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CONSERVATION OF THE MECHANICAL PROPERTIES UNDER THE ACTION OF THE ENVIRONMENTAL EFFECTS IN CASE OF THE E-GLASS / VINYL-ESTER COMPOSITES

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ABSTRACT
The paper describes the aspects concerning moisture effects on the mechanical characteristics of the randomly reinforced E-glass / vinyl-ester Atlac 582 composite. Specimens for tensile test and flexural test were manufactured. Three different environments (water, natural seawater from the Black Sea and water / detergent mix) were considered. The first of all, the absorption data were analysed. Some specimens were subjected to 60 thermal cycles. Then, the specimens were subjected to the tensile test and flexural test (using the three-point method). Results of the tests applied on the specimens after immersion time and after thermal cycles, were compared with the results obtained in case of the dry specimens. Herein, we show that the environment acts on the strength and stiffness characteristics of the composite material involved. Finally, we note that the moisture absorption into the E-glass / vinyl-ester Atlac 582 composite analysed leads to the decreasing of the mechanical characteristics.
Keywords: composite, moisture, flexural modulus, flexural stress, tensile strength.

1. INTRODUCTION
E-glass / vinyl-ester composites are used widely in the building and construction industry. They are used as an integral part of a structural or non-load-bearing wall panel, window frames, tanks, bathroom units, pipes and ducts are common examples. The automotive industry, , naval industry (boat hulls), aerospace industry are other big users of glass reinforced resins. These structural elements may also be exposed to the environmental effects (moisture, thermal cycles etc).
The diffusion of the water in polymer materials has been discussed in numerous papers [1, 2, 4, 5].
In this paper, the authors report the effects of the external factors (humidity, thermal cycles) on the mechanical characteristics of the E-glass / vinyl-ester Atlac 582 composite.

2. MATERIALS AND WORK METHOD
The chopped E-glass fibre composite was made in the form of 4 *mm* thick plate (625 x 800 mm^2) using hand lay-up technology. The composite had the average volume fibre ratio equal to 26 %, while the weight fibre ratio was 40 %. Then, the plate was cut to obtain the specimens according to [5]. The specimens were dried at 30 °C for one week. A total number of 30 specimens were manufactured (table 1 and fig. 1, 2). Prior to immersion, the specimens were stored in an oven at 30 ± 1 °C and weighted to ensure that they were dry prior to environmental conditioning.

Table 1 – Number of specimens tested made of composite materials

For tensile test				For flexural test				
Dry	Environment			Dry	Environment			
	Water	Water / detergent mix	Seawater (Black Sea)		Water	Water / detergent mix	Seawater (Black Sea)	Thermal cycles
5	6	6	6	5	6	6		

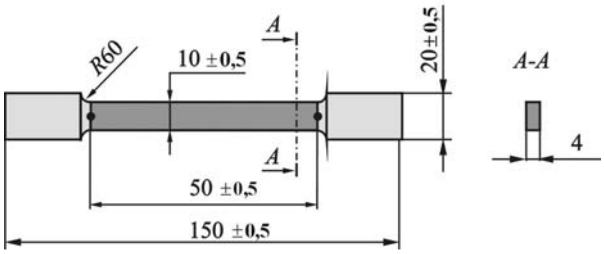

Figure 1. Composite specimen for tensile test

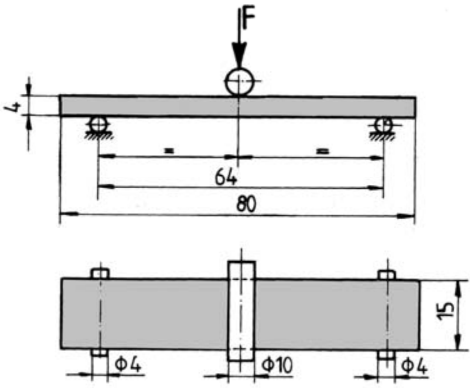

Figure 2. Composite specimen for flexural test

Water, water / detergent mix and fresh natural seawater from *Black* at room temperature (20 ℃) were used as wet environments. The salinity of the seawater was approximately of 1.6 %. The water tanks were covered to minimise evaporation and the water was changed every month to keep conditions constant.

