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FABRICATION, TESTING AND EVALUATION OF A RAINFALL SIMULATOR

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ABSTRACT

Information on soil loss under different slopes, vegetative covers and rainfall characteristics are not available in order to make specific recommendation for a particular region. This information is necessary for predicting soil and run off losses from watersheds, having different slopes vegetative covers, as well as soil groups. It will not be possible to generate all such vital information from field size or larger runoff plots within limited time space and resources. Generating all such information under simulated conditions through rainfall simulator is the only way out to overcome some of the above limitations of time and space, and to study the various aspects under controlled conditions. The attempt made at the CS&WCR&TI, Research Centre, Bellary have resulted in the development of a easily workable rainfall simulator which consists mainly (1) Rainfall simulator frame (2) Sprinkler hemispherical copper bowls (3) Drip screen with oscillating arrangement to simulate rainfall (4) Soil tray (5) Collection buckets etc. The other important component is a 0.5 HP electric motor to pump and supply water to the three numbers of sprinkler bowls through 1 " G.I. pipe connections. There are other minor accessories like drums to store and collect the excess water, measuring cylinder etc.

The above rainfall simulator has been fabricated locally, tested and evaluated at the Research Centre, Bellary. It has been found to be working well and satisfactorily.

INTRODUCTION

It is well recognised that soil erosion is a serious problem throughout India, and more specially in black soils of various depths. Even though a few necessary and corrective measures have been evolved and recommended to arrest large scale erosion, still a final solution is problematic and elusive. As a result vast areas are devoid of vegetative cover and crops. Rivers and reservoirs/dams are being silted up within a short time. Desilting dams at a huge financial outlay has to be resorted to at the cost of other developmental works and other nation building efforts and activities.

The rainfall simulator is an effective tool for runoff and erosion investigations because it can be used to produce desired storm conditions on different soils, slopes and management practices.

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Such rainfall simulators have also been widely used in studies of soil erodibility and are considered to be a quick and effective means of deriving valuable data. Such results are often used to guide planners in establishing standards and/or recommended practices for use in wide areas. It is, therefore, essential that the use of rainfall simulators for such studies are fully understood. This paper, mainly deals with the fabrication part of the rainfall simulators. The results obtained from this simulator is found to be comparable with that of field observations.

THE DESIGN AND FABRICATION OF RAINFALL SIMULATOR

This consists of the following parts:-

i) Rainfall simulator frame, ii) Shower/sprinkler heads,drip screen and oscillating arrangement for drip screen to simulate rainfall, iii) Soil tray and iv) Apparatus for collection of runoff.

i) Rainfall simulator frame:

The design considerations, for the simulator frame are that the from should be sufficiently rigid, high and spacious. It consists of 4 numbers of vertical angle iron (6.5 cm x 6.5 cm x 0.6 cm) posts at the four corners. The bottom and top horizontal struts are of similar sized M.S. angle iron, and secured firmly with M.S. Gusset Plates at corners. There are five numbers of horizontal angle iron struts running widthwise on the bottom angle iron horizontal struts, over which the soil tray is kept. The vertical distance between the bottom & top horizontal angle iron struts is about 3.4 m. Two numbers of horizontal angle iron struts are welded at the top angle iron frame, from which four numbers of M.S. rods are suspended and the same is connected to the drip screen, by means of bolts and nuts and hinged arrangements. The overall dimension of the frame is about 3.7 m x 1.7m. Provision has been made to place the drip screen at three different heights in order to get variable size of rain drops.

A pulley is kept across the M.S. angle iron horizontal strut running widthwise connecting. The vertical support posts,at the top. A rope is provided to swing the drip screen. The rainfall simulator is an independent unit supporting itself and resting on the floor. As bolts and nuts are provided at major joints, it can be easily dismantled and fixed at any place as desired, according to one's convenience and requirement.

Rainfall simulating arrangement:- The machanism comprises of the following four parts, viz: i) Water supply lines ii) Water sprinkling arrangements iii) Drip screens and iv) Drip screen oscillating arrangement.

