Rimvydas Milašius*,
Brigita Legaudienė,
Ginta Laureckienė

Influence of Weave Parameters on Woven fabric Tear Strength

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Kaunas University of Technology,
Faculty of Mechanical Engineering and Design,
Studentu 56, LT-51424, Kaunas, Lithuania
* E-mail: rimvydas.milasius@ktu.lt

Abstract

The influence of weave on woven fabric tear strength is analysed in this paper. Brierlay's factor F^m, Milašius' factor P and P' and modification of parameter P made by the authors (P'_{weft}) were used in the investigations presented. Woven fabrics of 100 % viscose multifilament yarn manufactured from the same yarns and with the same density but with seven different weaves (plain weave, weft rib 2/2, warp rib 2/2, twill 2/2, twill 3/1, basket weave 2/2 and 4 healds sateen) were used for the investigations. It was stated that the well-known weave parameters of Brierley F^m and Milašius P and P' cannot be used for the prediction of the tear strength of all kinds of weaves without any limitations. All parameters presented can be used for the strength prediction of a weave when they are divided into two groups – a rib-based group and twill-based group. Prediction of the tear strength for rib-based weaves in the weft has to be carried out using parameter P'_{weft}, where the influence of parameters P_1 and P_2 is varied.

Key words: *woven fabric, weave, tear strength.*

Introduction

The functional properties of fabrics are very important for their usage. One such property is the tearing strength. It is well known that the tearing strength depends on the properties of yarns from which the fabric is manufactured, as well as on the weave. Digital evaluation of the weave, whose value could be used for fabric property prediction, is very important. For more than one hundred years, various researchers, such as Ashenhurst at the end of the 19th century [1], have tried to find a parameter which could be used to evaluate the weave, but unfortunately we still do not have one particular parameter which could be used for the prediction of various fabric properties.

The influence of the weave on woven fabric tear strength is analysed in this paper. A quite satisfactory parameter for weave estimation was developed by Brierlay, who used the weave factor *F* after Ashenhurst and empirically determined the order *m* for factor *F* and proposed factor F^m [2]. Unfortunately this factor has some weakness such as it could be used only for weaves for which Brierlay calculated an empirical parameter *m*. It is necessary to note that Brierlay calculated this parameter for a lot of possible weaves, but unfortunately not for all, which it is the main disadvantage of this factor's usage in all cases. However, Brierlay's factor is used as the starting point for various new weave factor calculations. Usually it is considered that if the new factor correlates well with Brierlay's factor, it is good, if not – it is a big weakness of the new factor because Brierlay's factor is proved by various researchers for various fabric properties and manufacturing processes [3, 4].

At the end of 20th century, Milašius proposed a new weave factor *P*, which can be calculated directly from the matrix of the weave, does not need any empirical coefficients, and shows a high correlation with factor F^m [3, 4]. Some years later, he proposed the modification of the weave factor and named it *P'*, in which the influence of parameter P_1 is higher (70 %) than that of parameter P_2 (30 %), i.e. not in a proportion of 50/50, as in factor *P,* but 70/30 [5].

A lot of researchers have investigated the influence of the weave on various fabric properties. Matusiak presented the influence of the weave on the drapeability of woven fabrics and investigated the drape behaviour of fabrics of different weaves in both directions – warp and weft [6]. Other researchers analysed the weave influence on the strength of fabric [7-9] and Abromavičius with co-authors found that the calculation of parameter *P'* in a proportion of 60/40 shows higher correlation with the fabric strength. Other authors investigated the influence of fabric structure on such properties as the tightness of fabric, weaveability limits, thermal comfort, fabric drape, electrical properties etc. [10-14].

The tear strength of fabric has also been investigated by various researchers. The tear strength is affected by changes in yarn geometry, fabric geometry, the relaxation of fibres and their frictional characteristics, as well as various other parameters of yarns and fabrics [15-17]. Also it was noted that tear strength at a high level depends on the weave construction, but the authors analysed only plain and three kinds of rip-stop weaves, and did not analyse how the weave influences the tear strength nor how to predict this property for fabrics with various weaves [18].

