The Influence of Polypropylene Fiber and Silica Fume on the Mechanical Properties of No-Fine Concrete with Recycled Aggregate

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Abstract. No-Fines Concrete is a type of concrete produced without fine aggregate or sand. Because of its high porosity, it allows rainwater to seep into the ground, directly replenishing the groundwater aquifer. With a design load of three tons, no-fine concrete can be utilized as pavement for rural roads. Additionally, this type of concrete can be utilized as a sub-base material in both flexible and rigid pavements. Aside from No-Fines Concrete's permeability properties, asphalt overlays are another option. This research studied the impact of silica fume and polypropylene fiber on the properties of no-fine concrete with recycled aggregate. The ratios of cement to aggregate and water to cement were 1:4 and 0.3, respectively. The recycled aggregate was demolished reactive powder concrete used in percentages of 10, 20, and 30% as a substitution for coarse aggregate by volume. The recycled aggregate percentage of 10% was the optimal percentage as it showed the least adverse effect on the no-fine concrete mixes. The polypropylene fiber was then added to the no-fine concrete mixes with 10% recycled aggregate in the percentages of 0.5, 1, and 1.5% by volume. The optimum percentage of polypropylene fiber was 0.5%, which improved the mechanical properties of no-fine concrete. Silica fume was used as a partial substitution for cement at a percentage of 10% and added to no-fine concrete mix with 10% recycled aggregate. The results show that using 10% silica fume and 0.5% polypropylene fiber with 10% recycled aggregate increased the splitting tensile strength, flexural strength, compressive strength, and modulus of elasticity by (22.54 and 40.32%), (22.22 and 35%), (21 and 35.37%), and (22 and 38.19%) compared to reference mix (NC) and the no-fine concrete mix with 10% recycled aggregate (RNC10), respectively. In comparison, the dry density was higher by (1.34%) than RNC10 and lower by (0.68%) than NC.

Keywords: No-fine concrete; recycled aggregate; polypropylene fiber; dry density; silica fume.

1. INTRODUCTION

Recycled concrete aggregate is frequently used in structural and semi-structural concrete mixtures to achieve environmental sustainability. Due to the weak mortar that is linked to the natural aggregate, recycled concrete aggregate has poorer strength and stiffness than natural aggregate [1]. The growing environmental demand to reduce solid waste made the concrete industry use several strategies to accomplish this goal, including replacing fine and coarse aggregate with different waste materials. Utilizing recycled waste would be important from both an economic and environmental aspect. Private industries have substituted cutting-edge gear for ordinary labor to crush the old concrete and fully utilize it. When compared to natural aggregates, recycled aggregate made from waste concrete has very different mechanical properties. Therefore, if they were to be included in the concrete mix design, it would be important to develop an understanding of their behavior. The main difference between natural aggregate and recycled aggregate is that the latter is frequently bonded with old cement mortar and other components of old concrete, such as fly ash, silica fume, slag, and latex paint [2,3].

The most cost-effective way to employ recycled aggregate is likely to be porous concrete or no-fine concrete, which uses more than 80% aggregate [4]. No-fine Concrete is a porous structural material made of cement, water, and coarse aggregate with little or no fine aggregate. Several terms for no-fine concrete are frequently used: pervious concrete, zero-fine concrete, and porous concrete. This type of concrete is employed in road paving because it allows water to permeate the material [5]. Typically, the aggregate size utilized in no-fines concrete mixing ranges from that which passes through a sieve of 20 mm and is retained on 10 mm. No-fine concrete is an agglomeration of coarse aggregate covered in a 1.3mm-thick layer of cement paste. Large pores are present throughout this type of concrete, which plays a significant role in the material's low strength, poor thermal conductivity, and lightweight nature. Since the early 1950s, no-fines concrete has been increasingly used in buildings. Also, because of its density and porous nature, no-fine concrete has been used in pavement construction since it is cost-effective. Its intent to reduce pavement surface runoff and stormwater control was another justification for its use in pavement construction [6,7].

