STATISTICAL EVALUATION OF RAINFALL-SIMULATOR AND EROSION TESTING PROCEDURE

Final Report

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ABSTRACT

As had been stated in a previous developmental research study (3), much money, time and work are expended each year in evaluating new erosion control products, such as mulches or chemical additives for retarding soil erosion or promoting grass stand growth. Test locations in the field are now hard to find; therefore, a better method of first checking these products had to be found so that only the better products should be further field tested.

From this developmental study, a tentative laboratory test procedure involving a rainfall-simulator had been developed by which these products could be evaluated; however, complete testing for statistical purposes had not been accomplished.

The specific aims of the present research study were: (1) to supply documentation of statistical repeatability and precision of the rainfall-simulator and to document the statistical repeatibility of the soil-loss data when using the previously recommended tentative laboratory test procedure; (2) to reevaluate, if necessary, the design and operation of the rainfall-simulator; (3) to reevaluate, if necessary, the tentative laboratory test procedure in light of results obtained both in this study and the previous study; and (4) to provide additional test data on some of the materials tested, time permitting.

These aims were carried out in a series of repetitive tests, first with water tests alone to check out the design and operation of the rainfall-simulator, then together with several different series of soil-loss tests to check out the use of the tentative laboratory test procedure. Observations, test data and logic provided the basis for revisions both in the design and operation of the rainfall-simulator and in the use of the tentative laboratory test procedure.

Principal conclusions determined in the study were as follows: (1) the easily constructible revised rainfall-simulator was capable of statistically repeatable operation; (2) use of the revised tentative laboratory test procedure was justified from analysis of test results; (3) revisions were necessary in the original design and operation of the rainfall-simulator and were made, resulting in a better operating device; and (4) revisions were necessary in the original tentative laboratory test procedure as used in these studies and were made, resulting in a more efficient and simplified laboratory test procedure.

Principal recommendations were: (1) that the research study soil-loss data, water-output data and respective statistical-repeatability data be accepted as documentation of completion of specific aims of the study; (2) that the construction of the rainfall-simulator, as shown in the revised construction details found in the Appendix, be accepted as a necessary tool in performance of laboratory testing of new products in the erosion retardant field; and (3) that the revised laboratory test procedure entitled "Tentative Method of Test for Simulated Rainfall Soil-Loss Values," found in the Appendix, be accepted for use in testing new erosion control products placed on the market to determine whether these products are promising enough to be field-tested.

IMPLEMENTATION

Administrative decisions will be needed for acceptance and use of the tentative laboratory test procedure and for construction of the rainfall-simulator. Plans are available on the rainfall-simulator, and the New Products Evaluation Committee will be a key to the recommendation for the implementation of the report findings. Laboratory space, financial requirements or needs, adoption and familiarization with the tentative laboratory test procedure are some of the items to be dealt with in the implementation procedure. Full implementation should lead to a useful new test procedure and test device to evaluate erosion-retarding materials.

INTRODUCTION

From a previous research project, titled "Erosion Evaluation Study," (3)* a tentative laboratory test procedure had been developed by which new chemical additives or mulches for retarding soil erosion could be evaluated prior to determining the necessity for further field testing. A rainfall-simulator had been designed and operated using this procedure; however, complete testing for statistical purposes had not been accomplished. Complete sets of water test and soil-loss test data were still necessary to determine statistical repeatability and precision. Some additional data was also needed to substantiate the data obtained in the previous developmental study.

Further evaluations of the design and operation of the rainfall-simulator and of the structuring of the tentative laboratory test procedure were needed to confirm the reliability and best operation of the rainfall-simulator in this procedure. Revisions were to be made where necessary and practical.

*Underlined number in parenthesis refers to report listed in Bibliography.

PURPOSE AND SCOPE

The specific aims of this study were (1) to supply documentation of statistical repeatability and precision of the rainfall-simulator and to document the statistical repeatability of the soil-loss data when using the previously recommended tentative laboratory test procedure, (2) to reevaluate, if necessary, the design and operation of the rainfall-simulator, (3) to reevaluate, if necessary, the tentative laboratory test procedure in light of results obtained both in this study and a previous study, and (4) to provide additional test data on some of the materials tested.

These aims were to be carried out in a series of repetitive tests, first with water tests alone to check out the design and operation of the rainfall-simulator, then together with several different type series of soil-loss tests to check out the use of the tentative laboratory test procedure. Observations, test data and logic provided the confirmation for revisions both in the design and operation of the rainfall-simulator and in the use of the tentative laboratory test procedure.

METHODOLOGY

Since the prime aim of this study was to provide data on statistical repeatability of the rainfall-simulator and to check out the statistical repeatability of soil-loss data using the tentative laboratory test procedure, reconstruction of the rainfall-simulator was needed. After reconstruction the rainfall-simulator was prepared for operation, and all constants, controls and operational techniques were checked out.

A review was made of the previous literature search on the rainfall-simulator and all previous test data. Following observations of the reconstructed rainfall-simulator in operation, preliminary plans were made as to the scheduling or progress of the study. It was realized some revisions in the design and operation of the rainfall-simulator were necessary; however, these were to be made after the first series of statistical repeatability data was obtained operating under the same conditions as in the previous research study.

First Series of Tests

The constants for the design and operation of the rainfall-simulator as recommended in the previous study (3) and used in obtaining the first series of tests in this study were as follows:

1.	Test Nozzle	Spraying Systems Company, Fulljet 3/4 HH 50 SQ
2.	Height of Nozzle	Eight feet (2.44 meters) directly above the center of the test surface
3.	Spray Direction	Downward perpendicular to the floor, platform or ground
4.	Water Pressure	6.0 psi (41.4 kPa)
5.	Water Flow	4.0 gpm (0.25 liters per second)
6.	Water Intensity for 1 Hr.	21.5 in. per hour (54.6 cm. per hour)

7. Slope Angle of Test Pan* 4°

8. Sampling Time with Test Application* 12 minutes

*Later revised for second set of data to 8° and 5 minutes, respectively.

A water pressure regulator was used to reduce and regulate the line water pressure to a constant pressure of 6 psi (41.4 kPa). Also, dual pressure gauges at the nozzle assembly were used to eliminate any chance of erroneous single pressure gauge readings during operation.

As noted in the previous research study, all of the characteristics incorporated in the design and operation of the rainfall-simulator should produce simulated rainfall-data with uniformity of distribution and reproducible intensities. The main objective of this study was to verify consistency, which certainly was achieved.

Actual construction details of the rainfall-simulator, such as materials, framing, bracing, etc., will be subject to change as the builder and/or user sees fit to take care of safety, durability, appearance, ease of construction and ease of operation. In this study the rainfall-simulator was constructed of slotted steel, making the erection simple and low cost. The previously mentioned constants were still the main details to always be kept the same, no matter what other details were changed.

The first step in the laboratory study procedure was the procurement of a suitable soil to be used as the test soil. A good topsoil was delivered to the test site, where it was stockpiled and covered.

Soil test pans essentially were 4" (10.2 cm.) deep and 32 3/8" (82.2 cm.) square, yielding a surface area of 1/6000 acre. Soil-loss runoff was channeled through a flume from the pans to a collecting tank with dimensions of 2' x 2' x 2' (61.0 cm. x 61.0 cm. x 61.0 cm.).

