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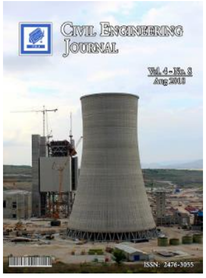

Design, Operation and Construction of a Large Rainfall Simulator for the Field Study on Acidic Barren Slope

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Abstract

The utilization of rainfall simulators has turned out to be more far reaching with the automated instrumentation and control systems. This paper portrays a rainfall simulator designed for analysis of erosion on steep (2.5H: 1V). A rainfall simulator designed to perform experiments in slope is introduced. The large scale of the apparatus allows the researcher to work in remote areas and on steep slopes. This simulator was designed to be effortlessly set up and kept up as well as able and additionally ready to create a variety of rainfall regimes. The nozzle performance tests and lateral spacing tests were performed at Research Center for Soft Soil (RECESS), which is another Research and Development (R and D) activity by Universiti Tun Hussein Onn Malaysia. This test system is the standard for research involving simulated rainfall. The rainfall simulator is a pressurized nozzle type simulator. It discharges uniform rainfall on a square plot 6 m wide by 6 m (19.685 ft) long. The fundamental parts of a sprinkler rainfall simulator are a nozzle, a structure in which installs the nozzle, and the connections with the water supply and the pumping system. The structure of the test system was manufactured created with four fixed hollow rectangular galvanised on which a header with 25 nozzles attached to it. The nozzles are spaced 1 m apart. Flow meters control the inflow of water from the storage tank, ensuring each nozzle has a similar release rate, regardless of the introduction of the test system. The tank that was utilized has the 200 gallons of water which is 757.08 Lit and the full with water in tank can run the artificial rainfall simulation roughly around 50 to 60 minutes. The support system is collapsible, easy to set up and maintain. The subsequent test system is conservative (under RM9,000 to build), made with industrially accessible parts, simple to set-up and maintain and highly accurate.

Keywords: Rainfall Simulator; Large Scale; Nozzles; Barren Slope.

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1. Introduction

In the most recent decades, rainfall simulators have represented a widespread tool for studying hydrologic interactions of rainwater with soils, the main fields of investigation including soil erosion, overland flow generation, and infiltration [1, 2]. The designing, building and testing of a portable field rainfall simulator for simulating rainfalls that induce runoff and soil erosion [3]. Rainfall simulators are used on experimental hydrology, in areas such as, e.g., urban drainage and soil erosion, with important timesaving when compared to real scale hydrological monitoring [4, 5]. Aksoy et al. [6] designed a rainfall simulator which is easy to operate and transport while maintaining the intensity, distribution and energy characteristics of the natural rainfall. Artificial rainfall experiments on small plots provide a relatively quick and economical way to obtain necessary erosion information in a controlled [7]. Requirements for small portable rainfall simulations in soil erosion and soil hydrology studies [8-10]. A rainfall simulator allows producing rainfall with a known intensity and duration on an erosion plot in a controlled manner, making it possible to evaluate superficial runoff and

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soil loss. Cornelis et al. [11] constructed a wind tunnel and a rainfall simulator to focus the effect of wind and rainfall characteristics on soil erosion. The test system consisted of three funnels covering a 12 × 1.2 m portion with sprinklers working with pressurized water. Used a rainfall simulator to compare runoff and sediment production under distinct rainfall intensities in a vineyard plantation in Spain [12]. The test system contained a sprinkler situated at a stature of 2.5 m with pressurized water for 30 min simulations on a 0.45 m diameter plot. Aoki and Sereno (2006) [13] utilized a small scale rainfall simulator to study water infiltration in the soil in a 0.25 × 0.25 m plot comprising of an acrylic drop box in with 49 plastic in its base tubes to form drops with water reservoir.

