



## Effect of Short Jute Fiber Content on the Water Absorption of Cement Mortars

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**Abstract:** This study analyzes the effect of short jute fiber content (maximum length 5 mm), incorporated at dosages between 0.25% and 2% by weight of cement, on the properties of cementitious mortars, with a particular focus on water absorption. In the fresh state, the addition of fibers induces a slight setting delay—moderate at 0.5% but more pronounced at 2%—due to chemical interactions between the soluble compounds of the plant fibers and the cementitious binder. Furthermore, a decrease in flow is observed, reflecting a loss of workability. However, all mixtures exhibit zero bleeding, indicating excellent stability and homogeneity without segregation. The air content varies slightly between 4.2% and 3.8%, and the apparent density remains unchanged, confirming that fiber incorporation does not significantly alter the overall fresh-state properties. In the hardened state, the reference mortar exhibits an open porosity of 20.31%, while the fiber-reinforced mortars show a moderate increase ranging from 0.78% to 7.43%. This evolution directly impacts water absorption, the central parameter of this study. Indeed, the reference mortar displays an absorption of 5.80%, whereas the fiber-containing mortars show values between 6.00% and 6.50%, representing a relative increase of 3.33% to 10.77%. Despite this rise, absorption remains limited, reflecting good compactness and satisfactory homogeneity of the mixtures. The obtained results allow these mortars to be categorized into classes R1, R2, and R3 according to the NF EN 998-1 (2016) standard in terms of capillary absorption. Mechanically, the addition of fibers improves tensile strength for dosages between 0.25% and 1.25%, with an optimum at 0.5% (gain of 1.01% to 4.68%). Compressive strength also reaches a maximum at 0.5%, with a 9.18% increase at 28 days. Beyond this threshold, a progressive decline in performance is observed. Thus, an optimal dosage of 0.5% enhances mechanical properties while limiting the increase in water absorption.

## 1. Introduction

In recent years, the use of plant fibers has attracted renewed interest. Indeed, these fibers may represent an alternative to traditional fibers used in construction materials, such as polypropylene fibers. Sustainable development requires environmentally friendly materials, particularly natural materials. In this context, plant fibers used as reinforcement in cementitious materials constitute a very attractive option for the construction industry (Belkadi *et al.*, 2018). In general, the incorporation of fibers, whether metallic or synthetic, into cementitious materials improves their performance by limiting crack propagation, enhancing mechanical strength (tensile and flexural strength), and

improving the toughness of the hardened material (Ali *et al.*, 2013), among others. Nevertheless, the production cost of these fibers remains high, and their manufacturing process emits CO<sub>2</sub> and consumes non-renewable resources (Tonoli *et al.*, 2010). Consequently, current research is increasingly focused on the possibility of replacing them with natural fibers (Wei *et al.*, 2015). Plant fibers are biodegradable and renewable (Di Bella *et al.*, 2014). In some countries, they may even be derived from the valorization of local resources. These plant fibers can provide interesting mechanical properties while significantly reducing the production cost of cementitious composites (Tonoli *et al.*, 2010).

Water absorption can influence the durability of mortar. The higher the amount of water absorbed by the mortar, the lower its durability. Water absorption, generally measured by drying a specimen to constant mass, immersing it in water, and determining the increase in mass as a percentage of the dry mass, is one of the important properties governing mortar durability. Good mortar mixtures generally exhibit water absorption values well below 10% by mass. Factors such as material type, additives, temperature, and exposure duration may affect the amount of water absorbed (Dorozhkin, 2013; Singh and Siddique, 2025; Toouareb *et al.*, 2025; Jabri *et al.*, 2026). Water absorption may also influence the strength of mortar (Gani, 1997). This paper investigates the influence of water on the durability of mortars, with a particular focus on open porosity and the capillary water absorption coefficient. The analysis specifically concerns bio-based mortars reinforced with short jute fibers. The objective is to determine the extent to which the incorporation of these fibers modifies the pore network of the matrix, thereby affecting permeability and resistance to aggressive agents.

