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Mechanical Performance of Concrete with Graphene-Oxide-Treated Recycled Coarse Ceramic Aggregates: Effects on Aggregate Water Absorption and Workability

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Abstract

The replacement of natural aggregates with recycled aggregates in concrete production has gained attention as a sustainable approach for valorizing construction and demolition waste (CDW). Although regulatory frameworks in this area remain underdeveloped, extensive research has demonstrated that acceptable mechanical and durability properties can be achieved. However, the elevated water absorption associated with recycled materials—mainly due to residual attached mortar and increased porosity—continues to pose a challenge. When used without prior treatment, these particles absorb part of the mixing water intended for cement hydration, potentially compromising both fresh and hardened concrete performance. This study explores the use of graphene oxide (GO) nanocoating as a surface modification strategy to mitigate water absorption. Absorption test were performed to evaluate the effectiveness of the treatment, followed by the preparation of multiple concrete mixes incorporating varying substitution rates of natural aggregate with untreated and GO-treated recycled material. The mixtures were assessed for workability and compressive strength. Results indicate that GO nanocoating substantially reduces water (up to 30%) uptake and improves the overall performance of concrete containing recycled constituents, increasing its compressive strength by up to 32%, highlighting its potential as a viable pretreatment for sustainable concrete production.

Keywords: construction and demolition waste; treatment of recycled coarse aggregate; graphene oxide; water absorption; slump test; compressive strength

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1. Introduction

The depletion of natural resources, coupled with the large volume of construction and demolition waste (CDW) generated by the construction industry, has led to global environmental concern. Consequently, numerous research efforts have focused on identifying sustainable solutions to this issue [1–3]. In this context, there is an increasing trend in construction practices towards the reuse and valorization of CDW, primarily through the incorporation of recycled aggregates (RAs) as a partial or total replacement for natural coarse aggregates.

Globally, several countries have established regulations governing the use of recycled aggregates in concrete production. The leading nations in this regard include those within the European Union, particularly Spain, Germany, the Netherlands, and France-, as well as the United Kingdom, the United States, Japan, and Australia [4–6]. In most of these countries, the use of recycled aggregates derived from clean structural concrete is permitted, although its incorporation if often limited to specific proportions to ensure the mechanical performance and durability of recycled concrete. The use of mixed aggregates or those with a high ceramic content is more restricted; many countries authorize their application only in non-structural elements. Only a few, such as Germany and the Netherlands, have incorporated provisions in their regulations allowing the use of such aggregates in structural concrete production [7,8].

Despite the limited legislation on recycled concrete and the lack of specific standards governing its production in most countries, the scientific literature includes a substantial number of studies [9–13] that have investigated the properties of concrete produced by partially or fully replacing natural aggregates with various types of recycled aggregates. These studies have demonstrated the technical feasibility of such practices. However, there is a general agreement that the high water absorption capacity of recycled aggregates remains one of the main limitations, as it negatively affects the consistency and workability of the fresh mix as well as the mechanical and durability properties of the hardened concrete.

In Spain, Chapter 30.8 of the Structural Code (Structural Code, Royal Decree 470/2021, of 29 June) [14] specifically regulates the use of recycled aggregates to produce recycled concrete. This code establishes the physical requirements for recycled aggregates, including a maximum water absorption limit of 7%. However, most recycled aggregates of mixed or ceramic origin exhibit water absorption values that exceed these regulatory thresholds. Aggregates derived from crushed concrete tend to show higher water absorption capacities compared to natural aggregates, primarily due to the presence of residual mortar adhered to their surface, which increases the overall porosity of the material [15–19]. In the case of recycled aggregates with a high ceramic content, water absorption values are even higher. This is mainly attributed to the intrinsic characteristics of ceramic components, which are rich in clay minerals and exhibit a highly porous crystalline structure [20–22].

The high water absorption capacity of these aggregates directly influences the amount of effective water available for the mix, thereby affecting both cement hydration and the workability of fresh concrete, as well as the mechanical and durability properties of the hardened material. Several researchers [23–25] have reported a decrease in slump values as the replacement ratios or natural aggregates with recycled concrete aggregates increase. Moreover, this trend becomes more pronounced with higher ceramic content in the recycled aggregate. Various studies [26,27] have also highlighted that the increased porosity of the components used in recycled concrete production results in inferior mechanical performance, reflected in reductions in compressive strength, elastic modulus, freeze–thaw resistance, shrinkage resistance, and other related parameters.

