RESEARCH REGARDING THE BREAKING STRENGTH AND THE SECTION MACROSCOPIC SHAPE FOR COMPOSITE SANDWICH BARS REINFORCED WITH STEEL WIRE MESH

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Abstract. *In this paper, starting from some samples built from polypropylene honeycomb core (with the thickness of 10, 15 and 20 mm) reinforced with steel wire mesh, I have determined the breaking strength by using the homogenization and Strength of Materials theories. Also, I have presented the macroscopic shape of the transversal breaking section. In the end I have inserted some new formulas, using the regression analysis, to determine the breaking strength depending on the sample thickness.*

Keywords: composite bar, sandwich bar, breaking strength, stress

1. Introduction

In Krysan (1986) [1] there has been studied the behaviour of composite materials in the vicinity of a stress raiser. Using Mellin's transformation, it is proposed a solution for two connected wedges made of different anisotropic materials in the plain strain conditions or the generalized stress plane state. There is analyzed the special feature of the stress state at the boundary of the element from the composite-metal joint. The results obtained on the basis of theoretical investigations were verified for the boron-reinforced aluminum-titanium joint.

In Degtyarev (1972) [2] there is studied the deformation criteria under simple and composite stresses. There is solved the problem of the material limiting state in the composite stress state. Strain criteria of failure for structural steel with alloys have a number of advantages over stress criteria, since, in an experimental study of the material strain property subjected to various stress conditions, a number of fine distinctions were discovered associated with the in homogeneity of the strain process in specimens and with the effects of strain anisotropy.

In Baldan (2004) [3] are examined the factors that affect the mechanical and environmental durability and performance of the adhesively bonded joints in various adherents including metallic alloys, composites, polymers. There are presented two basic mathematical approaches for the analysis of adhesively bonded joints: a closed-form model (solved by analytically means) validated with finite element analysis. The two methods used present similar results. Some studied regarding the mechanical properties for composites reinforced with textile fibers were made in Tărâţă (2000) [4].

Berbinau (2001) [5] has investigated the failure of orthotropic laminates with a filled hole subjected to biaxial compression-tension loading. The considered case simulates a situation where the impact damaged laminate has been repaired by drilling a hole and then plugging the hole with a perfect-fit core made of dissimilar material. The failure strength predictions are compared to the open hole results and experimental data.

Van de Meer (2012) [6] has presented a review for the mesolevel modeling of failure in composites laminates. There are discussed, in the end, the limitations and challenges for mesolevel analysis of composite failure. Other composite researches were made in Burada (2010) [7] and Burada (2011) [8].

2. Experimental determination of the maximum force and displacement

Some composite materials samples with polypropylene honeycomb core have been built. These have been marked in this way:

- set 1: core = 10 mm, width= 40 mm;
- set 2: core = 10 mm, width= 50 mm;
- set 3: core = 15 mm, width= 40 mm;
- set 4: core = 15 mm, width= 50 mm;
- set 5: core = 20 mm, width= 40 mm;
- set 6: core = 20 mm, width= 50 mm.

General views with the samples from the set 1 and 2 are presented in fig. 1 and 2.