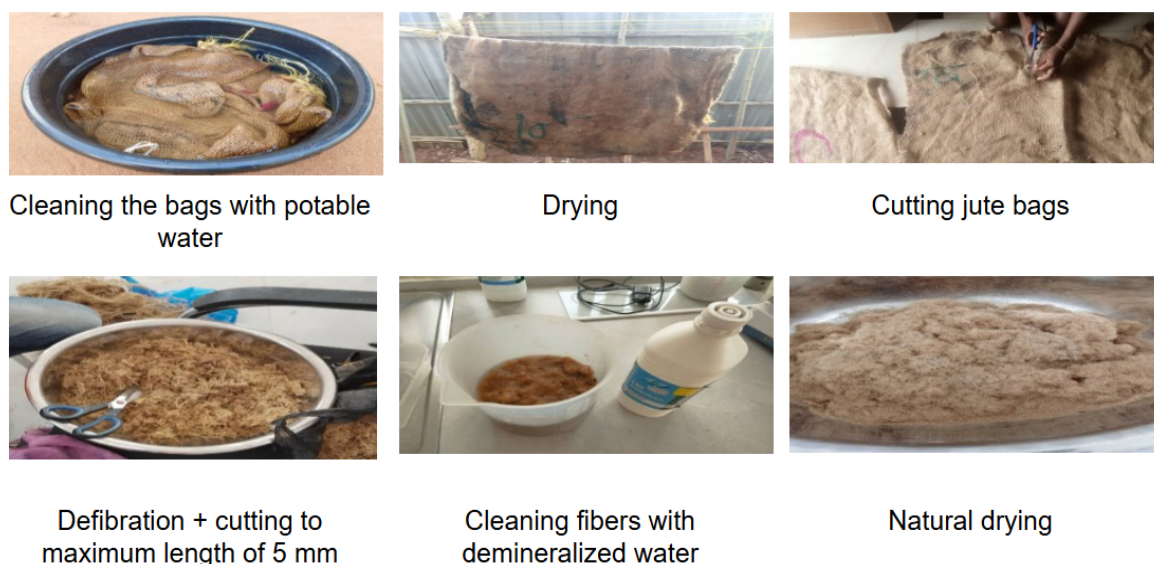
## 2. Methodology

### 2.1 Sourcing and preparation of Specimen

The materials selected for this study include lagoon sand sourced from Cocotomey-Zounga in southern Benin (6.361562° N, 2.304888° E) and a CEM I 52.5 R cement produced by the NOCIBE plant (7.139438° N, 2.548478° E), chosen for its high early strength and its ability to accelerate the development of the mortars' mechanical performance. The mixing water is potable water supplied by SONEB, ensuring purity levels consistent with construction industry standards. The bio-based reinforcement consists of jute fibers recycled from agricultural packaging bags collected at the Dantokpa International Market (Benin). This valorization approach transforms these used containers originally dedicated to the transport of foodstuffs into an economical and sustainable resource, the incorporation of which aims to modify the microstructure and porosity of the mortar to evaluate its impact on durability and capillary absorption.

### 2.2 Experiments

The fiber extraction process follows the methodology established by (Zomahoun *et al.*, 2025) (Figure 1). This procedure begins with the immersion of jute bags in water to facilitate the dissociation of the fibrous strands. After meticulous cleaning and initial drying, the material is manually defibered. The resulting filaments are then cut using shears to achieve a maximum length of 5 mm. To eliminate any organic impurities that could interfere with the hydration of the cementitious matrix, the fibers undergo a secondary washing stage with demineralized water. Final drying is conducted at ambient temperature to preserve the fibers' physical and chemical integrity. Furthermore, to ensure statistical reliability and reproducibility, each experimental test was performed in six (06) replicates. The data presented represent the arithmetic mean of these measurements, thereby minimizing experimental uncertainties and enhancing the scientific significance of the findings.



**Figure 1.** Fiber extraction stages (Zomahoun *et al.*, 2025)

### 2.3 Product characterisation

The experimental evaluation of the material properties was conducted in strict accordance with the prevailing regulatory and normative frameworks governing concrete and mortar performance. These procedures primarily rely on the harmonized European standards (NF EN) adopted by AFNOR, as well as the French NF P series and national documentation booklets (FD). The identification and characterization of the constituent materials—specifically the lagoon sand, short jute fibers, and CEM I 52.5 N cement—were performed following the protocols detailed by (Zomahoun *et al.*, 2025). For the sake of conciseness, these preliminary experimental details and results are not reproduced in this section but serve as the baseline for the subsequent analysis. Finally, the mixing water used was potable water provided by the Société Nationale des Eaux du Bénin (SONEB), meeting the required standards for cementitious mixtures.

## 3. Results and Discussion

### 3.1 Mortar formulation and codification

The selected mix proportions for the mortar formulations are presented in Table 1, and the nomenclature used for specimen identification is detailed in Table 2.

### 3.2 Setting time

As illustrated in Figure 2, the incorporation of jute fiber powder—at dosages between 0.25% and 2% by weight of cement appears to cause a marginal deceleration in the mortar's setting process relative to the control mixture. This trend suggests that the presence of these organic particles slightly extends the time required for the initial and final set compared to a conventional mortar. At low dosages (0.5%), the impact is moderate; however, at higher levels (2%), the delay becomes more noticeable due to the increased disruption of the cementitious network. The observed setting delay is linked to various interaction mechanisms between the dissolved chemical constituents of the plant fibers and the mineral binder used.

