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A Study on Prevention of Soil Erosion in Hilly Region Using Jute Footrub Mats

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ABSTRACT- Topsoil erosion is the most common issues in today's world related to soil distresses. Soil erosion can cause contamination of drinking water, disturbs ecosystem of lakes and other water bodies and can cause landslides problems in hilly regions. It becomes necessary to prevent soil erosion by using some methods. This project discusses to prevent soil erosion by using jute mats or jute sacks in hilly regions. For this project work we have choose the nearby hill of Bhimber Gali which has experienced landslide in recent days. After that, we have to prepare the box model of dimensions 150cm*50cm*40cm to show all the site properties such as field density, moisture content etc. in physical modeling. Moreover, it is needed to measure slope inclination of the hill by help of theodolite surveying and prepare same slope in box model. Then, rainfall data analysis is necessary for simulation of rainfall in laboratory for this we have to take rainfall data of Poonch district of J&K for last 5 years. Further then, scaling of model dimensions and rainfall data is done accordance with the need. Then simulation of rainfall must be done in laboratory by calibrating according to the scaling value of rainfall intensity and simulation of rainfall must be done by applying jute mats and steel fence as well as without applying them. After simulation of rainfall we have to measure soil erosion by the help of runoff collector method as well as we have to examine the slope changes and slope failure, if happen. Further then, if slope failure of box model not take place by applying jute mats then examine the slope changes or failure at different intensities greater than given district rainfall intensity.

KEYWORDS- Water Content, Field Density, Shear Strength, Rainfall Intensity, Displacement, Jute, Footrub Mats

I. INTRODUCTION

A. General

Land degradation reasons high erosion quotes resulting from agriculture, grazing, mining, woodland fire or deforestation and this causes monetary, social and environmental damage. However, the most important erosion charges and the most degraded soils are generally discovered in areas suffering from growth, infrastructure or urbanization. Civil engineering initiatives often result in steep slopes with naked soil, that's fantastically at risk of soil erosion, as a result of both effect powers from raindrops or by means of floor run-off. Well-set up, low-developing, dense plant life cover is able to manage soil loss via two or three orders of significance compared to naked soil conditions. The maximum decrement of erosive run-off turned into recorded on permanently grassed plots. However, the establishment of vegetation plant cover may be disrupted for the duration of early plant growth tiers, leaving the slopes uncovered to further erosion methods with poor consequences for slope balance. Soils play a vital role in most important worldwide biogeochemical cycles (carbon, nutrients, and water), even as web hosting the biggest diversity of organisms on land.

B. Factors Affecting Soil

1) The Amount and Intensity of Precipitation

Precipitation is the most intense perspective causing disintegration through raindrops and extreme spillover of soil. Downpour drop disintegration is sprinkle, which winds up from effect of water drops, at the present time on soil. Despite the fact that the effect of downpour drops on water in shallow streams probably won't sprinkle soil, it reasons disturbance, providing an additional residue conveying capacity. On the off chance that downpour falls daintily, it'll enter the dirt wherein it activities and a couple of will gradually keep running off, in any case in the event that it happens in deluges, as for the most part the rainstorm downpours does, there isn't in every case enough time for the water to take in by means of the dirt and it keeps running off causing disintegration. Keep running off that reasons disintegration, in this way, depends on profundity, length, sum and recurrence of precipitation.

2) Topography

Slope speed up erosion as it will increase speed of flowing water. Small variations in inclination make huge distinction in harm. As per legal guidelines of hydraulics, three-time boom in inclination increase rate of water runoff by almost two times. This increased speed can increase strength of erosion by five instances as well as sporting potential from using thirty-two times.

3) Physical and Chemical Properties of Soil

A few soils dissolve more easily than other underneath the indistinguishable circumstances. The erodibility of the dirt is empowered by means of its surface, structure, and home grown depend, nature of day and the amount and state of salts present. There is a decent arrangement substantially less disintegration in sandy soil because of the reality water is caught up without trouble due to over the top penetrability. Progressively regular fertilizer in the dirt

improves granular shape and water monitoring capacity. In sizeable, soil distinctness will development as the span of the molecule increments anyway soil transportability will increment with the lower in molecule estimate. Earth trash are more prominent extreme to segregate than sand, anyway are easily transported on a dimension land and masses additional quickly on slants.