Test samples were placed in the pans, with soil being loosely compacted in the pans to a depth of 3" (7.6 cm.) and smoothed over. Moisture contents were determined for each sample. All the test samples were obtained from the same source and tested the same way with the emphasis on consistency. Soil moisture samples were taken on each pan of soil tested and used in the calculation of dry weight of soil. With the empty pan weight and the weight of pan plus soil having been obtained, the dry weight of soil in the pan could be calculated.

Using standard recommended amounts (3) of grass seed, fertilizer and mulch, along with the quantity of water (3) recommended for the pan surface area, the materials were placed on the soil and water tests were run for immediate results. Appropriate pans were set aside for three weeks for grass to germinate and grow. Tests were then also run at the three-week period. Aside from statistical repeatability data, comparisons were made against a control set of test pans.

Testing procedures included: (1) placing the appropriate pan with soil in a position exactly centered on the platform and with a slope* of 4°, (2) attaching the appropriate flume to the pan at the low end in a position to drop the runoff into the collection tank, (3) making sure the collection tank was clean, in a condition to easily mark the volume of runoff sampling for the suspension tests, (4) having timing device (watch) available for 12-minute test time,** and (5) having tarpaulins in place for wind protection of water drops.

The following block diagram shows the first series of tests:

*Later revised to 8° for the second series of tests.

**Later revised to 5 minutes for the second series of tests.

BLOCK DIAGRAM FOR
FIRST SERIES OF TESTS

Number of Soil Test Pans or Tests

Sample	Immediate Tests	Three Week Tests
Control - A	3	3
Mulch - B	3	3
Mulch - C	3	3
Stabilizer - D	3	3

Water flow and water pressure at the nozzle were checked prior to testing to make sure adequate flow was present with a 6 psi (41.4 kPa) water pressure. Position of the nozzle perpendicular to the platform and downward was checked also.

Water was then turned on with a 6 psi (41.4 kPa) water pressure and kept on for exactly 12 minutes.** Two different measurements on runoff amounts were made on each pan, an oven-dried method of measurement and a solids-in-suspension method of measurement. Although the oven-dried method of measurement had been recommended from the previous developmental study, it was felt that both methods should be further tested statistically and an evaluation made for any possible revisions.

At two-minute intervals, beginning at the one-minute mark, equal portions of suspended runoff sample were collected in a can, to form one sample, from the drop-off point at the collection tank. A ratio or multiplication factor was established between the total volume of runoff collected in the tank and the volume of runoff sampled in the can. The dry weight of solid runoff material collected in the can was determined in grams, converted to pounds and multiplied by the previously determined ratio to obtain the total dry weight of solid runoff material in the test.

**Later revised to 5 minutes for the second series of tests.

When water testing on the soil was complete, the alternate method of determining soil-loss was used with the soild pans being placed in an oven to dry for three days; then each pan with soil was weighed. The dry soil weight could then be calculated since the weight of the pan was already known. The difference between the dry weights of soil before and after the water test was the amount of soil-loss due to runoff.

Test result data was accumulated, tabulated and analyzed.

Second Series of Tests

Before the second series of tests was begun, some preliminary testing was needed using various combinations of the slope of the pan and the time of testing or sampling. From observations and data on previous testing, it was felt that some revisions in these two items mentioned above were warranted. In order to check out the values considered best, other values were also tried along with these, and results were compared and evaluated. Consequently, the slope of the pan was changed to 8°, and the time of testing or sampling was changed to five minutes with all of the sample collected in the can at that one time. It was felt that the greater slope angle of the pan would create more runoff or soil-loss, and the change in sampling time would lessen the chance of error and make it more consistent. Revisions made in the design of the rainfall-simulator were for safety purposes and for better ease of operation.

The constants for the design and operation of the rainfall-simulator as used in the second series of tests in this study were as follows:

1.	Test Nozzle	Spraying Systems Company, Fulljet 3/4 HH 50 SQ
2.	Height of Nozzle	Eight feet (2.44 meters) directly above the center of the test surface
3.	Spray Direction	Downward perpendicular to the floor, platform or ground

4. Water Pressure 6.0 psi (41.4 kPa)

5. Water Flow 4.0 gpm (0.25 liters per second)

6. Water Intensity for 1 Hr. 21.5 in. per hour (54.6 cm. per hour)

7. Slope Angle of Test Pan 8°

8. Sampling Time with Test Application 5 minutes

The sampling or testing procedure on the second series of tests was by the solids-in-suspension method of measurement alone with immediate tests only. The only exception was that the stabilizer, sample D, was allowed to set up over a seven-day period before actual testing. Water pressure, water flow and water intensity remained the same as before; however, the slope angle of the test pan was established at 8°, and the entire sample of runoff was collected in the can at the five-minute time mark after commencing the soil-loss water test. The dry weight of solid runoff material collected in the can was determined in grams, and all comparisons were made with these values. Statistical repeatability data was calculated using the seven test results for better statistical purposes, first of a control sample, then a mulch and finally a stabilizer.

The second series of tests began with two types of water tests: a series of ten water tests for repeatability of water flow, then a series of ten water tests for repeatability of water intensity. Next a series of seven soil-loss tests was conducted on a control sample, a mulch sample and a stabilizer sample. The water tests were run before any soil-loss water tests, then sometime in the middle of the series, and finally after completion of the test series.

The following block diagram shows the second series of tests:

BLOCK DIAGRAM FOR
SECOND SERIES OF TESTS

Number of Tests in Order

Test Series	1	2	3	4	5	6	7	8	9
Water Flow	10				10			10	
Water Intensity		10				10			10
Control - A			7						
Mulch - B				7					
Mulch - C	-	-	-	-	-	-	-	-	-
Stabilizer - D							7		

Again test result data was accumulated, tabulated and analyzed.

DISCUSSION OF RESULTS

One of the major factors that determine soil-loss rate at any particular location is soil erodibility. This term has been described by Wischmeier and Meyer (11) as the inherent susceptibility of a soil to detachment and transport by rainfall and runoff. Major factors affecting the results of this study were the type of soil used, steepness of the slope of the test pan, and the distribution and intensity of water emitted at the nozzle of the rainfall-simulator. No matter how reproducible the water output or how accurate the representation of actual rainfall, the biggest drawback to statistical repeatability using the tentative laboratory test procedure was the soil itself. Even if all variables were constant for each test, the soil would produce problems with erosion patterns and amount, causing variations in the statistical repeatability.

The end result of all the research effort on this study and the previous study was to design and build a rainfall-simulator for use with a tentative laboratory test procedure to evaluate new erosion control products. This would help eliminate the need to test these products in the field, unless promising, and would thus save time, money and effort.

In assessing results of the repeatability tests in the light of the specific aims of this study, all aims have been accomplished to some degree. Some of the results were good and some were not so good; however, all results were useful and have led to certain revisions, principally bettering the tentative laboratory test procedure.

First Series of Tests

Table 1 on page 12 gives the summary of statistical repeatability data for the first series of soil-loss tests. This series was run essentially the same as in the previous study and followed the recommended tentative laboratory test procedure. This series consisted of three tests on a control sample A and three tests each on a mulch sample B, a mulch sample C and a soil stabilizer sample D. Both immediate and 21-day tests were made. Sampling and calculation of soil-loss/data were accomplished by two methods, an oven-dried method and a solids-in-suspension method with soil-loss data reported both in grams per sample and tons/acre.