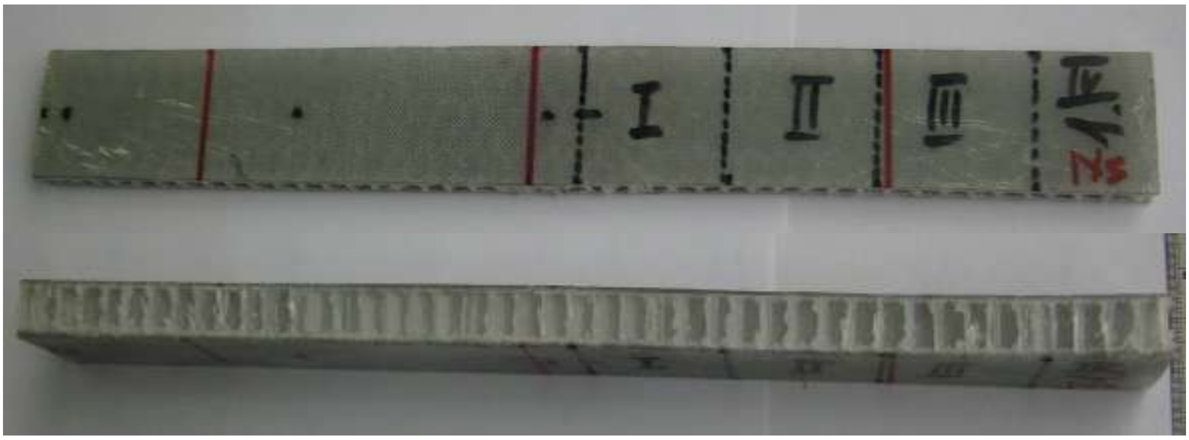

Fig. 1. A general view with the sample 1

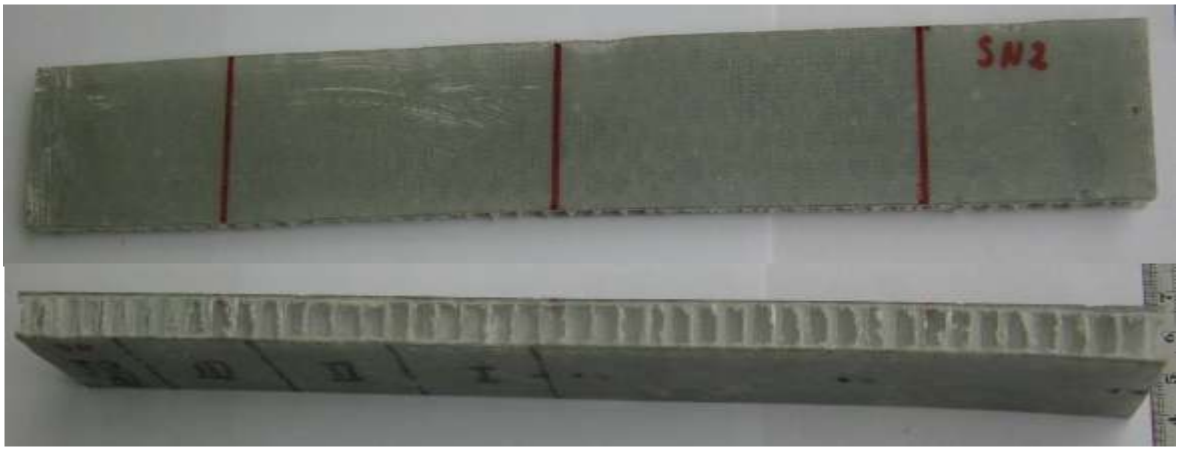

Fig. 2. A general view with the sample 2

The samples have been subjected to three points bending on the Walter Bai testing machine (maximum force is 30 kN). The bending scheme is presented in fig. 3.