1) Water supply line:- The main water supply line is taken from the two interconnected oil drums of 200 litres capacity, and these

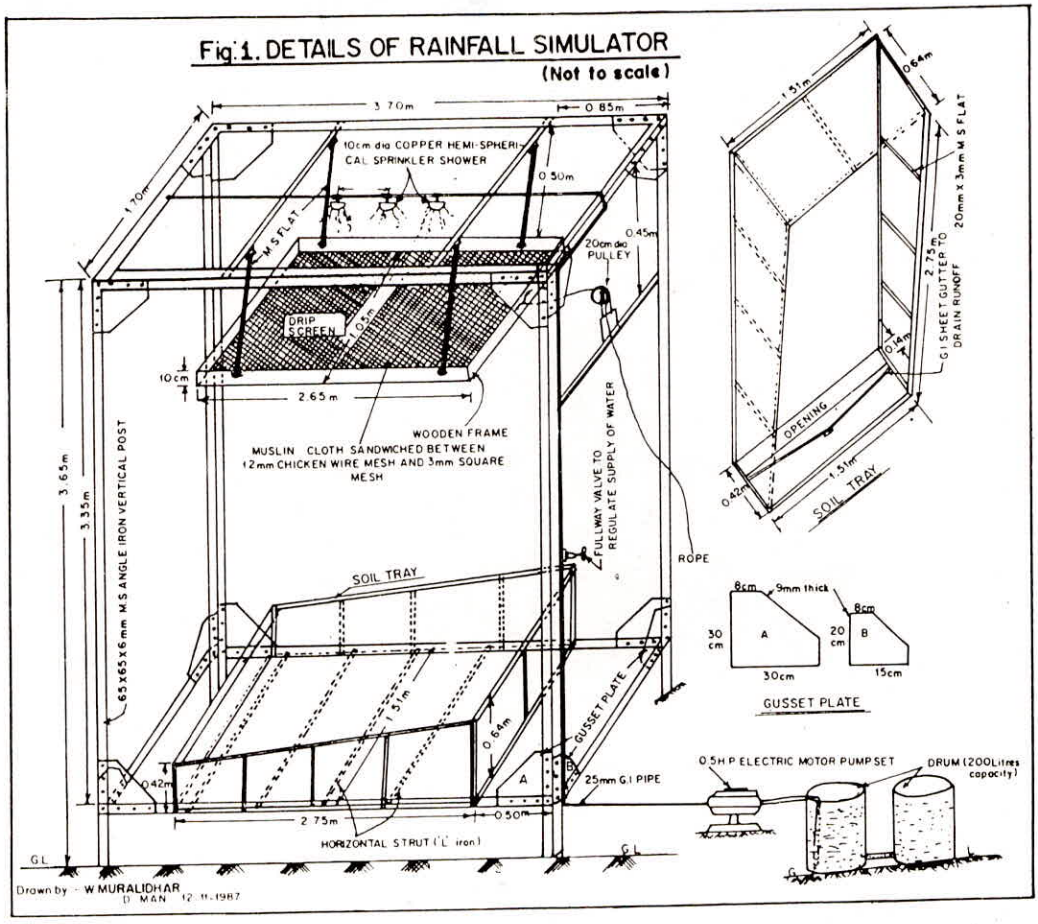
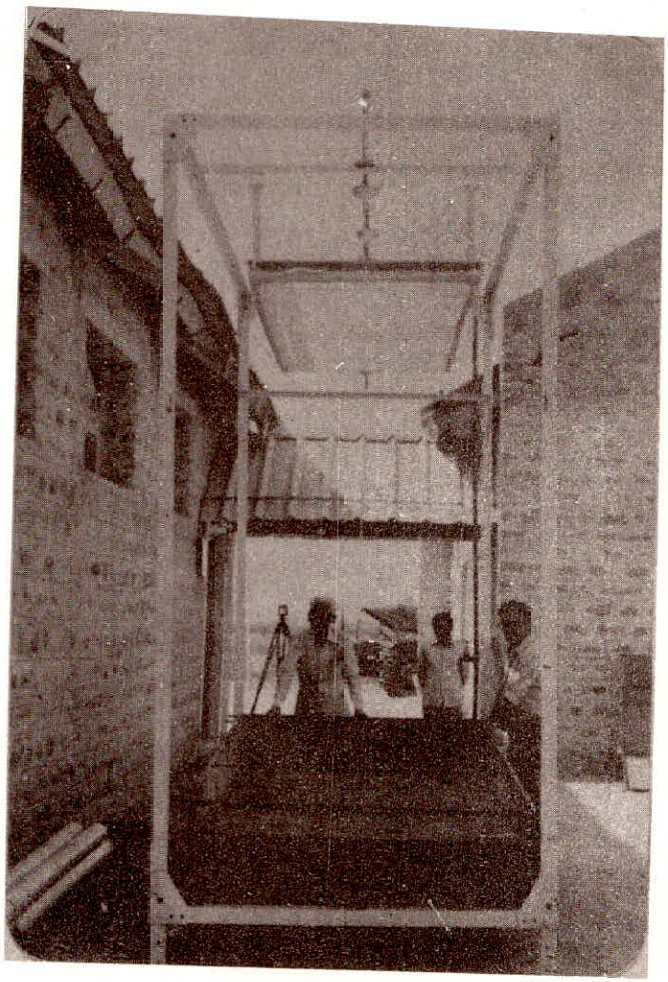


