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Mr. Bearce

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Report on Molding Sand Testing Technique - Investigation of Effect of Rammer Support on Physical Properties

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APPENDIX

ABSTRACT

Various methods of supporting the AFA standard sand rammer were studied to find their effects on sand strength and permeability. It was found that shock absorbing supports were unsatisfactory. Several acceptable methods are described.

Authorization

1. The study of steel castings was authorized by the Bureau of Engineering letter QP/Castings (6-19-Ds) of 13 July 1928.

Known Facts Bearing on the Problem

2. There has been considerable discussion regarding the cause of variations in sand test results between various laboratories when attempts are made to check techniques. One of the conditions suspected of causing variable results is the foundation of the sand rammer. It is generally agreed that it should be solid as possible but laboratories differ in their interpretation of the degree of solidity necessary.

3. At the Naval Research Laboratory one rammer is mounted on a cast iron pedestal and the other is mounted on an eight-inch wooden post both extending down to the concrete floor. Another laboratory uses a 1 x 18 x 22-inch steel plate which rests near the center of a large table. Concrete and wooden posts are frequently used for foundations while some rammers are secured to a table directly over one leg. On the underside of the rammer base is a boss which is designed to make good contact with the supporting foundation. It has been noted, however, that in some cases, the boss is not in a plane with the feet at the corners of the rammer. Consequently if the rammer is placed upon a flat surface it will be supported only at the corners and will give a spongy reaction.

4. Variations are also possible in the method in which the weight is raised and dropped. On rammers equipped with cams and cranks, the speed at which the crank is turned and the way it is manipulated seem to affect the results. On rammers without cranks, variations result from the manner in which the operator holds and releases the weight. Unless the hands are removed quickly they will absorb some of the energy of the drop. However, these are variables which can be readily standardized for any given laboratory.

Experimental Procedure

5. In order to determine the importance of securely mounting the rammer, a series of tests was made. As a preliminary step the bottom on the rammer was machined flat and scraped to match a surface plate. It was decided to mount the rammer on several types of foundations, including one with shock absorbers, and to place steel blocks of various weights between the rammer and the shock absorbers to see if it is possible to have a large enough reaction block to deliver all of the ramming energy to the specimen regardless of the springiness of the foundation.

6. A 200-pound batch of sand was mixed containing 188-pounds of washed silica sand, 10-pounds of western bentonite, 2-pounds of corn flour binder and approximately 4 percent water. This was mixed for one minute dry and mulled for five minutes wet. It was then screened through a one-quarter inch screen, placed in a ten-gallon galvanized can with a tight fitting cover and left to temper overnight.

7. Before starting tests the next morning, the sand was stirred in the can and a small amount removed and screened again. This was placed in a gallon jar which was sealed immediately. Each series of tests consisted on ten determinations of green permeability and green compressive strength. The weights of the specimens were also recorded. A slight correction was made when necessary on the weights of the second or third specimen. Plates 1 to 18 show the set-up used and the green permeability and green compressive strength. In each of the eighteen (18) plates, the last line is the average of the ten tests.

Discussion of Results

8. Series 1 to 6 (Plates 1 to 6) were made with the rammer resting on a spruce board, 1 x 12 x 60-inches, which was supported at each end by a brick, so that the unsupported length was 52-inches. In Series 1 (Plate 1) the rammer base was clamped directly to the board as shown in Plate 1, and in Series 2 to 6 additional weights were added between the base of the rammer and the board as shown in Plates 2 to 6, inclusive. It was thought that it might be possible to add enough mass so that energy from the drop weight would all be transferred to the specimen. The average of these six series of tests show that with 166-pounds underneath the rammer, compressive strength values are still increasing. Since green compressive strength seems to be the most sensitive test, the results of this test will be discussed instead of density and green permeability. These values are also reported in the tables for general interest.

9. Series 7 (Plate 7) shows the results of placing the rammer on the concrete floor. Two weights were placed under the rammer but at this time no method was available for fastening the assembly to the floor. The average green compressive strength was 7.244 pounds per square inch. The last figure given has little value and is retained only for computing percent deviation from average results. Extrapolating the curve shown in Plate 19 to intersect the strength value produced by placing the rammer on the concrete floor indicated the possibility that placing weights totaling 250-pounds under the rammer base might give results equal to those produced when the rammer was placed on the concrete floor. In later tests this did not prove to be the case.

10. As an alternative to the board, a group of rubber shock absorbers was placed under a stack of five weights as shown in Plate 8. The green compressive strength produced in this case was 6.962 pounds per square inch. A similar arrangement was tried with only one weight between shock absorbers and the base of the rammer. It is shown on Plate 9. This mounting produced a green compressive strength of 6.866 pounds per square inch. Thus it is seen that, even with a weight of 166-pounds, maximum compressive strength can not be developed on shock absorbing devices.

11. Series 10 (Plate 10) shows the effect of placing the rammer on the iron stand which has been used here for several years. The strength produced was 7.236 pounds per square inch. This checks very closely with that produced with the rammer on the floor. Series 11 (Plate 11) includes only five tests and was made with the rammer fastened to the top of the table over one leg. The table top was a two-inch plank, and the legs were 4 x 4-inches square and about 30-inches long. The strength produced was 7.294 pounds per square inch.

12. The tests described above were completed on the same day. Two days later seven more series of tests were run which were made on the same batch of sand but the results are not necessarily comparable to those from the tests described above because the sand had two additional days to temper. The first of these tests, Series 12 (Plate 12), was made with the rammer fastened to the concrete floor by small expansion shields called corkers. Care was taken to select a very flat area on the concrete. The strength produced was 7.472 pounds per square inch. Series 13 (Plate 13) was made with the rammer placed on rubber shock absorbers with weights totaling 261.7 pounds. The strength produced was only 7.138 pounds per square inch which is well below that produced by a rigid support. In Series 14 (Plate 14) the rammer was placed on a wooden foundation consisting of a cylindrical post, 8-inches in diameter and 38-inches high, to the top of which was fastened an oak block 2 x 7 x 10-inches. The post was fastened to the floor and the rammer secured to the top. The strength produced was 7.471 pounds per square inch which is almost identical with that produced when the rammer was on the concrete floor.

13. The tests on the iron stand were made by two different operators and are shown as Series 15 and 16 in Table 1. The strength of the specimens made by the first operator was 7.368 pounds per square inch while that produced by the second was 7.489 pounds per square inch, a difference of 0.121 pounds per square inch. The average of these results is 7.428 pounds per square inch. The deviation from the average is 0.061 pounds per square inch and the percent deviation is 0.8 percent. This is believed to be satisfactory agreement for tests of this type.

14. In order to give the shock absorbing devices the best possible test, it was decided to run one more series with a heavier weight than had been used previously. The board was used and loaded with steel blocks with weights totalling 328-pounds. The rammer was clamped on top of these and ten tests were made in which the green compressive strength averaged 7.210 pounds per square inch as shown in Series 17 (Plate 17). From this it is concluded that it is not practical to use shock absorbing devices of other non-rigid supports.

15. For the final series of tests the corner of the table was sanded to a very flat surface and the rammer clamped tightly to it. These tests, Series 18, produced a green compressive strength of 7.526 pounds per square inch. The average results from the eighteen series described above are shown in Table 1.

16. Since these tests were made on different days, those made the first day are not comparable to those made two days later. To form a basis for comparison it was decided to average the results of tests made on the rigid supports for each day separately. The individual results for each day may then be discussed as percentage deviations from the average for that day. This information is shown in Table 2. The green compressive strength is 0.207 pounds per square inch higher on the second day than on the first. The maximum deviation from the average was 1.30 percent and the average deviation from the average only 0.45 percent.

Conclusions

17. From this work the following conclusions may be drawn:

a. Between specimens rammed on rigid and non-rigid supports, a difference in density, permeability and strength exists. This difference is most easily detected in the green compressive strength tests. Values for the conditions tested ranged from 6.50 to 7.53 pounds per square inch.

b. Non-rigid supports should not be used. This includes wooden tables, tables on wooden floors, etc. Setting the rammer over the leg of a heavy table seems to be very satisfactory if supported on a concrete floor or foundation.

c. Shock absorbing devices, even with large weights between the rammer and the shock absorbers, do not produce specimens equivalent to those made on rigid supports.

d. Only minor differences were found to exist between the various types of rigid support. Steel, concrete or wooden columns, securely anchored with the rammer fastened tightly to the top, are all satisfactory. They should rest on a substantial floor, preferably of concrete. Mounting the rammer directly over the leg of a heavy table produces good results. In this case, care should be taken to be sure that the fit between the rammer base and the table top is good.

e. All four legs and the boss under the drop weight should bear on the support and the rammer should be securely bolted down.

f. It is desirable to have the bottom side of the rammer base machined flat or at least so that the boss and all the legs are in the same place. A good fit to any flat surface is then assured.

TABLE 1

Summary of Test Results

Date	Series No.	Weight Lbs.	Green Permeability	Green Compressive Strength	Description of Foundation
11/17/43	1	152	128	6.623	Board as described
"	2	152.5	126	6.495	Board with 29.5#
"	3	153.5	121.6	6.704	" " 60.5#
"	4	154	123.2	6.753	" " 95.6#
"	5	154	122.8	6.968	" " 130.9#
"	6	154.5	119	7.052	" " 166.0#
"	7	155	112.3	7.244	Concrete floor plus 65# - no corkers
"	8	154.5	119	6.962	Shock Absorbers plus 166#.
"	9	153.5	128	6.866	Shock Absorbers plus 35.1#
"	10	155.5	115	7.236	Iron Stand
"	11	155	115	7.294	Corner of Table
11/19/43	12	155	118	7.472	Concrete floor - corkers
"	13	154	123.2	7.138	Shock absorbers plus 261.7#
"	14	154.5	122	7.471	Wooden Post
"	15	154	125.6	7.368	Iron Stand, 1st oper.
"	16	154	126.2	7.489	Iron Stand, 2nd oper.
"	17	153	128	7.210	Board with 323#.
"	18	154.5	126	7.526	Corner of Table.

