BENDING FORCE OF LLDPE MONOFILAMENTS IN RELATION WITH THE DISTANCE OF APPLIED FORCE

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Abstract

The present paper was focused on the importance of the distance of the applied force on the value of the measured bending force. The paper takes in to consideration six different monofilaments, differing from their linear density and their cross section profile. The filaments used as pile layer in artificial turf systems are produced from Linear Low Density Polyethylene (LLDPE). The filament samples were randomly chosen from different not used synthetic fields. The bending tests were performed in the Dynamic Mechanical Analyzer (DMA) TA instrument, where the bending force is monitored very precisely. The tests were focused on two different distances of the applied bending force respectively 2 mm and 3 mm. From the obtained results was found that by increasing this distance, the bending force decreases significantly. Also, was observed that this relation is the same for all the tested samples.

Keywords**:** bending force, distance of applied force, monofilament, DMA.

1. Introduction

Synthetic carpets used in different sports applications have been the subject of many studies, with one objective, to improve their performance. The performance of artificial turf, although widely accepted in different sports, is still one of the main discussions in terms of long life service and quality. In addition, artificial turf is composed by different layers [G Schoukens 2009; P Sandkuehler, E Torres and T Allgeuer. 2010] and following the way of producing, it seems that the pile layer is the key for long term performance [T Joosten 2003]. Pile layer is composed by LLDPE fibres which are fixed on the backing part of the product-carpet [G Schoukens 2009]. The most discussed ones are football fields, considering that in these cases, the fibres are subject of many deformations, among which, bending is the most important.[FIFA] The bending force is applied at a certain distance from the fixed point of the filament. This is named as the distance of the applied force. The total length of the filament corresponding to the length from the point where the filament is clamped to the other end is called the free pile length.

In this paper the focus will be on the importance of the distance of the applied force on the value of the measured bending force.

2. Materials and Test method

2.1 Materials

Six different monofilament fibers were used in the testing program. All the fibers are composed of Linear Low Density Polyethylene (LLDPE) and the samples were randomly chosen from different not used synthetic fields. The monofilaments have resulted of different dimensional characteristics, in terms of linear density and cross section shape. [Kola, Kolgjini and al, 2017]. About the producing methods and processing parameters of the testing fibers. there is no information.

2.2 Test method

The test method is performed in the DMA (Dynamic Mechanical Analyzer) TA Instrument. This test is performed by modifying the DMA instrument, in order to use it for bending. The modification is done by the Department of Textile at University of Gent. The DMA is set to Controlled Force Mode [Kevin P. Menard. 2008] and the distance of applying the force is set to 2 *mm* and 3 *mm*. The detailed information is restricted from the University of Gent. In this test, the bending force is measured for a single monofilament.

For each fiber are performed 3 repetitions. The testing is done at the room temperature, which corresponds to 23 $\pm 2^0$C. Two of the fibers, B and F, for the reason of being "c" shape, are tested in both sides of the "c", because the fiber performs differently in each of the sides. The sides are denoted as (l) - the concave side, and (m) - the convex. For data analyses is used the TA Instruments Universal Analysis (UA) Program [Universal Analysis 2000]. For the 3 measurements of each fiber, the static bending force (N) is plotted versus the displacement (μm). The Onset Point (OP) 1 and Onset Point (OP) 2 are found in each graphic, through the UA Program (see Fig. 1) and the mean value is calculated. The same plot as below is obtained for each repetition of each sample.

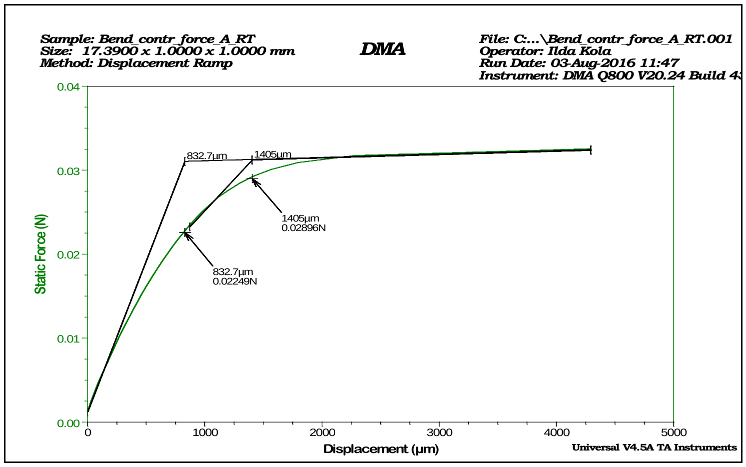

Fig. 1. The bending force of fiber A versus displacement and the Onset Points on the DMA.

