ISSN : 2394-2975 (Online)
ISSN : 2394-6814 (Print)

Study of Drapability of Paddy Straw Geomesh for Slope Erosion Control

[I]S. A. HALKUDE, [II]R. C. KATDARE
[I]Principal, Walchand Institute of Technology, Solapur, Maharashtra State, India
[II]Researches Student, Walchand Institute of Technology, Solapur, Maharashtra State, India

Abstract

The present paper deals with finding Drapability of the proposed handmade Paddy straw Geomesh for erosion control, expressed in terms of % Drape coefficient and Stiffness using locally designed setup based on Cusick Drape test, and Cantilever method respectively. These methods are generally used for testing of fabric/Geotextiles made up of manmade and natural fibres and are made applicable for proposed Geomesh also which falls under the category of Open weave Geotextiles(OWT) as per Erosion Control Technology Council (ECTC)'s categorisation. The Drapability calculated in terms of Drape coefficient works out to 93.32% in dry, 83.82% in normal wet and 64.88 % in saturated wet condition while Stiffness values work out to 313.69, 281.44, and 71.68 Gms cm respectively in the same three conditions. Further these properties viz. % Drape coefficient and Stiffness are found to be dependent on dry and different wettability conditions of Geomesh during testing and also show great correlation with each other. This would help in selecting the specific Geomesh even if either % Drape or Stiffness is known. The Paddy straw Geomesh which otherwise look like a hard and stiff material in dry and even under normal wet conditions, when placed under field condition start absorbing water, reduces its stiffness over a period of time and becomes good Drapable material. This property of the said Geomesh makes it capable to adjust itself to the contours, and undulation on the surface of the embankment, and further help prevent erosion. The drape and Stiffness value of 64.88% and 78.68 Gms cm respectively, meets the criteria mentioned in the Table-1 below, to make it compatible with other similar products available in the market, as effective erosion control material,

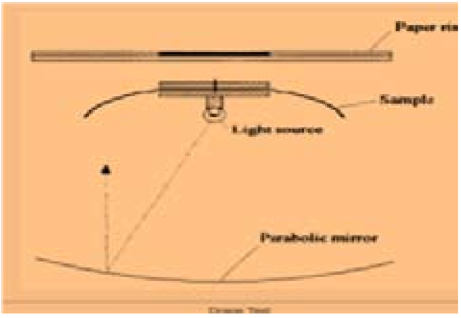
Keywords

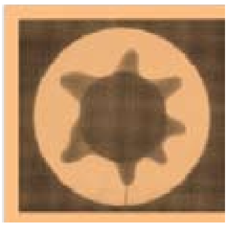
Geomesh, Paddy Straw, Drapability, Stiffness, water absorption, Erosion control

Introduction

Paddy straw is a Lignocellulosic waste material generated in abundance as a by-product of rice cultivation in rural India and there are limited options available for its effective disposal which includes incorporation into the paddy field to improve potassium deficit, use as livestock feed, making of compost, pulp, and straw boards etc. However most of the times, it is found that the huge quantity of paddy straw is often burnt into the field by farmers which unnecessarily cause heavy air Pollution and related diseases. Therefore the proposed use of Paddy Straw in the form of handmade Geomesh for erosion control would possibly generate greater demand of its production on large scale and which would help in establishing household industry to generate large scale employment in rural area and benefit the society at large. It is also to be noted that the Paddy Straw has been in use for erosion control since long in various forms like Bales, spreading of loose straw, wattles and blankets. However, unlike Jute and Coir, which have become commercially successful, the use of Paddy straw for the same purpose has not yet gained that popularity as its counterpart due to its non feasibility of extracting inexpensive fibre and yarn from it as described above [1].The effectiveness of natural Geotextiles(Paddy Straw Geomesh in this case) in decreasing soil erosion mainly depends on several physical and mechanical properties, such as mass per unit area, thickness, tensile strength, in dry and wet condition, water absorption and Drapability [2-6]. The natural Geotextiles after becoming wet should expand to the soil surface, enhancing its adherence to surface micro topography and thereby control runoff and erosion.[7].This property of bending ability of a Geotextile to make full contact with the soil and taking the shape of the contour of the soil surface is called Drapability. Drapability is a term generally associates with the comfort properties of the fabric in and it describes the way a fabric hangs under its own weight and the drape coefficient is defined as ratio of a projected pleating fold area formed by a piece of fabric after draping under its own weight to the original area of this piece of fabric without draping [8]. The higher the fabric drape coefficient, the lower the fabric Drapability[9].Basically fabric drape is not an independent fabric property and is related to fabric bending, shear, tensile, fabric thickness and fabric weight [10]. The bending length of the fabric specimen found from cantilever test is correlated with the drape property [11] and is also stated to be a strict measure of the draping property [12].

Under the objective evaluation method, the fabric drape is generally worked out by two methods viz. Drape test [13] using Cusick Drape meter (Figure 1) and finding stiffness by measuring bending length of two-dimensional fabrics (material bends under its own weight) by Cantilever method using Shirley's apparatus [14]. While the former test is carried out in accordance with B.S.5058-1973(1997), the latter follows ASTM D1388 describing Standard Test Method for Stiffness of Fabric (Figure 2).





