PERMEABILITY OF GRANULAR SUBBASE MATERIALS

Interim Report
for
Project MLR-90-4

September 1991

Project Development Division

Iowa Department of Transportation

Interim Report
for
MLR-90-4

Permeability of Granular Subbase Materials

by

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Incorrect Project Information

IR-80-8(110)284--12-8	Should Be	IR-80-8(110)284--12-82
IR-80-5(130)143--12-7	Should Be	IR-80-5(130)143--12-77
IR-80-6(136)193--12-7	Should Be	IR-80-6(136)193--12-79
F-169-6(31)--20-94	Should Be	FN-169-6(28)--21-94
F-520-3(11)--20-94	Should Be	F-520-3(6)--20-94

Can't Find These Project Locations

IR-280-8(98)303--12-8	Could Be	IR-280-9(98)303--12-82
IN-35-6(60)159--15-35		
FM-60(25)--55-60		
BRF-10-4(2)38-11		

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8. ABSTRACT

The purpose of this research was to evaluate the materials Iowa uses as a granular subbase and to determine if it provides adequate drainage.

Numerous laboratory and in-situ tests were conducted on the materials currently being used in Iowa. The following conclusions can be made based on the test results:

1. The crushed concrete that is used as a subbase material has a relatively low permeability compared to many other materials used by other states.

2. Further research and tests are needed to find the necessary parameters for crushed concrete to make sure it is providing its optimum drainage and preventing premature damage of the pavement.

3. We have definitely made improvements in drainage in the past few months, but there are many areas that we can improve on that will increase the permeability of this material and insure that the pavement system is safe from premature damage due to water.

The current gradation specification for granular subbase material at the start of this study was:

Sieve #	% Passing
1"	100
#8	10-35
#50	0-15
#200	0-6

9. KEY WORDS

Permeable base
Granular subbase
Drainage
Drainable bases

10. NO. OF PAGES

71

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I would like to personally thank all of the people who made this research possible. The nature of this research and testing involved coordination and cooperation between many different offices and people.

First, I would like to thank my boss, Champ Narotam, for giving me the opportunity to take over this project and having the confidence in me to get the job done. Also, Kumari Bharil did an excellent job of recording all the results of the work she did before I took over the project.

Wayne Strum was extremely helpful and cooperative in fitting in my requests for tests during the busiest part of the year. Cliff Dalbey was very helpful in obtaining all of the necessary equipment needed to run the field tests.

Reilly Construction deserves recognition for their cooperation in making various changes throughout the project. All of the construction people at the various sites I visited are too numerous to mention by name, but were nonetheless instrumental in helping obtain samples and answering questions about the projects.

Bob Steffes was extremely helpful in conducting tests and making the long trips to projects.

A very special thanks goes to Dan Mathis from the Federal Highway Administration for all of his assistance in this research: from answering the numerous questions and supplying technical information to getting the New Jersey Falling Head Permeameter (NJFHP) for our use.

INTRODUCTION

The importance of providing excellent drainage for a pavement system to prevent premature failure has been recognized for many years.

However, recently there have been questions whether or not the material that Iowa uses for a granular subbase material is providing the proper drainage needed to prevent premature breakdown of the road.

There are three very important ideas to keep in mind when discussing permeability.

The first is to recognize that there is not a national value required for permeability and that there are not any long-term studies that supports spending a large amount of money to obtain a very high coefficient of permeability (>2000-5000 ft/day). The "value" that most states have adopted for a target permeability is around 1000 ft/day.

The second is that there is no standard method for measuring the permeability of a granular subbase material in the lab or the field.

The last thing to keep in mind is that the crushed concrete that Iowa uses is very different from the materials many other states use and the properties and behavior of this material are also very different.

These facts are important when discussing permeability because it is difficult to compare permeabilities and properties of materials when different test methods and materials are being used.

PREVIOUS TESTING

Kumari Bharil started this research and conducted many laboratory tests on various materials that Iowa uses for a granular subbase. The lab tests were conducted on a permeameter that was built to ASTM specifications for determining the permeability of materials that had low permeabilities, like soils. The permeability results from those tests and the different gradations are shown in Appendix A, pages 22 and 23.

The results of these tests would indicate that the materials being used in Iowa provide a range of permeabilities that is quite acceptable.

However, there are a few questions regarding the validity of these results. First, the permeameter designed was for low permeable materials like soils, not granular subbase materials. There may have been some other factors that caused the high values for permeability.

The reason for questioning the results are that tests performed by the Federal Highway Administration with a NJFHP indicated that the permeability of the crushed concrete in Iowa is significantly lower than the lab results showed. Also, tests conducted by the FHWA on materials from other states showed that Iowa was on the lower end in permeability.

It is important to keep in mind that permeability is a relative measurement and comparing the permeabilities of different materials and different test methods is not possible. There were no lab tests conducted with materials from other states to compare how Iowa's material compared to them.

FIELD TESTS

After the laboratory test results were analyzed and there was a question with the validity of the results, we decided to conduct in-situ permeability tests to determine how well the material was draining.

Since there was no standard procedure for measuring the in-situ permeability of a granular subbase material, a procedure was developed to obtain a relative idea of the permeability of the material.

This simple procedure consisted of coring out approximately a 4" diameter hole to a depth of 4"-5", filling the hole with 1 liter of water, and timing how long it took to drain from the hole.

We conducted in-situ tests on projects across the state that used crushed concrete and crushed stone for a granular subbase material. The results of these tests are in Appendix B, pages 29-36. The results from the field tests indicate that the virgin crushed stone material is providing adequate drainage, while the crushed concrete is not draining as well as anticipated.

CEDAR COUNTY PROJECT

We had an excellent opportunity to gather information about permeability on a project on I-80 in Cedar County near Tipton.

An agreement was made with the contractor to make changes in the gradation of the granular subbase material and to evaluate the effects on permeability. The letter and details of the project are in Appendix C, pages 38-43.

The agreement called for the contractor to construct the first one mile section of subbase to the regular Iowa specification of 100% passing the 1" sieve and 10%-35% passing the #8 sieve. The second mile section would involve changing the gradation so that 100% was passing the 1.5" sieve and 25% maximum passing the #8 sieve. Tests were to be conducted to determine the effects of this gradation change on permeability.

After the first section was completed, field tests were conducted and showed that the material was draining very poorly, if at all.

Field tests were conducted on the second mile section and showed a slight increase in permeability, but it was still relatively low.

We received a NJFHP from the FHWA, which significantly helped us to compare the permeability of the different materials. The NJFHP provided us with a quick and consistent way to compare the permeability and make a decision about the gradation for the rest of the project. The lab tests also indicated a slight improvement in permeability with the 1.5" material, but it was still in a range that was unacceptable.

There were also some other problems that we ran into on this project that caused the permeability of the material to be low. We noticed that the material seemed to break down quite significantly at the grade. We conducted gradation tests at the plant and from the field and found that there was a very severe breakdown in the crushed concrete. We attributed the breakdown to handling and over-compacting of the material. The differences in gradation are shown on pages 13-14.

There was also a severe problem with stockpile segregation. The segregation was noticeable just by looking at the stockpile. The results of field tests on pages 28-36 show how much the permeability varied in the same area due to segregation.

In an attempt to prevent breakdown of material and increase permeability, we called for a maximum number of 4 compaction passes with a steel-drummed roller.

Another problem encountered on this project was that the contractor was picking up the old existing subbase material in the removal of the pavement for crushing. This old material was very poor in quality and added fines to the subbase which reduced the permeability.

We made another change in the gradation that should improve the permeability. The change calls for a maximum of 20% passing the #8 sieve. This material is being produced and used on the project. Gradation results of this new material are on page 68. The reports show that the % passing the #8 sieve is around 17-20%. This new gradation is being produced by bleeding off about 12% of the fine material after crushing.

This project will be able to provide us with valuable information over time because of the various materials that were used.

CHANGES TO CORRECT PROBLEMS

We have taken steps to improve the permeability of the crushed concrete that is being used as a granular subbase. The gradation specification for crushed concrete has been changed and will go into effect for the November 1991 letting of contracts. The new specification will have 100% passing the 1.5" sieve and a maximum of 20% passing the #8 sieve. This change in gradation will remove some of the fines and open up the material to allow it to drain better.

From the results of the NJFHP, a relation between density and permeability was developed. The graph and results are on pages 15, 16 and 18. These results clearly show that the crushed concrete will provide adequate drainage if the density remains below 115 pounds per cubic feet (pcf).

In order to increase permeability we are looking at changing the compaction requirements and density of the material. The Construction Office is monitoring changes in the number of passes on the Cedar County project and trying to determine a minimum number of passes that will provide adequate stability.

The problem encountered with stockpile segregation is being corrected by monitoring the gradation from the belt before the stockpile and after it leaves the stockpile to insure there isn't any significant differences in gradation.

The construction inspectors are closely monitoring the removal of the existing pavement to make sure the contractor is not picking up the old existing subbase material that would lower the permeability.

RECOMMENDATIONS

Although we have made changes that improve the permeability of the crushed concrete, there is still some additional work that needs to be done. The following are my recommendations for the rest of this research:

1. Determine the compaction requirements that keep the subbase stable and at a density that provides good permeability.

2. Conduct lab tests with the NJFHP and the ASTM device and see how the results compare for similar materials. Hopefully, tests will show a correlation between the two methods and field tests. The NJFHP is a quick and easy device to determine permeability and if it can be proven that it provides valid results and a correlation with the ASTM device, we should look into buying or making these

permeameters and making them available to the districts to use to evaluate the permeability of the materials being used on various projects.

3. We should try an asphalt-cement treated or portland-cement treated stabilized subbase test section in the near future to get some experience with this type of procedure and to see how this section performs compared to a non-stabilized section over the years with traffic.

4. Iowa needs to work with other states that are also working on permeability research to exchange ideas and information. At the very least, this will help to avoid repeating research that has already been done. Also, the states need to work with the FWHA to establish a standard method for permeability testing for both the lab and field. As it stands now, different states use different methods, so any comparison in permeability values is not really possible.

5. We should try to obtain the FHWA in-situ permeameter to conduct tests next summer. This may help to develop a quick procedure to determine the in-situ permeability of material.

6. We have obtained samples of aggregate that exhibit a plasticity index (PI) greater than 5. Tests should be done to see the effects of PI on permeability.

7. The crushed concrete sets up and becomes very hard after being in place. Cores should be taken down through the subbase and tested to see if the hardened crushed concrete still drains after it sets up.

SUMMARY

There has been many recent changes to improve the permeability of the material used as a granular subbase. We are on the right track for improving the pavement system and need to keep making improvements. Additional tests are needed to finish this research project. Most of the testing should be completed this winter and some additional test conducted next summer.

TABLE TITLES

1. Gradations From I-80 Cedar County - 1" Crushed Concrete
2. Gradations From I-80 Cedar County - 1.5" Crushed Concrete
3. New Jersey Falling Head Permeameter (NJFHP) Results
4. New Jersey Falling Head Permeameter Results 1.5" Crushed Concrete-Scalped, Cedar County, I-80

TABLE 1

GRADATIONS FROM I-80 CEDAR COUNTY
1" CRUSHED CONCRETE

STOCKPILE

1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
100	84	70	56	37	26	19	13	8.0	5.3	4.0
100	90	79	56	37	26	19	13	8.0	5.3	4.0
100	91	79	65	45	34	24	16	8.5	4.9	3.1
99	91	81	70	50	36	27	18	9.6	5.7	3.7
100	87	73	61	43	31	23	15	7.5	4.0	2.2
100	88	73	61	41	30	22	15	8.0	4.8	3.2

IN-PLACE

1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
100	87	69	52	35	25	18	13	8.2	5.6	4.2
100	94	83	72	50	35	26	18	11	8.0	5.9
100	94	81	66	46	35	27	19	12	8.4	6.2
100	89	80	71	52	39	30	22	13	8.9	6.6
100	89	79	67	47	34	26	19	12	8.5	6.4
99	94	84	71	50	37	28	21	13	9.4	7.2
100	95	85	73	54	42	32	24	15	11	8.4

SPEC	#8: 10-35	#50: 0-15	#200: 0-6

TABLE 2

GRADATIONS FROM I–80 CEDAR COUNTY

1.5" CRUSHED CONCRETE

STOCKPILE

1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
100	88	72	54	43	29	22	17	13	9.2	6.9	5.5

IN–PLACE

1.5"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
100	94	82	71	59	41	30	23	17	12	9.0	7.0
100	96	90	83	76	64	48	36	27	18	13	10
100	94	88	77	65	47	36	27	21	14	10	8.2

SPEC											
						10–25			0–15		0–6

TABLE 3

NEW JERSEY FALLING HEAD PERMEAMETER RESULTS

1.5" CRUSHED CONCRETE – SCALPED
CEDAR COUNTY I–80

TRIAL	DENSITY (pcf)	PERMEABILITY (K, ft/day)	MATERIAL
1	95.34	1771.41	1.5"
2	97.81	1761.58	1.5"
3	98.60	1352.05	1.5"
4	101.14	358.99	1.5"
5	108.42	136.82	1.5"
6	108.51	723.90	1.5"
7	109.29	440.53	1.5"
8	111.43	246.47	1.5"
9	111.67	104.00	1.5"
10	112.32	146.79	1.5"
11	112.55	84.31	1.5"
12	123.43	11.93	1.5"

