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OLIVE SOLID WASTE-BASED CONCRETE

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A B S T R A C T

Agricultural waste has gained increasing potential for use in various civil engineering applications such as mortar, concrete, and additives, due to its abundance, recyclability, and promising environmental and energy-saving benefits. Our innovative green concrete material, based on Olive Solid Waste (OSW), contributes to these efforts and aligns with European initiatives promoting the integration of biosourced materials in the construction of both new and renovated buildings. This study explores various treatment methods for waterproofing OSW to make a treated biosourced Olive Solid Waste Concrete (OSWC). Additionally, it evaluates the material's mechanical and thermal properties, with the aim of using it in the manufacture of bricks or insulating panels.

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1. INTRODUCTION

In recent years, lignocellulosic biomass has gained significant attention due to its potential to address pressing environmental challenges. Rising CO2 emissions, as highlighted by (Lecompte, 2021), threaten global ecosystems, prompting urgent climate action under international agreements like the Paris Agreement and Kyoto Protocol (UNFCCC, 2015). These efforts emphasize carbon sequestration and climate mitigation. In France, for instance, 25% of materials in public building renovations must now be biosourced (Mette, 2021). Lignocellulosic biomass, derived from agricultural waste, is increasingly used in sustainable construction materials, such as green concrete and insulation (Al-Akhras et al., 2009). A thorough understanding of its properties and behavior in concrete is crucial for advancing eco-friendly building solutions.

Lignocellulosic biomass is typically characterized by its strong affinity for water, making it hydrophilic. When incorporated into concrete, these materials interact with other components of the mixture, which can significantly affect the amount of water available for cement hydration (Mo et al., 2014). This reduction in free water can, in turn, alter the mechanical and physical properties of the concrete (Barreca & Fichera, 2013). Additionally, their texture, often smooth and poorly adhesive to the cement paste, can limit the interaction between the waste particles and the cement matrix (Bonnet-Masimbert et al., 2020).

Previous studies on incorporating agro-sourced materials into concrete as agreggate, as reinforcements or as partially replacing cement (Dellagi et al., 2024), highlight the importance of reducing water absorption in these materials to ensure their performance (Mo et al., 2014). Islam (2016) recommended limiting the water absorption of olive stone waste (OSW) to improve compressive

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strength, thermal conductivity, and biodegradation resistance. Several methods have been developed to hydrophobize lignocellulosic biomass waste, improving its compatibility with concrete. These include heating (<200°C) to enhance cellulose crystallinity, torrefaction (200–300°C) to strengthen bonding, boiling to eliminate water-soluble sugars, and surface coatings to boost fiber-matrix adhesion (Guo et al., 2023). Other techniques, such as alkaline treatment, bleaching, and hornification, reduce water absorption and enhance mechanical performance, though excessive use of some methods may compromise bonding strength. (Ali et al., 2013).

Collectively, selecting the most suitable method remains challenging due to the wide range of variables and diverse methodological approaches involved. Therefore, the effectiveness of each treatment should be evaluated by carefully weighing its benefits against potential drawbacks. Traore et al. (2018) examined the effects of five different oil palm shell waterproofing treatments on the physical and mechanical properties of concrete, finding that lime treatments yielded the best results. Similarly, Sellami et al. (2013) applied a linseed oil coating to fibers from the wild Diss plant to reduce water absorption and improve material performance.

Tunisia, a top global producer of olive oil, generates significant waste from its olive oil industry, including olive solid waste, which make up about 20% of the total olive product approximately 200,000 tons annually (Medhioub et al,, 2021). Incorporating olive solid waste (OSW) into concrete production presents a dual benefit: reducing waste and lowering the carbon footprint of concrete, thereby promoting more sustainable construction practices.

This study focuses on evaluating different coating treatment methods for waterproofing olive solid waste and investigating the mechanical and thermal properties of cement-treated OSW based concrete (OSWC). By addressing these aspects, the research aims to advance the development of sustainable construction materials and promote the circular use of agricultural waste.

