

Setting Limits for Plain Woven Fabrics

I C SHARMA & G S BHARGAVA

Technological Institute of Textiles, Bhiwani 125 022

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S C AGARWAL

Digvijay Woollen Mills, Jamnagar

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A method of arriving at the square setting of woven fabrics has been described. An attempt has been made to relate cloth setting limits with cloth fell as controlled in the case of negative let-off motion during weaving. Taking the existing cloth setting theory to be applicable in mill practice, a criterion for comparison of setts is evolved and a possible practical relationship for obtaining the maximum practical loom setts in the case of plain woven fabrics is deduced. Samples have been woven using 48, 52, 56, 60, 64 and 68^s reeds, in each case running a series of different weft-sett, reaching up to the maximum possible sett. Two weft counts, 28^s and 40^s, with 22^s warp count have been used. In each case, the cloth-fell distance has been measured on the loom during weaving. In all the cases, limits for maximum setts have been found and the maximum setts attained have been compared with those obtained by Law [*Wool Rec Text World*, 21 (1922), 968] and Brierley [*Text Mfr*, 57 (1931), 3; 58 (1932), 178, 342; 78 (1952), 349, 431, 437, 449, 595; 79 (1953), 71, 189, 293].

Different cloth setting theories and rules for the estimation of maximum threads per inch in woven fabrics have been put forward by various researchers¹⁻⁴. These cloth setting theories are based either on the geometrical representation of fabric construction or on the experimental work carried out for the purpose. Geometrical representation of fabric construction is complicated, because fibres, yarns, fabric construction and interlaced threads do not follow definite geometrical shapes and forms. Threads when interlaced in woven fabrics are not circular in cross-section, but are distorted and flattened considerably. In certain woven structures, the threads tend to group and overlap, so that a simple geometry, even if the threads were of a regular shaped cross-section, would be complicated. Practical limit for threads per inch, obtained by the experimental methods, is the most appropriate criterion, as it provides to the manufacturer information regarding his actual way of production. Hence, this approach was the one used in the present work.

In plain woven structure, the threads interlace over one and under one throughout, the simplest possible form of interlacing. Plain structures are very often developed in square settings, with the same count of yarn in the warp and weft, and are called balanced or square built structures. When the warp to weft count and/or the sett differ, the structure is said to be unbalanced in count and/or sett respectively.

Considerable work has been carried out at the Leeds University⁹ on the limits of setts (both balanced and

unbalanced) that can be woven in various weave structures (plain, twills, sateens, etc.) and it has been observed that the relative weave values and the unbalanced sett relationships quoted in the various setting theories are not always correct. Most of the results of these workers regarding weave values and the estimation of square setts are in agreement. Their results regarding unbalanced setts vary according to the class of weave, average float and the square sett about which the unbalancing takes place, while the rules of Law⁵ and Brierley⁶ apply for unbalanced sett irrespective of the class of weave, average floats, etc.

It was considered worth while to carry out experiments on plain weave structure, since it has not been investigated so far.

Materials and Methods

All the experiments were carried out with 22^s cotton warp yarn and 28 and 40^s weft yarns. A warp sheet of 1872 ends was given 33% size, with stretch not exceeding 1%, on an ordinary sizing machine. Skip draft of 1-3-2-4 using different reeds, according to the setts required, was used for the various experiments. Weavers' beam was gaited on Cimmco Gwalior automatic loom fitted with pirn changing mechanism, having 40 in reed space and beam width and running at 120 rpm. For weft preparation, Hacoba Kavery fully automatic pirn winder with a spindle speed of 6000 rpm was used.

Measurement of shed—Measurements were taken with the loom at rest, the crank at back centre, and the

back rest in its normal position. The distance from the cloth-fell to top of back rest was 99.5 cm, cloth-fell to heald eyes of front shaft, 25 cm and cloth-fell to shed opening at first heald shaft, 7 cm.

