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Moisture content influence on the thermal conductivity and diffusivity of wood–concrete composite

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HIGHLIGHTS

- The influence of moisture content on the thermal proprieties of wood–concrete is studied.
- Lightening the concrete by wood shavings increases its thermal insulation capacity.
- Thermal conductivity increases rapidly with water content.
- Thermal diffusivity presents a maximum corresponding to a water content value W_m.
- The values of thermal diffusivity depend on the used counting model.

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ABSTRACT

The aim of the work reported in this paper is to determine the influence of moisture content on the thermal proprieties of wood–concrete composite, i.e. thermal conductivity and thermal diffusivity. The wood shavings have been incorporated, without any preliminary treatment, into a sand–cement mixture. Five formulations containing different percentage of shavings have been prepared and have been examined herein. The experimental results show that the lightening of concrete by wood shavings increases the thermal insulation capacity by decreasing the thermal conductivity and diffusivity; however these proprieties are strongly dependent on water content. The thermal conductivity increases rapidly with water content. Its experimental evolution with water content was confirmed by the comparison with three theoretical models. The values of the thermal diffusivity depend on the used counting model. The results stemming from three most used models are compared between them, and they show that in general the thermal diffusivity presents a maximum corresponding to a water content value W_m.

1. Introduction

The composite wood–concrete has been studied a lot these last years because wood fibers have many advantages: low cost, healthier production processes for the production of composites with different forms, the renewal and the recycling [1]. In addition, wood fibers are naturally degradable [2], which is not negligible in the current context of waste limitation. The reinforcement of concrete by wood fibers gives a composite material which can be used in many applications such as floor formwork, suspended ceilings, screeds and interior masonry blocks .

Several studies have focused on the use of wood as ash in concrete [3–5]. Based on its physical, chemical, and microstructural properties, the authors reported that wood ash has a significant potential for use in low and medium strength concrete, masonry products, roller-compacted concrete pavements (RCCPs), materials for road base, and blended cements. Coatanlem et al. [6] study the durability of wood chipping concrete mixture by examining compressive strength, flexural strength and microstructure. The results are encouraging and indicate the feasibility of producing a lightweight concrete. Bederina and Quéneudec [7], Ziregue [8] show that the addition of wood shavings in concrete improves its thermal insulation performance, while decreasing its compressive strength. However, it is possible to ensure a compromise between the compressive strength and the thermal conductivity for obtaining a structural insulation concrete.

Nevertheless, this material can present a high hygroscopic behavior due to the strong absorption of wood particles. When this material has being exposed to the conditions of temperature (T) and relative humidity (RH), which are variable between the interior

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and the exterior of the building, heat and moisture transfers occur within the medium. An important interaction develops between the heat and the moisture transfers and the different transport properties [9]. Indeed, the thermal, phonic and mechanical properties of the material are modified. It is thus crucial to quantify the variation of these properties with temperature and moisture content of the sample. But, this is not considered in most studies treating the use of this type of material in building. In this context, this study has been conducted to measure the effect of moisture content on the thermal conductivity and diffusivity of the wood–concrete composite.

2. Materials

2.1. Basic materials

The wood shavings used are a sawmill waste (Fig. 1). They correspond to the species generally used in the carpentry work in Morocco [10]. The granulometric analysis by sieving, established by a method identical to that proposed by the French standard NF P18-560 [11], demonstrates that the used wood shavings have a particle size between 8 mm and 20 mm. The sand is sea one of granulometry 0/5 and of bulk density on the order of 1500 kg/m^3. This sand is used without any washing procedure. Indeed, the test of sand equivalent made according to the standard NF EN 933-8 [12] gives the value 81%, which shows that it is a clean sand with a low percentage of clay fines, suiting perfectly for high quality concretes [13]. The cement used is Portland cement CPJ 35 equivalent to CEM II 22.5 and whose technical characteristics are in accordance with the Moroccan standard NM 10.01.004 [14]. The used mixing water is a tap water.

The concretes prepared are based on a mass ratio of 2/3 of sand and 1/3 of cement. The specimens are made with a mass ratio of water to cement (W/C) of 0.6. The study was conducted on five formulations containing different proportions of wood shavings.

2.2. Implementation of fresh concrete

The constituents are mixed in a mixer at slow speed on the order of 50 r min^{-1}, in order to obtain a good homogenization of the components. The durations of the different phases of mixing must be sufficiently long to allow a good homogenization and short enough to avoid leaving too much water to evaporate in ambient air. Thus, three phases are distinguished:

- Mixing cement and sand: 3 min.
- Adding pre-wetted wood shavings: 3 min.
- Adding mixing water and mixing: 5 min.

Fig. 1. General aspect of the used wood shavings.

Table 1
Principal physico-mechanical properties of samples.

Sample	Mix0	Mix1	Mix2	Mix3	Mix4
Mass ratio of wood shavings to cement (%)	0	6	15	24	30
Dry density (kg/m^3)	2142	1914	1779	1547	1495
Porosity (%)	21	24	31	44	55
Compressive strengths (MPa)[a]	27	16	13	9	7
Volumetric water content at the saturation W_{sat} (%)	20	22	29	42	53

[a] Compressive strength measured according to the European standard EN 196-1 [15].

2.3. Preparation of specimens

The homogenized mixture is then introduced into parallelepiped molds; two dimensions of molds were made according to the type of tests to be realized. As regards the thermal aspects, the molds of dimension (27 × 27 × 2 cm^3) were used. For mechanical strength, the molds (16 × 4 × 4 cm^3) were used. These different sizes are related to measuring devices (thermal box, mechanical press) whose dimensions are imposed. The use of the same manufacturing process, regardless of the mold, allows to work on the same material.

The specimens are preserved before and after turning out into the room test at a controlled temperature and humidity (T_a = 20 °C, RH = 60%). These conditions correspond to a standard climate and allow to reproduce real conditions of the use of the material.

2.4. Formulations

The elaborate formulations, containing various rations in wood shavings, are presented with their physico-mechanical properties in Table 1.

The density and the porosity are strongly influenced by the addition of wood shavings. Thus, a progressive decrease in density and an increase in porosity are observed. Indeed, the sand concrete, due to its small granularity, is lighter than ordinary concrete. The introduction of wood shavings reduces it more. The higher the proportion of wood shavings used the lighter the sand concrete will be [7,16,17]. This lightness is due, on the one hand, to the porous structure of wood, on the other hand, to an additional porosity led in the matrix when the water absorbed by the wood shavings evaporates during the drying.

The increase in shavings content reduces the mechanical strength of concrete. This decrease is due, on the one hand, to the low mechanical strength of the inclusions, and on the other hand, to the increase of porosity.

