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Improvement of the Mechanical Behavior of an Environmental Concrete Based on Demolished Concrete Waste and Silica Fume

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Abstract

The universal need to conserve resources, protect the environment, and use energy efficiently must necessarily be felt in the field of concrete technology. In Algeria, the rapid growth in the construction sector and the difficulties in setting up new quarries make it necessary to find effective alternatives to use them as building materials. The recycling of construction and demolition waste as a source of aggregates for the production of concrete has attracted growing interest from the construction industry. In this context, this work is a part of the approach to provide answers to concerns about the lack of aggregates for concrete. It also aims to develop the inert fraction of demolition materials, mainly concrete construction demolition waste (C&D), as a source of aggregates for the manufacture of new hydraulic concrete based on recycled aggregates. This experimental study presents the results of physical and mechanical characterizations of natural and recycled aggregates, as well as their influence on the properties of fresh and hardened concrete. The characterization of the materials used has shown that the recycled aggregates have heterogeneity, a high-water absorption capacity, and medium-quality hardness. However, the limits prescribed by the standards in force do not disqualify these materials from use for application as recycled aggregate concrete. The effect of silica fume and superplasticizer percentage on the mechanical and physical properties of concrete with NA and RA was analyzed and optimized using full-factorial design methodology. The results obtained from the present study show acceptable mechanical, compressive, and flexural strengths of concrete based on recycled aggregates by using Superplasticizer and 5% of silica fume, compared to those with natural aggregates. The results of the water absorption as well as the UPV confirm the positive effect of the use of superplasticizer and silica fume on the physical and mechanical behavior of concrete with recycled aggregates. Factorial design analysis shows that the developed mathematical models can be used to predict the physical and mechanical properties of concrete with RAC, superplasticizer, and silica fume.

Keywords: Recycled Aggregates Concrete (RAC); Superplasticizer; Silica Fume; Compressive Strength.

1. Introduction

Over the past decades, the construction industry has grown rapidly, especially in developing countries, leading to the depletion of natural resources and the generation of large amounts of construction and demolition waste [1–3]. Recycled Concrete Aggregates (RA) make up the majority of waste aggregates from demolished concrete. The manufacture of RA-based concrete by replacing natural aggregates (NA) has been promoted as an efficient way to use

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construction waste and conserve natural resources [4–6]. It is generally believed that the poor characteristics of RA compared to NA, such as considerable water absorption, higher porosity, and low density, lead to an adverse effect on the fresh and hardened properties of concrete [7, 8]. Therefore, RA has been mainly limited to non-structural uses at present [1]. Moreover, the main cause of these disadvantages of RA is the mortar adhering to the aggregates [3]. This mortar forms a new interface transition zone (ITZ) between itself and the new cement paste, which becomes the weakest region in the concrete with RA [9–11].

Consequently, the performance of recycled aggregate concrete should be improved by improving the properties of RA and/or ITZ to facilitate the reuse of this waste on a large scale in the construction field [9, 12]. Several researchers have proposed many techniques to try to improve the properties of RA. These techniques can be classified into three categories: (1) Removal of old mortar bonded in RA; (2) Reinforcement of the old mortar bonded in RA; (3) Improvement of the transition zone between RA and the new RA mortar. The methods that have been adopted to remove the old mortar stuck in the RA, one distinguishes between mechanical grinding with balls [7, 8, 13, 14], pre-soaking in acid solutions such as HCl [15, 16], and ultrasonic cleaning [17]. However, the disadvantages associated with these methods are increased energy consumption, higher CO_2 emissions, more waste fines produced, and increased chloride and sulfate contents in RA due to acidic solutions [1]. The techniques to reinforce the old mortar adhered in RA, we find the researchers [12, 16, 18, 19] applied the accelerated carbonation test to the RA to precipitate the CO_2 in the pores and H_2O which react with $Ca(OH)_2$ and (C-S-H) increasing the hardness of the old mortar. Thus, Li et al. (2021) [1] immersed ARs in nano-silica to fill the voids between the grains of the old mortar. Another method to reinforce this mortar is to immerse the RA in a solution of sodium silicate, which can significantly reduce the water absorption of the RA [14], but this method could increase the risk of alkali silica reaction [1].

Another way to improve the properties of RA is to improve the new interface area between the RA and the new cement mortar. On the one hand, some studies have been carried out on the coating (before or during mixing) of the surface of ARs with a pozzolanic material such as silica fumes, fly ash [10, 14]. In addition, some researchers have covered the ARs with chemicals such as geopolymers or polymers [20, 21], lithium silicate [22], bio-bacteria [3]. On the other hand, according to Dimitriou et al. (2018) [9] replaced part of the cement with two mineral additions (silica fumes and fly ash). They concluded that the mechanical properties and durability of RAs were improved. Mistri et al. (2020) and Wang et al. (2020) [23, 24] have carried out a critical analysis of the different treatments for RA that exist in the literature. They concluded that the best, most economical, and environmentally friendly treatment is to incorporate pozzolanic additives into the concrete. The presence of these additions to the concrete can fill the voids between the ARs and the paste due to the pozzolanic reaction.

1.1. Research Significance

Numerous studies have been carried out on the use of RAs and examined their impact on the mechanical and physical properties of concrete. Recently, the methods of treating RA have been increasing. However, the number of studies of treatment methods with pozzolanic products and their combination with the superplasticizer on concrete has remained limited. In addition, a statistical analysis was performed to have models that predict the phenomena studied experimentally. Therefore, the main purpose of this paper is to use 100% RA so that the concrete produced undergoes acceptable mechanical and physical performance. For this, we will add 5% of the silica fume and 1.5% of the superplasticizer to the concrete with and without RA. Compression, ultrasonic bending, and absorption tests were performed on hardened concrete.

2. Experimental Procedures

In this study, a combined experimental and modeling approach was used. Figure 1 summarized the flowchart of the research methodology.

2.1. Materials

In this study, A CEM II / B 42.5 cement confirming the requirements of EN 197-1 [25] was used in all the concrete mixes; it has an initial and a final setting time of 40 and 125 minutes respectively and an absolute density of 3.1 g/m^3. Silica fume as mineral addition was also used, the chemical composition of cement and silica fume are presented in Table 1 .

