Industrial Science
Vol.1,Issue.2/Nov. 2013 **ISSN** : 2347-5420

Research Papers

EROSION CONTROL OF EMBANKMENT USING PADDY STRAW

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Abstract

Soil erosion is the process of wearing away of land surface by the action of natural agencies as water and wind. The main causes of erosion are by the action of water and wind. Research is conducted worldwide on erosion control and use of various natural materials such as jute, coir, paddy straw etc. Paddy straw is considered to be less popular material for use as soil erosion control as compared to natural material like Jute,coir which have ability to convert into fibers. These materials are used conventionally by dry spreading in the field, mulching, bales and wattles. Apart from these popular methods there is no standard procedure and validation for these material. Paddy straw is used to form geomesh and used for slope erosion protection. Experiments are carried out on paddy straw keeping constant factors such as rainfall intensity, rain drop size and height of fall of rain. Soil erosion is observed which is in terms of sediment weight. Similar experiments are also carried on bare soil and results are compared.

KEY WORDS:
Soil erosion, paddy straw, rainfall simulator.

INTRODUCTION

Erosion is mainly causes due to water and wind, top layer of soil contains proteins, fertilizers and nutrients etc. similarly non natural activities such as movement of cattles and human on embankment. Various methods and materials used for erosion control of embankment, some of them have no procedure and validation, and some of them are effective but not with commercial.Paddy straw is an agricultural by product of rice crop, it has become solid waste disposal problem not only in India but worldwide due to its abundant availability, no commercial value and is poorly digested by cattles as compared to other hay. Coventional method of disposal of paddy straw is plugging it into the soil which consumes lot of time and energy. Its residue takes long time to decompose, burning of straw produces CO2, CO, CH4, N2O etc which results into serious health hazards. Research is done world wide to use paddy straw effectively for erosion control etc.

2. LITERATURE REVIEW

Paddy straw can be woven as a geomesh which can be used to minimize erosion of embankment by laying and fixing the mesh. The woven mesh has been tested in laboratory. The soil erosion is checked using artificial rain conditions using rainfall simulator, these simulators are used to creates artificial rain conditions in laboratory.Various type of rainfall simulators have been built in United states and Canada for use on erosion control study, Ashley Covert [et. al]1a sample of five 1-m2 plots was grouped in each study site with steel plot border constructed of 3-mm steel plate with 10-cm sides, installed for each plot. The downslope edge of the border was levelled with the ground surface so the surface runoff and sedimentflow directly into a trough. The experiments were carried out for 20 min duration. After the plot border was installed the simulator was centered over the plot using the level and plumb bob to achieve the

correct height and position. A calibration was done to ensure the correct rainfall intensity. The raindrop size was 1.4 mm, slope of embakment were 50% , the simulator designed for high intensity, short duration. The downslope edge of the border was level with the ground surface so the surface runoff and sediment flow directly into a trough. A trough is a PVC gutter pipe with a cap at one end and open valve at other end.The water captured in in tray was measured in 1000 ml graduated cylinder to determine the resulting rainfall intensity. After the rain was turned off, another bottle was immediately placed under the nozzle unit runoff ended. A final bottle used to collect remaining sediment from the trough resulting in a total of 22 bottles per simulation. The article intended to help in the construction and application of a rainfall simulator for use in forested environments. The resulting data can be used to help understand soil erosivity and to aid forest management application.

Sawatsky [et. al]2designed system to simulate intensities up to 200mm/h, the plot area 16m2 , and steep slope of 2.5H:1V.The rainfall simulator consists of a system of sprinkler nozzle which applies artificial rain on test plot, A system of PVC pipe was designed to convey the water to the nozzles. The system consists of a manifold upstream of the plot with five mains to create subsystem to convey the flow down the slopes between the two plots and branch lines which carry the discharge laterally across each plot. This layout was selected to minimize differences in pressure between the two plots and between individual nozzles.The runoff was measured by collecting the overhead flow in troughs and conveying the water and sediment to a sediment trap equipped with a V notch weir at its outlet. The nozzles used in the rainfall simulator produces drop size of aproximately 1mm. The rainfall simulator described was able to replicate the desired intensities and durations of design rainfall hyetographs. The simulator was also able to produce raindrop sizes and velocities approaching natural rainfall conditions at high intensities. This system of rainfall simulator has proven to be a cost effective tool measure components in the rainfall runoff erosion process and to demonstrate the long term sustainability of reclaimed slopes exposed to extreme rainfall events.