**Table 1.** Summary of reactor performance

Materials	Proportion for 1 m <sup>3</sup>
Cement	450 Kg
Sand	1350 Kg
Water	247,5 liters
Water/Cement Ratio E / C	0,55

**Table 2.** Mortar Coding

Designation	Codification
Control Mortar	M0
Mortar + 0,25 % de fibers	M1
Mortar + 0,50 % de fibers	M2
Mortar + 0,75 % de fibers	M3
Mortar + 1,0 % de fibers	M4
Mortar + 1,25 % de fibers	M5
Mortar + 1,50 % de fibers	M6
Mortar + 1,75 % de fibers	M7
Mortar + 2,0 % de fibers	M8

Specifically, fiber polysaccharides are trapped by alkalis resulting from the dissolution of the binder. These can be transformed into soluble oligosaccharides, which subsequently inhibit the hydration of the cementitious and pozzolanic paste (Matthieu 2022). These results align with findings in the literature (Chafei 2014; Page 2017; Hoang 2013), which have demonstrated the disruptive effect of plant fiber addition on the hydration process. (Sedan 2007) attributed the setting delay to the action of pectins within the fibers on the calcium ions released during the binder's hydration reactions. The author noted that pectins are responsible for the decrease in calcium ion concentration, a drop that becomes more significant as the fiber content increases. Furthermore, the author showed that Si<sup>4+</sup> ions increase because the low quantity of calcium ions is insufficient to trigger precipitation, thereby hindering the formation of calcium silicate hydrate (C-S-H) gel.

### 3.3 Flow table

Fluidity is a crucial parameter governing the application conditions of a mortar (Matthieu 2022). The rheology of the material was evaluated using the flow table test. This test was conducted in accordance with the NF EN 1015-3 (1999) standard. The principle consists of measuring the flow diameter of the mortar on a flow table after applying 15 jolts (drop height: 10 mm). As shown in Figure

3, the incorporation of short jute fibers tends to reduce the flow diameter, reflecting a decrease in the mortar's workability. This observation indicates that the fibers hinder the fluidity of the fresh mixture, leading to a more viscous consistency. This behavior is consistent with the observations reported by (Matthieu 2022), who highlighted a reduction in workability when fibers are present.