Several facts became apparent from results of these tests and observations made during testing. Twenty-one day test results showed high coefficients of variation; particularly with the oven-dried method. The best and most consistent results were obtained using the solids-in-suspension method, tested immediately with data reported in grams of soil-loss. This method was the simplest and easiest to obtain and report and gave consistent and fairly repeatable data. Some experimental tests were run with various combinations of pan slopes and runoff collection times.

Consequently several changes were made for the running of the second series of soil-loss tests. The changes are listed as follows: (1) for better statistical repeatability data seven tests with soil pans were run for each type of material, (2) only immediate tests were run, (3) the slope of the test pan was changed to 8°, (4) only the solids-in-suspension method was used and then the collection of the sample was made totally at the five-minute mark, and (5) the soil-loss data was reported only in grams.

TABLE 1

SUMMARY REPEATABILITY DATA,
FIRST SERIES OF SOIL-LOSS TESTS

Items	Immed. Cont.-A	Immed. Mulch-B	Immed. Mulch-C	Immed. Stab.-D	21-Day Cont.-A	21-Day Mulch-B	21-Day Mulch-C	21-Day Stab.-D
Solids-in-Suspension Method								
1-Runoff, grams	6.30	1.37	1.77	0.33	11.61	1.24	3.52	0.15
2-Runoff, grams	6.44	1.29	2.00	0.67	16.52	3.47	2.14	2.11
3-Runoff, grams	5.96	1.09	2.06	0.60	18.00	2.25	2.01	0.32
Mean, $\bar{x}$, grams	6.23	1.25	1.94	0.53	15.38	2.32	2.56	0.86
Stan. Dev., s	0.25	0.14	0.15	0.18	3.34	1.12	0.84	1.09
Coef. of Var., CV	4.0	11.5	7.9	33.6	21.8	48.1	32.7	126.2
1-Runoff, tons/acre	3.81	0.75	0.99	0.18	6.60	0.75	1.95	0.09
2-Runoff, tons/acre	3.90	0.72	1.14	0.39	9.18	2.10	1.20	1.23
3-Runoff, tons/acre	3.60	0.63	1.17	0.36	10.02	1.35	1.11	0.18
Mean, $\bar{x}$, tons/acre	3.77	0.70	1.10	0.31	8.60	1.40	1.42	0.50
Stan. Dev., s	0.15	0.06	0.10	0.11	1.78	0.68	0.46	0.63
Coef. of Var., CV	4.1	8.9	8.8	36.6	20.7	48.3	32.5	126.7
Oven-Dried Method								
1-Oven*, tons/acre	3.39	3.81	2.55	3.09	0.36	2.46	1.92	6.69
2-Oven*, tons/acre	3.75	2.07	4.11	6.12	4.08	6.72	0.78	2.55
3-Oven*, tons/acre	2.70	4.56	6.09	6.15	7.50	3.12	0.57	11.67
Mean, $\bar{x}$, tons/acre	3.28	3.48	4.25	5.12	3.98	4.10	1.09	6.97
Stan. Dev., s	0.53	1.28	1.77	1.76	3.57	2.29	0.73	4.57
Coef. of Var., CV	16.3	36.7	41.7	34.3	89.7	55.9	66.6	65.5

*Soil-loss calculated from oven weights of pans.

Second Series of Tests

Water tests for both water flow and water intensity were run for statistical repeatability at various times including (1) preliminary to running the soil-loss tests, (2) between the series of soil-loss tests, and (3) after completion of all the series of soil-loss tests. Ten individual water tests were run for each statistical repeatability series. Table 2 on page 14 gives a summary of these water tests. Standard deviations ranged from 0.12 to 0.18 for the water flow tests and 0.20 to 0.25 on the water intensity tests with means running between 16.90 and 17.32 pounds of water for the water flow tests and means from 13.606 to 13.831 inches of water for the water intensity tests. The coefficients of variations ranged from 0.7 to 1.1 for the water flow tests and 1.4 to 1.8 for the water intensity tests.

Operation of the rainfall-simulator, in regard to water output and consistency, was very satisfactory, and only a check on the settings for the constants needed to be done from time to time. The only apparent problems encountered were the effective controlling of the wind or air movement affecting the water spray and the channeling and runoff of the water for collection or sampling purposes.

For the second series of soil-loss tests determining statistical repeatability, seven tests were run using a control set, a mulch set, and a stabilizer set in order to obtain a wide spectrum of results. Table 3 on page 15 gives a summary of the second series of soil-loss tests. Standard deviations ranged from 0.23 for the stabilizer to 4.34 for the mulch and 6.86 for the control sample with respective means of 0.92, 19.36 and 32.66 grams of soil-loss. Coefficients of variations ranged from 21.0 to 25.4. Considering the conditions of testing and the materials involved in testing, these were adequate and logical results.

TABLE 2

SUMMARY REPEATABILITY DATA,
SECOND SERIES - WATER TESTS

Item	1 Water Flow* Before	2 Water Flow* During	3 Water Flow* After	1 Water Intensity** Before	2 Water Intensity** During	3 Water Intensity** After
Test 1	17.00	17.40	17.31	13.562	13.750	13.500
Test 2	17.15	17.15	17.00	13.812	13.750	13.875
Test 3	16.80	17.25	17.18	13.875	13.938	13.625
Test 4	16.95	17.25	17.31	14.000	13.750	14.000
Test 5	16.90	17.35	17.31	14.252	13.625	13.687
Test 6	16.80	17.25	17.35	13.500	13.562	13.625
Test 7	16.50	17.40	17.38	13.875	13.688	13.562
Test 8	17.05	17.20	17.35	14.125	13.312	13.875
Test 9	16.80	17.55	17.51	13.625	13.312	14.000
Test 10	17.00	17.42	17.21	13.688	13.375	14.000
Mean $\bar{x}$	16.90	17.32	17.29	13.831	13.606	13.775
Stan. Dev., s	0.18	0.12	0.14	0.25	0.21	0.20
Coef. of Var., CV	1.1	0.7	0.8	1.8	1.6	1.4

* Water flow tests, weight of water in pounds collected in thirty seconds.

** Water intensity tests, in depth of water in inches collected in six minutes in a 2 3/8" (6.0 cm.) diameter graduated cylinder.

TABLE 3

SUMMARY REPEATABILITY DATA,
SECOND SERIES OF SOIL-LOSS TESTS

Item	Immediate Control-A	Immediate Mulch-B	Immediate Stab.-D
Test 1*, grams	39.60	15.26	1.00
Test 2*, grams	25.51	13.10	1.38
Test 3*, grams	29.27	24.16	0.64
Test 4*, grams	34.53	19.53	0.78
Test 5*, grams	25.70	25.16	0.88
Test 6*, grams	30.59	19.13	0.97
Test 7*, grams	43.40	19.15	0.82
Mean, $\bar{x}$, grams	32.66	19.36	0.92
Stan. Dev., s	6.86	4.34	0.23
Coef. of Var., CV	21.0	22.4	25.4

Tests run on 8° slope and sampled at 5 minutes.

Revisions to Design and Operation of Rainfall-Simulator

The primary revision made in the design of the rainfall-simulator was to lower the elevation of the platform to a position 2'6" (76.2 cm.) above floor level. The nozzle height from floor level was also lowered; however, the basic distance from the nozzle to the projected top of the soil test pan, while in testing position, remained at 8' 0" (2.44 m.). These changes necessarily caused revisions in bracing and framing lengths. It was felt that the platform height of 2' 6" (76.2 cm.) was a much better height for safety purposes and for ease of operation in placing the soil test pans in their testing positions.