TABLE 2

Comparison of Results on Different Days using Rigid Foundations

Date	Series No.	Average of Series	Deviation from the Average	Percent Deviation from the Average
11/17/43	7	7.244	.014	0.19
"	10	7.236	.022	0.30
"	11	7.294	.036	0.49
		7.258 pounds per square inch - Average Compressive Strength on Rigid Foundations		
11/19/43	12	7.472	.007	0.09
"	14	7.471	.006	0.08
"	15	7.368	.097	1.30
"	16	7.489	.024	0.32
"	18	7.526	.061	0.82
		7.465 pounds per square inch - Average Compressive Strength on Rigid Foundations		

0.45 percent mean deviation from average.

SERIES I

Weight	Green Permeability	Green Comp. Strength
155	128	6.32
152	128	6.50
152	128	6.72
152	128	6.64
152	128	6.62
152	128	6.68
152	128	6.80
152	128	6.65
152	128	6.70
152	128	6.60
Average	128	6.623

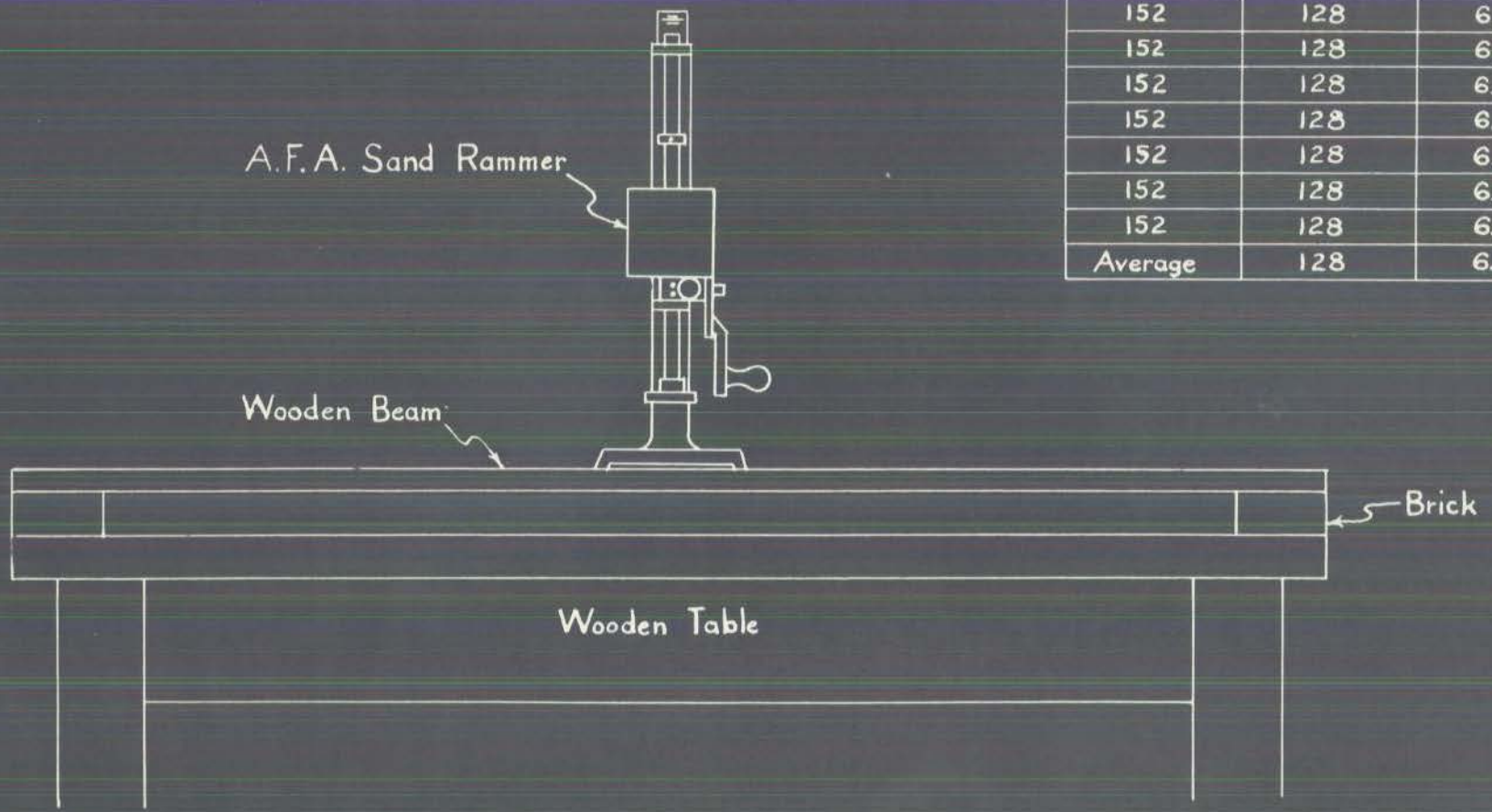


PLATE I

AFA SAND RAMMER MOUNTED ON WOODEN BEAM

SERIES 2

Weight	Green Permeability	Green Comp. Strength
152	126	6.38
152.5	126	6.42
152.5	126	6.38
152.5	126	6.52
152.5	126	6.58
152.5	126	6.42
152.5	126	6.82
152.5	126	6.48
152.5	126	6.54
152.5	126	6.41
Average	126	6.495

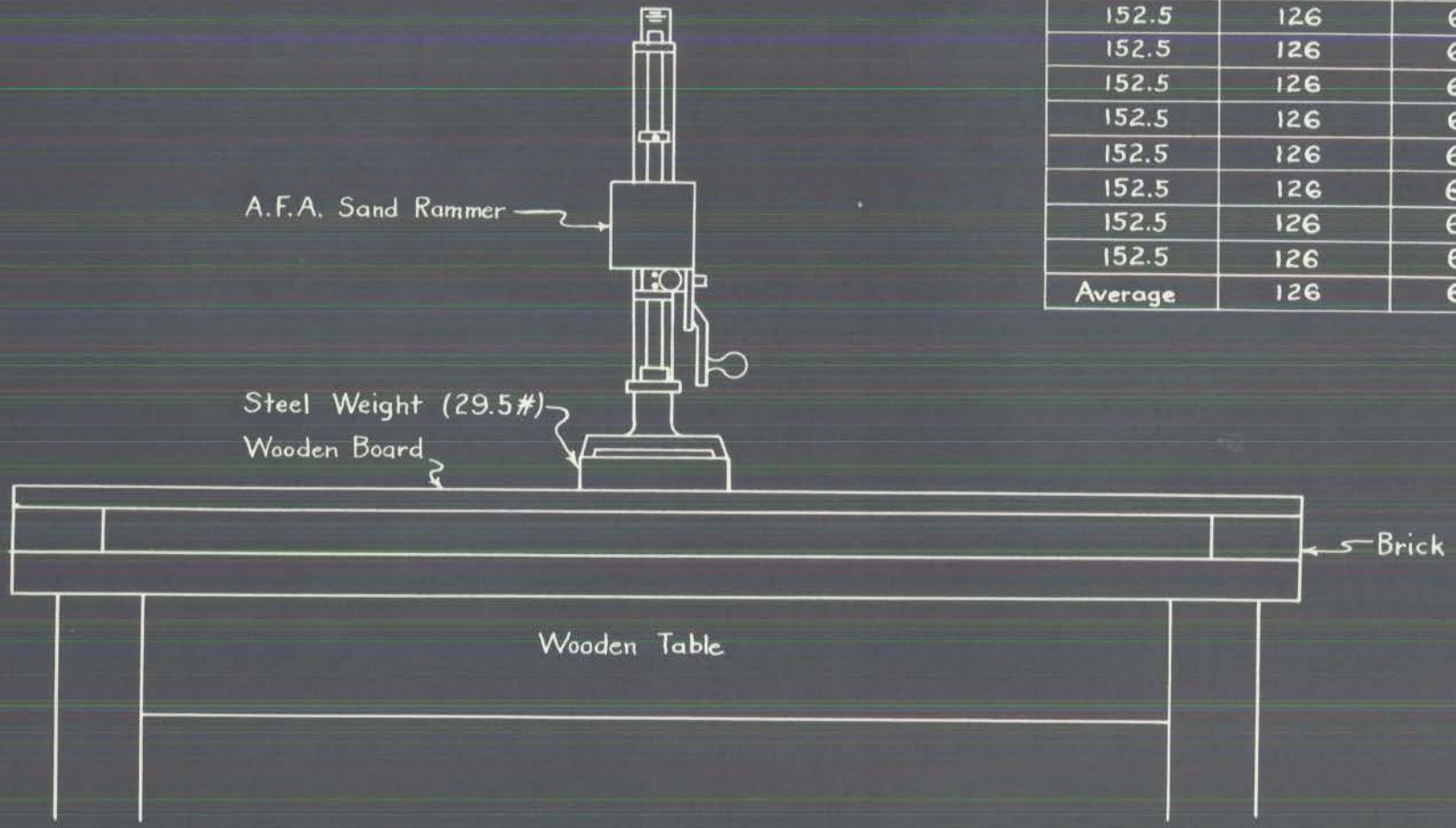


PLATE 2

AFA SAND RAMMER MOUNTED ON WOODEN BEAM WITH 29.5 LB. REACTION BLOCK

SERIES 3

Weight	Green Permeability	Green Comp. Strength
153	119	6.88
153.5	119	6.52
153.5	119	6.54
153.5	119	6.82
153.5	126	6.60
153.5	122	6.94
153.5	122	6.82
153.5	122	6.64
153.5	122	6.58
153.5	126	6.70
Average	121.6	6.704