2. MATERIALS AND METHODS

2.1 Materials

The Olive Solid Waste (OSW) used in this study was supplied by Botria Oil, an olive oil extraction company based in the Glelja region. The OSW, a byproduct of the third phase of the olive oil extraction process, was collected from an open-air storage facility. The bulk density and relative density of the OSW were measured at 550 kg/m³ and 1150 kg/m³, respectively. The particle size distribution of the OSW is shown in Figure 1.

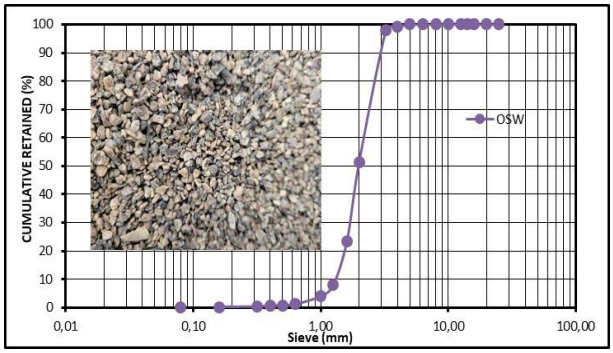


Figure 1. Particle-size distribution of OSW

Additionally, the water absorption and swelling capacity of the OSW, as reported by Medhioub et al. (2022), are depicted in Figure 2.

The cement used in the experiments was CEM I 42.5, manufactured by SOTACIB Kairaouan. It has a bulk density of 1050 kg/m³ and a relative density of 3090 kg/m³.

The sand used in the study was sourced from a quarry in the Oueslatia region. A sand equivalent test resulted in a value of 75%, confirming its suitability for producing high-quality concrete. The bulk density and relative density of the sand were measured at 1.55 kg/m³ and 2500 kg/m³, respectively.

The crushed gravel fractions (4/12 and 12/20) were obtained from the Fayedh rock quarry. These gravels have bulk and relative densities of 1400 kg/m³ and 2750 kg/m³, respectively.

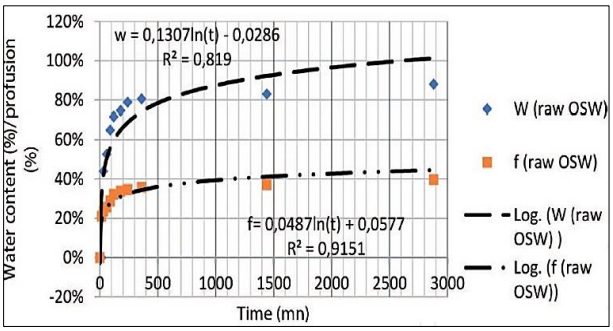


Figure 2. Water absorption and swelling of OSW immersed in water (Medhioub et al., 2022)

2.2 OSW treatments

In this study, four distinct treatments were applied to olive solid waste (OSW) to mitigate its hydrophilic properties and/or alter its surface characteristics. The first treatment, Cement Treatment (CT), involved blending OSW with a solution of Portland cement (CEM II 32.5) and water. The second, Lime Treatment (LT), followed a similar procedure but utilized lime ($Ca(OH)_2$) in place of cement. The third treatment, Poly-treatment (PT), entailed coating the OSW with a polyvinyl alcohol (PVA) solution. The fourth, Synthetic Treatment (ST),

involved applying "Sikagard 790 All-in-One Protect," a fluorinated acrylic copolymer in an aqueous phase.

The procedure for Lime Treatment (LT) and Cement Treatment (CT) was as follows: Raw OSW was initially washed and sieved through a 0.08 mm mesh to eliminate fine particles, then dried at 50 °C for 24 hours. The coating process was optimized using mass ratios of 3:1 for water to binder and 1:1 for OSW to binder. The mixture of OSW, hydraulic binder, and water was agitated for 1 hour at 140 rpm using a Jar Test mixer. The coated OSW was subsequently separated from the paste using a 1.6 mm sieve and stored outdoors at ambient temperature (20 °C) for 28 days before being incorporated into cementitious composites (Al-Mohamadawi, 2016). For the Poly-treatment (PT) and Synthetic Treatment (ST), the procedure differed: OSW was treated with a solid-to-liquid mass ratio of 0.75. The mixture was stirred at a constant speed of 140 rpm for 3 minutes)-(Traore et al., 2018). The liquid phase was then separated from the solid phase using a 1.6 mm sieve, and the OSW was dried at 50 °C for 24 hours.