A change was made in the flume opening for the runoff. The previous opening of 8 3/4" (22.2 cm.) was narrowed down to 3" (7.6 cm.). This change facilitated an improvement in the runoff sampling procedure. Revised construction details for the rainfall-simulator are shown in the Appendix.

The material types for bracing and framing are subject to change as the builder and/or user sees fit to take care of economies, safety, durability, appearance, ease of construction and ease of operation. The primary details necessary for successful operation are the dimensions, as discussed in the first paragraph above, and the water constant of 6 p.s.i. (41.4 kPa) water pressure. These, with use of the tentative laboratory test procedure, form the basis for testing.

If the rainfall-simulator were to be built and used in an outside mode, then a wind shield would have to be added to protect the water drops from any air movement. Again, this could be left up to the builder and/or user as he sees fit. If using the wind shield, care must be taken to prevent ricochet of water drops off of the shield and onto the soil test pan, and to make sure only direct fall from the nozzle to the soil test pan occurs with the water drops.

Adequate water supply and drainage would be also left up to the builder and/or user to provide.

Revisions to the Tentative Laboratory Test Procedure for Soil-Loss

As stated on page 11, using the original tentative laboratory test procedure, the 21-day tests showed high coefficients of variation, particularly using the oven-dried method to determine the soil-loss. The best and most consistent results were obtained using the solids-in-suspension method, tested immediately with the data reported in grams of soil-loss. This method was also the fastest, simplest and easiest to obtain and report.

After the experimental tests were run with various combinations of pan slopes and runoff collection times, the results were compared and several changes were decided upon. The slope of the test pan was changed to 8° and the collection of the runoff sample was made totally at the five-minute mark. It was felt that the greater slope angle would create more runoff or soil-loss and be more definitive, and the experimental tests indicated a straight-line correlation with slope angle change. It was also felt that the change in sampling time would lessen the chance of error and make the testing and sampling more consistent. The revised tentative laboratory test procedure is found in the Appendix.

Although the acceptance criterion from results of this test procedure may not be an actual part of the test procedure, it will be discussed in this section. This criterion has given the most problems in its determination. It is difficult to adequately justify any rigid allowable values. It is still a matter of observation and judgment with review of test data and comparative results that determines allowables. Review and revisions will continually have to be made, since this was the first time to do this type of new product testing. The recommended tentative laboratory test procedure for determination of soil-loss data and the testing device, the rainfall-simulator, are tools to be used to compare new products in the erosion field for adequacy and acceptable use. These tools should be used for consistency of tests and realistic allowable values for acceptance of products.

We say acceptance of products, but in the laboratory it is only comparative testing and only to determine if good products should be further tested in the field. Principally the inadequate products should not get past the laboratory testing, although something that looks good in the laboratory might not prove out successful in the field, or vice versa. Again, here judgment plays a part.

The laboratory allowable values, although quoted as set or rigid values, should still be flexible and tempered with judgment in borderline cases as to whether further field testing should be necessary. Previous allowables were established generally at 50% of the soil-loss value for the control sample. For the time being, this value should remain the same for mulches or stabilizers, with these values being subject to change. The new procedure tends to give higher runoff values and is stricter with these runoff values approaching the allowable value.

Of course, in new products evaluation other factors play a part too, such as economics, need, availability, and experience with proven results. In this study only a testing device and a test procedure were evaluated for statistical repeatability and proposed use.

Additional Test Data on Materials

A secondary aim of the study was to provide additional data to evaluate some of the materials tested. In this way a reevaluation of the acceptance criteria was also attempted. Because of the changes made in two of the test constants, namely the degree of slope of the test pan and the amount and time of runoff test sample collection, it was very difficult to provide any good comparison of values from the second series of tests.

However, there were good comparisons of previous results to the first series of test results, where the two constants mentioned above were not a factor and where the oven-dried method of soil-loss determination was not involved. The results on mulches B and C remained fairly consistent, expecially the percentage soil-loss, and also mulch C remained consistent with a higher soil-loss value than mulch B. Stabilizer D varied a little bit, but good results were still obtained. A comparison table is shown below.

TABLE 4

COMPARISON SOIL-LOSS VALUES TO PREVIOUS RESULTS

Solids in Suspension Method

	Immediate Soil-Loss, Grams			21-Day Soil-Loss, Grams		
Item	Previous	1st Series	Average	Previous	1st Series	Average
A Control	10.20 (-)	6.23 (-)	8.22 (-)	9.21 (-)	15.38 (-)	12.30 (-)
B Mulch	1.54 (15%)*	1.25 (20%)*	1.40 (17%)*	0.73 (8%)*	2.32 (15%)*	1.52 (12%)*
C Mulch	3.66 (36%)*	1.94 (31%)*	2.80 (34%)*	2.16 (23%)*	2.56 (17%)*	2.36 (19%)*
D Stabilizer	(0.89 Projected(9%)*	0.53 (8.5%)*	(0.71) (9%)*	1.44 (16%)*	0.86 (5.5%)*	1.15 (9%)*

*Percentage of Control Values

These three products were well within the allowables from results of testing using the original test methods and soil-loss value determination methods. The revised test method with its new constants and soil-loss value determination method is more severe and probably will give values closer to the allowables, thus making it a stricter test. With results nearer the borderline range, judgment as to further testing would be required more often. More products with wider ranges of acceptability need to be tested for better determination of the allowable values. Time and more testing are continually necessary to adjust these allowable values.

CONCLUSIONS AND RECOMMENDATIONS

The following conclusions were warranted from a review of data obtained on this study: (1) the easily constructible revised rainfall-simulator was capable of statistically repeatable operation; (2) use of the revised tentative laboratory test procedure for determination of soil-loss data was justified from analysis of results in regard to statistical repeatability and acceptance criterion for laboratory erosion product evaluation; (3) revisions were necessary in the original design and operation of the rainfall-simulator and were made, resulting in a better operating device; (4) revisions were necessary in the original tentative laboratory test procedure as used in these studies and were made, resulting in a more efficient and simplified laboratory test procedure; and (5) soil-loss data obtained in this study was comparable to previous results obtained in the "Erosion Evaluation Study," (3) both in amount measured and percentage of control values. Data can be used thus in a pooled way.

The following recommendations are put forth: (1) that study soil-loss data, water output data and respective statistical repeatability data be accepted as documentation of completion of specific aims of the study; (2) that the construction of a rainfall-simulator, as shown in the revised construction details found in the Appendix, be accepted as a necessary tool in performance of laboratory testing of new products in the erosion retardant field; (3) that a revised laboratory test procedure entitled "Tentative Method of Test for Simulated Rainfall Soil-Loss Values," found in the Appendix, be accepted for use in testing new erosion control products placed on the market to determine whether these products are promising enough to be field tested; and (4) that if the recommendations listed above are implemented, a recommendation be made to continue checking laboratory and field data for this type of testing to continually revise and upgrade the allowable values set for laboratory erosion product evaluation.

