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Experimental characterization of behavior of a composite panel plate

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Abstract. This study focused on the buckling behavior of an organic source concrete panel reinforced by polymer materials. The concrete was made of a mortar matrix, reinforced with natural reinforcement such as wood sawdust. These panels are reinforced on the faces by a polypropylene fabric and a polymer plate. This technique allows us to give some strength to the panel, to avoid the crumbling of the panel during handling, transport and installation, and to give a finish to the External facing of the wall constituted by the assembly of the various panels. The results are very encouraging and highlight the value of the proposed design of an organic-source mortar panels which have a specific mechanical properties acceptable for their use, low densities, lower cost of manufacture and labor, and above all a positive impact on the environment.

Keywords: Design, Characterization, Multilayer, Buckling, Analysis.

1 Introduction

Technological advances in most industrial areas have made it possible to develop materials with exceptional properties for the different applications for which they are intended. Currently, environmental, aesthetic and sustainability requirements are desired and desired criteria. The materials must be efficient, economical, biodegradable and recyclable with easy and energy-saving methods. In civil engineering, the development of modern technologies requires the use of construction materials with high mechanical properties which are specific to their use, low densities, lower cost of manufacture and labor, and above all an impact Positive on the environment. This progress, which aims to improve the performance/mass ratio, has led to the development of new generations of composite structures and materials. The use of plant fibers in construction is not new in the literature, several examples of materials using natural fibers and different binders are presented [1–4]. In general, agro-sourced materials are available at low cost, renewable and recyclable since they are generally derived from local agricultural activity. Experimental characterization efforts to better show the energy performance of buildings using plant fiber insulation [5–6] or numerical simulation to take into account water transfer and their influence on heat transfer have been performed [7–8]. The incorporation of the plant fibers in the

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concrete thus improves the tensile strength, the ductility or the post-fracture behavior of the prepared concrete. The vegetable aggregates used as fillers in the concrete modify the properties of the concretes, in particular the density, the porosity, but especially the thermal properties.

Our work constitutes a contribution to the experimental analysis under loading of buckling of a panel of organic source mortar, consisting of a core based on a mortar matrix lightened by a mass fraction of wood sawdust. The lower and upper flanges are respectively reinforced with a polypropylene fabric and a polymer plate bonded with an epoxy resin. The proposed panel, which has both reduced weight and acceptable strength, is intended for insulation applications in civil engineering structures with the aim of improving the thermal, acoustic and sound properties of the structure by very interesting properties: low density, high dimensional compressibility, good thermal, acoustic and vibratory insulation, chemical stability and durability of sawdust. The faces are reinforced with a polypropylene fabric and a polymer plate to give a certain resistance to the panel and to avoid the crumbling of the panel during the handling, transport and installation, and to give a finish to the facing of the wall constituted by the assembly of the various panels.

In this paper, we present the mechanical resistance performances given by the various tests. Compared to similar mortar structures only (reference panel), the proposed panel exhibits better breaking strength and a very light weight. The ease of making and of making the panels suggests a certain speed in the construction of the walls with finished facing constituted from the assembly of the panels.

2 Experimental

2.1 Materials used

The prismatic specimens were manufactured according to Eurocode 2. A Portland cement CIMPOR CEM II/A-L 42.5R, sand pit, tap mixing water and a superplasticizer are mixed in a conventional rotary mixer of 60 L to obtain a mortar. Three ranges of wood sawdust from proximity woodworking were made from particle size analysis. G_1: 8 -12.5 sieve; G_2: Sieves 3.15-6.3; And G_3 Sieve: 0.125 -1.25.

Preliminary bending tests were carried out by considering different mass fractions of the components given in Table 1 to optimize the appropriate formulation of the organic source mortar. The variant will be used in the manufacture of organic source mortar panels reinforced with a polypropylene fabric and a polymer plate generally intended for industrial applications of insulation for the making of partitions and ceilings. The various components of organic source mortar panels and the physical aspect are illustrated respectively in Fig 1 and Fig 2. The physical properties of the various ranges of wood sawdust are summarized in Table 2.

