Short Communications

Relationship among seam strength, weft-way fabric strength and stitch density of B. Twill jute bag

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The influence of weft-way fabric strength and stitch density on the seam strength of B. Twill jute bag has been studied. Study reveals that a correlation exists among seam strength, weft-way fabric strength and stitch density of B. Twill jute bags sewn with herakle stitches. A regression equation for seam strength as a function of two factors namely weft-way fabric strength and stitch density has been established.

Keywords: B. Twill jute bag, Herakle stitch, Seam strength, Weft-way fabric strength, Stitch density

Jute as a packaging material has been in extensive use over a long period for filling a wide range of commodities like foodgrains, sugar, etc. Out of various varieties of jute bags, the most commonly used variety is B. Twill jute bag which is used for packing 50 kg of foodgrains. In the year 2012-13, FCI and other state agencies have procured around 145.2 crores of B. Twill jute bags for packing wheat and rice.

The standard B. Twill bags are prepared from jute sacking fabric of double warp 2/1 twill construction and cloth weight of 579 g/m^2. The nominal warp and weft densities of the cloth are 76 ends/dm and 28 picks/dm respectively. The nominal counts of warp and weft yarns used in this fabric are generally 362 tex (10.5 lb/spy) and 879 tex (25.5 lb/spy) respectively, though it varies from mill to mill. B. Twill bag is stitched at the two sides along the selvedges with three ply of 310 tex/ply jute yarn and herakle stitch (type 502).

In a packaging material like jute bag, load bearing capacity of the each component of the bag under actual usage condition is very important as far as its durability and performance are concerned. In jute bag, the sewn part is considered as the weakest point and adequate stitch density with moderate weft quality is used to provide satisfactory performance level.

One of the most important indicators of the sewed product quality is seam strength, which depends on numerous technical-technological parameters, such as fabric type, stitch type, stitch density, sewing thread count, sewing needle count, seam type, and seam bite[1-3]. Out of all these parameters, seam strength of a B. Twill bag depends mainly on fabric strength, sewing twine quality and stitch density, while others can be considered as minor influencing parameters.

Here, again, these are the weft yarns which bear the stresses at the seam and hence the seam strength depends on the weft-way strength of the fabric. It has also been observed that if proper twine with standard tensile strength is maintained, the failure of seam occurs mainly due to cloth break. It is quite reasonable to analyze two important factors, namely weft way fabric strength and stitch density, as a function of failure in seam strength.

Lot of research works have been carried out in the past to identify the parameters that influence seam quality of B. Twill bags. Bose and Mukhopadhay[4] established a correlation between fabric strength and seam strength of A. Twill bag with overhead and safety stitches at the edges. However, no work has been reported on establishing correlation among seam strength, weft-way fabric strength and stitch density for B. Twill jute bag with herakle stitches at the sides of the bag without any safety stitch. The present study has therefore been undertaken to investigate the correlation among seam strength, weft-way fabric strength and stitch density for B. Twill jute bag.

Experimental

The test samples have been collected from 22 different sources. Ten sample bags of 665 g nominal weight and dimension of 94 cm × 57 cm were selected from each source for their

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characterization. Standard batch of jute, as stipulated in JMDC Productivity Norm - 2005, was used for warp, weft and sewing twines as shown below:

Warp
TD 4	63.6 %
TD 5	36.4 %
Total	100%

Weft
TD 5	10.0 %
TD 6	46.0 %
Ropes & habijabi	10.0%
Root cuttings	22.0%
Thread waste	10.0%
Caddies	1.0%
Gunny cuttings	1.0%
Total	100%

Sewing twine
TD 3	30.0 %
TD 4	70.0 %
Total	100%

where all the grades are as per IS 271: 2003 of standard grading system.

The above batches are, however, subjected to change from mill to mill, depending upon the availability of each quality of jute. Moisture regain (MR) of all the bags was measured and found well within the range of standard MR% for these bags, as mentioned in IS 12650: 2003 (second revision).

Determination of Breaking Strength of Fabric and Seam

Weft-way breaking strength of fabric was determined on a raveled strip specimen of 100 mm width as per IS 1969. Two weft-way samples have been drawn from each bag and tested in CRT type Goodbrand fabric strength tester keeping a test length of 200 mm and jaw speed of 450 mm/min. The average of two test values has been considered as weft strength of respective bag.

The breaking strength of seam was determined as per IS 9030 on double 'T' shaped specimen having 50 mm wide raveled down cloth and 100 mm wide seam at the centre, as shown in Fig. 1. As practiced for weft, two samples have been drawn from each bag and tested in Goodbrand 113.5 kg capacity cloth-testing instrument with a gauge length of 200 mm. The rate of traverse of the lower jaws was kept at 300 mm/min. The tests were performed in standard atmospheric conditions. The two test values have been averaged out to

represent seam strength of corresponding bag. During breaking of each sample, nature of break i.e. whether the sample was breaking at cloth (C), Twine (T) or at the edge (E) due to slippage or combinations thereof was noted.

