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STIFFNESS EXPERIMENTAL ANALYSIS OF HIGH DENSITY POLYETHYLENE TUBES

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Abstract: *The paper presents the most important results obtained during tensile and three-point bend tests accomplished on 20 x 2, 25 x 2, 40 x 2.3, 63 x 4 and 90 x 6 high density polyethylene (HDPE) tubes used for water supply networks. Specimens have been cut from various tubes to be subjected to tensile tests. Three-point bend tests have been accomplished on 100 mm tubes' length. The experimental tests have been carried out at the Laboratory for Materials Testing, Department of Mechanics within Transilvania University of Brasov, Romania. In tensile tests the Young's modulus increases with the increase of tubes' diameter. In three-point bend tests the Young's modulus of bending decreases with the increase of tubes' diameter.*
Keywords: *Stiffness, Tensile test, Three-point bend test, HDPE tubes, Young's modulus*

1. INTRODUCTION

High density polyethylene (HDPE) is a thermoplastic material used as "embedded material" for fibres to increase its mechanical properties. Common reinforcing materials for HDPE are glass and carbon fibres but natural fibres as jute, also. In the technical literature there are a lot of papers that describes the outstanding possibilities of HDPE to be reinforced and to achieve quite interesting properties. For instance, Mohanty and Nayak presented an experimental study on the mechanical and rheological behavior of high density polyethylene (HDPE)/jute composites [1]. HDPE with short jute fibers of 6 mm length has been melt-mixed employing Haake torque rheocord followed by compression molding. Various types of chemical treatments such as mercerization, cyanoethylation, coupling agent treatment, etc. have been performed to improve interfacial adhesion between the fibers and HDPE matrix. Variations in fiber loading, surface treatment, coupling agent concentration, and treatment time period as a function of mechanical strength have been studied. Mechanical tests showed that composites treated with 1% maleic anhydride grafted polyethylene (MAPE) exhibit an increase of 47.3, 26.4, and 28.1% in tensile, flexural, and impact strengths, respectively [1]. Paesano et al. described a number of thermoplastic systems that have been evaluated in conjunction with 1 k tow T300 plain-weave carbon fabric as reinforcement [2]. Three thermoplastic resin candidates have been selected: polypropylene (PP), high-density polyethylene (HDPE), and glycol-modified polyester terephthalate (PETG). Physical, mechanical, and thermal properties of the systems as well as the commercial availability of these systems in thin sheets have been presented [2]. Liang and Yang presented a kind of carbon black (CB), which was surface-treated by silane-coupling agent, was compounded with high-density polyethylene (HDPE) in a twin-screw extruder, and then the composites have been molded into specimens with a plastic injection molding machine [3]. The effects of CB loading on the mechanical properties, such as tensile yield strength, tensile fracture strength, tensile fracture elongation, flexural strength, flexural modulus and impact strength of the HDPE/CB antistatic composites, were investigated [3]. Fei et al., presented series fire tests simulating cable fires in plenum caused by exposed and aged combustible cables were carried out in a real-scale flatletmodel containing burn room, ceiling plenum, and target room [4]. A special communication cable type insulated with HDPE and sheathed with LLDPE has been used. A related fire reference scenario was designed to simulate how cables in plenum were involved in a fire from potential fire loads to substantial fuel by the role of an external flaming source and to characterize related fire issues. The burning of exposed tested cables in plenum easily poses a high potential of fire hazard even at a relatively low fire load [4]. Ambroziak et al., carried out tensile and temperature tests of an optical fibre cable [5]. Positive results of these tests showed proper excess fibre length selected during the cable production. SEM and DTA investigations of the standard PBT tubes disclosed a finely dispersed crystalline phase of ca. 29%. The value is much lower than the maximal content ofthe crystalline phase liable to develop in PBT, estimated at 66% [5].

