Comparison of Different Tearing Test Methods

I C SHARMA & D ADHIKARY
The Technological Institute of Textiles, Bhiwani 125 022
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A comprehensive comparison of the major tear test methods in use (single rip test, tongue double rip test, wing rip test, trapezoid test, impact tear test and wound bursting strength test) has been made with the objective of assessing their relative merits and establishing correlations among them. The fabrics used for the purpose were polyester-viscose blends. Single rip test has been found to be the most suitable one for carrying out a tearing test. Single rip, double rip and impact tear tests show similar performance and provide almost identical values of fabric characteristics, while the wing rip test differs only marginally. The trapezoid test shows a relatively poor correlation with these test methods, and the wound bursting method differs widely from them.

A number of methods are employed for determining the tear strength of fabrics, but no attempt seems to have been made to establish definite correlations among these methods. The reason is that the tear failure of materials depends mainly on the conditions of use or testing, the stress pattern being largely determined by the variables, which are characteristic of the method used, or more precisely, of the specimen geometry at disposition of the operator rather than of the material under test. In the present investigation, a comparison of most of the established tear test methods has been attempted with the objective of working out correlations among them. In doing so, however, it was apprehended that a possible difficulty could arise while comparing the test results obtained using different test procedures due to the wide variation in specimen dimensions used in these methods, especially the tear length, tail length and tail width.

The different test methods included in the study are: single rip test, tongue double rip test, wing rip test, trapezoid test, impact tear test (performed using Elmendorf tester) and wound bursting strength test (bursting tear test). The rip test has been taken as the standard method and the results of the other test methods have been compared with those obtained by this method.

An attempt has also been made to study the tear behaviour of fabrics with changes in blend composition and fabric density. In the first case, polyester and viscose were chosen as the component fibres of yarn and their mutual proportions changed. In the second case, the pick level was changed.

Materials and Methods

Nine fabric samples were prepared from yarns of three different polyester-viscose blends, viz. 48/52, 60/40 and 80/20, using them in both warp and weft ways. This was done to observe the effect of blend composition on the tear strength of the fabric. The experimental conditions employed were as follows: ends/in, 64; picks/in, 56; yarn count, 2/36" (for both warp and weft); and TPI, 20 for single and 16 for all the samples. Two more samples were prepared with two more pick levels, namely 48 and 52, keeping the yarn blend composition the same (60/40: P IV) for both warp and weft and other variables unchanged. In the nomenclature of the sample codes (Table 1), the first digit denotes the warp blend composition (polyester: viscose), i.e. A-60/40, B-80/20 and C-48/52, the second digit the picks/in, i.e. P-48, Q-52 and R-56, and the third digit the weft blend composition, i.e. X-60/40, Y-80/20 and Z-48/52.

Prior to testing, all the samples were conditioned in a standard atmosphere (RH, 65% and temperature, 27 ± 2°C) for 48 hr. Standard test methods as per the Indian standard specifications were used to determine the yarn and fabric characteristics. For yarn testing, skeins of 120 yd weft yarn were prepared and the average count was tested on Knowle's balance. The average warp yarn count was tested on a quadrant balance. Yarn crimp for both warp and weft was measured on Eureka crimp tester (Type FT-07) taking 10 g tension and 20 cm test length. The single yarn strength and elongation at break were measured on Instron tensile tester. The cross-head speed was so adjusted that rupture of the specimen occurred in 20
A sample was found from 10 observations. Elmendorf bursting strength tester. The average strength of each sample was found from 10 observations. Elmendorf tester (range 0-6400 g) was used for the impact tear test. Instron tensile tester was used for single rip, tongue double rip, wing rip and trapezoid tear tests. The cross-head speed and the ratio between the cross-head speed and the chart speed were kept as 100 mm/min and 2:1 respectively. Clamping lengths were 100, 180, 1150 and 25 mm for single rip, double tongue rip, wing rip and trapezoid tear tests respectively. The full scale load was 10 kg for single rip and wing rip tests, 20 kg for tongue double rip test and 50 kg for trapezoid tear test. The average tear strength of each sample was found from 5 observations in both warp and weft ways.