Consequently, it is essential to implement techniques aimed at reducing the water absorption capacity of recycled aggregates to mitigate the effects associated with their high porosity and to ensure that concrete mixtures achieve the target water-to-cement (w/c) ratio defined in the mix design. The strategies proposed to date can be broadly categorized into four main approaches: (i) removal of adhered mortar form the surface of recycled aggregates through chemical treatments (e.g., HCl or polymer-based solutions) or mechanical abrasion methods [28–30]; (ii) incorporation of water-reducing admixtures (such as plasticizers or superplasticizers) [31], pozzolanic materials [32,33], or nanomaterials [34]; (iii) optimization of the mixing procedure by employing two- or there-stage mixing techniques [35,36]; (iv) enhancement in recycled aggregate performance through

biodeposition processes [37–39], carbonation treatments [40–42], or nanomaterial-based surface coatings [43–45]. Within this last group of strategies, the technique proposed in the present study aims to address the issue of reduced workability of fresh concrete when recycled aggregates are used. The application of a nanocoating to these aggregates prior to their incorporation into the mix represents one of the most effective solutions in terms of enhancing the mechanical performance and durability of the final material.

Surface nanoengineering has emerged as a key strategy to optimize the performance of RA through the utilization of nanomaterials categorized by their morphology into nanoparticles (0D), nanofibers (1D), and nanosheets (2D) [46]. Among these, graphene oxide (GO) can be emphasized due to its high surface area, functionalization capability, large-scale availability, and low environmental impact [47].

GO has been proposed as a nanoengineering material for coating surfaces such as silica fume, enhancing the protection and performance of cementitious composites [48–52]. Its application on coated aggregates has been shown to favorably modify the concrete interface, resulting in a denser microstructure and reducing the thickness of the interfacial transition zone (ITZ) [51,53]. These findings have encouraged the investigation of GO as a coating for recycled aggregates, aiming to reduce their high permeability and enable their use a substitute for natural aggregates in concrete.

The present study aims to evaluate the technical feasibility of graphene oxide (GO) nanocoating of recycled aggregates as a strategy to improve the workability and consistency of recycled concrete, in scenarios involving various replacement levels of natural aggregates. In the first phase, the water absorption capacity of recycled aggregates subjected to different treatment methods was determined to assess their impact on the effective mixing water content. Subsequently, concrete mixes were prepared using different replacement ratios of natural aggregate with recycled aggregate, combined with distinct treatment types, to analyze their influence on the consistency of fresh concrete through slump tests. Finally, to validate the effectiveness of the applied nanocoating technique, compressive strength tests were conducted to evaluate its influence on the mechanical properties of hardened concrete.

2. Materials and Methods

2.1. Materials

The cement used for the concrete mixtures was a ground granulated blast furnace slag cement, type CEM III/A 42.5 N/SR (Tudela Veguín, Aboño, Asturias, Spain). The fine aggregate consisted of natural siliceous sand with a fineness modulus of 3.60. The natural coarse aggregate was siliceous gravel with a maximum particles size of 16 mm and a fineness modulus of 7.8. The recycled coarse aggregate was supplied by Excavaciones Germán Casas S.L., a construction and demolition waste management facility located in Barcelona, Spain. This aggregate had a maximum particles size of 16 mm and a fineness modulus of 8.7.

Initially, the aggregates were evaluated to verify its compliance with the requirements established in the EN 12620:2003+A1:2009 [54] standard and in Chapter VIII of the Structural Code [14] (Table 1, Figure 1).

The results revealed a single non-compliance for the mixed recycled aggregate, as the water absorption value exceeded the specified limit, as expected.

The age of the waste materials collected at the treatment plant ranged from 6 to 18 months, but it was not possible to determine the age of the original demolished buildings. These materials were collected from various urban construction sites and transported to an authorized treatment facility for processing.

Table 1. Physico-mechanical requirements for aggregates.