Table 1 Quantities used per test specimen.

Material	Range	%	Mass (g)	%	Mass (g)
Wood Sawdust	G_1	40	56	50	70
	G_2				
	G_3				
Mortar	Cement	60	68	50	57
	Sand		237		198
	Water		35		29

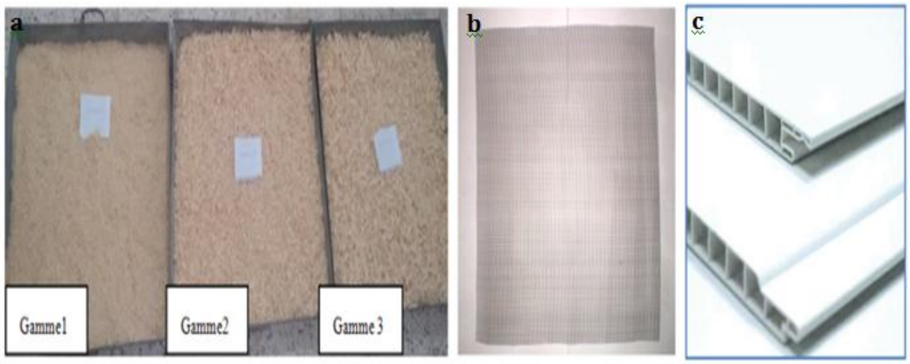

Fig. 1 The components of the proposed multi-layer panel

a) Different ranges of sawdust, b) Polypropylene fabric, c) Polymer plate.

Table 2 Physical properties of various range of sawdust.

Sawdust	**Characteristics**			
Range	ρ (kg/m^3)	ρabs (kg/m^3)	Compacity C(%)	Porosity P(%)
G_1	41,08		8.22	91,78
G_2	54,17	500	10.83	89,17
G_3	102,5		20.5	79,5

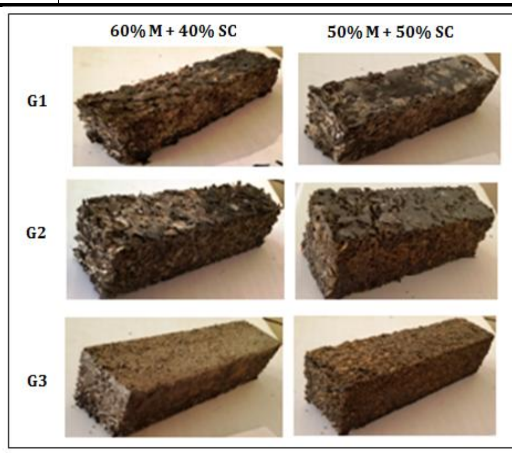

Fig. 2 The Prismatic specimens of wood sawdust reinforced mortar of different ranges.

2.2 Mechanical testing and results

Compression and flexural tensile tests on prismatic specimens based on organic source mortar are made using an IBERTEST branded machine. The machine is equipped with a maximum force cell of 200 KN. And of software of command and treatment of the results (wintest), which allows having the diagrams force-displacement and force-time, the histograms, with a good precision. The tests are carried out at an ambient temperature of approximately 20°C. The machine is driven at a constant traverse speed of 10 mm/min, ie 0.1KN/s. Fig. 3 illustrates the various force-displacement curves in compression and flexural traction of the best variant study composed of 60% M + 40% SC Type G_3 validated by the physical aspect illustrated in Fig. 2 and especially the mechanical resistances.

Table 3. Mechanical parameters of the specimen constituted by 60%M+40% SC- G_3.