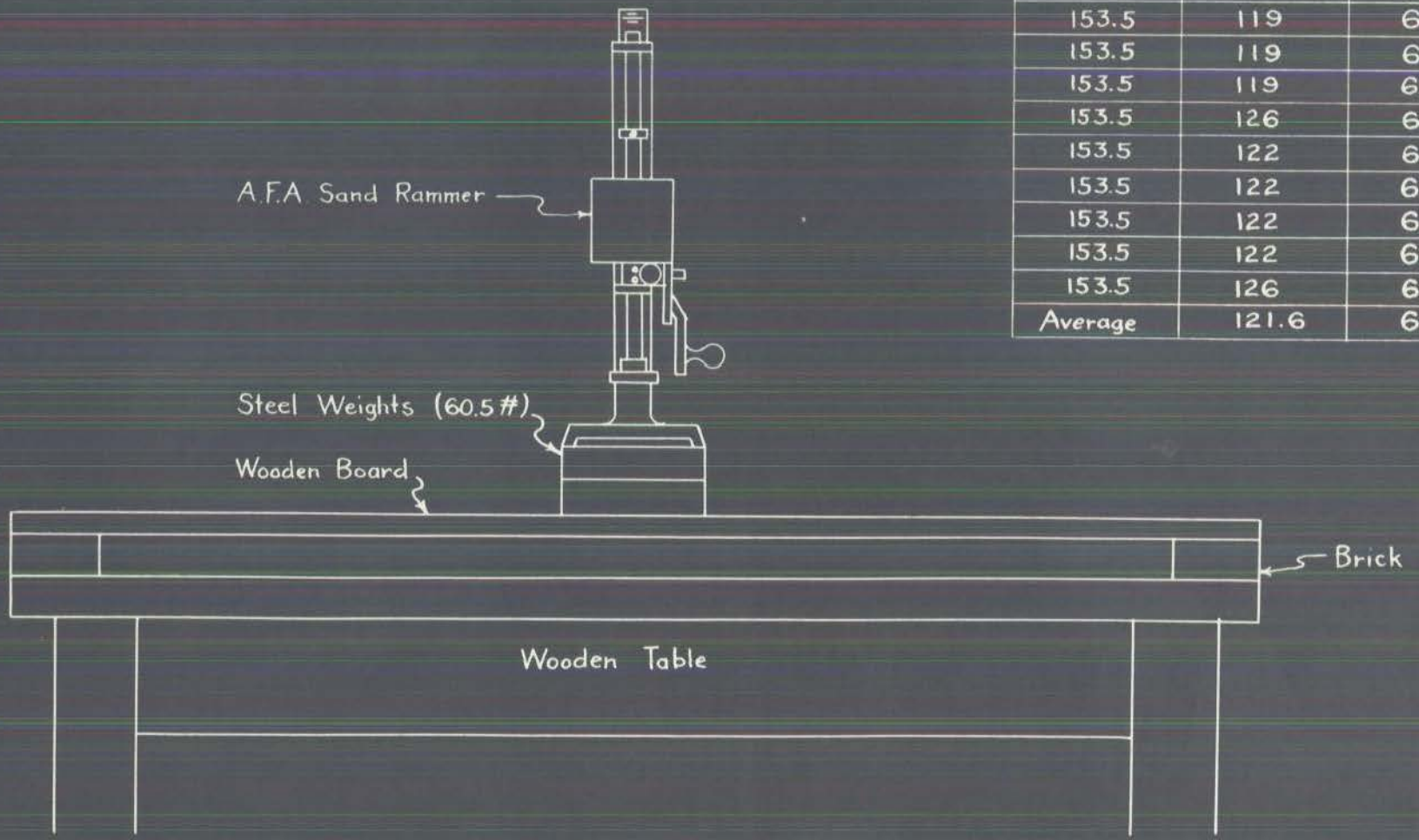


PLATE 3

AFA SAND RAMMER MOUNTED ON WOODEN BEAM WITH 60.5 LB. REACTION BLOCK

SERIES 4

Weight	Green Permeability	Green Comp. Strength
154	122	6.78
154	122	6.72
154	122	6.78
154	126	6.70
154	122	6.80
154	122	6.74
154	126	6.81
154	122	6.68
154	122	6.78
154	126	6.70
Average	123.2	6.753

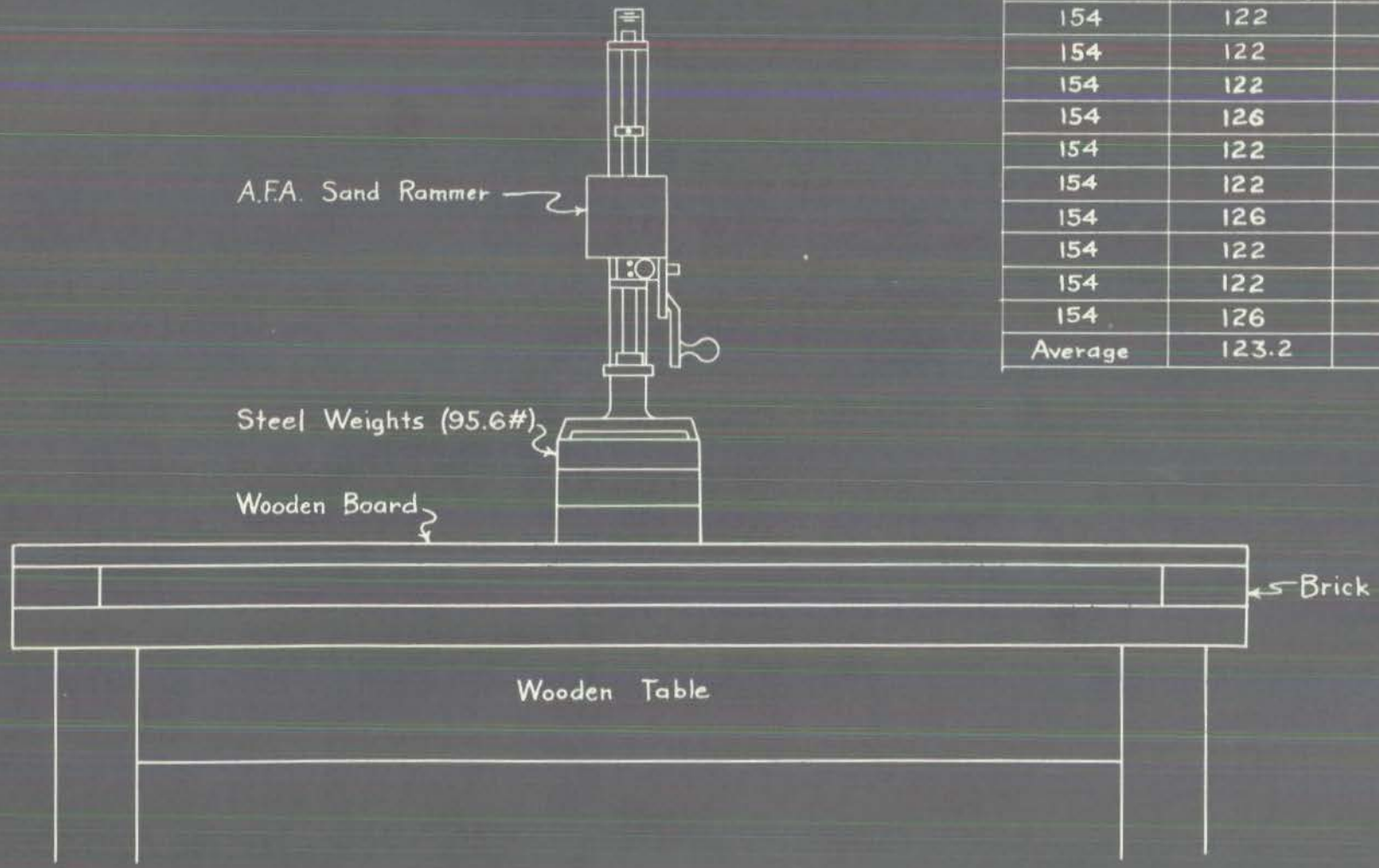
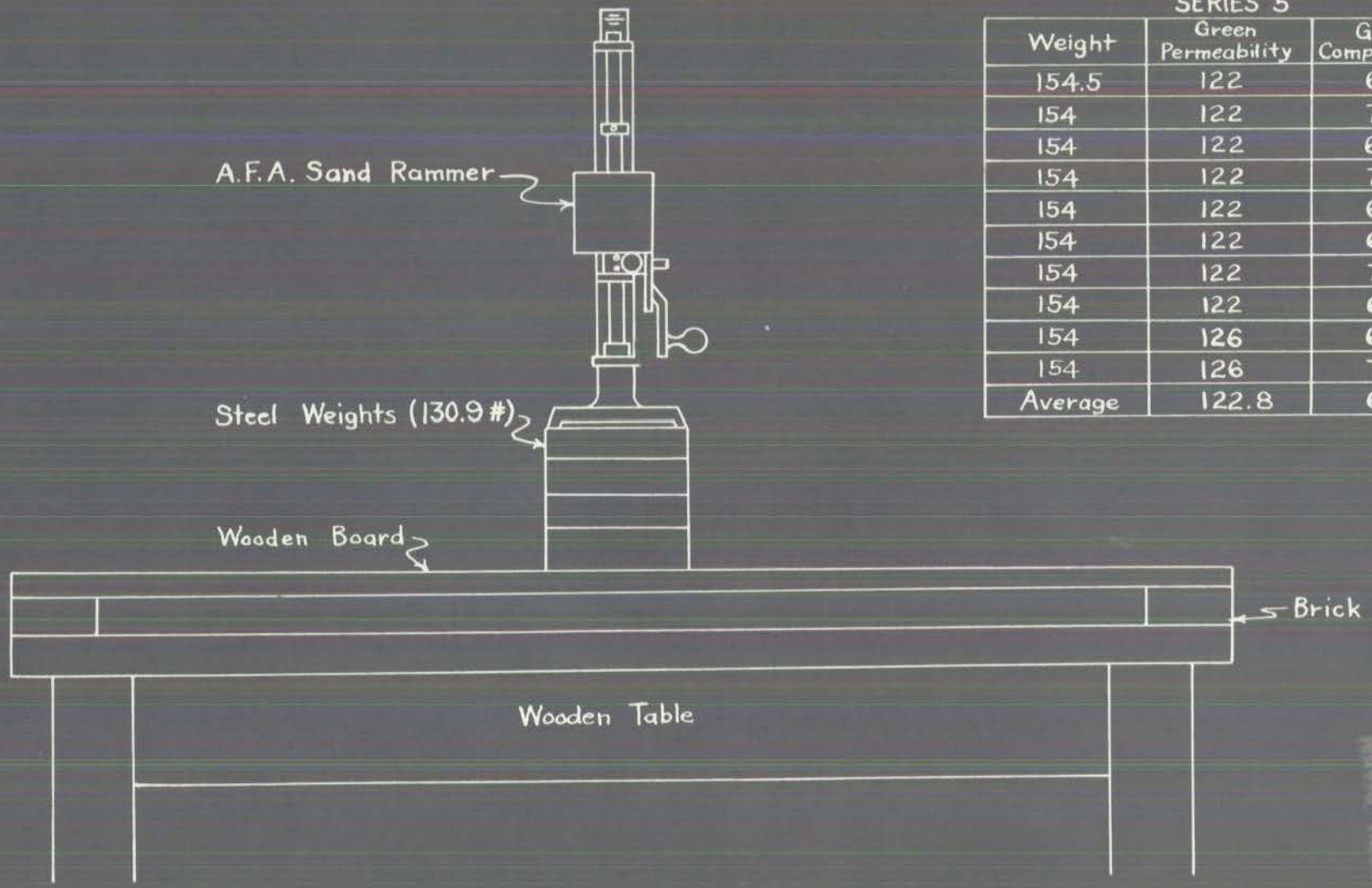