Table 1. Chemical composition of cement and silica fume

Component (%)	SiO_2	CaO	Al_2O_3	Fe_2O_3	MgO	SO_3	PF	Na_2O
Cement	20.7	62.92	4.75	3.75	1.90	1.98	1.72	0.09
Silica Fume	87	0.9	1.9	0.07	1	-	0.5	-

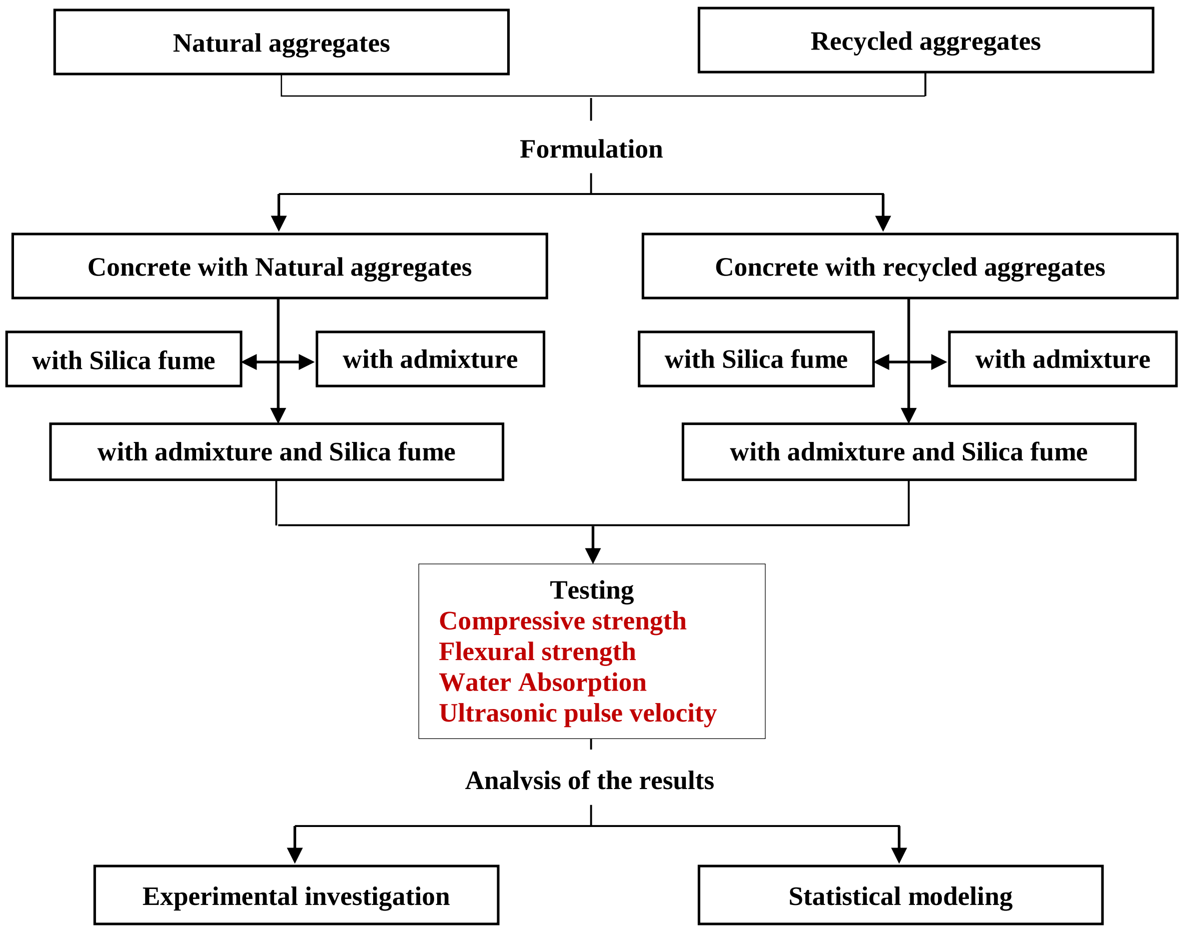

Figure 1. Flowchart of the research methodology

2.1.1. Natural Aggregates

A crushed limestone aggregate was used in this experimental investigation. Tow size fractions 3-8 and 8–16 mm were used. The physical and mechanical properties of natural aggregates (specific gravity, coefficient Los Angeles, and water absorption capacity) are shown in Table 2.

Table 2. The physical and mechanical properties

Aggregate	Specific gravity (g/ m^3)	LA (%)	Water absorption (%)
Natural aggregates	2.60	20.12	1.42
Recycled concrete aggregates	2.11	35.28	9.12

2.1.2. Recycled Concrete Aggregates

In this study, recycled aggregates RA were obtained from concrete specimens of the C 25-30 concrete class. The preparation process is based two main steps (Figure 2); Using a jaw crusher, concrete specimens were crushed into aggregate with a maximum size of 16 mm, then recycled aggregate was mechanically sieved and divided into fractions of 3/8 mm and 8/16 mm. In this step obtaining recycled coarse aggregate granulometry was similar to the natural aggregates (Figure 3).

MEDAFLUID SP 40R Superplasticizer was used. In addition to its function as a water reducer, it has a second function as a setting retarder for concrete. The properties of the Superplasticizer admixture used are given in Table 3. Tap water free of all impurities was used in this study. The raw materials used are shown in Figure 3.