4) Ground Cover and its Nature

The presence of flora cover retards erosion. Forests and grasses are more effective in supplying cover than cultivated vegetation.

Vegetation intercepts the erosive hitting motion of falling raindrops retards the quantity and speed of surface run off, allows extra water flow into the soil and creates greater storage capacity inside the soil. It is the lack of flora that creates erosion permitting situation.

5) Deforestation and Burning

The previously mentioned reasons are a piece of exchanging development rehearsed inside the sloping zones of northern India, especially north-eastern Indian states. When consuming obliterates trees, it likewise harms the vegetation and fauna, and effects water accessibility, for example, springs. The issue isn't any less genuine while ranchers consume crop deposits. It is through harvest buildup that supplement reusing happens in nature. The deposits amass on the dirt surface and discharge nutrients, which may be retained legitimately or in an indirect manner being incorporated into the natural be tallied. With consuming, those nutrients are almost totally lost. Another inconvenience brought about by consuming is the disposal of the conveyance of shimmering natural materials to the dirt.

C. Need of Study

Soil erosion is a severe hassle threatening sustainability of agriculture and contaminating surface waters. Soil erosion can result in landslides trouble in hilly regions. When the topsoil is eroded from an area, that vicinity loses its maximum nutrient-wealthy layer, and consequently decrease soil quality. When soil is carried faraway from a farmer's land by water, it incorporates with it contaminants, together with fertilizers and insecticides which could reason water pollution that contaminates consuming water and disrupts ecosystems of lakes and wetlands. Soil erosion can also result in landslides and floods, negatively affecting the structural integrity of homes and roadways.

D. Scope of Study

In order to study about soil erosion in landslide we have to perform different laboratory and field experiments such as field density(table no.2&3), specific gravity(table no.1), moisture content, direct shear test(table no.4) and sieve analysis. Moreover, we have to prepare the box model so that it can show the site characteristics. Also the site slope must be provided in physical modeling by the help of tachometric surveying. Then, collect the rainfall data and simulate the rainfall (figure no.1) by scaling the rainfall data as per required. Now, collect the soil runoff(figure no.2) in a cylinder container and put in oven and take the dry weight of it. This procedure must be done with or without jute foot rubs mats.

E. Objectives of Study

The main objective of the project work is to minimize the soil erosion by using jute mats or jute sacks. For this, we need to prepare the box model having dimensions (1.5m x 0.5m x 0.4m) in which we need to calibrate the moisture content, slope and field density with the site slope and density. Then, there is need of analysis of rainfall data of the Bhimbar Gali, Poonch district from where the soil is taken and with the help of soil data simulate the soil in laboratory with the help of spray nozzle. The other objective of the project is the measurement of soil erosion by the help of runoff collector method. In this method, a runoff collector is used in which the collection of soil runoff must be taken and this soil is put in oven for 24 hours at the temperature of 105^{o} and measure its dry weight and this method is been done by applying the jute sacks or jute foot rubs or without applying the jute sacks. Moreover, the another objectives is to check the soil erosion and slope changes or slope failure with the different intensities of rainfall by applying jute mats and steel fence if failure does not happen at the given district intensity of rainfall.

II. LITERATURE REVIEW

A. General

V. H. Duran et al.[1] study the inside the Mediterranean spot the powers and measures of soil misfortune and spillover on inclining land are led by utilizing precipitation test and blooms cowl. Wild types of fragrant and vegetation have been chosen for disintegration plots to choose their viability in diminishing water disintegration on slope inclines of the Sierra Nevada Mountain (SE Spain). The disintegration plots (counting a stripped soil plot as oversee), set at 1,345 m in height, set up and had 13% slopes. the base overflow and soil disintegration cites, going from nine to 26 mm/year and from 0.01 to zero.31 Mg/ha.yr, individually, over the entire view term enrolled the absolute best rates a couple of the plant covers analyzed, spillover going from seventy seven to 120 mm yr and disintegration from 1.67 to a couple of 60 Mg/ha.yr. In the stripped soil plot, spillover extended from 150 to 200 mm/yr and disintegration from 5.46 to 8.32 Mg ha reliable with the outcomes, the most reduced developing plant covers disheartened the dirt disintegration and overflow more adequately than did the taller and open medium-sized bushes following enabled additional immediate linkage to be made among plant covers and the aversion of scraped area, with suggestions for feasible mountain horticulture and ecological assurance. The essential end that can be drawn from this examine is that the preservation or development of the vegetation with sweet-smelling, restorative, culinary and utilizes can help spare you overflow and soil disintegration on soak slants, accommodating economical rural and the natural assurance. From the impacts of the overall test the in connection to exposed soil decreased overflow by means of 80, 69, 65, 76, 59 and 39% even as disintegration by means of 95, 92, 90, 75 and 55%, separately.