PLATE 4

AFA SAND RAMMER MOUNTED ON WOODEN BEAM WITH 95.6 LB. REACTION BLOCK

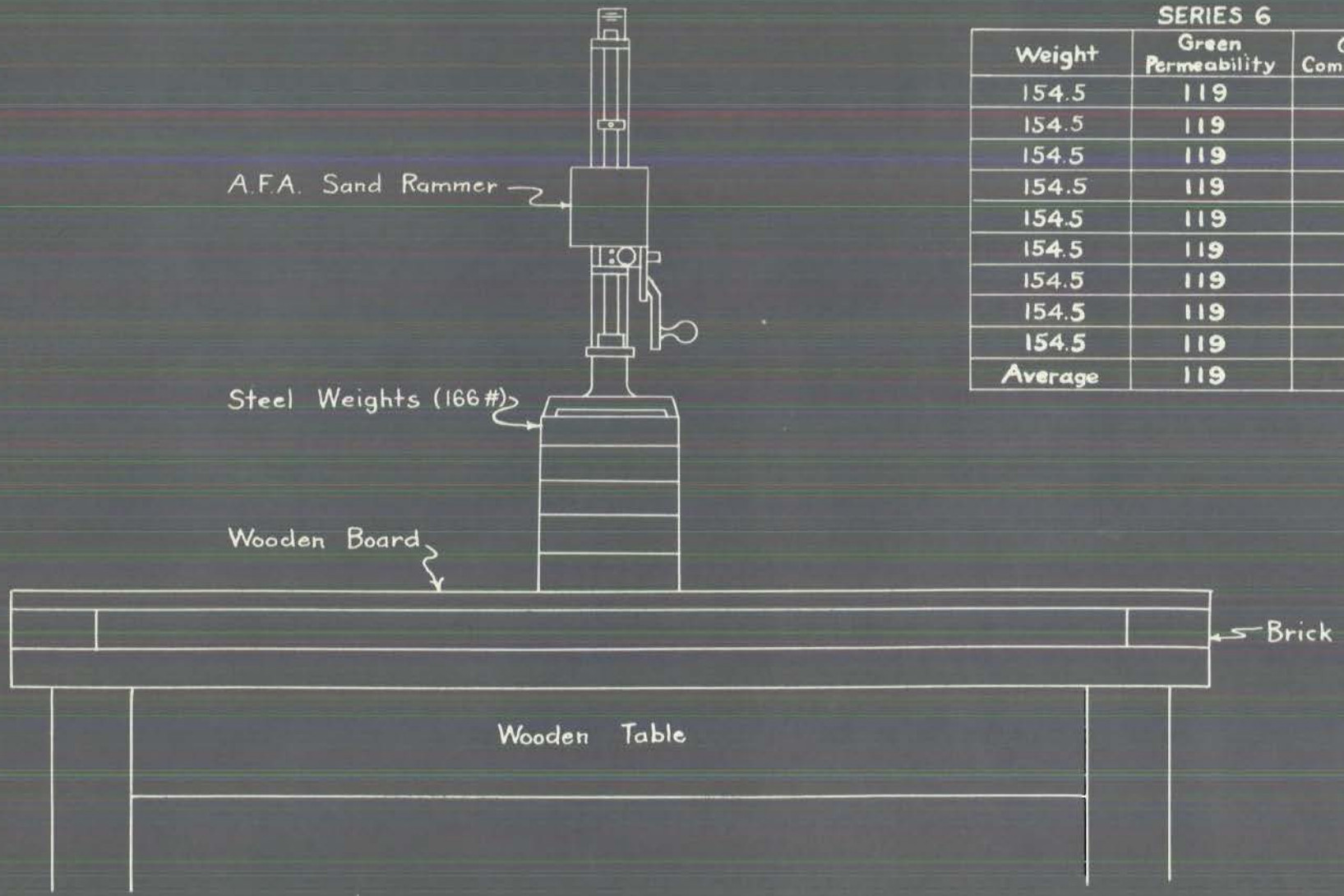


SERIES 5

Weight	Green Permeability	Green Comp. Strength
154.5	122	6.92
154	122	7.02
154	122	6.82
154	122	7.00
154	122	6.88
154	122	6.98
154	122	7.22
154	122	6.82
154	126	6.94
154	126	7.08
Average	122.8	6.968

PLATE 5

AFA SAND RAMMER MOUNTED ON WOODEN BEAM WITH 130.9 LB. REACTION BLOCK



SERIES 6

Weight	Green Permeability	Green Comp. Strength
154.5	119	7.20
154.5	119	7.00
154.5	119	6.88
154.5	119	7.20
154.5	119	7.28
154.5	119	6.92
154.5	119	7.18
154.5	119	7.02
154.5	119	6.92
Average	119	7.052

PLATE 6

AFA SAND RAMMER MOUNTED ON WOODEN BEAM WITH 166.0 LB. REACTION BLOCK

SERIES 7

Weight	Green Permeability	Green Comp. Strength
155	112	7.20
155	112	7.38
155	112	7.24
155	112	7.30
155	115	7.12
155	112	7.22
155	112	7.12
155	112	7.30
155	112	7.28
155	112	7.28
Average	112.3	7.244

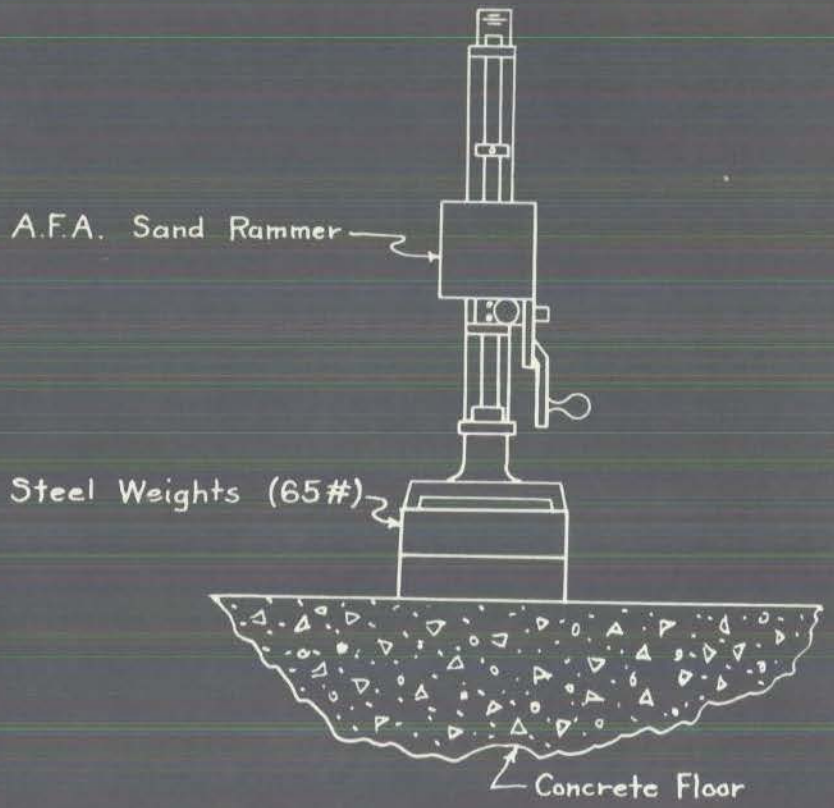
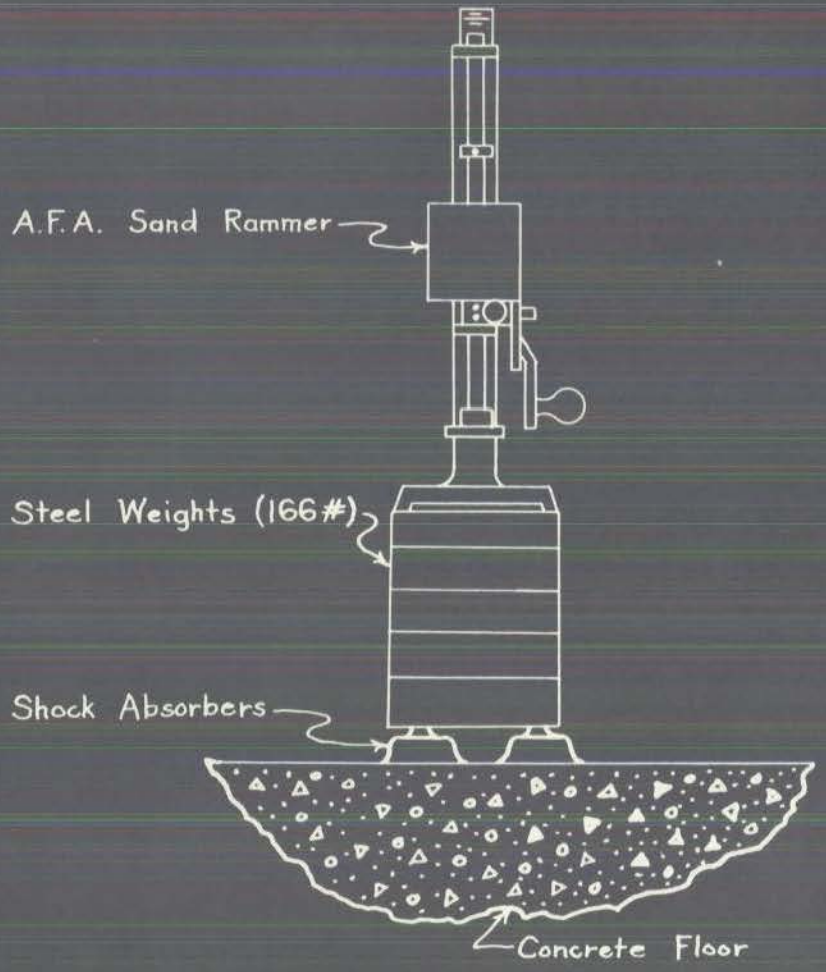


