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HEXAGONAL PRECAST BLOCK MODEL COMBINE WITH GRASS VEGETATION AS SURFACE RUNOFF PROTECTION ON CLIFF

Arsyuni Ali Mustary, Muh. Saleh Pallu, Rita Tahir Lopa and M.Arsyad Thaha
Doctoral Program of Sivil Engineering of Hasanuddin University, Jalan Poros Malino Km. 6 Bontomarannu Kabupaten Gowa, 92119, South Sulawesi, Indonesia

ABSTRACT

Cliff restoration to reduce surface runoff and erosion is a fundamental challenge in the management of the river basin. Surface runoff and erosion are strongly influenced by soil cover and cliff slope, erosion is also affected by splash or rain impact factors, therefore soil cover with Hexagonal Block Precast Combined of Grass Vegetation allows for this purpose.

This study has been analyzed the effect of Hexagonal Precast Block land cover model with grass vegetation combined on surface runoff rate in the form of "C" runoff coefficient or land use factor, and have been found the general equation form produced by the model.

The form of this research is the study of hydrological models by modeling estimates of the amount of surface flow from a small area have used rational methods with Rainfallsimulator tools, The results have been found that the reduction of surface runoff on surface for sample soil without cover (NC) compared with block precast combined grass cover (BG) of 51,2 %, with a coefficient range value of C = 0.128 - 0.266 on moderate to steep slope with moderate rainfall intensity, Eq. the generalresult is, t_{max}, Surface Slope S, Rainfall Intensity i.

Keywords: Surface Runoff rate, soil cover, rainfall simulator

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1. INTRODUCTION

As result of rainfall which can affect the soil surface, the effect of runoff will worsen especially if the land is not covered by vegetation, various methods to reduce runoff that have been used but the method is not yet able answer all problems and tend to ignore the effects on the environment, but along with the development of the concept of river- and slope restorations, it becomes a demand in slope protection to maintain the characteristic of ecological. Various types of slope protectors have their advantages and disadvantages both pure vegetation and pure structure, for that we evaluate and design slope protector models from both methods, namely by designing Block Precast Hexagonal and varying with grass vegetation to obtain benefits from both methods.

The method of research by testing a model of cliff protection with Block Precast Hexagonal in combination of grass vegetation against runoff with rainfall variations, soil slope and variation of soil cover using Rainfall Simulator device, then by testing the performance of river slope strengthening model with Block Precast Hexagonal in combination of grass vegetation against runoff, to formulates the relationship of slope protector of Block Precast Hexagonal in combination of grass vegetation against runoff and coefficient value of slope runoff.

2. LITERATURE REVIEW

Factors Affecting Runoff ,such as rainfall intensity, duration and distribution, there are several locational specific factors (water catchment areas) that are directly related to the incidence and runoff volume; a) Type of soil. Such condition is only applying if the condition of the soil surface remains intact and no disruption. It is known that the average size of rainwater drops increases with increasing rainfall intensity, b) Vegetation. The magnitude of interception on vegetation crown depends on the type of vegetation and its growth phase. Common interception values are 1-4 mm. Vegetation also inhibits the runoff, especially on slope lightly, so that water has more chance to seep into the soil or evaporate, c) Slope and size of catchment area. Observations on runoff measuring plots indicate that plots on steep slopes produce more runoff than slope lightly. In addition, the amount of runoff decreases with increasing slope length.

Runoff estimation depends on 3 (three) factors, as follows; a) The maximum amount of rainfall in time unit (maximum intensity), b) Rainfall that becomes runoff (factor value of runoff). The magnitude of this factor value depends on the topography, slope, texture of soil, and also the type of soil cover and its management, c) Catchment area.

The result of runoff hydrograph as one that are considered in overcoming hydrological problems such as planning water sources and flood estimates. It because the hydrograph describes a time distribution of runoff at a measurement site, the results in graphs that can indicate when the peak discharge occurred. Through a rain simulator device, it becomes an alternative modeling to show the process of rain-runoff. The rain simulator is a measurement at Rainfall Simulator Laboratory using the formula:

$$Q = Vl / t \qquad (1)$$

Where, Q is Runoff discharge that occurs (liter/second), Vl is Measured runoff volume of (Liter), t is Time (seconds).

Rain intensity is amount of rain in time unit (mm/hour, mm/min, mm/sec). The time of rain is the length of rain lasts; the duration of rain is the length of rainfall in minutes or hours. It can represent the total rainfall or rainy period which is expressed by relatively uniform rainfall (Asdak, 2010).

Rain intensity is crucial in calculating runoff and the magnitude can be obtained from observations in the field. The magnitude of rain intensity will depend on the density, duration and the frequency of rain by comparing the height of rain with the duration of rain in mm/hour unit or by the following formula:

$$I = \frac{d}{t} \quad (2)$$

Where I is Rain inteisnsity (mm/hour), d is Rain height (mm),t is Time (hours),V is Volume of rain in an area (mm^3), A is Width of rain area (mm^2).