This investigation gives that impact of mash strands increments on soil that are exposed to water retainment and development to look at its viability to diminish soil misfortune.

Raghuvanshi Ram, et al.[2] study the after-effects of a field test directed in the grounds of Propelled Material and

Procedures Exploration Establishment (CSIR), Bhopal, Madhya Pradesh, India, to test the adequacy of geotextiles as a dirt disintegration control measure. Until now, there is no explicit geotextile like sisal geotextile economically accessible. Be that as it may, sisal is a locally accessible plant and the material can be created by little scale industry. Along these lines, this is a superior option material for soil disintegration control. There is a requirement for explicit data about huge parameters of such items as far as disintegration control. The outcomes uncover that treatment with sisal geotextiles in comparison with coir and jute geotextiles is an effective eco-hydrological measure to shield the precarious slant lands from disintegration. This paper examines the performance of the sisal geotextile as contrast with different geotextiles regarding soil disintegration control.

All the physical, synthetic, mechanical and field explore information demonstrate that the sisal geotextile has better degree for soil disintegration control. Subsequently, sisal geotextile might be utilized for incline adjustment and soil disintegration control. 251 Sisal providers should give dependable information giving specialized subtleties of the geotextiles offered and their normal conduct. Subsequently, near investigation demonstrates that, the sisal geotextile has extremely persuading outcome for soil and water preservation. The residue misfortune and spill over information demonstrate that the sisal geotextile assimilates more water and in this manner, the spill over and residue disintegration are less as contrast with Jute and coir geotextiles. This study gives that effect of different materials such as coir, and sisal and their different properties on soil erosion.

T. L. Chow et al.[3] investigate the effect of joining this fabric at statements equivalent to 0.6, 1.1, 2.1, and 5.0% natural check number inside the furrow layer of a gravelly topsoil soil on chosen soil physical houses and soil disintegration become assessed. The objectives had been to decide the effect of mash fiber augmentations on chose soil homes, which may be relevant to water maintenance and movement and to assess its adequacy in diminishing spillover and soil misfortune, basic contributing ways to deal with soil corruption. Compound assessment of mash fiber discovered that each one substantial metallic fixation had been appropriately underneath suitable focuses. On the elective hand, the soaked pressure driven conductivity and specific dampness content quickened with developing expenses of cures. Results on water-solid totals discovered that the common issue in the mash fiber blended littler totals to shape vast totals, following in a bigger extent of macropores contrasted with micropores. The helpful impacts of the

4% natural be tallied treatment comprise of 2.0 occasions place off in overflow commencement, and 24and 74% decrease in spillover and soil misfortune, individually. In spite of the fact that the valuable outcomes in soil and water protection are evident, a minor drawback gives off an impression of being decline subject soil dampness content. Vast scale execution of the expansion of this fabric in potato fields must continue just with alert. In spite of the fact that the helpful consequences of the mash fiber are obvious, a minor weakness of fusing pulpfibre into the furrow layer is that it appears to bring down floor subject soil dampness content. Sufficient soil dampness is fundamental under a downpour encouraged potato generation framework. Expansive scale programming of mash fiber for soil protection in potato fields should continue with notice. This investigation gives that impact of mash fiber increases on soil that are appropriate to water maintenance and development to assess its viability to lessen soil misfortune.