2.3 Experimental protocol for water absorption analysis of treated OSW

Following the recommendation in (RILEM, 1975), the water absorption analysis of treated olive solid waste (OSW) was conducted through a systematic experimental protocol. Initially, a mass m0 of treated OSW was weighed and then dried in an oven at 105°C for 24 hours until mass stabilization (variation<0.1%). After drying, the stabilized mass m1 was recorded. To evaluate the impact of immersion time on absorption behavior, the sample was fully submerged in water for varying durations (0 to 2880 minutes). At each interval, the final mass mt of the immersed OSW was recorded. The water absorption coefficient Wt was calculated using the formula (1):

$$W_t = \frac{m_t - m_1}{m_1} x100. \quad (1)$$

where: m_1 is the dry mass of the treated OSW, m_t is the mass after immersion for time t.

This approach allowed for the quantification of water absorption dynamics over time.

2.4 OSW based concrete formulation

The volumetric concrete formulation used in this study ensures that the total volume of all components in the mix, whether mineral, polymer, organic, or otherwise, sums to one cubic meter.

For the OSW concrete mix design, 350 kg of cement per cubic meter was employed, with a water-to-cement (W/C) ratio of 0.50. The ratios of coarse to fine gravel and the mix proportions of 4/12 mm and 12/20 mm gravel to sand were set at 1.85 and 1.5, respectively, based on experimental optimization of mixture compactness. Additionally, a selected treated Olive Solid Waste (OSW) was incorporated as a substitute for 30% of the total volume of mineral aggregates.

OSW concrete specimens were cast into three cylindrical molds, with a diameter of 16 cm and a height of 32 cm. The specimens were vibrated in three layers and cured in a wet room maintained at 20°C ± 5°C. After 24 hours, the specimens were demolded. Compressive strength tests were performed using a calibrated hydraulic press at 7 and 28 days of curing. The thermal conductivity of the OSWC was determined using a Hot Disk Thermal Analyzer, in accordance with the methodology described in (ISO, 2022).

3. RESULTS AND DISCUSSIONS

At first glance, the water absorption behavior of treated olive solid waste (OSW) (Figure 3) follows a trend similar to that observed in other bio-based materials, such as oil palm shells (OPS) treated with lime, polyvinyl alcohol (PVA), sodium silicate, etc. (Traore et al., 2018).

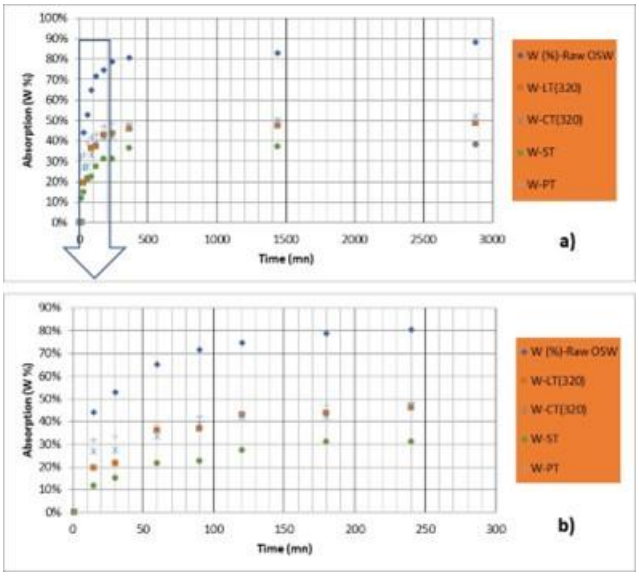


Figure 3. Water absorption kinetics of the OSW aggregates during 48 h (a) with a detailed view of the first 5 hours (b)