Short-term rainfall is expressed in hourly intensity as called rainfall intensity (mm/hour). The average rainfall intensity in *t* hours (I_t) is expressed by the following formula:

$$I_t = \frac{R_t}{t} \quad (3)$$

Where I_t is Average rainfall intensity, R_t is Rainfall in *t* hour, Tis Time.

Rain intensity is crucial in calculating runoff and the magnitude can be obtained from observations in the field. The magnitude of rain intensity will depend on the density, duration and the frequency of rain by comparing the height of rain with the duration of rain in mm/hour unit. The magnitude of rainfall intensity varies depending on the length of rainfall and its frequency. The high intensity of rainfall generally lasts for a short duration and covers a limited area. Rain which covers a wide area, rarely with high intensity, but can lasts with a long duration. The effect of rainfall intensity on runoff depends on infiltration capacity. If rainfall exceeds the infiltration capacity, the magnitude of runoff will immediately increase in accordance with the increase in rainfall intensity (Triatmodjo, Bambang, 2013). Artificial rain intensity is calculated by using the following formula:

$$I = \frac{V}{AT} x600 \quad (4)$$

Where I is Rain intensity (mm/hour), V is Water volume in containers (ml), A is Container surface area (cm^2), T is Time (minutes).

In estimating the runoff peak rate, there are at least 3 (three) methods that commonly used namely rational, cook, and USSCS (U,S Soil Conservation Agency).

a) Rational method

This formula is the oldest formula among other empirical formulas. To estimate the peak runoff, Q_P, a rational method (U.S. Soil Conservation Service, 1973) is an appropriate technique. This method is relatively easy to use and because it is intended for small-scale watersheds, less than 300 ha (Goldman, et al 1986). A general form of rational formula is based on:

$$Q = C.I.A \quad (5)$$

The method of modification rational is the development of a rational method where the time of rain concentration takes longer. It considers the effect of retention coefficient in estimating the magnitude of peak runoff discharge (Kaharuddin, 2014). Its formula is:

$$Q = 0,0028.Cs.C.I.A \quad (6)$$

For catchment areas where the time of peak discharge (Te) is greater than the time of concentration:

$$Qp' = Cs'.C.I.A \quad (7)$$

Where Q is Peak discharge (m3/sec), I is Rain intensity (mm/hour), A is Width of drainage area (km2), C is Drainage coefficient, Cs is Retention coefficient , Tc is Time of concentration (hour) , Td is Drain flow time (hour).

3. METHODOLOGY

The type of research is a research with simple hydrological model by modeling the runoff estimation of a small area using a rational method. This model estimates peak flow (Qp) by using rain intensity, width and land use factor. There is no time difference between falling rain and peak flow. The equation used is:

Qp = C I A (*English units*) or Qp = C I A/360 (*metric units*)

Where C is a coefficient of land use factor and no unit. I the average rain intensity (inch/hour) and a width (acre). In a metric system, I as the average rain intensity (mm/hour), A as width in hectares. Factor 1/360 is required to calculate the peak flow in m3/second units.

The value of C is obtained by using coefficient tables as in the figure, runoff coefficients for various types of land use C. The rational method is used to calculate the runoff from a limited area.

As graph of flow hydrograph, it can be obtained the relationship between runoff and parameters of rainfall intensity, soil slope, and time, so that from linear regression can be obtained the equation of the relationship between parameters.

The instrument used in runoff testing as follows:

3.1. Rainfall intensity measurement tool

It uses Hydrologic Systems Rainfall Simulator and Irrigation System Unit (ESHC) 2x1 m, testing using 8 (eight) small containers which are spread on the surface of the container then measured in 3 types of rotation so it yields 3 (three) variations of rainfall intensity

3.2. Container for sample testing

The container for sample testing is designed in the form of a rectangular box as a test material container with an oblique side made of clear acrylate board with a thickness of 80 mm, while the size of the container is 120 cm long, 100 cm wide, first side height 20 cm, and the second side is 120 cm, by giving mark of slope variation on the side of the test container that is slope of 150, 250, and 450. In the bottom layer of the container is not closed, but on the front wall of the container is given a hole using a hand drill with a diameter of 1 cm and in front of the container is given plastic in order to accommodate the runoff to be measured.

Measurement tool for runoff is also uses a measuring tube with milliliter (ml) unit as measured by the result of runoff that accommodated at the water reservoir produced from the Rainfall Simulator device.