Naturally, no-fine concrete has a very low compressive strength. Polypropylene fibers were incorporated into the no-fine concrete in order to enhance its compressive strength [8]. Polypropylene fiber is a type of polymer used extensively around the world because of its wide availability and affordable manufacture [9]. Due to its high rigidity, low density, and excellent chemical and microbiological resistance, polypropylene fiber is one of the most cost-effective product fibers, with a global productivity of 4 million tons a year. Many civil engineering applications use polypropylene as a fiber material. All types of Portland cement can be used with polypropylene fibers since they are chemically resistant to acids and alkalis. Polypropylene fiber is added to concrete during manufacture and doesn't require any effort to make. It's also simple to use and improves various properties of concrete [10,11]. There are numerous approaches to improve the quality of concrete in order to minimize the damage that happens as a result of the partial replacement of natural aggregates with recycled ones. The use of silica fume, a pozzolanic substance, is one of those solutions [12]. Adding silica fume to concrete improves its qualities, especially its compression, abrasion, and bending resistance. It could be used in the concrete mix as a partial substitution for cement and considerably influences the final product's qualities. These changes were made due to the addition of a very fine powder to the cement paste and pozzolana reactions between free calcium hydroxides and silica fume [13-15].

Many researchers have studied the impact of recycled aggregate on no-fine concrete. Dahri [16] studied the no-fines concrete's compressive strength, using 20% to 100% of demolished waste as coarse materials. The batches of the suggested concrete experienced a drop in weight and compressive strength. Results indicate that at 40% replacement, compressive strength decreased by 19%, and sample weight reduced by 9%. Salih [17] investigated various mechanical characteristics of no-fines concrete that are made by utilizing demolished concrete as coarse aggregate, which is subsequently crushed into varying sizes. Natural aggregate and crushed demolished concrete were used in two weight ratios (1:5 and 1:7). Superplasticizer was necessary to maintain the same workability across all mixtures while maintaining a water-to-cement ratio of 0.4. The results revealed that the oven-dry density, flexural, splitting tensile, and compressive strengths of no-fine concrete with crushed demolished concrete at 28 days of age exhibited a reduction of approximately 4, 21, 22, and 29%, respectively, in comparison to no fine made with natural crushed aggregate.

Various studies have also investigated the impact of polypropylene fiber on no-fine concrete. Elavarasan [8] examined how polypropylene fiber influenced the mechanical characteristics of no-fine concrete. The ratio of cement to aggregate was 1:4, while the ratio of water to cement was 0.45. The addition percentages of polypropylene fiber were 0.5, 1, and 1.5% by volume of cement. The split tensile strength and compressive strength were calculated at 7 days and 28 days, respectively. They found that the ideal percentages of polypropylene fiber additions were 0.5% for splitting tensile strength and 1% for compressive strength. Al-Shathr [18] studied the influence of polypropylene fiber on the no-fine concrete's mechanical properties. The fibers with volumetric percentages of (0.1, 0.2, 0.3, 0.4, and 0.5%) were added to the concrete (1:5, 1:6, and 1:7), along with the necessary amounts of Superplasticizer, using a constant w/c ratio of 0.4. According to the results, 0.3% is the ideal volumetric percentage for the added polypropylene fibers, and 0.5% by weight of cement is the ideal amount of superplasticizer. When employing concrete mixtures of 1:5 and 1:6, this percentage of fibers results in increases in modulus of rupture, splitting tensile strength, and compressive strength by 67.8%, 56.1%, and 22.5%, respectively. However, this percentage decreased to 8.8%, 23.8%, and 24%, respectively, when utilizing a concrete mix ratio of 1:7. The results also demonstrated that the incorporation of fibers barely changed concrete's thermal conductivity and density.

Many researchers also looked into the effects of silica fume. Tariq and Kaushal [19] investigated the optimum silica fume percentage for pervious concrete's economic and environmentally friendly production. It has been found that the ideal silica fume proportion was 15%, which improved the strength considerably but reduced the workability. The results also exhibited that compressive strength enhanced by 27% after 28 days. Raghwani [20] examined how silica fume influenced pervious concrete's porosity, compressive strength, and abrasion resistance. The porosity and w/c ratio were 20% and 0.33, respectively. The results demonstrated that using 8% silica fume enhanced the abrasion resistance by 40% and achieved the required porosity of 20%, while using 10% silica fume improved the compressive strength by 30%.