2. SPECIMENS AND TENSILE TEST PROCEDURES

Five specimens with dimensions 4 x 10 x 150 mm have been cut, from various HDPE tubes and subjected to tensile tests on a "LS100 Plus" testing machine produced by Lloyd Instruments (fig. 1). The testing machine presents the following specifications:

- force range: 100 kN;
- speed accuracy: <0.2%;
- travel: 840 mm
- load resolution: <0.01% of load cell used;
- extension resolution: <0.1 micron;
- load cell: XLC-100K-A1;
- analysis software: NEXYGEN Plus.

The specimens have been subjected to a test speed of 15 mm/min and an extensometer has been used. Following main features have been determined: stiffness, Young's modulus, stress at maximum load, strain at maximum load, extension at maximum load, extension at maximum extension, etc.

Figure 1: Lloyd Instruments "LS100 Plus" testing machine

3. SPECIMENS AND THREE-POINT BEND TEST PROCEDURES

Various HDPE tube specimens with dimensions 20 x 2, 25 x 2, 40 x 2.3, 63 x 4 and 90 x 6 and 100 mm length have been subjected to three-point bend test on a "LR5K Plus" testing machine produced by Lloyd Instruments, UK (fig. 2). The testing machine presents the following specifications:

- force range: 5 kN;
- speed accuracy: <0.2%;
- travel: 840 mm
- load resolution: <0.01% of load cell used;
- extension resolution: <0.1 micron;
- load cell: XLC-5K-A1;
- analysis software: NEXYGEN Plus.

The tubes have been subjected to a test speed of 3 mm/min and the span has been chosen of 80 mm. Following main features have been determined: stiffness, Young's modulus of bending, flexural rigidity, maximum bending stress at maximum load, maximum bending strain at maximum load, extension at maximum load, extension at maximum extension, etc.

Figure 2: Lloyd Instruments "LR5K Plus" testing machine

4. EXPERIMENTAL RESULTS

Various features determined experimentally in tensile and three-point bend tests have been presented in figs. 3-6.

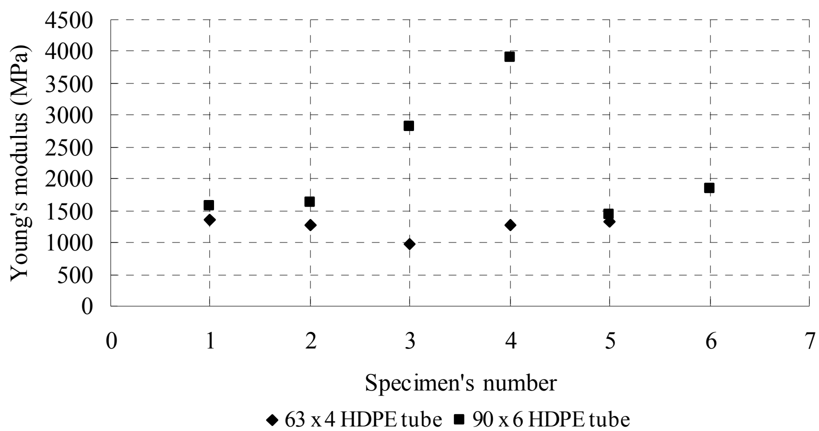

Figure 3: Young's modulus distribution in case of specimens cut from various HDPE tubes subjected to tensile tests