Drops with a normal diameter of 4.7 mm were created for a 1.5 m drop height. Sheridan [14] used a simulator to obtain a modified erodibility index which could be utilized to predict annual erosion rates for forest streets. They utilized a rainfall simulator on 1.5 × 2.0 m plots, and carried out simulations for 30 min with an intensity of 100 mm h-1. The most fundamental qualities of a rainfall simulator are cost, transport and assembling, capacity to generate homogeneous rainfall, and water consumption [15]. Rainfall simulators represent a widespread tool for studying hydrologic processes involving collaborations of rainwater with soils, for example, soil erosion, overland flow generation, and infiltration. By the by, researchers must often create devices suiting their specific needs, due to a lack of a standard design. Large scale (44 by 72 m) rainfall simulator capable of reproducing rainfall rates ranging from 15 to 200 mm/h with attributes fundamentally the same as common rain, because of the high height (16 m) of the nozzles above the soil surface [16]. On a littler scale, Ochiai et. al., (2004) [17] could apply artificial rainfall at the rate of 78 mm/h to their slope by way of a rainfall simulator consisting of a framework of steel pipes with 24 sprinkling nozzles arranged 2 m above the soil surface. This paper is focused on the description of a large rainfall simulator, which was designed to use in slope conditions.

2. Materials and Methods

2.1. Preparation the Embankment

The field observing was completed on an embankment developed on a recovered land situated at the Research Center of Soft Soil Malaysia (RECESS), Universiti Tun Hussein Onn Malaysia (UTHM). The ground was observed to be very heterogeneous and the water table was 0.5 to 0.63 m. As appeared in Figure 1, there were four slants surface on the embankment. The inclination angle and height of the slope were 30° and 1.2 m (see Figure 1), separately. The width of the slope was 2 m on the peak and 3 m at the toe. Rainfall simulators have been widely used in rainfall erosion experiments on plots shorter than 10 m [1].

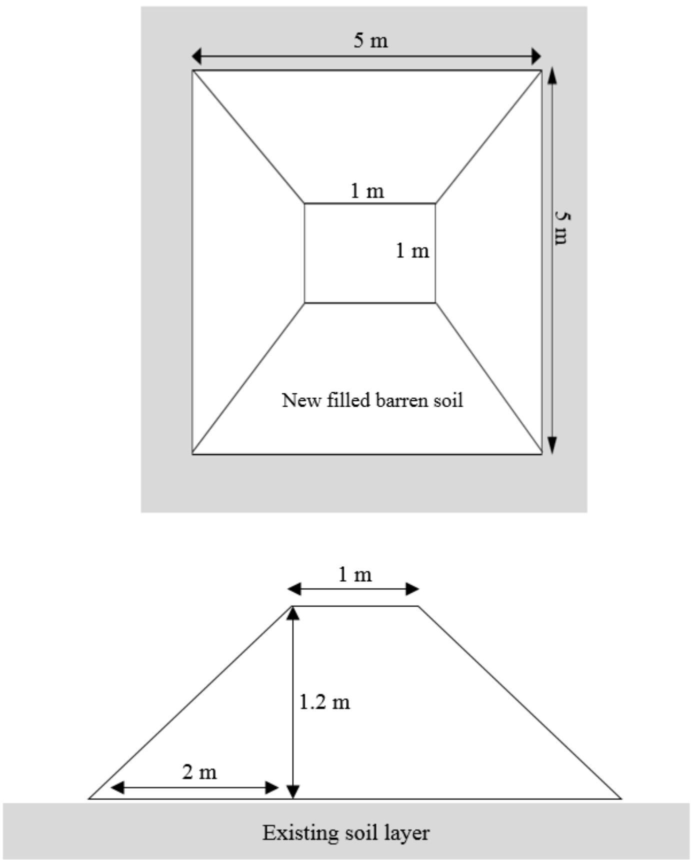

Figure 1. Schematic diagram of scale embankment by top and plan view

2.2. Layout and Schematic the Simulator Rainfall

Figure 2 demonstrate the plan of the rainfall simulator. There are comprises water sources, water tank, water pressure pump, ball valve, sediment filter, gate valve, flow meter, pressure gauge and nozzles. Flowmeter were introduced in the primary water supply line of a nozzles system to record the total amount of water sprinkled onto the slope within a given time interval. The pipe was utilized is measurement 20 mm, it on the grounds that to minimize friction losses, which can be considered negligible for the assumed flow range, compared to other energy losses [18].