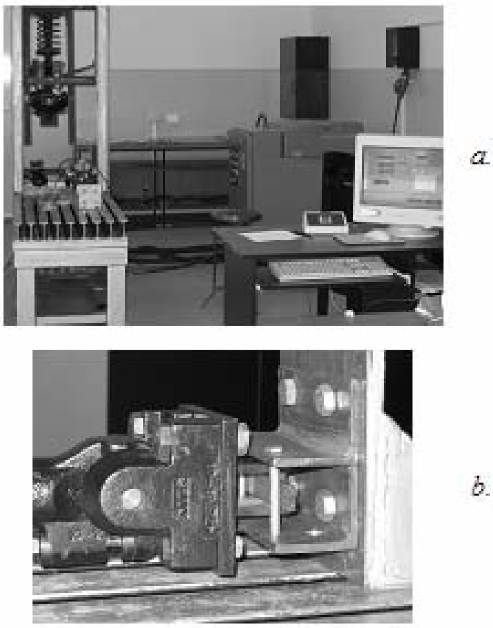

Figure 3. Experimental stand for the flexural test: a. Hydraulic testing equipment; b. Gripping device (three-point method)

The tensile specimens (fig. 1) were subjected to tensile test after 7000 *hours* of soaking. Tensile test was made by using a special machine (DZ 20).

After 9200 *hours* of soaking, the flexural specimens were subjected to a flexural test [5]. The loading scheme (three point method) and dimensions of the specimen are shown in the figure 2. The testing equipment (fig. 3), manufactured by MTS System USA, used for flexural test consists of hydraulic power supply with 40 *HP*, 2 actuator assemblies, with integrated inductive stroke transducers, FlexTest GT digital control system, personal computer, test stand and clamping devices load cells. The loading rate was 2 *mm/min*. The testing equipment allowed us to record pairs of values (force, deflection) in form of files having 3000-5000 lines.

Using an oven (fig. 4) some specimens manufactured were subjected to 60 *thermal cycles* (fig. 5). The thermal cycle was thought for members used in automotive industry, marine industry whose temperature reaches 70ºC in warm summer days.