Thus investigations of the weave influence on various characteristics of fabric and ,particularly, on the tear strength are still important and are discussed in various works of a lot of researchers. The goal of the present paper was to investigate the influence of the weave on tear strength and to find a parameter with which the tear strength could be predicted with high accuracy. Brierlay's factor F^m, Milašius' factors *P* and *P'* [2, 3, 5] as well as modification of parameter *P* made by the authors of this paper (P'_{weft}) were used in this paper.

Materials and methods

Woven fabrics from 100% viscose multifilament yarns of 8,4 tex in the warp and 13,3 tex in the weft, with a density in the warp of 42 cm^{-1} and in the weft of 34 cm^{-1} , and with seven different weaves (plain weave, weft rib 2/2, warp rib 2/2, twill 2/2, twill 3/1, basket weave 2/2 and 4 healds sateen) were used for investigations. The weaves were chosen to cover various main kinds of weave construction – plain, rib, twill, basket weave, and sateen. 4 healds sateen was chosen due to the possibility of manufacturing fabric from the same beam of warps and with the same density of yarns, which could be used for real fabric manufacture. Sateen with higher floatining would be unusual for real fabric due to the low density of yarns in the fabric. All fabrics were

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manufactured by JSC "Liningas" (Lithuania) using the same beam and the same time of manufacturing (in a period of one hour) without any other changes in the technological parameters of the loom and weaving. In such a manner, other factors which can influence the tear strength were eliminated. The weaves of the fabrics are presented in ***Figure 1***.

Tear strength tests were done at standard conditions (20 ± 2 °C temperature and 64 ± 4% humidity) with a universal computer-integrated tensile-testing machine – Zwick/Z005 (the speed was 100 mm/min, the distance between clamps – 100 mm, and the load cell – 5 KN). Test strips were prepared and tests performed according to the standard EN ISO 13937-2:2000, Textiles, Tear properties of fabrics, Part 2: Determination of tear force of trouser-shaped test specimens (Single tear method). Tearing tests were done using prepared strips in the warp and weft directions (in the warp direction – tear wefts, in the weft direction – tear warps). The shape of the strip is presented in ***Figure 2***, and a view of the tearing test is presented in ***Figure 3***.

The maximum force at tearing was used for tear strength estimation, the average values of all kinds of fabrics were calculated from five tests for each variant, where the coefficient of variation of all results did not exceed 10%.

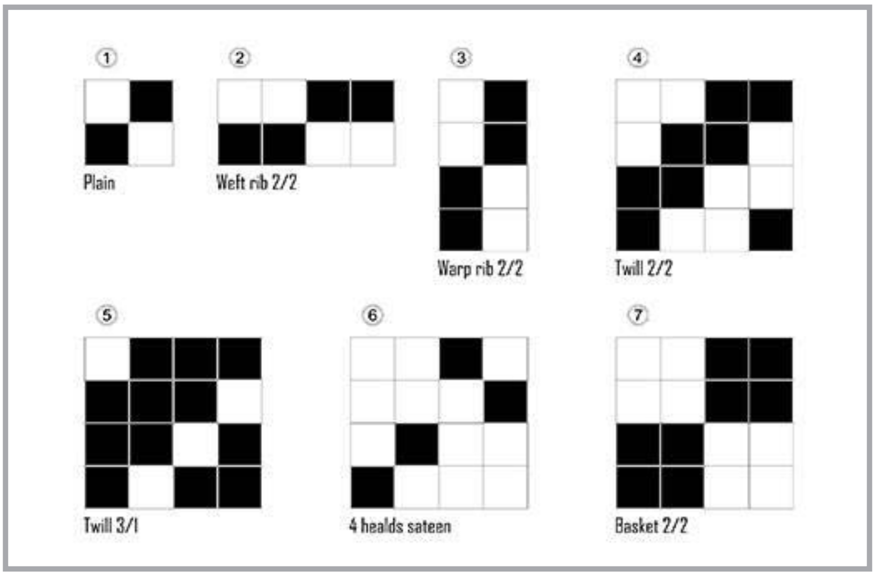

Figure 1. *Weaves of fabrics.*

Results and discussion

Results of the tear strength and weave parameters P, P_1, P_2, P' and F^m calculated are presented in ***Table 1***.