Measurement of yarn withdrawal force—Keeping parity with Taylor's experiment, a strip of fabric (5 in long and 3 in wide) was taken. Leaving 2 in from one end of the longer sides to allow the specimen to be gripped by the fabric jaws, and another 0.5 in for a clearance from the jaw line, a transverse cut was made across the width of the specimen. The specimen was then marked across its width at a distance of 1 in from the transverse cut and all the crossing threads in the remaining portion of the specimen were unravelled, so that the length of each of the freed longitudinal yarns from the marked line was 1.5 in. The yarn clamp, initially being separated from the jaws by a distance of 2 in, was then moved apart until the said yarn was completely withdrawn from the strip; the force required to remove the yarn was recorded in the autographic device. Three such specimens from fabric samples BRX, BRY and BRZ were tested in the filling direction.

Effect of dimensional changes on tear strength—Specimens were prepared from the sample CQY with changes in tail width, tail length and tear length to study the effect of these variables on the tear strength. This experiment was carried out to facilitate comparison of different tear test methods, taking rip test as the standard, because the specimen dimensions in other tests varied widely.

Selection of method for interpretation of charts—The average method is tedious and time-consuming, as each peak load in the chart is required to be measured. This is not very logical too, because it does not ensure the propagation of tear through the fabric.

The use of average method becomes further undesirable when pendulum type machines are used for testing, as the charts obtained from such machines do not show the details of fluctuations and show only a single maximum where inertia error is too high. In fact, the records obtained in many cases in pendulum type testers do not allow the treatment of data to be carried out as referred to in the standard handbooks. In the present study, Instron tester has been used where such errors are not encountered and so the argument put forward in the last paragraph does not hold much ground. Yet, the reason mentioned earlier is sufficient to warrant the acceptance of the average method. The same reason applies to the energy method. In addition, this method involves some other complications arising from the extensibility of the fabric.

Median method loses its ground the same way as the average method. Besides, it involves some error in the determination of the single rip strength using Instron tester in that some minor maxima always occur in the chart, which do not essentially indicate yarn rupture. The test results from Instron tester show lower values than those from pendulum type testers. The relation has been given by Turl as:

\[
\text{Tearing strength (pendulum type)} = 1.10 \times \text{Tearing strength (Instron type)}
\]

In such cases, the single highest peak value will be desirable, because it ensures tear propagation. But then, the particular single value in question may be said to have occurred merely due to chance, which does not provide sufficient accuracy. Hence, considering all pros and cons, it seems that the average of five highest single values will be best fitted for the purpose and it will ensure tear propagation as well as a high level of accuracy. The average of ten single highest peak values may provide better accuracy, but then the difference will be marginal. Turl's experimental result shows that the ratio of ten single highest peak values to five of the same is 0.978. Hence, use of five instead of ten values is justified.

In fact, the method accepted in the present study tallies with the US Federal specification for the trapezoid test. Turl suggested picking up of five highest peak values at five equal intervals. But this also does not seem to be logical in that some of the peak values taken at five equal intervals may be lower than the average of five highest peak values taken from the entire load diagram (keeping no bar on the interval), because a single interval may be comprising five or more values, which are higher than those in the rest of the diagram. In that case, the average value worked out by his procedure will in no way ensure tear propagation through the fabric.

Results and Discussion

The tear mechanisms of single rip, double rip, wing rip and impact tear tests show that the number of yarns in the ladder of a del at the tear locus depends upon the extent of yarn slippage and yarn extension. With a
higher polyester content in the yarn, the extensibility of the yarn increases. Consequently, the number of active threads in the del increases and hence contributes more to the system in supporting a higher load. The tear mechanism in the trapezoid tear test too is governed mostly by the ultimate elongation of the yarns or in other words by the unextended initial length and extensibility of the yarns. However, its effect on tearing strength could be better judged from the equation given by Teixeira et al.4 for single rip test and from the equations given by Steele5 and Hager et al.6 for trapezoid tear test. Though Taylor’s equation7 takes a good account of yarn strength, it ignores the role of yarn extensibility.