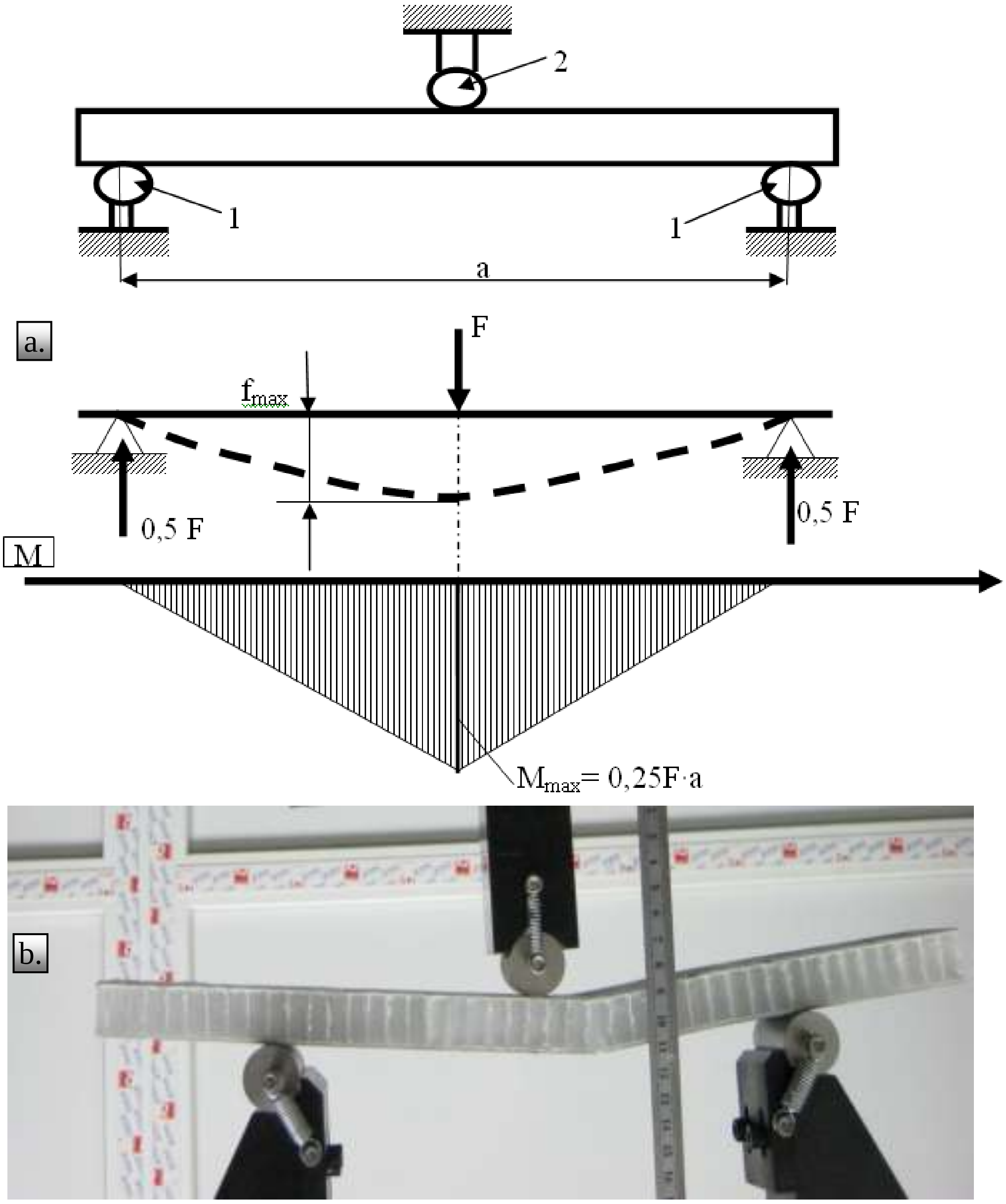

Fig. 3 Bending loading; a. loading scheme; b. the fracture process of the studied samples

The force versus the displacement, for all the samples 1, 2 and 3, is presented in fig. 4, 5, and 6. The maximum forces (with approximations), where there is produced the samples breakage, are:

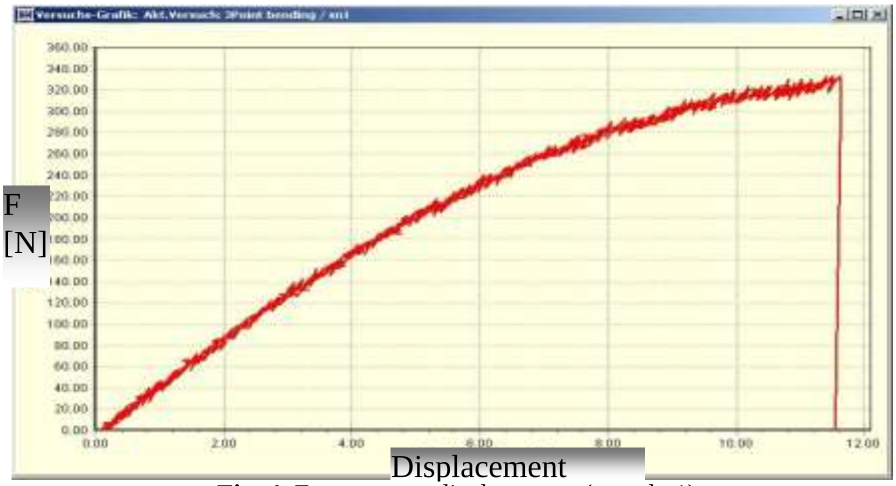

Fig. 4. Force versus displacement (sample 1)

Fig. 5. Force versus displacement (sample 2)

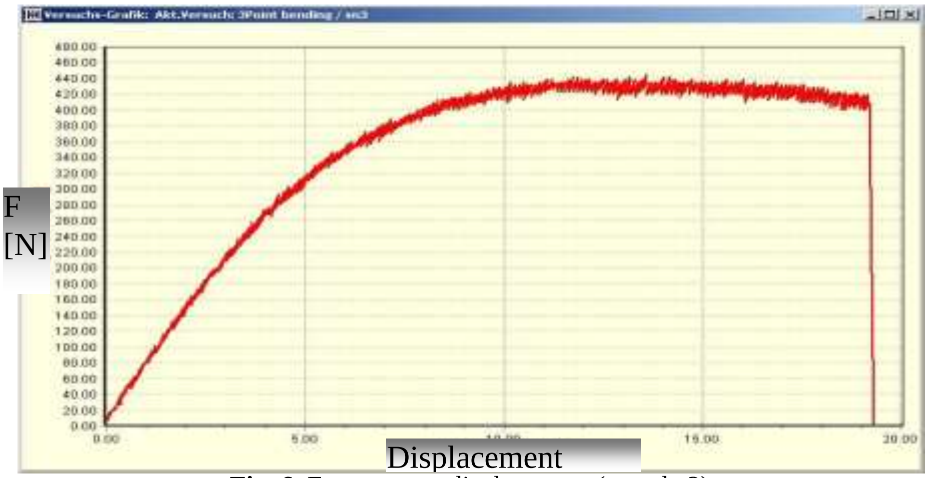

Fig. 6. Force versus displacement (sample 3)

- sample 1: 333 N;
- sample 2: 376 N;
- sample 3: 416 N;
- sample 4: 422 N;
- sample 5: 430 N;
- sample 6: 448 N.

3. Breaking strength calculus

In order to rapidly obtain the breaking strength, by using the homogenization theory, I will use the formula (1).

$$\sigma_r = M_{max} \cdot W_y^{-1} = 0{,}25 \cdot F_{max} \cdot a \cdot W_y^{-1} \quad (1)$$

In (1) I have marked with W_y the axial strength modulus which is determined with the classical formula from Strength of Materials, corresponding to a rectangular area. The results are:

- sample 1: 29,97 MPa;
- sample 2: 27,072 MPa;
- sample 3: 16,64 MPa;
- sample 4: 13,504 MPa;
- sample 5: 9,675 MPa;
- sample 6: 8,064 MPa.

Using the regression analysis, I have determined direct calculus formulas for the breaking strength, which depend on the bars thickness. So, if the bars have a width of 40 mm I recommend the formula (2), and for the width equal to 50 mm, formula (3). The correlation factor R^2 for the formula 2 is 0,999 and for the formula (3) is 0,9927.

$$\sigma_r (g) = 52{,}3439045626 \cdot e^{-0{,}5653258212 \cdot g} \quad (2)$$

$$\sigma_r (g) = 48{,}1372103971 \cdot e^{-0{,}6055451360 \cdot g} \quad (3)$$

4. Macroscopic aspect of the section failure

The macroscopic aspects of the section failure are presented in fig. 7 (samples 1, 2, 3, 4) and fig. 8 (samples 5 and 6).

