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TRACTION TESTS TO DETERMINE THE BEHAVIOR OF THE MATERIALS USED IN WATER SUPPLY NETWORKS

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Abstract: *The paper study the mechanical properties of a high density polyethylene used for the tubes of a water supply networks. Experimental tests are made in order to obtain the mechanical characteristics of the test specimens obtained from the HDPE. Tubes and fittings made from this material are characterized by a long service life and their maintenance costs are reduced. A good knowdlege of these materials is necessary. The results are presented in the paper and can be used in practice and in further research. It is presented the main mode of rupture of a such material, called "parrot beak".*

Key words: *composite materials, panel, sandwich, bending, test*

1. INTRODUCTION

The paper aims to analyze, from the point of view of mechanical properties, a basic element in the field of liquid transportation, namely the tube. Research is directed towards the experimental identification of traction behavior in standard load cases. The use of tubes is widespread in the transport of liquids, especially for transporting oil, gas and water to human communities. Data from 2014 indicates a total length of approximately 3,500,000 km of oil and gas pipelines built in 120 countries of the world [37]. The tube, which is the main element of a power supply network, strictly necessary for water transport, has been made of traditional materials (stone, burned, wood, metal, non-metallic) for more than two millennia. At present, the elite material for the manufacture of tubes is plastic. The most suitable plastic currently used to produce the tubes needed to transport water to modern water supply networks has been shown to be high density polyethylene (HDPE) [1], [3], [22], [23], [25], [36].

Tubes and fittings made from this material are characterized by a long service life and their maintenance costs are reduced. Tubes and fittings made of high density polyethylene follow quality standards and are remarkable for their outstanding strength and low weight. High density polyethylene tubes are already in the third generation of material; polymerization conditions and special catalysts give quality granules, which give the tubes thus obtained by extrusion methods outstanding properties and high mechanical qualities. The theoretical basis for the study of these types of material is found in [10]-[12]. A more refined calculus can be made using dynamic models using the methods presented in [19],[20]. In the following we present some constructive elements used in the construction of water supply systems made of PEDH. Figs. 1-4 illustrates the types of polyethylene pipes used in a) water supply networks; b) branch lines; c) the distribution network; d) arteries.

Fig.1. Pipes used in water supply networks

Fig.2. Types of polyethylene pipes used in branch lines

Fig.3. Types of polyethylene pipes used in distribution network

Fig.4. Types of polyethylene pipes used in arteries

The study aimed to determine the traction behavior of these tubes, which was why experimental tests were carried out in the laboratory. The design of the experiments was done taking into account the standards in the field and the results obtained by other researchers [27]- [33],[35].

2. TRACTION TESTS

The first traction tests were carried out on high density polyethylene from which 63 x 4 and 90 x 6 tubes were made. Because there are no test specimens made in the same time with the tubes, for the most commonly used pipes used in the distribution network the test specimens were cut from the tubes. Tests have been conducted on the LS100 Plus, Lloyd Instruments, United Kingdom. The work test speed was set at 15 mm /min [4], [6, [8], [9], [13], [24].

On high-density polyethylene specimens were mounted an extensometer to determine the Young's modulus. The specimens were tested for traction until breakage. The following diagrams were carried out during high-density polyethylene traction tests (Figs. 5-12). The Young's modulus, stress at the maximum load toward the strain at the maximum load, force at maximum load toward to the displacement at the maximum load, Young's modulus toward to the traction strength, rigidity toward the force at maximum load, stress at maximum deformation according to strain at maximum deformation, breaking force toward the displacement at break, stress at breaking toward strain at breaking.