TABLE 4

NEW JERSEY FALLING HEAD PERMEAMETER RESULTS

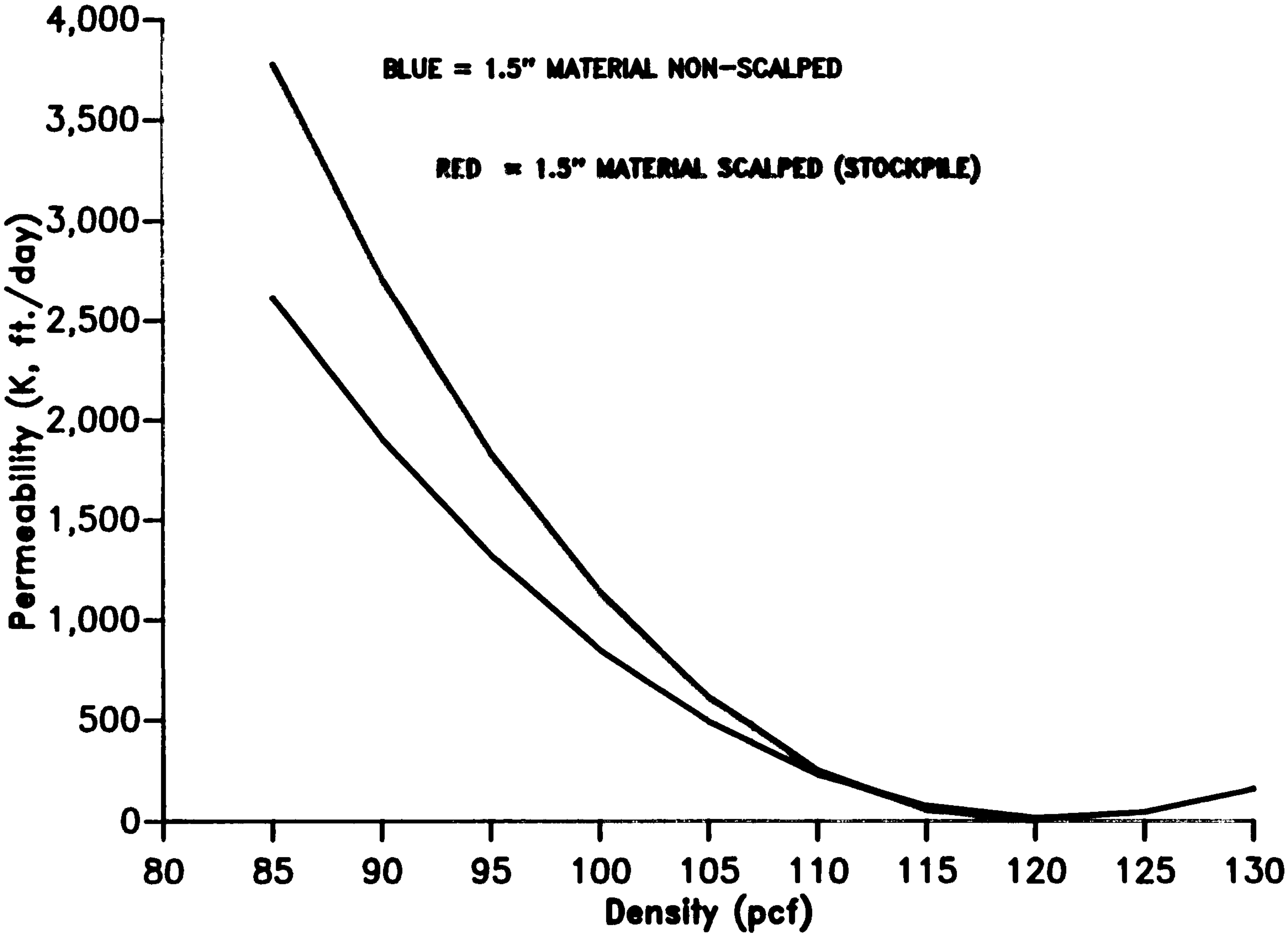
TRIAL	DENSITY (pcf)	PERMEABILITY (K, ft/day)	MATERIAL
1	96	67	1"
2	98	439	1"
3	115	58	1"
4	87	2288	1.5"
5	91	1905	1.5"
6	93	1532	1.5"
7	100	694	1.5"
8	106	443	1.5"
9	111	101	1.5"
10	119	181	1.5"
11	120	43	1.5"
12	121	64	1.5"
13	129	21	1.5"

FIGURE CAPTIONS

1. Permeability Results

FIGURE 1

Permeability Results



APPENDICES

APPENDIX A

Lab Permeability Results and Gradations

PERMEABILITY AND GRADATIONS

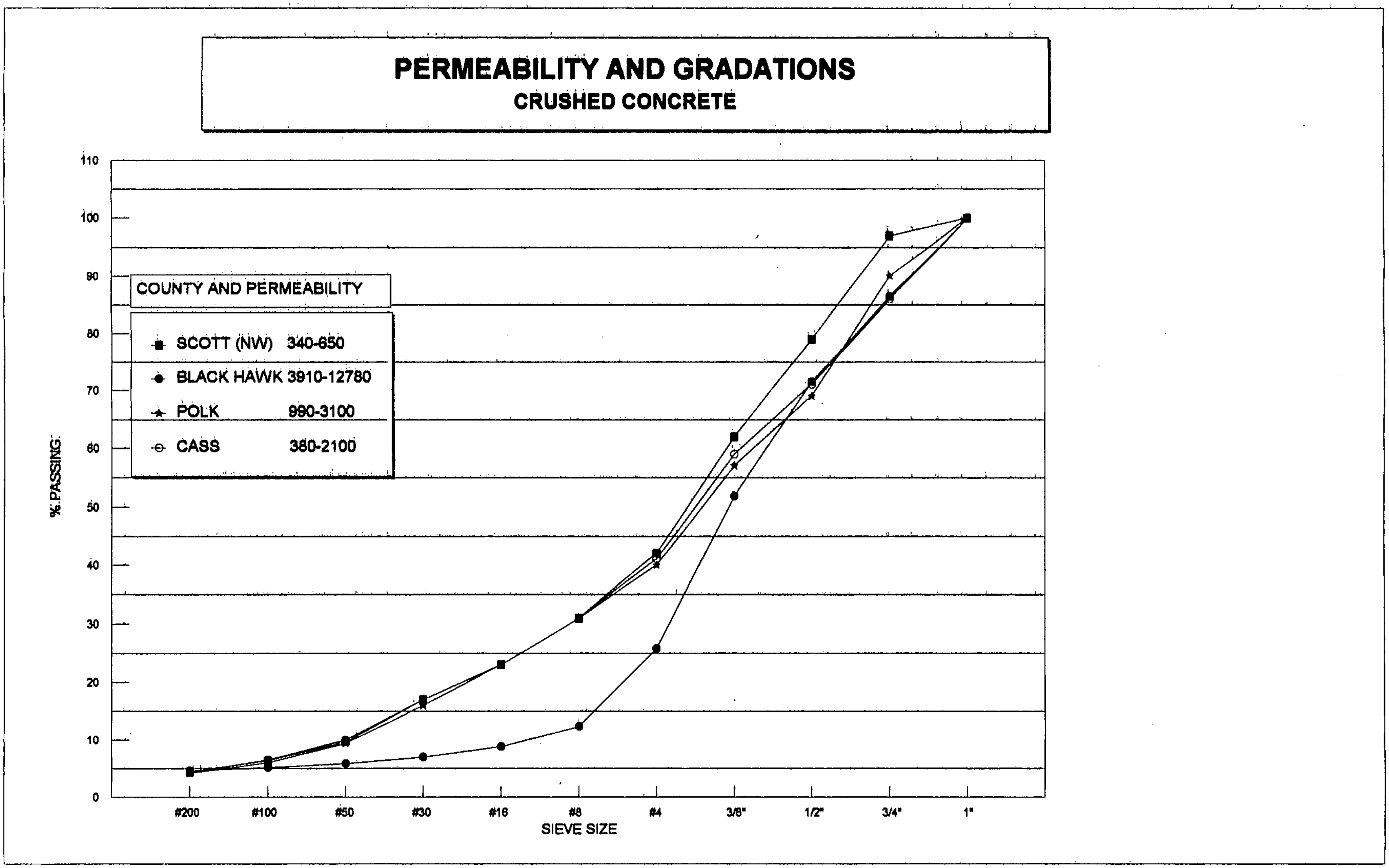
	SCOTT (LC)	POWESHEIK	DUBUQUE	HAMILTON	LYON (33)
	7000-7720	770-1170	8490-18760	11500-36900	22000-26000
SIEVE #	PERCENT PASSING				
1"	100	100	100	100	100
3/4"	100	82	90	88	100
1/2"	100	59	68	64	65
3/8"	97	43	48	47	35
#4	55	30	25	22	20
#8	26	23	14	14	14
#16	12	18	9.5	12	11
#30	6.8	14	7.9	10	8.9
#50	4.5	9.3	7	8.9	6.3
#100	3.1	6.7	5.8	6.9	4.3
#200	1.9	5	3.6	4.8	3.3

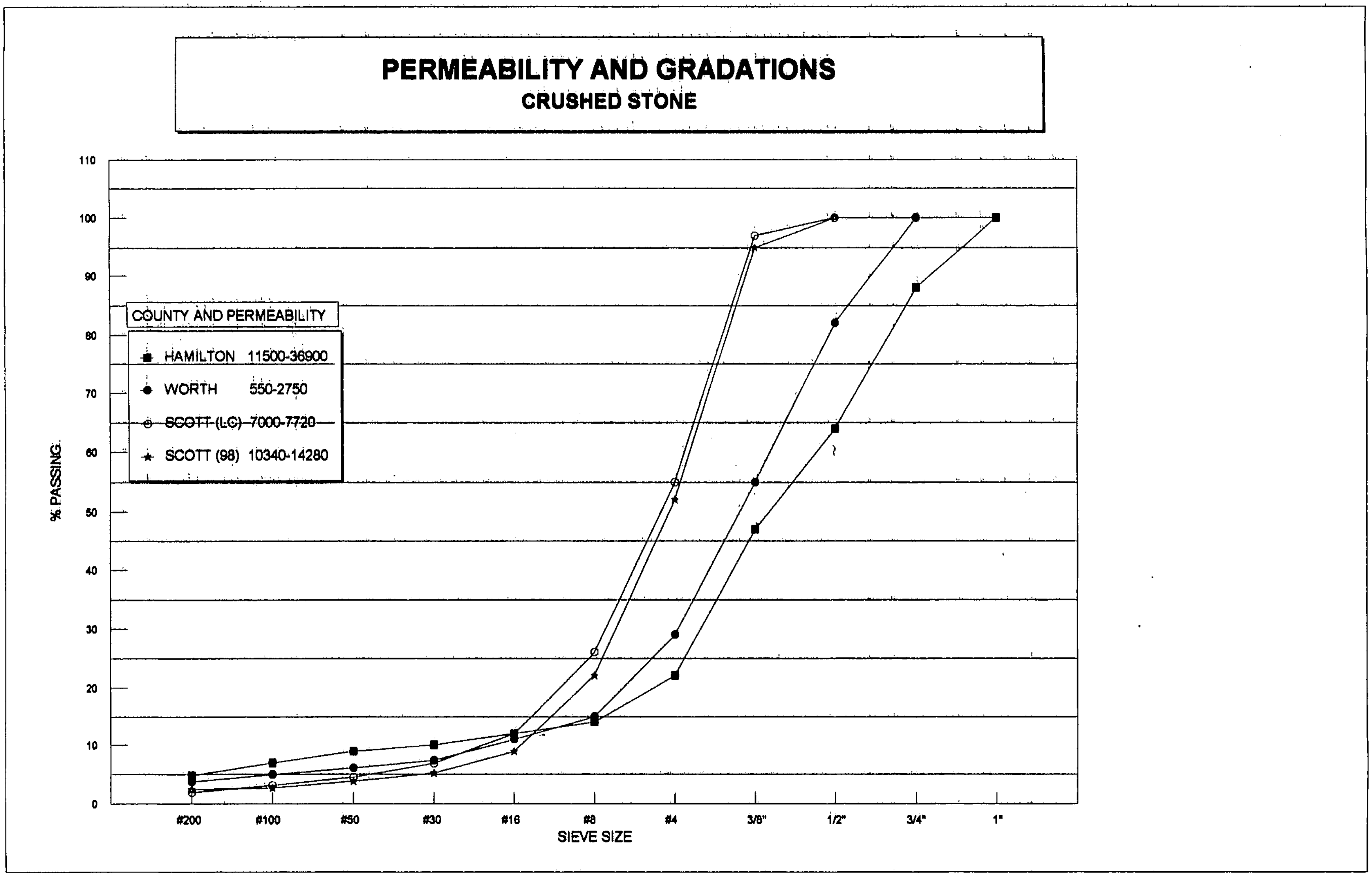
	WEBSTER (23)	BUENA VISTA	WORTH	SCOTT (NW)	CASS
	9000-26000	>40000	550-2750	340-650	380-2100
SIEVE #	PERCENT PASSING				
1"	100	100	100	100	100
3/4"	91	100	100	97	86
1/2"	68	100	82	79	71
3/8"	49	96	55	62	59
#4	20	49	29	42	41
#8	13	16.2	15	31	31
#16	11	6	11	23	23
#30	9.1	3.2	7.3	17	17
#50	8	1.7	6.1	9.7	10
#100	5.6	1.4	4.9	6.3	6.4
#200	4.2	1.2	3.7	4.4	4.3