Determination of Herakle Stitch Density of Bags

Herakle stitch density of the bags at the side seams was measured by stitch counter gauge as per IS 9113. Bags were kept on a flat table and straightened by hand to remove creases from the bags. Herakle stitches present in the bags in 10 cm length were counted using the counter gauge. Observations were made in both the sides of the bag and average of the observations was considered as stitches per decimeter of that bag.

Seam Efficiency and Seam Utilization

For each sample, seam efficiency (%) and seam utilization (%) were calculated from the test data, as defined below:

$$\text{Seam efficiency (\%)} = \frac{\text{Seam strength} \times 2 \times 100}{\text{Weft way fabric strength}}$$

$$\text{Seam utilization (\%)} = 100 - \text{Percentage twine break}$$

Results and Discussion

After considering the average of two test values of each parameters of each bag, a total of 220 values have been obtained for each parameter. It is observed that the strength values are varying widely even between the bags collected from one source.
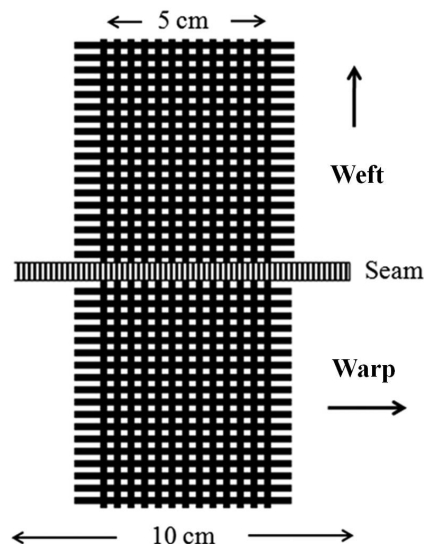

Fig.1—Specimen for testing seam strength

Hence, for the ease of analysis and to study the dependency of seam strength on weft-way fabric strength and stitch density individually as well as collectively, the test values of weft-way fabric strength are sorted in ascending order, keeping the respective seam strength, stitch density and nature of break unaltered.

From the sorted data, average of weft-way breaking strength of a specific interval is considered. Similarly, average of corresponding test values of other parameters in that interval is also calculated. The detailed sorted test data and other calculated parameters obtained from the test results is given in Table 1.

Effect of Weft-way Fabric Strength on Bag Seam Strength

It is observed that with the increase in weft-way fabric strength, seam strength of B. Twill bag is also increasing. Since the weft yarns are axially oriented in direction to the application of load, it can be assumed that weft-way fabric strip is one of the major load bearing components in seam strength determination and hence stronger weft-way fabric strength is assisting to achieve higher seam strength. The trend shows a very good correlation between weft-way fabric strength and seam strength with a correlation coefficient (r)

of 0.87. The regression equation for line of best fit was calculated and the relationship obtained is as follows:

Seam strength (kg) =
    0.152 × Weft-way fabric strength (kg) + 33.5 … (1)

Effect of Stitch Density on Bag Seam Strength

A similar trend, as of weft-way fabric strength, is also observed between stitch density and seam strength. From the test results data sorted out on the basis of ascending stitch densities and the plot between stitch density and seam strength it is revealed that higher stitch density improves the seam strength of B. Twill bags. This may be attributed to higher binding force exerted by the joints of two fabrics during testing.

Effect of Stitch Density and Weft-way Fabric Strength on Bag Seam Strength

It is found that both the parameters, namely weft-way fabric strength and stitch density, play significant role in deciding seam strength. In this part of the study efforts have been made to investigate the collective effect of these two parameters on seam strength. For this, a multiple regression method is exercised using the values of seam strength, stitches/dm and weft-way breaking strength (Table 2).

Table 1—Test results of B. Twill jute bags

Weft strength range, kg	No. of observation within the range	Average of weft strength values within the range kg	Average of corresponding stitch density stitches/dm	Average of corresponding seam strength kg	Seam efficiency %	Nature of break (C-T-E)* %	Seam utilization %
60-69	3	68	9	41	120.6	83-17-0	83
70-79	3	76	9	50	130.4	67-33-0	67
80-89	7	84	8	44	103.9	83-17-0	90
90-99	7	94	9	47	100.5	64-36-0	64
100-109	23	105	9	53	101.2	74-24-0	74
110-119	21	115	8	48	83.3	43-57-0	43
120-129	35	124	9	51	82.5	60-38-2	62
130-139	25	134	10	58	86.8	53-41-6	59
140-149	32	144	9	54	75.5	48-50-2	50
150-159	27	153	9	59	76.9	33-67-0	33
160-169	12	166	11	61	73.6	38-62-0	38
170-179	8	174	9	55	63.3	31-59-0	31
180-189	9	183	9	56	61.5	28-67-5	33
190-200	8	197	9	68	69.4	25-75-0	25

* C-T-E: Cloth rupture – Twine break – Edge break.