In the case of wound bursting test, the role of yarn extensibility induces some complicacy and does not lend itself easily to critical analysis, primarily because the threads in one direction tend to prevent the full application of load in the other. Hence, the ratio of yarn extensibilities along and across the direction of tear, or in other words, the elongation balance between the two sets of threads right angled to each other is an important factor in determining the bursting tear strength (Table 1). To better understand the matter, we focus attention on Table 1 to mark out three values of warp tearing strength for three different warp blend compositions, viz. 48/52, 60/40 and 80/20, when the weft blend compositions are the same, i.e. 60/40. The values are 5.60, 5.93 and 6.43 respectively. In the first case, where the warp blend is 48/52 and the weft blend 60/40, i.e. the warp yarn has got a lower extensibility than the weft yarn4, application of force causes the wound warp to rupture before the maximum extension of weft yarns has occurred. So, the contribution of the weft yarns in offering resistance to the applied load is poor. In the second case, where the extensibility of warp yarns is elevated to the level of that of the weft yarns (the blend compositions being 60/40 for both), the warp yarn distends more than that in the first case before it fails and hence utilizes more weft services, leading to increase in tearing strength. In the third case, where the warp yarn extensibility has been increased further, exceeding that of the weft yarn (the blend compositions being 80/20 and 60/40 for warp and weft respectively), the warp yarn, before it ruptures causes the weft yarn to distend further than that in the earlier two cases. Eventually, it earns further contribution from weft yarn and thus yields a fabric of higher strength. This is quite evident from our results, the strength increasing from 5.93 to 6.43.

The warp tear values, when the weft blend compositions are changed and the warp blends are the

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Sample code</th>
<th>Warp/ Weft</th>
<th>Tear test</th>
<th>Single rip kg</th>
<th>Double rip kg</th>
<th>Wing rip kg</th>
<th>Trapezoid tear kg</th>
<th>Elmendorf kg</th>
<th>Wound bursting kg/cm²</th>
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<tbody>
<tr>
<td>4</td>
<td>ARY</td>
<td>F</td>
<td>Trapezoid tear</td>
<td>8.158</td>
<td>11.559</td>
<td>4.904</td>
<td>17.589</td>
<td>4.761</td>
<td>7.830</td>
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<td>5</td>
<td>ARZ</td>
<td>W</td>
<td>Elmendorf</td>
<td>6.264</td>
<td>10.076</td>
<td>4.379</td>
<td>15.708</td>
<td>4.169</td>
<td>5.860</td>
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<tr>
<td>6</td>
<td>ARZ</td>
<td>F</td>
<td>Wound bursting</td>
<td>4.850</td>
<td>7.976</td>
<td>3.379</td>
<td>10.122</td>
<td>3.171</td>
<td>6.120</td>
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<tr>
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<td></td>
<td>8.359</td>
<td>12.186</td>
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<td>21.251</td>
<td>5.043</td>
<td>6.430</td>
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<td>5.180</td>
<td>20.786</td>
<td>4.884</td>
<td>6.740</td>
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<tr>
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<td>F</td>
<td></td>
<td>8.050</td>
<td>11.790</td>
<td>4.932</td>
<td>17.828</td>
<td>4.768</td>
<td>7.650</td>
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<tr>
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<td>W</td>
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<td>12.063</td>
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<td>22.700</td>
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<td>3.523</td>
<td>5.600</td>
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<td></td>
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<td>10.204</td>
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<td>14.768</td>
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<td>18.783</td>
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<tr>
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<td></td>
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<td>13.129</td>
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</table>