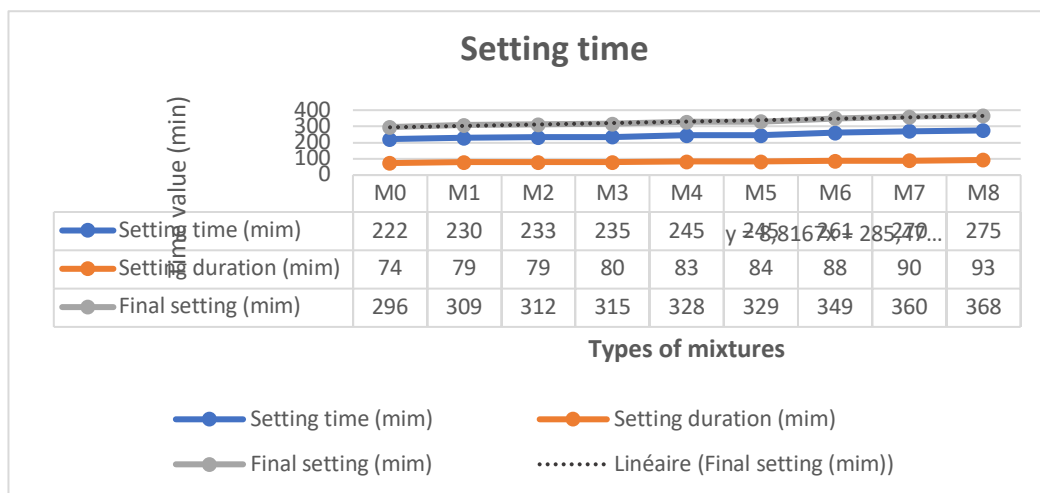


Figure 2. Setting time

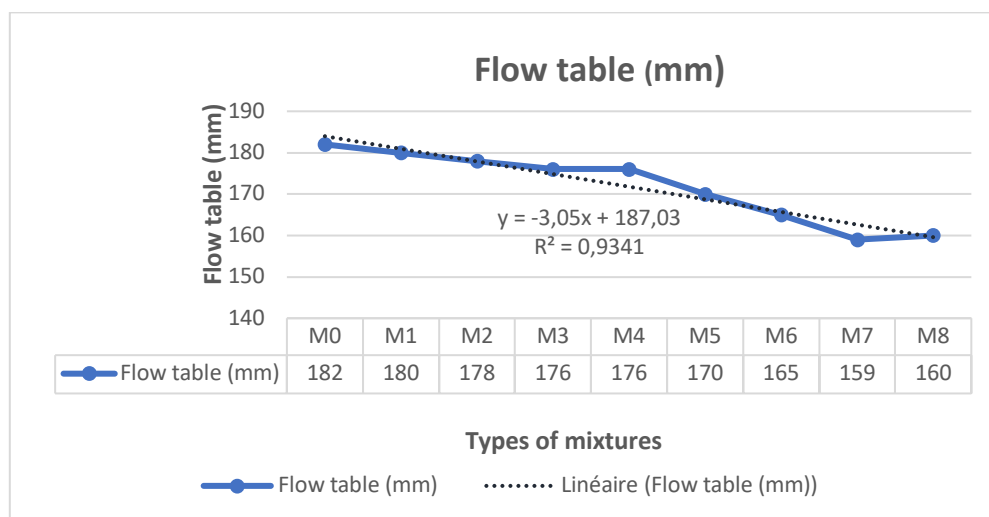


Figure 3. Flow table

### 3.4 Free bleeding

It is observed that the reference mortar, as well as the mixtures containing short jute fibers, exhibit zero bleeding, regardless of the addition percentage. Zero bleeding indicates excellent stability of the mortar in its fresh state. No water rises to the surface, which signifies a homogeneous mixture, free from segregation or settling of solid particles.

Table 3. Free bleeding

	M0	M1	M2	M3	M4	M5	M6	M7	M8
Free bleeding	0	0	0	0	0	0	0	0	0

### 3.5 Air content

As displayed in Figure 4, the reference mortar exhibits an air content of 4.2%, while mixtures reinforced with jute fibers show values between 3.8% and 4.2%, regardless of the fiber content. This trend indicates that the addition of these natural fibers has no significant effect on the air void volume within the cementitious matrix. This slight variation remains minimal and indicates that the introduction of fibers did not significantly disrupt the structure of the mortar in its fresh state. (Baričević et al. 2022) demonstrated in their research that the average reduction in air content in fresh mortar was 16%, 44%, and 38% for glass, basalt, and carbon fibers, respectively, compared to the reference mix. This results in a higher fresh density: for glass fiber mortar, it is on average 4% higher, while for basalt and carbon fiber mortars, it is on average 9% higher than that of the reference mix.

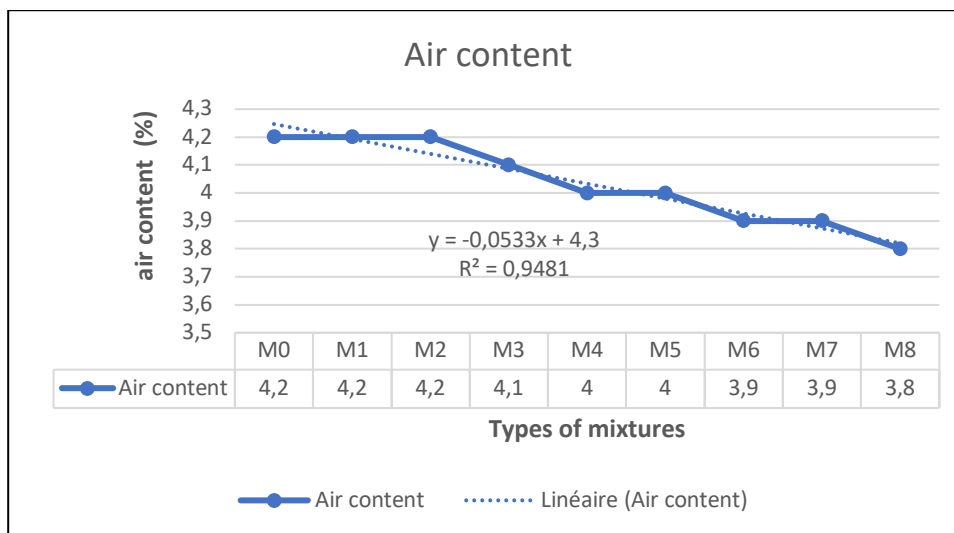


Figure 4. Air content

### 3.6 Open porosity of the mortar

As shown in Figure 5, it is observed that the reference mortar exhibits an open porosity of 20.31%. For mortars containing short jute fibers, a slight increase in porosity is observed following the incorporation of the fibers, ranging from 0.78% to 7.43% relative to the reference mortar. This trend indicates that the addition of fibers leads to a moderate increase in the mortar's porosity. However, this increase remains limited and does not significantly affect the overall quality of the rendering mortar. (Pederneiras et al., 2021) demonstrated that mortars using cement as the sole binder exhibit the lowest open porosity values. This is attributed to the cementitious matrix, which is characterized by fewer and smaller pores, and a higher strength compared to lime-based matrices (Stefanidou et al., 2005). (Giosuè et al., 2019) also found that the incorporation of wool fibers increased the open porosity of mortars at an early age. The authors attributed this increase to the presence of fibers which, through their interfacial bonding with the matrix, generate larger diameter pores within the mortars. Wider capillary pores would result in higher capillary coefficients, which was indeed observed at 28 days. This may, therefore, also explain the increase in porosity observed in this study at that age.