3.2.1. Soil cover

The soil cover is used by two groups, namely non-Block Precast Heaxagonal and Block Precast Hexagonal, for formerly using two types of material, namely Soil cover without protector (NC) and Soil cover with grass vegetation (G), while the second uses two types of material, namely; Soil cover with Block Precast Hexagonal (B) and Soil cover using Block Precast Hexagonal in combination of grass vegetation (BG), the four variations of soil cover can be seen in the following figures.

3.2.2. Making test material

The material used was a prototype of Block Precast Hexagonal test material and grass vegetation vetiver, each test material can be explained as follows:

4. TEST MATERIAL OF HEXAGONAL-SHAPED BLOCK PRECAST

It has a size of 15 cm hexagonal side and 10 cm high, then made a laboratory model with a ratio of 1:3 of the actual size, the size of the hexagonal side 5 cm x 3.33 cm height, material for making *Block Precast Hexagonal* is portland cement, fine sand and water made on wood molds.

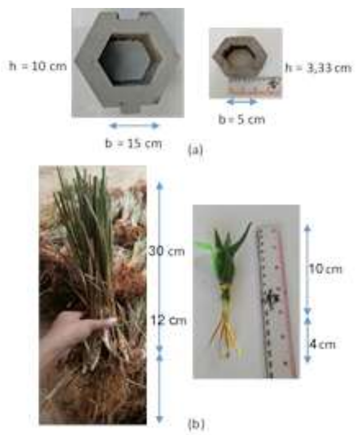

Figure 1 Block Precast Hexagonal in actual size and model dimensions with a ratio of dimensions 1:3 (a), Vetivera Grass in actual size and model dimensions with a ratio of dimensions 1:3 (b).

Material of Grass Vegetation It uses a grass prototype vetiver made of plastic grass with a model and size 1:3 from the size of actual vetiver grass seeds, with 10 cm high, and 8 cm length and 3 cm diameter.For the formation of test material can be seen in the following figure:

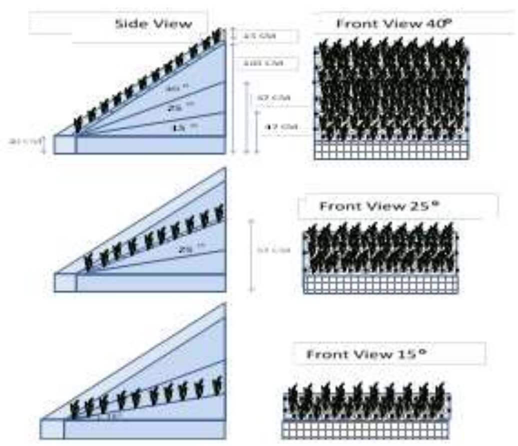

Figure 2 Side- and front views of the formation model of Block Precast Hexagonal and grass vegetation on soil slope variations in the container of Rainfall simulator (a) formation at a slope of 26%, (b) formation at slope of 42%, (c) formation at a slope of 64%

The following figure is a documentation of the installation of test material on the Rainfall Simulator device.

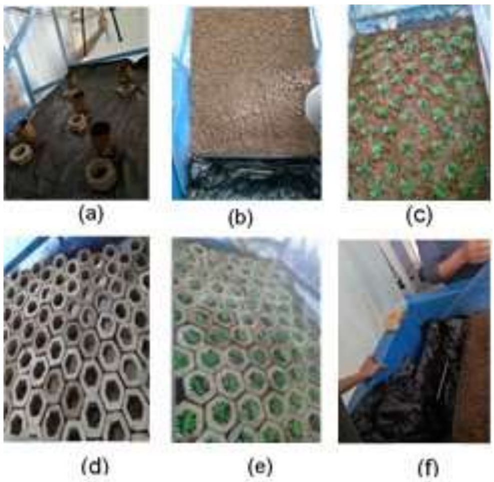

Figure 3 Data collection on *Rainfall Simulator* device (a) Rainfall intensity data, (b) No cover runoff data (NC), (c) grass cover runoff (G), (d) *Block Precast* runoff (B), (e) grass cover runoff and *Block Precast* combine grass cover (BG), and (f) Installation of plastic bag as runoff container

5. RESULTS AND DISCUSSION

5.1. Measurement result of runoff

Comparison of runoff rates is presented by data as result of observation every ten minutes for 90 minutes or one half hours, in the soil cover without Block Precast and the soil cover with Block Precast, with the following analysis:

Table 1 Measurement results of runoff on the grass soil cover Precast Hexagonal (BG) at rainfall intensity 110,5 mm/hour