Standard	Test	Test and Result		Limit Value [14]
		Recycled Aggregates	Natural Aggregates	
UNE-EN 933-1:2012 [55] UNE-EN 933-2:2022 [56]	Particle size analysis D/d ratio Fines content	 4 1.46%	 4 0.02%	 ≥1.4 ≤1.5%
UNE-EN 1097-6:2025 [57]	Water absorption Apparent density After oven-drying density Saturate surface density	8.68% 2.58 Mg/m^3 1.91 Mg/m^3 2.17 Mg/m^3	1.18% 2.63 Mg/m^3 1.94 Mg/m^3 2.58 Mg/m^3	≤7.0% - - -
UNE-EN 933-3:2012 [58]	Flakiness index	4.64%	3.60%	≤35%
UNE-EN 1097-2:2021 [59]	Los Angeles coefficient	38.47%	24.06%	≤40%

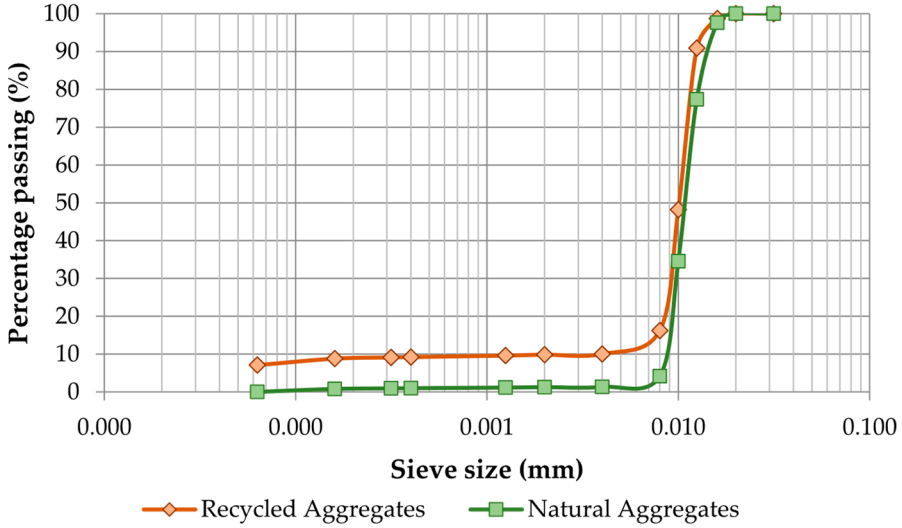


Figure 1. Particle size curve of natural and recycled aggregates.

The processing sequence at the treatment plant comprised the following stages: reception and preliminary sorting of the waste, during which incompatible materials (such as plastics, wood, non-ferrous metals, gypsum, etc.) were discarded; primary and secondary crushing, performed using jaw and cone crushers, respectively, to achieve the target particle size distribution; granulometric classification by screening; and impurity removal through magnetic separation and washing systems aimed at reducing the presence of adhered fines and enhancing the quality of the recycled aggregate.

The macroscopic composition of the recycled aggregate is also a factor to be considered; therefore, it was determined in accordance with the UNE-EN 933-11:2009 [60] standard and is presented in Table 2. Furthermore, the chemical composition of the recycled aggregates was determined by X-ray fluorescence (XRF) analysis, the results of which are presented in Table 3.

Table 2. Recycled aggregate composition.

Component	Recycled Aggregates (%)
Ru: Natural aggregates	0.0
Rb: Bricks and tiles	98.6
Rc: Concrete and mortar	1.4
Ra: Bituminous materials	0.0
Rg: Glass	0.0
X: Others	0.0

Table 3. XRF chemical composition.

Elements (wt%)											
SiO_2	Al_2O_3	Fe_2O_3	MnO	MgO	CaO	Na_2O	SO_3	K_2O	TiO_2	P_2O_5	LOI
42.04	11.54	4.28	0.07	2.51	20.66	0.76	2.71	1.99	0.54	0.14	12.67

2.2. Concrete Mixes

Four concrete mixtures were prepared using natural aggregates (NAs) and recycled aggregates (RAs) in the combinations shown in Table 4.

Table 4. Quantity of natural and recycled aggregates used in various concrete mixes.

Mixtures	Amount of NA	Amount of RA
Mix 0	100%	0%
Mix 20	80%	20%
Mix 50	50%	50%
Mix 100	0%	100%

All concrete mixtures were designed to achieve a target average compressive strength of 25 MPa [61]. The proportions of all components used in each mixture are detailed in Table 5.

Table 5. Components of concrete mixes.

Components (kg/m^3)	Quantity of RA			
	0%	20%	50%	100%
Natural aggregates	1060.9	790.0	442.6	0.0
Recycled aggregates	0.0	197.5	442.6	732.3
Sand	667.1	669.2	744.1	811.0
Cement	390.0	390.0	390.0	390.0
Water	215.0	215.0	215.0	215.0
Water/cement ratio	0.55	0.55	0.55	0.55

2.3. Treatment of Recycled Aggregates

The recycled aggregates used in the different mixtures were subjected to the following pretreatment conditions:

- No treatment.
- Immersion in water for 10 min, followed by oven drying for 48 h at 70 ± 5 °C (Figure 2).
- Immersion in graphene oxide for 10 min, followed by oven drying for 48 h at 70 ± 5 °C (Figure 2).