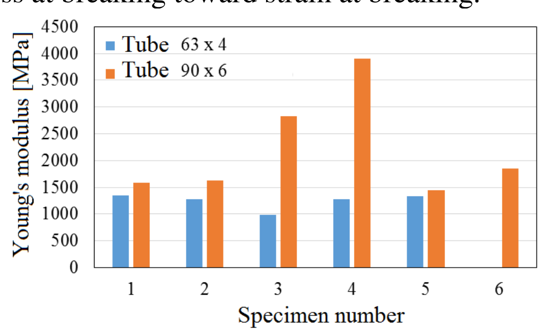

Fig.5 Diagram of Young's modulus

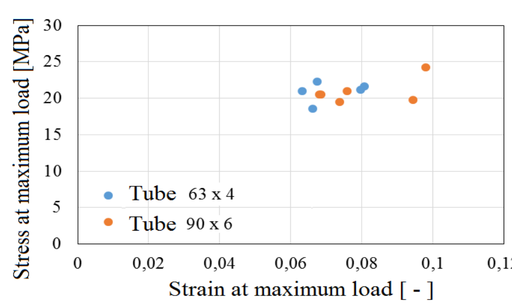

Fig.6. Diagram of the stress at maximum load

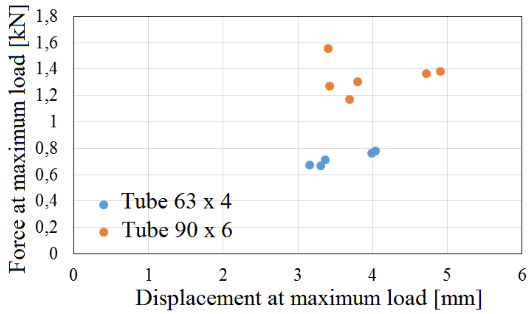

Fig.7. Diagram of force at maximum load

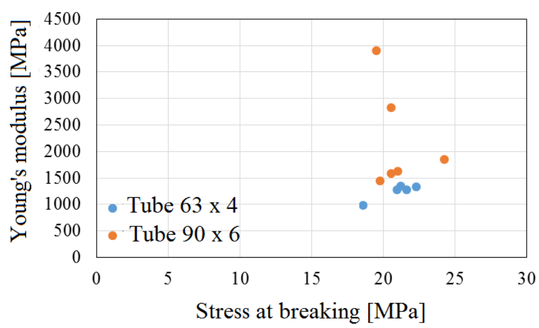

Fig.8. Diagram of the Young's modulus

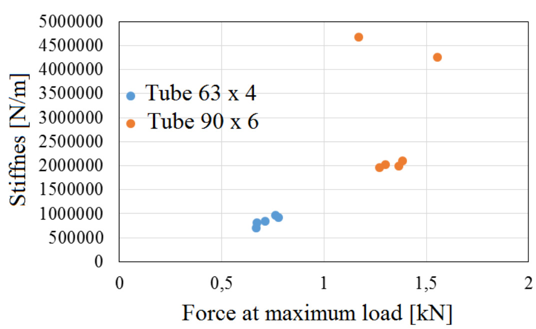

Fig.9. Diagram of stiffnes

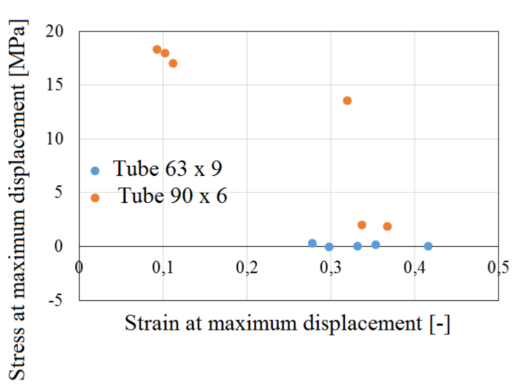

Fig.10. Diagram of stress

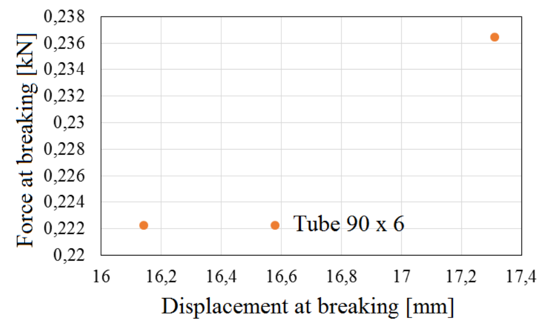

Fig.11. Tube 90 x 6 mm. Diagram of breaking force

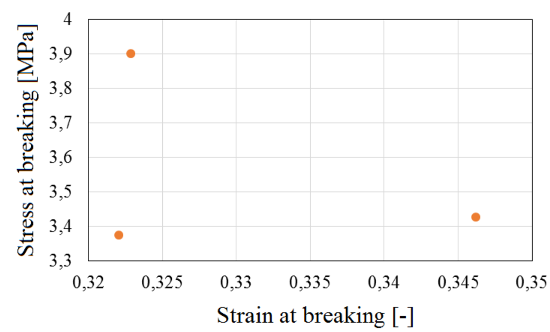

Fig.12. Tube 90 x 6 mm. Diagram of breaking stress

It can be seen that as the diameter of the tube increases, the dispersion of the values increases. The values of mechanical properties for high density polyethylene used from water distribution pipes are close to those found in the literature. The most important disperssion of the values was obtained at the value of the stress at the maximum displacement toward the strain for both types of specimens made from high density polyethylene tubes.

Fig. 13. The rupture "parrot beak"

The ductile rupture mode is characterized in significant elongations in the immediate area of the rupture. The rupture looks like a "parrot beak" illustrated by Fig. 13 in which some pipes are used by Company Apa Brașov S.A.