Fig. 1. DETAILS OF RAINFALL SIMULATOR
(Not to scale)
3.70m
0.85m
10cm dia COPPER HEMI-SPHERICAL SPRINKLER SHOWER
0.50m
1.70m
M.S FLAT
0.45m
20cm dia PULLEY
DRIP SCREEN
1.05m
10cm
2.65m
WOODEN FRAME
MUSLIN CLOTH SANDWICHED BETWEEN 12mm CHICKEN WIRE MESH AND 3mm SQUARE MESH
3.65m
3.35m
65x65x6mm M.S ANGLE IRON VERTICAL POST
FULLWAY VALVE TO REGULATE SUPPLY OF WATER
ROPE
SOIL TRAY
1.51m
0.64m
0.42m
2.75m
0.50m
HORIZONTAL STRUT ('L' iron)
GUSSET PLATE
25mm G.I PIPE
A
B
GL
1.51m
0.64m
20mm x 3mm M.S FLAT
2.75m
G.I SHEET GUTTER TO DRAIN RUNOFF
0.34m
OPENING
0.42m
1.51m
SOIL TRAY
8cm
9mm thick
8cm
30 cm
A
20 cm
B
30cm
15cm
GUSSET PLATE
0.5H.P ELECTRIC MOTOR PUMP SET
DRUM (200Litres capacity)
Drawn by - W.MURALIDHAR
D.M.A.N. 12.11.1987



drums are kept on the ground 8 to 10 metres away from the rainfall simulator. No over head water supply tank is required, as a 0.5 HP electric motor pump set is operated to pump the water to the sprinkler bowls thro 2.5 cm dia G.I. pipe connections. Water is taken from the water drums thro' plastic pipes which is finally connected to the G.I. pipe fittings/connections. A full way (gate) valve is provided near the starting point of the G.I. pipe to regulate the water supply to the sprinkler heads. A method of water recycling system is provided by which either the entire quantity of water or a portion or a part of it can be taken to the sprinkler heads, and the left over water is allowed to drain into the original water source.

ii) Water sprinkling showers/Sprinkler arrangement:

Three hemispherical bowls (10 cm dia.) made of copper sheet are used to serve as sprinkling water over the drip screen. These are provided with 1 mm dia holes and at 1 cm spacement. These sprinkler bowls, which are connected to the pipe, runs lengthwise and is kept 0.5 m above the drip screen. The water kept in the 200 litres capacity drum is pumped to these sprinkler bowls with the help of 0.5 HP electric motor pump. The pressure of water into these bowls is controlled by means of a control (full way) valve. Each hemispherical bowl is closed at the top with 2 mm thick plate and these three sprinkler bowls are connected to the main G.I. pipe of 2.5 cm dia, by means of 1.25 cm dia G.I. pipe. These sprinkler bowls are placed in such a manner that the sprinkling is distributed equally over the bottom soil tray.