R. Bhattacharyya, M.A. Fullen [4] propose the organic geotextiles could be a viable and reasonable soil protection strategy, with tremendous worldwide potential. In any case, restricted quantitative information is accessible on the erosion-reducing impacts of natural geotextiles. Subsequently, the goal is to assess the adequacy of organic geotextiles in decreasing overflow and soil misfortune under controlled research centre conditions and under field conditions reflecting mainland, mild and tropical situations. In lab tests, interrill spill over, interrill disintegration and concentrated stream disintegration were mimicked utilizing different precipitation forces, stream shear stresses and incline angles. Field plot information on the impacts of organic geotextiles on sheet and rill disintegration was gathered in a few nations (UK, Hungary, Lithuania, South Africa, Brazil, China and Thailand) under common precipitation. Generally speaking, in light of the field plot information, the tried organic geotextiles decrease overflow profundity and soil misfortune rates all things considered by 46 percent and 79 percent, individually, contrasted with the qualities for exposed soil. For the field and research centre information of all tried geotextiles joined, no huge distinction in relative overflow profundity between field estimations and interrill lab tests is watched. Be that as it may, relative soil misfortune rate for the concentrated stream research centre trials are essentially higher contrasted with the interrill lab tests and the field plot estimations. Despite the fact that this investigation focuses to certain deficiencies of leading research centre examinations to speak to genuine field conditions, it tends to be reasoned that the range and the mean relative overflow profundity and soil misfortune rate as saw with the field estimations is like those as seen with the interrill lab tests. This study gives that utilization of mats as buffer strips was very successful in conserving soil properties on a loamy sand soil.

Elisabeth Dian Atmajati, et al. [5] decide the critical values of the measured physical parameters or take a look at the early caution system itself, a laboratory scale model of a rotational landslide turned into advanced. This rotational landslide model had a size of 260×40×35 cm^3 and become geared up with soil moisture sensors, accelerometers, and automated size gadget. The soil moisture sensors had been used to decide the water content in soil sample. The accelerometers have been hired to detect movements in x-, y-, and z-direction. Consequently, the drift and rotational landslides had been predicted to be modeled and characterized. The evolved landslide version could be used to evaluate the results of slope, soil kind, and water seepage on the incidence of landslides. The existing test showed that the model can display the prevalence of landslides. The presence of water seepage made the slope crack. As the time went through, the crack became bigger. After comparing the obtained traits, the be fell landslide become the drift type. This landslide took place while the soil sample changed into in a saturated situation with water. The soil actions in x-, y-, and zdirection have been

additionally observed. Similarly experiments need to be executed to recognize the rotational landslide.

A laboratory scale version of a rotational landslide has been advanced. This model had a size of 250×45×40 cm^3 and it's far geared up with accelerometers, soil moisture sensors, and an automated size gadget. From the test, it became discovered that the model can display the incidence of landslide. The presence of water seepage made the slope crack. As time went by way of, the crack became bigger. Consistent with the traits acquired, the be fell landslide was categorized because the go with the flow kind. This study gives that model had a dimension of 250×45×40 cm^3, the model can show the occurrence of landslide.

Leo Stroosnijder [6] studied the manipulate of the insidious erosion method is the issue of determining its significance. Four reasons are regularly cited inside the literature: the large temporal and spatial variation of abrasion, the paucity of accurate erosion measurements, the trouble of extrapolating facts from small plots to higher scales and the conversion of abrasion into production and economic gadgets (effect).This paper gives a crucial evaluation of current measurements strategies for erosion at unique spatial and temporal scales. Examples are supplied of techniques for direct measurements in addition to for indirect measurements, i.e., measurements of soil properties that serve as enter for models. The paper is concluded with a crucial assessment.

It is the creator's feeling that there is an emergency in disintegration estimations in light of the fact that there are deficient observational information of satisfactory quality, an absence of assets to improve that circumstance, an absence of improvement of new innovations and hardware and an absence of gifted work force. Because of their high information request and the narrative absence of good information disintegration forecast models frequently use input information which are assessed or got from (experimental) pedotransfer capacities. Subsequently, albeit numerous disintegration models are named deterministic they may be called experimental too.

This study gives that change in weight and change in slope are the best suited method for measurement of soil erosion.