Distilled water was used for water-based treatment. In contrast, the graphene oxide treatment was performed using GO dispersion at a concentration of 0.5 mg/mL. This dispersion was commercially sourced and produced from graphite, which was subjected to a series of chemical processes to obtain monolayer graphene sheets that were subsequently dispersed in water. The amount of dispersion absorbed by the recycled aggregates was 3.0 mL, resulting in a final GO particle deposition of 1.5 mg on the surface of the aggregates after oven drying.



(**a**) (**b**)

Figure 2. Images of the type of treatment of the recycled aggregates (**a**). Images of the recycled aggregates after treatment (**b**).

2.4. Water Absorption

Recycled aggregates exhibit higher porosity compared to natural aggregates, resulting in an increased capacity to absorb water. Consequently, a portion of the mixing water becomes unavailable for the cement hydration reaction. One of the aims of nanocoating is to provide a technique capable of reducing the water absorption capacity of recycled aggregates, thereby ensuring that more water remains available for the mixture during the batching process.

To evaluate the effectiveness of nanocoating, a study based on hydrostatic weighing was conducted to assess the water absorption behavior of recycled aggregates over time established by UNE-EN 1097-6:2025 [57]. The water absorption test was conducted following a controlled procedure to ensure comparability between treated and untreated samples. The aggregates were immersed in water maintained at a constant temperature of 20 ± 1 °C for a duration of 1 h. Prior to immersion, the samples were oven-dried at 70 ± 5 °C until a constant mass was achieved. After the immersion period, the aggregates were superficially drained and immediately weighed to determine the absorption percentage.

2.5. SEM Analysis

To investigate the distribution of graphene oxide (GO) coating on the recycled aggregates, a microstructural analysis was conducted using scanning electron microscopy (SEM). The observations were performed with a Hitachi S-4810 scanning electron microscope.

2.6. Consistency

One of the most significant challenges in producing concrete with recycled aggregates is the reduction in workability. The concrete tends to become drier and more difficult to handle, which may give the impression that there is insufficient water in the mix; however, the water is “retained” within the aggregates.

To assess the effectiveness of the nanocoating technique, a slump test was conducted in accordance with the guidelines established in UNE-EN 12350-2:2020 [62]. This test involves compacting the fresh concrete into a conical mold (Figure 3). Upon lifting the cone vertically, the vertical displacement due to the slump of the concrete serves as an indicator of its consistency.



Figure 3. Slump test.

2.7. Compressive Strength

The water-to-cement ratio can be disrupted by the high water absorption capacity of recycled aggregates, potentially leading to reductions in the mechanical strength of the concrete. Uncontrolled absorption results in inconsistent mixtures, reducing the homogeneity of the concrete and leading to irregular compressive strength values.

To verify that nanocoating enhances control over the water-to-cement ratio, as well as the compactness and cohesion of the concrete matrix, a 28-day compressive strength test was performed on three specimens in accordance with UNE-EN 12390-3:2020 [63]. This ensured that the concrete incorporating nanocoated recycled aggregates achieved the target average compressive strength.

2.8. Statistical Analysis

Experimental results are reported as mean values accompanied by their standard deviation, calculated from a minimum of three repetitions for each test. Error bars in the figures represent the corresponding standard deviation, allowing for the visualization of data variability and reproducibility.

3. Results and Discussion

3.1. Water Absorption

Water immersion tests performed to assess the water absorption capacity of the recycled aggregates showed that those coated with graphene oxide (GO) exhibited significantly reduced water uptake compared to uncoated counterparts. This finding indicates that the nanocoating is effective in reducing the water absorption capacity of recycled aggregates. As shown in Figure 4, recycled aggregates pretreated with water absorb approximately 7–10% of water within the first 3–5 min of immersion. In contrast, recycled aggregates coated with GO absorb only about 5–9% during the same period. Therefore, the application of GO-based coating enables a reduction of up to nearly 30% in water absorption by mixed recycled aggregates within the first 3 min of water exposure, which implies a greater availability of mixing water for the cementitious matrix. It is important to highlight that, over

time, the reduction in water absorption capacity of the GO-nanocoated recycled aggregates remains consistently stable at approximately 13%.

