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RESEARCH REGARDING THE IMPACT BEHAVIOR OF SANDWICH STRUCTURE WITH ORGANIC FIBROCEMENT

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Abstract: *Research on the design and manufacture of new materials, for different products, aim to produce them at a price as low cost, quality and higher reliability. Using new materials is a priority for both manufacturers and users. Depending on the characteristics of materials, they have a wide use in various areas such as: machine building, aviation, aeronautics, construction and civil engineering, etc. The objective of this paper is to analysis the impact behavior of sandwich structures with organic fibrocement for building industry.*

Key words: *sandwich structure, organic fibrocement, impact.*

1. INTRODUCTION

In the current period, due to technological progress, there is a growing demand for new products or improving existing ones.

This led to the emergence of new enterprises, it is necessary to constructed buildings and halls.

Because of the above, research in civil engineering and industrial, has been directed to find new materials, to be as strong and at a price as low cost [8].

The paper deals with the impact tests of a hybrid sandwich material used in construction and civil engineering. For comparison, research impact were made and a structure that is used routinely in civil and industrial buildings.

Material proposed for analysis (Fig. 1) is a hybrid sandwich structure (2ABS-G) composed of two plates organic fibrocement and a polyurethane core**.**

2. DATA ON MATERIAL USED TEST

Hybrid sandwich structure used in civil and industrial, 2ABS-B, is composed by:

- 2 plates (sides) with organic fibrocement, having the following characteristics (Table 1).
- polyurethane core (characteristics are shown in Table 2).

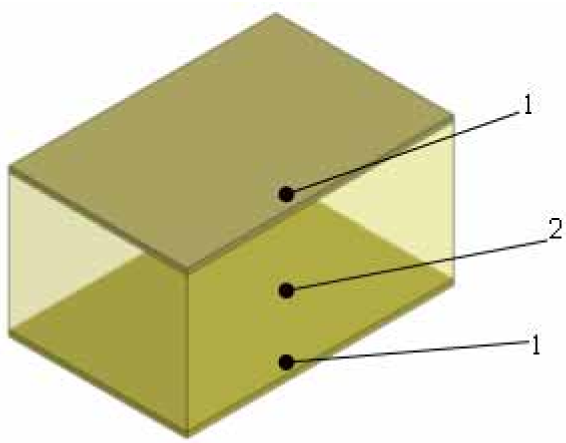

Fig. 1. Hybrid sandwich structure:
1 – plate with organic fibrociment; 2 – polyurethane.

Table 1

Plates characteristics

Plate dimensions, [mm]	Thickness, [mm]	Density, [kg/m^3]	Bending strength, [N/mm^2]	Bending moment, [Mpa]	Impermeability
2600 × 1200	5 ÷ 20	min 1300	– 15.0	min 13	good

Table 2

Core characteristics

Stuff cod	Weight, [g/l]	Density, [kg/m^3]	Viscosity to 20^0 C, [mPa.s]	Compression resistance, [N/mm^2]	Thermal conductivity, [W/m.K]
PX592/40-S	1200	38 ÷ 45	± 500	> 200	< 0.023

Specimens used to research the impact of hybrid structures have dimensions**:** L = 150 mm, l = 100 mm; g = 85 mm.

3. MECHANICS OF SANDWICH STRUCTURES TYPE PLAQUE

The knowledges on sandwich structure working modes is not yet sufficiently widespread and in some cases the mechanics of these modes is analytically describable only through approximate formulas.

When a sandwich structure is subjected to a shearing force, it undergoes a deflection due to this force. The deflection depends, through shear rigidity, on the following parameters: core shear modulus, core thickness.

In order to reduce the deflection, one can: select a high shear modulus material for the core; utilize a high thickness for the core [7]. The Young's modulus and thickness of the facings do not significantly influence the deflection [2].

The shearing force loads the core, yielding uniformly distributed shear stresses. If the shear stress exceeds the shear strength of the core material, the latter fails determining the collapse of the structure. The increase of facing thickness does not influence the shear stress in the core.

The shear rigidity of a sandwich depends on core thickness and shear modulus [3].

Let us consider the case of a sandwich beam structure with equal facing, simply supported and carrying central concentrated load. The calculation formulas for stress and deflection are the following [3]:

- The maximum direct stress in the facings:

$$\sigma_F = \frac{F \cdot l}{4w \cdot t_C \cdot t_F} \text{ [N/mm}^2\text{]}. \tag{1}$$

- The maximum shear stress in the core:

$$\tau_C = \frac{F}{2w \cdot t_C} \text{ [N/mm}^2\text{]}. \tag{2}$$

- The flexural component of maximum deflection:

$$f_f = \frac{F \cdot l^3}{48EI} \text{ [mm]}. \tag{3}$$

- The shear component of maximum deflection:

$$f_s = \frac{F \cdot l}{4w \cdot G_C \cdot t_C} \text{ [mm]}. \tag{4}$$

- The maximum deflection:

$$f_{max} = f_f + f_s \text{ [mm]}. \tag{5}$$

In formulas (1)–(5) we have:
F – applied load [N];
l – sandwich length [mm];
w – sandwich width [mm];
t_F – facing thickness [mm];
EI – sandwich flexural rigidity [N/mm^2];
G_C – core shear modulus [N/mm^2].