W, warp; F, weft
same (60/40), are 5.86, 5.93 and 6.80 for the weft blends 48/52, 60/40 and 80/20 respectively (Table 1). As the warp has the same blend and hence the same extensibility in all the cases, the weft yarn distends equally in each case. Hence, when the extensibility of weft yarn increases, its contribution towards the warp tear tends to decrease. But since the strength of weft yarn also increases, the ultimate contribution goes in favour of warp, causing increase in the warp tear strength. An interesting point here is that the weft yarn has never failed, even though it has got lower extensibility, apparently contradicting the contention that failure in a wound bursting strength test always occurs in the less extensible direction. In fact, the results show that in all the above cases, the weft extension has never reached its maximum value before the tear headed its way across the warp threads. A possible explanation for this is that while the weft yarn possesses a lower extensibility than the warp yarn due to the lower polyester content, it has a higher crimp level. This is due to the difference in bending rigidity and threads/in of the two sets. Hence, with the application of load, when the crimp is totally removed, the weft provides a greater unextended length than that provided by warp; this reduces the ultimate elongation imbalance between the two sets.

A close inspection of the fabric specimen during the bursting tear test shows that the force applied to the specimen tends to extend it in all possible directions. But as the fabric comprises only two sets of threads, viz. warp and weft, the total load on the sample is ultimately distributed in these two directions. Now, when some of the threads in one of the directions are severed, the resultant load in that direction is shared by the unsevered threads. So, the magnitudes of load supported by each yarn in these two directions obviously differ, depending upon the relative extensibilities and the population of the two sets (or on their respective thread spacing and length of cut).

Again, it is well known from the geometry of the bursting tear tests that the distension is always maximum at the central zone of the specimen and it falls progressively towards its periphery. Now, we consider a single thread belonging to any set being placed centrally in the specimen, which is interlaced at equal distance along its length with the crossing threads belonging to the other set. When the specimen is distended, the mutual pressure between the two sets increases and each of the two intersections acts as a clamp for the length of yarn being held between them. Thus, a single yarn can very well be supposed to be comprising a number of such clamped lengths. As the distension is maximum at the centre and minimum at the periphery, the clamped lengths, originally being equal, differ in extensions from each other. The extension of the yarn is maximum at the centre and minimum at its either end. The more frequent the interlacement, or in other words the more the number of crossing threads/in interlacing with the said yarn, the shorter is the intersected length and greater is the elongation difference. Consequently, the yarn yields to a lower strength.

It is clear from above that the central threads are the ones which are subjected to the maximum stress concentration at their centres, and when the central threads are severed, the threads immediately adjacent to the cut share the maximum load. Besides, the rubber diaphragm bulging out from the slit pulls the unsevered set of threads apart, causing further stress concentration on the severed set at the tear locus.

If the breaking strength and extensibilities of the two sets are such that the load shared by threads lying across and nearest to the cut reach their maximum capacity (it may be higher or lower than that of the other set at right angle), before their counterparts do, they will rupture at the point of maximum stress concentration, i.e. at their centres. With the rupture of the first threads on either end of the cut, the load will be redistributed among the rest of the threads and the second set of yarns will fail in a similar fashion. However, the rupture of yarns occurs in quick succession and the tear proceeds rapidly along the line of the cut. However, in reverse situation, the tear will be transferred to the other direction and will proceed centrally across the cut on its either side. In the present case, it is evident that the warp threads, despite their higher breaking strength and extensibility, must have reached the point of their maximum capacity before the weft threads did.

Thus, the tearing strength of a fabric in a bursting tear test is dependent on several factors, viz. the relative extensibilities and the ultimate and relative breaking strengths of the two sets of threads, the number of threads/in in either direction of the length of the cut, and the extent of thread slippage.

**Effect of yarn withdrawal force**—Increase in polyester content with simultaneous decrease in viscose content results in a higher coefficient of yarn friction and a lower yarn crimp level. The former is due to the higher static coefficient of friction of polyester fibre and the latter to the higher bending rigidity of polyester fibre. A higher value of static coefficient of friction always tends to increase the resistance to yarn withdrawal from a fabric and conversely a lower crimp tends to minimize it, but the effect of the former has a greater impact on the yarn withdrawal force and causes an increase in its value (Fig. 1).