Observation time		Measurement Result of Runoff (Qu)			Result of Rainfall Intensity (I)		
Time (t)	Time (t)	Measured runoff (Qu), with Grass and Block Precast (GB)	Measured runoff (Qu)	Measured runoff (Qu)	Rainfall Intensity	Rainfall Intensity	(I) by Obser. Time
(Hour)	(Min)	(ml/min)	(ml/sec)	(mm³/sec)	mm/sec	mm/sec	mm/sec
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Slope 26%							
0	0	0	0	0	0.00	0.00	0.0000
0.1667	10	795	13.2500	13250	110.50	0.0307	0.3069
0.3333	20	1250	20.8333	20833	110.50	0.0307	0.6139
0.5	30	1545	25.7500	25750	110.50	0.0307	0.9208
0.6667	40	1890	31.5000	31500	110.50	0.0307	1.2278
0.8333	50	1890	31.5000	31500	110.50	0.0307	1.5347
1	60	1100	18.3333	18333	110.50	0.0307	1.8417
1.1670	70	950	15.8333	15833	110.50	0.0307	2.1486
1.3333	80	190	3.1667	3167	110.50	0.0307	2.4556
1.5	90	0	0	0	110.50	0.0307	2.7625
Slope 42%							
0	0	0	0		0.00	0.00	0.0000
0.1667	10	1000	16.6667	16667	110.50	0.0307	0.3069
0.3333	20	1500	25.0000	25000	110.50	0.0307	0.6139
0.5	30	2100	35.0000	35000	110.50	0.0307	0.9208
0.6667	40	2800	46.6667	46667	110.50	0.0307	1.2278
0.8333	50	2800	46.6667	46667	110.50	0.0307	1.5347
1	60	840	14.0000	14000	110.50	0.0307	1.8417
1.1670	70	340	5.6667	5667	110.50	0.0307	2.1486
1.3333	80	130	2.1667	2167	110.50	0.0307	2.4556
1.5	90	0	0		110.50	0.0307	2.7625
Slope 64%							
0	0	0	0	0	0.00	0.00	0.0000
0.1667	10	1150	19.1667	19167	110.50	0.0307	0.3069
0.3333	20	1900	31.6667	31667	110.50	0.0307	0.6139
0.5	30	4350	72.5000	72500	110.50	0.0307	0.9208
0.6667	40	4350	72.5000	72500	110.50	0.0307	1.2278
0.8333	50	2800	46.6667	46667	110.50	0.0307	1.5347
1	60	2200	36.6667	36667	110.50	0.0307	1.8417
1.1670	70	876	14.6000	14600	110.50	0.0307	2.1486
1.3333	80	230	3.8333	3833	110.50	0.0307	2.4556
1.5	90	0	0	0	110.50	0.0307	2.7625

Source: Analysis results 2018

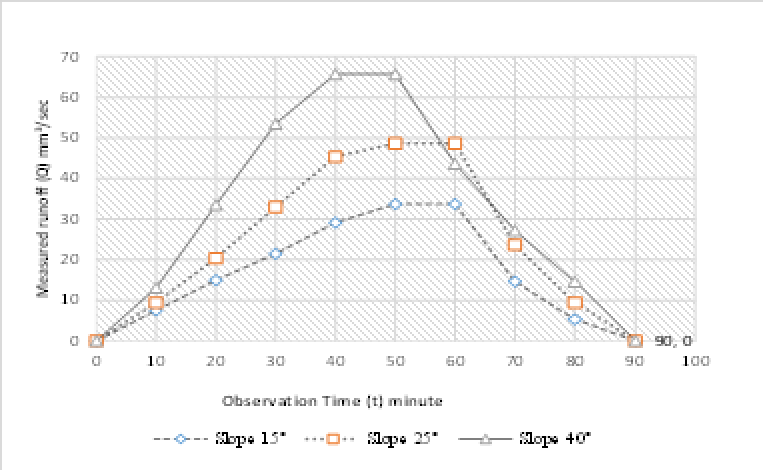

Figure 4 Relation graph of measured runoff discharge (Q) data with observation time on the soil cover in combination of grass and Block Precast (BG) on rainfall intensity 110,5 mm/hour.

At Table 1, has been shown the logical phenomenon that grass vegetation has a significant influenced on the reduction of runoff even though there is a Block Precast, the reduction in runoff rate caused by the combination of grass and Block Precast (BG) is still close to runoff caused by grass cover (G) because the grass as a medium for infiltration into the soil.

5.2. Analysis Result of Runoff Coefficient (C)

An influential parameter in determining the results of runoff coefficient (C) is the maximum average runoff (Qmax) in mm3/sec unit compared to the rainfall intensity (I) in mm/sec unit and the land surface area (A) in mm3 unit, this equation is obtained from the rational formula Q = C.I.A.