3. RESULTS

In the following, traction tests are performed directly on the tubes. Tests were performed on the HDPE tube Φ20 × 2. Material tests were carried out in the Material Test Laboratory of the Mechanical Engineering Department of the Faculty of Mechanical Engineering at Transilvania University of Brașov on the Lloyd LS 100 for traction/compression [14]-[18],[21],[26].

The test machine is the Lloyd LS 100 and it is shown in Fig. 14, with a detail.

Fig.14. Testing machine tip Lloyd LS 100 and a tube Φ20×2

The second material studied is obtain from the tube Φ 63×4. Dimensions of test specimens are: 150 × 10 × 4. The traction tests were performed on the LS 1OO PLUS type test machine, produced by Lloyd Instruments, UK, Fig. 14 used with NEXYGEN Plus software. The specimens were subjected to a test speed of 3 mm/min and an extensometer was used. The following characteristics were determined: stiffness; Young's module; stress at maximum load; strain at maximum load; displacement at maximum load.

Fig. 15. Specimens 1 to 5 subjected to traction

Fig. 16. The extensometer used

In Fig. 15 shows the specimens that have been subjected to the traction test and in Fig.16 the extensometer used. The third test was made on the material of the tube Φ 90×6. The dimensions of the specimens are: 150×10×6.

Fig.17. Test specimens for the tube Φ 90×6.

Fig. 17 shows the broken test specimens.

4. DISCUSSION

Based on the set of tests performed, the following traction characteristics were determined: Young's modulus; maximum stress; strain at the maximum force and strain at break. The method consists in applying a progressive traction load in the direction of the longitudinal axis of the specimen.

To determine the traction characteristics of the high density polyethylene tube, specimens of the type shown in Fig. 15 and Fig.17 are used. In the case of high density polyethylene pipes used in the execution of water supply systems, the specimens are cut out of the pipes used in practice, these having different diameters and thicknesses of the walls. Pipes with external diameters between 20-110 mm are used for the distribution. For transportation are used the arteries with outer diameters between 110-400 mm. For adductions pipes with external diameters between 400-1000 mm. The specimens are cut to a width of 10 mm and a length of 150 mm, their thickness being given by the thickness of the respective pipe wall. For each determined feature, a minimum of 5 specimens is required. If greater accuracy is sought for an arithmetic average of the values, the number of specimens to determine a characteristic can be increased.

The speed of displacement of the test attachment heads is the test speed. This is chosen so as to ensure a percentage extension increase rate of about 1-2% per minute. For the specimens shown above, a test speed of 2 mm / min is adopted. It is determined: stress, strain, displacement, Young's modulus. The test speed shall be maintained by a deviation of -10% ...+10% . Pipe specimens are measured to determine the width and length framing in quota tolerance according to the standards. The specimens that don't respect the dimensions are removed. The thickness of the specimens is given by the thickness of the pipe wall and has been found to be constant.

Each specimen is attached to the fastening clips of the machine, taking care that the longitudinal axis of the specimen must coincides with the axis of the test machine. The test speed is adjusted to 2 mm/min, then the corresponding displacements and forces are recorded.

The traction tests were performed on specimens of all types of pipes used in distribution in water supply networks. We present the results obtained for several types of tubes.

Traction tube Φ 20 × 2 HDPE. The test results are shown in Fig. 18.