PLATE 7

AFA SAND RAMMER MOUNTED ON CONCRETE FLOOR



SERIES 8

Weight	Green Permeability	Green Comp. Strength
154.5	119	6.94
154.5	119	6.88
154.5	119	6.78
154.5	119	7.12
154.5	119	6.92
154.5	119	6.84
154.5	119	7.12
154.5	119	7.06
154.5	119	6.94
154.5	119	7.02
Average	119	6.962

PLATE 8

AFA SAND RAMMER MOUNTED ON SHOCK ABSORBERS AND 166.0 LB. REACTION BLOCK

SERIES 9

Weight	Green Permeability	Green Comp. Strength
152.5	128	6.88
153.0	126	7.12
153.5	128	6.52
153.5	128	6.70
153.5	126	7.10
153.5	126	6.88
153.5	126	6.84
153.5	128	7.18
153.5	128	6.80
153.5	128	6.64
Average	127.2	6.866

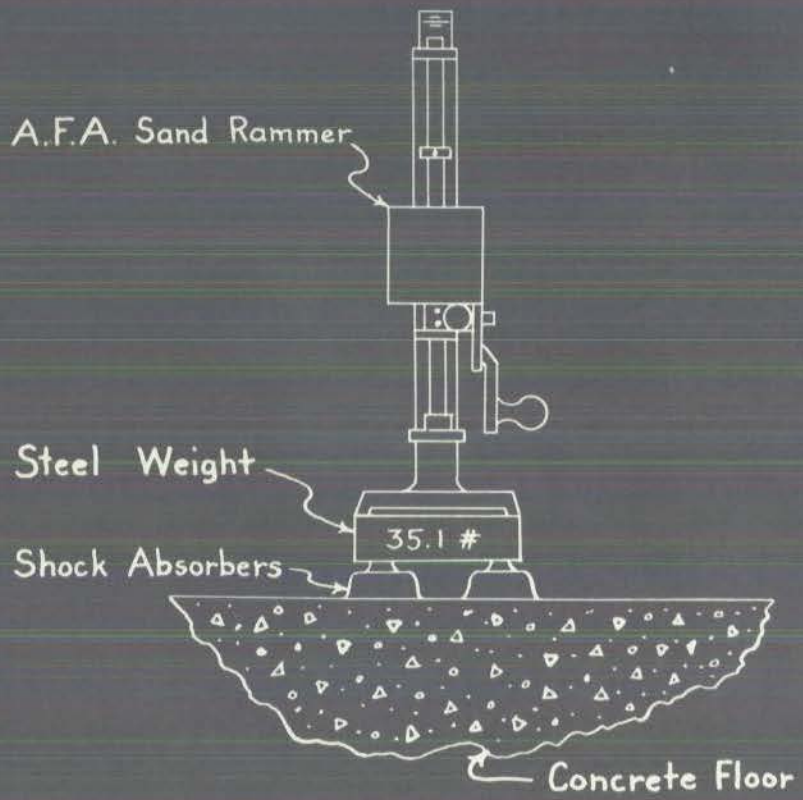
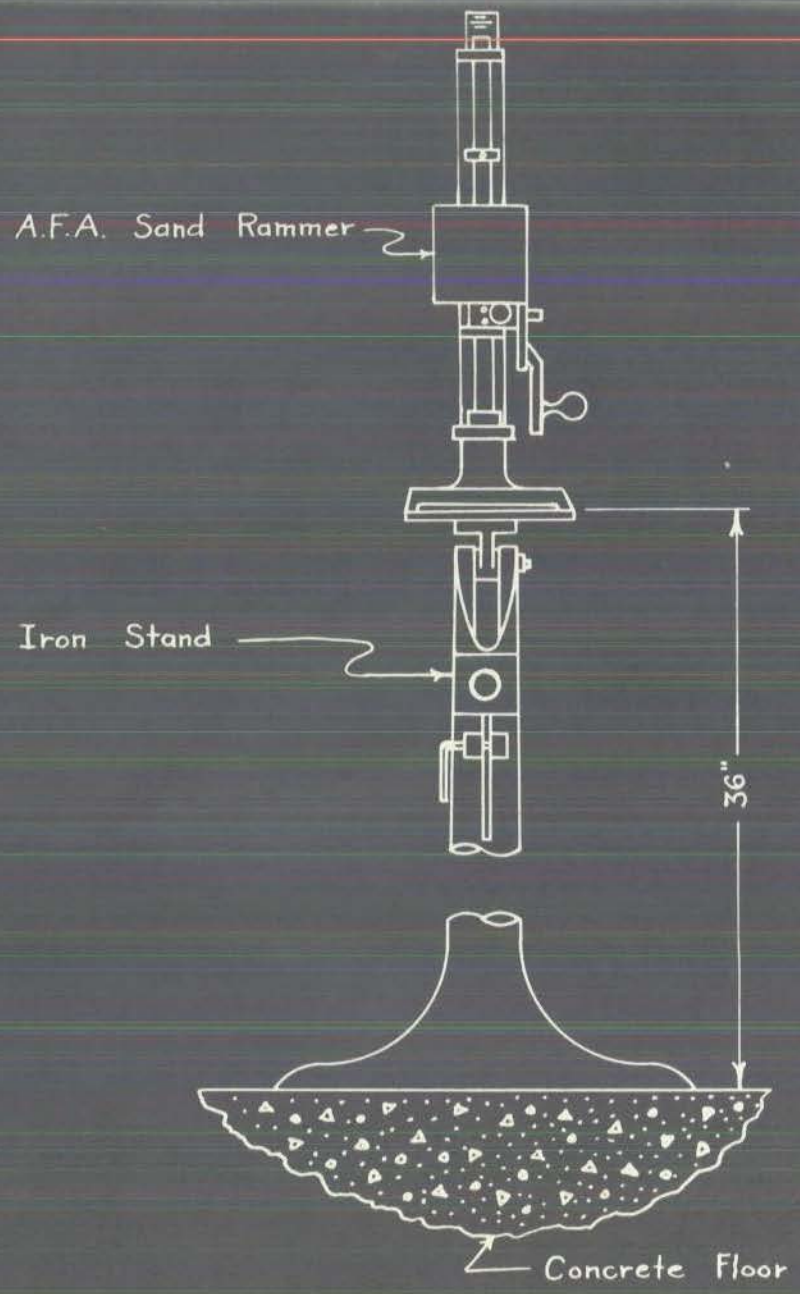


PLATE 9

AFA SAND RAMMER MOUNTED ON SHOCK ABSORBERS AND 35.1 LB. REACTION BLOCK



SERIES 10

Weight	Green Permeability	Green Comp. Strength
155	115	7.18
155.5	112	7.52
155.5	115	7.38
155.5	115	7.18
155.5	115	6.80
155.5	115	7.30
155.5	115	7.20
155.5	115	7.10
155.5	115	7.12
155.5	115	7.58
Average	114.7	7.236

PLATE 10

AFA SAND RAMMER MOUNTED ON IRON STAND

SERIES II

Weight	Green Permeability	Green Comp. Strength
154.5	115	7.22
155	115	7.42
155	115	7.28
155	115	7.30
155	115	7.25
Average	115	7.294

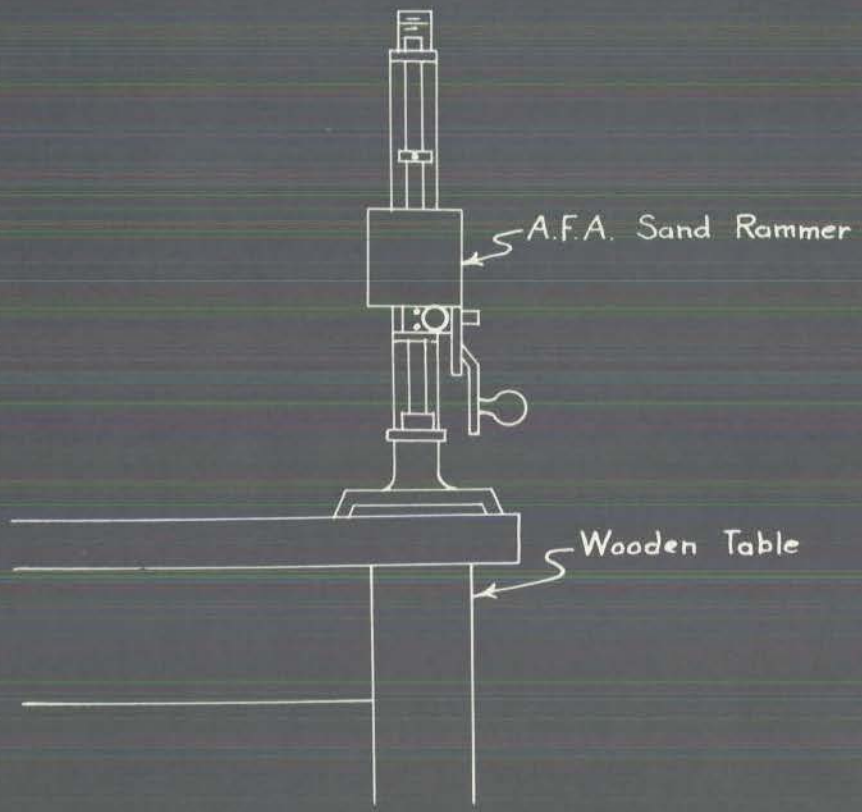


PLATE II

AFA SAND RAMMER MOUNTED ON CORNER OF WOODEN TABLE, FIRST DAY

SERIES 12

Weight	Green Permeability	Green Comp. Strength
155	119	7.38
155	119	7.40
155	119	7.32
155	119	7.40
155	119	7.50
155	119	7.38
155	122	7.20
155	119	7.62
155	119	7.86
155	115	7.66
Average	118.9	7.472