Figure 4. Oven

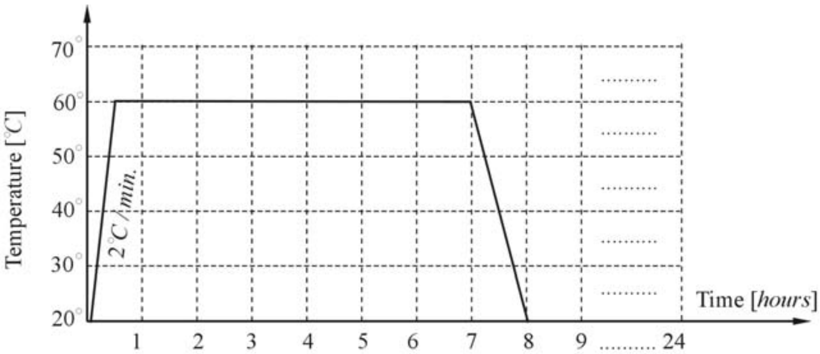

Figure 5. Thermal cycle

3. RESULTS

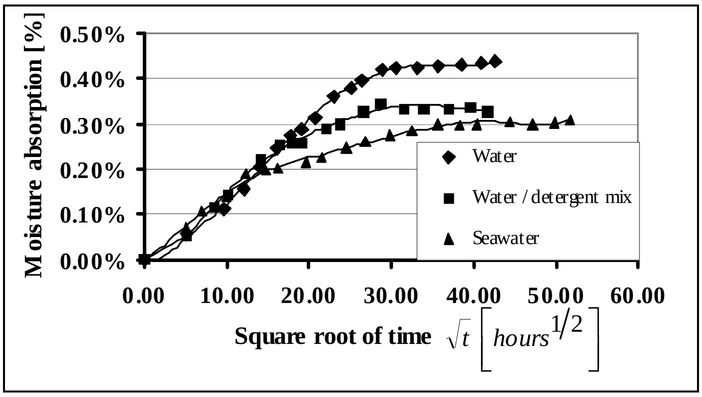

Figure 6 - Absorption data for E-glass/vinyl-ester Atlac582

The first of all, moisture behaviour was analysed during ten months (fig. 6). Then, tensile test and flexural test (using the three-point method) were considered. The results were compared with the results obtained in case of the dry specimens.

From tensile tests the results are graphically drawn as shown figure 7. Analysing the results we observe that after 7000 hours of immersion the tensile strength decreases.

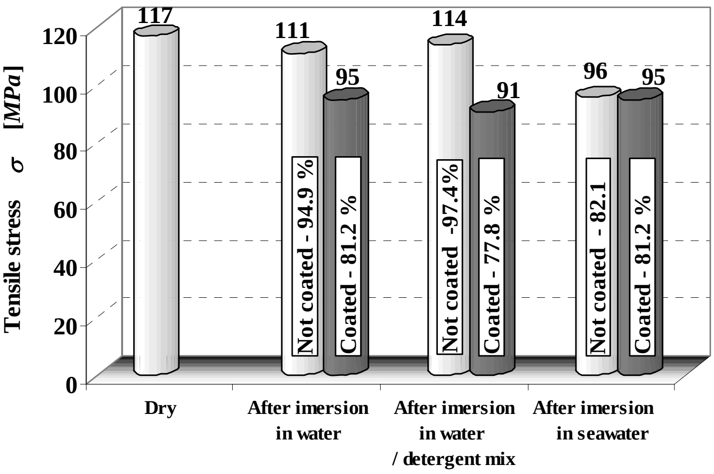

Figure 7. Change of the tensile strength for the E-glass / vinyl-ester Atlac 582 composite after immersion (for 7000 hours)

Some flexural specimens were immersed in water, water / detergent mix, seawater (soaking time: 9200 *hours*) while the others were subjected to 60 thermal cycles. Then, they were subjected to the flexural test. The experimental data recorded by using testing equipment presented above, were graphically represented as shown in the figure 8 (Deflection *v* at the midpoint of the specimen as a function of the external force *F*).

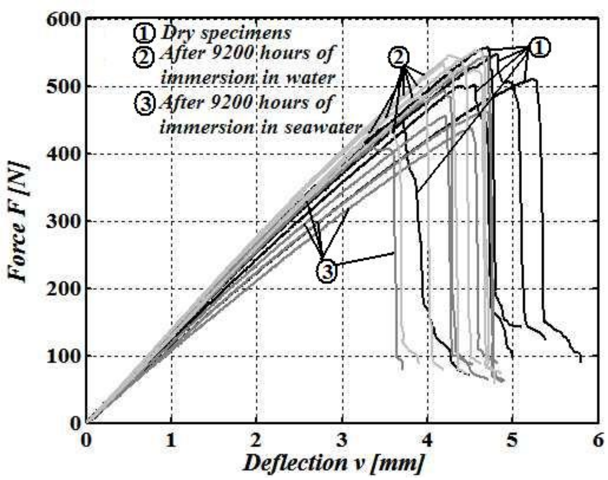

Figure 8. Variation of the deflection v with respect to the force applied F in case of the flexural test

The results concerning the effects of the environment on the flexural modulus *E* and flexural stress σ_e are shown in the figures 8 and 9, respectively. The flexural modulus was computed on the linear portion of the force-deflection curve. The experimental results obtained show us that the effects of the wet environments considered are approximately the same. In general, the decrease of the flexural modulus *E* was about 5 % apart from the case of immersion in water (not coated specimens) when a decrease of 10 % was recorded.

Increase of the flexural modulus (fig. 9) and flexural stress σ_e at the elastic limit, after 60 thermal cycles tells us that E-glass / vinyl-ester Atlac 582 composite were post-cured.