Top view of Draped fabric sample

Fig. 1: Cusick Drape Tester for testing Drapability

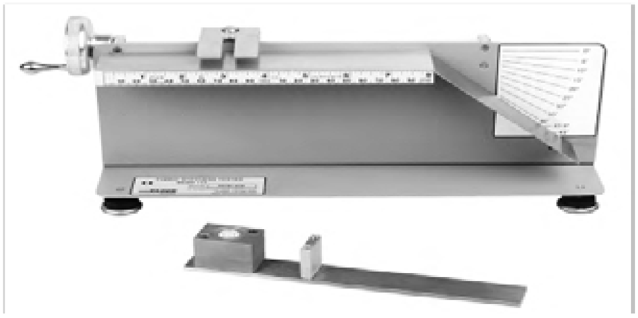


Fig. 2: Shirley's apparatus for testing Bending Stiffness

The drape test of the fabric using Cusick Drape meter, works on the principle that a circular fabric specimen is held concentrically between smaller horizontal discs and an annular ring of fabric is allowed to drape into folds around the lower supporting disc. The shadow of the draped specimen is cast into an annular ring of paper of the same size as the unsupported part of the fabric specimen. The outline of the shadow is traced into the ring of paper, the mass of which is then determined. The paper is then cut along the trace of the shadow and the mass of the inner part representing the shadow is determined. The drape coefficient is calculated from the two masses.
Similarly in Cantilever method using Shirley's apparatus, the fabric drape is measured in terms of fabric stiffness by measuring overhang (i.e. bending length of two-dimensional fabric sample) when the sample is flexed to a 0.724 radian (41.5º) angle from the horizontal plane. The length of the sample overhang and the angle is then used to calculate the Bending Stiffness and Flexural Rigidity of the fabric. The third method called "Hanging Drop Method" is generally used to find drapability of fabrics that are too limp to give satisfactory result by the cantilever method, may have their Stiffness measured by forming them into loop and allowing it to hang under its own weight [15].
The drapability of a Jute Geotextiles (JGT), expressed as Stiffness (also called as flexural stiffness or flexural rigidity) is actually found out just like that of fabric using Shirley's apparatus as per the procedure described in ASTM D 1388.
This flexibility or stiffness of a fabric (Geotextiles in this case), is different from its modulus or the modulus of elasticity which is determined as the initial portion of the stress-versus-strain curve. In this case the flexibility is the stiffness of the material when bent in one plane under the force of gravity and is determined by sliding a fabric strip in a direction parallel to its longer dimension, so that one of its end projects from the edge of a horizontal surface, like a table [16] [17]. Another method is prescribed to find drapability of JGT by placing the samples (of equal unit weight) over an open span and measuring the sag during dry state as well as wet state of the fabric [18].
The first two of the above three methods, are generally used for fabrics are made applicable to find Drapability of the Geotextiles (Geomeshes in this case) made up of natural material like Jute, coir, hemp and Paddy Straw (in this case)
In short it is observed that Stiffness test (ASTM D 1388), is more popularly practiced vis-à-vis drape test (B.S.5058-1973-1997) , for finding the drapability of Geotextiles. Another observation is that, the Paddy Straw while use as mulching material can be crimped, rolled, or punched into the soil like fabric, but the proposed Geomesh which is made up of plaits/strands naturally is more stiff both in wet and dry condition. As such it, when put to use for Erosion control, it will be appropriate to find drapability of the said Geomesh by both the methods viz. Drape test using Cusick drape meter and stiffness test using Shirley's stiffness test apparatus to cover the whole range of crimpness to rigidness. Moreover the natural Geotextiles absorbs water to capacity; its flexibility is increased approximately, 25 per cent thereby improving its Drapability, i.e. its ability to maintain Intimate contact with soil, which further helps in reducing erosion [19]. Therefore the drape test and stiffness test of the Geomesh is performed not only in dry but different wet conditions in order to match field conditions and are finally correlated using statistical Software [20]. The table 1 below shows drape coefficient and stiffness of some of Geotextiles made of natural material.

Table 1: Drape coefficient and Stiffness values of Geotextiles/ RECP collected from literature and market.

S.N.	Material used	Drape Coefficient in %	Stiffness unit	Source
1	Jute Geotextiles(JGT)	80.40 – 83.00	330 gm/denier	[21]
2	100% Cotton fabric	29.77-56.86	-	[22]
3	Coir fibre (Product : Koir Mat) 400/700/900 Gsm	-	4.070x3.923 Gm cm 12.896x8.132 Gm-cm 14.019x9.329 Gm-cm	[23]
4	Straw Blanket(3 D Matrix)	-	67.699 Gm-cm	[24]
5	Geosynthetics (Non organic)	-	40.000 Gm cm	[25]
6	Rolled Erosion Control Product (RECP) of natural material like jute, coir, straw	-	62.714-43.787 Gm cm	[26]

Methodology: The handmade Paddy Straw Geomeshes used throughout in the present study is dimensionally designated as 6G-12 wherein, 6 stand for thickness in mm, G for Geomesh and 12 for aperture size of 12x12 mm. The Drape and Stiffness test of the Paddy Straw Geomesh is done separately under the following conditions.

ISSN : 2394-2975 (Online)
ISSN : 2394-6814 (Print)

i) The proposed handmade Geomesh does not have web and weft kind of weaving, but has plaits/strands, that are manually weaved in horizontal and vertical direction to form mesh. However test procedure and no. of readings to be taken is done as prescribed in the relevant codes considering web & weft of the Geotextiles.
ii) Instead of using the branded equipments like Cusick drape meter for drapability test and Shirley's stiffness test apparatus for Stiffness test of the Geomesh, the similar facility is created in house using local equipments.
iii) Since the proposed Geomesh has to function in wet conditions in the field, the samples are tested both for drape and stiffness tests, in normal and saturated wet conditions. One separate study on capacity of Paddy Straw Geomesh to absorb water reveals that the Geomesh continue to absorb water and increase in weight even after initial 10 minutes and reaches initial saturation point at the end of 360 minute.
Therefore the time interval decided for Geomesh to be wetted for is 10, 30, and 360 minutes for both the tests.
iv) The experimental values of drape coefficient and bending stiffness are then correlated and further analysed by Regression analysis using IBM's software 'SPSS, and 'Excel Easy' . The details of set up are as follows.