With ultimate increase in yarn withdrawal force, the del limits itself within a smaller area and depth, bringing fewer yarns into action. Obviously, the
The supporting capacity of the del system is reduced and a lower tearing strength is recorded. The above findings suggest that with increase in the polyester content of yarn, all the above-mentioned component variables change and contribute differently to the tearing behaviour of a fabric. While the yarn withdrawal force tends to minimize the tear strength, the other two tend to increase it. The gross effect of the latter two is more than that of the former and this causes increase in strength. However, the effect of blend composition seems to be more pronounced in the trapezoid tear test, which shows a steeper change in strength compared to any other test procedure (Table 1). The trapezoid tear test also yields the highest value in tearing any sample and it is followed in both respects by the double rip, single rip, bursting tear, wing rip and impact tear tests. The tearing strength in any of the methods depends on the number of yarns sharing the applied load simultaneously. Again, the population of the active threads in the del, in the case of trapezoid tear test, depends markedly on the yarn extensibility, crimp, fabric density in either direction and the initial jaw separation, or in other words, on the initial unextended length of yarn being placed immediately across the cut. In the double rip test, the yarn withdrawal force plays a major role, with contribution from yarn extensibility and fabric density in either direction, in determining the yarn population in the del. But the yarn withdrawal force, in turn, is governed by the number of threads/in at right angles, coefficient of friction, mutual pressure between the two sets of yarns, and percentage crimp. It is clear that the factors influencing the tearing strength in the trapezoid and double rip tests are different and can be manipulated to get the opposite result. For example, the yarn withdrawal force in any sample can be reduced by altering the surface finish of yarn without affecting the other variables, and in that case, the disagreement between the two test results will be diminished. Or, if the fabric density along the tear direction is decreased, the double rip will give rise to its recorded strength, while the trapezoid will react conversely (Table 1).

The possibility of double rip test giving a higher value than the trapezoid test for a very open fabric is evident from the data given in Table 1. The trapezoid values appear to cross the double rip values at a lower pick level.

It is observed from Table 1 that the trend lines of single rip and bursting tear tests and those of wing rip and impact tear tests have crossed each other. This shows that their relative positions are dependent more on the characteristics peculiar to the sample than on the methods themselves. However, for the present study, the number of active threads in the tear region of the samples must have been more in the case of trapezoid test than in the case of double rip test (though double rip comprises two sets of yarns acting simultaneously in two separate del structures) that resulted in a higher value in the former test.

Again, as the initial unextended lengths of the threads are more in the case of trapezoid tear test than in the case of double rip test in the tear zone because of the specimen geometry, any increase in yarn extensibility leads to a greater enhancement in yarn extension and hence in the number of active threads in the former. The effect is accentuated by the simultaneous effect of increased yarn strength and creates a larger gap between the two test values, as is shown by the present results. In this respect too, double rip may assume the position of trapezoid if other yarn and cloth constructional parameters are manipulated in the sample, i.e. the trend lines shown here may not be reproducible in other samples with altered variables. This is also established by the data in Table 1, where the trapezoid test shows a change in the direction of its trend. Besides, the trend lines of wing rip and impact tear tests, having crossed each other in and without crossing in, reflect that either one or both of them must have changed their directions in the second case. These changes in the behaviour of the trend lines have been caused by changes in fabric density along and across the tear directions. While in the first case they are 64 and 56, in the second case they are 56 and 46 respectively.
So, the observations that the trapezoid tear test results assume the highest ranking and are affected more distinctly by changes in yarn blend composition may not be reproducible if the other parameters are altered. This shows that the various test methods do not reflect and/or involve the same fabric and yarn characteristics in the tearing action, at least not in an identical fashion. The mechanisms of tear in the single rip, double rip and impact tear tests are basically the same and hence show similar trends in an identical fashion. Double rip, of course, always records the highest value, impact tear the lowest, and the single rip an intermediate position. The obvious reason for this is that double rip consists of a couple of del structures during tear and hence always provides nearly double the number of threads than those provided by the other two in supporting the load in the entire specimen. In impact tear, which is basically a single rip test, a large frictional force is developed among the slipping threads due to the rapid pace at which this test is carried out. Thus, the del collapses earlier at a much lower load before it can increase considerably in area.