Table 2 Recapitulation of analysis results of surface runoff coefficient value *C* on the cover with hexagonal precast block (B) and the cover with hexagonal precast block combined Grass Vegetation (BG)

Criteria of rainfall intensity	Type of Cover	Slope	Surface Runoff Coeficient (C)		
61,6 - 110,5 mm/hour	Cover With Hexagonal Precast Block (B)	≤ 26%	0.169	-	0.268
		≤ 42%	0.272	-	0.295
		≤ 64%	0.295	-	0.345
61,6 - 110,5 mm/hour	Cover With Hexagonal Precast Block Combined Grass Vegetation (BG)	≤ 26%	0.128	-	0.184
		≤ 42%	0.137	-	0.214
		≤ 64%	0.147	-	0.266

The results of the analysis of the determination of runoff coefficient (C), among others on the cover with hexagonal Precast Block (B) and The cover with hexagonal precast block combined grass vegetation (BG) on rainfall intensity 61.6 mm/hour to 110,5 mm/hour.

Table 3 Analysis results of the determination of surface runoff coefficient (C) on the soil cover in combination of grass and Block Precast (BG) on Rainfall intensity 110,5 mm/hour

Observation time		Measurement Result of Runoff (Qu)			Result of Rainfall Intensity (I)		
Time (t)	Time (t)	Measured runoff (Qu), with Grass and Block Precast (GB)	Measured runoff (Qu)	Measured runoff (Qu)	Rainfall Intensity	Rainfall Intensity	(I) by Observ. Time
(Hour)	(Min)	(ml/min)	(ml/sec)	(mm^3/sec)	mm/sec	mm/sec	mm/sec
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Slope 26%							
0	0	0	0	0	0.00	0.00	0.0000
0.1667	10	795	13.2500	13250	110.50	0.0307	0.3069
0.3333	20	1250	20.8333	20833	110.50	0.0307	0.6139
0.5	30	1545	25.7500	25750	110.50	0.0307	0.9208
0.6667	40	1890	31.5000	31500	110.50	0.0307	1.2278
0.8333	50	1890	31.5000	31500	110.50	0.0307	1.5347
1	60	1100	18.3333	18333	110.50	0.0307	1.8417
1.1670	70	950	15.8333	15833	110.50	0.0307	2.1486
1.3333	80	190	3.1667	3167	110.50	0.0307	2.4556
1.5	90	0	0	0	110.50	0.0307	2.7625
Slope 42%							
0	0	0	0		0.00	0.00	0.0000
0.1667	10	1000	16.6667	16667	110.50	0.0307	0.3069
0.3333	20	1500	25.0000	25000	110.50	0.0307	0.6139
0.5	30	2100	35.0000	35000	110.50	0.0307	0.9208
0.6667	40	2800	46.6667	46667	110.50	0.0307	1.2278
0.8333	50	2800	46.6667	46667	110.50	0.0307	1.5347
1	60	840	14.0000	14000	110.50	0.0307	1.8417
1.1670	70	340	5.6667	5667	110.50	0.0307	2.1486
1.3333	80	130	2.1667	2167	110.50	0.0307	2.4556
1.5	90	0	0		110.50	0.0307	2.7625
Slope 64%							
0	0	0	0	0	0.00	0.00	0.0000
0.1667	10	1150	19.1667	19167	110.50	0.0307	0.3069
0.3333	20	1900	31.6667	31667	110.50	0.0307	0.6139
0.5	30	4350	72.5000	72500	110.50	0.0307	0.9208
0.6667	40	4350	72.5000	72500	110.50	0.0307	1.2278
0.8333	50	2800	46.6667	46667	110.50	0.0307	1.5347
1	60	2200	36.6667	36667	110.50	0.0307	1.8417
1.1670	70	876	14.6000	14600	110.50	0.0307	2.1486
1.3333	80	230	3.8333	3833	110.50	0.0307	2.4556
1.5	90	0	0	0	110.50	0.0307	2.7625

Source: Analysis results 2018

While, the value of coefficient (C) of soil cover Block Precast in combination of grass (BG) on the slope of 26% is obtained coefficient values between 0.128 to 0.184, at a slope of 42% is obtained coefficient values between 0.137 to 0.214, at a slope of 64% is obtained coefficient values between 0.147 to 0.266.

5.3. Relationship between Runoff Discharges (*Q*) and Time (*t*) Parameters

The relationship between runoff (Qt) parameter to the observation time is the equation to obtain peak time (t_{max}), the usual peak time is also termed the time to reach a constant point, or the maximum time needed to achieve maximum runoff. When runoff is constant, the rain is stopped, or in other words the soil is saturated with water and the infiltration process occurs very slowly so that the water that will fall in the form of rain and will overflow the surface entirely.