B. Specific Gravity of Soil

The below table shows the result of specific gravity of the soil find by the help of pycnometer method:

Table 1: Result of specific gravity of soil

Si.No.	Determinations	Sample
01	Wt. of clean & dry pycnometer , in gm W1	781.3 gm
02	Wt. of pycnometer + dry soil , in gm W2	1090.0 gm
03	Wt. of pycnometer + dry soil + water , in gm W3	1970 gm
04	Wt. of pycnometer + water , in gm W4	1600.5 gm
05	Specific gravity ,G = $(W_2 – W_1)/\{(W_4 – W_1)-(W_3 –W_2)\}$	**2.64**

In the above table 1, it can be concluded that specific gravity of given soil is 2.64 which is applicable for the range of coarse-grained soil i.e., 2.64 to 2.66. So, the specific gravity test result of the given soil is correct.

C. Field Density of Soil

Table 2 is showing that the unit weight of sand for calibration is 1.682g/cm3. This unit weight of sand is used further for calculations of field density of soil.

Table 2: Result for calibration for unit weight of sand

SI no.	**Calibration of Unit Weight of Sand**	**Sampling**
01	Volume of calibrating cylinder, V (cm^3)	1000
02	Weight of SPC+ sand, W_1 (g)	4696
03	Weight of sand required to fill the conical portion on a flat surface, W_2 (g)	440
04	Weight of SPC + sand (after filling calibrating cylinder), W_3 (g)	2574
05	Weight of sand required to fill the calibrating cylinder, $W_C = (W_1 – W_2 – W_3)$ gm	1682
06	Unit weight of sand, $\gamma(g/cm^3)$	1.683

Table 3: Result of calibration of field density

Layer no.	**Weight of soil in shear box sampling in gm**	**Volume of shear sampling box in cm^3**	**Density of soil in g/cm^3**
1.	158.9	72	2.206
2.	160.5	72	2.229
3.	159.7	72	2.218
4.	159.5	72	2.214
5.	160.2	72	2.226

In the table 3, it can be concluded that the bulk unit weight of the soil is 2.22g/cm3 which is approximately in range for the sandy or cohesion less soil. Moreover, by the help of bulk unit weight the dry unit weight of the soil can also be determined.

D. Direct Shear Test

Table 4: Result of direct shear test on soil

S.No	Displacement (mm)	Normal load (0.5 Kg/m^2)		Normal load (1 Kg/m^2)		Normal load (1.5 Kg/m^2)	
		Load (KN)	Shear stress (KN/m^2)	Load (KN)	Shear stress (KN/m^2)	Load (KN)	Shear stress (KN/ m^2)
01	0	0	0	0	0	0	0
02	0.02	0.004	1.12	0.014	3.89	0.024	6.67
03	0.05	0.008	2.24	0.02	5.56	0.037	10.28
04	0.25	0.015	4.167	0.031	8.61	0.055	15.27
05	0.68	0.03	8.34	0.05	13.89	0.075	20.83
06	1	0.041	11.38	0.068	18.88	0.1	27.78
07	1.19	0.048	13.34	0.082	22.77	0.121	33.61
08	1.3	0.053	14.72	0.09	25.02	0.134	37.22
09	1.48	0.061	16.94	0.104	28.88	0.149	41.38
10	1.64	0.067	18.61	0.114	31.66	0.163	45.27
11	2.02	0.074	20.55	0.133	36.94	0.19	52.77
12	2.28	0.081	22.50	0.144	40.02	0.211	58.61
13	2.55	0.088	24.44	0.158	43.88	0.231	64.16
14	2.97	0.096	26.66	0.18	50.04	0.256	71.11
15	3.32	0.102	28.33	0.197	54.72	0.275	76.38
16	3.8	0.105	29.17	0.214	59.44	0.298	82.77
17	4.21	0.11	30.83	0.224	62.22	0.312	86.66
18	4.65	0.113	31.38	0.231	64.16	0.321	89.16
19	5.76	0.116	32.22	0.238	66.11	0.324	90.07
20	5.94	0.118	32.02	0.237	65.83	0.323	89.72

In the above table 4 is showing the value of load and shear stress at different values of displacement.

- The discharge must be applied to the plan area of the model for simulation of rainfall. For applying this discharge first of all calibration of spray nozzle is necessary which is done by the help of water regulator by regulating the flow of water for 10 minutes and checked with this discharge value.