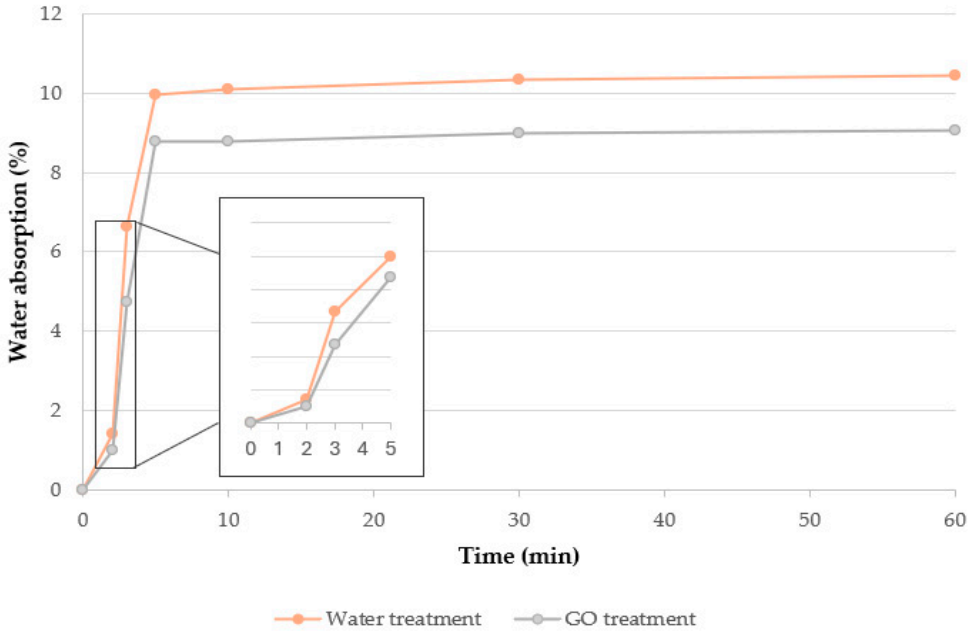


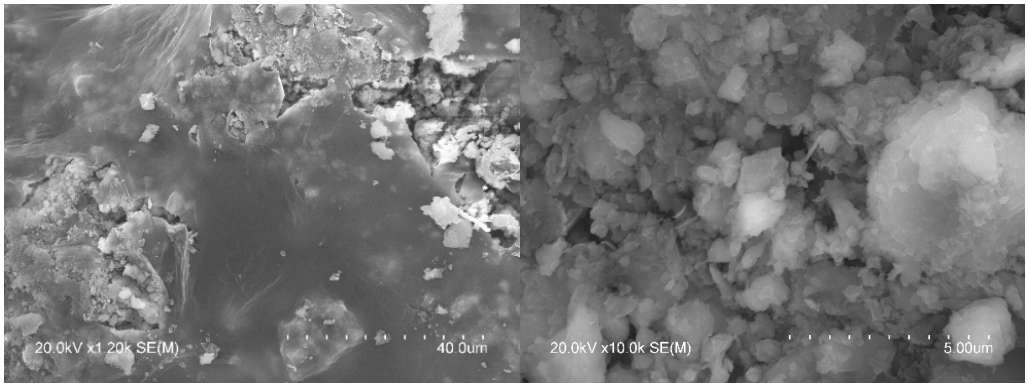
Figure 4. Water absorption percentage of mixed recycled aggregates with different surface treatments.

The application of graphene oxide coating on recycled aggregates contributes to the reduction in their water absorption capacity primarily due to two mechanisms: the blockage of surface pores and the chemical interaction between GO and the aggregate. Graphene oxide exhibits a lamellar structure composed of extremely thin nanoscale sheets, which can penetrate and coat the surface pores of the aggregate [64]. This creates a physical barrier that hinders water ingress into the pores, thereby reducing water absorption. Additionally, the functional groups present in GO can react with compounds found in the residual mortar adhered to the aggregates [65], forming a sealing layer that effectively fills microcracks or open capillaries within the recycled aggregate.

These findings are consistent with the studies conducted by Lu et al. [66] and Nguyen et al. [53], which demonstrated that the application of a graphene oxide (GO) nanocoating on recycled aggregates effectively reduces their water absorption capacity. These authors reported an initial reduction in water absorption of up to 14%, with further improvements reaching up to 52% when a silane coupling agent (KH550) and ethanol were used to enhance the adhesion of the GO nanocoating.