Prior research demonstrated that using recycled aggregate in no-fine concrete exhibits several disadvantages, including reduced strength and density compared to conventional concrete. Also, it demonstrated that incorporating silica fume or polypropylene fiber in no-fine concrete improved its characteristics. Hence, this research investigated the influences of silica fume and polypropylene fiber on the characteristics of no-fine concrete with recycled aggregate.

2. MATERIALS AND METHODS

2.1 Cement

Ordinary Portland cement grade 32.5 R employed in this study, its physical and chemical properties shown in Tables 1 and 2, conformed to Iraqi specification No. 5/2019 [21].

Table 1: Physical properties of cement.

Physical Properties		Test Results	Limit of IQS. No. 5/2019
Setting Time	Initial (min)	106	Min. 45
	Final (hrs.)	4.83	Max. 10
Compressive Strength (MPa) at age	2 days	11.25	Min. 10
	28 days	33.31	Min. 32.5
Specific Surface Area (Blaine), (kg/m^2)		306	Min. 250

Table 2: Chemical properties of cement.

Oxide compositions	Content %	Limit of IQS. No. 5 / 2019
CaO	61.55	-
SiO_2	21.62	-
Al_2O_3	5.94	-
Fe_2O_3	3.32	-
SO_3	2.25	SO_3 <2.8 If $C_3A > 5$
L.S.F	0.86	-
I.R	0.88	Max. 1.5
L.O.I	1.07	Max. 4
MgO	2.85	Max. 5
Main Components		
C_3S	35.11	-
C_2S	35.07	-
C_3A	10.13	-
C_4AF	10.09	-

2.2 Coarse Aggregate

This investigation utilized two kinds of coarse aggregate: natural coarse aggregate and recycled coarse aggregate. The natural coarse aggregate was obtained from the Al-Nibaai quarry in Samara, while the recycled coarse aggregate shown in Figure 1, was demolished waste reactive powder concrete obtained by crushing the waste with a hammer. Their properties are demonstrated in Table 3. The two types of aggregate were of a single size, which passed through a 20mm sieve and was retained on a 10 mm sieve, and they conformed to Iraqi Specification No. 45/1984 [22].

Table 3: Properties of coarse aggregate.

Property	Natural coarse aggregate	Recycled coarse aggregate	Limit of IQS. No. 45/1984
Specific gravity	2.68	2.5	-
Sulfate content %	0.07	0.08	≤ 0.1%
Density kg/m^3	1695	1510	-
Absorption %	0.75	3	-

2.3 Polypropylene Fiber

Monofilament polypropylene fiber (SikaFiber PPM-12) was employed in this study as shown in Figure 2, with a diameter of 32 (μm), length of 12 (mm), and aspect ratio of 375 products by Sika Company. The fiber properties shown in Table 4 and they were conformed to EN 14889-2 [23] according to the manufacturer datasheet.

Table 4: Properties of polypropylene fiber.

Property	Value
Appearance/color	Transparent fiber
Melting point	~160 (℃)
Density	~0.91 (g/cm^3)
Specific tensile strength	~30 (cN/tex)
Composition	100% polypropylene
Product declaration	Class 1a: Mono-filamented

*According to the manufacturer

2.4 Silica Fume

The silica fume employed in this work was MegaAdd MS (D), shown in Figure 3, and its typical properties were conformed to ASTM C1240 [24].

Figure 1: Recycled aggregate.

Figure 2: Polypropylene fiber.

Figure 3: Silica fume.

2.4 Admixture (Superplasticizer)

The BETONAC-1030 high-range water reducer admixture was employed in this work; its properties demonstrated in Table 5 and were conformed to ASTM C 494 type F [25].

Table 5: Properties of Superplasticizer.

Properties	Details
Density	1.14 (gm/ml) ±0.02
Color	Light yellow
Chloride content	Nil
PH	7.5

*According to the manufacturer

2.5 Water

The water utilized in this study for mixing and curing according to Iraqi specification No.1703/2018 [26].