### 3.7 Water absorption by mortar saturation

As shown in Figure 6, it can be observed that the reference mortar exhibits a water absorption percentage of 5.80%. For the studied mixtures, a slight increase in water absorption compared with the reference mortar was observed. This increase ranges from 3.33% to 10.77%, corresponding to absorption values varying

between 6.00% and 6.50%. This relatively limited absorption capacity reflects the good homogeneity of the mixtures, regardless of the percentage of addition used. (Borhan *et al.*, 2011) reported water absorption values ranging from 7% to 15.7% for polymer-modified mortars. (Ramírez *et al.*, 2020) also demonstrated that all mixtures exceeded the 4.5% weight increase obtained for the reference mortar MREF, except for MMIX, whose total absorption decreased by approximately 8.90% compared with this reference. It should be noted that after 24 h, the mortar containing waste fibers with the highest total absorption was MRLR (4.75%), compared with the mortar containing commercial fibers, MPP (4.93%). The MMIX (4.1%) and MFV (4.59%) mortars, containing waste fibers and commercial fibers respectively, exhibited lower total absorption capacities. The values obtained in the present study, which are lower than those reported in the literature, suggest that the incorporation of jute powder does not lead to a significant increase in the open porosity of the mortar, thereby confirming the good compactness and microstructural stability of the material.

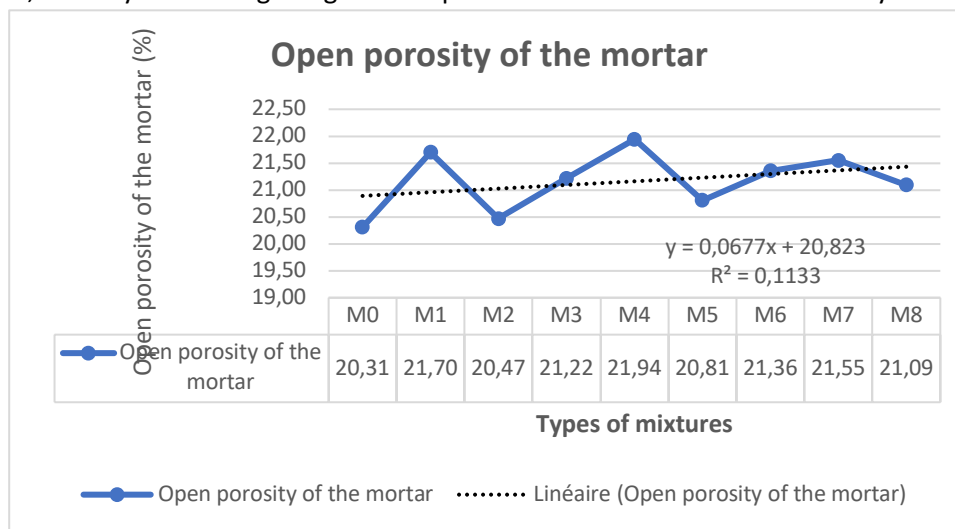


Figure 5. Open porosity of the mortar

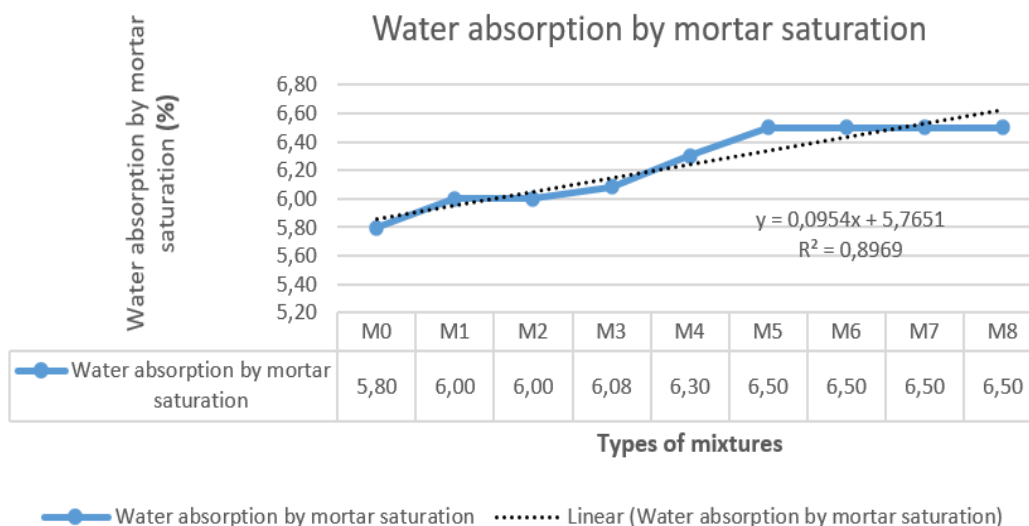


Figure 6. Water absorption by mortar saturation

### 3.8 Capillary water absorption

The average results of the capillary water absorption tests, carried out on six specimens from each mixture and the reference mortar, are presented in the following curve. These mortars must absorb as