The water absorption capacity is very sensitive to the addition of wood shavings. Thus, there is a significant increase in W_{sat}. Indeed, wood particles have a very marked fibrous aspect. The canals which lead the sap give this material a high porosity communicating via orifices. This leads to a strong hygroscopic character [18]. It is noted that the concrete sand, itself, is characterized by an absorption capacity higher than that of ordinary concrete [19], and that the addition of wood increases it further. Similar results were obtained for hemp-concrete [20].

3. Thermal conductivity models

Many models have been proposed in the literature to predict the effective thermal conductivity of three-phase mixtures. The models used in this work are as follows:

3.1. Krischer and Kroll model [21]

The Krischer and Kroll model is a combination between the serial and the parallel models. The authors suppose that the volume fraction θ of layers oriented perpendicular to the direction of heat flow is arranged in series with the complementary fraction $(1-\theta)$ of layers oriented parallel to the direction of heat flow. Firstly, the authors suppose that the fluid phase consists only of gas (air in general). Afterwards, they extend their model for a fluid phase consisting of gas and liquid (water in general). The apparent thermal conductivity is given by a harmonic mean of the series and parallel models:

$$\lambda = \frac{1}{\frac{1-\theta}{\lambda_{//}} + \frac{\theta}{\lambda_{\perp}}} \quad (1)$$

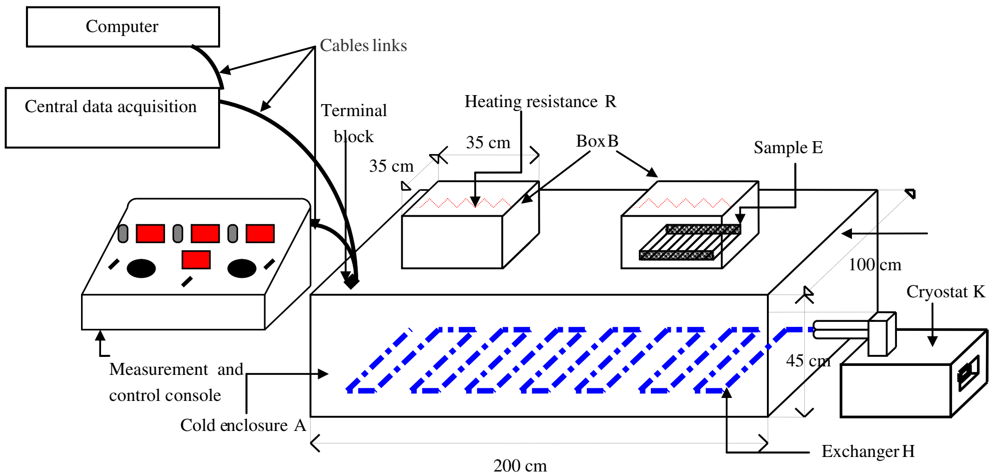

Fig. 2. Experimental setup of the box method.

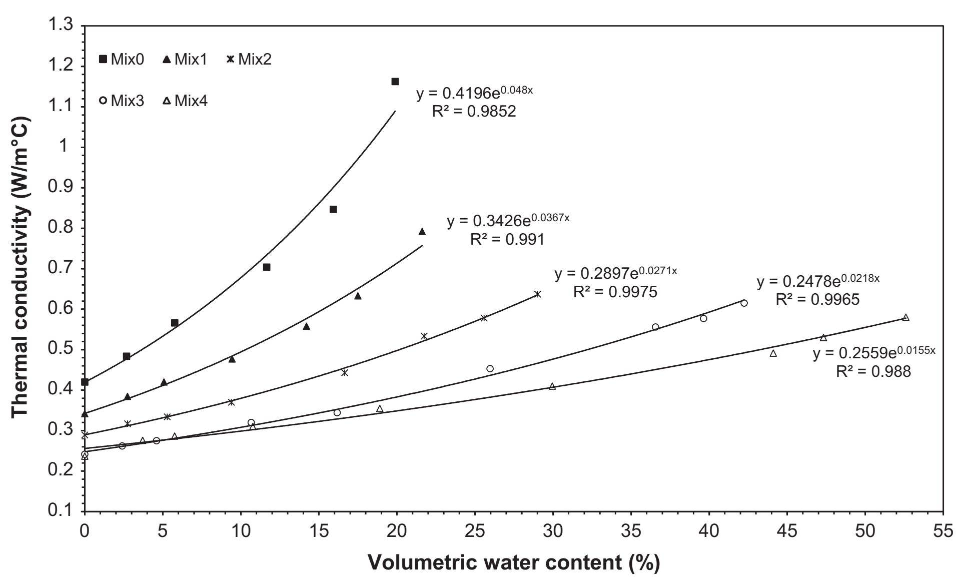

Fig. 3. Thermal conductivity as function of water content of the various samples.

$$\lambda_{//} = (1 - P_T)\lambda_s + (P_T - W)\lambda_a + W\lambda_l : \text{Parallel model} \quad (2)$$

$$\lambda_{\perp} = \frac{1}{\frac{1-P_T}{\lambda_s} + \frac{(P_T - W)}{\lambda_a} + \frac{W}{\lambda_l}} : \text{Series model} \quad (3)$$

With λ_s is the thermal conductivity of the solid phase; λ_a the thermal conductivity of air; λ_l the thermal conductivity of liquid water; P_T the total porosity and W volumetric water content.

Many authors use this model to predict effective thermal conductivity in a wetted porous media: Carson [22] in porous food, Bal et al. [23] in laterite based bricks, etc. The effective thermal conductivity predicted by the model was in good agreement with the experimental data.

According to Krischer and Kroll [21], the thermal conductivity of the solid matrix λ_s and the parameter θ are determined by solving a system of two unknowns:

$$\theta_{dry}(\lambda_s) = \frac{1/\lambda_{dry} - 1/\lambda_{//}}{1/\lambda_{\perp} - 1/\lambda_{//}} : \text{Dry stat } (W = 0) \quad (4)$$

Table 2
Report of the thermal conductivities $\lambda_{sat}/\lambda_{dry}$ of the studied samples.

Sample	Mix0	Mix1	Mix2	Mix3	Mix4
λ_{sat}/λ_d	2.76	2.31	2.20	2.54	2.44

Table 3
Parameters λ_s and θ of different samples.