2.6 Mix Design and Mixing Procedure

After several trail mixes, a ratio of cement to aggregate 1:4 was used; the weight of the cement was 275 kg/m^3; the ratio of water to cement was 0.3; and the superplasticizer dose was 1% of the cement. The Superplasticizer was 0.1% by weight of cement, which kept a constant water-to-cement ratio in all mixes. The mix details are shown in Table 6. In this study, nine mixes were prepared: a reference mix; three mixes in which recycled aggregate from demolished concrete was used in place of the coarse aggregate in proportions of 10%, 20%, and 30% by volume; three mixes in which polypropylene fiber was added in the proportions of 0.5%, 1%, and 1.5% to the concrete that contains the ideal percentage achieved of recycled aggregate a mix in which 10% silica fume was used as a partial substitution for cement in no-fine concrete contains the ideal percentage achieved of recycled aggregate; and the final mix in which the ideal percentage of polypropylene fiber was added with 10% of silica fume to the no-fine concrete with the ideal percentage of recycled aggregate. A 0.1 m^3 capacity mixer was utilized to mix the materials, and the procedure was as follows: Before use, the interior of the mixer was moisturized and cleaned. The coarse aggregates were added to the mixer with half the amount of water, and the mixture was stirred for one minute. The remaining water containing the superplasticizer and the cement were added to the mixer. The mixer was turned on until the coarse aggregate was well coated with the cement paste, and a homogenous mixture was achieved. The preparation process for mixes containing recycled aggregate, polypropylene fiber, and silica fume was the same, except recycled aggregate was mixed with natural aggregate, polypropylene fibers were manually added, and the mixture was thoroughly mixed, and silica fume was blended with cement. Before casting samples, the molds were prepared and cleaned, and a thin oil layer was applied to the inner surface to prevent the concrete from adhering to the mold walls, conforming to ASTM C192/C192M [27]. The samples were cast into three layers and manually compacted using a rod. After that, the molds were wrapped with nylon sheets for 24 hours. Then the samples were taken out from the molds and put in the curing containers until they were tested. Figure 4 shows the no-fine concrete samples.

Table 6: Mixture's detail.

Mix	Cement (kg/m^3)	Coarse Aggregate (kg/m^3)	C/A	Silica Fume (kg/m^3)	W/C	Recycled Aggregate (kg/m^3)	Polypropylene Fiber Vf (%)	SP (% by cement)
NC	275	1100	1:4	-	0.3	-	-	-
RNC10	275	1002.7	1:4	-	0.3	97.29	-	0.1
RNC20	275	905.4	1:4	-	0.3	194.57	-	0.1
RNC30	275	808.1	1:4	-	0.3	291.86	-	0.1
R10P0.5	275	1002.7	1:4	-	0.3	97.29	0.5	0.1
R10P1	275	1002.7	1:4	-	0.3	97.29	1	0.1
R10P1.5	275	1002.7	1:4	-	0.3	97.29	1.5	0.1
R10 SF10	247.5	1002.7	1:4	27.5	0.3	97.29	-	0.1
R10P0.5SF10	247.5	1002.7	1:4	27.5	0.3	97.29	0.5	0.1

Figure 4: No-fine concrete samples.

2.7 Testing Samples

2.7.1 Dry Density

The measurement of the density was done conforming to BS 1881-114, 1983 [28]. A cubic sample (100x100x100) (mm) was used. The concrete samples were placed in an oven at a temperature of 100–115 (°C) for 24 hours. Each sample was then taken out of the oven and given time to cool. Then its weight was calculated.

2.7.2 Compressive Strength

This test was conducted conforming to BS EN12390-3:2019 [29] using cubical samples of (100x100x100) (mm), and the mean results of three samples taken at 7, 28, and 90 days for each mix.

2.7.3 Splitting Tensile Strength

This test was done conforming to ASTM C496/C496M-17 [30], using cylinder samples with a size of (100x200) (mm) and using the mean of three sample results at 7, 28, and 90 days for each mix.

2.7.4 Flexural Strength

This test conducted according to ASTM C293/C293M-16 [31]. The flexural strength was measured under center point load; prism specimens with a size of (80x80x380) mm were employed. The mean of three sample results at 7, 28, and 90 days for each mix was used.

2.7.5 Modulus of Elasticity

This test was done according to ASTM C469/C469M-14 [32]. In this test, cylinders of 300 mm height and 150 mm diameter were employed.