Moreover:

$$t_C = t_{C*} + \frac{t_{F1} + t_{F2}}{2} \text{ [mm]}, \tag{6}$$

where:
t_C – distance between facing centroids [mm];
t_{C*} – core thickness [mm];
$t_{F1,\,F2}$ – thickness of facing 1, 2 [mm].

The following formula allows for the calculation of the flexural rigidity of a sandwich with facings of different Young's modulus and different thickness [3]:

$$EI = w \cdot E_{F1} \cdot E_{F2} \frac{t_{F1} \cdot t_{F2} \cdot t_C^2}{E_{F1} \cdot t_{F1} + E_{F2} \cdot t_{F2}} \text{ [N mm}^2\text{]}, \tag{7}$$

where:
$E_{F1,\,F2}$ – Young's modulus of facing 1, 2 [N/mm^2];
w – sandwich width [mm].

If the sandwich has the facings of equal elastic modulus, but different thickness, the formula (7) becomes [6]:

$$EI = w \cdot E_F \frac{t_{F1} \cdot t_{F2} \cdot t_C^2}{t_{F1} + t_{F2}} \text{ [N mm}^2\text{]}, \tag{8}$$

where E_F is the Young's modulus of the facing [N/mm^2].

If the sandwich has the facings of equal elastic modulus and equal thickness, the formula (7) becomes:

$$EI = w \cdot E_F \cdot t_F \frac{t_C^2}{2} \text{ [N mm}^2\text{]}, \tag{9}$$

where t_F is the facing thickness [mm].

4. THE EQUIPEMENT USED TO RESEARCH

The tests were conducted in Laboratory for Tests Polymeric Composite Products (LIPCP) (Fig. 2).

The laboratory is accredited RENAR with nr. LI 729/24 nov.2009.

To conduct the research were used the following equipment:

- Machine INSTRON test impact, type "Dynatup Drop Weight Impact Test Machine", model 8200,with the following characteristics: dimensions: L = 457 mm; l = 406 mm; H = 1714 mm, minimum weight impact: 3.94 kg, maximum weight of impact: 13.6 kg, weights attached: 1.06 kg, height of maximum impact: 1000 mm, maximum speed impact: 4.4 m/s, the energy of impact: 1.356 J ÷ 132.8 J;

Fig. 2. Laboratory LIPCP.

Table3

The results obtained after impact (2ABS-G)

Nr. specimen	Characteristics					Results	
	m [kg]	*H* [mm]	*v* [m/s]	*E* [kg m]	*W* [J]	Impact type	Obs.
1	3.94	100	1.4148	0.2573	4.0539	mark of impact to ≈ 36 % from outside thickness the plate	
2		150	1.7295	0.5651	5.5401	mark of impact to ≈ 65 % from outside thickness the plate, with occurrence of cracks on the bottom	
3		200	1.9495	0.7280	7.1372	mark of impact to ≈ 73 % from outside thickness the plate, with occurrence of cracks the bottom	
4		250	2.2007	0.9407	9.2225	mark of impact to ≈ 89 % from thickness, with occurrence of crack the bottom	
5		275	2.4052	1.1049	10.8323	mark of impact with detach material from outside thickness the plate	maximum permissible impact
6		300	2.4638	1.1894	11.6607	mark of impact with detach material from outside thickness the plate	
7		325	2.5402	1.2020	11.7843	mark of impact with detach material from outside thickness the plate	
8		350	2.6169	1.3001	12.7460	mark of impact with detach material from outside thickness the plate	
9		375	2.7264	1.5431	15.1284	overall penetration of the plate	
10		400	2.7832	1.6167	15.8500	overall penetration of the plate	