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APPENDIX

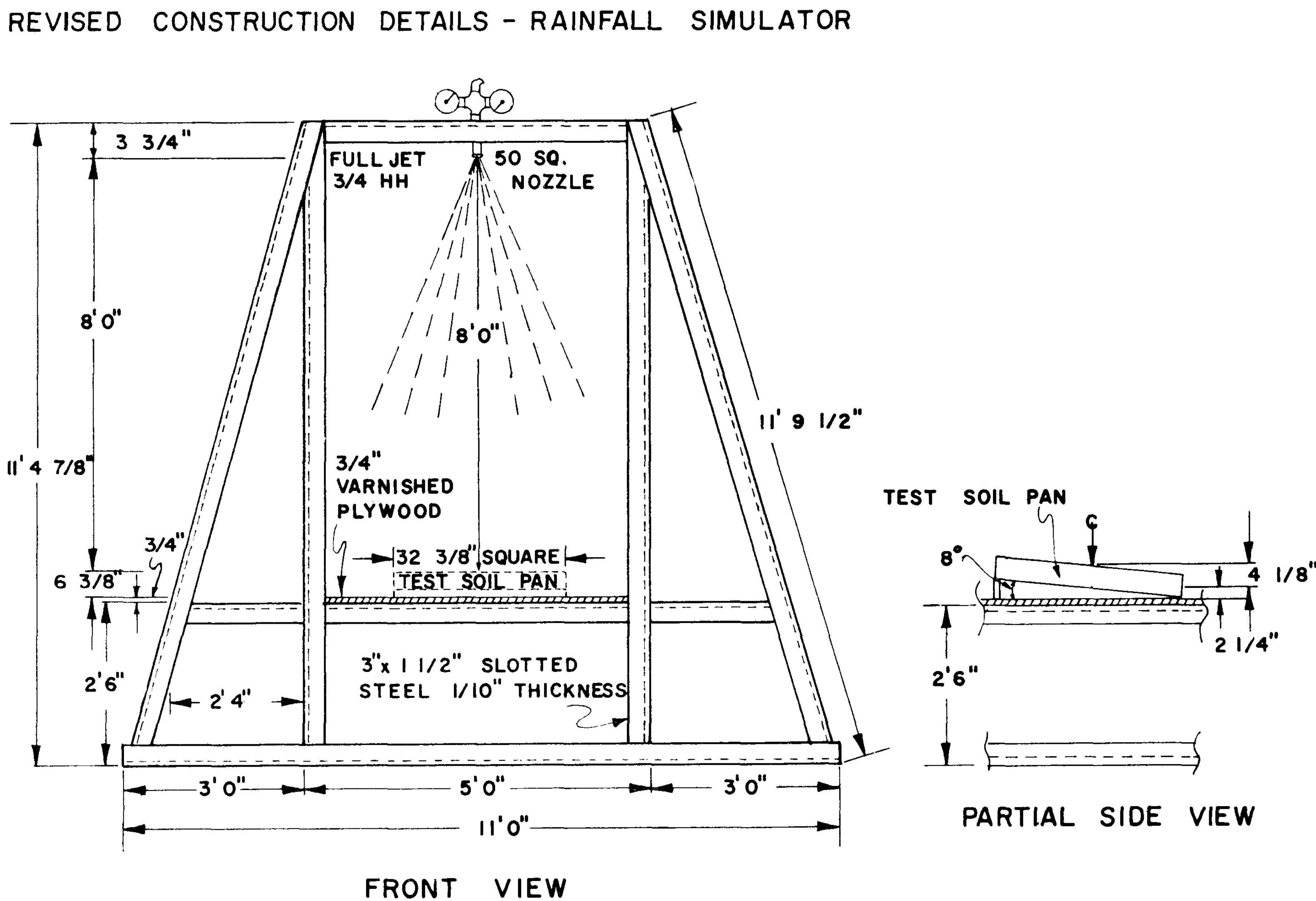

Figure 1
Front View and Partial Side View,
Rainfall - Simulator

REVISED CONSTRUCTION DETAILS - RAINFALL SIMULATOR

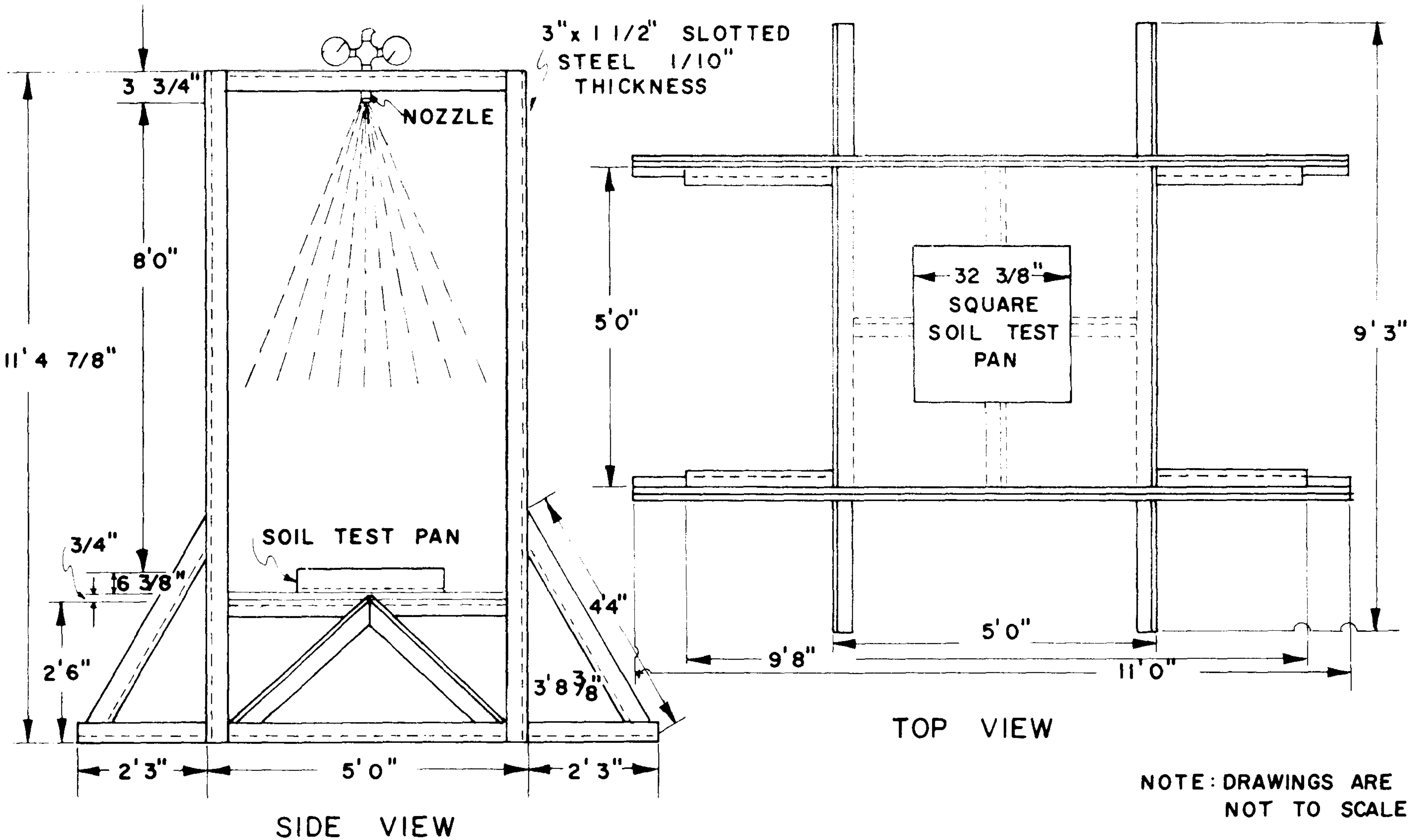

Figure 2
Side and Top Views,
Rainfall - Simulator

CONSTRUCTION DETAILS - SOIL TEST PANS
(FOR USE WITH RAINFALL- SIMULATOR)