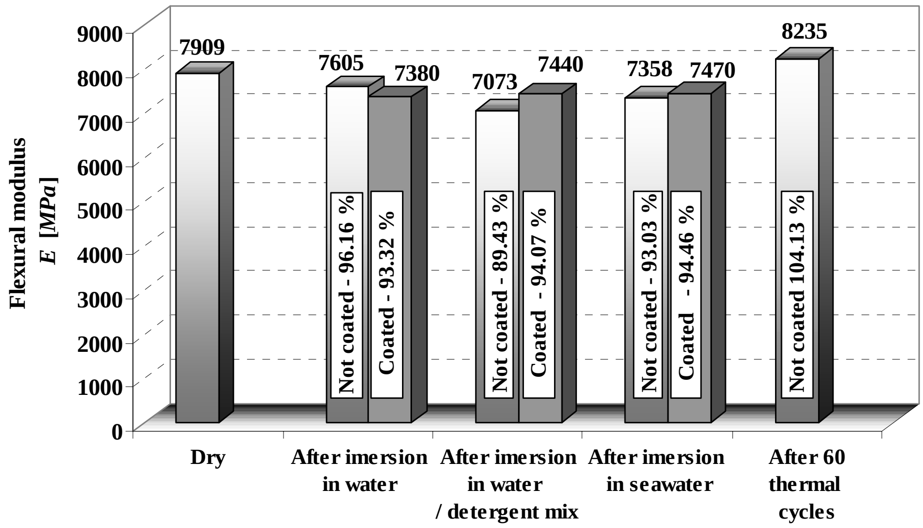

Figure 9. Change of the flexural modulus for the E-glass / vinyl-ester Atlac 582 composite after immersion (for 9200 hours) and after 60 thermal cycles

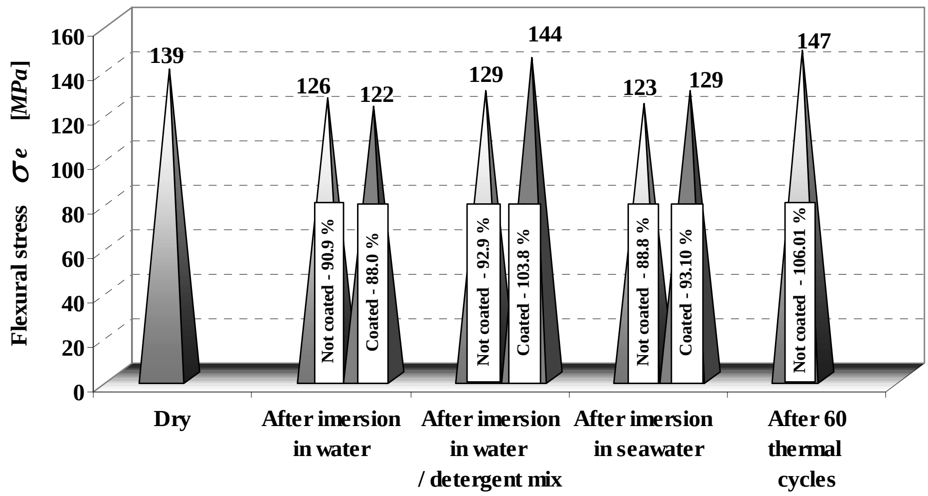

Figure 10. Change of the flexural strength for the E-glass / vinyl-ester Atlac 582 composite after immersion (for 9200 hours) and after 60 thermal cycles

4. CONCLUSIONS AND DISCUSSIONS

Analysis of the results leads us to the conclusion that the effects of the water absorption on the mechanical characteristics of the E-glass / vinyl-ester Atlac 582 composite may not be neglected. Therefore, the stiffness decreases (between 5 % and 10 %) while strength decreases down to 10 % after immersion. From this point of view, it is recommendable to take into account the results of this paper in the design of the structures made of the E-glass / vinyl-ester Atlac 582 composite, which work, in wet environment.

5. REFERENCES

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