This similarity confirms previous findings on the effect of treatments on the water absorption capacity of lignocellulosic biomass materials. For most treatments, including LT(320) and CT(320) which correspond to a concentration of 320 g of cement per liter of water as well as alcohol-based PT treatments, the water absorption of treated OSW is typically reduced by approximately 50% compared to its initial absorption capacity. In contrast, the synthetic treatment (ST) leads to a much more significant reduction, reaching approximately 65%. This difference in behavior can be attributed to the nature of the treatments applied, which alter the internal structure of the materials in distinct ways of surface roughness (Figure 4) on adhesion under real-world drying conditions and its interaction with the binder. This deeper understanding is essential to evaluate its impact on the

mechanical performance and long-term durability of composite materials. The absorption curves of treated OSW (Figure 3) can be explained by an initial gradual filling of inter- and intraparticle voids, until a saturation threshold is reached. Once this threshold is reached, water absorption slows significantly, although it does not cease completely. Indeed, the elasticity of the walls of bio-based particles allows them to expand, promoting additional water absorption. This phenomenon, commonly observed in treated lignocellulosic biomass materials, is characterized by an initial rapid absorption followed by a gradual stabilization.



Figure 4. Visual texture of the treated OSW aggregates

Moreover cement treatments have significantly modified the surface of OSW aggregates, giving them a rough appearance with more greater specific area than raw OSW (Figure 5).

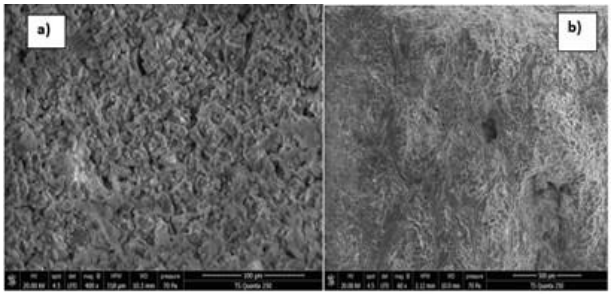


Figure 5. Visual texture of the treated OSW aggregates

This observation led to the hypothesis that cement treatment could enhance adhesion to the cement matrix. Building on these findings, cement-treated Olive Solid Waste (OSW) was chosen for further investigation in our experiments. The mechanical and thermal properties of OSWC (with 30% cement treated OSW replacement) are presented in Table 1.

Table 1. Compressive and flexure strength and thermal conductivity of the OSWC

Characteristics	Unit	Value
Compressive strength (7days)	MPa	6.3
Compressive strength (28days)	MPa	8.53
Flexure strength (28days)	MPa	0.98
Thermal conductivity	W/mK	1.08

It is noteworthy that the Innovative Solid Olive Waste based concrete (OSWC) with 30% cement treated OSW exhibits moderate mechanical properties while surprisingly displaying favorable thermal conductivity (1.08 W/mK). This value is significantly lower than that of conventional concrete, which typically has a thermal conductivity of 1.7 W/m·K (Penu Gina, 2015). These properties make it particularly well-suited for applications in the building sector, such as masonry blocks or insulating panels, where thermal performance is prioritized over mechanical strength.

4. CONCLUSION

This study highlights the potential of Olive Solid Waste (OSW), a renewable and abundant byproduct of the olive oil extraction process, as a key component in the development of Olive Solid Waste-based Concrete (OSWC). By investigating various treatment methods to enhance the waterproofing properties of OSW, our findings demonstrate that the water absorption behavior of treated OSW follows trends similar to those observed in other lignocellulosic biomass materials, such as oil palm shells (OPS). Mineral treatments, including lime, cement, and alcohol-based treatments, typically reduce water absorption by approximately half compared to untreated OSW, while synthetic treatment achieves an even more significant reduction. These variations arise from the distinct ways in which treatments alter the internal structure of the material. The absorption curves of treated OSW reveal an initial phase of gradual void filling by the treatment solution, followed by a slowdown as saturation is approached. Nevertheless, the elastic nature of bio-based particles allows for continued, albeit slower, water absorption a phenomenon consistent with treated lignocellulosic biomass materials.

Additionally, cement treatments have markedly transformed the surface morphology of OSW aggregates, resulting in a rougher texture and increased specific surface area compared to raw OSW. This observation supports the hypothesis that cement treatment enhances adhesion to the cement matrix, making cement-treated OSW a promising candidate for further exploration and application. Notably, the Innovative Solid Olive Waste Composite (OSWC) with 30% cement-treated OSW exhibits moderate mechanical properties while demonstrating superior thermal resistance compared to conventional concrete.