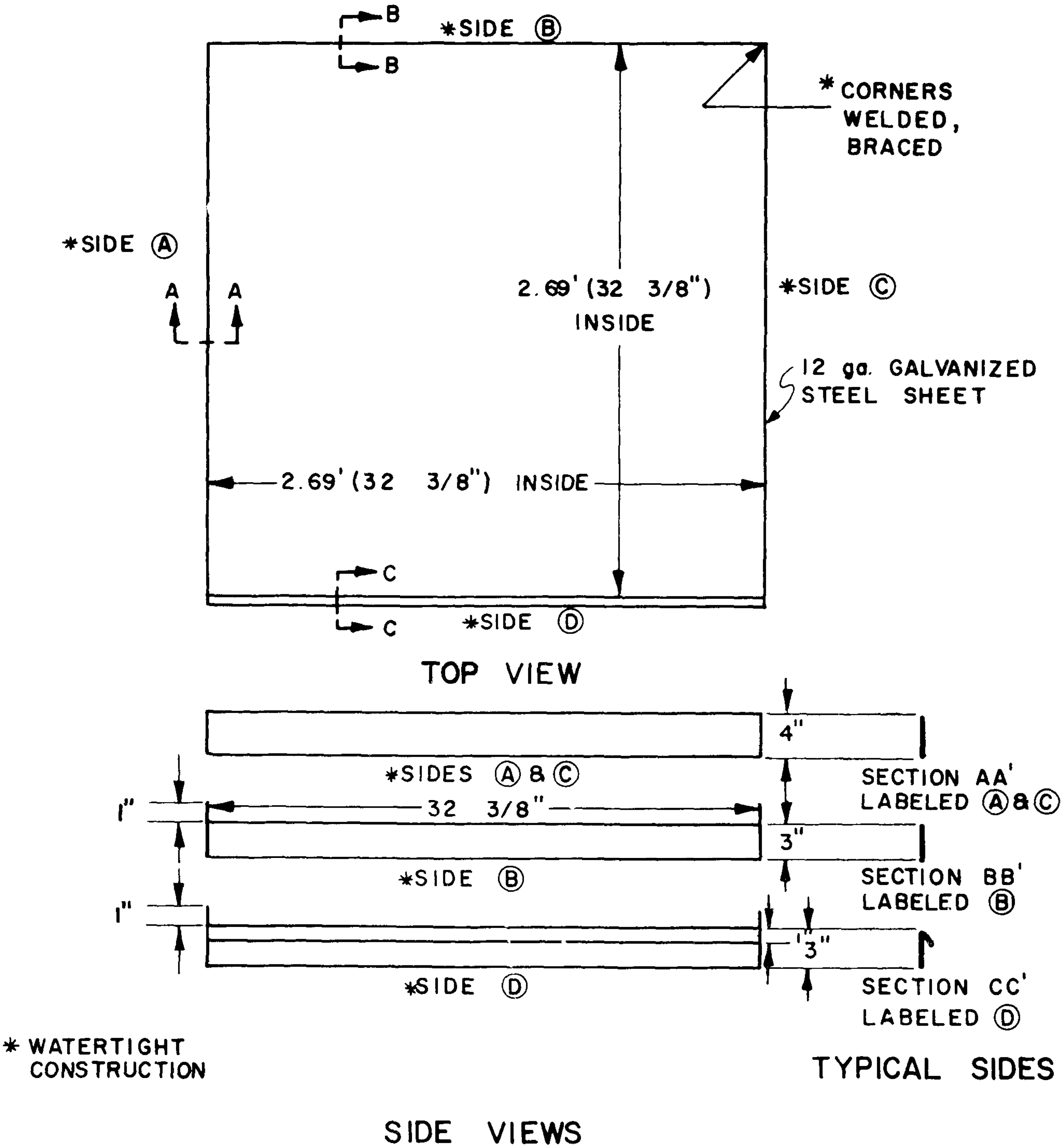

Figure 3
Soil Test Pans

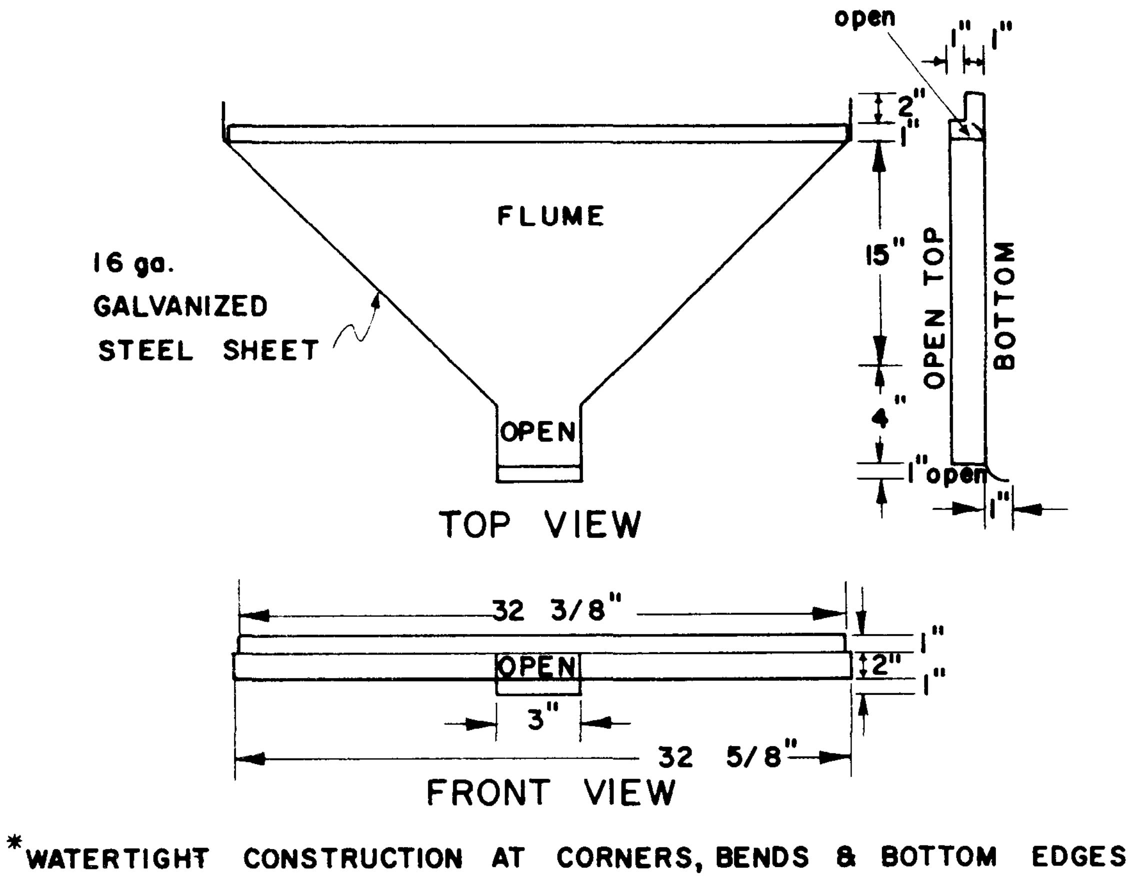

Figure 4
Flume or Channel

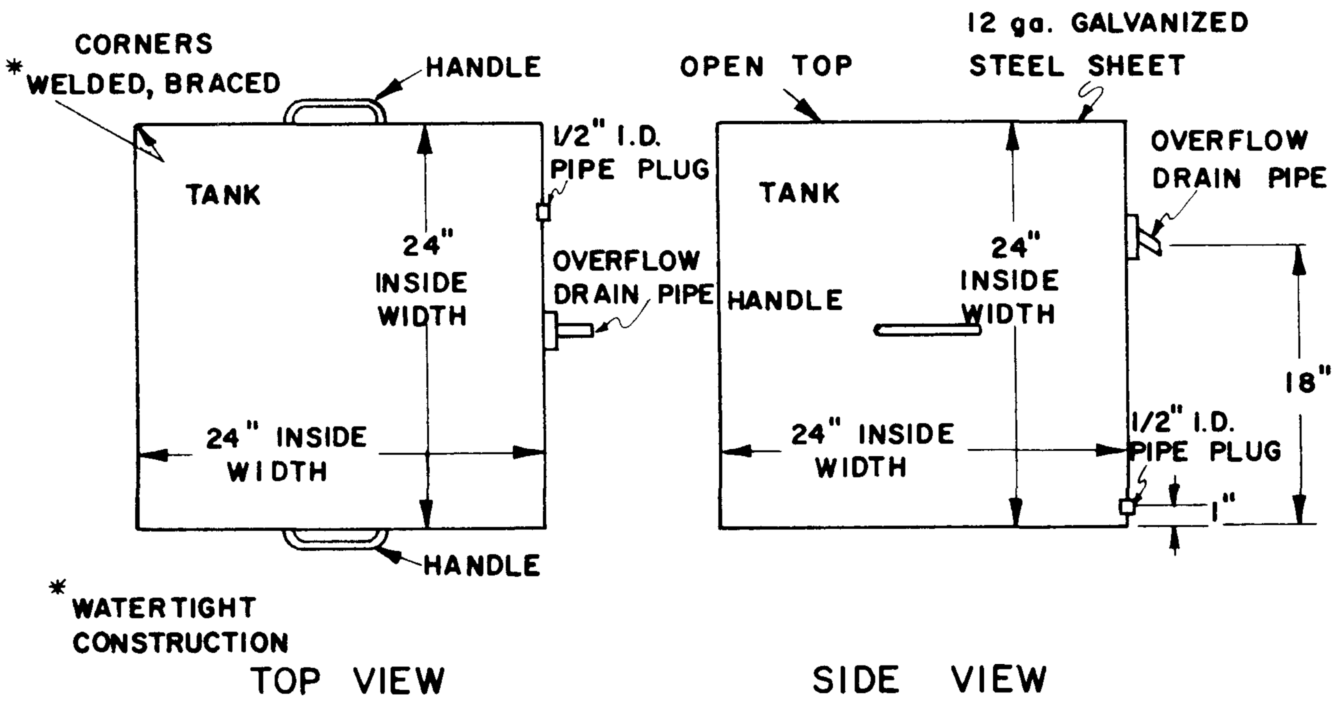

Figure 5
Holding Tank

TENTATIVE METHOD OF TEST FOR SIMULATED RAINFALL SOIL-LOSS VALUES
LDH DESIGNATION: TR -76

Scope

1. This method is intended to describe a tentative test procedure for the determination of soil-loss under simulated rainfall as a comparative value when testing mulches, erosion retardant materials or soil stabilizers placed on a standard typical top soil. New products coming out on the market, those designed to help resist or retard erosion of the soil or to help germinate grass seed to do this work, will be tested by this method and procedure for determination of which products are to be further tested in the field for approval.

Apparatus

2. (a) Rainfall-simulator (as shown in Figure 1).
   (b) Water spray nozzle (Fulljet 3/4 HH50SQ) (Figure 2).
   (c) Water pressure gauges (0-15 psi or 0-103.4 kPa range) (Figure 2).
   (d) Water pressure regulator (5-28 psi or 34.5-193.1 kPa range, set at 6 psi or 41.4 kPa) (Figure 3).
   (e) Plastic water pipe and other appurtenances, clamps, etc.
   (f) Water runoff apparatus (metal flumes or channels and metal tank) (Figure 4).
   (g) Stopwatch.
   (h) Metal test pans (as shown in Figure 5).
   (i) Metal cans (1 pint) for sampling runoff.
   (j) Graduated cylinder (250 cc.) for measuring amounts of water or liquid to be added to each soil sample.
   (k) Small calibrated scale (range 0-1000 grams, sensitivity 0.01 grams).
   (l) Handling and mixing tools, small tools, etc.
   (m) Electronic calculator.
   (n) One gallon sample can (with top rim removed for smooth flow).
   (o) Small pans for material weighing and handling.
   (p) Drying apparatus (oven or hot plates) for removing water from runoff sample solution.

Preparation of Soil Pan Samples

3. (a) For each testing time, there will be a control test pan and, in addition, one test pan for each material tested.
   (b) Fill each metal test pan (Figure 6) with loose soil secured from a stockpile of standard typical top soil (consistent for each test).
   (c) Break up any clods or balls of soil using a 1/4" box screen, then smooth soil surface to where the soil in each pan is loosely compacted but the surface level.

(d) Place or pour material to be tested (either mulch, erosion retardant material or soil stabilizer), and mixed with the proper amount of water evenly, over the soil surface in each pan using the manufacturer's recommended amount for that pan area, which is 1/6000 acre.