As is seen from ***Table 1***, Brierley's parameter F^m does not show differences between twill fabrics, nor does Milašius' parameter P between ribs, while parameter P' for all kinds of weaves is different, which is the main advantage of this parameter. The influence of the various parameters calculated on the tear strength is presented in ***Figure 4*** (here and in all other cases index 1 means the warp direction and index 2 – the weft direction).

As is seen from ***Figure 4***, the best result (the highest coefficient of determination R^2) was obtained in the case of parameter P'. However, the values of coefficient determination are also too low for tear strength prediction with high accuracy. Due to that, the weaves were divided into two groups: rib-based and twill-based. Both rib and basket weaves were as-

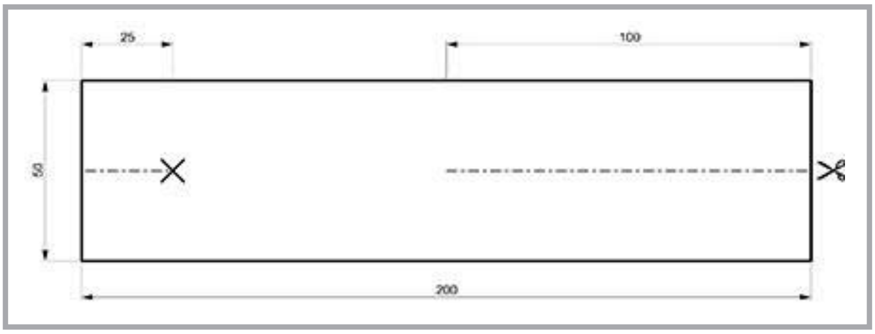

Figure 2. *Shape of trouser-shaped test specimens.*

Table 1. *Tear strengths and weave parameters.*

Weave	In warp		In weft		Weave parameters				
	F, N	V, %	F, N	V, %	F^m	P	P'	P_1	P_2
Plain	7.39	0.76	6.33	3.9	1	1	1	1	1
Weft rib 2/2	19.05	4.03	19.27	2.18	1.185	1.154	1.118	1.000	1.309
Warp rib 2/2	24.9	1.95	16.68	7.68	1.152	1.154	1.249	1.309	1.000
Twill 2/2	17.18	7.29	15.24	4.57	1.310	1.265	1.265	1.265	1.265
Twill 3/1	18.32	9.54	14.47	4.71	1.310	1.333	1.333	1.333	1.333
4 healds sateen	18.34	9.65	15.14	5.22	1.337	1.298	1.298	1.298	1.298
Basket 2/2	32.1	3.71	29.48	4.01	1.336	1.359	1.359	1.359	1.359