Figure 1: Discharge of rainfall on model

- In this case, slope failure take place even by applying jute mats but that is less than soil without applying jute mats.

Figure 2: Slope failure and soil erosion at high intensity (i=1.2mm/hr) with using jute mats

III. RESULTS AND DISCUSSION

A. Sieve Analysis Results

Sieve size having percentage finer 60%, D60= 2mm
Sieve size having percentage finer 30%, D30 ≈ 0.85mm
Sieve size having percentage finer 10%, D10≈ 0.21mm
Coefficient of uniformity, Cu= D60/D10
= 2/0.21 ≈10
Coefficient of curvature, Cc= D302/ (D60*D10)

$= 0.852/ (2*0.21) \approx 1.72$

Since, the value of Cu is greater than 6 and value of Cc lies between 1 and 3 and as well fineness less than 5% which shows that the given soil is well graded sand i.e., SW

B. Testing on Water Content

Average water content = (7.17% + 6.86% + 7.56% + 7.72%)/4 = 7.33%

From the given table, it can be concluded that the water content of given soil is 7.33% since the soil characteristics of the site is mainly cohesion less due to which it has less water content as cohesion less soil particles does not attach with water.

C. Specific Gravity of Soil

Specific gravity, G=(W2 – W1)/ {(W4 – W1)-(W3 –W2)} = (1090-781.3)/ {(1600.5- 781.3) - (1970-1090)} = 2.64

D. Slope Determination of Hill

k=100, c=0

Case 1: $\Phi 1 = 0^o$

$D1 = k\cos^2\Phi 1 + c\cos\Phi 1$

$=100*0.07*1 = 7m$

Case 2: $\Phi 2 = 10^o$

$D2 = k\cos^2\Phi 2 + c\cos\Phi 2$

$=100*0.09*(\cos 5^o)^2 = 8.73m$ Case 3: $\Phi 2 = 15^o$

$D3 = k\cos^2\Phi 3 + c\cos\Phi 3$

$=100*0.105*(\cos 15^o)2 = 9.79m$

Now, $x2 = D2 * \tan 10 = 8.73*0.176 = 1.539m$

$\tan\Phi = x2/(D2-D1)$

$=1.539/(8.73-7)$

$\Phi = 44.138^o \approx 45^o$

Therefore, the slope angle of hill determine is approximately 45 degree so in physical modeling of hill angle used must be approximately 45 degree.

E. Field Density of Soil

Weight of sand used to fill, WC = W1 – W2 – W3

= 4696-440-2574

=1682gm

Volume of calibrating cylinder, V= 1000cm3

So, Unit weight of sand, $\gamma = Wc / V$

$=1682/1000 = 1.682g/cm3$

Weight of sand in hole, Wp= W1 – W4 – W2

= 5240-2880-440

= 1920gm

Volume of sand used to fill hole, VP = WP/ γ

=1920/1.683=

1140.82cm3

Bulk unit weight of soil, γ = Wp /Vp = 2533/1140.82 =2.22g/cm3

F. Direct Shear Test

From the table we can conclude that,

Value of cohesion, c= 1.65kN/m2

Angle of internal Friction, $\Phi = 32.45^o$

This confirmed that given soil is having very less cohesive properties and soil is mainly cohesion less since it has very less cohesive value and high value of angle of internal friction which is properties of coarse-grained soil.

G. Scaling of Model

1) Length Scaling

In scaling of model firstly scaling of length take place for model dimensions so it can scale site dimensions to model dimensions. Here, Poonch district area is used for scaling as rainfall data analysis is taken of Poonch district.

Given Poonch district area=1931km²

Let 1cm=930m (scale)

Then, 1931km2= 1931*1010/930002*1

Model area = 2240cm²

2) Rainfall Intensity Scaling

Rainfall intensity, i =0.6mm/hr

Let 1mm/hr = 200cm/hr(scale)

So, 0.6mm/hr= 200*0.6

= 120 cm/hr

So, on model plan area we have to simulate rainfall of intensity 120cm/hr and take this intensity in discharge formula for finding discharge to be needed for one hour rainfall. This discharge formula can be used for both small and large areas i.e.,area less than 500m2 as well as area greater than 500km2 so in this project also this formula is also applicable for project calculations.