The northan ladder type simulator is spray boom that oscillates across a test plot at varying speed to produce variable intensities. The nozzle used was veejet 80100 nozzle. The drop size of rain ranges from 1 mm to 7 mm, the average drop size was considered 1.71 mm. the framework supporting the boom and machined components of the control box are made from aluminium. The uniformity of rainfall was 90% over the plot area, the plot size was 3.56 m long and 1 m wide. Author Jaqueline blanquies [et al]3 decided criteria for the designing the simulator are, the drop size distribution nearer to the natural rainfall, uniform rainfall intensity, uniform application of rain over the plot, vertical angle of impact etc.rainfall simulator was designed in such a way that it should meet all above criteria.

Soil erosion is becoming major problem in India, erosion occurs due to various reasons such as water, wind, snow etc. Canal embankment can be constructed in locally available soil but due to rain, wind, human interferences etc. embankment will get affected. The process of erosion gradually destroy riverbank, offshore areas. Conventional methods to control erosion are use of jute, coir, stone pitching etc. Stone pitching is considered costly as compared to any other method, jute and coir are natural material widely used for control erosion. Kelly Sutton [et. al]4 observed Paddy straw to control erosion on embankment by spreading loose straw, mulching, wattle rolls etc. Bales have commonly been used for erosion control by strategically trench excavating and staking them at an angle to create a “catch basin” into place at key locations along drainages and other sites susceptible to erosion.Application of protective layer of hand scattered or blown straw with or without chemical tackifiers is practiced. Mulch itself can reduce erosion by 90%. Wattles products are manufactured by filling long, cylindrical tubes of netting with paddy straw. Rain erosion will largely affect embankment due to its splash, it will get affected by various factors such as rain drop size, intensity of rain, duration etc.

3. SCOPE OF WORK:

1.To study the use of paddy straw for erosion control.
2.To Study of erosion of embankment at different slopes with and without paddy straw.
3.To study degradability and durability of paddy straw material.
4.To find out costing per Sqft of embankment construction with paddy straw.

4. EXPERIMENTAL SETUP

A geomesh using paddy straw is made of 8mm thicknessand 20 mm aperture size, which can be

laid on the embankment slopes. A masonry tank is constructed with1 m2 area, the rainfall simulator system designed to generate homogenous rainfall by considering height of fall of rain is 3m, rain drop size approximately 2 mm, intensity of rain is constant over the area.

4.1 Paddy straw as Geo mesh

Conventially paddy straw is used in mulching, wattle rolls, loose pattern etc., the attempt is made to prepare the geomesh of paddy straw from raw material, the raw material is obtained from single source.The ropes are hand woven and are twisted by the same person keeping the similar technique.The thickness of mesh is 8mm, aperture size is 20mm chosen for experimentation. The paddy straw geo mesh is laid on slopes and to avoid sliding of geo mesh it was pinned at four corners.The masonry tank is divided into two part, a150 mm baffle wall is constructed between the tank, one part consists of area on which the murum is laid in slope and on top of murum the geomesh is laid and other part consists of collection of eroded soil. The rainfall simulator consists of a system of sprinkler which applies rain on test plot. A system consist of 1 ½" G.I. pipe to convey water to sprinkler from tank. The rain falls through sprinkler on slopes, runoff created which overflow baffle wall and can be collected through PVC pipe. The simulator should produce rainfall intensities which varies with time but are relatively uniform over plot area and which mimic the characteristics of natural rainfall as closed as possible. The height of fall of rain is 3m from bottom of inclined surface, rain drop size is considered approximately 2 mm, the intensity of rain is considered 35.2 mm/h, the slope for experiment is 1V:1.5H, the intensity is measured by using measuring cylinder. The eroded soil is collected using PVC pipe and weighed.

5.OBSERVATION

Observations are taken for slope 1V:1.5H, 1V:2.25H and 1V:3H, with paddy straw geomesh and on bare soil. The soil erosion is calculated by collecting turbid water. It is spread in large pan dried in sunlight for 24 hrs. After complete drying, the residual soil is weighted.