3. RESULTS AND DISCUSSION

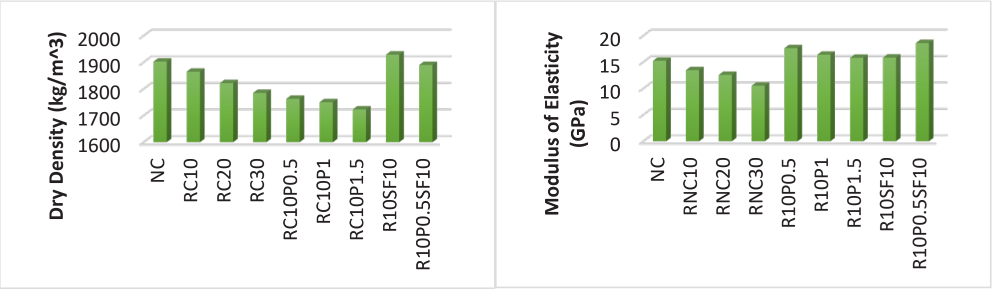
3.1 Dry Density and Modulus of Elasticity

Table 7 and Figure 5 (a) demonstrate the impact of employing recycled coarse aggregate made from demolished concrete, polypropylene fiber, and silica fume on the dry density of no-fine concrete. Results show that the density decreases with the use of recycled coarse aggregate compared to that of natural coarse aggregate, until it reaches a reduction percent of 6.2% with 30% replacement of recycled coarse aggregate by volume. This occurred due to recycled aggregate's low density. Moreover, the old cement mortar's poor adherence and porous nature lead it to adhere poorly to recycled aggregate, which agrees with the research result [33]. The results also exhibit that incorporating polypropylene fiber to the no-fine concrete with 10% replacement of recycled coarse aggregate showed a reduction in density with increasing percentages of addition. This may be attributed to compaction issues that caused more voids in the samples, as found in the research [34], also due to the low density of polypropylene fiber. Using silica fume as a partial substitution for cement in the percentage of 10% increased the dry density by 1.37% and 3.43% compared to NC and RNC10, respectively. Using 0.5% polypropylene fiber and 10% silica fume with 10% recycled aggregate increased the dry density by 1.34% compared to RNC10 but was still lower than NC by 0.68%.

Table 7 and Figure 5 (b) demonstrate the results of the modulus of elasticity at 28 days. The results exhibit that using recycled aggregate in the percentages of 10%, 20%, and 30% declines the modulus of elasticity by 11.74%, 17.57%, and 31.02%, respectively, compared to NC. The results also demonstrate that adding polypropylene fiber in the proportions of 0.5%, 1%, and 1.5% improves the modulus of elasticity by 16.61%, 7.54%, and 3.67%, respectively, in comparison with NC and by 31%, 21.84%, and 17.46%, respectively, in comparison with RNC10. This improvement is due to fiber bridging, which increased the modulus of elasticity, which is compatible with [35]. Employing silica fume as a partial substitution for cement in percentages of 10% increased the modulus of elasticity by 3.87% compared to NC and 17.68% compared to RNC10. This could be due to silica fume's tendency to fill the concrete's voids, resulting in a densely packed structure that is compatible [36]. Using 0.5% polypropylene fiber and 10% silica fume with 10% recycled aggregate increased the modulus of elasticity by 22% and 38.19% compared to NC and RNC10, respectively.

Table 7: Dry density, Water absorption, and Modulus of elasticity results.

Mix	Dry Density (kg/m^3)	Modulus of Elasticity (GPa)
NC	1903	15.25
RNC10	1865	13.46
RNC20	1822	12.57
RNC30	1785	10.52
R10P0.5	1763	17.63
R10P1	1750	16.4
R10P1.5	1723	15.81
R10SF10	1929	15.84
R10P0.5SF10	1890	18.6



(a) (b)

Figure 5: Effect of recycled aggregate, polypropylene fiber, and silica fume on (a) dry density (b) modulus of elasticity.