Table 4 Analysis result of surface runoff discharge (Qt) and observation time on the soil cover in combination of grass and Block Precast (GB) on Rainfall intensity 110,5 mm/hour

Time (t)	Measured runoff discharge (Qu), with Grass and Block Precast cover(BG)				Analysis of surface runoff discharge / 10 minutes (Qt)					
	surface runoff discharge (Qu)	surface runoff discharge (Qu)	surface runoff discharge (Qu)	Cumulative (Qu)	Rainfall Intensity (I)		Land Area (A)	Rain discharge (Qh) = IA	Coefficient of measured runoff (C) = Qu/Qh	Qt = C.I.A
(Minute)	(ml/min)	(ml/sec)	mm³/sec	mm³/sec	mm/hour	mm/sec	mm²	mm³/detik		mm³/detik
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Slope 26%										
0	0	0	0	0	0	0	0	0	0	0
10	795	13.2500	13250	13250	110.5	0.30694	388200	119159	0.1112	13250
20	1250	20.8333	20833	34083	110.5	0.61389	388200	238312	0.1430	34083
30	1545	25.7500	25750	59833	110.5	0.92083	388200	357468	0.1674	59833
40	1890	31.5000	31500	91333	110.5	1.22778	388200	476623	0.1916	91333
50	1890	31.5000	31500	122833	110.5	1.53472	388200	595779	0.2062	122833
60	1100	18.3333	18333	141167	110.5	1.84167	388200	714935	0.1975	141167
70	950	15.8333	15833	157000	110.5	2.14861	388200	834091	0.1882	157000
80	190	3.1667	3167	160167	110.5	2.45556	388200	953247	0.1680	160167
90	0	0	0	160167	110.5	2.76250	388200	1072403	0.1494	160167
Slope 42 %			Rata-rata	104426		1.38472	388200	595779	0.1753	104426
0	0	0		0	0	0	0	0	0.0000	0
10	1000	16.6667	16667	16667	110.5	0.30694	413790	127001	0.1312	16667
20	1500	25.0000	25000	41667	110.5	0.61389	413790	254003	0.1640	41667
30	2100	35.0000	35000	76667	110.5	0.92083	413790	381004	0.2012	76667
40	2800	46.6667	46667	123333	110.5	1.22778	413790	508005	0.2428	123333
50	2800	46.6667	46667	170000	110.5	1.53472	413790	635007	0.2677	170000
60	840	14.0000	14000	184000	110.5	1.84167	413790	762008	0.2415	184000
70	340	5.6667	5667	189667	110.5	2.14861	413790	889009	0.2133	189667
80	130	2.1667	2167	191833	110.5	2.45556	413790	1016011	0.1888	191833
90	0	0		191833	110.5	2.76250	413790	1143012	0.1678	191833
Slope 64 %			Rata-rata	131741		1.38472	413790	635007	0.2075	131741
0	0	0		0	0	0	0	0	0.0000	0
10	1150	19.1667	19167	19167	110.5	0.30694	488525	150057	0.1278	19167
20	1900	31.6667	31667	50833	110.5	0.61389	488525	300514	0.1692	50833
30	4350	72.5000	72500	123333	110.5	0.92083	488525	450771	0.2736	123333
40	4350	72.5000	72500	195833	110.5	1.22778	488525	601028	0.3258	195833
50	2800	46.6667	46667	242500	110.5	1.53472	488525	751285	0.3228	242500
60	2200	36.6667	36667	279167	110.5	1.84167	488525	901542	0.3097	279167
70	876	14.6000	14600	293767	110.5	2.14861	488525	1051799	0.2793	293767
80	230	3.8333	3833	297600	110.5	2.45556	488525	1202056	0.2476	297600
90	0	0		297600	110.5	2.76250	488525	1352313	0.2201	297600
			Rata-rata	199978		1.53472	488525	751285	0.2662	199978

Source: Analysis results 2018

In the table has been shown the maximum Q for the lowest grass soil Block Precast (TRB) at a slope of 150 and the rainfall intensity 61.6 mm/hour by 42545 mm3/sec, while the highest maximum Q is at a slope of 40^0 and the rainfall intensity 110.5 mm/hour by 199977 mm3/second, it can be analyzed that the increase in the amount of runoff discharge is directly proportional to the increasing of rainfall intensity and soil slope.

Based on the result a linear graph is made of the relationship between parameters of discharge (Q) with rainfall intensity (I) and soil slope.

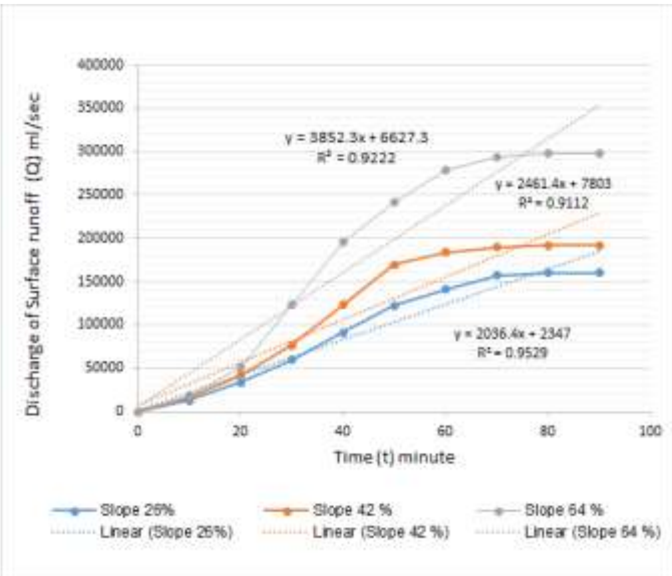

Figure 5 Graph of the relationship of runoff (Qt) by time (t) on variations in soil slope and at rainfall intensity 110,5 mm/hour, on the grass soil cover Block Precast (BG)