Drip Screen:

The purpose of the drip screen is to intercept the spray from the sprinkler arrangement and allow the drops of water to fall vertically over the tray which is filled with soil with required percentage of slope. This will, in effect, simulate actual rainfall conditions. The main frame of the drip screen is made of teak wood reepers and has a dimension of 2.65 m x 1.05 m. This drip screen is provided with G.I. chicken wire (12 mm) mesh and G.I. wire of 3 mm square mesh, one below the other and fastened with nails & screws over the sides of the T.W. frame of the drip screen. The muslin cloth is kept sandwiched in between these two meshes, and secured firmly at all the four sides of the frame. This muslin cloth serves as a water pocket in each mesh. The drip screen is provided with 4 Nos, M.S. flatiron with hinges so as to make it oscillate freely from the top of the simulator. On one side of the drip screen is provided a hook to which a rope is tied and the same is broutht over a pulley. The rope is sufficiently long so as to facilitate pulling it, whenever oscillation of the drip screen is required. When the rope is pulled, the drip screen starts swinging giving the effect of natural rain drops over the soil tray kept beneath.

Oscillating mechanism:- The drip screen is hung from the rainfall simulator frame by means of suspension (M.S. flat) plates

with hinged arrangement. When the rope running over the pulley is operated (Pulled) a horizontal motion of about 20 cm on either side is achieved. A cast iron pully of 20 cm dia (with groove) is fixed at the centre of strut which is placed width wise and placed 45 cm below the tope frame of the simulator. When the rope is pulled firmly by the operator, the drip screen is made to swing towards the operator and when the rope is let loose, it tends to move towards the opposite direction. The drip screen is given around 15 to 20 oscillations perminute. For constant and uniform operation and to avoid human error, it is felt better, to allow the same person/operator to operate the oscillating mechanism. This is also important for getting uniform impact of raindrops all over the soil tray, for the period of each operation.

Soil Tray:

This is a rectangular tray (2.75 m x 1.50 m) size made of 20 gauge Galvanised iron sheet, having depths of 0.64 m at one and and 0.42 m at another end. The base and sides of the tray are provided with cross braces and reinforced with M.S. Angle iron - revetted, welded and soldered wherever necessary. On one side is provided a gutter, along the widthwise of the tray, to collect & drain the runoff from the simulated rainfall, into a collecting apparatus through a spout, provided in the middle of the gutter. Buckets, or any other plastic or steel container can be used as collecting apparatus. To maintain the shape of the tray, even after filling it with soil and falling simulated rain water over the soil, necessary M.S. tie rods and angle iron struts have been provided across the tray wherever necessary.

EVALUTION AND TESTING OF RAINFALL SIMULATOR

Soil tray (surface area 4.125 m^2) was first filled up with send to about 10 cm depth at the bottom and then filled with black soils and the slope was adjusted to 1.0%. Rainfall was simulated for 3.2 to 5.5 minutes after determining the antecedent moisture, on 6, 8, & 10 April 1987 and again after a gap of 30 minutes on the same dates and the effect of simulated rainfall on funoff and soil loss was studied. The data presented in table is found to be comparable with actual field data.

TABLE 1

Storm No.	Date	Rainfall (mm)	Runoff (mm)	% of runoff	Antecedent moisture content	Soil loss (T/ha)
1.	6.4.87	24.2	4.2	17.3	24.2%	0.89
2.	6.4.87	33.4	9.7	29.0	-	1.45
3.	8.4.87	20.2	4.1	20.0	27.7%	0.37
4.	8.4.87	21.8	6.6	30.3	-	0.57
5.	10.4.87	23.0	3.6	15.8	22.9%	0.26
6.	10.4.87	21.8	7.5	34.4	-	0.64

It is evident from the table that the rainfalls simulated 30 minutes after the first simulated rainfall on each of the three dates,

produced more run off and soil loss due to high antecedent moisture content.

Note: 1. Rainfall was recorded with the help of Symon's raingauge, placed on the tray.
2. Runoff was collected in buckets.
3. Sediment concentration was found out in Laboratory.

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