Figure 3. *View of tearing test.*

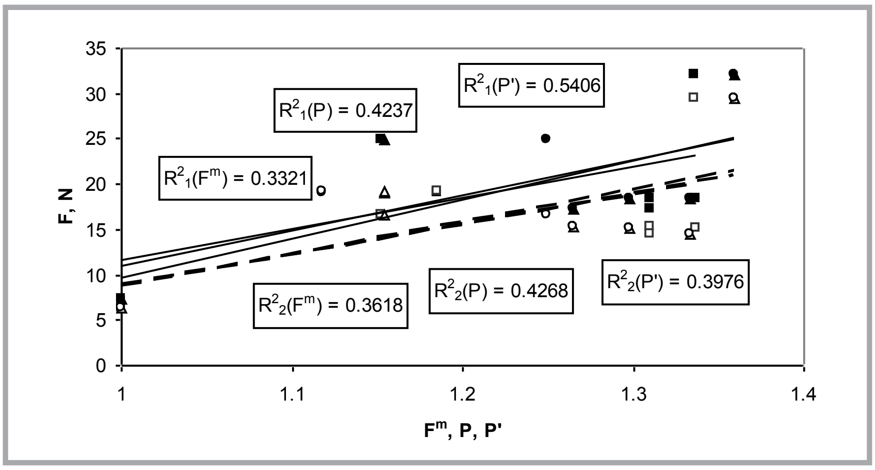

Figure 4. Influence of weave on tear strength (index 1 and continuous curve – in warp, index 2 and dash curve – in weft).

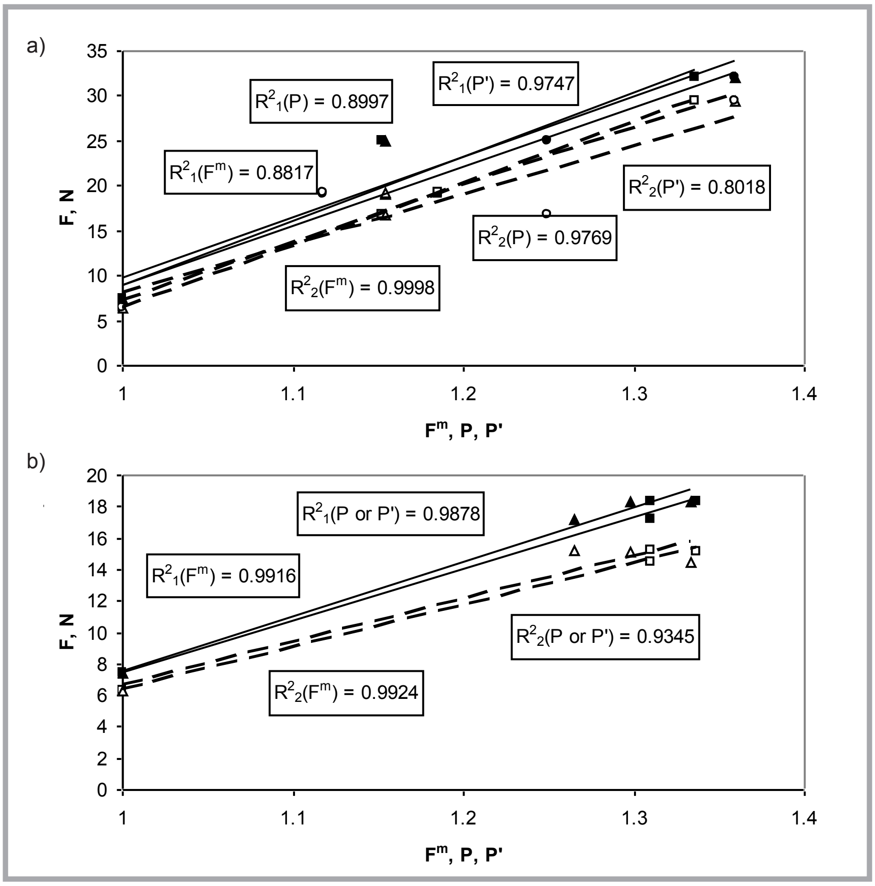

Figure 5. Influence of weave of two groups on tear strength: a) rib-based group, b) twill-based group (index 1 and continuous curve – in warp, index 2 and dash curve – in weft).

signed to the rib-based group (as basket weave is double ribbed), and twills and sateen were put in the twill-based group (as sateen is a modification of twill). Plain weave was assigned to both groups as it is not only a weave but also the main element for all kinds of weaves. The influence of weave parameters of both groups of weaves on the tear strength is presented in ***Figure 5***.

As is shown in ***Figure 5***, the coefficient of determination R^2 in all cases is really high, which means that the method of splitting the weave into two groups presented is quite good, and the accuracy of tear strength prediction will be high.