Denotation	Symbol	Value
Compressive stress corresponding to the peak.	f_{mc} (Mpa)	3,86
Elastic compression stress.	$f_{mc\ elas}$ (Mpa)	2,51
Deformation corresponding to the peak in compression.	ε_{mc}	0,0082
Ultimate tensile force.	F_{mt} (N)	582
Displacement corresponding to ultimate tensile stress.	U_{mt} (mm)	1,1
Young's Modulus.	E_m (Mpa)	429
Poisson' ratio.	ν_m	0,29

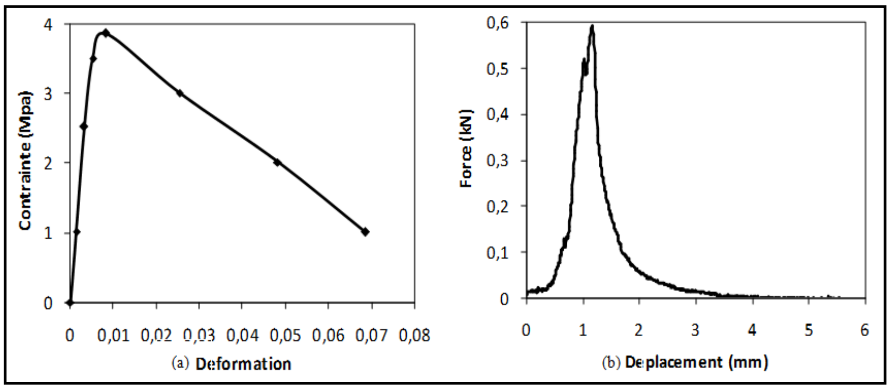

Fig. 3 Stress-strain curves of core materials: a) Compression behavior; b) Tensile behavior.

Standard specimens, according to NF EN ISO 527-1, were made from polypropylene fabric and polymer plate. These test pieces were tested in longitudinal and transverse tension for the made-up test piece of the polymer plate Fig. 4.

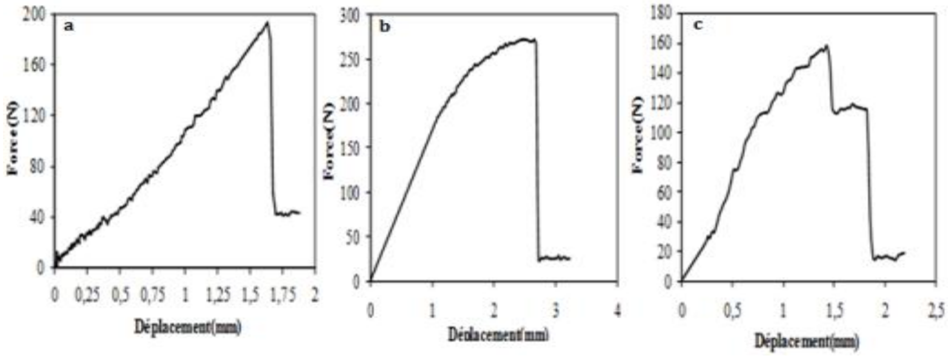

Fig. 4 Tensile behavior of reinforcement components

a)Tissue; b)Plate/longitudinal direction; c) plate/transverse direction.

Table 4 Mechanical properties of the polypropylene fabric used.

Denotation	Symbol	Value
Tensile strength of the polypropylene fabric.	F_{max} (N)	190
Displacement corresponding to tensile failure.	U_{max} (mm)	3,56
Displacement corresponding to the elastic limit.	U_{elas} (mm)	1.71
Tensile rupture stress of polypropylene fabric.	σ (Mpa)	19,3
Deformation corresponding to the tensile elastic limit of the fabric.	ε_{elas}	0,017
Young Modulus of polypropylene fabric.	E (Mpa)	1930
Poisson's ratio of the polypropylene fabric.	ν	0,31

The reinforced polymer have an elastic behavior in both main directions (longitudinal and transverse), it comprises, from an elastic point of view as an orthotropic material, its behavior will be described in the hypothesis of plane stresses, since its thickness is negligible In front of its main directions. The polymer is characterized by a longitudinal tensile stress in the order of 271 MPa and a transverse rupture stress in the order of 155 MPa with a corresponding moderate deformation as are depicted in table 5.

Table 5 Mechanical properties of reinforced polymer plate used.