3.2. SEM Analysis

The scanning electron microscopy (SEM) analysis provides clear evidence of the GO treatment applied to the surface of recycled aggregates. As shown in Figure 5a, a continuous graphene oxide (GO) film uniformly covers the aggregate surface, indicating effective coating formation. These observations align with those reported by Lu et al. [66], who also explored GO as a nanocoating for recycled aggregates and observed strong adhesion and homogeneous surface coverage. In contrast, Figure 5b displays the untreated recycled aggregate surface, characterized by a significantly rougher and more irregular morphology, with open pores, loose particles, cracks, and surface impurities clearly visible.



(**a**) (**b**)

Figure 5. (**a**) Surface of recycled aggregate coated with GO; (**b**) surface of control recycled aggregate.

It is noteworthy that the rough microstructure of the aggregate remains visible through the graphene oxide (GO) coating, as shown in Figure 5a, indicating that the coating has a minimal thickness. The preservation of the surface roughness after coating application is a typical characteristic of conformal coatings. Therefore, it can be concluded that GO functions as a thin, conformal nanocoating that adheres effectively to the aggregate surface.

This feature of the GO nanocoating arises from its composition, which consists exclusively of GO nanosheets with thicknesses in the order of nanometers [67]. Previous studies [68,69] have demonstrated that these nanosheets can assemble into laminar structures acting as membranes with selective filtration capabilities, rendering GO an effective barrier. This selective filtration property is one of the most notable characteristics of two-dimensional GO assemblies. Various metal ions, such as Al^{3+}, Ca^{2+}, and Mg^{2+}, can serve as cross-linking agents between the GO layers, stabilizing the assembly structure and enhancing its filtration capacity. It is important to note that these alkaline earth cations are fundamental components of the recycled aggregates employed. Therefore, it is plausible that chemical interactions occur between GO and these cations present on the aggregate surface, contributing to improved adhesion of the coating to the substrate [70,71].

3.3. Slump Test

Figure 6 presents the slump test results for each of the concrete mixtures produced, which include different replacement levels on natural aggregates with recycled aggregates, as well as the various surface treatments applied: GO treatment (aggregates coated with graphene oxide), water treatment (aggregates treated with water), and control treatment (untreated aggregates).

The results indicate an increase in concrete workability when washed recycled aggregates (water-treated) are used. This phenomenon occurs because untreated recycled aggregates contain a high content of fine, dust, and adhered particles, which absorb more water and act as a “sponge”, thereby reducing the amount of free water available in the mix. Water treatment of recycled aggregates removes many of these fine particles, leaving more water available for the mixture, which results in improved workability. These findings are consistent with the studies by Revilla-Cuesta et al. [72] and Zheng et al. [73], which demonstrated that the use of pre-washed recycled aggregates enhances concrete workability due to the increased free water content in the mix.

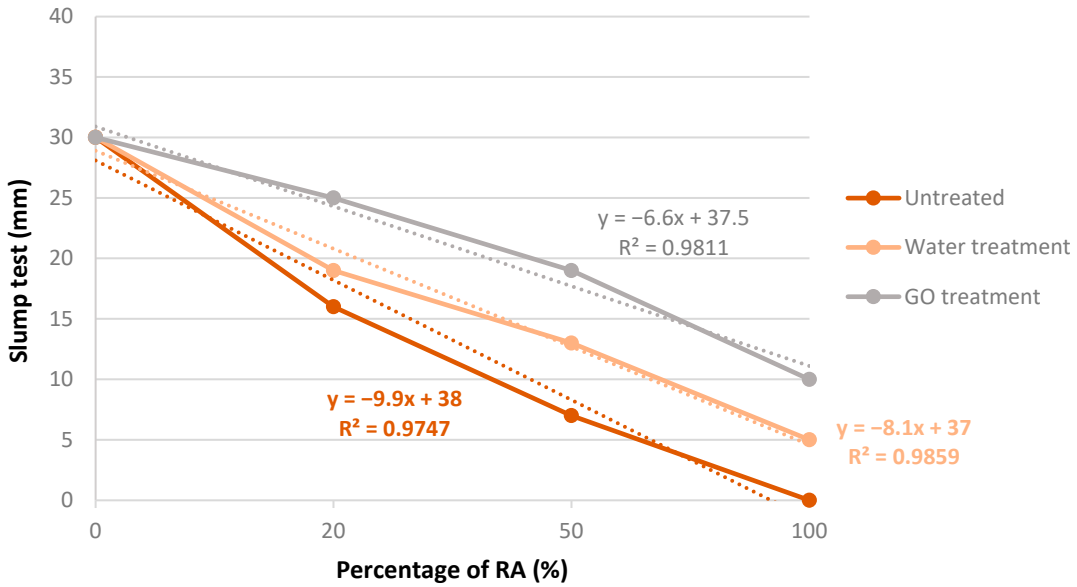


Figure 6. Slump test results for each concrete mix substitution and type of treatment of recycled aggregate.