Material And Methods:

1) Finding drape coefficient of Paddy Straw Geomesh (6G-12) using locally prepared Cusick type Drape meter

Material:

I. A Pan of concave spherical shape of size 300 mm dia. and 110 mm deep, made of Indolium metal which is pasted with silver foil to give spherical reflecting surface- 1 (one) No.
II. A point source of light in the form of Torch having LED Lamp (FEILEX brand, ACDC 50/60 Hz power), about 208 mm long with focus glass of dia. 30.0 mm and operating on Nickel Cadmium battery - 1(one) No.
III. Plastic discs of 130 mm dia, 2 nos; one lower and other upper to hold Geomesh sample sandwiched.
IV. 360 mm dia. circular shaped Paddy Straw Geomesh samples (6G-10) - 36 Nos (6 samples for testing in each four conditions viz. dry, Wetted in water for 10,30 and 360 minutes). The Sample size adopted is as per the recommendation of B.S.5058-1973(1997) for stiff fabric.
V. 1/18 size electrical wire about 3000 mm long,
VI. Translucent paper specimen of 500 mm dia and having uniform density (since the paper size of 500 mm dia. instead of 360 mm dia, is found to accommodate the full shadow of Geomesh sample of 360 mm dia. fully) ,
VII. Electronic weighing Balance capable of measuring mass up to 0.001 Gms.

Method: The experiment is carried out on dated 14/03/2015 at 2000 hrs. The LED torch is tested for its functioning of switching on and off and then lower disc is fitted into it by suitable packing, taking care that the on/off button remains free to operate. The sample 1 is then placed over lower disc and covering and fixing it with upper disc. This end torch assembly is now tied down to one end of the nylon string by a hook made at the end of the Torch. The other end of the string is passed over another small hook fitted on the adjacent wall such that the said torch assembly with Paddy Straw Sample may be lifted or lowered down over a spherical reflecting surface (as described above) which is placed on the floor just below Torch assembly.
1(one) Paper Sample of 500 mm dia.(Since the 360 mm dia. Geomesh sample, to cast its shadow fully requires minimum 500 mm dia. of Paper sample) is also passed through string and placed at the rear side(end) of the torch assembly to obtain the reflected shadow of sample. The distance of torch assembly (now with paper added) is adjusted in such a way that the LED Lamp rests at the focus of the spherical reflecting surface to obtain good clear shadow of the sample and rings (lower + upper) on the paper. This distance works out to be about 670 mm from the bottom of reflecting surface to LED Lamp level as shown in Figure 3.1 to 3.9.

Fig.3.1: Geomesh Samples, 360 mm dia.

Fig.3.2: White paper samples,

Fig.3.3:Paper sample cut along draped periphery

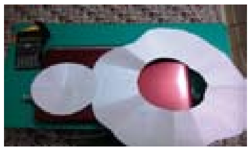


Fig.3.4:Annular ring is cut before weighing

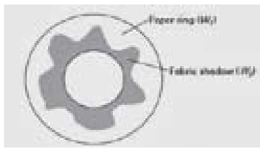


Fig.3.5: shows area for weighing W_1 and W_2

Fig.3.6:Anticlockwise from left bottom)
LED Torch as source of light
Parabolic reflecting surface
Geomesh sample of 450 mm dia.
Paper ring of 500 mm dia.

Fig.3.7: Testing of LED torch assembly, with draped Geomesh & paper sample suspended over the reflecting surface at its focus

Fig.3.8: Adjustment of LED torch assembly with paper concentrically above to get clear draped image of sample

Fig.3.9: Measuring the Mass of the M_1 and M_2 of various samples on weighing balance measured up to 3 decimal.

Figure 3: Setup to test Drapability of the Paddy Straw Geomesh on the lines of Standard Cusick Drape Tester for testing Drapability of Fabric in accordance with B.S.5058-1973(1997)

The torch is now switched on and without delay the periphery of the shadow of the draped sample DT-1(in dry condition) is marked on paper with the pencil. The circular paper is now taken out, folded and its mass is measured on weighing balance to the nearest 0.01 Gms and is termed as M_1. The said paper is then cut according to the traced image of draped sample on the paper and its mass is measured and is termed as M_2, after discarding the no shaded portion of the sample. The drape coefficient is calculated using the formula; Drape coefficient = Mass of paper only with marked image of sample(M2) / Mass of the full paper with marked image of sample(M1) x 100 and the values are mentioned in Table 1 only. The procedure is repeated for two more times on the Sample DT-1 and with the other surface uppermost, thus making total 6(six) measurements on Sample DT-1.Similarly 6(six) measurements are taken on each of the Sample DT-2,DT-3,DT-4,Dt-5 and Dt-6 in dry condition and thus making the total observation equal to 36 Nos. The average of each six observations is noted as the value of drape Coefficient.

The experiment is repeated, for the Sample no. DT-6 to DT-12, DT-13 to DT-18 and DT-19 to Dt-24 in different wet conditions after Keeping them immersed in water respective for 10, 30 and 360 minutes as mentioned above. In all total 144(6x 24) readings are taken. The average drapability values of six observations of each Sample no. viz. DT-1 to DT-6 in dry and DT-6 to DT-23 in different wet condition mentioned as above is recorded. Further, barring drape value with respect to initial water absorption time interval of 10 minutes, rest drape values are interpolated for equal interval of 30 minutes and are tabulated in Table 1.

Table-1: Shows values of (%) Drape coefficient from the Drape test on the Paddy straw Geomesh (6G-12) samples of 360 mm dia. with respect to its time of absorption

Time in Minutes	0	10	30	60	90	120	150	180	210	240	270	300	330	360	390	420
% Drape Coefficient	93.32	83.82	72.06	71.33	70.61	69.88	69.15	68.42	67.69	66.97	66.24	65.51	64.78	64.88	64.80	64.8

Note: The Geomesh is in dry condition at ‘0’ minutes and is then immersed in water for specific duration and then tested for finding % Drape coefficient values with respect to time of absorption.