In figure 5, the graph of the relationship of runoff discharge every ten minutes of observation time (Qt) on the *Block Precast combine grass cover* (BG) on rainfall intensity 110,5 mm/hour, where the equation of linear regression between the variables of runoff and time (10 minutes and multiples) is obtained equation; f (x) = 928.52x - 3494.8 for a slope 26%, f (x) = 1028.4x - 2734.2 for a slope of 42%, and f (x) = 1277.4x – 2100 aslope of 64%.

In general, the maximum time (t_{max}) is strongly influenced by the soil slope, as evidenced by the peak time from the linear equation between runoff and time, it tends shows that the yield (t_{max}) is influenced by the soil slope, the greater of slope, the faster of peak time to reach, or the faster to reach a constant point. As result of analysis of the maximum time (t_{max}) it is found that the greater of soil slope, the faster to reach its maximum time.

5.4. Relationship between Maximum Runoff (Qmax) and Observation Parameters

To determine the relationship between parameters in this case runoff (Qmax) and rainfall intensity (I), a regression analysis was performed to find the relationship, in order to get equality that relating between runoff, rainfall intensity and slope of soil cover variation.

Table 5 Analysis result of maximum runoff (Qmax) on variations in slope and rainfall intensity (I) on the grass combine Block Precast soil cover (GB)

Grass combine Block Precast Soil Cover (GB)	Maximum Runoff (Qmax)			
	C	Average	A	Q=C I A
Units		mm/sec	mm²	mm³/sec
I1 = 61.6 mm/hour				
S = 26 %	0.1281	0.8556	388200	42545
S = 42 %	0.1367	0.8556	413760	48382
S = 64 %	0.1469	0.8556	489525	61542
I1 = 96,93 mm/hour				
S = 26 %	0.1841	1.34625	388200	96239
S = 42 %	0.2139	1.34625	413760	119157
S = 64 %	0.2105	1.34625	489525	138730
I1 = 110,5 mm/hour				
S = 26 %	0.1753	1.53472	388200	104426
S = 42 %	0.2075	1.53472	413760	131741
S = 64 %	0.2662	1.53472	489525	199977

Source: Analysis results 2016

While, the relationship of maximum runoff (Qmax) rate to the soil slope of the Block Precast cover (B) is shown in Figure, where the form of linear regression equation between the variables of runoff and the soil slope are obtained equation; f (x) = 9498,1x + 31824 for the intensity of Rainfall Intensity 61.6 mm/hour, f (x) = 21245x + 75551 for the Rainfall Intensity 96.93 mm/hour, and f (x) = 47776x + 49830 for the Rainfall Intensity 110.5 mm/hour.

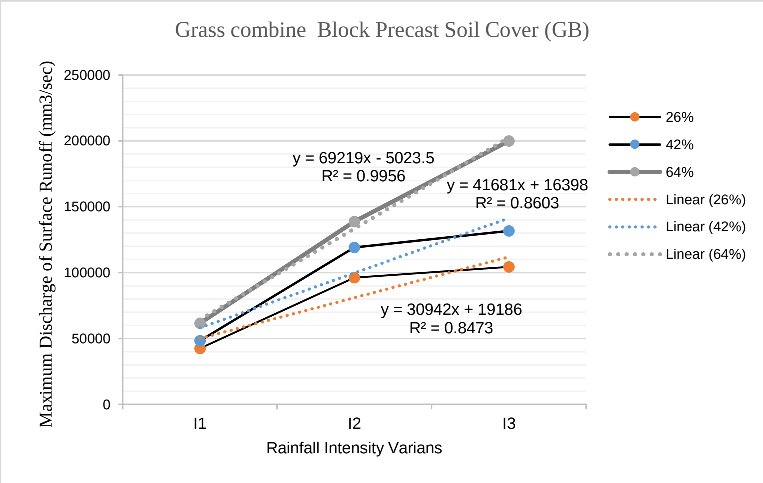

Figure 6 Graph of the relationship of maximum runoff (Qmax) and Rainfall Intensity (I) on slope variation, on the Block Precast combine Grass Cover (BG)

As result of the linear regression equation from the graph of the relationship between runoff (Q) and rainfall intensity (I) can be used to determine the value of rainfall intensity from the magnitude of runoff rate (Q), for example the equation f (x) = 30942x + 19186 for a slope of 26%, function f (x) can be analogous as a result of runoff discharge, then its equation will be, Q = 30942x + 19186, so that the value of *x* can be analyzed to be, $x = \frac{Q}{30942} - 0.62006$, the result of value *x* is multiplied by the average slope interval (unit in degree, (0) or percent, %) so that the value of the soil slope can be obtained from this equation with one of these units.