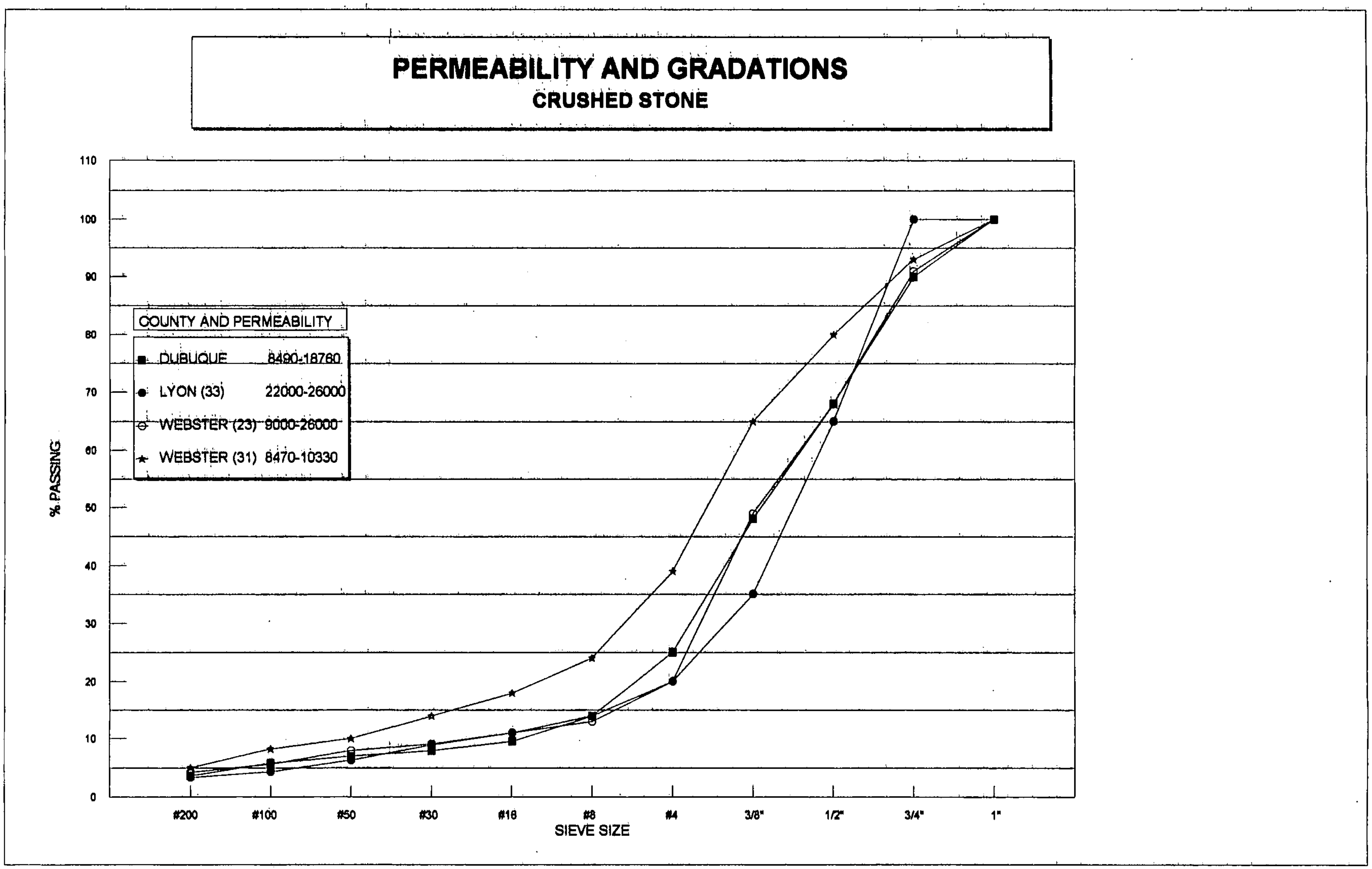
	BLACK HAWK 3910-12780	SCOTT (98) 10340-14280	POLK 990-3100	LYON (25) 200-275	WEBSTER (31) 8470-10330
SIEVE #			PERCENT PASSING		
1"	100	100	100	100	100
3/4"	86.4	100	90	100	93
1/2"	71.5	100	69	96	80
3/8"	51.8	95	57	84	65
#4	25.8	52	40	65	39
#8	12.4	22	31	48	24
#16	8.8	8.9	23	35	18
#30	6.9	5.2	16	22	14
#50	5.8	3.8	9.4	8.4	10
#100	5.1	2.7	6	4.2	8.2
#200	4.5	2.4	4.1	3.5	5

PERMEABILITY OF GRANULAR SUBBASE (MLR-90-4)

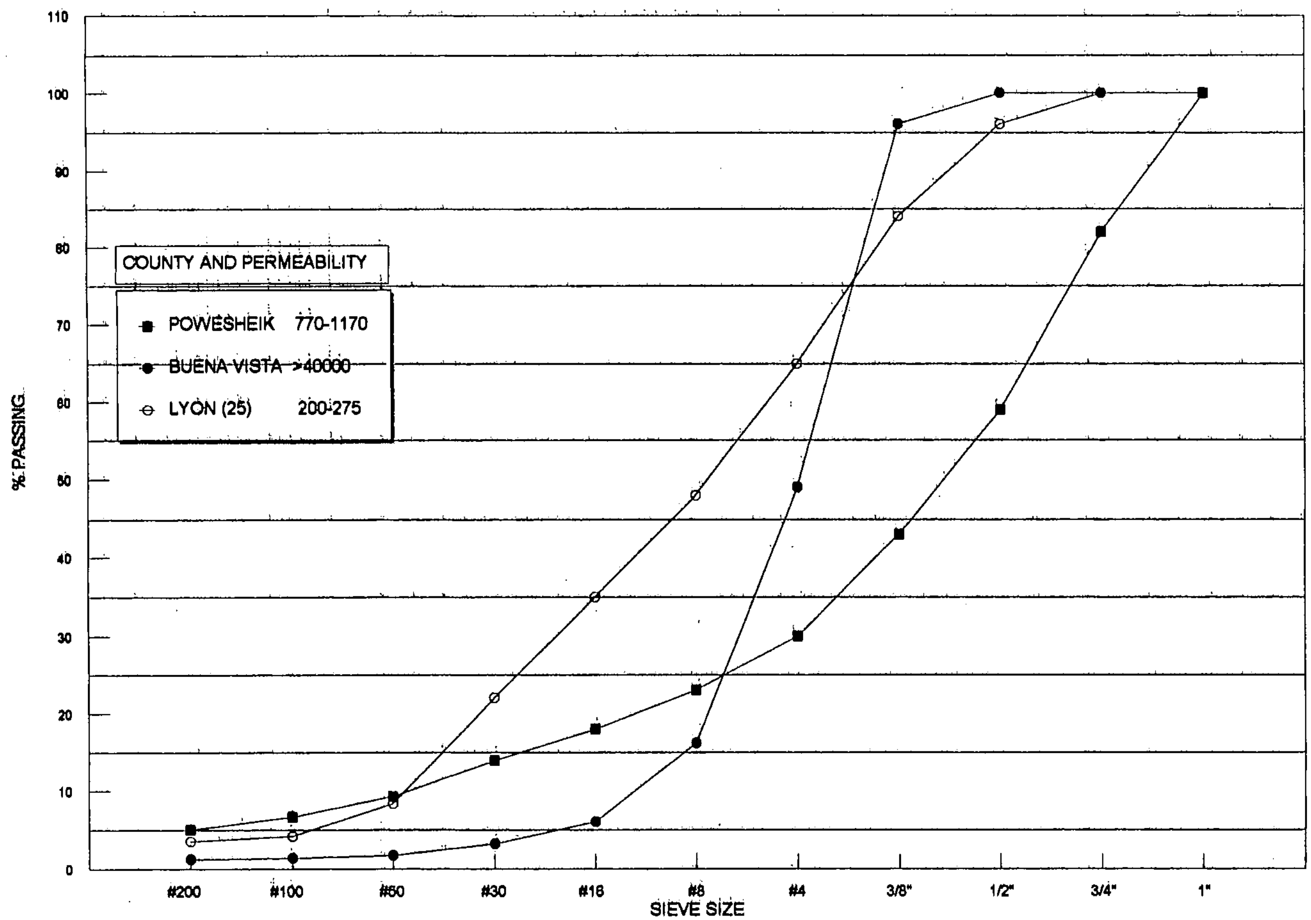
PROJECT NUMBER	DISTRICT	COUNTY	COEFFICIENT OF PERMEABILITY	PLASTICITY INDEX	MODIFIED DENSITY	CONSTANT HEAD	MATERIAL
IR-80-1(174)40-12-15	4	CASS	380-2100	NON-PLASTIC	112 @ 12%	1"-2"	CRUSHED CONCRETE
IR-80-8(110)284-12-8	6	SCOTT(NW)	340-650	NON-PLASTIC	126 @ 11%	1"-1.25"	CRUSHED CONCRETE
IR-80-5(130)143-12-7	1	POLK	990-3100	NON-PLASTIC	124.3 @ 11%	.5"-.75"	CRUSHED CONCRETE
IX-218-7(78)-3P-07	2	BLACK HAWK	3910-12780	NON-PLASTIC	131.4 @ 7%	1"-1.5"	CRUSHED CONCRETE
IR-80-8(110)284-12-8	6	SCOTT(LC)	7000-7720	NON-PLASTIC	125 @ 8%	.75"-1.5"	CRUSHED STONE
IR-280-8(98)303-12-8	6	SCOTT (98)	10340-14280	NON-PLASTIC	127 @8%	1.25"-1.5"	CRUSHED STONE
F-61-8(40)-20-31	6	DUBUQUE	8490-18760	NON-PLASTIC	136.8 @ 7%	.5"-1"	CRUSHED STONE
FN-9-1(33)-21-60	3	LYON (33)	22000-26000	NON-PLASTIC	133.6 @ 6%	.75"-1.5"	CRUSHED STONE
F-169-6(31)-20-94	1	WEBSTER (31)	8470-10330	NON-PLASTIC	139.9 @ 8%	.5"-2"	CRUSHED STONE
RP-520-4(26)-16-40	1	HAMILTON	11500-36900	NON-PLASTIC	137.2 @ 8%	1.5"-1.75"	CRUSHED STONE
IN-35-6(60)159-15-35	2	WORTH	550-2750	NON-PLASTIC	133 @ 8%	2"-3"	CRUSHED STONE
F-520-3(11)-20-94	1	WEBSTER (23)	9000-26000	NON-PLASTIC	136 @ 8%	.75"-1"	CRUSHED STONE
FM-60(25)-55-60	3	LYON (25)	200-275	NON-PLASTIC	136.5 @ 8%	2"-2.5"	GRAVEL
BRF-10-4(2)38-11	3	BUENA VISTA	>40000	NON-PLASTIC	129 @ 11%		GRAVEL
IR-80-6(136)193-12-7	1	POWESHEIK	770-1170	NON-PLASTIC	120 @ 12.5%	.5"-3"	GRAVEL (PEA)


PERMEABILITY AND GRADATIONS
CRUSHED CONCRETE
COUNTY AND PERMEABILITY
SCOTT (NW) 340-650
BLACK HAWK 3910-12780
POLK 990-3100
CASS 380-2100
% PASSING
110
100
90
80
70
60
50
40
30
20
10
0
#200
#100
#50
#30
#16
#8
#4
3/8"
1/2"
3/4"
1"
SIEVE SIZE


PERMEABILITY AND GRADATIONS
CRUSHED STONE
COUNTY AND PERMEABILITY
HAMILTON 11500-36900
WORTH 550-2750
SCOTT (LC) 7000-7720
SCOTT (98) 10340-14280
% PASSING
0
10
20
30
40
50
60
70
80
90
100
110
#200
#100
#50
#30
#16
#8
#4
3/8"
1/2"
3/4"
1"
SIEVE SIZE


PERMEABILITY AND GRADATIONS
CRUSHED STONE
COUNTY AND PERMEABILITY
DUBUQUE 8490-18760
LYON (33) 22000-26000
WEBSTER (23) 9000-26000
WEBSTER (31) 8470-10330
% PASSING
0
10
20
30
40
50
60
70
80
90
100
110
#200
#100
#50
#30
#16
#8
#4
3/8"
1/2"
3/4"
1"
SIEVE SIZE

PERMEABILITY AND GRADATIONS
GRAVEL



Appendix B

In-situ Test Results

IN-SITU PERMEABILITY RESULTS

DATE TESTED: JULY 2, 1991
PROJECT: I-80
TYPE OF SUBBASE MATERIAL: CRUSHED CONCRETE
LOCATION: POTTAWATAMIE

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	44 ***
2	38 ***

AVERAGE K 41

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: JULY 2, 1991
PROJECT: I-80
TYPE OF SUBBASE MATERIAL: CRUSHED CONCRETE
LOCATION: CASS CO

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	198
2	35 ***
3	58 ***
4	0 ***
5	58 ***
AVERAGE K	70

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: JULY 3, 1991
PROJECT: I-520
TYPE OF SUBBASE MATERIAL: CRUSHED STONE
LOCATION: HARDIN CO.