Results of Erosion Study

Slope	Weight of soil collected		% reduction
	With mesh	Without mesh	
1V:1.5H	1.886	2.752	**45.91**
1V:1.5H	1.780	2.984	**67.64**
1V:2.25H	0.796	1.474	**85.17**
1V:2.25H	0.876	1.233	**40.75**
1V:3H	1.134	3.087	**172.22**
1V:3H	1.209	2.872	**137.55**

Result of Tensile strength

Samples	No of days	Sample No.	Break Load (N)	Break Elongation (mm)	Max. load (N)	Strength before immersion (kN/m)	Max. elongation (mm)	Strength (kN/m)
Sample-I (Geo-mesh+Water)	15	1	627.2	25	823.2	8.281	21.4	**4.508**
	30	2	294	26.8	901.6	8.281	19.7	**4.116**
	45	3	147	43.9	264.6	8.281	34.8	**2.94**
Sample-II (Geo-mesh+ murum +Water)	15	1	117.6	21.7	196	8.281	15.6	**3.822**
	30	2	382.2	22	499.8	8.281	19.1	**3.185**
	45	3	39.2	25.8	78.4	8.281	23.7	**2.401**

Cost of construction consists of material cost + labour cost, finding out cost of construction for embankment along with paddy straw geomesh. The cost of construction of embankment of chaskaman site is Rs. 40.53 per sqft. The cost of raw material of geomesh and labour cost for making mesh is Rs. 15 per sqft.

Construction cost of embankment without geomesh

Description	Construction Cost (Rs.) for embankment per Sqft.
Embankment for murum available at site by using required machinery and labours.	40.53

Construction cost of embankment with geomesh

Description	Construction Cost (Rs.) for embankment per Sqft.
Embankment for murum available at site by using required machinery and labours.	40.53
Cost of paddy straw geo mesh raw material, labour charges.	15
Total cost	**55.53**

Cash flow of construction and maintenance cost with and without mesh

Years	Construction and Maintenance cost With Geomesh	Construction and Maintenance cost Without Geomesh
0	55.53	40.53
1		6.07
2		6.07
3		6.07
4	21.07	6.07
5		6.07
6		6.07
7		6.07
8	21.07	6.07
9		6.07
10		6.07
11		10.13
12	25.13	10.13
13		10.13
14		10.13
15		10.13
16	25.13	10.13
17		10.13
18		10.13
19		10.13
20	25.13	10.13
Total	**173.06**	**202.53**

From above table it is seen that the embankment cost with laying of paddy straw geomesh will be 1.37 times of embankment cost without geomesh. The mesh cost will be divided as 80% for material and 20% is for labour. But maintenance of embankment will start immediately and it to be done at every year after rainy season. The maintenance cost for first 10 years will be 15% of construction cost and 25% after 10 years up to 25 years, Fig. 5.14 shows the comparison of maintenance cost of embankment with and without mesh. The duration for comparison considered is 20 years, after 20 years the maintenance cost with mesh will be Rs. 173.06 and without mesh will be Rs.202.53. The % saving in cost will be 17.02%.

6. CONCLUSION

· From the result of study of experimentation using rainfall simulator, it can be concluded that % reduction of soil on slope of 1:1.5, 1:2.25, and 1:3 is 67.64, 85.17, and 172.22 respectively.

· From the result of study of tensile properties of material, it can be concluded that the tensile strength of mesh in

dry condition is more compared to mesh in wet condition, tensile strength of mesh in combination of mesh + water the % reduction in strength after 15, 30 and 45 days is 83.69, 101.19 and 181.67 respectively. In combination of mesh + water + murum % reduction in strength after 15, 30 and 45 days is 116.67, 160 and 244.89 respectively. It is also seen that the tensile strength of paddy straw geomesh in dry condition is very less compared to other natural material like Jute, coir etc.

· From the study of construction and maintenance cost, it can be concluded that cost ofconstruction of embankment with paddy straw will cost 1.37 time more compared to embankment cost without paddy straw mesh. Maintenance cost of embankment with paddy straw mesh will be saved by 17.02% when compared to without geomesh.

· Easy availability and cheap cost of paddy straw geomesh holds promise for its use as natural geomesh for slope protection. There are also chances of creation of employment in the rural area since

material is available in every household and manufacturing process of the said geomesh is not going to be a difficult exercise. This would increase the socio-economic and financial standards of rural people. With possible inception of this waste material as natural geomesh the disposal problem of paddy straw which results in its burning in open fields and thereby inducing environment pollution is also likely to get controlled.

7. REFERENCES

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