On the other hand, the results also indicate an increase in concrete workability when recycled aggregates coated with graphene oxide are used. This improvement can be attributed to several technical factors: the GO coating forms a nanometric film on the surface of the aggregate, which reduces its surface porosity [74]. As a result, water absorption in the fresh mix decreases, increasing the amount of free water available to lubricate the cement paste. Furthermore, GO possesses hydrophilic and functional properties that enhance the interaction between the recycled aggregate and the cement paste [75,76], thereby reducing internal friction within the mix, facilitating particle movement, and improving overall flowability. Similar results were reported in several studies [77,78], in which various researchers demonstrated improved consistency and workability of concrete when recycled aggregates were coated with a GO dispersion. In some cases, the fresh workability of the concrete increased by up to 13%.

3.4. Compressive Strength

The results of the 28-day compressive strength tests are presented in Figure 7. On one hand, the compressive strength increased with the application of water treatment to the recycled aggregates. Regarding the expected improvement in mechanical performance due to water treatment, concrete mixtures incorporating water-treated recycled aggregates exhibited an increase in compressive strength of up to 15% compared to the control mixtures (produced with untreated recycled aggregates). This behavior has also been reported in several previous studies [79,80]. Sun et al. [79] concluded that the moderate incorporation of recycled aggregates into self-compacting concrete yields satisfactory performance, particularly when the aggregates undergo a pre-washing process. This treatment removes adhered fines, which in turn significantly enhances compressive strength. Similarly, Dabiri et al. [80] demonstrated that concrete produced with water-washed recycled aggregates displays higher compressive strength than concrete made with untreated aggregates.

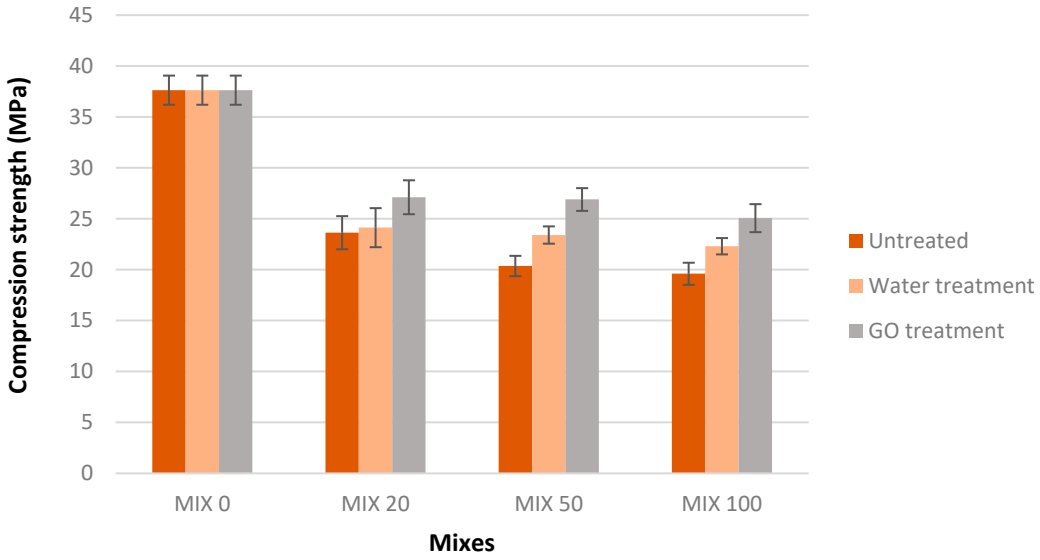


Figure 7. Compressive strength test results.