(e) Control soil pan sample will be set up and tested just as the material samples are, except only soil will be placed in the pans.
(f) If the material sample is a mulch, then this pan may be tested anytime after two to three hours from the end of the sample preparation.
(g) If the material is a soil stabilizer, then this pan will be allowed to set for up to seven days (or to when the soil stabilizer is set up) under cover free from the effects of the weather, but exposed to sunlight.

Test Procedures

4. (a) The rainfall-simulator will be under cover or in a building with adequate water supply and drainage, with the water spray protected against the effects of wind or air movement.
(b) A check run of water spray will be made prior to the actual test run. The 6 psi (41.4 kPa) water pressure will be checked on the two water pressure gauges located immediately in front of the water nozzle.
(c) The water nozzle will be checked to make sure it is in a vertical and perpendicular position to the floor or ground, centered over the test pan.
(d) At the prescribed test period, the soil test pan will be placed on the platform of the rainfall-simulator, centered under the water nozzle and the proper end of the test pan placed in a raised position (4 1/2" or 11.4 cm.) to form an 8° slope.
(e) The metal flume or channel will be attached to the opposite end of the soil test pan and placed where any runoff will be emptied over the edge of the platform into the metal holding tank below. (One type of setup is shown in Figure 4.)
(f) When the soil test pan is in position to be tested and all other required conditions are met, then the water is turned on and the stopwatch time is started.
(g) At exactly the five minute elapsed time, a pint can sample of runoff will be collected from the flow over the end of the channel or flume.
(h) After this sample has been taken, the water can be turned off and the test is complete.
(i) The solids in solution are then dried out and the total solids are weighed and recorded in grams.

Reports

5. Report the following data:

(a) Sample number or identification and solid weight of runoff material, in grams.
(b) Name of material, type of material and manufacturer of material tested.
(c) Any additional information pertaining to recommended installation weights of materials, volume of water application or miscellaneous information.
(d) Recommendations and remarks.