2) Finding Stiffness of Paddy Straw Geomesh in terms of bending

Material:

i) Rectangular steel table of size 601 x 460 mm fitted with Acrylic *Perspex* Plastic *Glas*s top – 1 no.

ii) Foldable steel table of size 660 x 400 mm capable of slanting its top surface to desired degree with the horizontal level of rectangular steel table when attached - 1 no.

iii) Acrylic travel bag of size 630 x 510 mm, pasted with sketch of the Protractor on its vertical surface in such a way that when joined, the top of rectangular table coincides with the 00.00 line of the Protractor - 1 no.

iv) Paddy Straw Geomesh samples of size 25 x 200 mm – 24 Nos (6 Samples for each category like BT-1 to BT-6 in dry condition and other 18 samples,BT-7 to BT-12, BT-13 to BT-18 and BT-19 to BT-24 in respective wet conditions i.e. kept immersed under water for 10, 20 and 30 minutes). The Sample size adopted is as per the recommendation of ASTM D-1388 for stiff fabric.

v) Weigh balance to obtain weight in Gms up to 0.001 decimals,

vi) 300 mm long graduated wooden scale, hanging arrangement, Lead pencil and eraser etc.

Method: The ASTM D1388, recommends fabric sample size of 25 x 200 mm in a Standard Test Method done to measure bending stiffness of the fabric which includes recording of actual 4(four) readings of 3(three) samples for each web and weft direction. However since the proposed handmade Paddy Straw Geomesh unlike fabric has same weaving in the web and weft direction, therefore directly 6 samples of size 25 x 200 mm are taken for testing in dry and wet condition of the sample.

First of all the rectangular table is placed on a level surface and nearer to the vertical surface. One end of the folding table is now connected in slant position to one end of the table while other touches the ground making an angle of 41.5^0 with the horizontal. This setting is done using the sketch of the protractor pasted on the Acrylic travel bag manually attached to the rectangular table. The whole arrangement is displayed in Figure 6. Now the sample BT-1 is taken and is weighed in balance to obtain Mass per unit area (M) of the sample. It is then placed at the centre along the longer side of rectangular table. The levelling up of the table top is again ensured using level tube. Wooden scale of 300 mm is placed over the sample BT-1 (Figure 7) and then by sliding, both the things are slowly brought near the starting of the slant portion.

Fig.4.1: Top of Table is flushed with reference - 00

Fig.4.2: sliding table inclined at 41.5^0 & connected to ref.-00

Fig.4.3: shows set up ready for the testing

Fig.4.4:Another view of set up

ISSN : 2394-2975 (Online)
ISSN : 2394-6814 (Print)

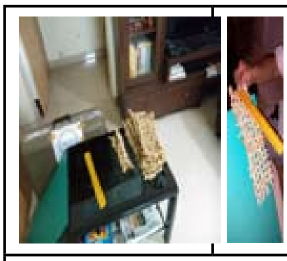


Fig.4.5: Test sliding of Geomesh Cut to 25x200mm

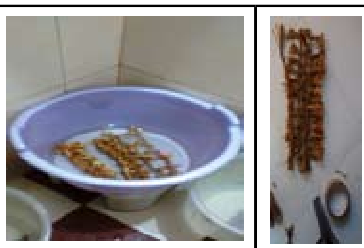


Fig.4.6: Samples kept under water for different durations.

Fig.4.7: Actual testing of Geomesh samples

Fig.4.8: weighing samples in wet & dry condition

Figure 4: Setup to test Bending Stiffness of the Paddy Straw Geomesh on the lines of Shirley's apparatus used to test Stiffness of Fabric in accordance with ASTM D1388

Now the sample BT-1, under wooden scale is slowly pushed over the slant portion in straight line, while it starts bending down the wooden scale moves ahead in straight line. The moment the sample BT-1 touches slant portion of the folding table and flushes with surface, the overhanging length (L in mm) which is twice the bending length (C) of the sample BT-1,with $\theta=41.5^0$ is measured on the wooden scale. four readings are taken for sample BT-1 in dry condition with one face up and one face down on the first end, and then the same for the second end. The procedure is then repeated for remaining five samples viz. BT-2 to Bt-6 in dry condition. Similarly four readings of remaining 18(eighteen) samples viz. BT-7 to BT-12, BT-13 to BT-18 and BT-19 to BT-24 in different wet conditions which are created by immersing set of above mentioned Geomeshes in water for 10, 30, and 360 minutes respectively. The average of each four readings is taken as Stiffness value of the Geomesh sample under a specified dry and wet category. Further, barring Stiffness value with respect to initial water absorption time interval of 10 minutes, rest Stiffness values are interpolated for equal interval of 30 minutes and are tabulated in Table 2.

Table-2: Shows Stiffness values from Stiffness test performed on Paddy straw Geomesh (6G-12) samples of size 25 x 200 mm with respect to its time of absorption of water.

Time of absorption in Minutes	0	10	30	60	90	120	150	180	210	240	270	300	330	360	390	420
Stiffness Gms /cm	313.69	281.44	112.9	108.78	104.65	100.53	96.41	92.29	88.17	84.05	79.93	75.80	71.68	71.68	71.68	71.68

Note: The Geomesh is in dry condition at '0' minutes and is then immersed in water for specific duration and then tested for finding Stiffness values with respect to time of absorption.

Result and Discussion

The data obtained from the drapability and bending stiffness test of Paddy Straw Geomesh is processed for finding their correct values, validating them by finding correlation with each other.

Water absorption capacity of the Paddy Straw Geomesh: The Geomesh Sample 25 x 200 mm size, prior to Stiffness test experiments are tested for water absorption by immersing all samples in water for the different time "T". Average weight of the each six Geomesh is taken for plotting curve between % water absorption vrs time in hours as shown in Figure 5 below.