By utilizing renewable resources like OSW, this work contributes to the development of eco-friendly building materials, aligning with global sustainability goals and driving the transition toward greener construction practices.

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References:

Al-Akhras, N. M., Al-Akhras, K. M., & Attom, M. F. (2009). Performance of olive waste ash concrete exposed to elevated temperatures. *Fire safety journal*, *44*(3), 370-375.

Al-Mohamadawi., A. H. (2016). Contribution à l'étude de l'impact de l'environnement vis-à-vis d'éco-matériaux lignocellulosiques. Autre. (Doctoral thesis, Université de Picardie Jules Verne, Français).

Ali, M., Lee, H., & Chouw, N. (2013). Experimental investigations on bond strength between coconut fibre and concrete. *Materials & Design (1980-2015)*, *44*, 596-605. https://doi.org/10.1016/j.matdes.2012.08.038

Dellagi, A., Ayed, R., Skouri, S., Bouadila, S., & Guizani, A. (2024). Analyzing recycled waste-infused mortars: Preparation and Examination of thermal, mechanical, and chemical characteristics. *Construction and Building Materials*, *425*, 135996. https://doi.org/10.1016/j.conbuildmat.2024.135996.

Guo, A., Sun, Z., Feng, H., Shang, H., & Sathitsuksanoh, N. (2023). State-of-the-art review on the use of lignocellulosic biomass in cementitious materials. *Sustain. Struct*, *3*(1), 000023. doi: 10.54113/j.sust.2023.000023

Barreca, F., & Fichera, C. R. (2013). Use of olive stone as an additive in cement lime mortar to improve thermal insulation. *Energy and Buildings*, *62*, 507-513.

Bonnet-Masimbert, P. A., Gauvin, F., Brouwers, H. J. H., & Amziane, S. (2020). Study of modifications on the chemical and mechanical compatibility between cement matrix and oil palm fibres. *Results in Engineering*, *7*, 100150. https://doi.org/10.1016/j.rineng.2020.100150.

Islam, M. M. (2016). Durability properties of sustainable concrete containing high volume palm oil waste materials. *Journal of Cleaner Production* (137), 167–177. doi: https://doi.org/10.1016/j.jclepro.2016.07.061

ISO (2022). ISO 22007-2:2022 Plastics- Determination of thermal conductivity and thermal diffusivity-Part 2: Transient plane heat source (hot disc) method.

Lecompte, T. (2021). Ecomatériaux du Génie Civil à base d'agroressources. MECAMAT.

Medhioub, S., Euchi, J., & Makhloufi, S. (2021). Autonomous water and nutritional anti-stress device to solve a plant irrigation problem based on harvested rainwater: a Tunisian case study. *Irrigation and Drainage*, *70*(4), 705-718. https://doi.org/10.1002/ird.2580.

Medhioub, S., Bouraoui, S., Ellouze, A., & Sabeur, H. (2022). Nutrients Deficit and Water Stress in Plants: New Concept Solutions Using Olive Solid Waste. In *Plant Defense Mechanisms*. IntechOpen (pp. 87-99).

Mette, L. E. (2021). Nos Députés.fr. Retrieved from https://2017-2022.nosdeputes.fr/15/amendement/3995/7012;

Mo, K. H., Alengaram, U. J., & Jumaat, M. Z. (2014). A review on the use of agriculture waste material as lightweight aggregate for reinforced concrete structural members. *Advances in Materials Science and Engineering*, *2014*(1), 365197.

Penu Gina. (2015). La Thermique du Bâtiment. DUNOD.

RILEM. (1975). Recommandation, n°10.2 et n°4.

Sellami, A., Merzoud, M., & Amziane, S. (2013). Improvement of mechanical properties of green concrete by treatment of the vegetals fibers. *Construction and Building Materials*, *47*, 1117-1124.

Traore, Y. B., Messan, A., Hannawi, K., Gerard, J., Prince, W., & Tsobnang, F. (2018). Effect of oil palm shell treatment on the physical and mechanical properties of lightweight concrete. *Construction and Building Materials*, *161*, 452-460.

UNFCCC. (2015). United Nations Framework Convention on Climate Change. Adoption of the Paris Agreement (FCCC/CP/2015/L.9/Rev.1). Retrieved from https://unfccc.int.

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