The wing rip, however, distinguishes itself from the above three methods in respect of the geometry of tear locus and the manner in which the load is applied to the specimen. Due to the changed geometry of the tear locus in the wing rip test, there is less scope for thread slippage and the load is applied to the specimen more directly, ultimately yielding a lower tear strength. However, there are instances when the wing rip shows tear strength even lower than that shown by the impact tear test (Table 1). Again, a critical inspection of the trends, showing the effect of weft blend composition on the warp tear strength for the two tear methods, reveals that their relative positions have changed and even reversed with change in warp blend composition (Table 1). This shows that the impact of yarn blend composition on the tearing strength in these two methods is different and provides sufficient ground to support the dissimilarity of the two test procedures, the difference being not very marked, of course. The effect of warp and weft blend compositions on the weft and warp tear strengths (Table 1) respectively is negligible and does not indicate any definite trend.

**Effect of fabric density**—Data presented in Table 1 show that with increase in fabric density along the tear direction, the different test methods exhibit a mixed behaviour. The tear value increases in the trapezoid and bursting tear tests and decreases in the rest of the methods. In the single rip test, increase in fabric density along the tear direction increases the number of crossing points or frictional points per unit area of the fabric. This effect causes a greater resistance to be offered to the yarn translation, tending to induce a decrease in the del zone. Similarly, because of the increased cloth cover, the fabric ahead of the del region jams earlier in the direction of the tear and the extent of yarn movement in that direction being lesser there is reduction in the depth of the del. Hence, the del now, with smaller area and depth, comprises fewer yarns. However, increase in fabric density itself tends to increase the population of active threads, but this has lesser impact relative to the previous two, and eventually the tearing strength falls (Table 1). Similar is the case with double rip, wing rip and impact tear tests.

In the trapezoid tear test, increase in the number of threads/in the direction of tear increases the population of active threads in the del zone. On the contrary, due to the increased number of frictional points and a higher shear deformation, the frictional resistance developed against yarn movement in the fringe area is higher and increases the load concentration. But this effect has been quite subdued under the dominance of the former and ultimately a higher tear strength results.

The warp tear strength decreases in all the test methods with increase in pick level (Table 1). The effect is, however, less pronounced in the bursting tear test.

In the single rip test, increase in fabric density across the tear direction increases the number of frictional points per unit area of the fabric. Thus, the extent of yarn translation being less now, the area of del is reduced and the strength eventually falls again.

The above arguments apply equally to the double rip, wing rip and impact tear tests. In the bursting tear test, increase in fabric density across the direction of tear reduces the strength.

The trapezoid tear test exhibits a similar trend, but reacts in a different manner. With increase in fabric density across the tear direction, the crimp in the active set of threads increases. As trapezoid tear is basically a tensile strength test, being carried out with a wound specimen having progressively changing length of yarn, any application of force results in complete transfer of this increased crimp from the active to the idle set of threads. The idle set of threads, now assuming a higher crimp level, tends to contract more in length and exerts an increased load to active ones, the stress concentration being maximum along a line at points farthest from the jaws. Again, due to increase in the density of idle threads, the number of frictional points along any of the active threads is more. Hence, during the extension of the active threads, any single one of them meets higher frictional resistance. Eventually the fabric gives way at a lower load.

**Comparison of different tear test methods: Effect of specimen dimension on tear strength (single rip):** It is seen from Fig. 2 that changes in specimen dimensions have negligible effect on the tear strength of a fabric. The only exception is when the tail width is reduced to...
Thus, both result in increase in the resultant spring constant of the total system or in other words increase in tearing strength.