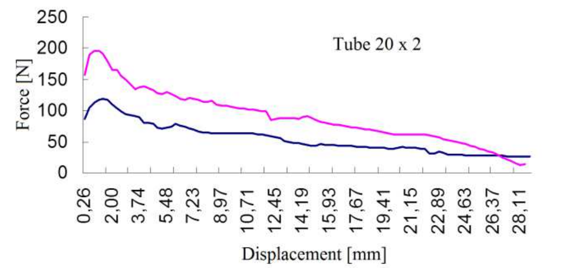

Fig. 18. Force-displacement diagram for the material of the tube Φ20×2

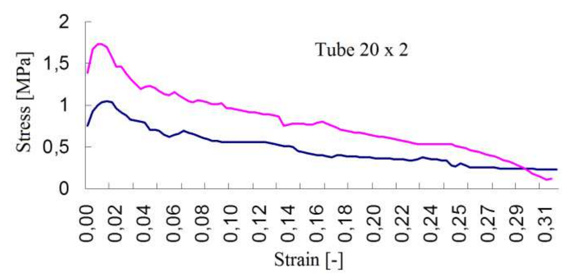

Fig. 19. Stress-Strain diagram for the material of the tube Φ20×2

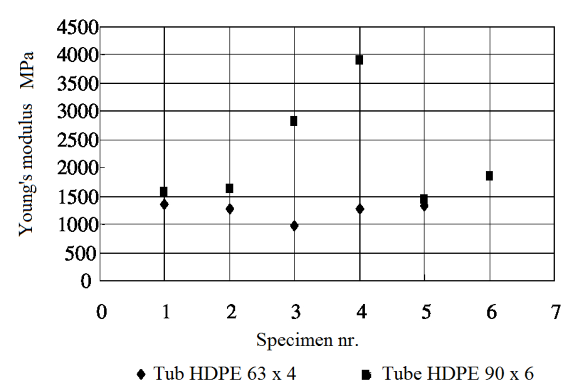

Fig. 20. Young's modulus for tubes Φ 63×4 and Φ 90×6

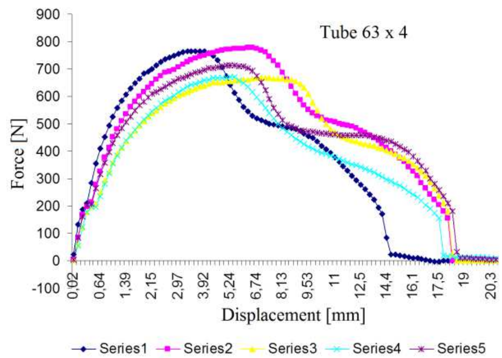

Fig. 21. Force-displacement diagram for the material of the tube Φ 63×4

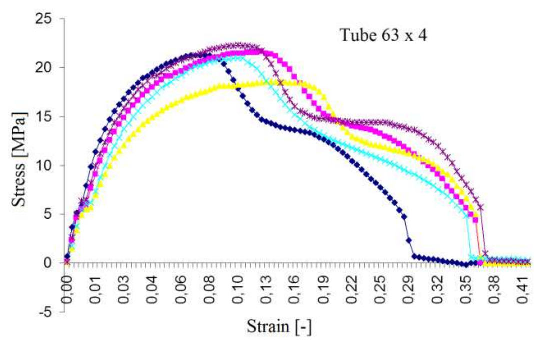

Fig. 22. Stress-Strain diagram for the material of the tube Φ 63×4

The Young's module for the traction test of the test specimens made by the Φ 63 × 4 and Φ 90 × 6 tubes is shown in Fig.20. The results of the traction tests of the test specimens made by the tube Φ 63 × 4 are shown in Fig.21 and Fig. 22.

The research concern the study of the mechanical properties of a high density polyethylene used for the tubes of a water supply networks. Experimental tests are perform in order to obtain the mechanical properties at traction of the test specimens obtained from the HDPE. The study is important in the water supply network due to the facts that the tubes and fittings made from this material are characterized by a long service life and their maintenance costs are reduced. Consequently, a good knowdlege of these materials is necessary.

The Young's modulus values ranged between 1500 and 4000 MPa for high density polyethylene samples cut from the Φ 90 x 6 mm tube and between 1000 and 1400 MPa for high density polyethylene samples cut from the Φ 63 x 4 mm tube. The average of the stresses at the maximum load toward the strain at the maximum load ranged around 20 MPa for both types of specimens. The force at the maximum load of high density polyethylene cut from the Φ 90 x 6 mm tube was between 1.2 kN and 1.6 kN and in the case of high density polyethylene from the Φ 63 x 4 mm tube was between 0.7 kN and 0.8 kN.

Tubes and fittings made of high density polyethylene follow quality standards and are remarkable for their outstanding strength, low weight and have very good mecanical properties.

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ÎNCERCĂRI DE TRACȚIUNE PENTRU DETERMINAREA COMPORTĂRII MATERIALELOR UTILIZATE ÎN REȚELELE DE APĂ

Rezumat. *În lucrare sunt studiate proprietățile mecanice ale polietilenei de înaltă densitate (HDPE) utilizată la fabricarea tuburilor din rețelele de alimentare cu apă. Pentru a obține aceste proprietăți sunt efectuate încercări de tracțiune pe epruvete fabricate din HDPE. Tuburile şi elementele de legătură realizate din acest material sunt caracterizate de o durată de funcționare îndelungată iar costurile de întreținere sunt scăzute. O bună cunoaştere a acestor materiale se impune. Rezultatele obținute în lucrare pot fi utilizate direct în practică sau pot fi folosite în cercetări viitoare. Este prezentat principalul mod de rupere al materialului, numit "cioc de papagal".*

Cuvinte cheie: *material compozite, panel, sandwich, încovoiere, tracțiune, bending, incercări*

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