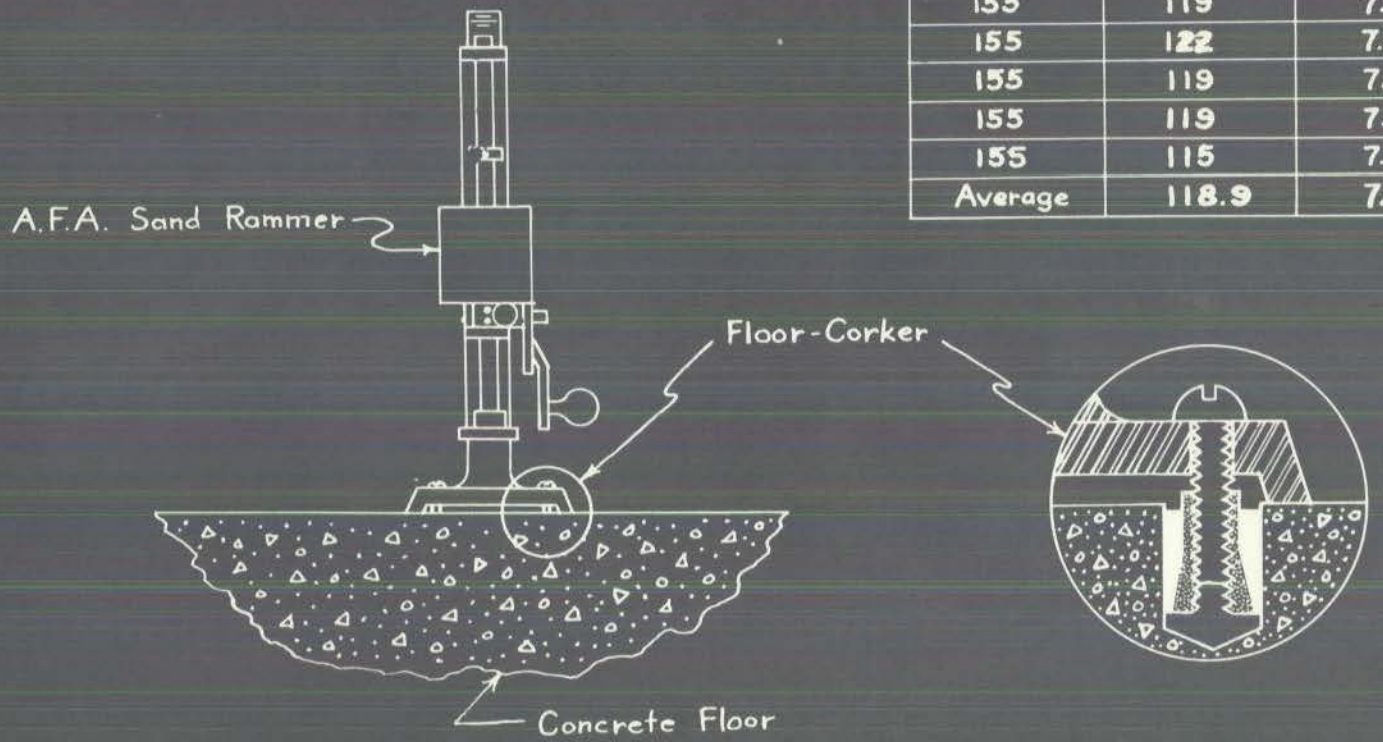
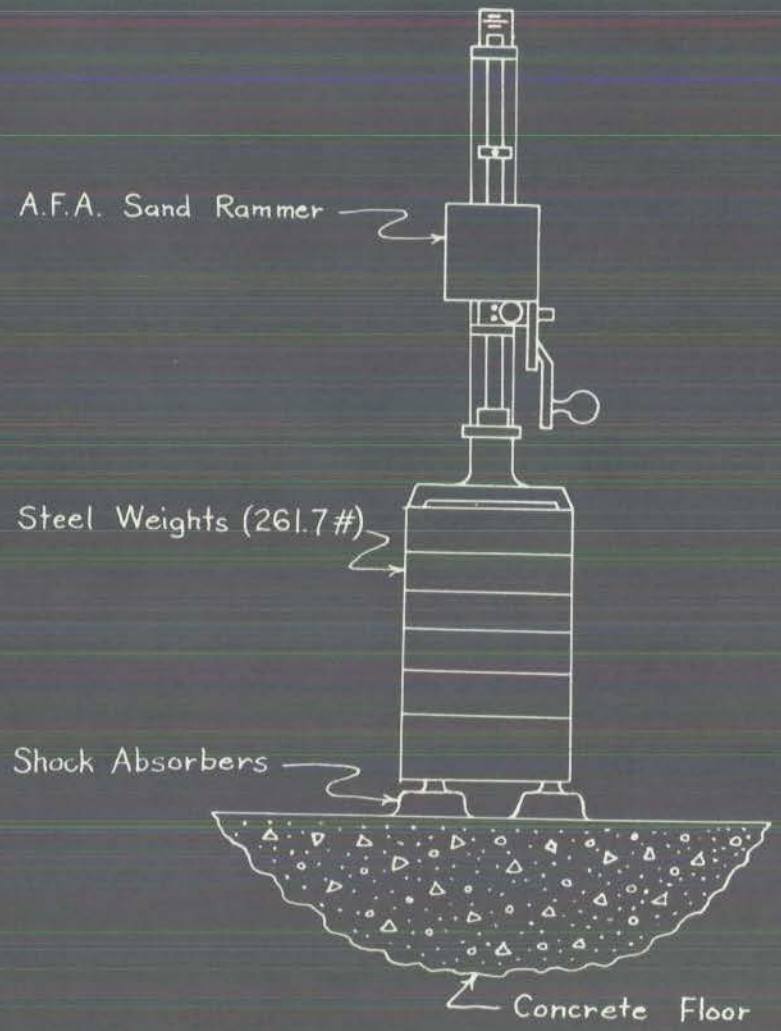


PLATE 12

AFA SAND RAMMER MOUNTED ON FLOOR AND SECURED WITH CORKERS

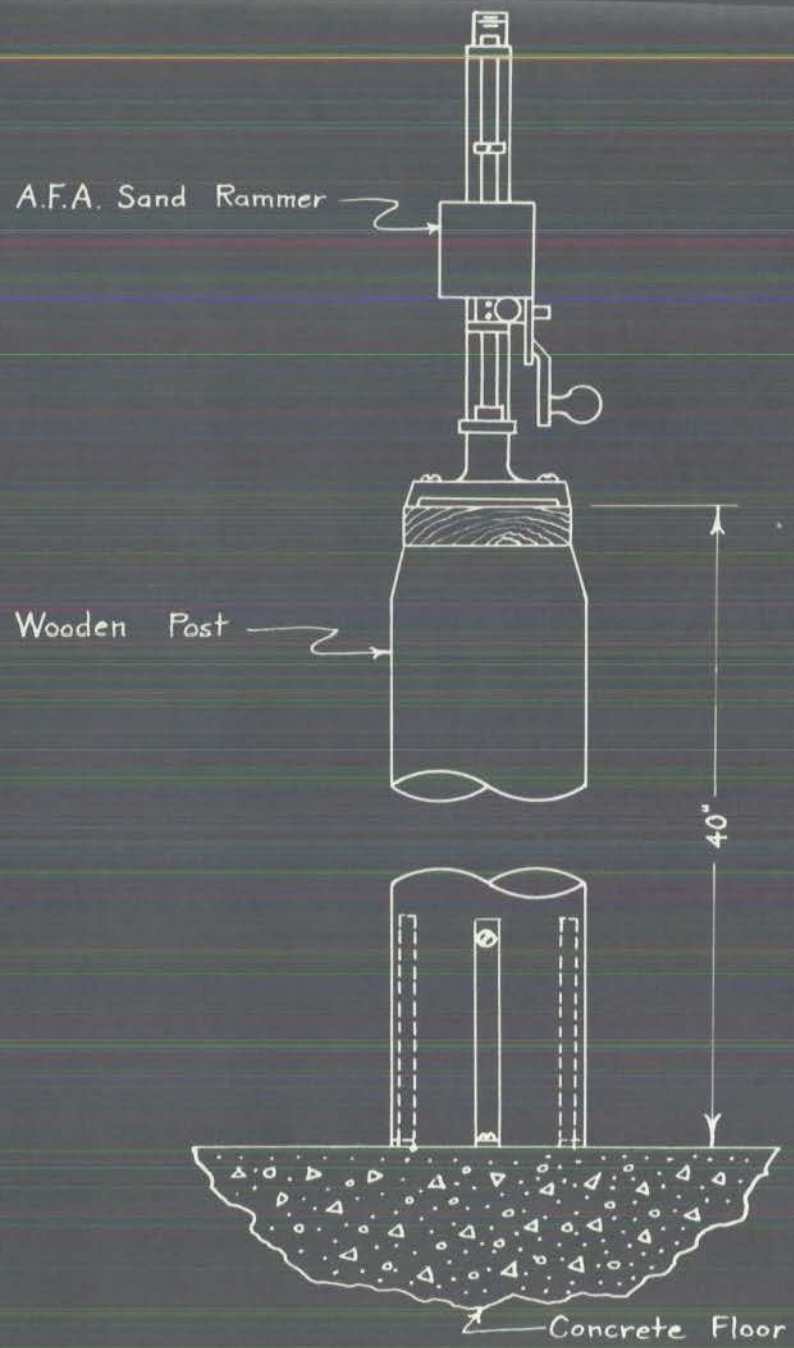


SERIES 13

Weight	Green Permeability	Green Comp. Strength
155	122	6.98
154	122	7.20
154	122	7.40
154	122	7.28
154	126	7.08
154	122	7.10
154	122	7.02
154	122	6.98
154	126	6.92
154	122	7.42
Average	123.2	7.138