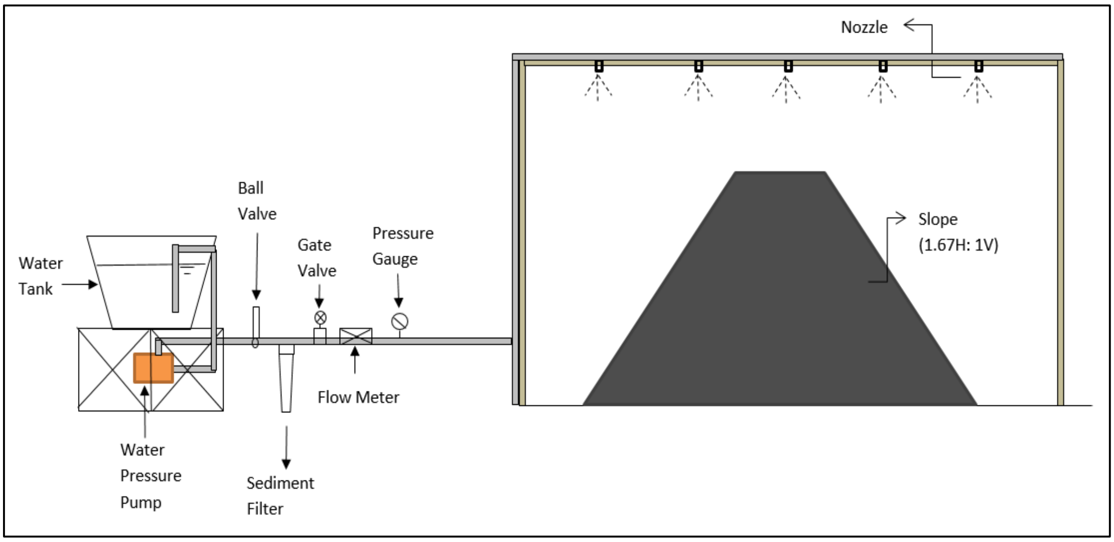

Figure 2. Layout and design of the simulator rainfall

2.3. Large Scale Modelling Setup

The design of the rainfall simulator presented in this paper was based on a review of available literature and discussions who have had direct experience in rainfall simulation. The large scale embankment was setup at the RECESS. It will begin with planning the embankment where the full measurement scale was carried out. Along these lines, the simulator rainfall as an artificial rainfall was setup then the rain gauge also was used to measure the intensity and duration of the rainfall. The essential parts of a sprinkler precipitation test system are a nozzles, a structure in which introduces the nozzles, and the connections with the water supply and the pumping system (Figure 3). The structure comprises of a square platform of 6 by 6 m, and height of the frame is 2 m, consisting of a framework of steel pipes. Artificial rainfall design in this study quite similar to researcher [18, 20] that used a large scale simulator.

Figure Error! No text of specified style in document.. **Full scale rainfall simulator**

2.4. Selecting the Source of Water

Utilizing water tanks and pumps be sure the pumps are capable of delivering a water supply that exceeds the minimum pressure and flow rate. The tank that was utilized has a 200 gallons of water which is 757.08 lit. The full of water in tank can run the artificial rainfall simulation approximately about 50 to 60 minutes. It is possible to control the flow rate for each nozzle type independently [19].

2.5. Selecting the Nozzle Size to Use

Artificial rainfall was recreated utilizing microspray nozzles (Figure 4). The nozzles were installed at a height of 2 m above the ground surface, and each nozzles could cover a round region of about from 1.0-1.5 mm in measurement with sensibly uniform appropriation of precipitation. The angle of impact of the drops from the nozzle is vertical. A group of 25 nozzles was observed to be adequate to cover the plot and produce the desired rainfall intensity. Each microspray nozzles has an optimal performance pressure and flow to achieve proper droplet size and intensity. Choice of nozzle size for use in a particular study is determined in relation to the intensity (cm/hr) of the natural rainfall event to be represented. Nozzles sizes that have been recognized for use with this precipitation test system and their related rainfall intensity, pressure and flow parameters are presented. Choice of nozzle size depends on the desired rainfall intensity. Rainfall intensity and duration correspond to a precipitation event of a certain return period for a specified study location. Besides that, the nozzles were chosen to reduce the size of the drops, in order to minimize impact kinetic energy and prevent soil erosion. Figure 4 show the connection of the nozzles with the pumping system, the pipes dimensions and the location of the inlet water and end of pipe, which is the control system for the rainfall characteristics. The 25 nozzles was used arranged 2 m above the soil surface.