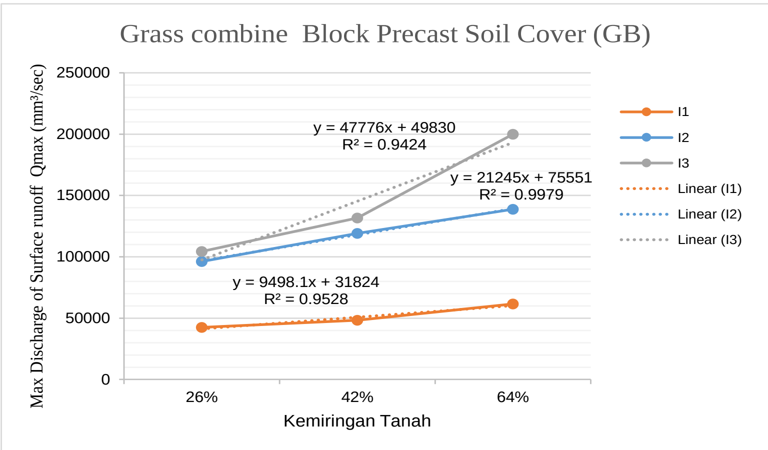

Figure 7 Graph of the relationship of maximum runoff (Qmax) and slope on variation of Rainfall Intensity (I), on the Block Precast combine grass vegetation Cover (GB).

Likewise, the results of the linear regression equation from the graph of the relationship between runoff (Q) and the soil slope (S) can be used to determine the magnitude of soil slope from the runoff rate (Q), for example the equation f (x) = 9498.1x + 31824 for the intensity of CH of 61.6 mm/hour, f (x) is included in the runoff rate, it will be, Q = 9498,1x + 31824, so that the value of *x* can be determined, $x = \frac{Q}{9498.1} - 3.3505$, the result of value *x* is multiplied by the average rainfall intensity interval (unit in mm/hour or mm/sec) so that the value of the rainfall intensity can be obtained from this equation with one of these units.

6. CONCLUSION

Addressing the objectives described at the beginning of this writing, based on the results and discussion of the research, some conclusions can be drawn as follows:

1. Results of research on soil cover without Block Precast Hexagonal appears a phenomenon related to the runoff rate that runoff capacity (Q) on soil without cover (NC) and soil with grass cover (G) is influenced by the rainfall intensity (I) and soil slope (S), as well as on soil cover with Block Precast Hexagonal the runoff capacity (Q) on soil with Block Precast Hexagonal (B) and soil with grass cover Block Precast Hexagonal (GB) is influenced by rainfall intensity (I) and soil slope (S).
2. Results of performance analysis of soil cover without Block Precast Hexagonal and with Block Precast Hexagonal show similar phenomenon as previous conclusions, Runoff capacity (Q) is also influenced by land use factor or analogous to factor of soil cover type, in the form of runoff coefficient (C), where the value of C shows the ratio of runoff capacity with rainfall capacity, so that the performance of cover model can be seen from the difference between the soil cover using Block Precast Hexagonal and without Block Precast Hexagonal, significant reduction can be seen in the soil without cover (NC) compared to Block Precast cover (B) and Block Precast combine grass cover (BG) with a runoff reduction 34% to 49%, with a coefficient range value of C = 0.128 - 0.266 on moderate to steep slope with moderate rainfall intensity
3. The results of the evaluation of the influence of several parameters in the runoff are; a) Parameter of slope, that the results of runoff will be greater with the magnitude of the slope (S), b) parameter of rainfall intensity, that the runoff will increase as the intensity of rainfall increases (I). It means that the magnitude of rainfall intensity and slope is directly proportional to the runoff rate.
4. A general equation as result of hydrograph analysis that occurs in the variation of soil cover based on time in reaching a constant point, that the soil slope has a dominant influence on time in reaching a constant point tmax = $\frac{Q}{2036.4}^{-1.15252}$, and soil slope on variations in soil cover yield equations, among S = $\frac{Q}{30942}^{-0.62006}$, to obtain the magnitude of rainfall intensity so that a value can be determined, I = $\frac{Q}{94981}^{-3.3505}$, the value of rainfall intensity can be obtained from multiplied by the average rainfall intensity interval.

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