little water as possible considering their intended application. This particularly concerns mortars exposed to rain and those located at the base of foundations. The greater the water absorption, the higher the risk of moisture infiltration. In all cases, the standard requires for R1 mortars  $R1 c \leq 0,4 \text{ kg/m}^2 \text{ min}^{0,5}$ , for R2  $c \leq 0,3 \text{ kg/m}^2 \text{ min}^{0,5}$  and for R3 mortars  $R3 c \leq 0,2 \text{ kg/m}^2 \text{ min}^{0,5}$ . According to the results shown in Figure 7, it can be concluded that the mortars reinforced with short jute fibers, as well as the reference mortar, satisfy the requirements of classes R1, R2, and R3 according to the NF EN 998-1 (2016) standard, in terms of capillary water absorption measured in accordance with NF EN 1015-18 (2003). (Ramírez *et al.*, 2020) demonstrated that mortars containing waste fibers exhibited a higher absorption coefficient than the reference mortar (MRFV: 16.7%; MRLR and MMIX: 8.3%), whereas this coefficient was significantly lower for mortars containing commercial fibers (MPP: 20.8% lower and MFV: 25% lower). The mortar exhibiting the highest capillary water absorption capacity was MRFV ( $0,28 \text{ kg/m}^2 \text{ min}^{0,5}$ ), while MFV showed the lowest value ( $0,18 \text{ kg/m}^2 \text{ min}^{0,5}$ ).