Denotation	Symbol	Value
Rupture tensile strength in the longitudinal direction.	F_{1max} (N)	270
Rupture tensile strength in the transverse direction.	F_{2max} (N)	160
Tensile displacement in tension in the longitudinal direction.	U_{1max} (mm)	4.48
Tensile displacement in tension in the transverse direction.	U_{2max} (mm)	2,51
Displacement corresponding to the elastic limit in the longitudinal direction.	U_{1elas} (mm)	2,92
Displacement corresponding to the elastic limit in the transverse direction.	U_{2elas} (mm)	1,15

3 Reinforced organic source mortar panels

3.1 Types of panels used

All panels were produced with the variant 60% M + 40% SC Type G_3, according to standard (NF P 74-203/DTU 59-3). The composition for making a panel is given in Table 6. Several study variants are considered:

- MSC-symmetrical panels, both sides are reinforced by the fabric, designated: MS-TT,
- MSC-symmetrical panels, both sides are reinforced by polymer plates, designated MS-PP;
- MSC-asymmetric panels, one side reinforced by a fabric and the other face by the polymer plate.

Table 6 Quantities of the components of specimen constituted by 60%M+40%SC-G_3.

Material		Percentage fraction %	Mass (g)
Wood sawdust	G_3	40	855.36
Mortar	Cement	60	1026.43
	Sand		3500
	Water		864

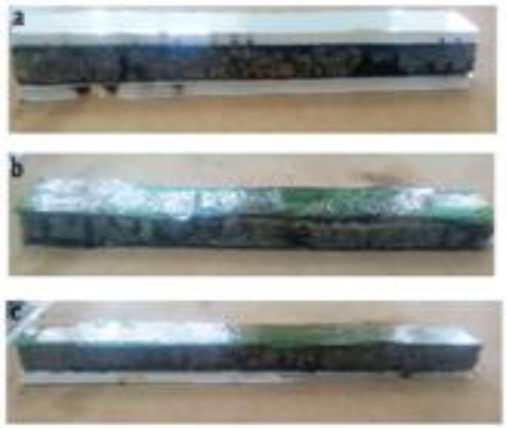

Fig. 5 Types of panels and prismatic specimens for buckling test considered: a) M-SC-PP, b) M-SC-TT, c) M-SC-TP.

3.2 *Buckling of reinforced panels*

The mechanical behavior of organic source mortar panels with a standard size of 450x23x50 mm subjected to buckling stresses according to NF T 54-604 is studied. The loading is applied in compression in the longitudinal direction of the panels PP, TT and PT. The specimens are tested using the IBERTEST machine. Fig.6 illustrates the force-displacement curves of the buckling-loaded organic source mortar panels (PP, TT and PT).

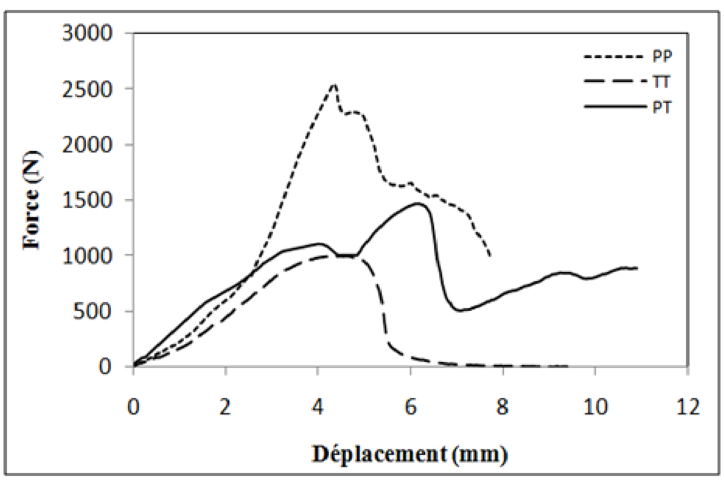

Fig. 6 Force-displacement curves of the panels (MS-PP, MS-TT and MS-PT) under buckling load.