3.2 Compressive, Splitting Tensile and Flexural Strengths

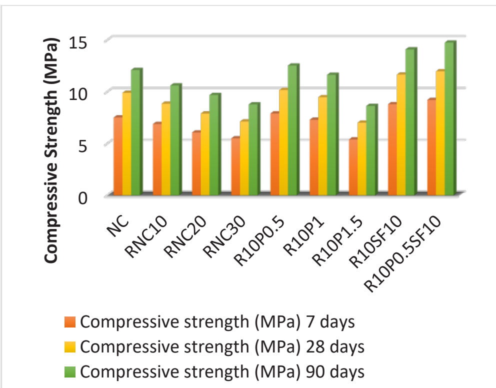
Table 8 and Figure 6 (a) demonstrate the compressive strength of no-fine concrete mixes at (7, 28, and 90) days. The results reveal that the no-fine concrete produced with recycled coarse aggregate has a lower compressive strength than the design mix. The compressive strength declined at 28 days with 10, 20, and 30% substitution of recycled coarse aggregate by 10.61, 20.2, and 27.98%, respectively. This is because of the lower characteristics of recycled aggregate from demolished concrete in comparison to natural aggregate, which reduces the compressive strength of no-fine concrete. The optimum percentage of recycled aggregate was 10%, since it exhibits less reduction in compressive strength than 20 and 30%. The inclusion of polypropylene fiber to no-fine concrete with 10% recycled coarse aggregate exhibits a slight increase in compressive strength at 28 days by 2.73 and 14.92% when compared to NC and RNC10, respectively, with a fiber addition of 0.5%, while it indicates a decrease in compressive strength with fiber percentages of 1% and 1.5%. The decline in the compressive strength was due to the rise in the air void as the addition of the fiber increased, adversely affecting the compressive strength, as agreed with research [37]. Employing silica fume as a partial substitution for cement in the percentage of 10% with 10% recycled aggregate increased the compressive strength at 28 days by 17.78 and 31.75% when compared to NC and RNC10, respectively. This increased strength is because of the smaller particles of the silica fume that fill up any gaps in the concrete, producing a densely packed structure with reduced porosity, thus increasing the concrete's strength, which is compatible with [36]. Using 0.5% polypropylene fiber and 10% silica fume with 10% recycled aggregate increased the compressive strength by 21 and 35.37% in comparison to NC and RNC10, respectively.

Table 8 and Figure 6 (b) exhibit the splitting tensile strength of no-fine concrete mixes at (7, 28, and 90) days. The results indicate that the tensile strength decreases by 12.68%, 21.83%, and 24.65% with the employment of recycled aggregate as a partial substitution of natural coarse aggregate in the percentages of 10%, 20%, and 30%, respectively, in comparison to NC at 28 days. The ideal percentage of recycled aggregate was 10%, as it has the least reduction in tensile strength. The results exhibited that the ideal parentage of fiber addition was 0.5%, which was added to the mix of no-fine concrete with 10% substitution of recycled coarse aggregate by volume and resulted in increasing tensile strength by 3.52% and 18.55% compared to NC and RNC10, respectively, at 28 days. This can be attributed to the fiber's binding ability that is present in the concrete matrix, which is compatible with [8]. The use of silica fume as a partial substitution for cement in the percentages of 10% increased the splitting tensile strength at 28 days by 14.08% and 30.65% compared to NC and RNC10, respectively, and this could be due to the enhancement of the interface between the recycled aggregate and new matrix and enhancing the old paste structure that still adheres to the recycled concrete aggregate, which is compatible with [38]. Using 0.5% polypropylene fiber and 10% silica fume with 10% recycled aggregate increased splitting tensile strength by 22.54% and 40.32% compared to NC and RNC10, respectively.

Table 8 and Figure 6 (c) show the flexural strength of no-fine concrete mixes at (7, 28, and 90) days. The results show that using recycled aggregate in percentages of 10%, 20%, and 30% declines the flexural strength at 28 days by 9.43%, 18.86%, and 27.95%, respectively, compared to NC. The ideal percentage of recycled aggregate was 10%, as it showed the least reduction in flexural strength. This reduction is because waste concrete aggregate tends to deform more than natural aggregate, which is compatible with [17]. The polypropylene fiber was incorporated into the no-fine concrete with 10% recycled coarse aggregate, and the ideal percentage of fiber addition was 0.5%, which resulted in increasing flexural strength at 28 days by 20.2% and 32.71% compared to NC and RNC10, respectively. This can be attributed to the fiber's binding ability in the concrete matrix. The incorporation of silica fume as a partial substitution for cement in percentages of 10% with 10% recycled aggregate increased the flexural strength by 16.5% and 28.62% compared to NC and RNC10, respectively. This is because silica fume has a strong pozzolanic activity and the ability to fill the voids, which is compatible with [12]. Using 0.5% polypropylene fiber and 10% silica fume with 10% recycled aggregate improved the flexural strength by 22.22% and 35% compared to NC and RNC10, respectively.