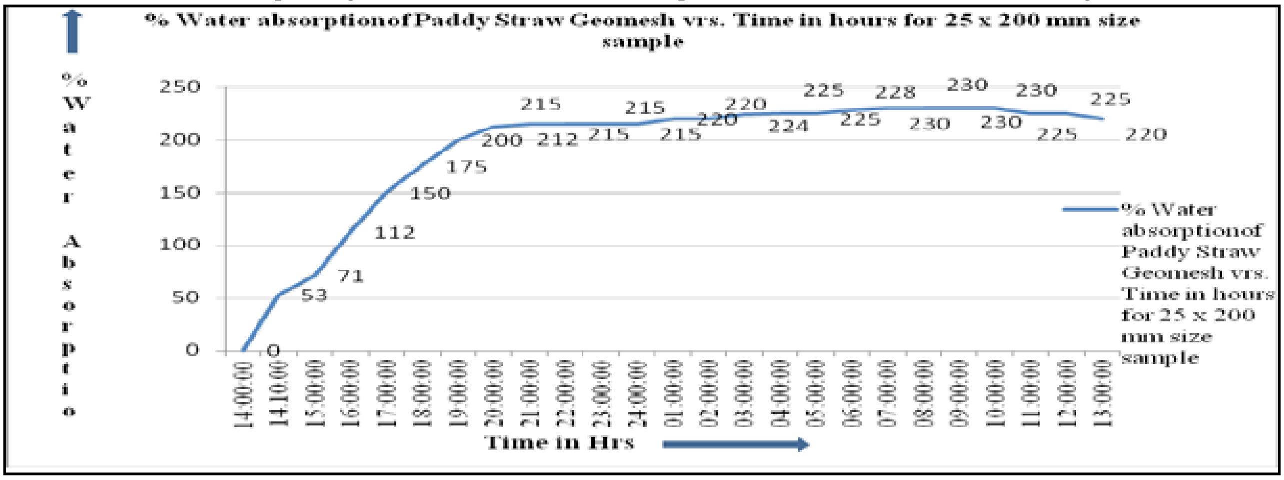


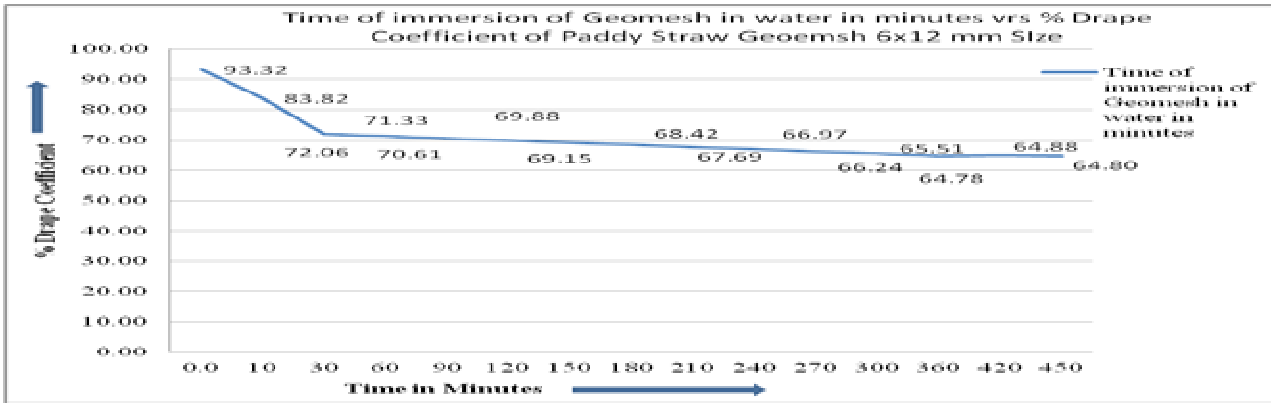
Figure 5 : Shows water absorption capacity of Paddy Straw Geomesh at the end of different time Interval

The Geomesh Samples 25 x 200 mm size when kept under water for different durations and weighed after every one hour (starting time 14.00.00 hrs on 1st day) except for the duration of 10 minutes in the beginning when it is seen that the Geomesh absorbs water at very high rate nearly equal to 53%. This rate however gets slowed down and till the end of the 30 minutes become about 71%

i.e. only 18 % increase in last 20 minutes. The subsequent increase is gradual and slow as compared in the beginning and reaches first saturation point at the end of the 6.0 hours (IST 1300 hrs) when the absorption becomes almost 215 % as seen from the curve beyond which no gain in the weight is observed up 11.00 hours (IST 0100 hrs.). In this condition also the Geomesh sample is in good shape and easy to handle for the test. However at the end of 18.0 hours (IST 0600 hrs on 2nd day), the strands of the Geomesh get opened up and it start looking weird and does not remain suitable for testing. The maximum water absorption rate at this time is seen to have reached 230%which is slightly more than that at 1st saturation stage. Accordingly the test for finding drape coefficient and Bending Stiffness is carried out in four conditions viz. in dry state, after wetting respectively for 10, 30 and 360 minutes (beyond which Geomesh sample becomes unsuitable for testing) which justifies its four phases of initial, rapid, gradual and maximum absorption of water by these Geomeshes to simulate field condition.

Effect of time (water absorption) on Drape coefficient of Paddy Straw Geomesh (6G-12):

Using the data of table 1, a curve is plotted between drape coefficient values in % and the times of absorption of water in minutes and is depicted in Figure 6 below.