Figure 2. Processes used in the production of recycled concrete aggregates

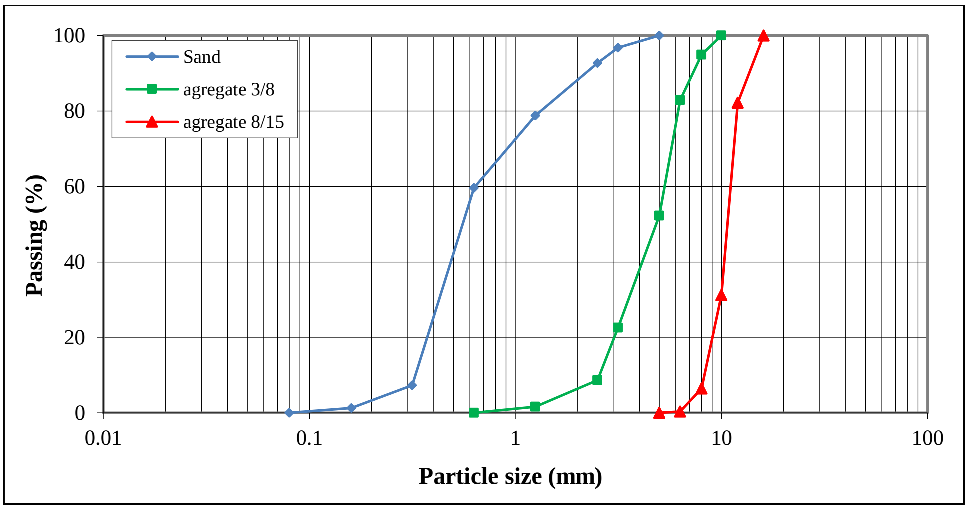

Figure 3. Particle size analyses of natural and recycled aggregate

Table 3. Properties of the Superplasticizer admixture

	Density (g/m^3)	Chloride content (g/L)	pH value
Superplasticizer	1.17 ± 0.02	≤ 0.1	8-9

Figure 1. Raw materials

2.2. Concrete Specimens

All mixes prepared were proportioned using the Dreux_Gorisse method [26]. Table 4 summarizes the proportions of mixtures. The specimens used in this study were as follows:

- Concrete cubes of 100 mm side were used to determine the compressive strength according to NF EN 12390-3[27].
- Concrete prisms of 70*70*280 mm were used to determine the flexural strength according to NF EN 12390-5[28].

Table 4. Proportions of mixtures

	Cement (Kg/m^3)	Water (Kg/m^3)	Sand (Kg/m^3)	Natural aggregates (Kg/m^3)	Recycled concrete aggregates (Kg/m^3)	Silica Fume (%)	SP (%)
CC			579.55	1123.04	0	0	0
OCA			579.55	1123.04	0	0	1.5
OCF			579.55	1123.04	0	5	0
OCAF	336.11	209.31	579.55	1123.04	0	5	1.5
RC			495.05	0	1,223.76	0	0
RCA			495.05	0	1,223.76	0	1.5
RCF			495.05	0	1,223.76	5	0
RCAF			495.05	0	1,223.76	5	1.5

Where, CC is the control concrete, OCA is the Ordinary Concrete with admixture (1.5%), OCF is the Ordinary Concrete with silica fume (5%), OCAF is the Ordinary Concrete with admixture (1.5%) and silica fume (5%), RC is the Recycled concrete, RCA is the Recycled Concrete with Admixture (1.5%), RCF is the Recycled Concrete with Silica fume (5%) an RCAF is the Recycled Concrete with admixture (1.5%) and silica fume (5%).

3. Results and Discussion

3.1. W/C Ratio

The results of the effective water /cement ratio as a function of concrete mixtures are shown in Figure 5.The results indicated that the recycled concrete (RC) presented the highest value of W / C ratio compared to ordinary concrete (CC) by an increase of 8.2%. The same for mixtures based on RC and with silica fume and/or Superplasticizer, which also showed an increased water /cement ratio compared to the specimen composite with the same composition with natural aggregate. This increase in the W/C ratio is due to the high absorption of water for recycled aggregate relatively with natural aggregate; in which, water absorption for recycled aggregate is between 3 –10% (9.12% in our case) and less than 5 % for natural aggregates[29, 30]. The addition of the combination (silica fume and the Superplasticizer) increased W / C ratio by about 4.34% for concrete with RA comparatively with natural aggregate concrete.

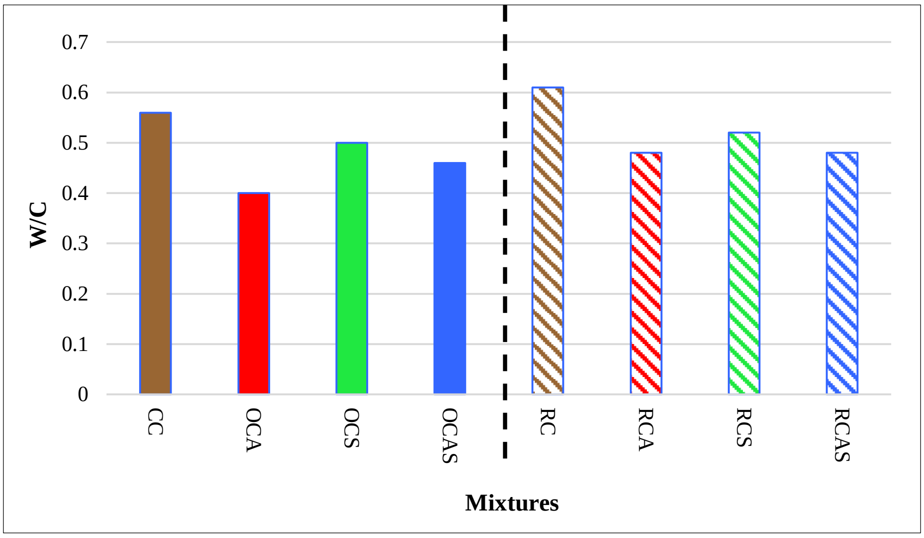

Figure 5. The variation of water/cement ratio for studied mixtures

3.2. Compressive Strength

The results of the compression strength tests of the reference mixtures containing NA and four series of concretes based on the recycled aggregates are given in Figure 6, each result representing the average of three cubic specimens of 100×100×100 mm. According to Figure. 6, a reduction in compression strength for RC mixtures relative to the OC has been found. This decrease is around 9%, 8%, and 17% to 7, 14, and 28 days, respectively. Because of the replacement effect of the quantity of natural crushed aggregates by recycled aggregates with a rate of 100% which weakens the adhesion between the aggregates and cement binding hydrates therefore a lower mechanical performance behavior. Moreover, the new interfacial transition zone ITZ between the new cement paste and recycled aggregate (RA) presents the weakest region in concrete with recycled aggregate (RC) type [3,31].