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	58 ***
2	35 ***
3	311
4	32 ***
5	1720
6	1400
7	25 ***
8	622
9	439

AVERAGE K 516

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: JULY 10, 1991
PROJECT: I-80
TYPE OF SUBBASE MATERIAL: CRUSHED CONCRTE
LOCATION: POWESHEIK CO.

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	38 ***
2	58 ***
3	58 ***
4	50 ***
5	9 ***
6	50 ***
7	500
8	280
9	170
10	86
11	115
12	58 ***
13	184
14	109

AVERAGE K 126

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: JULY 17, 1991

PROJECT: I-380 (BRIDGE APPROACHES)

TYPE OF SUBBASE MATERIAL: CRUSHED STONE

LOCATION: JOHNSON CO.

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	1023
2	789
3	177
4	90 ***
5	1589
6	1942
7	320
8	219
9	589
10	533
11	492
12	376
13	23 ***
14	2056
15	1344
16	276
17	184
18	3880
19	3177

AVERAGE K 1004

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: AUG 1, 1991
PROJECT: I-80
TYPE OF SUBBASE MATERIAL: CRUSHED CONCRTE 1" MATERIAL
LOCATION: CEDAR CO.

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	38 ***
2	48 ***
3	166
4	105
AVERAGE K	89

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: AUGUST 8, 1991
PROJECT: I-80
TYPE OF SUBBASE MATERIAL: 1.5" CRUSHED CONCRETE (4 PASSES)
LOCATION: CEDAR

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	11
2	11
3	30
4	16
5	32
6	19
AVERAGE K	20

*** HOLE DID NOT DRAIN

IN-SITU PERMEABILITY RESULTS

DATE TESTED: AUG 13, 1991
PROJECT: I-80
TYPE OF SUBBASE MATERIAL: CRUSHED CONCRTE 1.5" MATERIAL
LOCATION: CEDAR CO.

TEST NUMBER	PERMEABILITY (K FT/DAY)
1	80
2	70
3	17 ***
4	51 ***
5	1256
6	863

AVERAGE K 390

*** HOLE DID NOT DRAIN

NOTE:
THERE WAS SEVERE OBVIOUS SEGREGATION
PERMEABILITY MUCH LOWER

Appendix C

I-80 in Cedar County Project

Form 000021
12-89

IOWA DEPARTMENT OF TRANSPORTATION

To Office	Materials	Date	July 18, 1991
Attention	B. C. Brown	Ref. No.	570 Cedar County I-80
From	K. L. Dirks KLD		
Office	Road Design		
Subject	Granular Subbase Recommendations		

The Iowa Limestone Producers and Reilly Construction Company have proposed a trial gradiation change to allow 100% passing the 1½ inch sieve for granular subbase produced from recycled concrete. They made this proposal based on project experience concerns indicating that increased crushing efforts cause considerable variability in the amount of material passing the number 8 sieve. This problem results in considerable wastage on some projects and usually results in a finished product which runs very near the upper allowed limit for all sieve sizes. We have found that increased break down occurs in these same problem aggregates during compaction. This combination of factors produces unacceptable drainability.

For this reason I recommend that we allow a mutual benefit, one mile long, trial section on the upcoming Cedar I-80 inlay project. Agreed upon changes are as follow:

1. Gradiation: 100% passing the 1½" sieve
   10 to 25% passing the #8 sieve
   0-15% passing the #50 sieve
   0-6% passing the #200 sieve

2. Reilly would produce the first mile of production at the current specification limits. The second mile (about one weeks run) would then be produced with the above controls under a mutual benefit agreement.

3. The Materials department would do increased control testing including gradiation tests from the finished grade and would perform permeability testing on the two test sections..

4. Depending on the results of this trial a decision would be made on which gradiation control is used for the remainder of the project. This decision would be based on obtaining improved drainability while maintaining acceptable workability and construction stability.

5. If the decision is made to allow the 1½" gradiation material for the remainder of the project, Reilly Construction would evaluate production savings and consider a price reduction.

Thank you for your assistance in implementing this trial.

KLD:mk
cc: D. A. Anderson
G. F. Sisson
D. L. East
E. T. Cackler
Roger Boulet, DME, Cedar Rapids

IOWA DEPARTMENT OF TRANSPORTATION

TO OFFICE: District Six Materials DATE: July 25, 1991

ATTENTION: Roger Boulet REF. NO.: 435.01

FROM: Bernard C. Brown

OFFICE: Materials Engineer

SUBJECT: Granular Subbase - I-80 Cedar County

As we discussed recently, we are interested in altering the gradation of the granular subbase to enhance the drainability on the above referenced project. Kermit Dirks' July 18, 1991 memo (attached) outlines the plan for an in-place evaluation. I support the plan as does Tom Cackler.

The Central Construction Office will be formally contacting the district to arrange for this test section. The purpose of this memo is to advise you that we should have at least 5 gradation tests on the crushed material going into each of these test sections. If you can get representative samples from the compacted subbase we would like to have 5 gradation tests from each of these sections also.

I'm not sure what the proper way to evaluate permeability should be but at the very least the contractor should be prepared to use a truck to deposit water on each section.

Please keep us advised of the construction schedule so we can be on the scene for the tests.

Please let me know if you have any questions.

BCB:esb
ATTACHMENT
cc: D. A. Anderson
E. T. Cackler
K. L. Dirks

IOWA DEPARTMENT OF TRANSPORTATION

TO OFFICE: District No. 6

DATE: August 9, 1991

ATTENTION: Bruce Kuehl

REF. NO.: Cedar County
IR-80-7(57)265
PCC Inlay

FROM: E. Tom Cackler

OFFICE: Construction

SUBJECT: Granular Subbase

Overcompaction of the granular subbase has resulted in excessive crushing of the crushed concrete. The excess fine particles reduces the drainability of the material.

In order to reduce this crushing, we are proposing several changes in the method of compaction. On a trial basis, we are requesting the following changes be implemented on this project only:

1. The moisture content of the granular material shall be within 2% of the optimum moisture content, as determined by the Central Materials Laboratory. Target 9% 8-9-91 [initials]

2. The full thickness of the granular subbase material shall be compacted with four passes of a steel drum roller, operating in the static mode, or a pneumatic-tired roller.

3. No nuclear density testing will be required, although some nuclear testing may be requested later to evaluate the number of roller passes versus compaction.

4. The modified gradation shall continue to be used. The modified gradation was:

   100% passing the 1 1/2" sieve
   10-25% passing the #8 sieve
   0-15% passing the #50 sieve
   0-6% passing the #200 sieve

As per the existing specification, hauling shall not be permitted on the completed granular subbase.

ETC:wik
cc: D. Anderson, M. Burr, R. Boulet, M. Brandl, K. Dirks, J. Lane, D. Mathis, FHWA

Aug 12, 91
B. Brown
V. Marks
F. Miyagawa
C. [illegible]
[initials]

IOWA DEPARTMENT OF TRANSPORTATION

TO OFFICE: District 6

DATE: August 16, 1991

ATTENTION: Bruce Kuehl

REF. NO.: Cedar County
IR-80-7(57)265

FROM: Thomas R. Jacobson

OFFICE: Office of Construction

SUBJECT: Granular Subbase

This letter serves to confirm our telephone conversation this morning and authorize changes in the granular subbase material.

The items to be changed include:

1. The broken concrete pavement is to be passed through a 2" scalper screen prior to crushing. The material passing through the 2" screen is to be wasted.

2. Lower the no. 8 sieve passing requirement to 10-20 percent. The modified gradation will be:

   100 percent passing the no. 1 1/2" sieve

   10-20 percent passing the no. 8 sieve

   0-15 percent passing the no. 50 sieve

   0-6 percent passing the no. 200 sieve

3. The changes will be evaluated after approximately one mile of this material is placed.

TRJ:pc
cc: D. Anderson
M. Burr
R. Boulet
M. Brandl
K. Dirks
J. Lane
D. Mathis, FHWA

cc: B.C. Brown
Marks
Champ
Frank
Jim Grove

8/20/91

File 435.01

Aug 16, 1991

K. Dirks
T. Jacobson
J. Grove
F. Miyagawa
V. Marks
R. Boulet, B. Kuehl
D. Mathis
B. Brown
T. Cackler

This is an update on information from the Cedar Co. I-80 project related to crushed concrete granular subbase.

The Davenport RCE Office reports nuclear density results from the roadway on 1½" top size material placed with four static roller passes of 101.2 (118.5) lbs per cubic ft.
(See Aug. 19 memo)

Based on the curve F. Miyagawa developed using the N. Jersey ~~permeta~~ permeameter this indicates permeability in the 500 to 1000 ft. per day.

J. Lane

File 435.01

Aug 19, 1991

K. Dirks
T. Jacobson
J. Grove
F. Miyagawa
V. Marks
R. Boulet, B. Kuehl
D. Mathis
B. Brown
T. Cackler

IMPORTANT NOTE

Error Correction

This is to correct an error I made in my note of Aug 16, 1991 about granular subbase road way density. The density from four passes of a static roller should have been 118.5 lbs per cu. ft. instead of 101.2 which I reported. This drops the estimated permeability to something below 50 feet per day.

J. Lane

Appendix D

New Jersey Falling Head Permeameter Procedure

Form AD-40 5/77 NEW JERSEY DEPARTMENT OF TRANSPORTATION 2209

MEMORANDUM

TO O. Abbott FROM V. Mottola

SUBJECT Laboratory Compaction and Permeability of Non-Stabilized and Bituminous Stabililzed Open-Graded Base Course Materials DATE 5/27/88 TELEPHONE NO. 2-5730

As per our discussion at the Interagency Meeting, attached are the methods of tests for open-graded materials which should be included into Section 990 of the NJDOT Standard Specifications. These tests outline the procedure for Laboratory Compaction and Permeability of Non-Stabilized and Bituminous Stabilized Open Graded Base Course Materials. The following have been written in the format followed by Section 990 of the 1983 Standard Specifications.

Method of Tests

Q-1 Compaction of Non-Stabilized Open Graded (NSOG) Base Course Materials

Q-2 Compaction of Bituminous Stabilized Open Graded (BSOG) Base Course Materials

Q-3 Falling Head Permeability Test for Non-Stabilized and Bituminous Stabilized Open Graded Base Course Materials

If you require additional information, please contact me.

Victor E. Mottola

Victor E. Mottola

Attachments
cc: J. Croteau

Q-1 COMPACTION OF NON-STABILIZED OPEN-GRADED (NSOG) BASE COURSE MATERIALS

1. Scope

This method of test determines the density of NSOG base course material and outlines the procedure for compaction in preparation for falling head permeability testing.

2. Apparatus

Modified NSOG compaction equipment as shown in Figures 2 and 3.

A Burmister Vibratory Table meeting ASTM D-2049.

Four (4) inch diameter permeability molds with #16 sieve screen.

12 lb. lead surcharge.

A heavy duty scale capable of weighing samples up to 20 Kg. with an accuracy of ± 1 gram.

A steel ruler with 1/100 of an inch gradations.

A stopwatch capable of 0.1 second accuracy.

3. Procedure

Place the 4 inch diameter mold into the recess of the bottom retainer on the Burmister Table. Secure the retainer to the table with threaded rods and wing nuts.

Weigh out 3.5 lb. of NSOG material and place the sample loosely into the mold and level the surface. Enter the weight of sample into Figure 6.

Place the spacer plate onto the mold and level the surface. Fit the top retainer plate over the threaded rods and cylinder mold.

Secure the top retainer with wing nuts.

Q-1 COMPACTION OF NON-STABILIZED OPEN-GRADED (NSOG) BASE COURSE MATERIALS

1. Scope

This method of test determines the density of NSOG base course material and outlines the procedure for compaction in preparation for falling head permeability testing.

2. Apparatus

Modified NSOG compaction equipment as shown in Figures 2 and 3.

A Burmister Vibratory Table meeting ASTM D-2049.

Four (4) inch diameter permeability molds with #16 sieve screen.

12 lb. lead surcharge.

A heavy duty scale capable of weighing samples up to 20 Kg. with an accuracy of ± 1 gram.

A steel ruler with 1/100 of an inch gradations.

A stopwatch capable of 0.1 second accuracy.

3. Procedure

Place the 4 inch diameter mold into the recess of the bottom retainer on the Burmister Table. Secure the retainer to the table with threaded rods and wing nuts.

Weigh out 3.5 lb. of NSOG material and place the sample loosely into the mold and level the surface. Enter the weight of sample into Figure 6.

Place the spacer plate onto the mold and level the surface. Fit the top retainer plate over the threaded rods and cylinder mold.

Secure the top retainer with wing nuts.

Measure and record (to the nearest .01") the distance from the top of the sample to the top of the cylinder mold.

Lower the 12 lb. surcharge to sit freely onto the spacer plate and begin vibrating the sample for 30 seconds at an amplitude of 50 on the scale described in ASTM D-2049.

Remove the surcharge and measure the compacted height of the sample.

