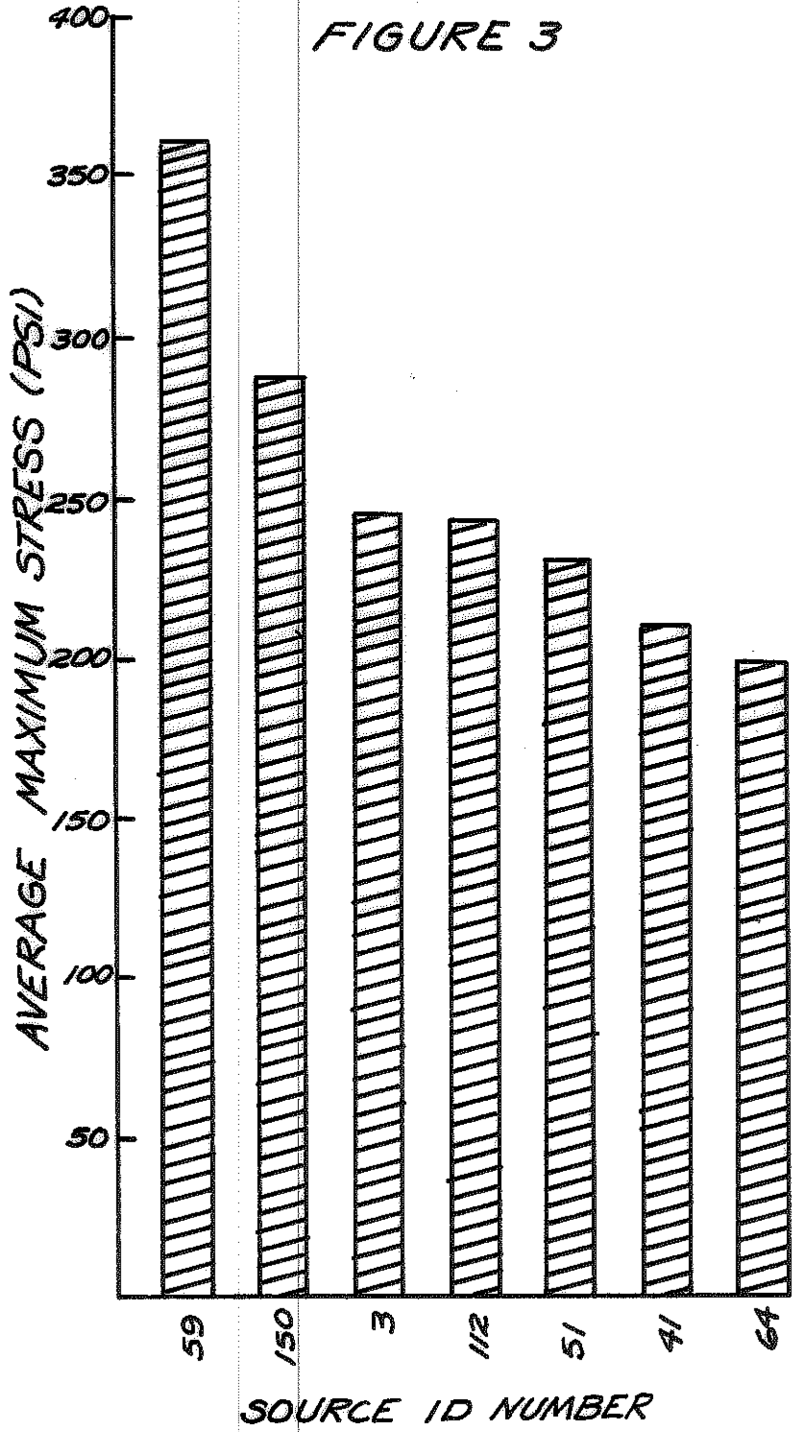
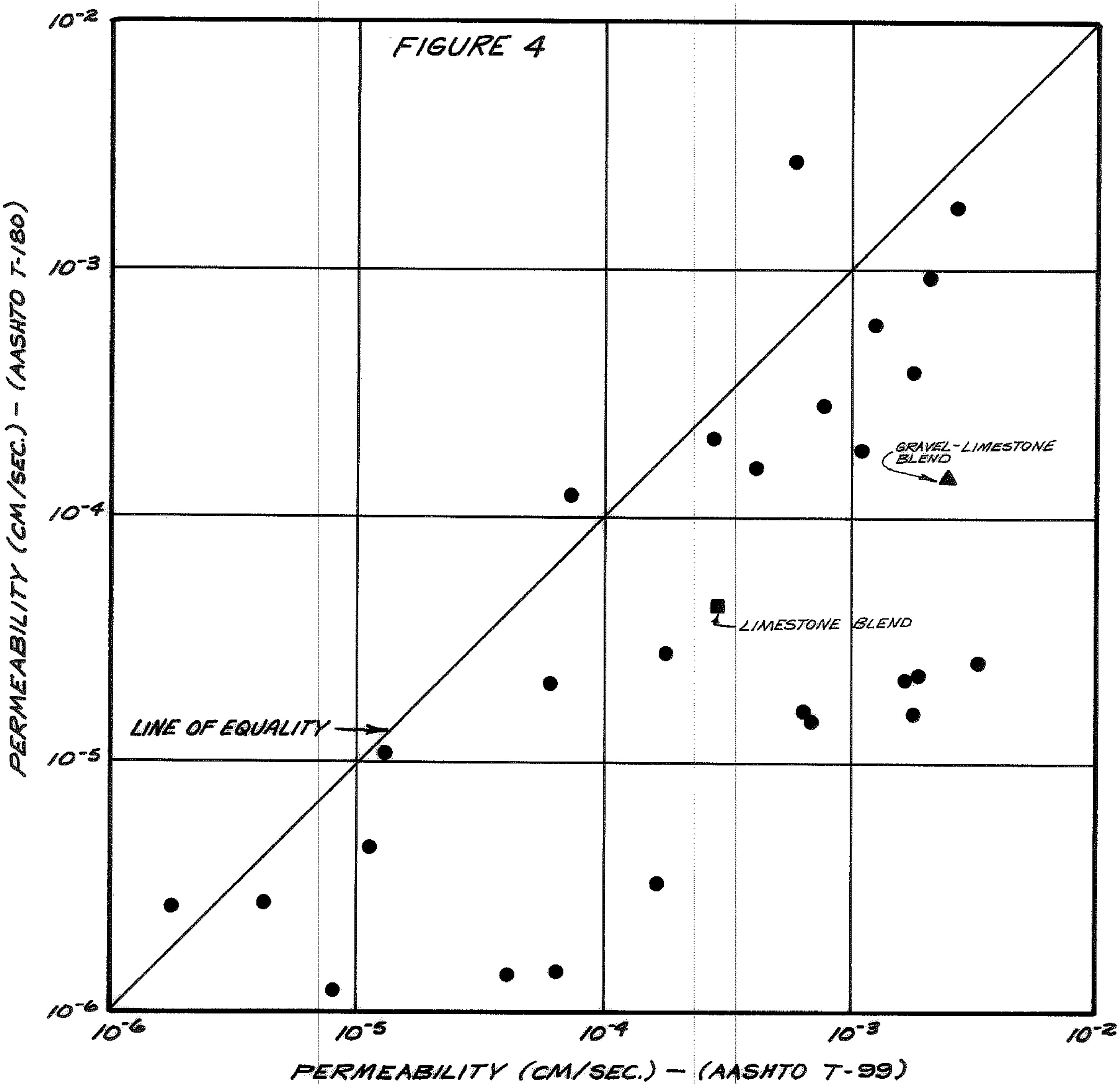


FIGURE 3





PERMEABILITY (CM/SEC.) — (AASHTO T-180)
PERMEABILITY (CM/SEC.) — (AASHTO T-99)
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
LINE OF EQUALITY
GRAVEL-LIMESTONE BLEND
LIMESTONE BLEND

FIGURE 4