Sample	Krischer and Kroll model		Chaudhary and Bhandari model		Woodside and Messmer model
	λ_s (W/m °C)	θ	λ_s (W/m °C)	θ	λ_s (W/m °C)
Mix0	1.449	0.200	1.65	0.476	0.862
Mix1	1.071	0.193	1.375	0.480	0.779
Mix2	0.734	0.140	0.811	0.342	0.845
Mix3	0.699	0.110	0.765	0.295	1.367
Mix4	0.643	0.050	0.71	0.173	3.529

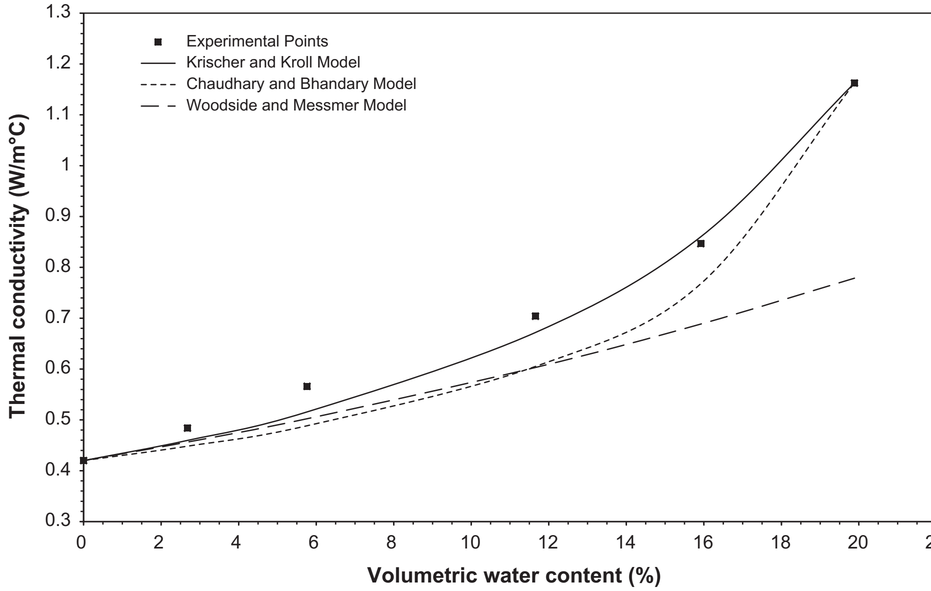

Fig. 4. Comparison between the experimental evolution of the thermal conductivity with water content and that simulated by theoretical models: Mix0.

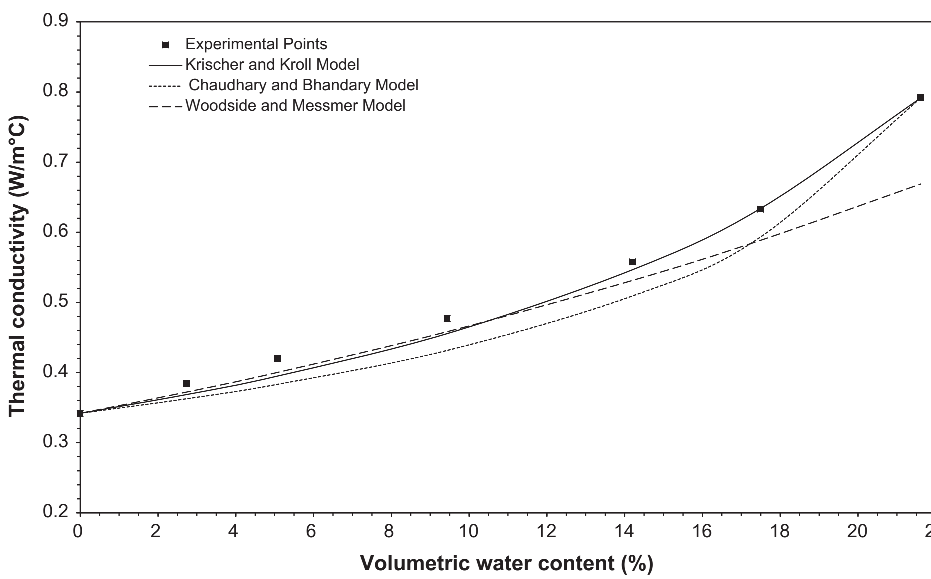

Fig. 5. Comparison between the experimental evolution of the thermal conductivity with water content and that simulated by theoretical models: Mix1.

$$\theta_{sat}(\lambda_s) = \frac{1/\lambda_{sat} - 1/\lambda_{//}}{1/\lambda_{\perp} - 1/\lambda_{//}} : \text{Saturation stat } (W = P_T) \quad (5)$$

$\theta_{dry}(\lambda_s)$ the value of θ at the dry state and $\theta_{sat}(\lambda_s)$ the value of θ at the saturation state. λ_{dry} and λ_{sat} are the thermal conductivities measured respectively at the dry state and at the saturation state.

The system of equations in θ and λ_s is difficult to solve. In this study, the determination of these unknowns is done using Newton's method, which consists in determining by successive approaches the value of λ_s for which:

$$\theta_{dry}(\lambda_s) = \theta_{sat}(\lambda_s) \quad (6)$$

The values used for the thermal conductivity of air and that of liquid water are: λ_a = 0.026 W/m °C and λ_l = 0.58 W/m °C [24].

3.2. Chaudhary and Bhandari model [25]

The apparent thermal conductivity, according to the Chaudhary and Bhandari model, is estimated by a geometric mean of the series and parallel models:

$$\lambda = \lambda_{\perp}^{\theta} \lambda_{//}^{(1-\theta)} \quad (7)$$

Experimental results of the effective thermal conductivity obtained by Sugawara [26] on calcareous sandstone partially filled with water are compared with values calculated by this model. The calculated values agree well with the experimental results.

In this study, it is proposed that the parameters λ_s and θ, relative to this model, is determined by following the same approach as that in the case of the Krischer and Kroll model. The system of equations in θ and λ_s will be given by:

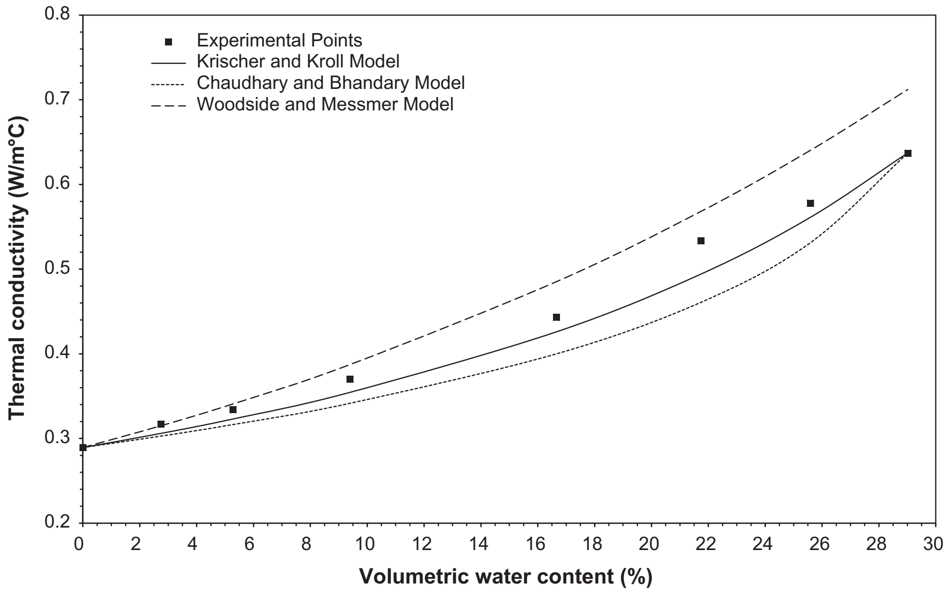

Fig. 6. Comparison between the experimental evolution of the thermal conductivity with water content and that simulated by theoretical models: Mix2.

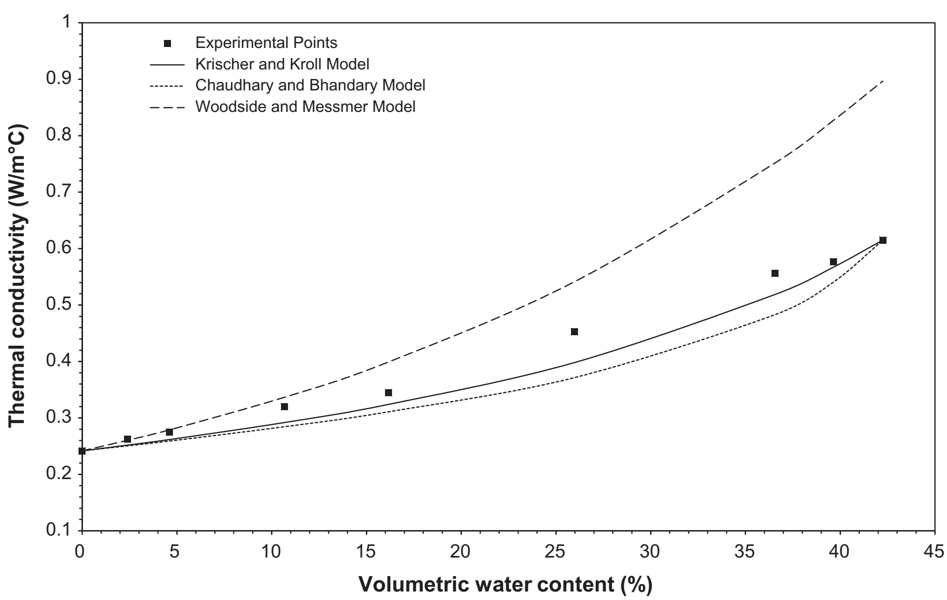

Fig. 7. Comparison between the experimental evolution of the thermal conductivity with water content and that simulated by theoretical models: Mix3.

$$\theta_{dry}(\lambda_s) = \frac{Ln(\lambda_{dry}/\lambda_{//})}{Ln(\lambda_{\perp}/\lambda_{//})} \tag{8}$$

$$\theta_{sat}(\lambda_s) = \frac{Ln(\lambda_{sat}/\lambda_{//})}{Ln(\lambda_{\perp}/\lambda_{//})} \tag{9}$$

3.3. Woodside and Messmer model [27]

The authors calculated the values of thermal conductivity of saturated rocks (two-phase system), using a weighted geometric mean relationship of the two phases. The model is in good agreement with the experimental results. Chaudhary and Bhandari [25] have generalized this model for three-phase porous medium. The thermal conductivity is given by:

$$\lambda = \lambda_s^{(1-P_T)} \cdot \lambda_a^{(P_T-W)} \cdot \lambda_l^W \tag{10}$$

In this study, it is proposed that the parameter λs, relative to this model, is determined through the value of thermal conductivity in the dry state. It has as expression:

$$\lambda_s = \frac{Ln\left(\lambda_{dry}/\lambda_a^{(P_T-W)} \cdot \lambda_l^W\right)}{(1-P_T)} \tag{11}$$

4. Test methods

The technique used to measure the thermal conductivity is called “Boxes method” (Fig. 2). It presents the advantage of a very simple implementation and the measurement precision is comparable to that obtained by conventional methods (hot wire, hot disk, etc.). This technique has been developed in the laboratory of Thermal and Solar Studies of the Claude Bernard University-Lyon I in

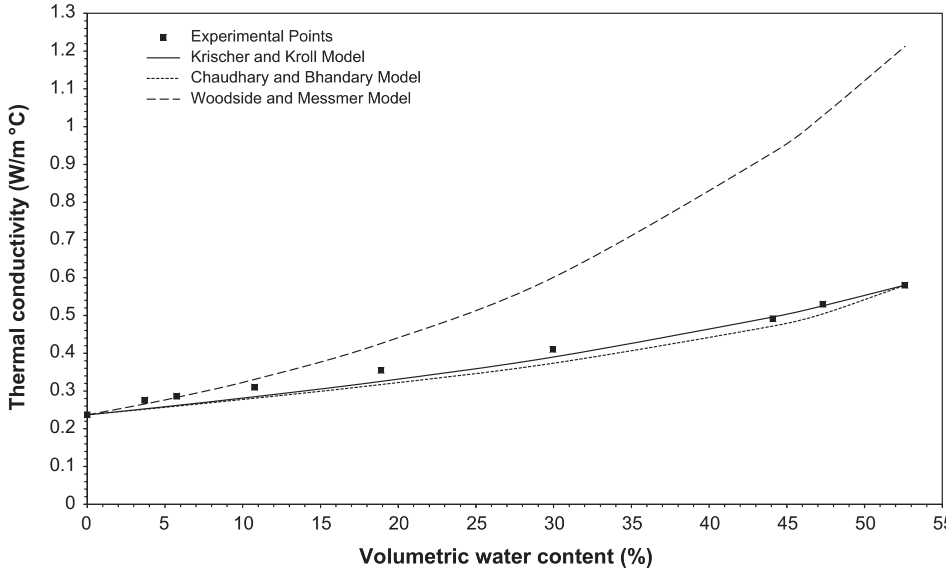

Fig. 8. Comparison between the experimental evolution of the thermal conductivity with water content and that simulated by theoretical models: Mix4.