Table 2—Comparison of actual and predicted seam strength

Weft-way fabric strength kg	Stitch density stitches/dm	Seam strength, kg				
		Actual	Predicted from Eq. (1)	Deviation from actual, %	Predicted from Eq. (2)	Deviation from actual, %
122	9.8	47	52.1	-10.9	54	-15.4
242	9.9	58	70.3	-21.3	70	-20.7
107	9.6	58	49.8	14.1	52	10.7
153	10	62	56.8	8.4	59	5.2
183	10.2	57	61.4	-7.7	63	-10.9
172	9.9	65	59.7	8.1	61	6.2

Form the output of the multiple regressions, a very good correlation can be observed among seam strength, weft-way fabric strength and seam strength with a highly impressive correlation coefficient (r) of 0.90. A multiple regression equation is therefore obtained from the study which can be given as under:

Seam strength (kg) = 2.65 × Stitches/dm + 0.129 × Weft-way breaking strength (kg) + 12.55   … (2)

Validation of the Regression Equation

For the validation of the regression equations [Eq. (1) and (2)] obtained from the test results of the current study and to determine the effectiveness of predicting seam strength of jute bags by these two relations, three different types of bags (100 each) with similar stitching pattern but different thread densities in warp direction were obtained from two different sources. Out of these three bags, one was double warp single weft 2/1 twill woven, one was single warp double weft 2/1 twill woven and one was single warp double weft plain woven. The bags were then tested according to the procedure used for the experimental bags. Table 2 shows the comparison of actual and predicted seam strength values obtained from the equations.

From Table 2, it can be observed that both the regression equations are reasonably good to predict seam strength of jute bags. However, Eq. (2) is slightly more accurate as it takes consideration of stitch density as well. Hence, it can be concluded that the relationships may hold good for other jute bags also irrespective of construction and type of weave, provided the fabric is of sacking quality and the bag is sewn along the selvedge.
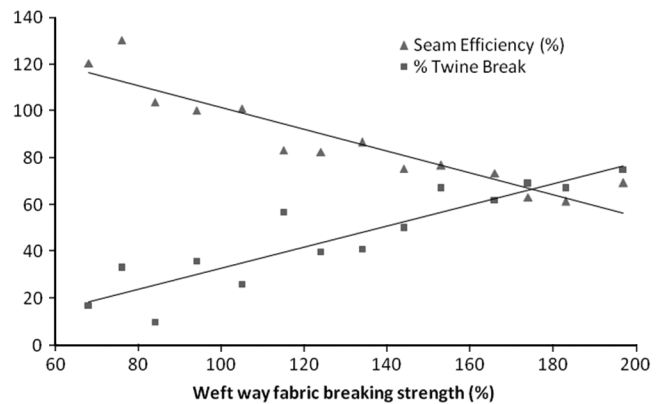

Fig. 2—Relationship between weft-way fabric strength and seam efficiency

Effect of Weft-way Fabric Breaking Strength on Seam Efficiency

Figure 2 shows the effect of fabric strength on seam efficiency. It can be observed from the graph that seam efficiency is higher at very low weft way fabric strength and then declines as the weft way fabric strength goes on increasing. This may be due to nature of break occurred during seam failure. When the fabric strength is low, during seam strength testing, chances of cloth breakage are increased and twine rupture is decreased. This results in higher seam efficiency owing to very low denominator in seam efficiency relation. Moderate seam efficiency is observed in the middle region of the plot. In this region both cloth and twine bears the load, but either cloth or twine breaks first depending on their load bearing capacity. When the fabric strength is very high, the sewing twines get ruptured before the cloth can be ruptured and thus causes poor seam utilization. This makes seam efficiency to decrease with the increase in fabric strength. The phenomenon of nature of break discussed here can be observed from the twine break

curve (Fig. 2). When the fabric strength is poor, percentage of twine break is also low and cloth break is high. Likewise, when fabric strength is very high, chances of fabric rupture as a cause of seam failure is low and seam failure due to twine break is high, which makes poor seam utilization. Seam failure due to edge slippage is rarely observed in this study.

From the study, it can be concluded that

(i)   Seam strength depends upon weft-way fabric strength and stitch density.

(ii)   A strong correlation exists among seam strength, weft-way fabric strength and stitch density. Following regression equations can be used to predict seam strength of sacking quality jute bags. The later is more accurate than the former.

- Seam strength (kg) = 0.152 × Weft-way fabric strength (kg) + 33.56
- Seam strength (kg) = 2.65 × Stitches/dm + 0.129 × Weft-way breaking strength (kg) + 12.55

(iii) Seam efficiency decreases with the increase of weft-way fabric breaking strength due to decreased seam utilization.

(iv)   The nature of seam failure shifts from cloth rupture to twine break as the weft-way fabric strength increases.

Acknowledgement

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