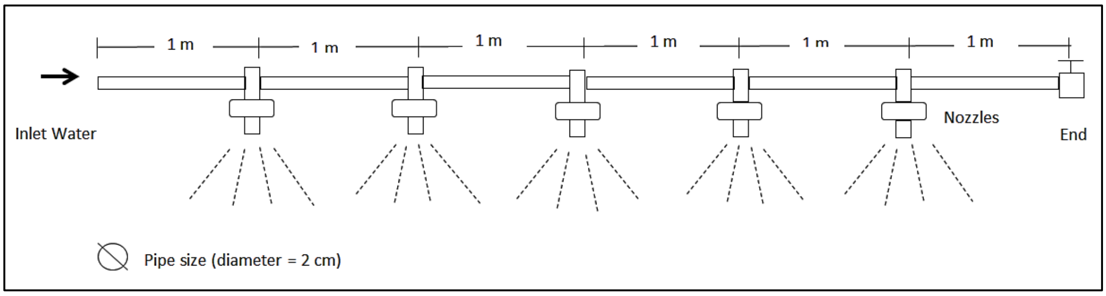

Figure 4. Characteristics of the connections between the pumping system and the nozzle

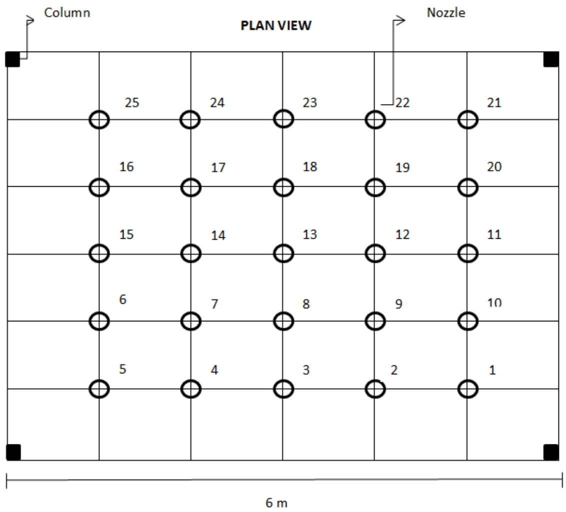

Figure 5. Sketch of the plot area with the vertical position of the nozzles

Figure 6. The type of nozzles are used

2.6. Rainfall Simulator Operation

Position the single lever ball valve (Figure 7) to the closed position, lever at 90 degree edge crosswise over pipe, and turn on the primary water source (municipal or pump). Open the single lever ball valve totally. Partially close the in-line flow control valve until the flow meter reads the approximate flow rate in litre per min for the nozzle in use and the pressure gauge reads the approximate bar for the nozzle in use. Close the single lever ball valve to stop the flow without changing the flow rate and pressure settings. A DOL motor starter additionally contains protection devices, and in some cases, condition monitoring. Overload protection for an electric motor is important to avoid burnout and to ensure maximum operating life. The rainfall intensity was measured by data logger rain gauges positioned at the top surface. For this study the rainfall intensity was controlled by gate valve.