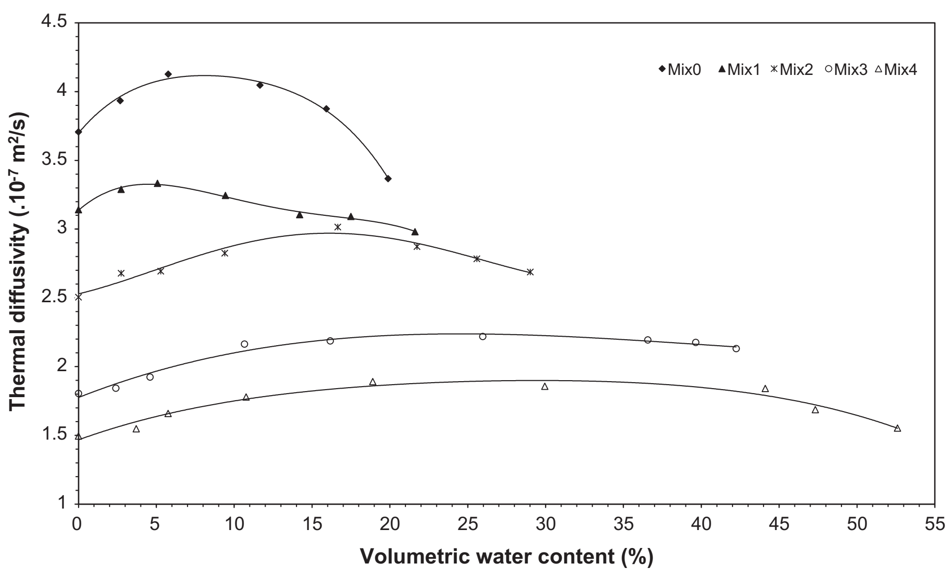

Fig. 9. Thermal diffusivity as function of water content for the different samples: Parker model.

France [28–30]. The Boxes method allows to measure thermal conductivity of materials tested in permanent regime by realizing an energy balance of the system. The measuring principle is based on achieving a permanent unidirectional heat flow through the sample, supposed homogeneous and without internal generation of heat, by creating a temperature gradient between its two faces. Indeed, the sample of parallelepiped form is placed between two enclosures, one of which is heated and the other is cooled, in such a way that the lateral flows are negligible. Once the permanent regime is established, the thermal conductivity is given by the Fourier law:

$$\lambda = \frac{qe}{S\Delta T} \tag{12}$$

q is the heat flow through the sample (W); e the thickness of the sample (m); S the area of the faces of the sample perpendicular to the flow lines (m^2) and ΔT temperature difference between the two faces of the sample.

The thermal diffusivity was measured in the transition regime. The Flash method was used [31]. Its Principle is to produce a heat pulse of short duration t_0 (Dirac pulse) on one face of the sample and recording the temperature evolution on the other face, not irradiated, as function of time. The exploitation of the experimental thermogram obtained by this manner and the theoretical thermogram stemming from the modeling allows to estimate the thermal diffusivity a. In this work, existing theoretical models in the literature are used to identify the thermal diffusivity by means of the Flash method.

For measuring the moisture influence on the thermal conductivity and diffusivity, the used variable is the volumetric water content W. This is done by practising successive weightings of the material since the partial saturation state until the dry state. Thus, the first wet measure is obtained after immersion of the material, for a few days, in water until its mass remains constant for 24 h (mass variation <0.1%), which corresponds to the partial saturation state. For the intermediate wet measures, the first three drying

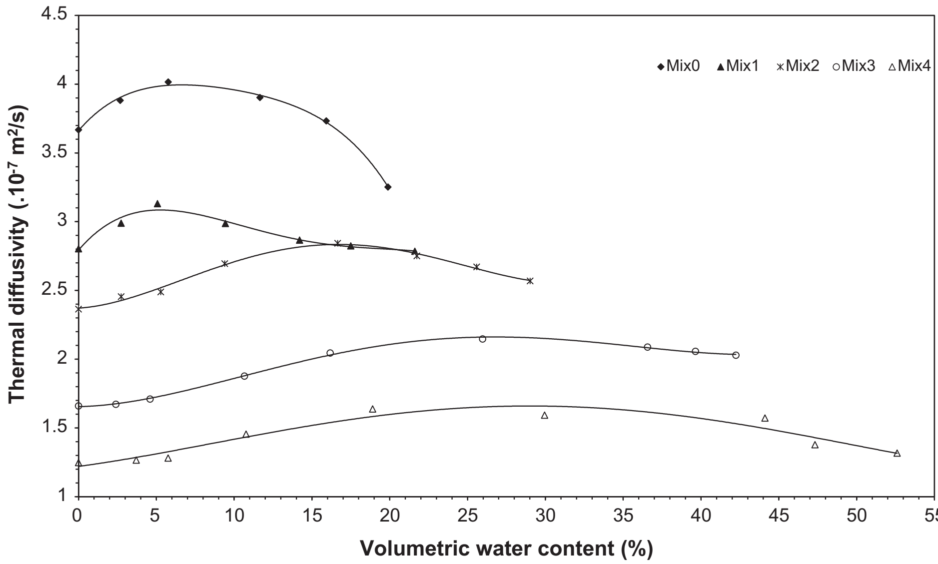

Fig. 10. Thermal diffusivity as function of water content for the different samples: Digiovanni model.

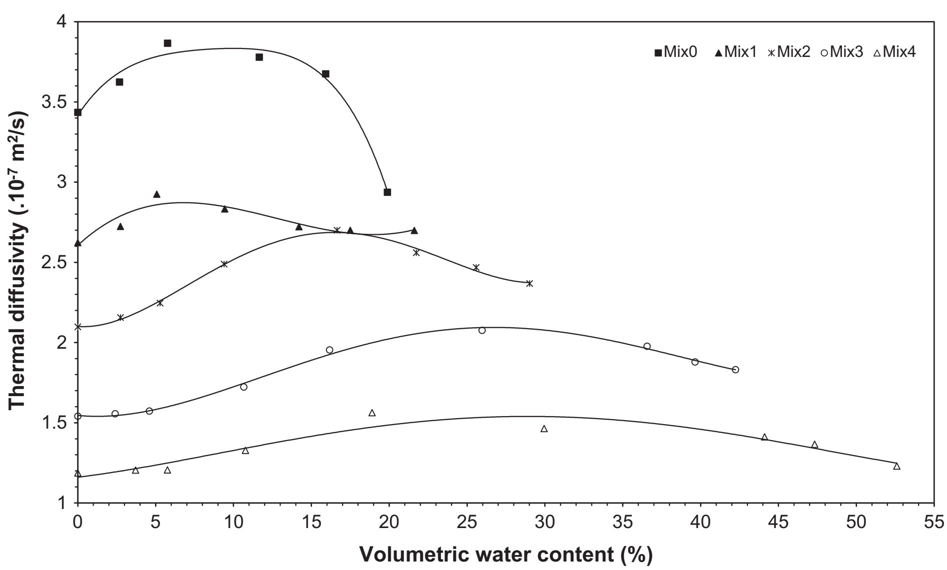

Fig. 11. Thermal diffusivity as function of water content for the different samples: Yezou model.

operations are done in the ambient air with the measure of the corresponding values of thermal conductivity and diffusivity. Then, the drying is continued in a ventilated and regulated oven at 80 °C until the dry state. This is for obtaining certain continuity of the curves which give the variation of λ and a as function of volumetric water content.