Measurement of fell position—Fell-creep distance was measured by taking a permanent fixed reference line on the breast beam. The distance between the reference line and the reed at front centre was measured, which is always same for a loom; a reference line was provided on the breast beam. The loom was stopped at back centre, keeping the front healds raised, and the distance between the reference line and the last pick of weft was measured. The difference of the two was taken as the fell-creep distance and was noted in each case.

Reeds of various counts were used, so that different warp setts could be obtained. Warp setts and cloth-fell distance were recorded. Maximum setts were obtained using 48, 52, 56, 60, 64 and 68^s reeds and 28 and 40^s weft yarns.

Relaxation treatment—Samples were soaked in 0.5% Lissapol-D solution (heated to 40°C) for 30 min, rinsed twice and then dried at 60°C in relaxed state by spreading on the clean floor. Prior to testing, all the samples were conditioned in a standard atmosphere (65% RH and 27 ± 2°C) for 48 hr. For determining the ends and picks per inch, a standard pick counting glass of 1 in size was used.

Warp tension—The load arranged on the lever depends on the count of yarn, number of threads in warp and the weaving difficulty, i.e. difficulty encountered by a loom while beating the pick in the fabric. This is dependent on the count of yarn, threads per inch in warp and weft directions, threads interlacing and loom tuning. It is also affected slightly by the yarn friction against the reed, healds and back rest.

If the warp tension is lower than it ought to be, the beat-up tension is insufficient to force the picks into the cloth without buckling at the beat up. In such cases, the weight lever is oscillated to a greater degree and the fell creeps towards the reed.

Normally, it would be expected that the beat-up force required should increase with increase in picks per inch, other conditions remaining the same. This increased beat-up force could come only from the increased warp tension.

Keeping in view the above contention, an attempt was made to keep the fell-creep distance constant at an arbitrary value of 1/20 and 2/20 cm by putting additional weights on let-off lever. If the load on the lever is greater than it ought to be, the excessive warp breakages will occur and the shuttle will not pass smoothly through the shed from one box to the other. Therefore, it was necessary to maintain a suitable fell-

creep distance before carrying out the experiments and to visualize the relationship between warp tension and fell-creep distance.

The maximum weavable weft sett for any given warp sett depends on the tension in the warp yarn. It was, therefore, necessary to arrange a warp tension which would give a normal fell-creep distance. The fell-creep distance, which is governed by the tension on the warp, can be varied by changing the weight or modifying its position relative to the fulcrum of the lever. Therefore, it can be taken as an indirect method of measuring the total warp tension. Lease rod tensiometer was used to record the warp tension. The average single thread warp tension was 85 g.

Recording of fell-creep distance—Chamberlain⁷ and Snowden⁸ have described how the difficulty encountered in beating the weft picks into the cloth is reflected in the magnitude of peak warp tension at beat-up. It has also been shown by Snowden that the increase in single thread warp tension from that at crank back centre to that at beat-up was similar in character to that of increase in weight lever oscillation in a controlled warp let-off motion. Therefore, normal weaving difficulty with a given warp and weft sett will be obtained by a weight lever load, which will give the normal average fell-creep distance. An attempt has been made to relate weaving difficulty with tension and fell-creep distance. It has been observed that the warp sheet tension decreases as the fell-creep distance increases (Fig. 1). A linear relationship exists between them, the equation of the straight line being.

$$Y = -69.4 X + 9.246$$

where X is the warp tension in g; and Y , the fell-creep distance in cm.

There may be a slight difference in slope and intercepts in individual cases on account of the change in warp and weft count and thread density. Hence, it was decided to use the fell-creep distance as the criterion for getting the maximum weft sett in the present work.