The appropriate modification in our mixtures by incorporating a mineral addition such as silica fume (SF) may result in improved concrete properties [32-34]. By way of example, the presence of 5% of the SF in the RCS causes an increase in compressive strength by 17% compared to RC at 28 days. The technical objective of the use of pozzolanic additions is the decrease of pores of the concrete due to secondary hydration between these added additions and a by-product of the cement hydration (Ca(OH)2). Thus, the resistance of the concrete depends directly on the presence of the pores and internal cracks in the composite [10]. Li et al. [35] examined the effect of RA coating by pozzolanic solutions (silica smoke and blast furnace slag). They concluded that the presence of these additions in the RCA is more efficient on mechanical performance with a denser ITZ. Regarding the chemical addition (the Superplasticizer) in the RC presents significant efficiency at 28 days. RCA concrete revealed an increase in 19% compression strength compared to RC at 28 days. This increase is probably due to the reduction of the E / C ratio causing a decrease in capillary pores in concrete. Thus, the presence of Superplasticizer promotes a good homogeneity of the concrete and a good repair of the grains of the cement that can reveal an improvement of the ITZ. However, there is no significant effect of these additions (silica fume or Superplasticizer) in RC compression resistance at maturities 7 and 14 days. This observation agrees with previous studies declaring that the effect of SF at 7 days is negligible and improved resistance to compression is possible at a more advanced age [4, 36].

The positive effect of SP and SF separately has pushed us to test a mixture of RC and OC containing a combination of these factors. According to Figure 6, a similar resistance of RCAS and RC has been found. Therefore, no significant effect of (SP + SF) has been noted. However, the OCAS mixtures reveal a slight increase in the resistance of 3% by comparing with OC at 28 days. This phenomenon needs a more in-depth study.

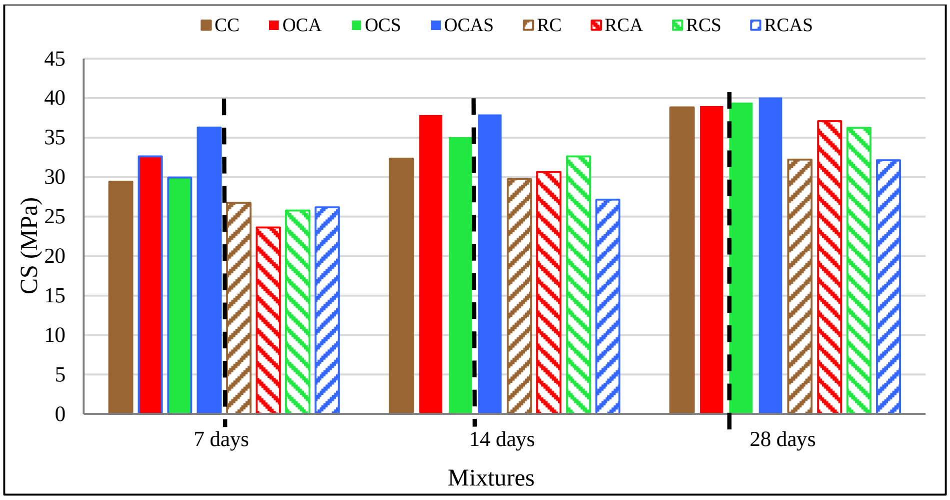

Figure 2. The variation of compressive strength for studied mixtures

3.3. Flexural Strength

The results of the flexural strength tests of the reference mixtures containing NA and four series of concretes based on the recycled aggregates are given in Figure 7, each result representing the average of three prismatic specimens of 70mmx70mmx280mm.From the results obtained in Figure 7, a decrease in flexural strength of the order of 20.9% in concretes containing 100% recycled aggregates (RC), compared to the reference concrete (CC) was observed.

In addition, the introduction of silica fume in recycled concrete (RCF) causes a considerable increase in flexural strength of 43.6% over the RC at 28 days. This can be explained by the decrease in the pores of the SCR due to the secondary hydration between the silica fume and the portlandite ($Ca(OH)_2$) from the hydrated cement [10]. In addition, the introduction of the Superplasticizer reveals effectiveness in the flexural strength of all mixtures. Thus, RCA concrete showed an increase in flexural strength of 32% compared to RC. This increase is probably due to the reduction in the amount of water causing a decrease in capillary pores in concrete [36]. Moreover, the presence of Superplasticizer promotes good homogeneity of the concrete and good repair of the cement grains which can improve the interface zone between the recycled aggregates and the new cement matrix. Regarding the effect of the combination between FS and SP, we see that RCAS shows an increase in flexural strength of 34% compared to RC. Therefore, a significant effect of (SP + SF) was found. In addition, the OCAS mixtures show a slight increase in strength of 4% when compared with OC. The same result was found for compressive strength.