PLATE 13

AFA SAND RAMMER MOUNTED ON SHOCK ABSORBERS WITH 261.7 LB. REACTION BLOCK

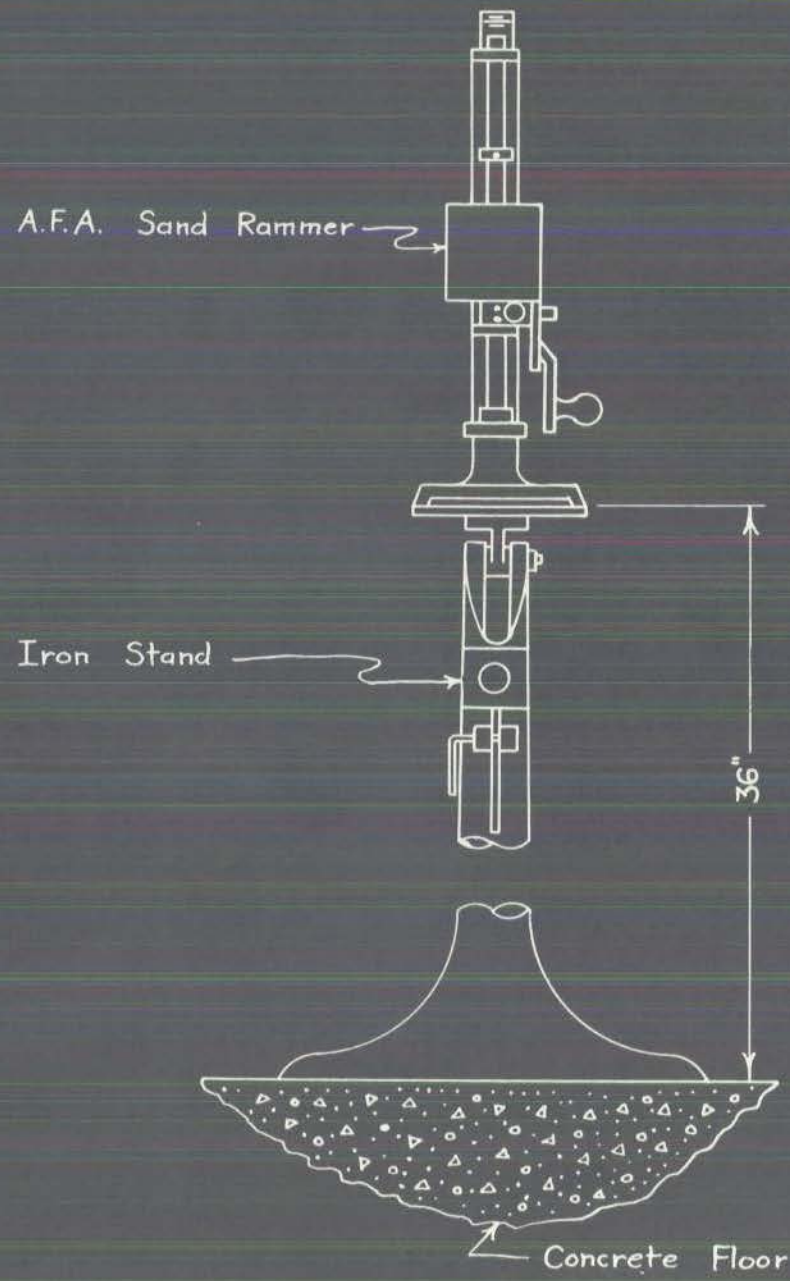


SERIES 14

Weight	Green Permeability	Green Comp. Strength
155	122	7.28
154.5	122	7.28
154.5	122	7.64
154.5	122	7.46
154.5	122	7.35
154.5	122	7.48
154.5	122	7.50
154.5	122	7.64
154.5	122	7.50
154.5	122	7.48
Average	122	7.471

PLATE 14

AFA SAND RAMMER MOUNTED ON WOODEN POST

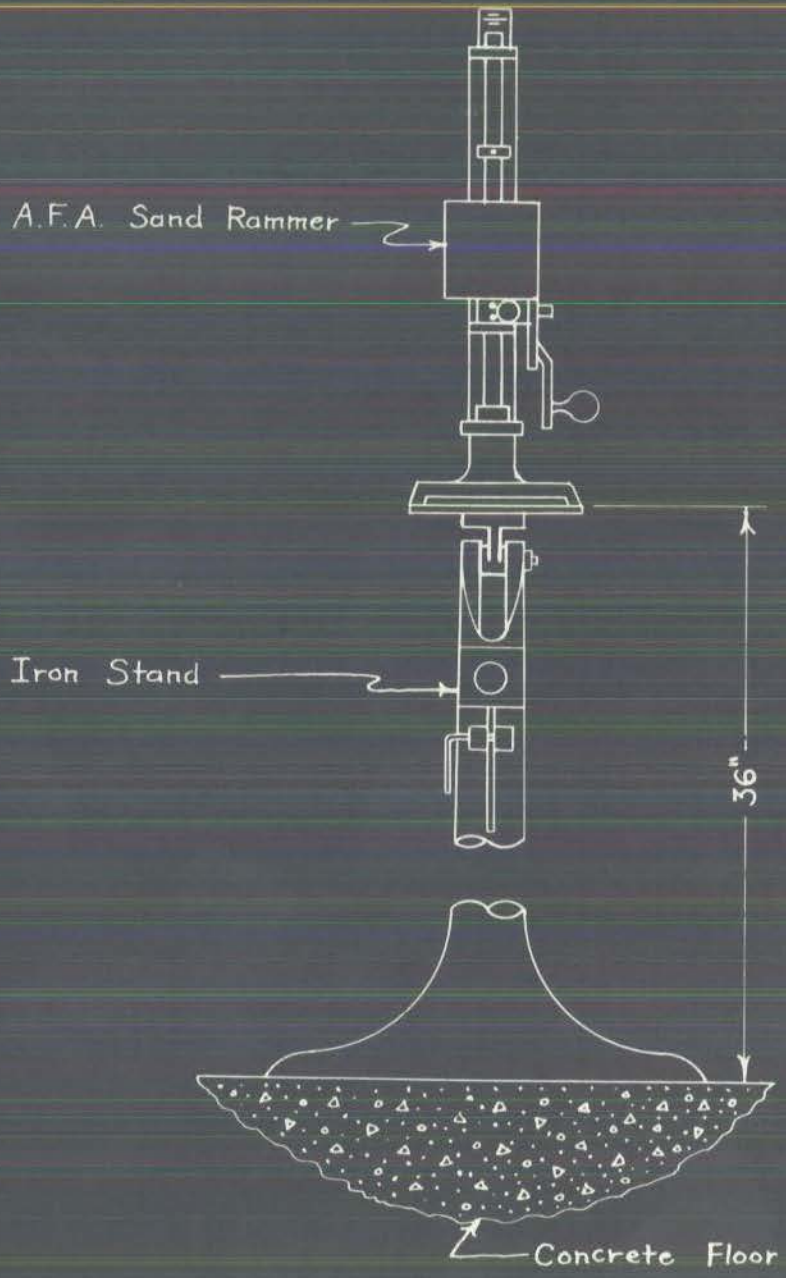


SERIES 15

Weight	Green Permeability	Green Comp. Strength
154.5	126	7.22
154	126	7.42
154	122	7.34
154	126	7.46
154	126	7.50
154	126	7.24
154	126	7.36
154	126	7.42
154	126	7.42
Average	125.6	7.368