Cloth setting—With a given warp tension and warp sett, there is a certain value of weft sett which will enable weaving to proceed without any abnormal difficulty in beating up the weft and without excessive end breakages. When this sett is exceeded or the spacing decreased, there will be an increase in the amplitude of lever oscillation at beat-up as a result of the relative difficulty in weft insertion into the cloth by the reed and the consequential rise in peak warp tension at beat-up. Any decrease in sett or increase in weft spacing will give a slightly lower value of fell-creep distance or lever oscillation^{9,10}, because with any weft spacing greater than the minimum, the difficulty in beating up the weft picks will not be very different. The

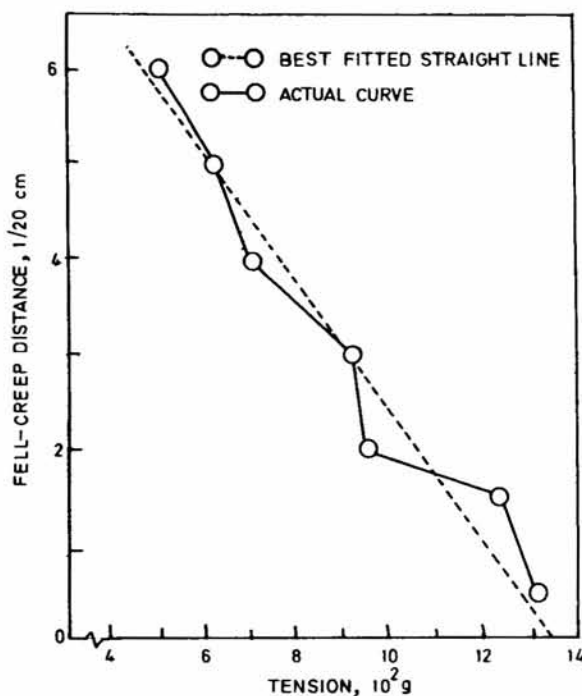


Fig. 1—Relationship between fell-creep distance and tension

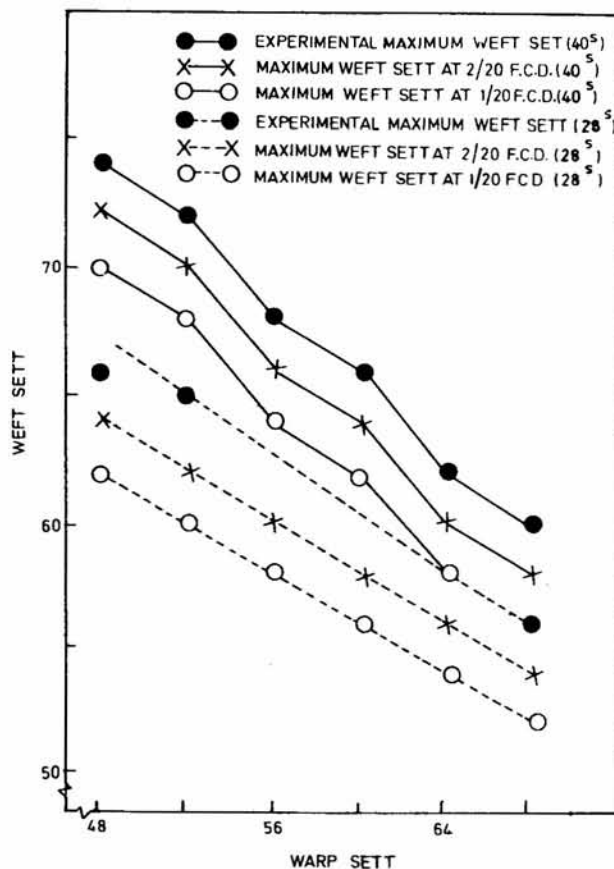


Fig. 2—Relationship between warp sett and weft sett

increase in fell-creep distance and lever oscillation with closer sett or decreased weft spacing results from the fact that picks are not pressed sufficiently close in the fabric during beat-up. The cloth fell will, therefore, move nearer to the reed and the cloth will buckle at the beat-up. The warp is, therefore, pulled forward as the cloth is bumped to the fully forward position of the reed. This will depress the back rest and the weight lever will be lifted excessively. As the weaving proceeds, the creep of the cloth fell towards the reed will cause still greater lever oscillations, which will ultimately reach a mechanical limit and in that case the lever will strike against the floor. Thus, for obtaining maximum weft sett for any given warp sett, picks per inch were increased gradually at suitable intervals, keeping the fell-creep distance to a limit of 1/20 and 2/20 cm. After weaving 10-12 in, the fell-creep distance was recorded and the actual picks per inch inserted near the fell of the cloth were noted. With each warp sett, the maximum attainable weft setts were noted, maintaining 1/20 and 2/20 cm fell-creep distance.