Repeat the procedure for a total of 5 trials.

After completion of each trial, unfasten the cylinder mold with compacted sample from the Burmister Table and place the mold into the modified falling head permeameter for permeability testing (see Method of Test Q-3).

4. Calculations

Measure the compacted density of each NSOG sample as follows:

$$\text{Density} = \frac{\text{W sample}}{\text{V sample}}$$

where:

w = Weight of compacted sample (lbs.) = 3.5 lbs.

$$V = \frac{\text{Height of Sample (in)} \times (12.56\ \text{in}^2)}{1728}$$

5. Report

The densities of five compacted NSOG samples shall be reported on Figure 6 5, Compaction and Permeability Data Sheet.

Q-3 FALLING HEAD PERMEABILITY TEST FOR NON-STABILIZED AND BITUMINOUS STABILIZED OPEN GRADED BASE COURSE MATERIALS

1. Scope

This method of test describes the procedure determining the permeability of non-stabilized (NSOG) and bituminous stabilized (BSOG) open graded base course materials.

2. Apparatus

Modified falling head permeabilitv apparatus as shown on Figure 6.

8.5" high x 4" I.D. steel molds with #16 sieve screen soldered to bottom of mold for testing of NSOG materials and without screen mesh for testing of BSOG materials.

A source of clean water capable of supplying a minimum flow of five to six gallons per minute.

A stopwatch capable of measuring up to 30 minutes with an accuracy of + 0.1 second.

A 12" steel ruler with 1/100 inch gradations.

3. Procedure

Place the 4" diameter cylinder mold with compacted NSOG or BSOG sample (see Method of Test Q-1 or Q-2 for compaction procedure) into the bottom support ring of the falling head permeameter. A rubber gasket shall be placed along the bottom edge of the cylinder mold to prevent water leakage.

Place the rubber stopper at the bottom of the permeameter and close the bottom flap gate.

Q-2 COMPACTION OF BITUMINOUS-STABILIZED OPEN-GRADED (BSOG) BASE COURSE MATERIAL

1. Scope

This method of test describes the procedure for determining the compacted density of BSOG base course material in preparation for falling head permeability testing.

2. Apparatus

Modified BSOG compaction apparatus as described in Figures 4 and 5 and illustrated in ASTM D-1074.

8.5" high x 4" I.D. steel molds as shown in Figure 5.

A Lancaster mechanical mixer with at least 5 lb. capacity suficient to blend an asphalt cement stone mix.

An Instron Universal testing machine or similar device capable of producing accurate molding pressures up to 2000 psi or 25,000 lbs. total load.

A heating oven capable of heating materials to at least 325°F.

4 inch diameter paper discs.

3. Procedure

Weigh out approximately 5 lbs. of materials for a BSOG mix.

Heat all materials to be blended and the mixing utensils to appropriate temperatures to assure compaction of the mix in the mold at 250°F as follows:

a. Stone to 325°F

b. Asphalt Cement to 275°F

c. Mixing utensils and bowls to 325°F

If BSOG mix has already been batched (samples taken from field), heat the mix to 300°F.

Blend and mix 5 lb. of the heated asphalt cement and stone mix in the Lancaster mixer for two minutes or until stone is fully covered by A.C., whichever comes first.

Lightly oil compaction mold and plunger components.

Place half ring supports and mold on bottom plunger.

Insert paper disc into bottom of mold.

Pour 1600 grams (3.5 lbs.) of the heated asphalt cement-stone mix into the 4.0" diameter mold. This is done in three equal lifts. After each lift, the mix is rodded 25 times using a spatula (10 times of the surface of the layer and 15 times around the stone-mold interface.

Place a paper disc on sample and insert the top plunger.

Begin compaction with the Instron Universal testing machine. Compactive pressures should be limited to 600 psi for carbonate rock aggregate, and 1000 psi for aggregates of all other stone types so that excessive pressures do not crush the aggregates.

Compaction should follow procedures outlined in ASTM D-1079.

Remove the cylinder mold and compacted BSOG sample from the Instron machine.

Measure and record the height of the compacted BSOG sample in inches (nearest .01").

Repeat the procedure for a total of 5 trials.

After completion of each trial, calculate the density as outlined below and place the cylinder mold with the compacted sample into the modified falling head permeameter. For permeability testing, see Method of Test Q-3.

4. Calculations

Measure the compacted density of each BSOG sample as follows:

$$\text{Density} = \frac{\text{W sample}}{\text{V sample}}$$

where:

W = Weight of compacted sample (lbs.) = 3.5 lbs.

$$V = \frac{\text{Height of Sample (in)} \times (12.56\ \text{in}^2)}{1728}$$

5. Report

The densities of five compacted BSOG samples shall be reported on Figure 6, Compaction and Permeability Data Sheet.

4. Calculations

Measure the compacted density of each BSOG sample as follows:

$$\text{Density} = \frac{\text{W sample}}{\text{V sample}}$$

where:

w = Weight of compacted sample (lbs.) = 3.5 lbs.

$$V = \frac{\text{Height of Sample (in)} \times (12.56\ \text{in}^2)}{1728}$$

5. Report

The densities of five compacted BSOG samples shall be reported on Figure 6, Compaction and Permeability Data Sheet.

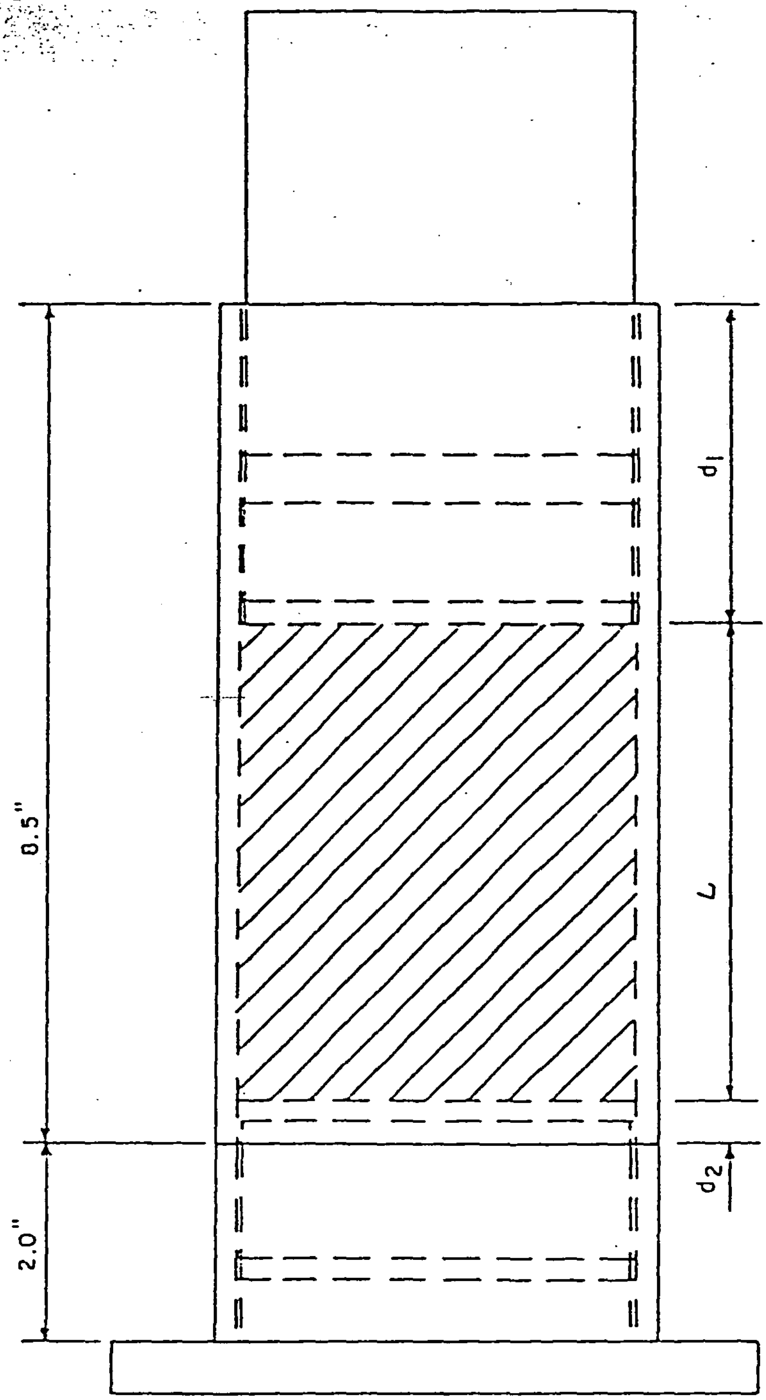


FIGURE ~~DT~~ #4 BSOG COMPACTION EQUIPMENT ASSEMBLY.
SCALE: 1" = 2"

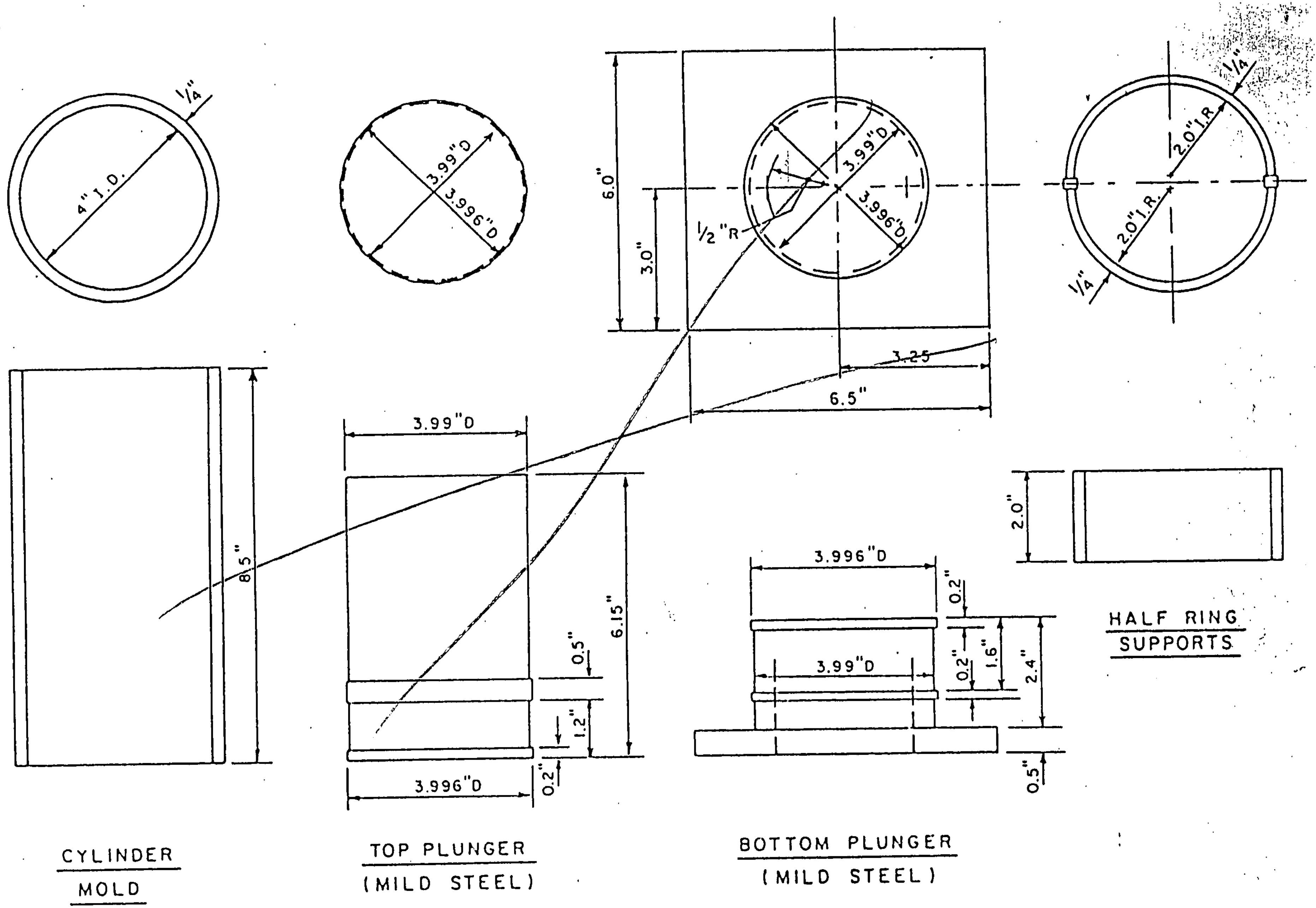


FIGURE D2 BSOG COMPACTION EQUIPMENT ASSESSORIES.