PLATE 15

AFA SAND RAMMER MOUNTED ON IRON STAND, FIRST OPERATOR

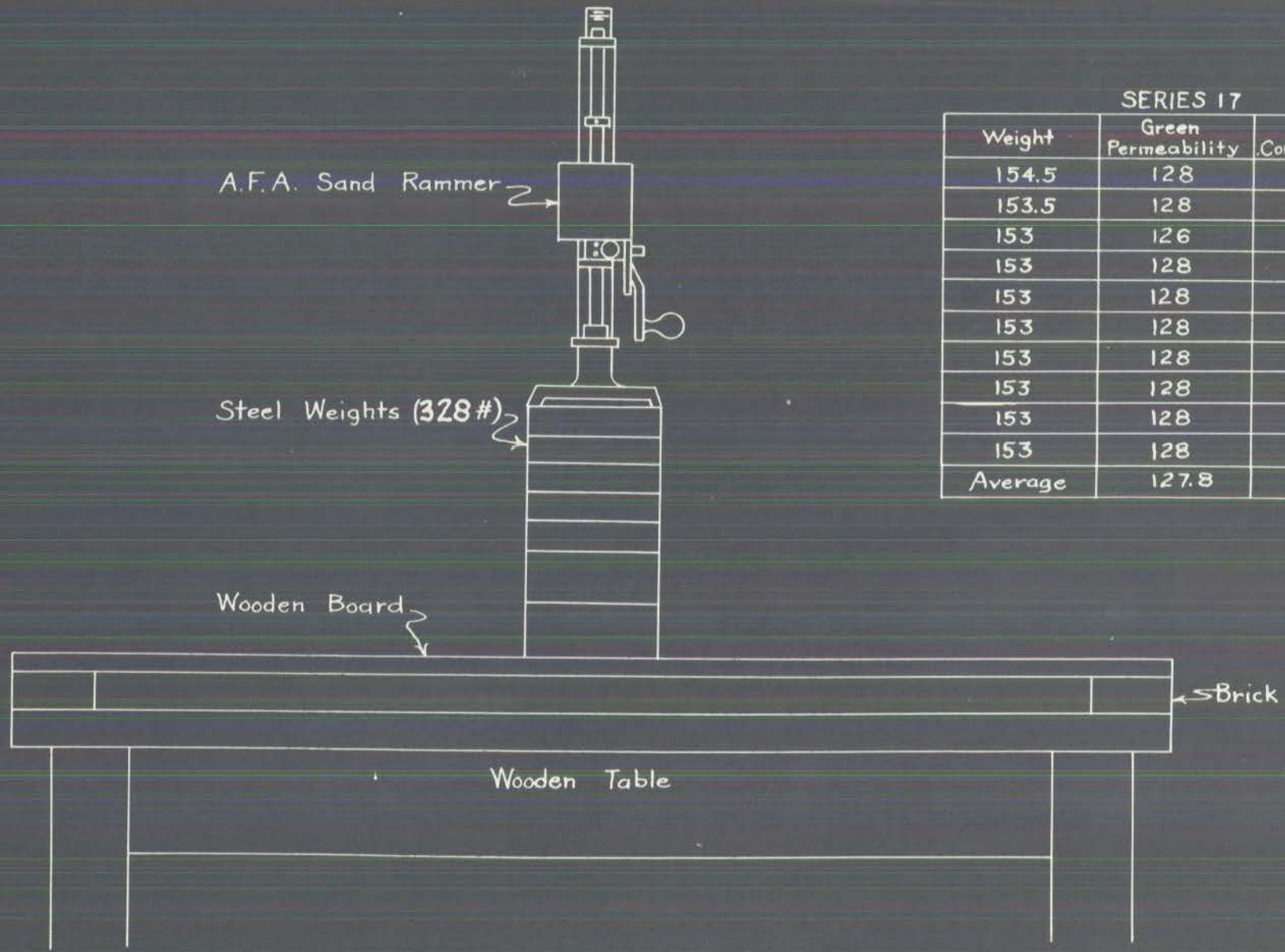


SERIES 16

Weight	Green Permeability	Green Comp. Strength
154	126	7.48
154	126	7.52
154	128	7.52
154	126	7.43
154	126	7.51
154	126	7.56
154	126	7.52
154	126	7.47
154	126	7.45
154	126	7.43
Average	126.2	7.489

PLATE 16

AFA SAND RAMMER MOUNTED ON IRON STAND, SECOND OPERATOR



SERIES 17

Weight	Green Permeability	Green Comp. Strength
154.5	128	6.96
153.5	128	7.08
153	126	7.42
153	128	6.98
153	128	7.12
153	128	7.14
153	128	7.24
153	128	7.22
153	128	7.28
153	128	7.66
Average	127.8	7.210

PLATE 17

AFA SAND RAMMER MOUNTED ON WOODEN BEAM WITH 328 LB. REACTION BLOCK

SERIES 18

Weight	Green Permeability	Green Comp. Strength
154.5	126	7.42
154.5	126	7.52
154.5	126	7.68
154.5	126	7.50
154.5	126	7.52
154.5	126	7.72
154.5	126	7.48
154.5	126	7.40
154.5	126	7.52
154.5	126	7.50
Average	126	7.526

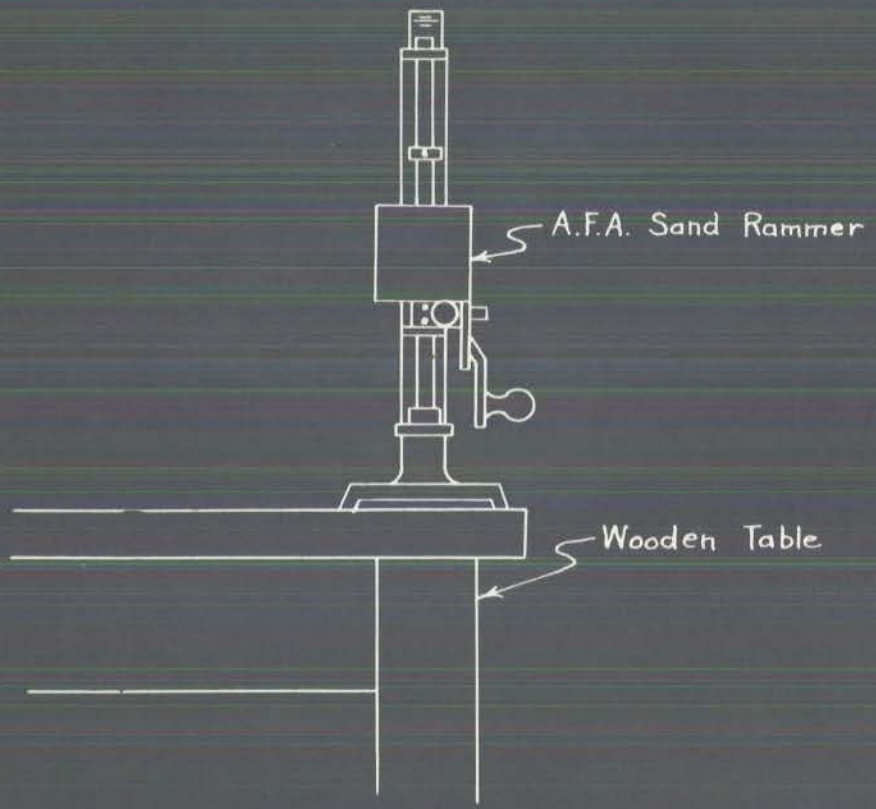


PLATE 18

AFA SAND RAMMER MOUNTED ON CORNER OF WOODEN TABLE, SECOND DAY

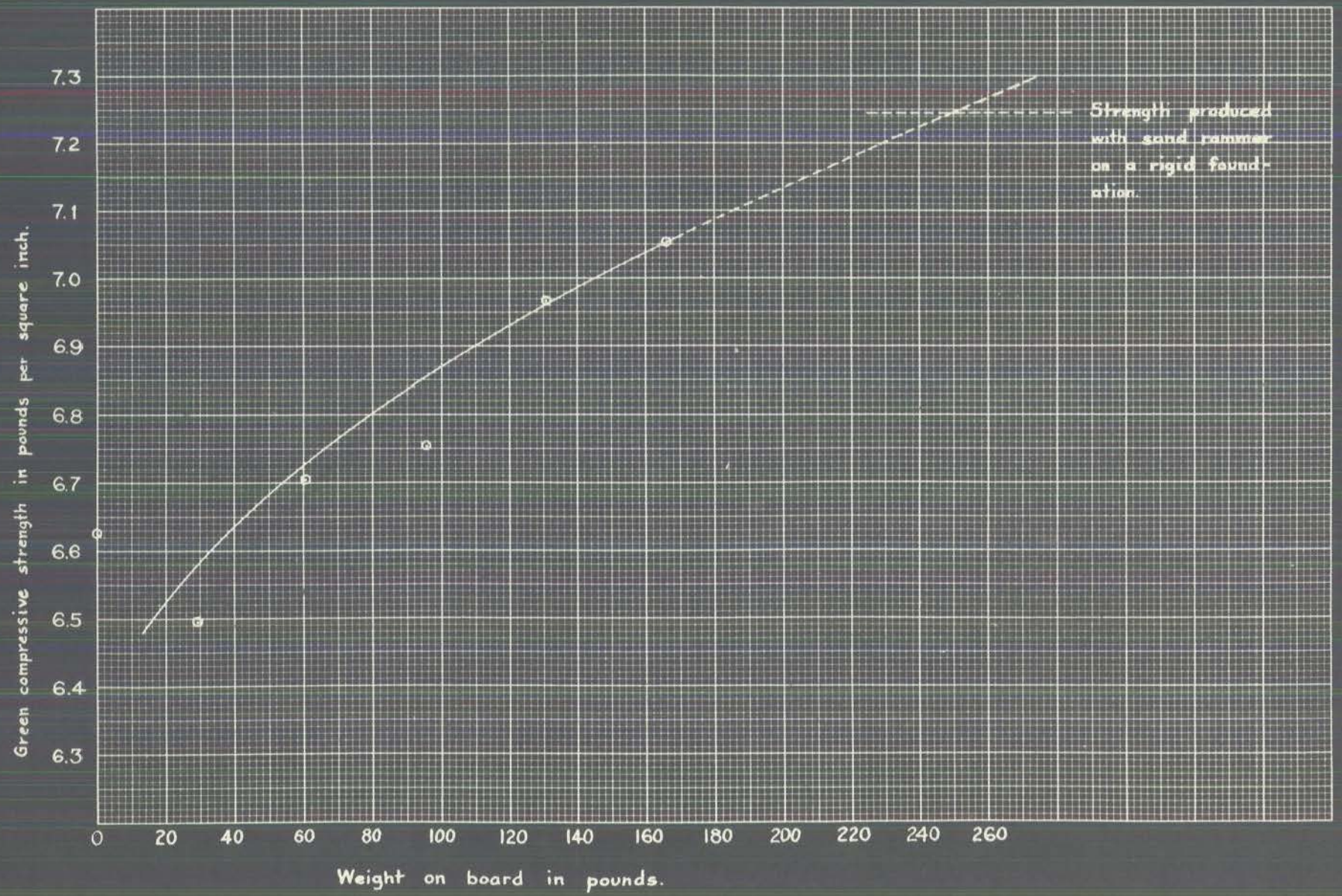


PLATE 19

STRENGTH AS A FUNCTION OF WEIGHT OF REACTION BLOCK