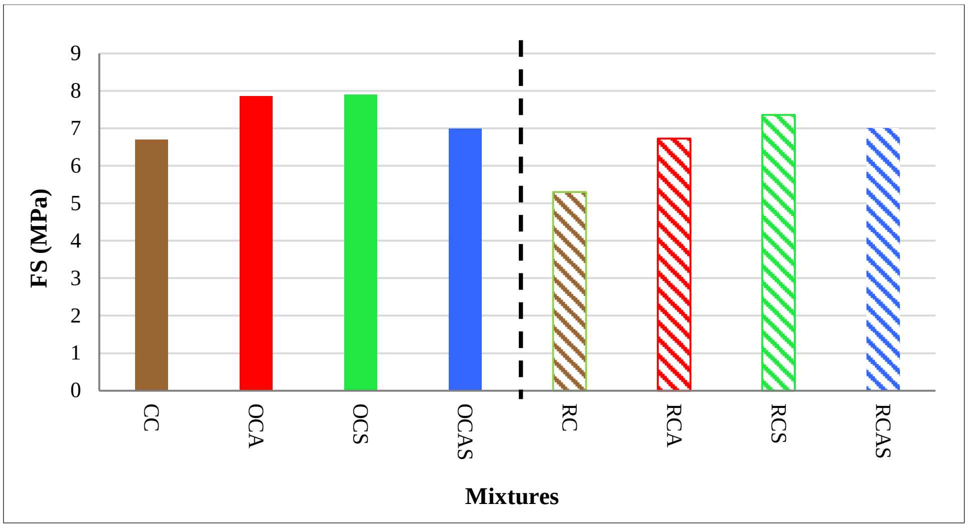

Figure 7. The variation of flexural strength for studied mixtures

3.4. Water Absorption

The water absorption rate of concrete is an important indicator of concrete durability [1]. The water absorption rate of concretes with recycled or natural aggregate is presented in Figure 8. The result has shown that the water absorption value is higher for recycled concrete by around 42% comparatively to control concrete (with natural aggregate); this increase translates the effect of the old mortar paste which remains on the surface of the demolition aggregates and make the recycled aggregates type much more absorbent to water. On the other hand, RCS (concrete with recycled aggregate and silica fume) presents the highest water absorption rate (5.62 %). However, the addition of Superplasticizer (RCAS mixture) clearly reduces the water absorption, this reduction is noticed by the effect of the Superplasticizer which especially the reduction in the amount of water as reducing agent.

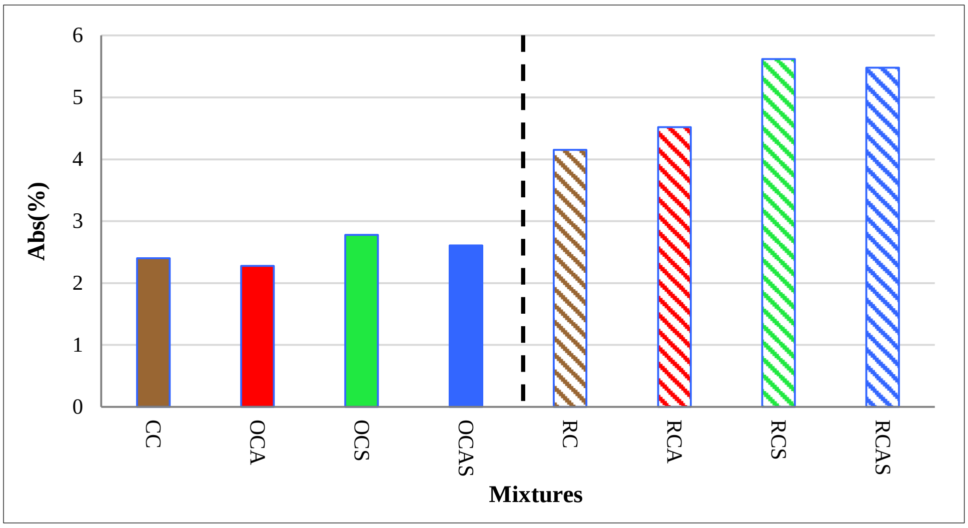

Figure 8. Water absorption of concrete for studied mixtures

3.5. Ultrasonic Pulse Velocity (UPV)

Figure 9 shows the effect of recycled aggregates and treatment methods on ultrasonic pulse velocity (UPV) for cubic samples (100×100×100 mm) after 7, 14, and 28 days of curing. From the results, concretes without RA had the highest pulse velocities of all mixtures with RA at 7, 14, and 28 days. These results are in agreement with Kou et al. [37]. This decrease is due to the high porosity and the low density of the concretes containing RA which are the two most important factors to reduce the pulse velocity [38]. As shown in Figure 8 The addition of silica fume in CRs causes an increase in UPV compared to CR without FS at 28 days. This is due to the pozzolanic reaction of FS. In addition, RCA (with SP) showed an increase in UPV of 16.4%, 1%, and 6% compared to RC at 7, 14, and 28 days. These results are in agreement with [1] who showed that increasing the w / c ratio resulted in a decrease in pulse velocities which can be attributed to an increase in porosity. Regarding the RCAFs revealed the lowest UPV of all mixtures. This reflects the incompatibility between the binder (Cement + SF) and the Superplasticizer.

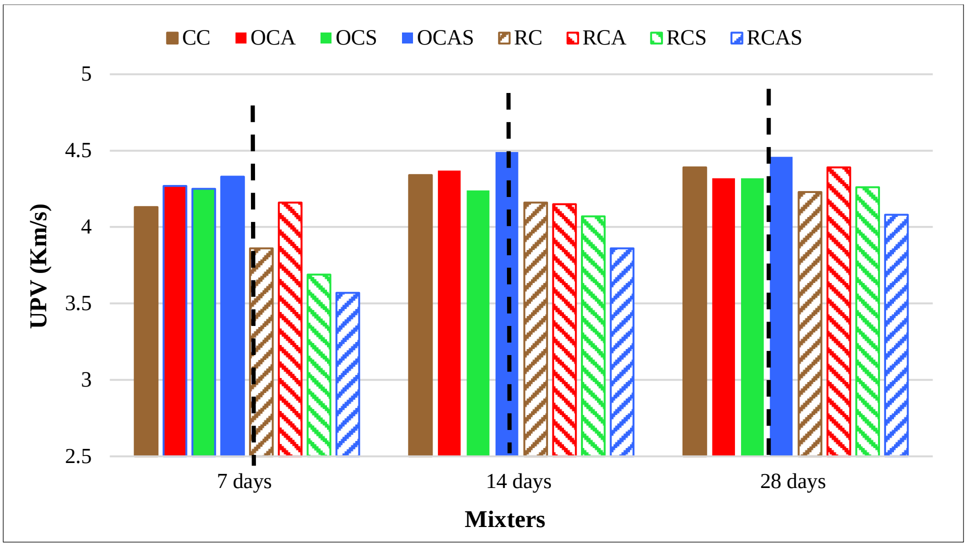

Figure 9. Ultrasonic pulse velocity UPV at (7, 14 and 28) days for studied mixtures

4. Statistical Modeling

A full factorial design (2^2) was established to investigate the effect of Superplasticizer (SP) dosage and silica fume content on the physical and mechanical properties of recycled aggregate concrete (RAC) and natural aggregate concrete (OC). The values of each factor and their respective levels are presented in Table 5. The design results of experimental tests were shown in Table 6. JMP software was used for statistical modeling.