Figure 1 represents the static bending force (N) plotted versus the displacement (μm). The Onset Point (OP) 1 and Onset Point (OP) 2 are found in each graphic, through the UA Program and the mean value is calculated.

3. Results and discussions

The results of the bending forces measured on the DMA, more precisely the Onset Points 1 and 2, are extracted from the UA Program, as shown on the test methods paragraph. The mean values, calculated for each fiber, are summarized in Table 1. In this analysis are considered both distances of applying the force 2 *mm* and 3 *mm*. As it is noticed from the results presented below, the bending force decreases significantly when the distance of applying the force changes from 2 mm to 3 mm. All the fibers undergo the same trend.

Table 1. Bending static force measured for the 2 and 3 mm distances. Onset Points (OP) 1 and 2.

Fiber Sample	**Point of applying the force**			
	2*mm*		3*mm*	
	OP 1 (cN)	**OP 2 (cN)**	**OP 1 (cN)**	**OP 2 (cN)**
Fiber A	3.361	4.243	2.272	3.213
Fiber B(l)	4.669	6.115	2.759	3.543
Fiber B(m)	7.433	8.278	3.465	4.291
Fiber C	2.210	2.807	1.106	1.401
Fiber D	3.125	3.869	1.423	1.764
Fiber E	4.717	6.121	2.299	2.809
Fiber F(l)	2.835	4.474	1.672	2.256
Fiber F(m)	6.124	6.690	3.625	4.168

To have a better view of the behavior of monofilaments under the bending force a comparison of this behavior for the two distances is done by combining the fibers two by two in terms of their cross sectional shape. The combinations of the fibers is done based more on function of the cross sectional shape and not on their linear density, because that is the physical property that affects significantly the bending force [Kola, Kolgjini at al. 2017].

Using the UA Universal Analysis Program, the static bending force is plotted versus the displacement for all the fibers. The curves are overlaid two by two in terms of the distance of the applied force and the similarity of the fibers cross section.

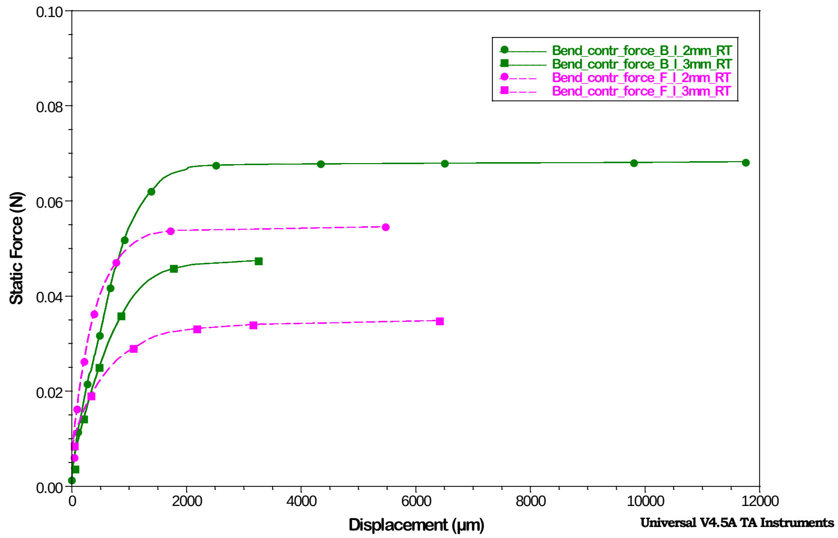

Fig.2. Bending force for fibers A and E for 2mm and 3mm.

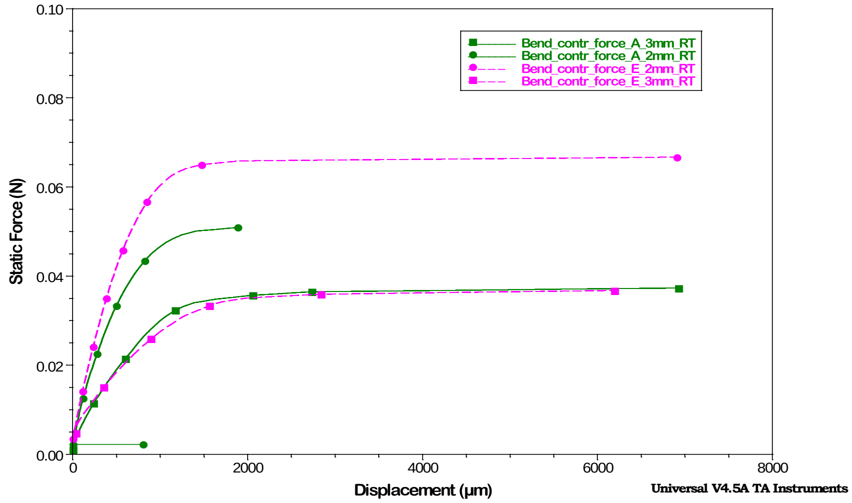

Fig.3. Bending force for fibers B(l) and F(l) for 2mm and 3mm.