Results and Discussion

Maximum weavable weft sett were obtained corresponding to 1/20 and 2/20 cm fell-creep distance. The weft setts attained are plotted in Fig. 2 which

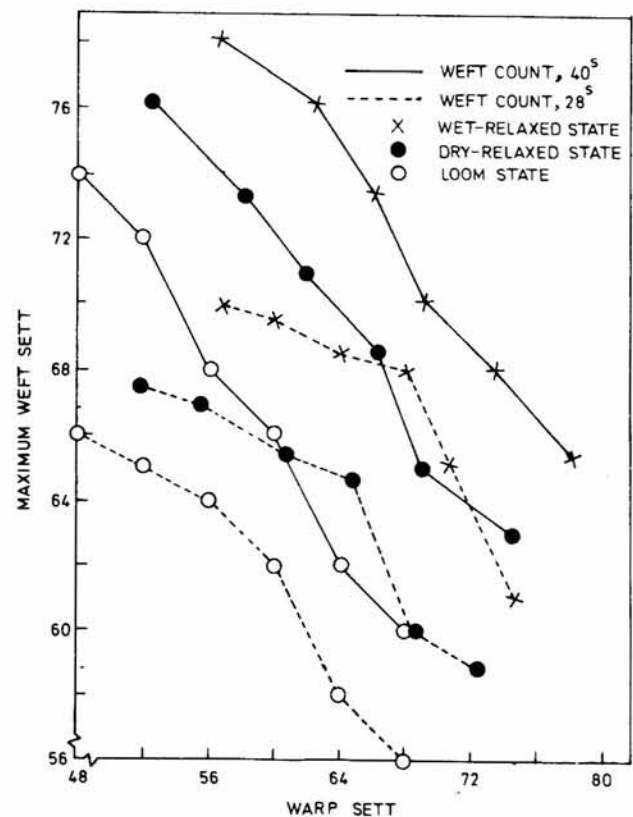


Fig. 3—Relationship between maximum weft sett and warp sett

shows ends/picks relationship for different weft counts. The relationship is almost linear and the curves have nearly similar slopes. Lower maximum weft sett is obtained for fabrics of equal firmness with finer weft yarn and lower reed. The reason for the former is that the coarser weft yarn is less compact and it is possible to insert more equivalent weft sett than the finer weft yarn for the same weaving difficulty.

Maximum setts on relaxation—The actual fabric weft setts obtained after dry and wet relaxation are shown in Figs 3 and 4. It is observed that the warp setts, weft setts and cover factor of the fabrics increase after dry relaxation and further increase with wet relaxation.

In the case of 28^s weft yarn fabrics, the warp and weft setts are found to increase by 12.7 and 8.3% respectively, whereas in the case of 40^s weft yarn, they increase by 16.4 and 7.2% respectively. A similar ends/picks relationship has been found in dry and wet-relaxed state fabrics, as is evident from Fig. 3.

With finer reeds, the total cover factor increases even at the maximum limits of setts. A similar trend is observed with dry- and wet-relaxed fabrics. This may

be due to the fact that the higher warp sett fabrics are woven at a higher warp tension and consequently they relax more. This mode of relaxation points out that any cloth setting theory will fit in all the three states of fabric, except slight shifting in the ends/picks curve.