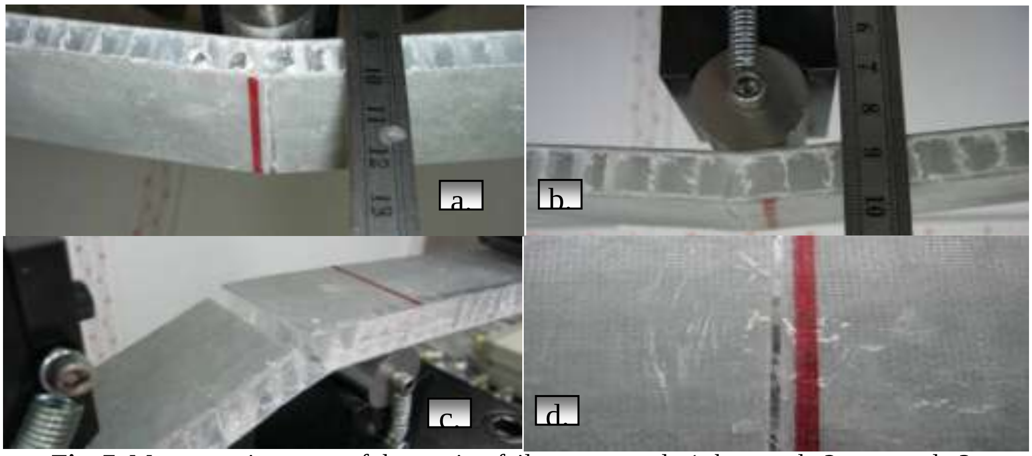

Fig. 7. Macroscopic aspect of the section failure; a. sample 1; b. sample 2; c. sample 3; d. sample 4

We can see that the fracture has been produced starting from the lower side of the composite bar, the face which is opposed to the acting roller.

5. Conclusions

In this paper I have built some new original composite sandwich bars with the core made of polypropylene honeycomb and the exterior layers reinforced with steel wire mesh. Then, for each bar, I have experimentally determined the maximum force, displacement, the characteristic curve of the material which was used to build the bars, the breaking stress.

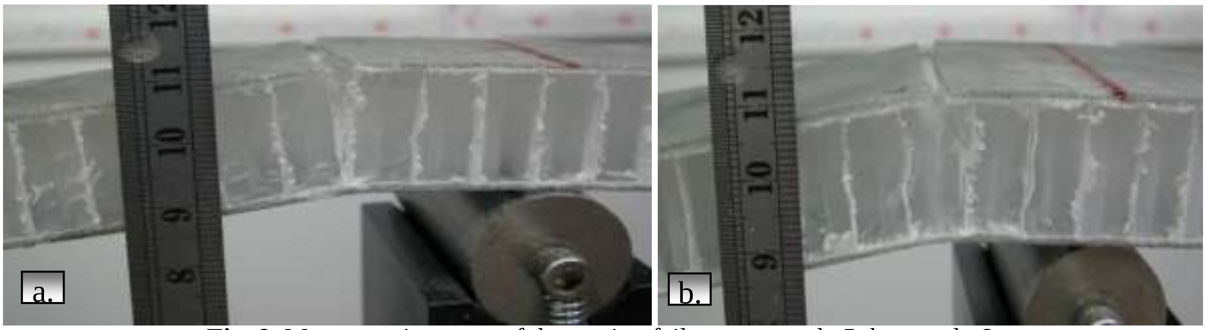

Fig. 8. Macroscopic aspect of the section failure; a. sample 5; b. sample 6.

The added value of this paper is:

- building some new original composite bars made of classical materials but combined in an original way;
- determining the dependence between the force and the displacement;
- determining the force-displacement curve of the material used to make the bars;
- determining the breaking strength;
- determining some calculus relation for the breaking strength depending on the bar thickness.

This type of bars can be used for: ship floor building, plane floor building, the frames for concrete forming, making parts of car and bus bodies and so on.

4. Acknowledgement

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