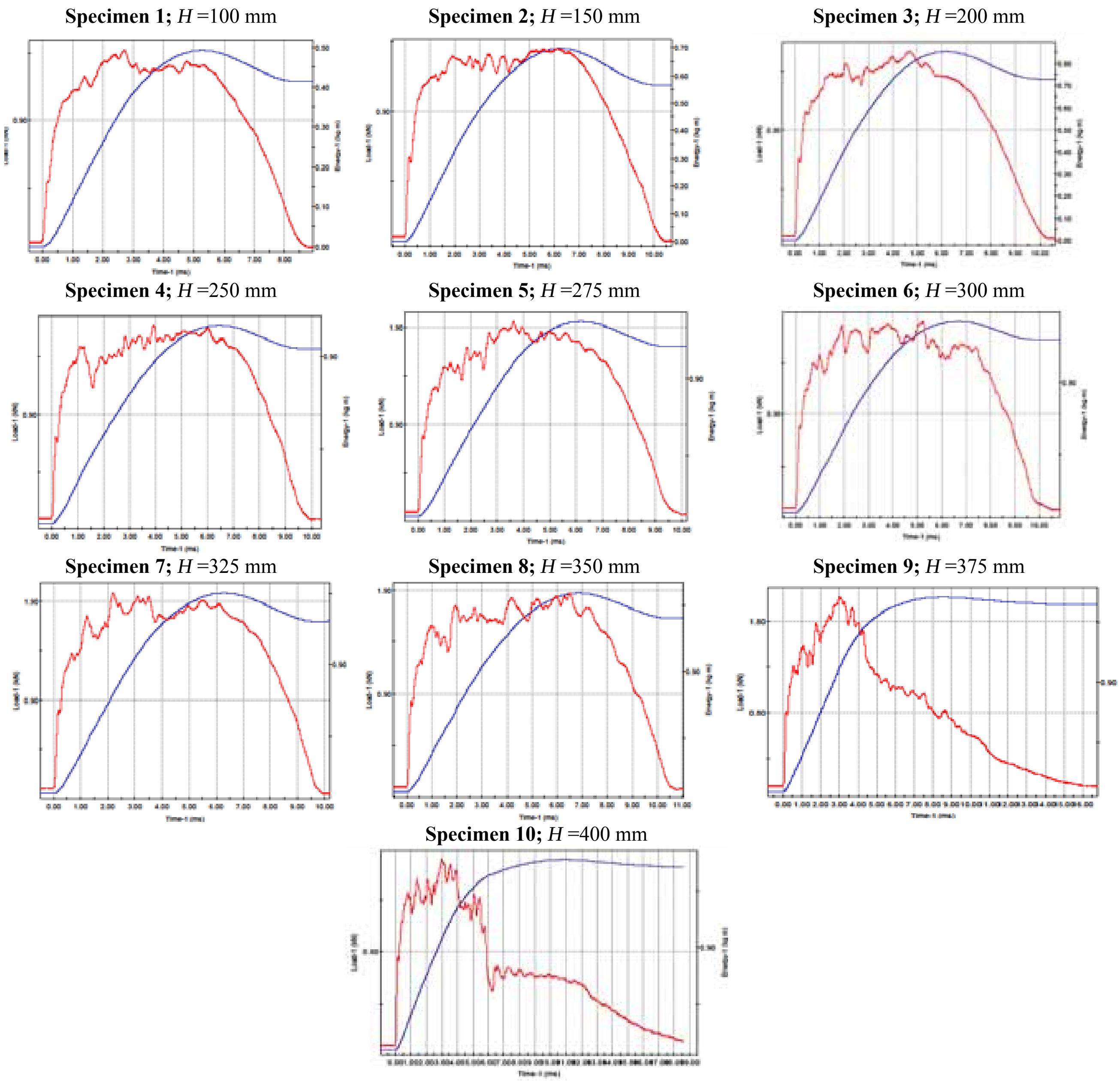

Fig. 3. Diagrams obtained after impact.

a (H =100 mm, H =150 mm)

b (H =200 mm; H =250 mm)

c (H = 275 mm)

d (H = 300 mm)

e (H = 325 mm)

f (H = 350 mm)

g (H = 375 mm)

h (H = 400 mm)

Fig. 4. Photographs of specimen after impact.

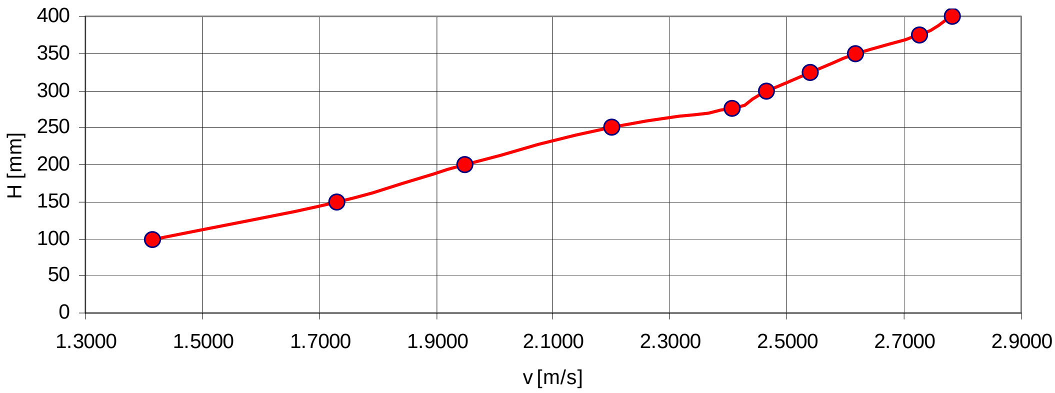

Fig. 5. Chart speed depending on the height of impact.