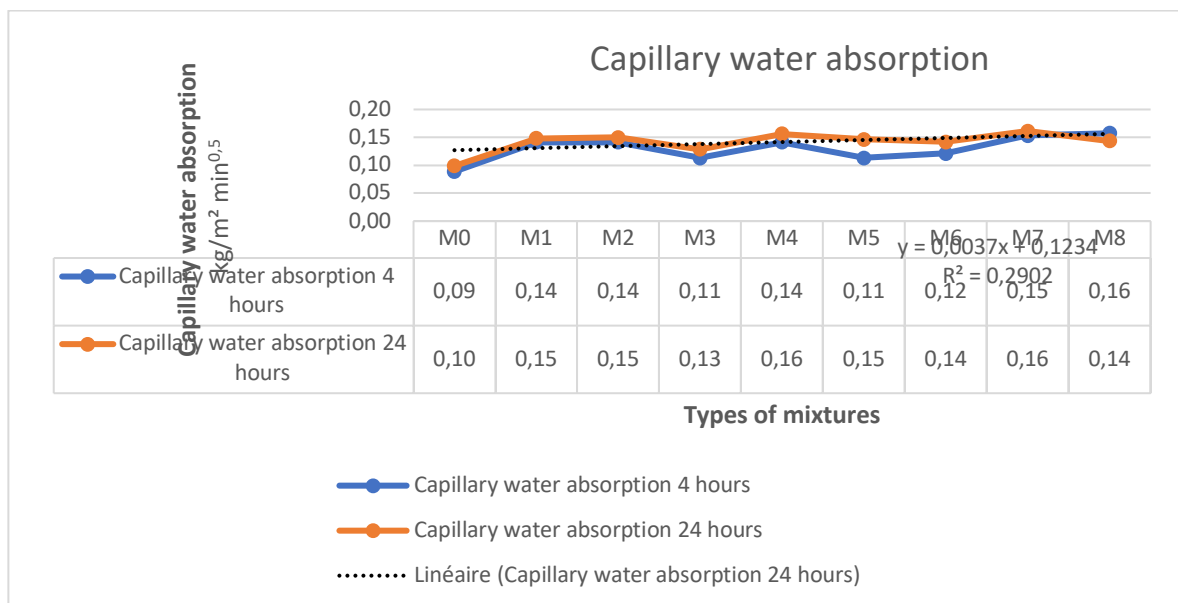


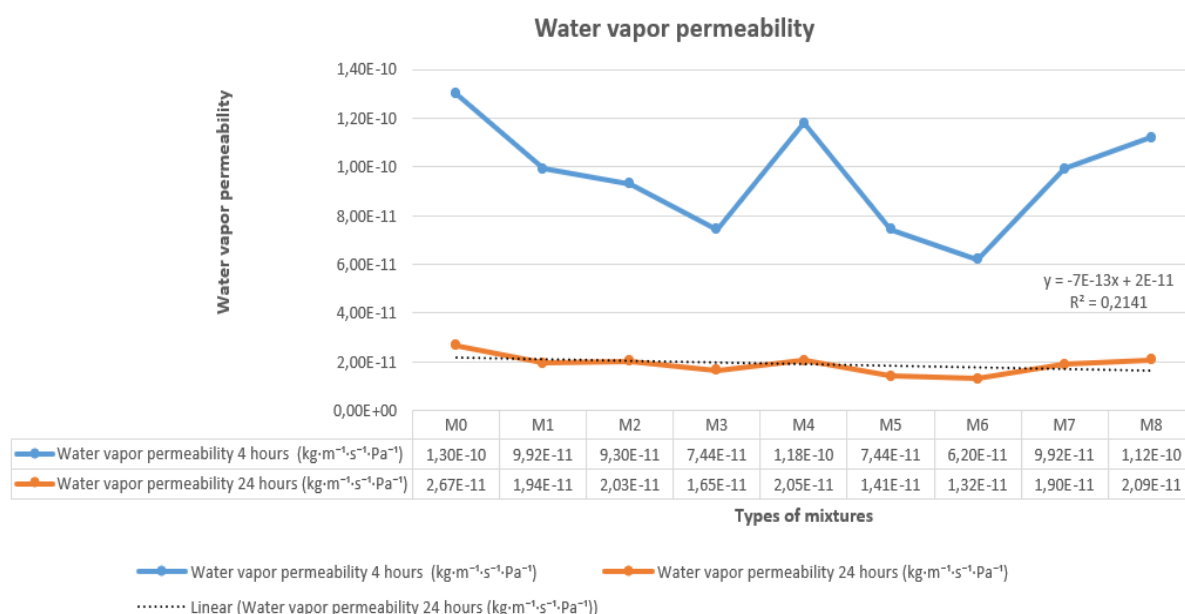
Figure 7. Capillary water absorption

### 3.9 Water vapor permeability

As demonstrated in Figure 8, the inclusion of short jute fibers results in a reduction of water vapor permeability compared to the control mortar. This trend suggests that the natural fibers enhance the resistance to vapor diffusion, leading to a less permeable cementitious structure. (Ramírez *et al.*, 2020) demonstrated that mortars containing waste fibers showed the lowest water vapor permeability values, namely 2.87%, 0.38%, and 1.15% lower than the reference mortar, respectively. This can be explained by the fact that, unlike water absorption values, mortars with a high aggregate content exhibit higher water vapor permeability values (Arizzi *et al.*, 2012), since CO<sub>2</sub> diffuses more easily through aggregates than through the matrix, thereby promoting permeability.

### 3.10 Bulk density

According to the results obtained in Table 4, the addition of short jute fibers slightly affects the bulk density of the mortar. This phenomenon is consistent with the findings of (Ramírez *et al.*, 2020), who also reported that the incorporation of fibers, whether from waste or commercial sources, leads to a marginal decrease in density compared to the reference mix, given the low dosage of fibers added.