5. Results and discussion

5.1. Thermal conductivity

The evolution of the thermal conductivity as function of volumetric water content of the various samples is illustrated on Fig. 3. Two remarks are to be underlined:

– The addition of wood shavings in the concrete reduces the thermal conductivity of the composite and consequently increases its thermal insulation capacity. This behavior is related to the insulating character of wood shavings, which have a low thermal conductivity. The thermal conductivity of a material depends on those of aggregates which constitute it. The lower the thermal conductivity of inclusions, the more the material is insulating. In addition, the increase in porosity decreases the density of the composite and consequently its thermal conductivity. This dependence is always verified on materials with mineral matrix and vegetable fibers according to Alrim et al. [32] which used a clayey matrix or, according to Khedari et al. [33] which used matrix based on portland cement. The values obtained for thermal conductivity make that the studied composite is a competitive material with lightweight insulating concretes. However, it is shown that increasing the heat insulation capacity is achieved at the expense of compressive strength. In fact, the compressive strength decreases with the incorporation of wood shavings (p. 2.4). The knowledge of the resistance level sufficient for a given use is therefore crucial for the optimal exploitation of the insulation quality. Anyway,

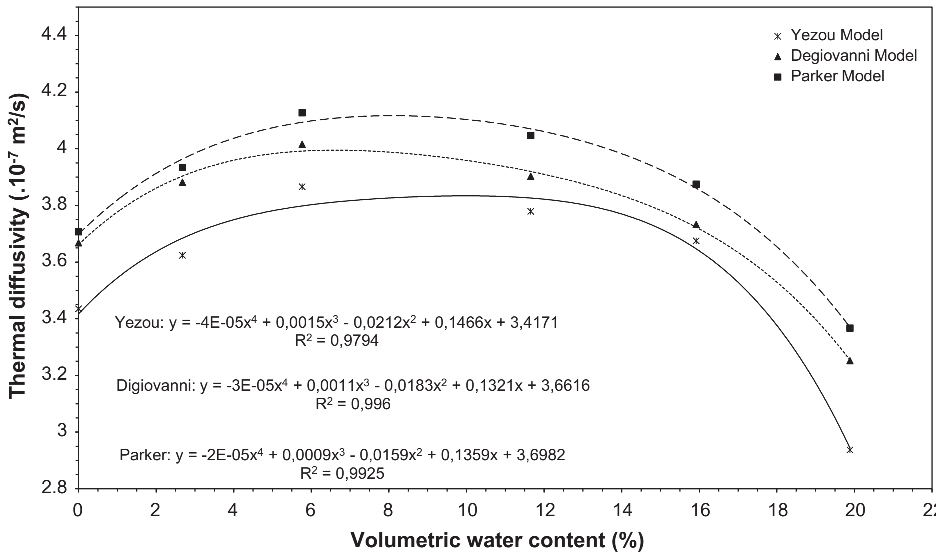

Fig. 12. Comparison between the thermal diffusivity given by Parker, Digiovanni and Yezou models: Mix0.

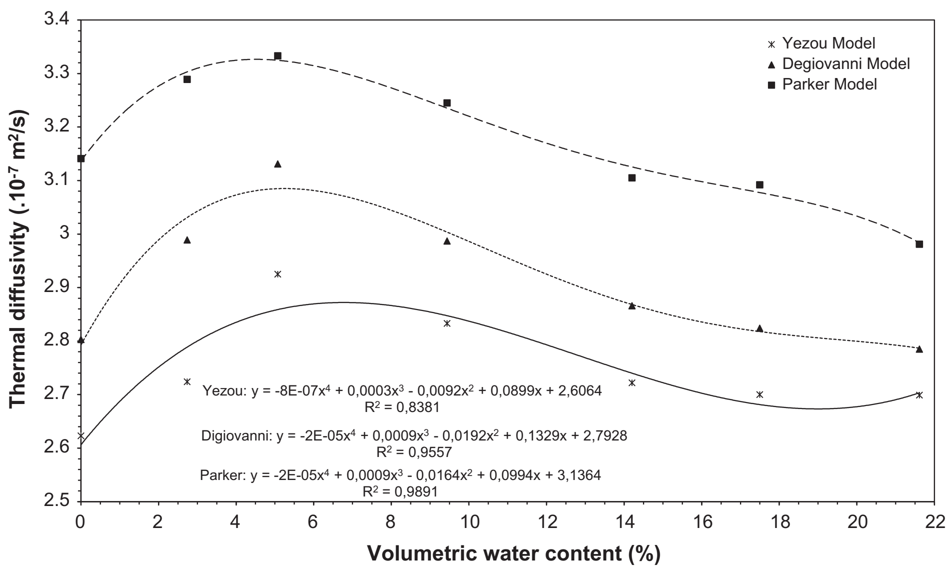

Fig. 13. Comparison between the thermal diffusivity given by Parker, Digiovanni and Yezou models: Mix1.

the compressive strength values obtained in this study are compatible with the use of the elaborated materials as load-bearing insulating concrete, according to the functional classification of RILEM [34]. Then, this composite should find it an important use in constructions (floor formwork, suspended ceilings, screeds, interior masonry blocks…).

– The thermal conductivity increases rapidly with water content. Table 2 gives, for every sample, the report thermal conductivity in the saturation state λ_{sat} than that in the dry state λ_{dry}. It appears that the thermal conductivity measured at the saturation state is two to three times greater than that measured in the dry state. Numerous works [21,35,36] bring to light this dependence (conductivity/water content) on other building materials.

The results of the calculation of the parameters λ_s and θ relative to the three proposed simulation models are included in Table 3. The fraction θ of the porous medium arranged perpendicular to the direction of heat flow is very low, which allowed to deduct that the layers of the studied materials are mostly arranged in parallel to the direction of heat flow. The values of λ_s and θ calculated through Chaudhary and Bhandari model are superior to those stemming from the Krischer and Kroll model. There is generally a strong deviation of the values of λ_s determined with Woodside and Messmer model compared to those determined with the other two models.