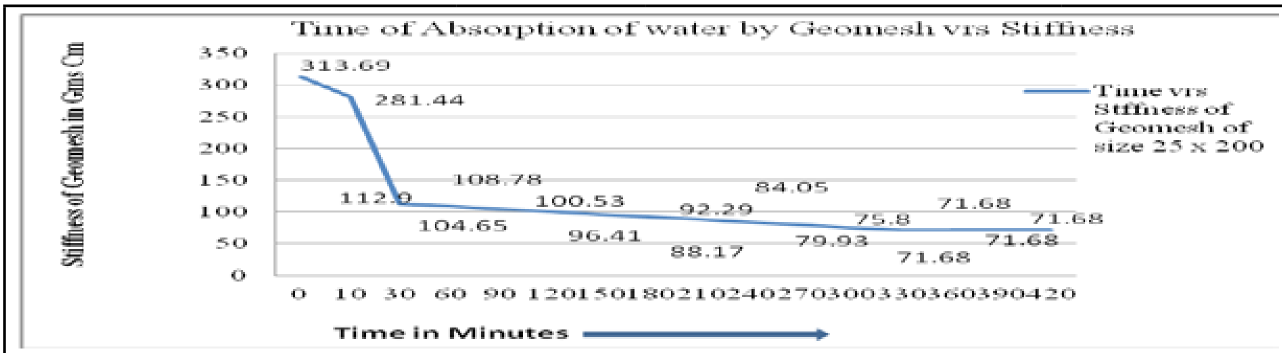


	Time	%Drape Coefficient	Free download software on Internet By "Excel Easy "
Time	1		
%Drape Coefficient	-0.737089095	1	

Figure 6 : Shows curve of Time of absorption of water by Paddy Straw Geomesh vrs % Drape coefficient

The curve of Figure 6 shows that the drape coefficient is highest and equal to 93.32% in the beginning signifying that the Paddy Straw Geomesh is very stiff in dry state. Then the drape coefficient subsequently reduces down further to 83.82% after remaining in water for 10 minutes and then tested. This also justifies that this reduction continues up to 65.51% when the Geomesh is wetted for 360 minutes and then tested. However from this point onward the drape values viz. 64.78 %, 64.88% and 64.80% appear to have stabilised down and thereby indicating the saturation in water absorption by Geomesh. This proves that the drapability of Paddy Straw Geomesh alike, Jute Geotextiles (JGT) is Maximum in dry condition, as mentioned in literature and is slightly less than maximum value under normal moisture content but goes down reducing with addition of moisture contents till it achieves saturation point of absorbing water.

The correlation coefficient calculated using statistical function of free download software on Internet By "Excel Easy works out to be equal to - 0.737089095 which indicates a strong downhill (negative) linear relationship between drape coefficient and time of absorption of water by Geomesh.



	Time	Stiffness of Geomesh Sample 25x200	Software "Excel Easy "
Time	1		
Stiffness of Geomesh Sample 25x200	-0.686498315	1	

Figure 7: shows curve of Time of water absorption vrs Stiffness of Geomesh of size 25x200 mm

Effect of time (of water absorption) on bending stiffness of Paddy Straw Geomesh (6G-12) Sample of 25 x 200 mm size.

Using the data of table 2, a curve is plotted between Stiffness values in Gms cm and the times of absorption of water in minutes

ISSN : 2394-2975 (Online)
ISSN : 2394-6814 (Print)

and is depicted in Figure 7 above. The curve of Figure 7 shows that the Stiffness of Geomesh samples of size 25x200 is highest in dry condition and is equal to 313.68 Gms-cm respectively. When the Geomesh samples are tested in normal wet conditions the bending stiffness of the Geomeshes stars reducing and giving values equal to 281.43 Gms-cm. The process continues when the Stiffness values of the Geomeshes reduces to 71.68 Gms-cm and which is the minimum value of Stiffness before full saturation of samples.
The details of correlation coefficient of the two variables, calculated using Free Excel software is tabulated in the body of Figure 7 itself. The correlation between Time of absorption and Stiffness of Geomesh samples 25 x200 shows value equal to -0.686498315 which indicates that a strong downhill (negative) linear relationship is existing between time of absorption of water by Geomesh and its Stiffness.

Relation between Drape coefficient and Bending Stiffness of Geomesh (6G-12) sample of 25 x 200 mm size:
From 2nd and 3rd Para under Result and Discussion, the two main properties viz. Drape coefficient and Stiffness of Paddy Straw Geomesh are observed to be correlated with time of absorption of water. Now in the same way the relation between Drape coefficient and Stiffness of Paddy Straw Geomesh (6G-12) is tried to be established by doing Regression analysis using IBM's SPSS software. The analysis is carried out between experimental values of % drape coefficient and Stiffness recorded earlier in Table 1 and 2 above. These values are now sorted and are reticulated in Table 3 below.

Table 3: Shows the experimentally calculated values of % Drape coefficient (dependent variable) and Stiffness calculated independently with Paddy Straw Geomesh (6G-12) in dry and different wet condition

Time of absorption in Minutes	0	10	30	60	90	120	150	180	210	240	270	300	330	360	390	420
% Drape Coefficient	93.32	83.82	72.06	71.33	70.61	69.88	69.15	68.42	67.69	66.97	66.24	65.51	64.78	64.88	64.80	64.8
Stiffness Gms /cm	13.69	281.44	112.9	108.78	104.65	100.53	96.41	92.29	88.17	84.05	79.93	75.80	71.68	71.68	71.68	71.68

Note: The Geomesh is in dry condition at '0' minutes and is then immersed in water for specific duration and then tested for finding % Drape coefficient and Stiffness values with respect to time of absorption.

i) The bivariate Correlation between % Drape coefficient and Stiffness of Paddy Straw Geomesh (6G-12) in dry and different wet conditions is found using IBM's statistical software SPSS and Excel Easy and is shown in Table 4 below.

Table 4: Shows correlation table for % Drape Coefficient and Stiffness values taken from Table 3.