SCALE : 1" = 3"

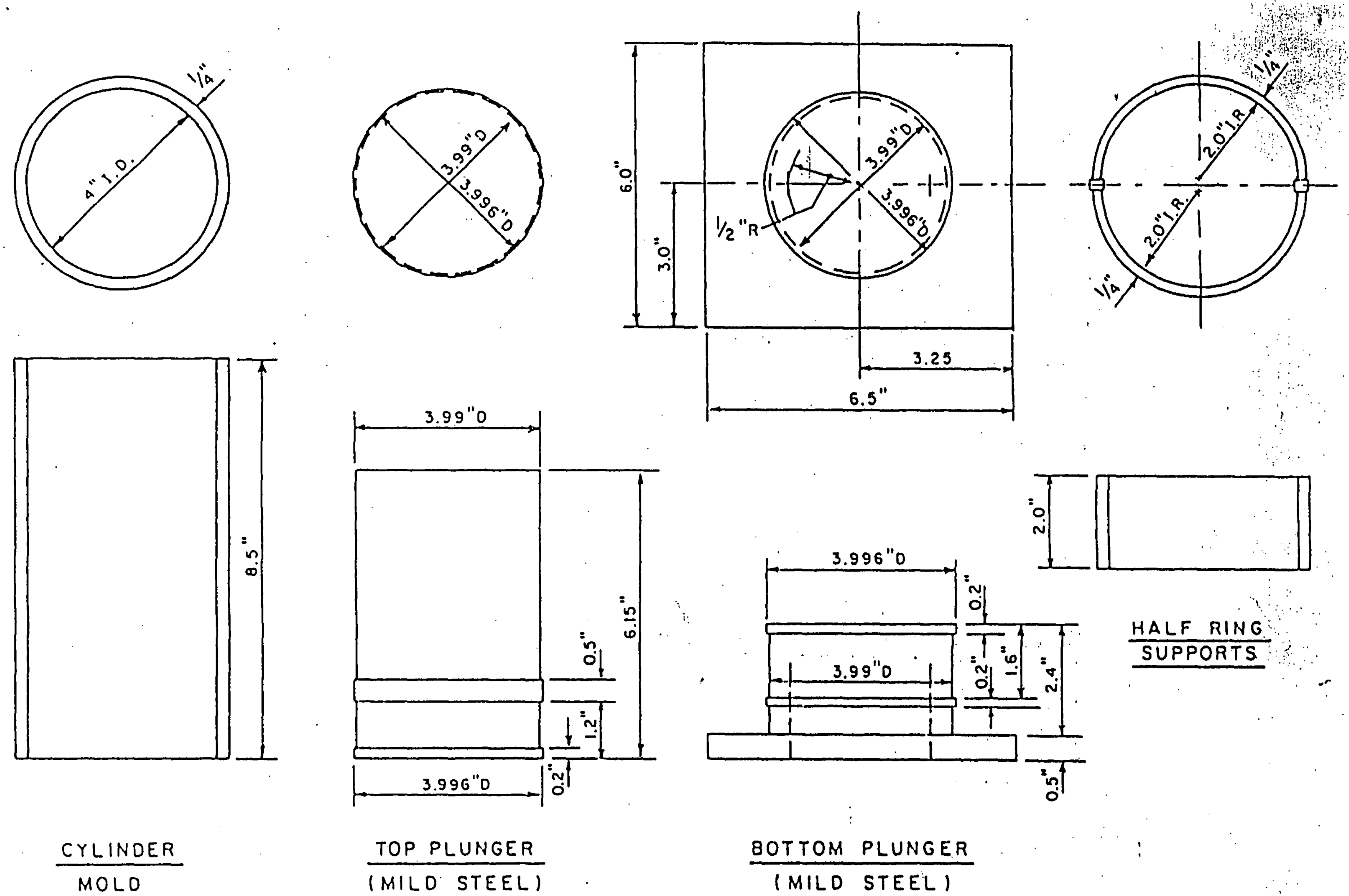


FIGURE D2 BSOG COMPACTION EQUIPMENT ASSESSORIES.

SCALE: 1" = 3"

Q-3 FALLING HEAD PERMEABILITY TEST FOR NON-STABILIZED AND BITUMINOUS STABILIZED OPEN GRADED BASE COURSE MATERIALS

1. Scope

This method of test describes the procedure determining the permeability of non-stabilized (NSOG) and bituminous stabilized (BSOG) open graded base course materials.

2. Apparatus

Modified falling head permeabilitv apparatus as shown on Figure 6.

8.5" high x 4" I.D. steel molds with #16 sieve screen soldered to bottom of mold for testing of NSOG materials and without screen mesh for testing of BSOG materials.

A source of clean water capable of supplying a minimum flow of five to six gallons per minute.

A stopwatch capable of measuring up to 30 minutes with an accuracy of + 0.1 second.

A 12" steel ruler with 1/100 inch gradations.

3. Procedure

Place the 4" diameter cylinder mold with compacted NSOG or BSOG sample (see Method of Test Q-1 or Q-2 for compaction procedure) into the bottom support ring of the falling head permeameter. A rubber gasket shall be placed along the bottom edge of the cylinder mold to prevent water leakage.

Place the rubber stopper at the bottom of the permeameter and close the bottom flap gate.

Place a rubber gasket at the top edge of the cylinder mold.

Place the upper support ring and plastic standpipe on top of the 4" diameter cylinder mold. Lock the upper support ring to the cylinder mold with the wing nuts.

The permeameter is now assembled and ready for permeability testing.

Place the assembled permeameter near the water source and suitable drain.

With the bottom flapgate closed, fill the plastic standpipe to overflowing with water from the cold water tap.

Once the standpipe is overflowing with water, start the permeability flow test by opening the bottom flapgate to allow water to flow through the sample. Start the watch at the time of opening the flapgate.

When the water level in the plastic standpipe reaches the predetermined mark situated 15.75" below the top of the standpipe, stop the watch.

Record the time in seconds on Figure 6, Compaction and Permeability Data Sheet.

Note the compacted height of the NSOG or BSOG sample (L) in inches.

Repeat the permeability test with additional compacted NSOG or BSOG samples for a total of 5 trials.

4. Calculations

Use Figure 6, Compaction and Permeability Data Sheet to calculate the permeability of the open graded materials.

Calculate the falling head permeability (K) as follows:

$$K = \left(\frac{L}{T}\right)\left[\ln\left(\frac{h1}{h2}\right)\right](7200)$$

where:

K = falling head permeability (ft./day)

L = height of compacted NSOG or BSOG sample (in.)

T = recorded time for water level to fall 15.75 in. from top of standpipe

h1 = height of assembled permeameter = in. 30.0 in

h2 = height from final water mark to bottom of cylinder mold = 14.375 in in.

ln = natural logarithm

Repeat the permeability calculation for each of the five trials.

5. Report

The permeabilities of five NSOG or BSOG samples shall be reported on Figure 6, Compaction and Permeability Data Sheet.

$$K = \left(\frac{L}{T}\right)\left[\ln\left(\frac{h1}{h2}\right)\right](7200)$$

where:

K	=	falling head permeability (ft./day)
L	=	height of compacted NSOG or BSOG sample (in.)
T	=	recorded time for water level to fall 15.75 in. from top of standpipe
h1	=	height of assembled permeameter = [redacted] in. 30.0 in
h2	=	height from final water mark to bottom of cylinder mold = [redacted] in. 14.375 in
ln	=	natural logarithm

Repeat the permeability calculation for each of the five trials.

5. Report

The permeabilities of five NSOG or BSOG samples shall be reported on Figure 6, Compaction and Permeability Data Sheet.

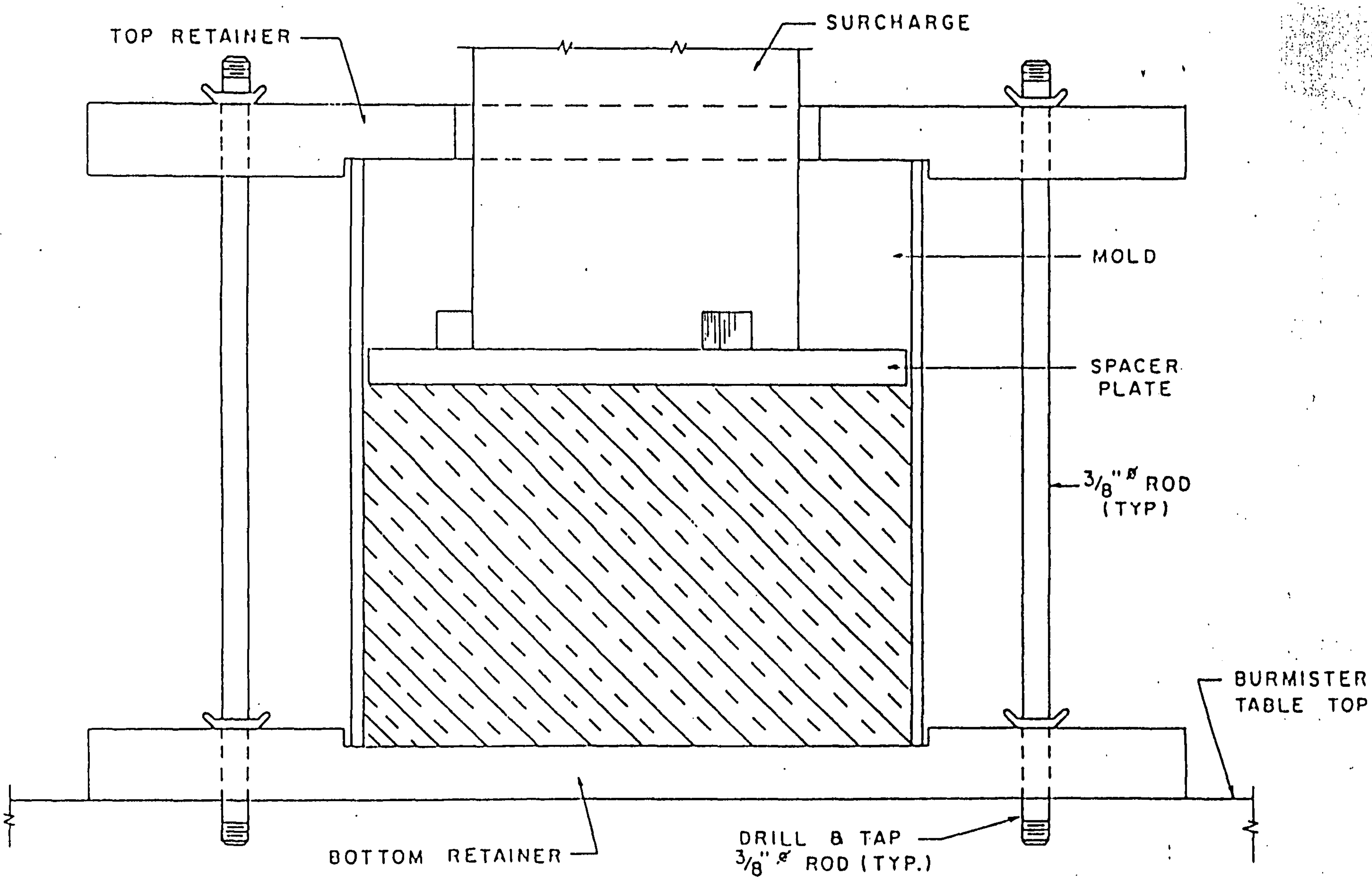


FIGURE D-3 MODIFIED BURMISTER EQUIPMENT ASSEMBLY.

SCALE: 1" = 2"

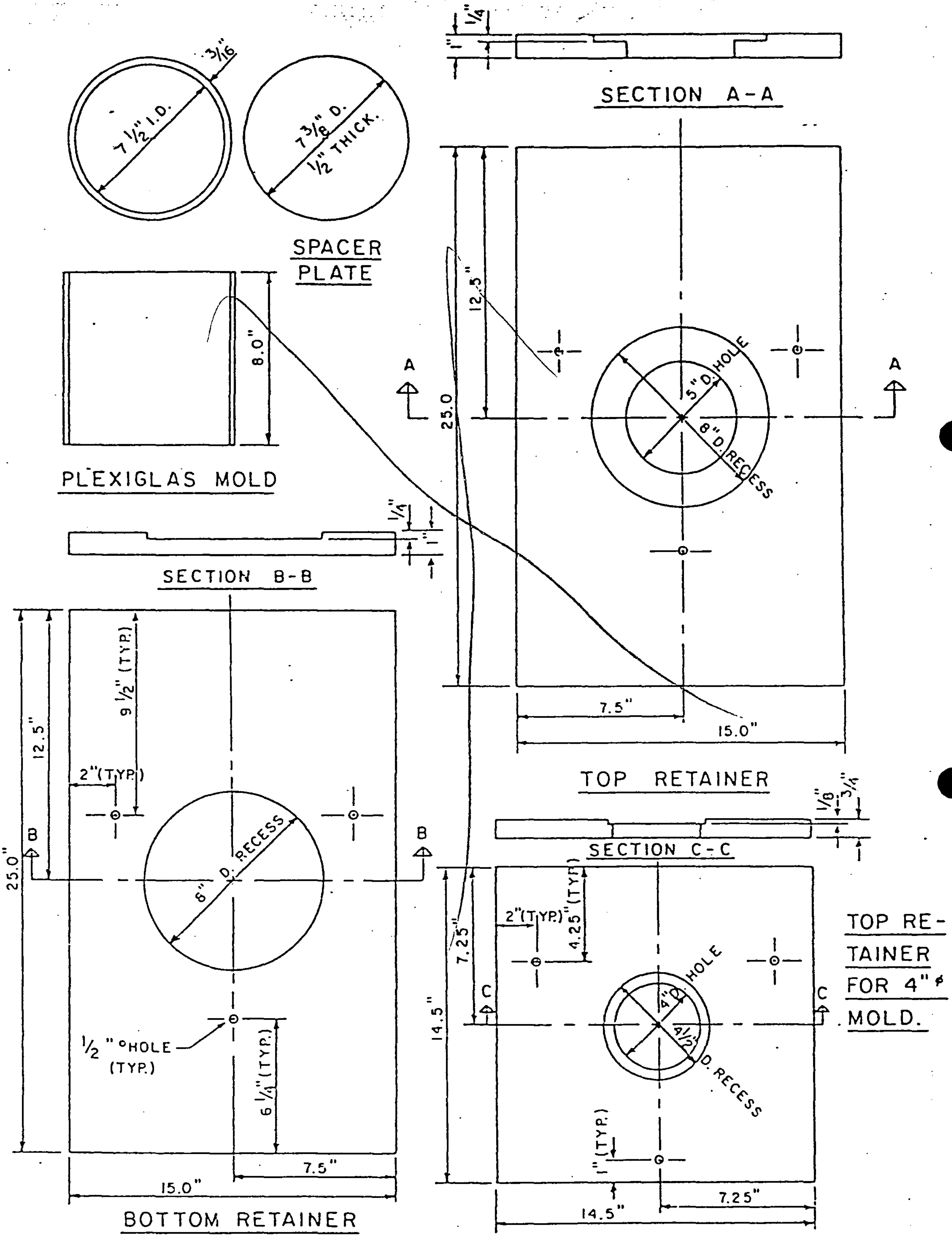


FIGURE # D4 MODIFIED BURMISTER EQUIPMENT ASSESSORIES.