The comparison between the experimental evolution of the thermal conductivity with water content and that simulated by the proposed theoretical models is illustrated on Figs. 4–8. The Krischer and Kroll model approach better measurement results. The mean relative error between experimental results and those given by this model is between 2.4% (Mix1) and 4.9% (Mix3). The Chaudhary and Bhandari model is still acceptable, with a mean relative error between 5.57% (Mix1) and 7.6% (Mix3). The good agreement of these two models with the experimental points is due to the effect that the domain, bounded by the assemblies of phases

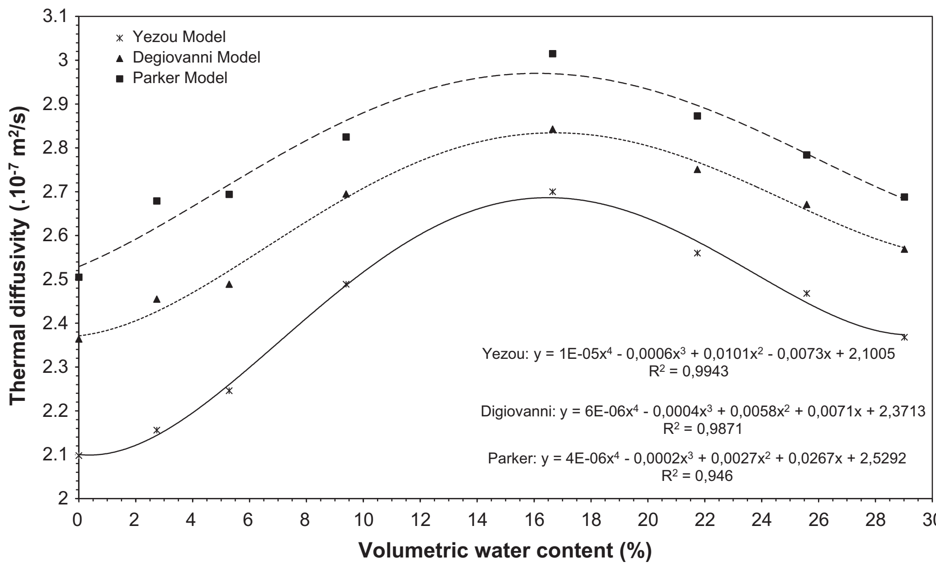

Fig. 14. Comparison between the thermal diffusivity given by Parker, Digiovanni and Yezou models: Mix2.

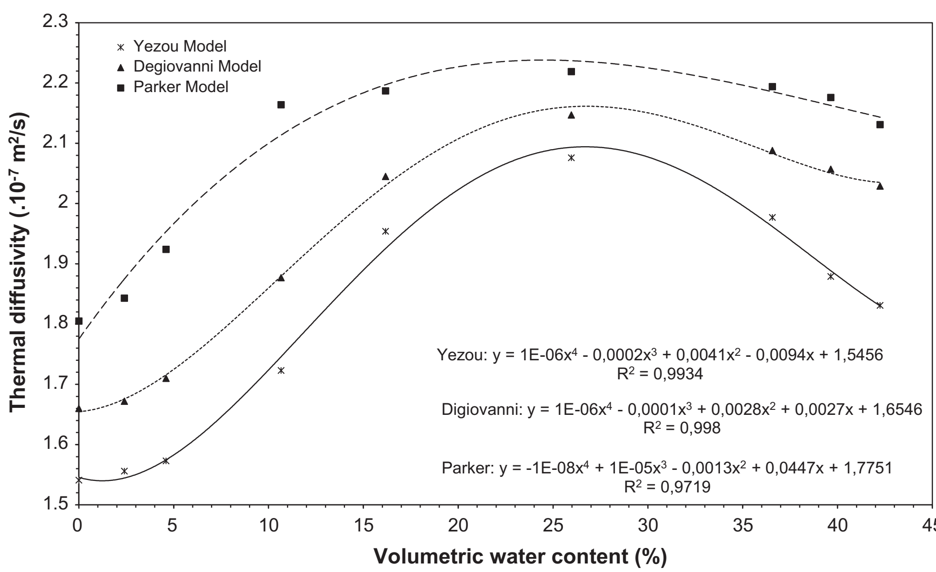

Fig. 15. Comparison between the thermal diffusivity given by Parker, Digiovanni and Yezou models: Mix3.

in series and in parallel, includes necessarily all properties of undamaged real materials, whatever the morphology and the distribution of its phases. Indeed, the series model represents the lower bound of the apparent thermal conductivity of the medium, and the parallel model represents the upper bound. The values simulated by the Woodside and Messmer model are relatively far away from experimental measurements except near the dry state. The agreement near the dry state is expected because this model has been found to hold good for two-phase systems [27]. The disagreement outside the dry state region can be attributed to the failure to take account in this model of the structure and distribution of the phases in the medium.

5.2. Thermal diffusivity

The thermal diffusivity a characterizes the velocity at which the heat propagates in a material. The lower its value, the more the heat takes the time to pass through a material. Thus, the insulation capacity of a material depends not only on the value of λ but also on the heat transfer velocity translated by a.

The study of the thermal diffusivity as function of moisture content is carried out in the same experimental conditions and with the same water contents than in the case of thermal conductivity. A comparison between the results obtained by three counting models of experimental thermograms is also conducted:

Parker model [31]: the thermal diffusivity is given by:

$$a = 0.139\frac{e^2}{t_{1/2}} \quad (13)$$

Degiovanni model [37]: the expressions of thermal diffusivity are given as follows:

$$a_{2/3} = e^2\frac{(1.150/t_{5/6} - 1.250\, t_{2/3})}{t_{5/6}^2} \quad (14)$$

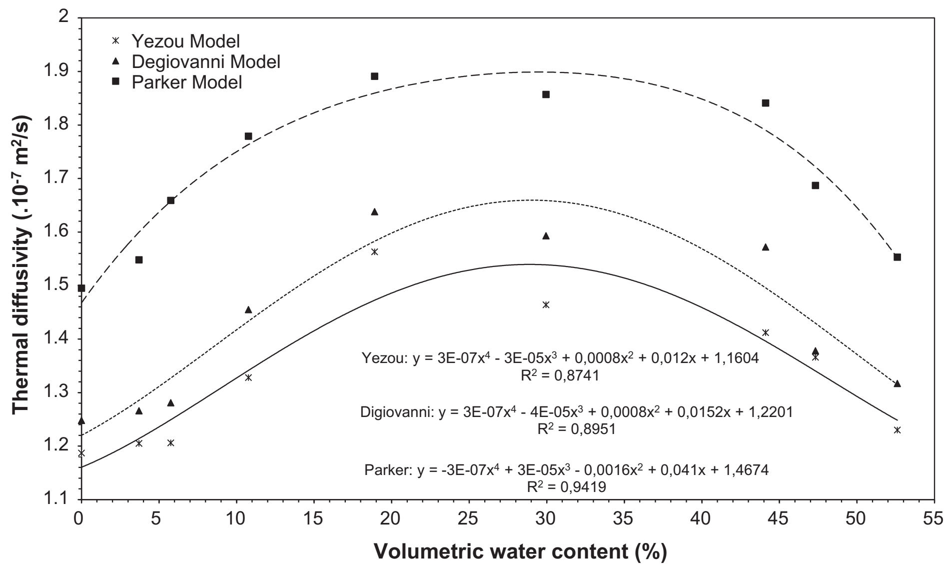

Fig. 16. Comparison between the thermal diffusivity given by Parker, Digiovanni and Yezou models: Mix4.