Comparison of experimentally obtained maximum weft setts with those of Law's and Brierley's rules—It is difficult to make an accurate comparison with maximum setts as obtained by the rules of Law⁵ and Brierley⁶, because the weaving conditions which they might have arranged were not known. Also, they did not specify whether the theoretically calculated values correspond to loom state, dry-relaxed or wet-relaxed state fabrics. The general rules for unbalanced setts in plain, matts, twills and sateens given by Law and Brierley have some drawbacks in a number of respects, e.g. (i) different classes of weave should in fact have different ends/picks relationships, (ii) a different ends/picks relationship should apply according to the average float of weave, and (iii) the ends/picks relationship should vary according to the square sett about which the comparison is made.

On the basis of the square setts deduced in the present work, the unbalanced setts of Law⁵ and Brierley⁶ were calculated. The calculated setts along

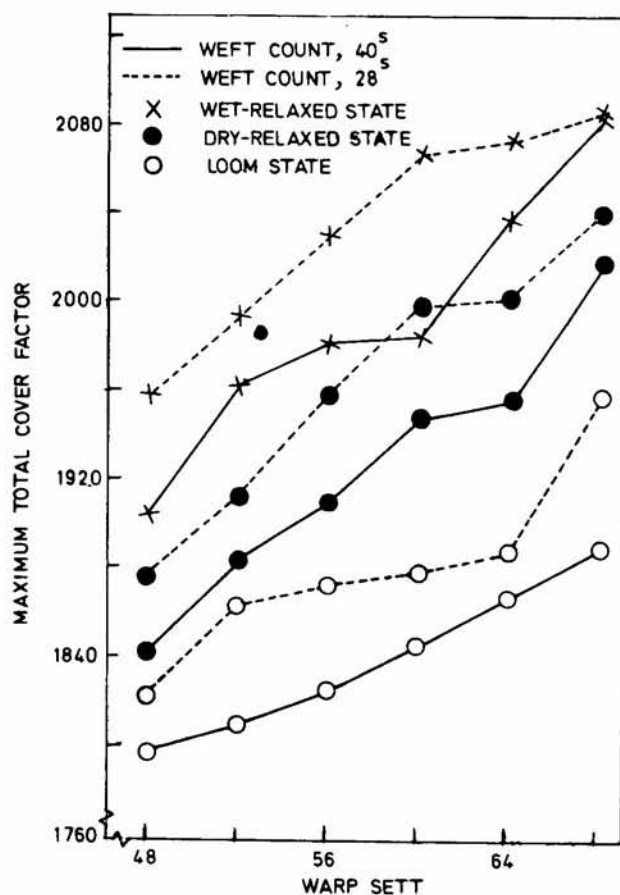


Fig. 4—Relationship between maximum total cover factor and warp sett

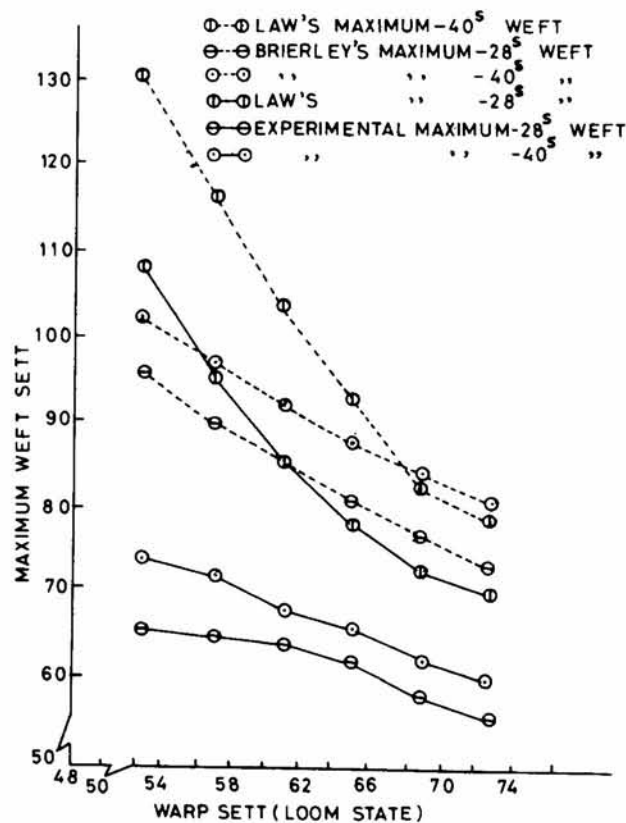


Fig. 5—Relationship between maximum weft sett and warp sett (loom-state)

with the experimental results are plotted in Figs 5-7. It is clear that the results of Law and Brierley give greater number of picks than can actually be obtained when the ends are reduced from the square sett. Also, they give a smaller number of picks than can be obtained when the ends are increased from the square sett.