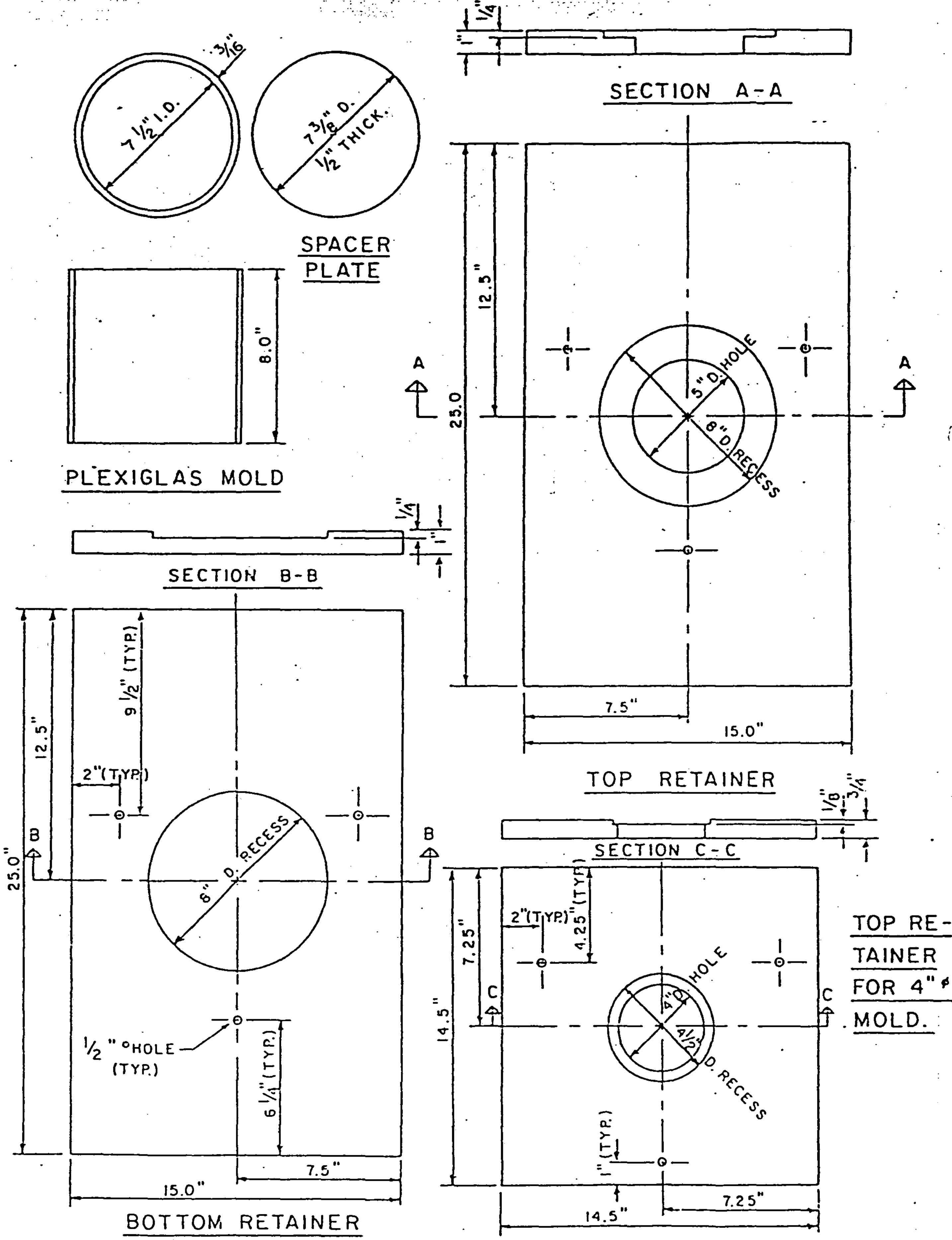
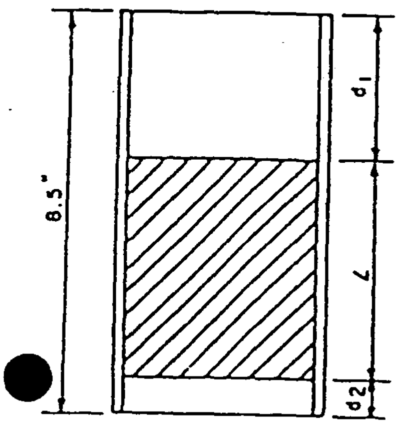


FIGURE # D.4 MODIFIED BURMISTER EQUIPMENT ASSESSORIES.

NEW JERSEY DEPARTMENT OF TRANSPORTATION
DIVISION OF RESEARCH AND DEMONSTRATION

COMPACTION AND PERMEABILITY DATA SHEET
COMPACTION OF NSOG / BSOG MATERIAL (circle one)

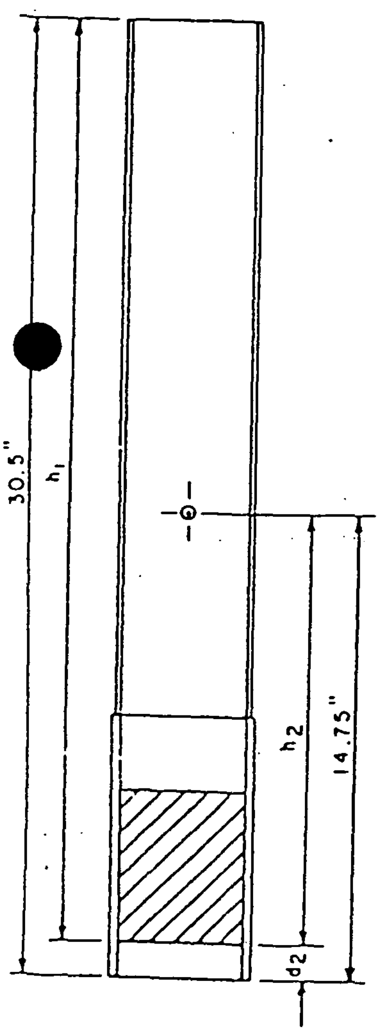
NJDOT SPECIFICATION: ____________ SPEC. PERMEABILITY: ____________
PROJECT: ____________ SECTION: ____________ COUNTY: ____________
MATERIAL: ____________ STONE SIZE: ____________
SOURCE: ____________ QUARRY: ____________



CYLINDER MOLD

DENSITY OF O.G. MATERIALS

Date	d1 (inch)	d2 (inch)	L=8.5 - (d1+d2)	Sample Weight W (lb)	Sample Volume V=12.6L (cu in)	Density W/V *1728 (pcf)



PERMEAMETER

PERMEABILITY OF O.G. MATERIALS

Trials	Time (sec)	h1 = 30.5-d2 (in)	h2 = 14.75-d2 (in)	L/T (in)/(sec)	$\ln\left(\frac{h1}{h2}\right)$	$K=\left(\frac{L}{T}\right)\left(\frac{h1}{\ln h2}\right)$ *(7200) (ft/day)

GRADATION OF O.G. MATERIALS

	Sieve Size	1.5	1	0.5	No. 4	No. 8	No. 16	No. 50	P.I.	
#1	% PASS									
#2	% PASS									
SPEC	% PASS									

ATTACHMENT ONE COPY: [illegible]

Q-2 COMPACTION OF BITUMINOUS-STABILIZED OPEN-GRADED (BSOG) BASE COURSE MATERIAL

1. Scope

This method of test describes the procedure for determining the compacted density of BSOG base course material in preparation for falling head permeability testing.

2. Apparatus

Modified BSOG compaction apparatus as described in Figures 4 and 5 and illustrated in ASTM D-1074.

8.5" high x 4" I.D. steel molds as shown in Figure 5.

A Lancaster mechanical mixer with at least 5 lb. capacity suficient to blend an asphalt cement stone mix.

An Instron Universal testing machine or similar device capable of producing accurate molding pressures up to 2000 psi or 25,000 lbs. total load.

A heating oven capable of heating materials to at least 325°F.

4 inch diameter paper discs.

3. Procedure

Weigh out approximately 5 lbs. of materials for a BSOG mix.

Heat all materials to be blended and the mixing utensils to appropriate temperatures to assure compaction of the mix in the mold at 250°F as follows:

a. Stone to 325°F

b. Asphalt Cement to 275°F

c. Mixing utensils and bowls to 325°F

If BSOG mix has already been batched (samples taken from field), heat the mix to 300°F.

Appendix E

MLR-90-4 Reports and Updates

PROJECT NO. : MLR-90-4 (REVISED) **DATE:** June 29, 1991

PROJECT TITLE: Permeability of Granular Subbase Materials

PRINCIPAL INVESTIGATOR: Frank Miyagawa

PURPOSE: To determine if adequate drainage is being provided by granular subbase materials.

OBJECTIVE: To determine a range of gradations and P.I.'s that will provide adequate permeability for drainage and to determine the in-place permeability of the subbase to compare with laboratory results.

PROCEDURE: This research will consist of two phases.

PHASE I-a: -test all granular base materials used in 1990 construction projects and determine gradations, permeability, plasticity index, and density. --**COMPLETE**

PHASE I-b: -gather samples of granular base materials from producers that exhibit a plasticity index from approximately 3-6 and determine the permeability.

PHASE II-a: -evaluate the results from I-a and select various gradations to be altered and view the effects of the alterations on permeability.

PHASE II-b: -measure the in-situ permeability from on-going projects.

- determine the in-place density, P.I., and gradations and compare with lab results.

RESPONSIBILITIES: The Aggregate and Soils section will conduct all lab tests. Frank Miyagawa will perform all the in-situ tests and prepare the final report.

CC: B. Brown
O.J. Lane
V. Marks
C. Narotam
K. Dirks
W. Strum

ATTN: Bernie Brown — Aug 27, 1991

FROM: Frank Miyagawa

SUBJECT: Summary of I-80 in Cedar Co. project

The following is a brief summary of the work that has been completed on the I-80 project in Cedar County regarding the permeability of granular subbase materials:

SECTION #1

The first mile section of subbase material was the standard 1" top size crushed concrete meeting gradation specification #4121. In-situ and lab permeability tests were conducted and showed that the material did not draining as well as it should have. Gradation tests revealed that there was a significant breakdown of the material from the stockpile to the grade. This first section has been paved over.

SECTION #2

The second section of material was the 1.5" top size material with a change in the maximum percent passing the #8 sieve from 35% to 25%. In-situ and lab permeability tests were also conducted on this material. There was a slight improvement in permeability compared to the 1" material, but the permeability was still relatively low. Gradation reports also showed a significant breakdown of material as with the 1" material.

SECTION #3

The third section of subbase involved a change in construction procedures. A maximum number of 4 passes with a steel-drum roller operating in the static mode or a pneumatic-tired roller was specified. Gradation tests are being conducted to determine if the new procedure decreases the amount of breakdown.

SECTION #4

The fourth section of material was produced with special care in making sure that the old base material from the existing pavement was not disturbed when the pavement was removed. This resulted in a material that kept the % passing the #8 sieve around 20-23%.

SECTION #5

The fifth section of crushed concrete is starting to be produced. This material will have a target of 17% passing the #8 sieve. This will be achieved by scalping the material through a 2" screen to remove some of the fines.

FUTURE PLANS

The following activities are planned for the rest of the project:

1. Conduct in-situ and lab permeability tests on the new material.

2. Run gradation tests on the new material to determine if the change in construction procedures decreases breakdown.

3. Obtain samples to run abrasion tests on the crushed concrete.

cc: O.J. Lane
C. Narotam
V. Marks
J. Grove
K. Dirks
R. Boulet
D. Mathis, FHWA

ATTN: Bernie Brown Sept 3, 1991

FROM: Frank Miyagawa

SUBJECT: Permeability Update

Bob Steffes and I traveled to the I-80 project in Cedar County on Aug 28 to obtain samples from the scalped crushed concrete and to conduct in-situ permeability tests.