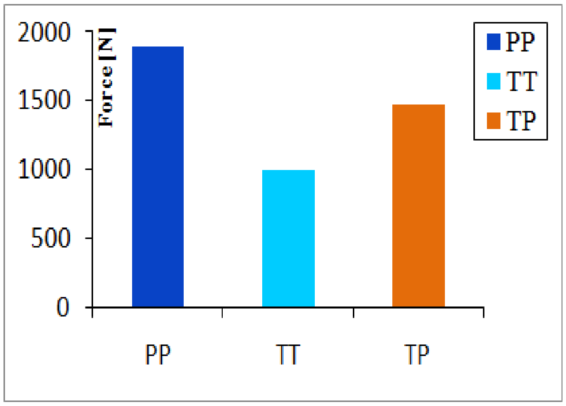

Fig. 7 Histogram of maximum strengths of different panels.

The curves show a first phase which shows a linear increase in the applied load, corresponding to small deformations, followed by a non-linear phase until the maximum load is reached and then a decrease in the applied load is observed, this corresponds to the initiation and vertical propagation of cracks in the panels. Attainment of the peak defines the maximum strength that characterizes the ultimate strength of the buckling panels. Cracks propagate until the rupture of the panel. The bearing capacities of the symmetrical panels MS-TT and MS-PP loaded in buckling are respectively of the order of 993 N and 2516 N with a corresponding axial displacement of 4 mm. The asymmetric organic source mortar panels MS-TP have an ultimate load of the order of 1472 N and a displacement at rupture of the order of 6 mm.

3.2 Buckling of reinforced panels

The rupture mode of the MS-PT asymmetric organic source mortar panels is similar to that of symmetrical organic source mortar panels, characterized by the crack initiation at the ends of the MS-PT panels. Densification of the cracks is observed at the edges of the panels, generating thereafter, the rupture of the element. The different modes of rupture of the different panels are illustrated in Fig. 8.

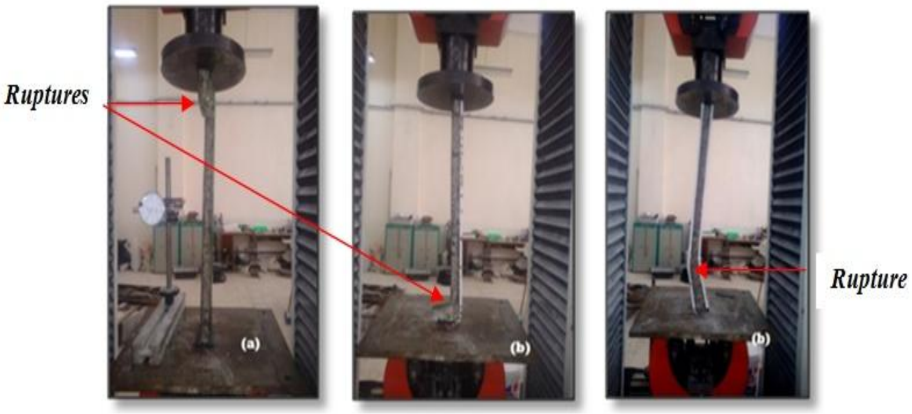

Fig. 8 Modes of rupture under buckling load: a) TT panel, b) PT panel, c) PP panel.

In the case of symmetrical panels MS-TT, rupture occurred, by shear effort, the rupture is localized at the extremity levels. In the case of symmetrical panels MS-PP, the rupture occurs at the level of the mortar core of the composite, the first crack of which appears in the skin when the maximum load is reached and propagates parallel to the two soles in reinforced polymer to the end of the test specimen.

4 Conclusion

The results allow us to formulate these conclusions:

- The proposed panels are lightweight compared to the reference panels, with ultimate resistances very acceptable for the envisaged destination;
- M-SC-PP and M-SC-TP have better mechanical characteristics compared to M-SC-PP panels; this can be explained by the thickness of the plate which provides the panel with a certain dimensional stability and better rigidity;
- Composite panels produced have both a low cost of production and a favorable ecological impact;
- The reinforcement of the panel by the fabric and the plate makes it possible to avoid the crumbling of the panel during handling, transport and installation and to give a finish to the external facing of the wall constituted by the assembly of the various panels.

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