The variations in Brierley's theoretical and experimental maximum weft setts are due to the different machine conditions. Snowden⁸ also pointed out that the limits of setts are obtained according to the type of loom, i.e. whether of light or heavy construction, whether it has positive or negative dobby, whether it has negative or positive let-off, or whether it has negative or positive take-up. He also found that different limits of setts are obtained according to the conditions of weaving, i.e. warp tension arranged, the timing of shed change and the position of back rest (neutral or raised) tension for the maximum effect.

The ends/picks relationship for different warp setts and the maximum weft setts attainable are similar in loom state, dry-relaxed and wet-relaxed state fabrics. With dry-relaxation and wet-relaxation treatment, the experimental values approach Brierley's value.

An attempt has been made to find out a constant K for developing a formula of practical utility under the prevailing conditions. The value of K has been estimated to be 148 for both the weft counts. Brierley's formula represents the nature of the ends/picks

relationship curve near the maximum limit of setts. The maximum attainable weft setts obtained are different for different warp setts and weft counts. For relaxed fabrics, maximum weft setts obtained are 11.8 and 13.4% below Brierley's maximum setts.

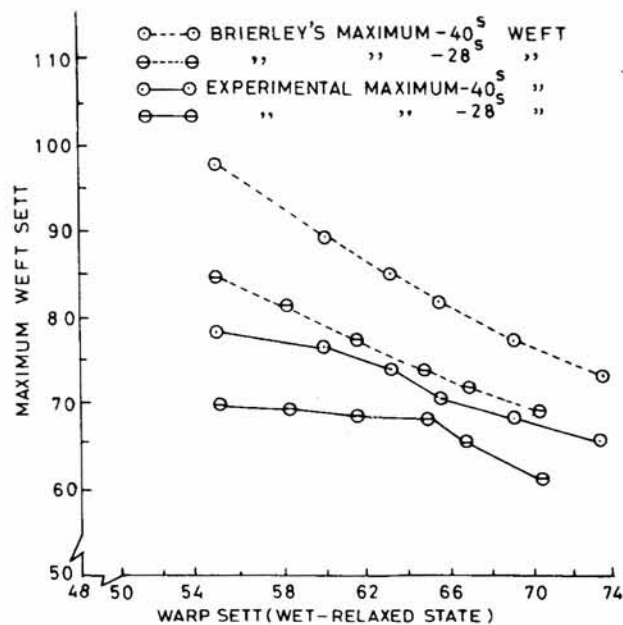


Fig. 7—Relationship between maximum weft sett and warp sett (wet-relaxed state)