According to Teixeira et al., the factor in fabric geometry which influences the shape of the del and the nature of the fabric structure in parallel with the del affects not only the load capacity of the del, but also the amount of assistance rendered by the untorn fabric. Hence, with increased tear length, the assistance rendered by the untorn fabric is higher and gives rise to tearing strength.

However, within a limited scope, the results show that the trapezoid has greatest sensitivity to any change in variables and the bursting tear has the least sensitivity. Double rip assumes the second position, being followed closely by single rip. But as far as reproducibility and reliability are concerned, single rip and bursting tear methods emerge to be the best methods followed by double rip, wing rip and impact tear tests, the trapezoid method coming last. However, double rip and trapezoid methods have the advantage of positional consistency compared to the other methods.

Again, it is apparent from the earlier discussions that single rip and/or double rip involve more variables in determining the tear behaviour of a fabric and reflect wider aspects of the yarn and cloth characteristics. Their tear mechanism further reveals that they are least dependent on specimen geometry and are governed more by the true merit of the cloth. Besides, they provide a much more stable result compared to any other method, trapezoid method having the least merit in this respect. However, one point goes in favour of bursting tear test: it replicates the true behaviour of the fabric in apparel use. In most of the cases, it has been experienced that a wound fabric in use gives way to the pressure mounted by the flesh of the body, with both warp and weft playing complementary roles.

The single rip method emerges as the second best in view of adaptability (i.e., its close simulation of the fabric behaviour in use), the double rip the last and others taking intermediate positions. Double rip satisfies the minimum number of field conditions under which the tear proceeds, because, in fact, the possibility of a fabric running a double tear simultaneously is remote. The trapezoid tear test has practically been excluded from this consideration, as it is, in fact, a replica of the tensile strength test, being carried out in a modified form. Hence, it has little relevance to field performance.

It is clear from the above discussion that the single rip tear test appears to be the best one, followed closely by the double rip, impact tear and wing rip tests. The ranking of all the samples assessed by the different test methods is shown in Table 2. It is observed that the wound bursting (bursting tear) results show the maximum deviation and its assessment seems to be more disorderly in relation to those of the others.

The rest of the methods show almost identical performance, the trapezoid showing some exceptions.

Fig. 2—Effect of tail width, tail length and tear length on tear strength
The first positions have been taken by samples 7, 11, 19 and 9 in all the test methods. The next six positions go to samples 4, 10, 16, 20, 21 and 22 in all, but the trapezoid method excludes samples 20 and 22 from this category and includes samples 3 and 5 instead. Again, for the next six positions, single rip and others pick up samples 1, 2, 3, 5 and 14, but trapezoid replaces samples 3 and 5 by 20 and 22. The last six positions have been assumed by the remaining samples in each method.

From the ranking of the samples, a basic similarity among the single rip, double rip, wing rip and impact tear tests is apparent. The coefficients of correlation for these methods range from +0.9264 to +0.9310, which are indeed quite high (Table 3). The correlations have been calculated taking the single rip as the basic method. While the trapezoid, due to its occasional deviations, shows a correlation value of +0.8448 with single rip, the bursting tear shows a poor correlation value of +0.3874.

It is, therefore, concluded that the single rip, double rip, wing rip and impact tear tests have good correlation and hence basic similarity with each other. Trapezoid shows a weaker relation and the bursting tear differs widely from them.

### Conclusions

1. Increase in fabric density along the tear direction increases the strength in the trapezoid and bursting tear tests and decreases it in the rest of the methods.
2. Increase in fabric density across the tear direction decreases the tearing strength in all the test methods, except the bursting tear test, which shows a marginal decrease.
3. Single rip test method is the most suitable method for carrying out a tearing test.
4. Single rip, double rip and impact tear tests show similar performance and provide almost identical values of fabric characteristics, while the wing rip test...
differs only marginally. The trapezoid method shows a relatively poor correlation with the above test methods and the wound bursting method differs widely from them.

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References

1 Indian standard specifications IS: 6359 (Indian Standards Institution, New Delhi) 1971.