$$a_{1/2} = e^2 \frac{(0.761\, t_{5/6} - 0.926\, t_{1/2})}{t_{5/6}^2} \quad (15)$$

$$a_{1/3} = e^2 \frac{(0.617\, t_{5/6} - 0.862\, t_{1/3})}{t_{5/6}^2} \quad (16)$$

where $t_{i/j}$ is the time corresponds to the ratio i/j of the maximum temperature.

Yezou model [38]: the terms of thermal diffusivity are given by:

$$a_{5/6} = \frac{e^2}{t_{5/6} + t_o/2}\left[0.713\left(\frac{t_{1/2}+t_o/2}{t_{5/6}+t_o/2}\right)^2 - 1.812\left(\frac{t_{1/2}+t_o/2}{t_{5/6}+t_o/2}\right) + 1.037\right] \quad (17)$$

$$a_{1/2} = \frac{e^2}{t_{1/2} + t_o/2}\left[-0.4032\left(\frac{t_{1/2}+t_o/2}{t_{5/6}+t_o/2}\right)^2 + 0.1103\left(\frac{t_{1/2}+t_o/2}{t_{5/6}+t_o/2}\right) + 0.2027\right] \quad (18)$$

For each model, the value of the thermal diffusivity is calculated as being the arithmetic mean of the given expressions.

Figs. 9–11 recapitulate the curves of the variation of the thermal diffusivity with water content for the five simples, using respectively Parker, Digiovanni and Yezou models. The Figures confirms that the incorporation of wood shavings in concrete decreases its thermal diffusivity. This result is expected and it is in agreement with the results found for thermal conductivity. The lightening of concrete by wood shavings has a positive effect on its thermal insulation capacity.

It is noted that both ascending and descending trends of the relationship between diffusivity and water content have been reported. In fact, a maximum of thermal diffusivity is observed for the values of water content W_m, about 6% for Mix0, 5% for Mix1, 17% for Mix2, 26% for Mix3 and 19% for Mix4. This phenomenon has been observed on other materials [35,39,40] and can be explained by the combined effects of thermal conductivity and volumetric heat capacity ρc according to the equation:

$$a = \frac{\lambda}{\rho c} \quad (19)$$

In the moisture range [0, W_m], the increase of the thermal diffusivity with moisture content can be explained by the fact that the value of λ increases faster than that of ρc. In the moisture range [W_m, W_{sat}], the decrease of the thermal diffusivity with moisture content can be explained by the fact that the value of λ increases slower than that of ρc.

The thermal diffusivity stemming from the three aforesaid models are clearly far away from each other (Figs. 12–16). This is normal, because of the difference between the basic hypotheses retained in each model. Indeed, for the development of their model, Parker et al. used cylindrical samples, and suppose that the following conditions are verified: homogeneous, isotropic and opaque sample, constant thermophysical properties, perfectly isolated sample, very short photothermal pulse uniformly distributed on the front face of the sample, unidirectional heat transfer. This model, of a simple and practical application, neglects several aspects of the physical reality. Indeed, the heat loss on the different faces of the sample is never null and the thermal pulse is never of negligible duration. Degiovanni model has the advantage to take into account thermal losses on all faces of the cylindrical sample without the need to evaluate them. For the Yezou model, the author used parallelepiped samples. It takes into account the irradiation time t_0 and the heat losses on the front and back faces of the sample. Lateral losses are neglected. However, it is possible to estimate that Yezou model reflects well the thermal behavior of the studied materials. This is justified by the fact that the author has used conditions similar to our experimental conditions (parallelepiped samples, thermal excitation of no negligible duration t_0). In general, this model is very suitable for building materials. Its precision is between 2% and 4%.

6. Conclusion

This paper is a contribution to the general problem of the sustainable development, the improvement and the control of the properties of wood–concrete composite. Thus, this work has aimed to study the influence of moisture content on the thermal properties of this type of material.

It is shown that even if the lightening of concrete by wood shavings engenders a significant increase of the thermal insulation capacity, the elaborated materials present high water absorption. The hygrothermal study allowed to demonstrate the important approximation made when only the thermal characteristics of wood–concrete composites are considered independently of their hydrous state. Indeed, the presence of water within the studied materials modifies considerably their thermophysical characteristics. The differences observed, especially between the thermal conductivity of a dry material and that of a wet one, imply consequences which can be very significant during the establishment of the thermal balances of buildings. The treatment of wood shavings can be envisaged in next works to decrease the water absorption capacity, and therefore reduce the perturbation of thermal properties upon a change of the humidity inside or outside the building. Bederina et al. [41] have shown that the treatment of the wood shavings reduced considerably the water absorption of concrete lightened by wood shavings. Ledhem et al. [42] have shown that the processing of wood shavings with oil intended for disposal allows significantly decreasing the water absorption of the shavings as well as that of wood–cement schistous fines composite.

The comparison of the experimental points of conductivity with those deduced from existing theoretical models in the literature shows that the Krisher–Kroll and Chaudhary–Bhandari models translate well the evolution of the thermal conductivity as function of water content. Indeed, these two models take into account several aspects of the physical reality of the material. Nevertheless, the proposed method for determining the parameters θ and λ_s makes that the simulation is strongly dependent on the quality of experimental measurements.

The study of the thermal diffusivity shows that its values depend on the model used for the counting of the experimental thermogram recorded on the nonirradiated face of sample. However, the curves which translate the evolution of the diffusivity as function of water content present a maximum correspond to a water content W_m.

The influence of temperature was not taken into account in this study, while it is known that it plays an important role in the thermal properties of wet porous mediums [43]. Therefore, it is necessary to conduct a systematic work to study the influence of temperature on the thermal conductivity and diffusivity of the developed wood–concrete composites.

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