Table 5. The experimental ranges and factors level

Levels	SP (%)	SF (%)
-1	0	0
+1	1.5	5

Table 6. Results of experimental tests

Factor		Responses					
		Ordinary Concrete			Recycled aggregate concrete		
SF(%)	SP(%)	CS 28days (MPa)	UPV 28days (km/s)	Abs (%)	CS 28days (MPa)	UPV 28days (km/s)	Abs (%)
-1	-1	38.85	4.39	2.4	32.23	4.23	4.15
-1	+1	39.01	4.32	2.28	37.08	4.39	4.52
+1	-1	39.45	4.32	2.78	36.23	4.26	5.62
+1	+1	40.09	4.46	2.61	32.15	4.08	5.48

The quadratic statistical models for compressive strength at 28 days, ultrasonic pulse velocity at 28 days, and the water absorption for both ordinary concrete and recycled aggregate concrete are given in equations 1 to 6 respectively:

$$\text{CS 28days(MPa) OC} = 39.35 + 0.42\frac{\text{SF}-2.5}{2.5} + 0.\,2\frac{\text{SP(\%)}-0.75}{0.75} + 0.12\frac{\text{SF}-2.5}{2.5}\frac{\text{SP(\%)}-0.75}{0.75} \tag{1}$$

$$\text{CS 28days(MPa) RC} = 34.422 - 0.232\frac{\text{SF}-2.5}{2.5} + 0.019\frac{\text{SP(\%)}-0.75}{0.75} - 2.23\frac{\text{SF}-2.5}{2.5}\frac{\text{SP(\%)}-0.75}{0.75} \tag{2}$$

$$\text{UPV 28days(Km/s) OC} = 4.245 + 0.045\frac{\text{SF}-2.5}{2.5} + 0.055\frac{\text{SP(\%)}-0.75}{0.75} - 0.015\frac{\text{SF}-2.5}{2.5}\frac{\text{SP(\%)}-0.75}{0.75} \tag{3}$$

$$\text{UPV 28days}\left(\frac{\text{Km}}{\text{s}}\right)\text{ RC} = 4.37 + 0.017\frac{\text{SF}-2.5}{2.5} - 0.017\frac{\text{SP(\%)}-0.75}{0.75} - 0.052\frac{\text{SF}-2.5}{2.5}\frac{\text{SP(\%)}-0.75}{0.75} \tag{4}$$

$$\text{Abs(\%) OC} = 2.52 - 0.177\frac{\text{SF}-2.5}{2.5} - 0.075\frac{\text{SP(\%)}-0.75}{0.75} - 0.0125\frac{\text{SF}-2.5}{2.5}\frac{\text{SP(\%)}-0.75}{0.75} \tag{5}$$

$$\text{Abs(\%) RC} = 4.94 - 0.61\frac{\text{SF}-2.5}{2.5} - 0.0575\frac{\text{SP(\%)}-0.75}{0.75} - 0.13\frac{\text{SF}-2.5}{2.5}\frac{\text{SP(\%)}-0.75}{0.75} \tag{6}$$

4.1. Compressive Strength

The magnitude of the coefficient in the Equations 1 and 2, which presented models for compressive strength of ordinary and recycled concrete respectively, indicates that the silica fume percentage has the most significant main effect on the compressive strength; the influence is positive for ordinary concrete but negative for recycled concrete. The isoresponse and surface response for compressive strength of the two concrete types presented in Figures 10 and 11 were plotted from the regression quadrature models that's why the contour lines had a curved fit.

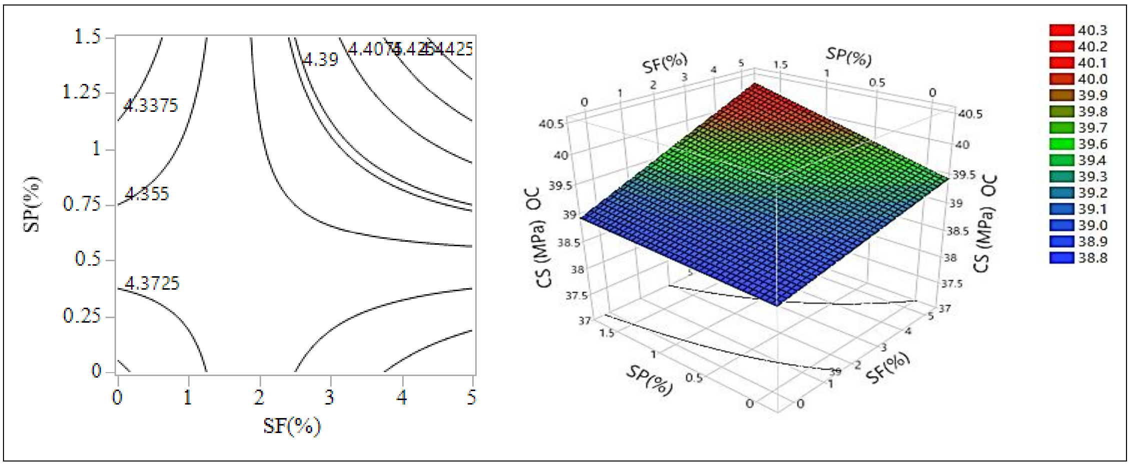

Figure 10. Isoresponse curves and response surfaces of compressive strength of ordinary Concrete as a function of Superplasticizer (SP) and silica fume (SF) percentages