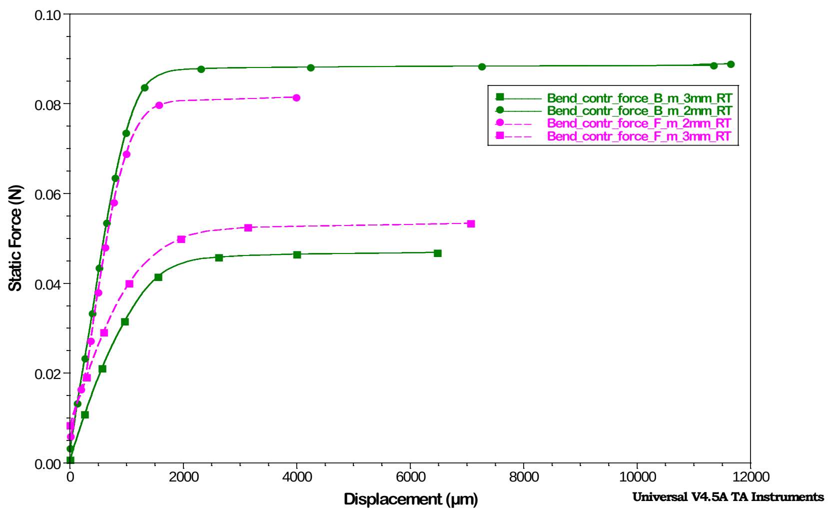

Fig.4. Bending force for fibers B(m) and F(m) for 2mm and 3mm

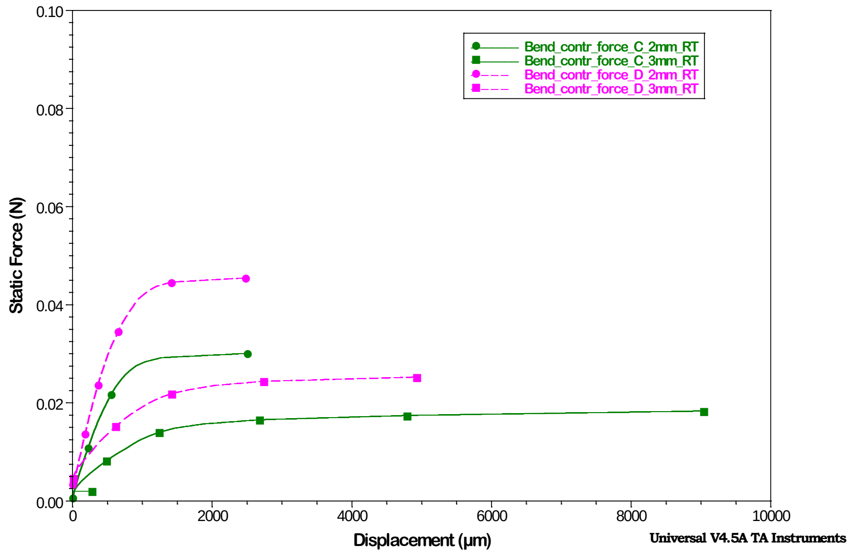

Fig.5. Bending force for fibers C and D for 2mm and 3mm.

In figure 2 are plotted the graphs for fibers A and E for both distances, and it is clearly noticed that the bending force decreases for both fibers in the distance of 3 mm. They perform almost the same in this distance of applied force.

In Figure 3 are plotted the graphs for fibers B and F performing on the concave side (l), for both distances. The reducing of the bending force for the 3 mm distance is almost in the same amount for both fibers.

In Figure 4 are plotted the best performing fibers in their convex side, B and F. It is clearly noticed that they perform similarly in both distances and the bending force is halved when the distance increases from 2mm to 3mm.

The last figure (Fig.5) shows the graphs of the fibers C and D. These are the worst performing fibers as it is easily noticed from the values of the static bending force. Despite this, both fibers have the same decreasing behavior by reducing the distance of the applied force.

4. Conclusions

The influence of the distance where the force is applied on the static bending force was the aim of this paper. Six different fibers and two distances were considered. From the obtained results is observed that fibers bending force is significantly related to the distance of applied force. By increasing the distance from 2mm to 3mm, the bending force is reduced by a considerably amount of force. Also, was observed that this relation is the same for all the tested samples. In the future, the research will be focused on the influence of the free pile length on the bending force.

1. References

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