On the other hand, the results also showed that compressive strength increased when recycled aggregates treated with graphene oxide were used in concrete mixtures. Regarding the probable enhancement in mechanical performance due to the presence of GO, concrete incorporating these treated aggregates exhibited an increase in compressive strength of up to 32% compared to the control mixture (with untreated recycled aggregates), and up to 15% compared to mixtures produced with water-treated recycled aggregates). Similar results were reported in the study by Lu et al. [81], in which recycled aggregates coated with graphene oxide were tested. The compressive strength of concrete specimens incorporating GO-coated recycled aggregates increased significantly by approximately 39% in comparison to those containing uncoated aggregates. The concrete mixtures with GO-pretreated recycled aggregates exhibited enhanced compressive strength primarily due to improvements in the interfacial transition zone (ITZ). A strengthened ITZ, characterized by an improved paste–aggregate interfacial bond and a more refined microstructure, likely contributed to the observed increase in compressive strength.

It is also worth noting that compressive strength decreased as the percentage of recycled aggregates used in the mixtures increased. This phenomenon can be attributed to the fact that higher replacement levels of natural aggregates led to a greater incorporation of recycled aggregates, which are generally of lower quality compared to natural ones. Recycled aggregates typically exhibit lower bulk density, a higher content of adhered mortar, and a weaker interfacial transition zone (ITZ) between the cement paste and the aggregate [82–84].

Despite these findings, it is important to note that the target average compressive strength of 25 MPa was not achieved in all the mixtures evaluated. This value was only reached in the mixtures incorporating GO-treated recycled aggregates. Therefore, the results confirm the effectiveness of the GO treatment in addressing the water absorption issue commonly associated with recycled aggregates.

4. Conclusions

This study demonstrates the feasibility of the GO nanocoating technique as an effective approach to mitigate the high water absorption typically exhibited by recycled aggregates in concrete production. The obtained results confirm that the pretreatment of recycled aggregates with a nanomaterial significantly reduced their water absorption capacity, which

in turn led to notable improvements in both the fresh-state workability and the compressive strength of the resulting recycled concrete.

Based on the results presented in this study, it was determined that immersing the recycled aggregates in a graphene oxide (GO) dispersion for 10 min, followed by oven drying, led to a significant reduction in their water absorption capacity.

The GO nanocoating contributed to an increase in the amount of free water available in the concrete mix, thereby enhancing the workability and resulting in higher slump flow values.

The incorporation of GO-coated recycled aggregates led to an improvement in the compressive strength of the recycled concrete, with enhancements of up to 30%. The GO treatment enabled the studied mixtures incorporating these treated recycled aggregates (even at a 100% replacement level) to achieve target average compressive strengths of 25 MPa.

Therefore, it can be concluded that the proposed technique constitutes a simple and rapid method to address the excessive water absorption commonly associated with recycled aggregates when used in the production of eco-efficient concrete. This solution not only enhances the material's performance but also relies on accessible and increasingly available technological resources.

In this context, the use of GO dispersion represents a viable option, as it is widely available on the market and relatively affordable. In fact, GO is the most economical graphene derivative, with Spain and other European countries highlighted as major producers. Currently, a dispersion with a concentration of 0.05% by weight is commercially available at an approximate industrial-use price ranging from USD 5 to 25 per liter.

Although the use of GO-coated recycled aggregates entails a significant increase in the cost per cubic meter of concrete, there are specific applications in which the benefits, particularly in terms of durability, sustainability, mechanical performance, or logistical efficiency, may justify the investment. This approach aligns with a "long-term value" perspective rather than a "lowest initial cost" mindset, making it especially relevant for advanced engineering projects, strategic infrastructure, or sustainable construction initiatives.

Nevertheless, although this study assessed the influence of graphene oxide (GO) coating on the water absorption of coarse recycled aggregates, as well as its effects on the workability and mechanical properties of concrete, durability-related tests were not considered. Specifically, parameters such as resistance to freeze–thaw cycles, exposure to sulfate-rich environments, or other aggressive agents were not evaluated nor was a microstructural analysis conducted to verify the long-term stability of the GO coating. It is recommended that future research address these limitations in order to achieve a more comprehensive characterization of the performance of concrete produced with various types of treated recycled aggregate.

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Data Availability Statement: The original contributions presented in this study are included in this article. Further inquiries can be directed to the corresponding author.

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Abbreviations

The following abbreviations are used in this manuscript:

CDW	Construction and demolition waste
GO	Graphene oxide
HCl	Hydrochloric acid
NA	Natural aggregates
RA	Recycled aggregates
ITZ	Interfacial interaction zone
XRF	X-ray fluorescence
SEM	Scanning electron microscopy

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