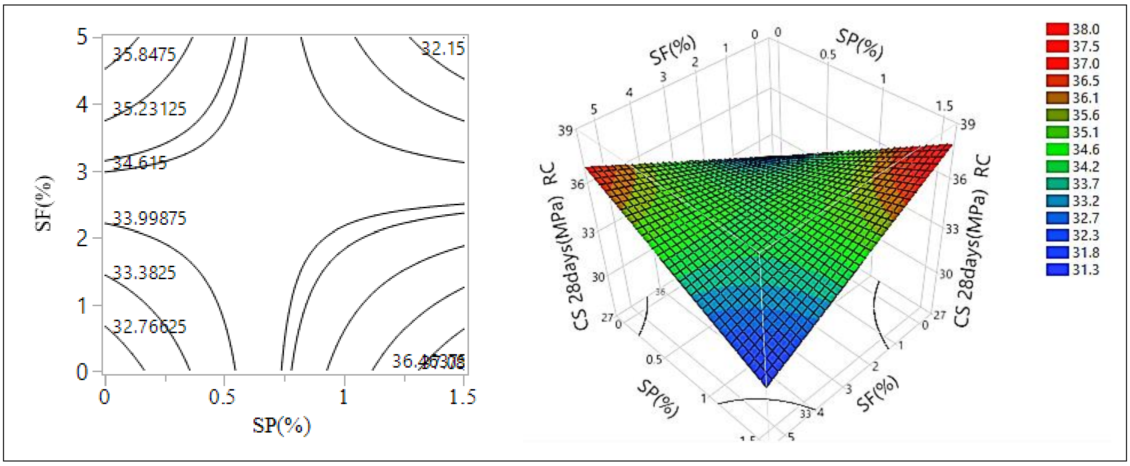

Figure 11. Isoresponse curves and response surfaces of compressive strength of recycled concrete as a function of Superplasticizer (SP) and silica fume (SF) percentages

For ordinary concrete isoresponse and surface, response shows clearly that the most effective factor on the compressive strength was the silica fume (SF). The optimum conditions of compressive strength were 5% silica fume and 1.5% Superplasticizer, respectively. On the inverse, the use of recycled aggregate causes different behavior when the optimum conditions of compressive strength were 0% silica fume and 1.5% Superplasticizer or 5 % silica fume and no Superplasticizer this mechanical behavior can be explained by the incompatibility phenomena of silica fume and Superplasticizer with recycled aggregate.

4.2. Ultrasonic Pulse Velocity

From Equations 3 and 4 of ultrasonic pulse velocity for concrete with natural and recycled aggregate, it can be observed that the silica fume positively influences the UPV for the two types of concrete. However, the Superplasticizer dosage effect positively the UPV in ordinary concrete but negatively in recycled concrete mixers. Figures 12 and 13 shows the isoresponse and surface response for concrete with natural and recycled aggregate, respectively. For ordinary concrete, the use of 5% silica fume and 1.5% Superplasticizer gives the optimum value of UPV. However, RC with 1.5% Superplasticizer and without SF presents the better ultrasonic pulse velocity registered results.

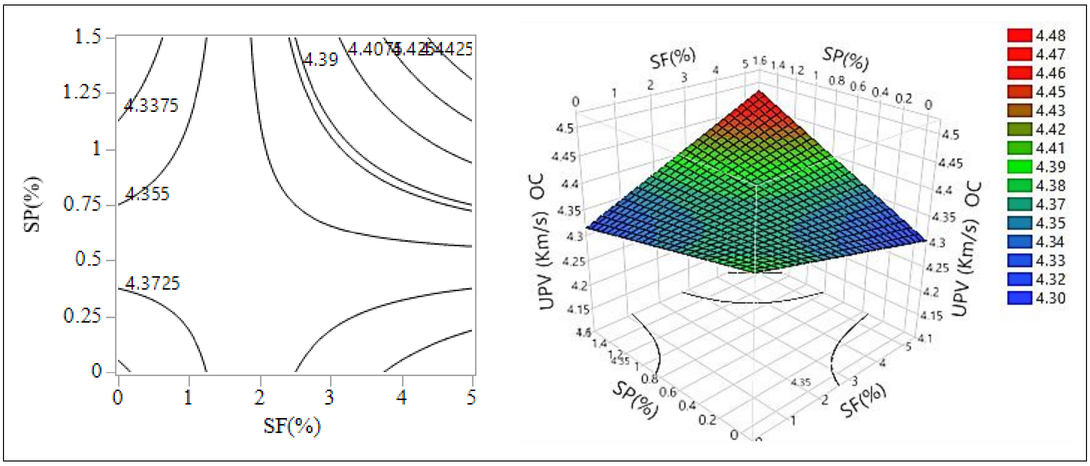

Figure 12. Isoresponse curves and response surfaces of ultrasonic pulse velocity of ordinary Concrete as a function of Superplasticizer (SP) and silica fume (SF) percentage

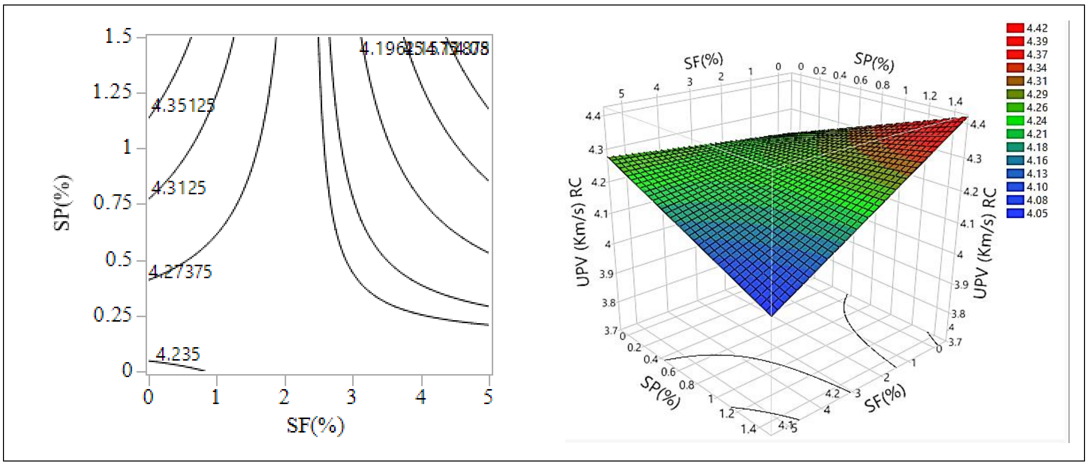

Figure 13. Isoresponse curves and response surfaces of ultrasonic pulse velocity of recycled concrete as a function of Superplasticizer (SP) and silica fume (SF) percentages

4.3. Water Absorption

According to Equations 3 and 4 of water absorption for concrete with natural and recycled aggregate, it can be observed that all factors have a significant negative effect on the response (Abs %). For ordinary concrete, the surface response (Figure 14) shows that the use of a Superplasticizer decreases water absorption. However, the use of Superplasticizer in recycled concrete mixtures has little influence on the absorption rate.

