AWeS0Me

Agricultural WastE as Sustainable 0 km building MatErial

DELIVERABLE D.T2.4.2

AGRO-WASTE BASED PANELS

Project number: ITALME-419

Work package: T2 Pilot action

Partner responsible for the deliverable: Politecnico di Bari

Dissemination level: PU - Public

Activity A.T2.4. Involving communities and farmers in public events to demonstrate self-building potentials, and explain environmental advantages of proposed technologies. This activity will be mostly developed in Molise with the supervision of PP2.

Deliverable D.T2.4.2. A sustainable tipology of building component will be obtained by mixing agro-waste with natural binder.

Status: Final

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1. Introduction

Different agro-waste may result in different physical properties when they are used as aggregates or filling elements. Even more important may be the role of binders which sometimes, especially when they fill all the open spaces between the waste, they may compromise thermal insulating properties. To this purpose, several laboratory tests were conducted and results are presented below to provide a solid background to the development of agro-waste base panels in practice.

2. Laboratory tests

In order to assess the thermal performances of the materials made with agro-waste, different samples were created in laboratory at Politecnico di Bari.
Considering the suitability of the bio-based fibers to be used by self-building techniques it was supposed to use various by-products to assess three different building methods:
1: loose filling in wooden formworks: pruning olive waste, almond skin fibers (used with different thickness)
2: panels: almond skin with Arabic gum, olive pruning waste with lime
3: multilayer panel: two internal and external layers of plywood (thickness 0,4 cm) and a filling of straw fibers (thickness 8 cm)
The measurement of the dry-state thermal conductivity λ ($W \cdot m^{-1} \cdot K^{-1}$), the thermal diffusivity α ($10^{-6}\ m^2 \cdot s^{-1}$), and the volumetric heat capacity ρc (106 $J \cdot m^{-3} \cdot K^{-1}$) were performed by an ISOMET 2104 (Applied Precision Ltd, Bratislava, Slovakia), a transient plane source device (Figure 1). Before recording the measurements, the specimens and the fibers were dried in a hot-air oven at 50 ◦C. Then, all the specimens were stabilized at 23 ◦C in desiccators containing silica gel.

Fig.1 ISOMET – Thermal conductivity measurements

The measurement of steady state thermal transmittance U (W/m^2K) was performed by a hot box, an experimental apparatus designed and build at Building Physic Laboratory of Politecnico di Bari for the evaluation of thermal conductivity of building materials. No reference standards are available for this specific system. The experimental setup is composed of one box with the external dimension of 30x30x40 cm. The walls of the hot box are built in polystyrene in order to limit the heat loss. In order to assess the thermal flux exchanges between indoor and outdoor environments there was created a thermal temperature gradient inserting a hot source inside the box.

The total thermal transmittance is defined of a building element (U-value) is defined in ISO 7345 as the "Heat flow rate in the steady state divided by area and by the temperature difference between the surroundings on each side of a system". A steady-state condition of a system or process is the condition that does not change in time; broadly it is a condition that changes only negligibly over a specified time. However, steady-state conditions are never achieved on a site in practice.

The U-value can be obtained by measuring the heat flow rate through an element with a heat flow meter, together with monitoring the temperatures on both sides of the element under steady state conditions.
Heat flow meter is a thin, thermally resistive plate with temperature sensors arranged in such way that the electrical signal given by the sensors is directly related to the heat flow through the plate.

Thus, the thermal transmittance of the specimen was calculated as follows:

$$U = \phi/(Ti\text{-}Te)$$

Considering the total thermal transmittance of the walls it was derived the thermal conductivity of the panel indirectly by means of the following equation:

$$U = \frac{1}{Rsi + \frac{s_1}{\lambda_1} + Rse} \mathrm{W \cdot m^{-2} \cdot K^{-1}}$$

where R_{Si} and R_{se} are the internal and external surface thermal resistance ($m^2 \cdot K \cdot W^{-1}$), s_1 is the thickness of the plywood panel (m); λ_1 is the thermal conductivity of the panel.

SPECIMEN		THERMAL MEASUREMENTS			
		λ [W/mK]	cp [J/m^{3}K]	α [10^{-6}m^2/s]	Tm [°C]
	Olive three pruning waste filling	0,0755	0,184	0,409	21,73
	Olive three pruning waste filling	0,077	0,437	0,176	21,84
	Multilayer panel with plywood and straw	0,033	-	-	-
	Almond skin waste filling (thickness 3 cm)	0,055	0,188	0,295	22,22
	Almond skin filling (thickness 7 cm)	0,0492	0,197	0,250	23,01
	Almond skin with Arabic gum	0,0740	0,180	0,416	23,33
	Almond skin with polyvynil glue	0,082	0,219	0,384	21,94

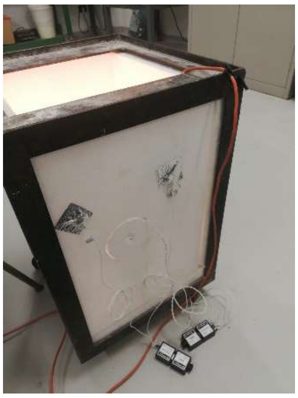

Fig.2 Hot box set-up, built at Building Physic laboratory of Politecnico di Bari

3. Conclusions

Different kind of agro-waste (almond skin, olive pruning waste, straw) were selected in laboratory to create samples suitable as aggregate for thermal insulation building components. Thermal conductivity, thermal diffusivity and volumetric heat capacity were measured. The results demonstrates that the agro-waste have a great potential to enhance the final thermal performances of the materials assuring high thermal comfort in the same way as common traditional material currently existing on market (e.g. EPS panels).
In conclusion, the framework built by the present report is a preliminary document for the study of the building prototype that will be realized by the next deliverable D.T2.3.1. At the end of the project one prototype in each territory will be built in public buildings. The prototypes will be monitored by means of sensors and suitable equipment

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