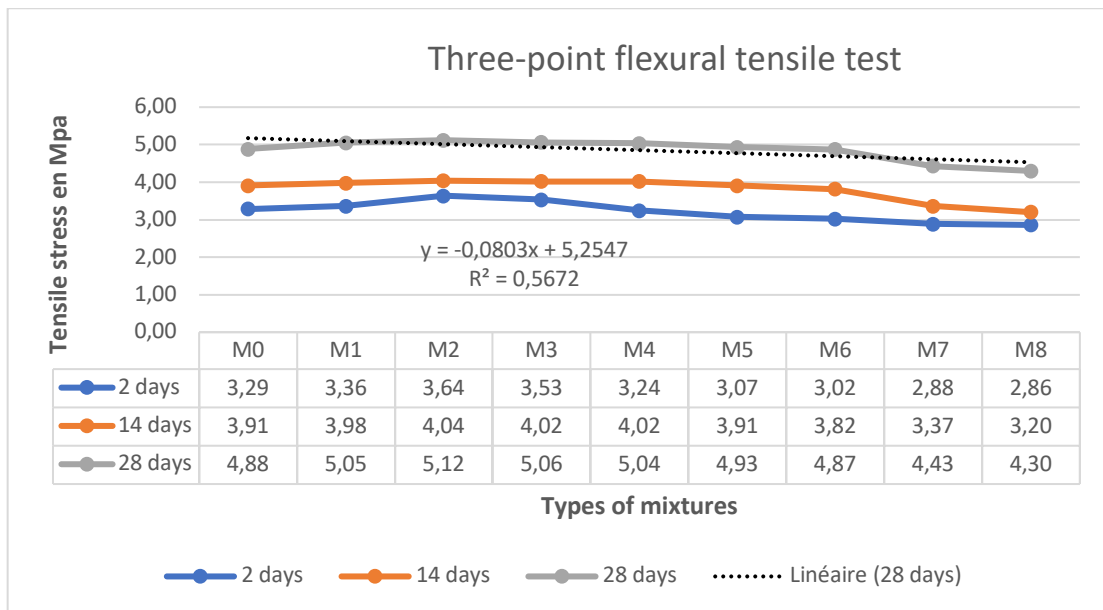
**Figure 8.** Water vapor permeability

**Table 4.** Bulk density

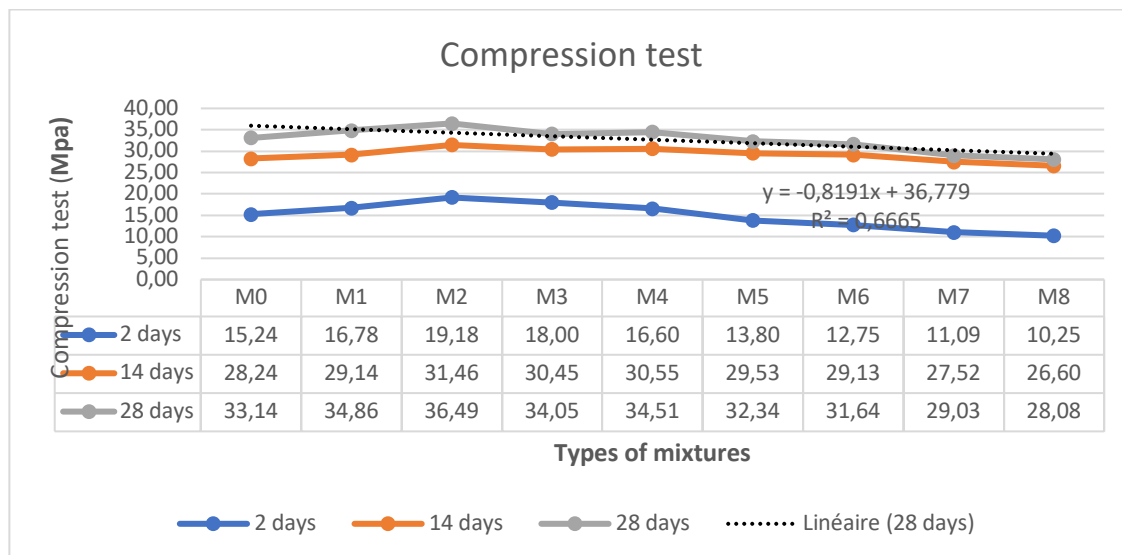
	M0	M1	M2	M3	M4	M5	M6	M7	M8
<b>2 days</b>	2,13	2,13	2,12	2,10	2,10	2,12	2,12	2,13	2,10
<b>14 days</b>	2,14	2,13	2,13	2,10	2,12	2,13	2,12	2,13	2,11
<b>28 days</b>	2,14	2,13	2,13	2,11	2,12	2,13	2,12	2,13	2,12

### 3.11 Tensile and compressive strength

The examination of [Figure 9](#) reveals that the incorporation of short twisted fibers within the cementitious matrix promotes an increase in flexural strength. The optimum performance at 28 days was achieved for a fiber content of 0.5% by weight. For comparison, ([Abdessamed 2017](#)) established that a content of 0.6% date palm fibers maximized tensile strength, reporting an increase of 0.05% compared with the control specimen. Furthermore, the work of ([Ezziane 2010](#)) highlighted that fiber reinforcement has a more significant influence on tensile behavior than on other properties; the incorporation of 0.58% steel fibers resulted in a 25% increase in flexural strength compared with conventional mortar. According to the data presented in [Figure 10](#), the peak compressive strength at 28 days also corresponds to the 0.5% dosage, representing an improvement of 10.11% compared with the reference mortar. Nevertheless, an inverse correlation is observed between the volume of incorporated plant fibers and the load-bearing capacity of the composites: beyond the optimum dosage, the compressive strength decreases. These observations are consistent with the findings of ([Kriker et al. 2005](#)), who attributed this phenomenon to a loss of matrix cohesion and an increase in porosity induced by fiber saturation.



**Figure 9.** Three-point flexural tensile test



**Figure 10.** Compression test

## Conclusion

The analysis of the results demonstrates that the incorporation of short jute fibers leads to a moderate increase in the water absorption of the cementitious mortars, which is directly linked to the porosity changes induced by the fiber presence. However, this increase remains contained, with values ranging between 6.00% and 6.50% (compared to 5.80% for the reference mortar), reflecting a controlled alteration of the material's compactness. Such behavior indicates that the introduction of plant-based fibers, despite their hydrophilic nature, does not result in significant degradation regarding capillary absorption phenomena. Furthermore, compliance with regulatory standards (classes R1, R2, and R3) confirms the suitability of these mortars for real-world applications.

Specifically, the optimal dosage of 0.5%, identified through mechanical performance assessment, also fulfills all requirements related to water absorption. This ensures an effective trade-off between durability and mechanical properties.

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**Disclosure statement:** *Conflict of Interest:* The authors declare that there are no conflicts of interest.

*Compliance with Ethical Standards:* This article does not contain any studies involving human or animal subjects.

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