The discharge formula is given by:-

Discharge, Q = ciA

Where, c = runoff coefficient (for hilly region =0.2) i= intensity of rainfall in cm/hr

A= Model area in cm2

Now, discharge Q= ciA

=0.2x0.6x2240=47.49liters/hr

H. Calibration of Field Density

The calibration of field density in physical modeling is needed for showing the characteristics of soil of site. For calibration the shear sampling box is used of which volume is known and weight has been taken in shear box from each layers of soil which is filled by tamping the soil. After tamping the soil it has been concluded that tamping the each layer of soil 27 times would provide the same density as that of field density.

Weight of empty shear box sampler= 152gm

Volume of shear sampling box= 6cm*6cm*2cm

= 72cm3

I. Soil Erosion Measurement

Dry Weight of the soil filled in the box model =138kg

1) Without Applying Jute Mats

Dry weight of soil runoff or soil erosion comes out to be equals to 356gm

Moreover, the slope failure of model takes place during simulation of rainfall without applying jute mats. In slope failure the soil from slope of hill will get dispatched and cause soil erosion.

2) By Applying Jute Mats and Steel Fence

Dry weight of soil runoff comes out to be equals to 102gm

Percentage reduce in soil erosion as compared to above case = (356-102)/356*100 =71.34%

In case of applying jute mats and steel fence almost no slope failure has been taken placed as well as the soil erosion is also get reduced to more than two third as that in the case of without applying jute mats.

The figure given below will show the soil erosion, which is very less as compared to above one, by applying the jute mats:

J. Results for Soil Erosion at Different Rainfall Intensities

Moreover, while performing the different intensities rainfall (greater than the former one) by applying jute mats we have examine different values of soil runoff and slope failure at high intensity even with jute mats.

- **At rainfall intensity, i=0.6mm/hr (given intensity)**

Dry weight or quantity of soil runoff comes out to be 102gm
Percentage reduction in soil erosion to that of without applying jute mats= (356-102)/356 =71.34%
Moreover, no slope failure will take place at this intensity

- **At rainfall intensity, i= 0.9mm/hr**

Dry weight or quantity of soil runoff comes out to be 136gm
Percentage reduction in soil erosion to that of without applying jute mats= (356-136)/356*100 =61.79%
In this case, slight slope changes take place but even in this case no slope failures take place.

- **At rainfall intensity, i= 1.2mm/hr**

Dry weight or quantity of soil runoff comes out to be 161gm
Percentage reduction in soil erosion to that of without applying jute mats= (356-161)/356*100
=54.77%
the precipitation will be calculated as:-
Since the precipitation is maximum for June month
So, precipitation value= 1.2mm/hr* 30*24
= 864mm
So for this rainfall depth slope failure take place even with use of jute mats and steel fence. This show the limits of jute mats used in prevention of soil erosion that the use of jute mats get limited to 864mm of rainfall.

IV. CONCLUSIONS

Based on the results of the experiment following conclusions can be derived:

- Using of jute mats with steel fence reduced the soil erosion for more than two third at the given rainfall intensity in all type of soils.
- Using of jute mats do not show any slope failure and almost negligible slope changes while simulation of rainfall
- At intensity of 0.6mm/hr (given district rainfall), reduce in soil erosion percentage comes out to be 71.34%.
- While increasing rainfall intensity
  the reduction in soil erosion percentage also get reduced i.e., at intensity of 0.6mm/hr, 0.9mm/hr and 1.2mm/hr the soil erosion percentage reduction will be 71.34%, 61.79% and 54.77%
  respectively
- The slope failure of soil by using the jute mats is taken place at intensity of 1.2mm/hr or at the precipitation value of 864mm.

V. RECOMMENDATIONS

From the above results the following recommendations can be made**:**

- Jute mats or jute sacks can be used for prevention of soil erosion in hilly regions.
- It is also recommended to use steel fence and attach with the jute mats by help of anchor pins to properly maintain the jute mats in its position
- Moreover, jute mats can be used only below the precipitation value of 864mm above that failure may occur in soils that can cause landslides.

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