As of Aug 28, the contractor was producing the new scalped crushed concrete at the plant, but it had not been used yet at the grade. The samples we obtained at the plant were from the belt, so the samples should be representative. In-situ permeability tests were performed on the 1.5" material that was produced without scalping and that was running around 20-25% passing the #8 sieve.

The in-situ test results were slightly better for the material that had the number of compaction passes limited to four. There were still some areas that took over 35 minutes to drain. However, most of the holes did drain. This would indicate that there is some improvement due to the new construction changes.

Laboratory permeability tests were conducted on the stockpile-scalped material. Attached are the results of those tests and a graph comparing the theoretical curves for the scalped vs. non-scalped material. There is significant improvement in permeability at lower densities for the scalped material, but it is clear that as the density approaches 115-120 pcf that there is little difference between the two materials. The in-place-scalped material would most likely have a lower permeability at the grade due to material breakdown. Laboratory tests are being conducted to evaluate the breakdown effects of the new construction procedures.

There was one interesting difference between the two materials. The scalped material was not as dense as the non-scalped material with the same compaction energy. For the standard proctor, the maximum density achieved in the New Jersey Falling Head Permeameter was 123 pcf, with two other samples only at 112 pcf. The maximum density achieved on the first material for a standard proctor was 129 pcf, with most running around 120 pcf. Although the accuracy of determining densities with the permeameter is subject to question, the two materials were compacted under similar conditions and this difference in characteristics is something that should be looked in to further.

There seems to be some improvement in permeability with the new procedures and material. However, it is obvious that the density has a great impact on the permeability of this material regardless of gradation. A possible solution would be to look at specifying a <u>**maximum**</u> density for the crushed concrete. Other states that use crushed concrete do have maximum densities that run around 110-115 pcf and provide adequate stability. The permeability of the crushed concrete in Iowa at 110-115 pcf seems to be in a range that would provide adequate drainage with very little increase in cost. Additional tests would be needed to determine if a density of 110-115 pcf would provide adequate stability with the material Iowa is using.

I am planning on conducting in-situ tests as soon as the new material has been placed. Lab tests with in-place samples will also be conducted to see how the results compare with the plant samples.

cc: O. J. Lane
V. Marks
C. Narotam
K. Dirks
T. Cackler
R. Boulet
D. Mathis, FHWA

ATTN: Bernie Brown September 18, 1991

FROM: Frank Miyagawa

SUBJECT: Summary of I-80 in Cedar Co. project

The following is a brief summary of the work that has been completed on the I-80 project in Cedar County regarding the permeability of granular subbase materials:

SECTION #1

The first mile section of subbase material was the standard 1" top size crushed concrete meeting gradation specification #4121. In-situ and lab permeability tests were conducted and showed that the material did not drain as well as it should have. Gradation tests revealed that there was a significant breakdown of the material from the stockpile to the grade. This first section has been paved over.

SECTION #2

The second section of material was the 1.5" top size material with a change in the maximum percent passing the #8 sieve from 35% to 25%. In-situ and lab permeability tests were also conducted on this material. There was a slight improvement in permeability compared to the 1" material, but the permeability was still relatively low. Gradation reports also showed a significant breakdown of material as with the 1" material. This section has also been paved over.

SECTION #3

The third section of subbase involved a change in construction procedures. A maximum number of 4 passes with a steel-drum roller operating in the static mode or a pneumatic-tired roller was specified. This section has been paved.

SECTION #4

The fourth section of material was produced with special care in making sure that the old base material from the existing pavement was not disturbed when the pavement was removed and with the change in compaction as section #3. This resulted in a material that kept the % passing the #8 sieve around 20-23%. In place gradation tests showed that the amount of breakdown with this new construction procedure was much less than before. The percent passing the #8 was 25.7 on the sample we obtained.

SECTION #5

The fifth section of crushed concrete is being produced and placed. Gradation tests show that the % passing the #8 is about 17-18% and the % passing the #200 is around 2-4.5%. In-situ tests need to be run and samples need to be obtained. This low amount of fines is being achieved by bleeding off about 12% of the fines after crushing. This is different from the original idea of scalping off material passing a 2" sieve before crushing. The contractor believed scalping over a 2" sieve would result in about 35% waste as opposed to the 12% now from bleeding off fines.

Abrasion tests were conducted on the 1.5" scalped material from the stockpile. The crushed concrete had an abrasion number of 39 and 41. This would indicate that this material is not as bad as we first believed as far as abrasion is concerned.

FUTURE PLANS

An interim report will be done in the next week with my recommendations for the rest of this research project.

cc: O.J. Lane
C. Narotam
V. Marks
J. Grove
K. Dirks
R. Boulet
D. Mathis, FHWA

Appendix F

Iowa DOT and Production Gradations

IOWA DOT CENTRAL LABORATORY GRADATIONS

Percent Passing

Sieve No.

Sample Description	1½"	1"	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200
1½" Stockpile	100	88	72	54	43	29	22	17	13	9.2	6.9	5.5
1½" Stockpile - Scalped	100	83	67	53	43	26	17	12	8.7	6.2	4.9	4.0
1½" Stockpile - Scalped	100	79	64	55	43	27	18	12	8.2	4.8	3.1	2.1
1½" In-Place #1	100	96	90	83	76	64	48	36	27	18	13	10
1½" In-Place #2	100	94	88	77	65	47	36	27	21	14	10	8.2
1½" In-Place - 4 passes only	98	94	77	62	51	35	26	19	14	9.0	6.5	4.5
1½" Trough	100	94	82	71	59	41	30	23	17	12	9.0	7.0
1" Stockpile	100	100	84	70	56	37	26	19	13	8.0	5.3	4.0
1" In-Place	100	100	87	69	52	35	25	18	13	8.2	5.6	4.2
1" Trough	100	100	94	83	72	50	35	26	18	11	8.0	5.9
1½" Specification	100						10-25			0-15		0-6
1" Specification		100					10-35					0-6

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2-89

Iowa Department of Transportation

CERTIFIED GRADATION TEST REPORT

County Cedar
Project IR-80-7(57)265--12-16
Contractor Fred Carlson Co.
Contract No. 33011
Design
Date 8/08/91 Report No. D1ML-189-19

[ ] Certified Sample
[xxx] Monitor Sample
[ ] Verification Sample

RECYCLED CR. CONC. FROM JUST W. OF THE CEDAR RIVER, EASTERLY TO APPROX. 1/2 MILE EAST OF THE SCOTT COUNTY
Source Name LINE ON I-80 T-203A No. ____ Source Location ____ Sec. ____ Twp. ____ Range ____ County ____

Material Granular Subbase, 1" Class ____ Gradation No. 12 Beds ____

Material Producer Reilly Const. Destination Jobsite Sampled At Recycle Plant and off of Grade

Date Sampled	Sample Identification	Sampled By	Tested By	Sieve Analysis — in	1 in.	¾ in.	½ in	⅜ in	No 4	No 8	No 16	No 30	No. 50	No. 100	No. 200 Percent Passing	Other Test Results			Comp.	Tons
*Production Limits			Max.		100					35			15		6					
			Min.							10			0		0	Sampled at				
7/30	D1RA-91	Lamantia, Wood, McCull	Abbott		100	90	79	68	47	34	25	17	9.3	5.4	3.4	Plant				
7/31	D1JL-121	"	Lowder		100	91	79	65	45	34	24	16	8.5	4.9	3.1	Plant				
7/31	D1JL-122	"	Lowder		100	94	81	66	46	35	27	19	12	8.4	6.2	Grade				
8/01	D1RA-93	Abbott McCull	Abbott	100	99	91	81	70	50	36	27	18	9.6	5.7	3.7	Plant				
8/01	D1RA-94	"	Abbott		100	89	80	71	52	39	30	22	13	8.9	6.6	Grade				
8/02	D1RA-95	Abbott Wood	Abbott		100	87	73	61	43	31	23	15	7.5	4.0	2.2	Plant				
8/02	D1AW-28	"	Wood		100	89	79	67	47	34	26	19	12	8.5	6.4	Grade				
8/02	D1AW-27	"	Wood		100	88	73	61	41	30	22	15	8.0	4.8	3.2	Plant				

Note to County and Resident Engineers—If County or Project Number is incorrect, please notify Inspector and Ames Office Promptly. Corrected Reports will be issued.

Comments ____

ESTIMATED QUANTITY ____ Tons
TOTAL PREVIOUSLY CERTIFIED ____ Tons
TOTAL CERTIFIED TO DATE ____ Tons
CERTIFICATION NUMBER ____

*AGREED by the contractor/producer

Reported By Harold E McCullough
Representing IDOT

Distribution: White Copy - District Materials Engineer; Canary Copy - Project Consruction Engineer; Pink Copy - Certified Technician; Goldenrod Copy - Area Inspector

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2-89

Iowa Department of Transportation

CERTIFIED GRADATION TEST REPORT

County Cedar
Project IR-80-7(57)265--12-1
Contractor Fred Carlson Co.
Contract No. 33011
Design
Date 8/08/91 Report No. D1ML-189-19

☐ Certified Sample
☒ Monitor Sample (xxx)
☐ Verification Sample

RECYCLED CR. CONC. FROM JUST W. OF THE CEDAR RIVER, EASTERLY TO APPROX. 1/2 MILE EAST OF THE SCOTT COUNTY

Source Name LINE ON I-80 T-203A No. Source Location Sec. Twp. Range County

Material Granular Subbase, 1" Class Gradation No. 12 Beds

Material Producer Reilly Const. Destination Jobsite Sampled At Recycle Plant and off of Grade

Date Sampled	Sample Identification	Sampled By	Tested By	Sieve Analysis — in	1 in	¾ in	½ in	⅜ in	No 4	No 8	No 16	No 30	Percent Passing No 50	No. 100	No. 200	Other Test Results			Comp.	Tons
*Production Limits			Max.		100					35			15		6					
*Production Limits			Min.							10			0		0		Sampled at			
8/05	D1AW-29	Abbott Wood	Wood	100	99	94	84	71	50	37	28	21	13	9.4	7.2		Grade			
8/06	D1RA-97	Garrity Abbott	Abbott		100	95	85	73	54	42	32	24	15	11	8.4					

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Note to County and Resident Engineers—If County or Project Number is incorrect, please notify Inspector and Ames Office Promptly. Corrected Reports will be issued.

Comments

ESTIMATED QUANTITY ______ Tons

TOTAL PREVIOUSLY CERTIFIED ______ Tons

TOTAL CERTIFIED TO DATE ______ Tons

CERTIFICATION NUMBER ______

*AGREED by the contractor/producer

Reported By Harold E McCullough

Representing IDOT

Distribution: White Copy - District Materials Engineer; Canary Copy - Project Consruction Engineer; Pink Copy - Certified Technician; Goldenrod Copy - Area Inspector

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Iowa Department of Transportation

County Cedar
Project IR-80-7(57)265--12-16
Contract No. C33011
Design
Date 8/3/91
Report No. 113-91

DAILY CERTIFIED GRADATION TEST REPORT

Plant Location Wilton-Cedar Source Location I-80 Sec. Twp. Range County Cedar
Material #12 gran. sub. & #30 spec. bkfill Material Producer Reilly Const. Co., Inc. Beds
Contractor Fred Carlson Co. Destination I-80 Sampled at stream flow-mill 7/26-8/2, 1991

Lab. No.	Identification of Samples		— in.	1 in.	3/4 in.	1/2 in.	3/8 in.	No. 4	No. 8	No. 16	No. 30	No. 50	No. 100	No. 200							
*Production Limits		Max.							35			15		6							
		Min.		100					15			—		—							
188-91	7/26/91			100	84	67	54	36	26	20	14	8.2	5.1	3.5							1500 ton
189	7/29		100	98	88	74	62	44	33	26	19	12	7.7	4.5	non-comp., fixed problem in plant						1500 ton
190	7/29			100	89	78	66	46	33	25	19	13	8.9	6.2	non-comp., changed operators						1500 ton
191	7/30			100	87	75	62	42	30	22	16	9.9	6.5	4.4							1500 ton
192	7/31			100	89	74	60	40	29	21	14	8.4	5.1	3.3							1500 ton
193	8/1			100	87	77	62	44	31	22	15	8.4	5.0	3.1							1500 ton
194	8/2			100	86	70	58	40	27	19	13	7.4	4.6	3.1							1500 ton

Note to County and Resident Engineers—If County or Project Number is incorrect, please notify Inspector and Ames Office Promptly. Corrected Reports will be issued.

Comments copies to: Roger Boulet
Harold McCullough
Sue Holthaus
Reilly office

*APPROVED by the contractor/producer

(Check One)

ESTIMATED QUANTITY 10,500 Cu. Yd. / Tons
TOTAL PREVIOUSLY CERTIFIED — Cu. Yd. / Tons
TOTAL CERTIFIED TO DATE 10,500 Cu. Yd. / Tons
CERTIFICATION NUMBER 1352
Sampled and Tested By Susan K. Holthaus
Representing Reilly Construction Co., Inc.

Distribution: White Copy-Materials Office; Canary Copy-Materials/Engineer; Pink Copy-Resident Construction Engineer/County Engineer; Goldenrod Copy-Certified Technician