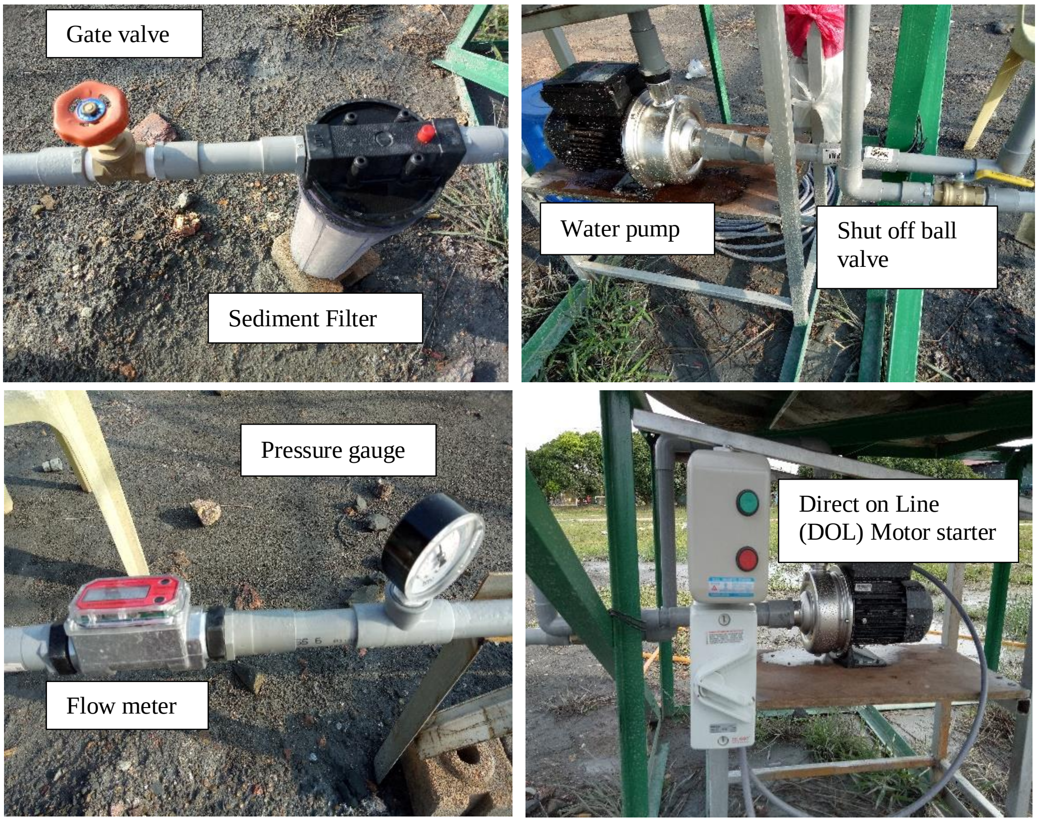

Figure 8. Rainfall simulator controls beginning from the water source and progressing through the plumbing system to the nozzle

3. Result and Discussions

3.1. Uniformity of coefficient

The measurement for rainfall was used the data logging Rain Gauge. The data logger records rain activity after some time when connected to a tipping-bucket type rain collector. The rain gage troughs gave a measure of total rainfall and a check on intensities applied during the tests. In general, the rainfall monitoring equipment provided a good measure of the average application amounts over the entire test area and the rainfall simulator provided an adequately uniform areal application that closely matched the desired application rates. Results of this analysis coefficient of uniform rainfall the rainfall intensity and uniformity coefficient, three different operating pressure (0.5, 0.75 and 1.0 bar) and three different duration operating (10, 15 and 30 min). It was found that the measured rainfall intensity ranged from 92.18 mm h-1 to 124.06 mm h-1 and uniformity coefficient ranged from 66.95% to 78.51%. The Table 1 show results in good performance in all cases. The values of the mean rainfall intensities and coefficient of uniformity obtained from field data agreed with the previous researcher.

Table 1. Results of the experiments with uniformity of coefficient

Researcher	p (bar)	Duration (min)	Q (L/min)	ί (mm/hr)	σ (mm/hr)	CU (%)	CV
	0.50	10	10.94	98.80	37.98	66.95	0.29
		15	9.86	111.75	42.25	67.90	0.38
		30	8.82	102.39	38.79	68.88	0.38
	0.75	10	11.26	108.00	37.95	76.76	0.35
		15	10.97	115.13	34.52	78.15	0.30
		30	10.81	124.06	33.92	78.51	0.27
	1.00	10	12.69	92.18	34.81	72.92	0.38
		15	12.26	98.25	33.36	74.23	0.34
		30	11.83	112.45	37.61	74.13	0.33
Esteves et al. (2000)	0.4	-	-	74.74	20.22	79.2	0.27
Welson et al. (2014)	0.08	-	-	61.6	18.2	75.7	-
M.Lora et al. (2016)	1.0	20	7.19	61.63	28.62	68.50	0.46

4. Conclusion

The objectives for the other more convenient considerations were additionally met. The outlined test system cost around nine thousand ringgit Malaysia. The valve at the source of water into the test system help keep the nozzles flowing at a similar rate, accordingly increasing both reliability and accuracy of the design rainfall. Improvements in the rainfall simulator would incorporate the development and use of a greater variety of nozzles to better simulate natural driving rain, a windbreak to extend suitable testing conditions, and automation of control valves. Regardless, increased automation and instrumentation must be weighed against cost if rainfall simulation is to remain a suitable device for mine reclamation planning and design. Few people are required to run the testing because the simulators are easy to set up and run.

5. Acknowledgment

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