Table 8: Compressive strength results.

Mix	Compressive strength (MPa)			Splitting Tensile Strength (MPa)			Flexural Strength (MPa)		
	7 days	28 days	90 days	7 days	28 days	90 days	7 days	28 days	90 days
NC	7.52	9.9	12.1	1.19	1.42	1.63	2.26	2.97	3.23
RNC10	6.89	8.85	10.61	1.04	1.24	1.52	2.07	2.69	2.95
RNC20	6.07	7.90	9.69	0.91	1.11	1. 37	1.82	2.41	2.82
RNC30	5.51	7.13	8.78	0.83	1.07	1.18	1.66	2.14	2.55
R10P0.5	7.91	10.17	12.53	1.06	1.47	1.83	2.88	3.57	3.92
R10P1	7.30	9.48	11.64	0.97	1.40	1.81	2.67	3.26	3.70
R10P1.5	5.40	7.02	8.63	0.63	0.85	1.07	1.92	2.41	2.89
R10SF10	8.80	11.66	14.09	1.37	1.62	1.78	2.57	3.46	3.73
R10P0.5SF10	9.21	11.98	14.75	1.22	1.74	2.18	2.95	3.63	3.97



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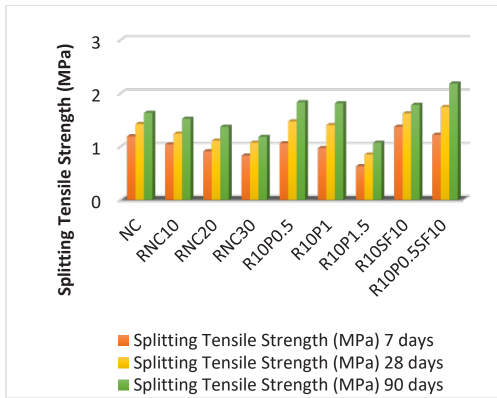

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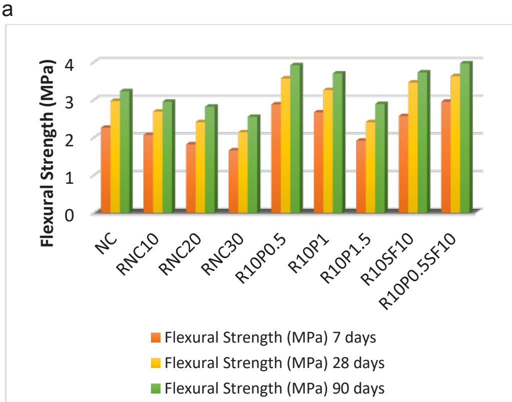

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Figure 6: Effect of recycled aggregate, polypropylene fiber, and silica fume on (a) compressive strength (b) splitting tensile strength (c) flexural strength.

4. CONCLUSIONS

The following conclusions can be made depending on the data obtained:

- The incorporation of recycled aggregate as a partial substitution for natural coarse aggregate negatively affected no-fine concrete mechanical properties.
- The ideal percentage of recycled aggregate was 10%, as it shows the least adverse impact on the properties of no-fine concrete.
- The best percentage of polypropylene fiber was 0.5%, added to 10% of recycled aggregate, which increased splitting tensile strength, compressive strength, modulus of elasticity, and flexural strength compared to NC and RNC10 while decreasing the dry density.
- Incorporating 10% silica fume as a partial substitution for cement with 10% recycled aggregate enhanced the strength properties of no-fine concrete compared to NC and RNC10 and increased the dry density.

- The mechanical properties of no-fine concrete were improved using 10% silica fume, 0.5% polypropylene fiber, and 10% recycled aggregate. This combination offered the best splitting tensile strength, compressive strength, modulus of elasticity, and flexural strength.

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