In the next step of our investigations, a modified weave parameter P'_{weft} was calculated. As was mentioned earlier, in the case of Milašius' parameter *P'*, the influence of P_1 is 70%. Parameter *P'* shows very good correlation with the tear strength in most cases, except for the tear strength in the weft for rib-based group fabrics, where the coefficient of determination obtained was only 0.8018. It is evident that for the tear strength in the weft, the influence of floatining in the warp cannot be higher than that in the weft as in this case the tear strength depends more on the fabric construction in the weft than in the warp. Due to that, for the prediction of the tear strength in the weft of the rib-based weave group , a new parameter P'_{weft} was calculated, where the influence of P_1 and P_2 was varied, i.e. the influence of P_1 was changed by 30% and that of P_2 by 70%. In ***Figure 6***, the influence of parameter P'_{weft} on the tear strength of fabrics of the rib-based group in the weft is presented.

As is seen from ***Figure 6***, in the case of P'_{weft}, the coefficient of determination obtained was much higher than in the case of *P'* (see ***Figure 5.a***). Thus it means that Brierley's parameter F^m and also parameter *P'* can be used for tear strength prediction, but it should be noted that for prediction of the tear strength in the weft for the rib-based weave group, parameter *P'* needs to be calculated changing the influence of parameters P_1 and P_2. Hence our investigations show that it is possible to predict tear strength by the well-known weave parameters F^m and *P'* and that the method presented leads the way for further investigations, which need to be carried out with various kinds of yarns as well as with weaves of higher floating, such as we used in this work. The authors of this work plan to carry out such investigations in the future and to present the results in the next paper.

Conslusions

It was stated that the well-known weave parameters of Brierley F^m and Milašius *P* and *P'* cannot be used for the prediction of tear strength for all kinds of weaves without any limitations. However, all parameters presented can be used for the strength prediction of weave when they are divided into two groups – rib-based and twill-based. The rib-based group includes plain, rib and basket weaves, while the twill-based group includes plain, twill and sateen. Prediction of the tear strength for rib-based weaves in the weft has to be carried out using parameter P'_{weft}, where the influence of parameters P_1 and P_2 is varied.

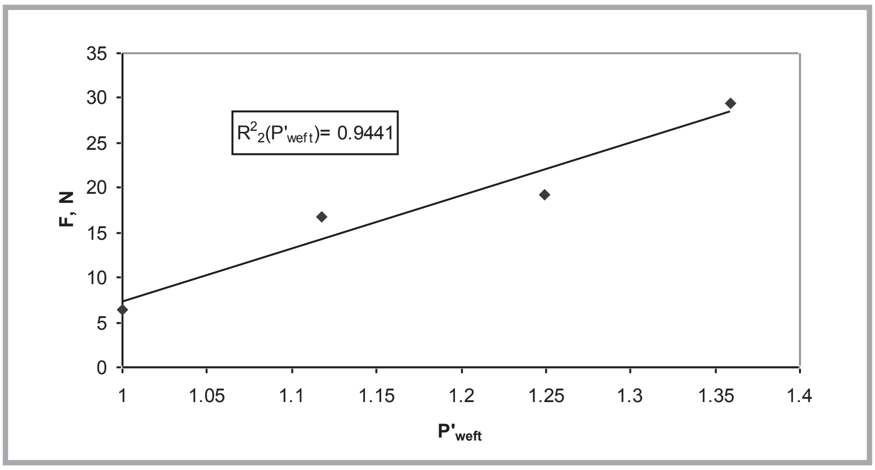

Figure 6. *Influence of parameter* P'_{weft} *on tear strength in weft of rib-based group.*

The conclusion presented is only preliminary as it is made only for one kind of fabric and for fabrics with low floatining. This conclusion must be proved with many more kinds of fabrics and weaves with higher floatining. In any case, the investigations presented show the right way for the tear strength prediction of fabrics with various weaves.

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