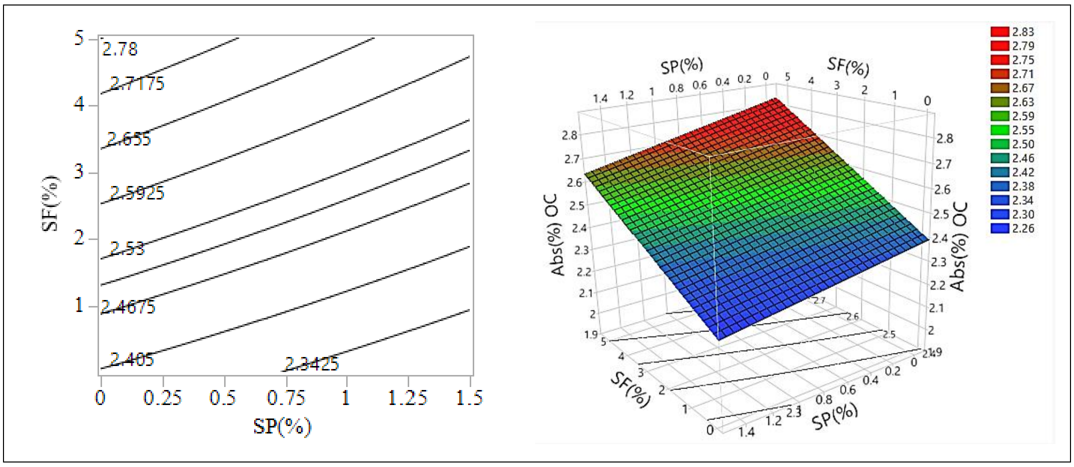

Figure 14. Isoresponse curves and response surfaces of water absorption of ordinary concrete as a function of Superplasticizer (SP) and silica fume (SF) percentages

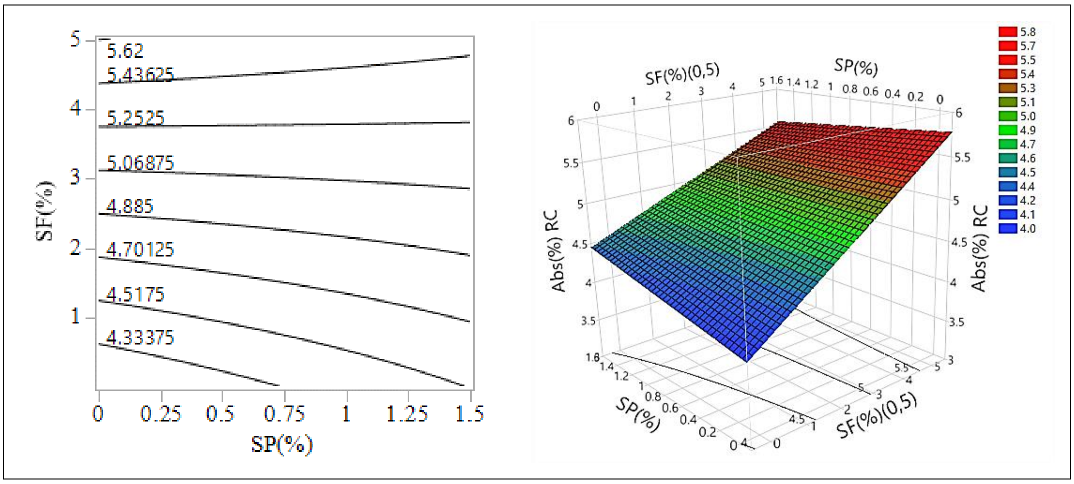

Figure 15. Isoresponse curves and response surfaces of water absorption of recycled concrete as a function of Superplasticizer (SP) and silica fume (SF) percentages

5. Conclusions

The use of aggregates recovered from old concrete can cause a drop in the resistance of recycled concrete in comparison with normal concrete. So, the performance improvement is based on recycled aggregates (suitable rheological properties and good strength). We opt for the addition of certain additives (silica fume) and admixtures (Superplasticizer) to ordinary and recycled concrete for this purpose. The results obtained from tests on recycled (CC/RC) test pieces formulated using (SF/SP) after discussion allowed the following conclusions to be drawn:

- Mineral additions combined with an admixture play an important role in improving the rheological characteristics and mechanical properties of both ordinary and recycled concrete (OC/RC).
- The recycled concrete (RC) indicated the highest value of W/C ratio compared to ordinary concrete by an increase of 8.2%. And the same principle applies to the other types of concrete used.
- In terms of mechanical behavior, a positive effect of superplasticizer and silica fume separately has been noted. Therefore, no significant effect of the combined use of (SP + SF) has been noted.
- The absorption of RC in this study is higher than that of OC by an order of 42%. This increase is explained by the effect of old mortar paste, which remains on the surface of the demolition aggregates of test pieces, resulting in greater porosity.
- The indirect test of ultrasonic pulse velocity (UPV) proves to be an important means for the evaluation of the mechanical response of the concretes tested in our study and confirms the values obtained by the direct crushing test (compression).
- The proposed statistical models could be used to evaluate the effect of silica fume and superplasticizer on the concrete with natural and recycled aggregate, as well as a better understanding of the interaction of factors.
- Finally, it could be concluded that the use of additions of silica fume and superplasticizers at optimal dosage remains advantageous in order to produce ordinary and recycled concrete types having good rheological and mechanical performance and better durability in the long term.

6. Declarations

6.1. Author Contributions

Conceptualization, K.O. and B.L.; methodology, K.O. and B.L.; software, K.O. and B.L.; validation, K.O., B.L., D.N., S.S. and A.Z.; formal analysis, K.O.; investigation, K.O. and B.L.; resources, K.O.; data curation, K.O., B.L., and D.N.; writing—original draft preparation, K.O. and B.L.; writing—review and editing, K.O. and B.L.; visualization, K.O. and B.L.; supervision, B.L. All authors have read and agreed to the published version of the manuscript.

6.2. Data Availability Statement

The data presented in this study are available in the article.

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6.4. Acknowledgements

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6.5. Conflicts of Interest

The authors declare no conflict of interest

7. References

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