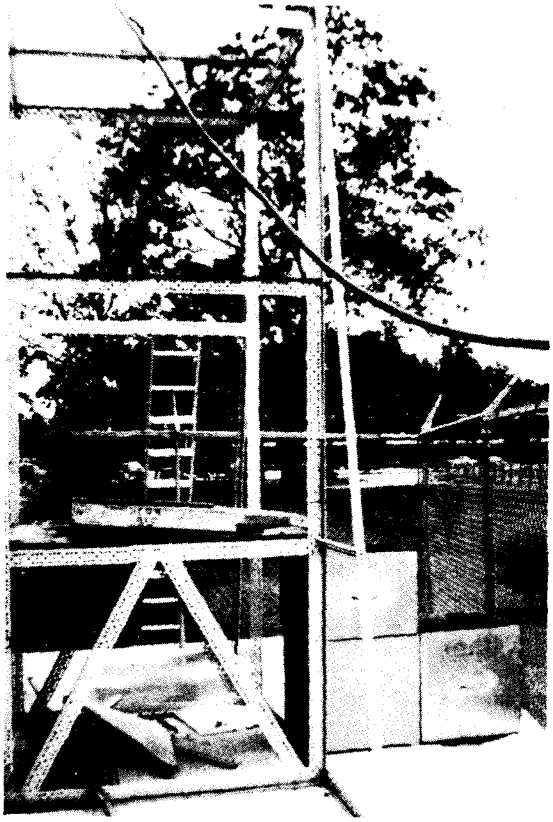

FIGURE 1
Rainfall-Simulator

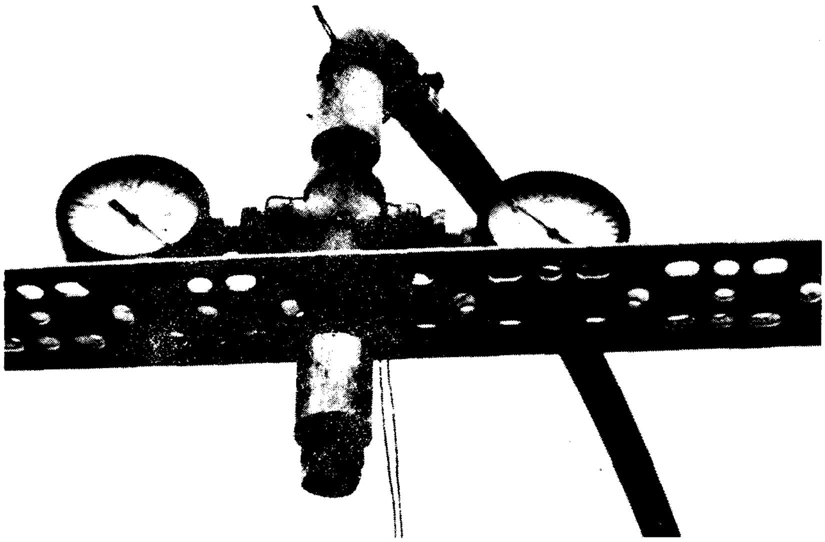

FIGURE 2
Water Spray Nozzle
and
Water Pressure Gauges

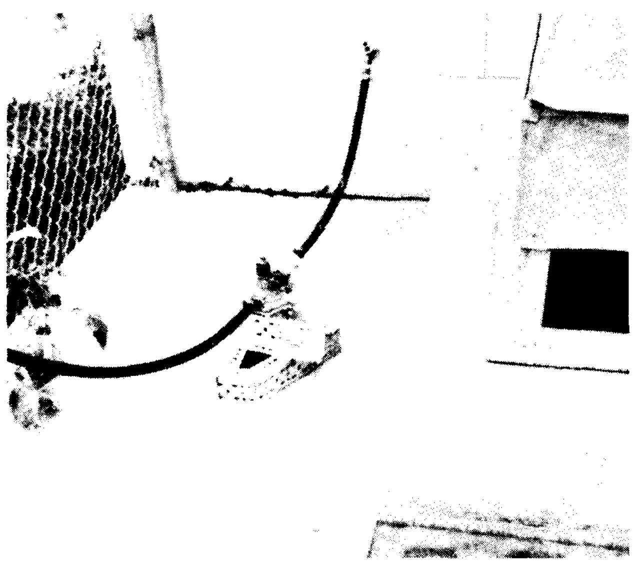

FIGURE 3
Water Pressure Regulator

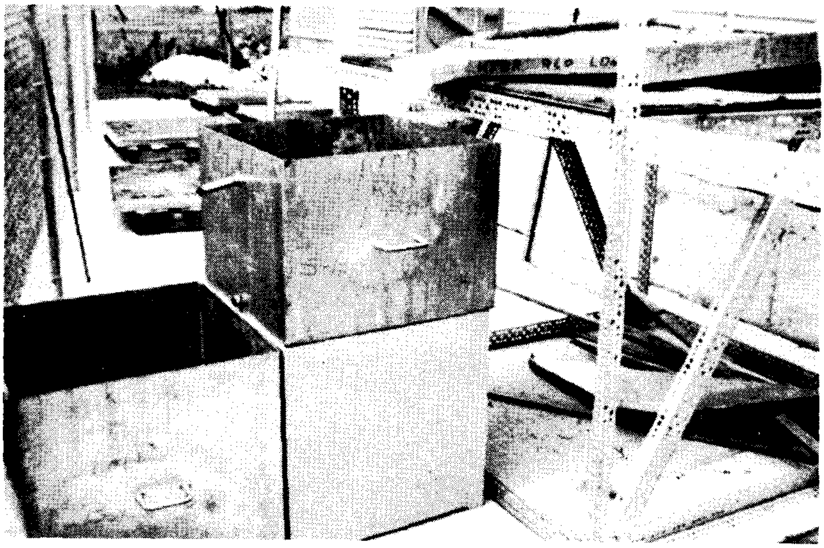

FIGURE 4
Water Runoff Apparatus

FIGURE 5
Metal Test Pan and Flume

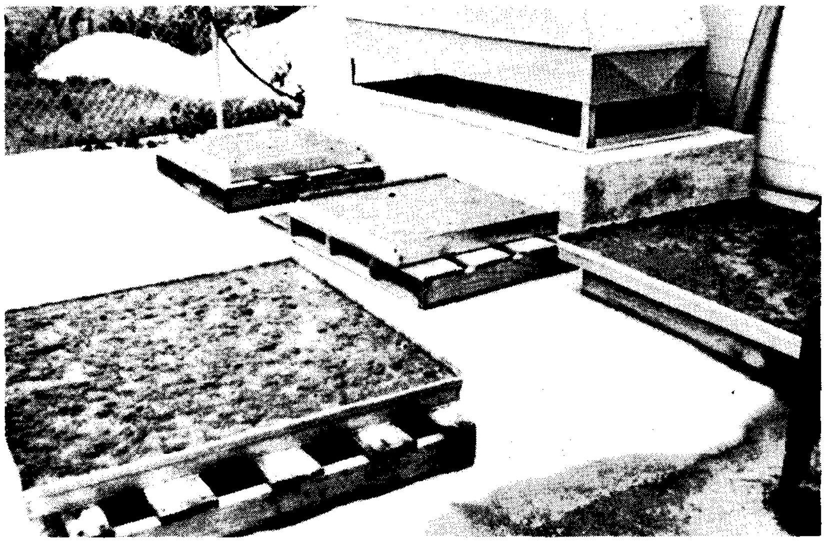

FIGURE 6
Soil in Metal Test Pans