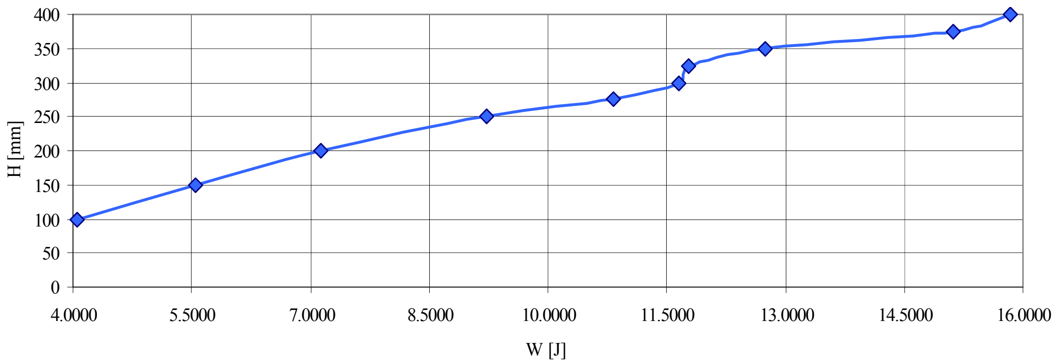

Fig. 6. Chart speed depending on the height of impact.

- Specialized Software: INSTRON;
- Computer, monitor;
- Bolt semi sphere: ∅20 mm, ASTM D2444;
- Digital-type calipers Taschers-Messschieber DIN 862, *L* =200 mm, 1 div. = 0.01mm;
- Device for orienting specimens.
- SANTO Professional ruler, Type AL – 1000, having *L* = 1000 mm, 1 div. = 1 mm.

5. RESEARCHES OF THE IMPACT SANDWICH HYBRID MATERIALS

Table 3 presents the results obtained after impact, and in Fig. 3, diagrams related to material 2ABS-G, where: *m* – mass used for impact; *H* – impact height; *v* – speed of impact; *E* – *m* (value given by the software equipment) – total energy consumed to break the shock of the specimen, in Kg m, (energy value is included gravitational acceleration); *W* – total energy consumed to break the shock of the specimen, in J.

Figure 4 shows the photographis of samples after impact. Height charts depending on the speed and impact energy are presented in Figs. 5 and 6. The *E* (energy) is the total energy consumed to break the shock of the specimen, in Kg m, (the energy value is included and gravitational acceleration) (1J = 0.102 Kg·m), and *F* (load) represents the impact force developed in kN.

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6. CONCLUSIONS

The sandwich structure with organic fibrocement is prefabricated structure and is used for the other insulation. The structure is composed to a block of polyurethane core covered with plate of fibrocement [1].

Due to the high degree of thermal isolation for isolating the structure with organic fibrocement with organic fibrocement are non-bearing walls and bearing in civil, commercial and industrial buildings to residential status, etc.

Also the structure with organic fibrocement gives a high sound insulation. The advantage of the structure with organic fibrocement is that the present low thermal conductivity by 65% compared to polystyrene [4].

Polyurethane core is also more resistant against water, even salt water and parasites. Since the sandwich structure with organic fibrocement are made by stamping polyurethane core is completely waterproof with a closed cell structure. The unique configuration of sandwich structure with organic fibrocement with two stiff face sheets and a polyurethane core provides high energy absorption capability suitable for collision protection application.

The final selection of the polyurethane core is a compromise between cost and technical limits: the weigh; the impact resistance; fatigue; moisture.

The experimental researches were accomplished in temperature and humidity conditions, in accordance with the standards in force.

The results of the experimental researches emphasize the following conclusion concerning the type break of the samples, depending on the impact height:

- H = 100 mm ÷ 250 mm $\rightarrow$ observed a change in the thickness of the evidence, the emergence of the cracks on the bottom plate;
- H = 275 mm ÷ 300 mm $\rightarrow$ detachment is observed in the plate material
- H = 375 mm and 400 mm $\rightarrow$ observed a total penetration outer the plate.

If the analyzed material is used in construction and civil engineering then *the fissure of the base plaque is the maximum acceptable break type*.

The minimum experimental conditions according to *the fissure of the base plaque are the following*: m = 3.94 kg; H = 200 mm; v = 2.0195 m/s; W = 9.6990 J.

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