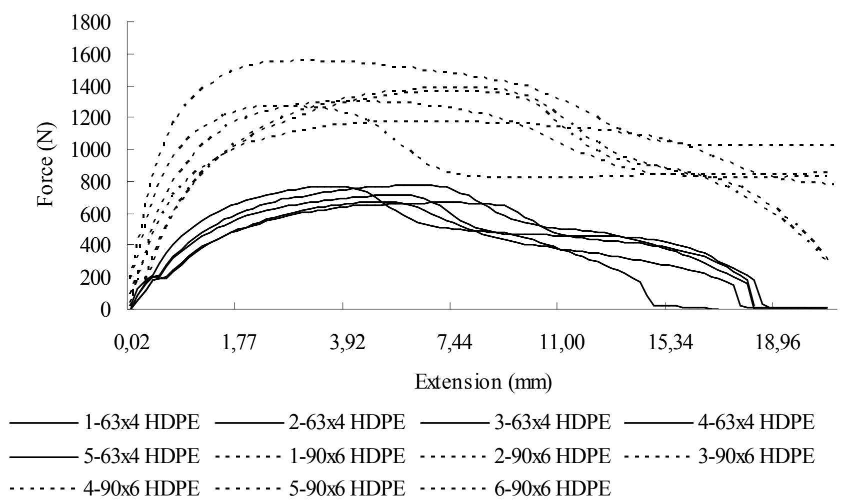

Figure 4: Force-extension distributions in case of specimens cut from various HDPE tubes subjected to tensile tests

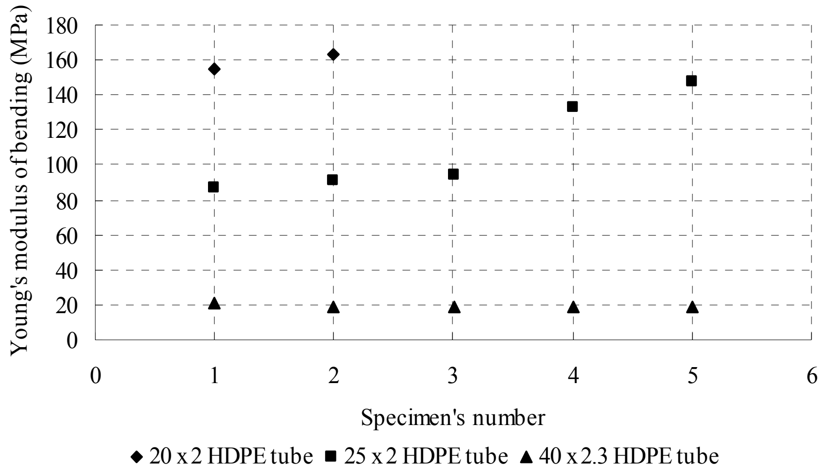

Figure 5: Distribution of Young's modulus of bending for various HDPE tubes subjected to three-point bend tests

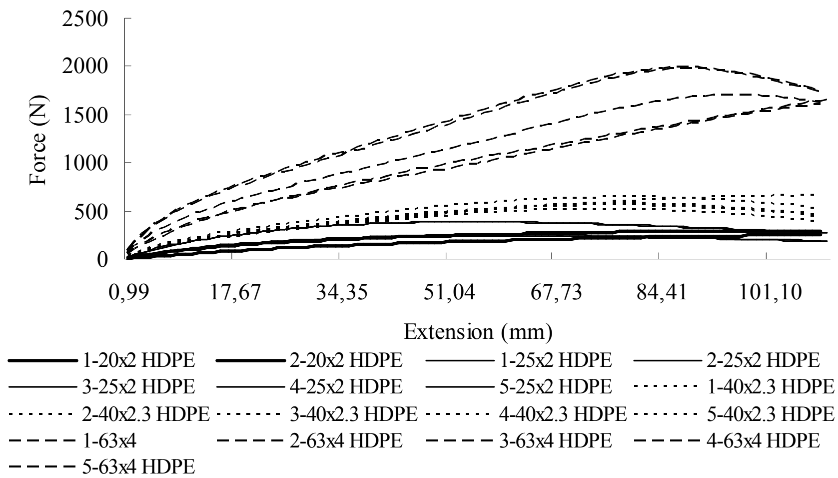

Figure 6: Force-extension distributions in case of various HDPE tubes subjected to three-point bend tests

5. CONCLUSIONS

In case of tensile tests results, with the increase of tube's diameter, the Young's modulus as well as the force-extension distributions increase. In case of three-point bend tests, with the increase of tube's diameter, the Young's modulus decreases and the force-extension distributions increase. The results show that ths high density polyethylene represent a suitable material to manufacture HDPE tubes for water supply networks applications.

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