Correlations			
		Drape Coefficient	Stiffness of 25x200 mm Geomesh Sample
Drape Coefficient	Pearson Correlation	1	.980**
	Sig. (2-tailed)		.000
	N	16	16
Stiffness of 25x200 mm Geomesh Sample	Pearson Correlation	.980**	1
	Sig. (2-tailed)	.000	
	N	16	16

**. Correlation is significant at the 0.01 level (2-tailed).

ii) The regression analysis is done to prove that there is a significant linear relationship between Stiffness (an independent variable *X*) and a Drape coefficient (dependent variable *Y*) which is also a test requirement for, regression analysis. The other assumptions are for each value of X, the probability distribution of Y has the same standard deviation (σ) /standard Error (SE) and for any given value of X, the Y values are independent. Accordingly the statement of hypothesis is as follows.
$H_{01:}$ Bending rigidity α Drape coefficient, Against alternative hypothesis; H_1: was developed assuming that there is the positive correlation in between Bending rigidity and Drape coefficient. Therefore, $H_{1:}$ Bending rigidity α drape coefficient.

iii) From Table 4, probability < 0.01 justifies the significant Correlation between two properties of Paddy Straw Geomesh which also indicate that the slope will *not* equal zero. Therefore null hypothesis (H01) can be rejected and accepted hypothesis is, H1; bending rigidity α drape coefficient. The regression analysis is now carried out using the same Software and following output in the form of variables entered/removed, model summary of regression analysis, ANOVA and Coefficients is obtained in Table 5, 6, 7 and 8 respectively.

Table 5: Shows Regression in which Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	Stiffness of 25x200 mm Geomesh Sample b	.	Enter

a. Dependent Variable: Drape Coefficient; b. All requested variables entered.

Table 6: Model Summary of Regression Analysis

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.980a	0.961	0.958	1.58313
a. Predictors: (Constant), Stiffness of 25x200 mm Geomesh Sample				

iv) The R value 0.980 (0.80-1.0); represents the simple correlation and indicates a high degree of correlation. The R^2 value indicates how much of the dependent variable, drape coefficient can be explained by the independent variable, bending rigidity. In this result, 96.1% can be explained.

Table 7: Table of ANOVA[a] ; a = Dependent Variable: Drape Coefficient ; b = Predictors: (Constant), Stiffness of 25x200 mm Geomesh Sample

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	864.568	1	864.568	344.956	.000[b]
	Residual	35.088	14	2.506	Residual	
	Total	899.656	15		Total	

v)The table of ANOVA shows the value of significance of F to be equal to 0.000 which being less than 0.05 justifies the use of stiffness as independent variable.

Table 8: Table of Coefficients [a]

Model	Unstandardized Coefficients		Standardized Coefficients	t	(p) Sig.
	B	Std. Error	Beta		
1 (Constant)	58.431	.750		77.896	0.000
Stiffness of 25x200 mm Geomesh Sample	.104	.006	.980	18.573	0.000

vi) Both P-values in the table 8 shows values equal to 0.000 and are well below the criteria of 0.05. Since F and P values are found to be less than 0.005 there is no need to do regression again. The table above shows hypothetical output for the following regression equation:

Y = 58.431+ 0.104 X, i.e. Drape Coefficient = 58.431 + 0.104 Stiffness………………………… (1)

Similarly the graphical representation of drape coefficient and bending rigidity is depicted in Figure 8.

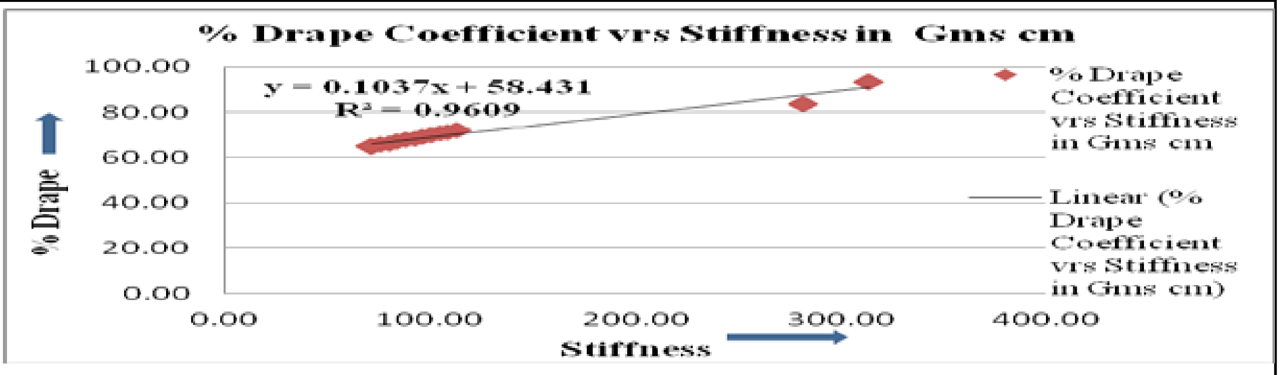


Figure 8: Shows the graphical representation of drape coefficient bending rigidity from the values of Table 3

Finally when the graphical representation of drape coefficient and bending rigidity is compared with theoretical relationship equation of (1), it is observed that the experimental values of both the properties have less deviation from theoretical graph.

Conclusion

The following conclusions have been drawn from the above study.

The drapability of Paddy Straw Geomesh (6G-12) is experimentally found out in terms of drape coefficient and stiffness (bending) by using the same methods as applicable to fabric and Geotextiles made of natural material. The experimental values of both the properties are validated using statistical tools are as follows.

The drape coefficient and stiffness values are respectively found to be 93.32 % and 313.69 Gms cm (Maximum in dry condition), 83.82% and 281.44 Gms cm (Moderate in normal wet conditions) and goes down reducing up to 64.88% and 71.68 Gms cm (under saturated wet condition).