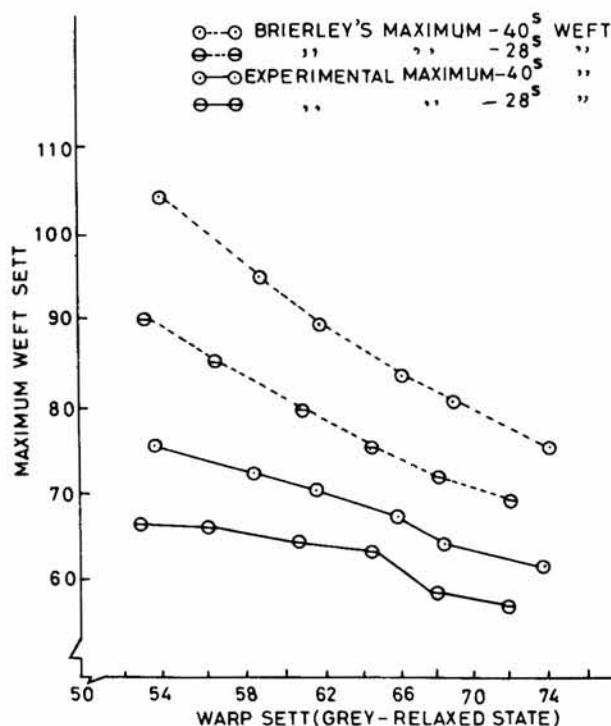


Fig. 6—Relationship between weft sett and warp sett (grey-relaxed state)

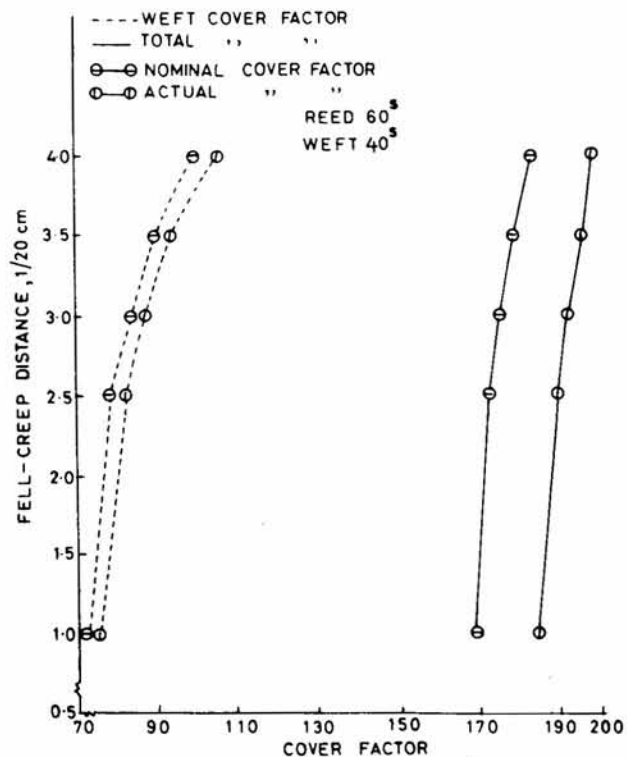


Fig. 8—Relationship between fell-creep distance and cover factor

Relationship between fell-creep distance and fabric cover factor—Fig. 8 indicates that with increase in weft sett, there is an increase in fell-creep distance, as the increase in weft sett causes an increase in weft cover factor as also the total fabric cover factor. The relationship between fell-creep distance and fabric cover factor is found to be non-linear. This finding is in agreement with those of Greenwood and coworkers^{11,12}.

Conclusions

- (1) The resistance encountered during weaving is related to fell-creep distance and warp sheet tension.
- (2) The warp sheet tension is linearly related to fell-creep distance.
- (3) The ends/picks relationships are linear and their slopes are approximately the same in all the three states of fabric.
- (4) The actual maximum weft setts obtained with 28 and 40^s weft yarn are 11.8 and 13.4% below Brierley's maximum sett for wet-relaxed state fabrics.
- (5) The total cover factor for different states of

fabric has a non-linear relationship with the fell-creep distance.

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