2) Moisture content and time to absorb it, plays vital road in reducing the drapability of paddy Straw Geomesh in terms of both drape coefficient and stiffness. About 200 to 215 % of water by weight of Geomesh is required to reduce about 30 % of the drape coefficient and 77 % stiffness of the Geomesh. Since the field conditions existing for Geomesh to function as erosion control material will always be wet, the reduction in the values of % drape coefficient and stiffness as 64.88% and 71.68 Gms cm, which are very well comparable with the values of similar product available in market and are mentioned in the Table 1 for suitability as effective

ISSN : 2394-2975 (Online)
ISSN : 2394-6814 (Print)

erosion control material.

3) Almost linear and a strong relationship exist between Time of absorption of water by Geomesh, its drape coefficient and stiffness. Thus for any known values of one variable, the other variable can be obtained to verify the Suitability of the Paddy Straw Geomesh from its drapability point of view to effectively serve the purpose of erosion control.

4) The proposed Paddy Straw Geomesh can be said to have sufficient drapability to effectively serve as Erosion control material.

Acknowledgment

The Authors are thankful to Mr. V. K. Patil of Bombay Textiles Research Association (BTRA), at Mumbai for allowing Authors to visit their laboratory to observe the procedure of textile testing.

References

[1]. Halkude, S. A. and Katdare , R. C. " Design of experimental setup for durability of paddy straw for Erosion control in Pune, India," International Journal of Advanced Research in Education Technology (IJARET) vol. 1, issue 1 (July - Sept. 2014) page 49-56

[2]. Shivkumarbabu, G.L. (2006)."An introduction to soil Reinforcement and Geosynthetics" Universal Press(India) Pvt. Ltd. 29-43,105-133,181-195

[3]. Ogbobe O, Essien KS, Adebayo A. 1998. A study of biodegradable Geotextiles used for erosion control. Geosynthetics International 5:545–553

[4]. Rickson RJ. 2006. Controlling sediment at source: An evaluation of erosion control Geotextiles. Earth Surface Processes and Landforms 31: 550–560.

[5]. Vishnudas S, Savenije HHG, van der Zaag P, Anil KR, Balan K. 2006. The protective and attractive covering of a vegetated embankment using coir Geotextiles. Hydrology for Earth System Sciences 10: 565–574

[6]. Sutherland RA, Ziegler AD. 2007. Effectiveness of coir-based rolled erosion control systems in reducing sediment transport from hill slopes. Applied Geography 27: 150–164.

[7]. Sutherland RA, Ziegler AD. 1996. Geotextile effectiveness in reducing interill runoff and sediment flux. In International Erosion Control Association Proceedings of Conference XXVI, 1995, Atlanta, USA;359–370

[8]. Saville, B.P. (1999). Physical Testing of Textiles, Woodhead Publishing LTD, Cambridge, England. ISBN0849305683

[9]. B.S.5058-1973(1997) ,British Standard method of Assessment of Drape of fabric

[10]. Hu, J. L. & Chung, S. Drape behavier of woven fabric , Textile Research Journal, 1989, 68, 93-919.

[11]. Z.M. Sudnik, "Objective Measurement of Fabric Drape –Practical Experience in the Laboratory", Textile Institute, vol. 59(1), 1972, pp 14-18.

[12]. F.T. Peirce, "The Handle of Cloth as a Measurable Quantity", Journal of Textile Institute, 21, 1930, T 377-417.

[13]. ASTM D1388, Standard Test Method for Stiffness of Fabrics

[14]. Seville R.G.(2002), "Physical Testing of Textiles" Woodhouse Publishing Co. In association with The Textile Institute, Abington, Cambridge CB1 6AH, England.,

[15]. Ingold, T. S. and Thomson,J.C.(1990) , " A design approach for performed erosion control systems, Proc.4th Int. Conf. on Geotextiles, Geomembranes and Related products, Den Haag: 375-380

[16]. Choudhary, K.P.(2013). "Use of jute Geotextiles in road, river and slope stabilization" published in "Proceedings of Indian Geotechnical Conference December 22 -24,2013, Roorkee", page 1 to 7

[17]. Koerner, R.M.(1994). Designing with Geosynthetics, 3rd Edition, Prentice Hall, Englewood Cliffs, NJ.

[18]. Shukla, S.K. (2002). Geosynthetics and their applications, 1st Ed., Thomas Telford Ltd. London

[19]. Mathur, sudhir, Guru Vittal, U.K., Sanyal, G T. and Choudhary, P.K., State of Art Report on use of Jute Geotextiles in Road Construction and Prevention of Soil Erosion Landslides., Published by Central Road Research Institute ,New Delhi-110025 Page 24-28

[20]. Niromi seram & Wajira rupasinghe, The influence of bending rigidity on drape coefficient of selected Light weight woven fabrics with seams" International Journal of General Engineering and Technology (IJGET) ISSN 2278-9928 Vol. 2, Issue 1, Feb 2013, 25-32 © IASET

[21]. Mathur, S., Guru Vittal, Sanyal, U.K., T., Choudhary, P.K. (2011)."State of Art Report on use of Jute Geotextiles in Road construction and prevention of soil erosion/ landslides " Published by Central Road Research Institute, New Delhi – 110 025 page 1-37

[22]. Agrawal, S. A. (2013), Study of Height Dependency of Drape Parameters. Published by Int. Journal of Engineering Research and Applications www.ijera.com Vol. 3, Issue 5, Sep-Oct 2013, pp.261-265

[23]. Product catalogue showing Technical Specifications for Koir Mat™ 400, 700, 900 , published by NEDIA 44675 Cape Court Suite 120 Ashburn, VA 20147

[24]. Product catalogue showing performance specification of North American Green DS150 straw erosion control blanket is updated by 9/2004.

[25]. Koerner, R.M. (1992),"Geosynthetics in Filtration, Drainage & Erosion Control" published by Elsevier publishers Ltd, England Page 197.

[26]. Li, M.H. and Khanna, S. (2005) "Aging of erosion control product for channel erosion control", Published by Geosynthetics International, 2005, 15, Vol.4 page 224-230