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Research Article

Mechanical properties of mortar incorporating environmentally friendly components

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ABSTRACT

An investigation is underway to examine the impact of waste materials on the mechanical properties for cement mortar. The incorporation of the waste materials, such as silica fume, waste tire, and plastic bottle fiber, has increased within the last two decades. This research investigates the effect of waste materials on the mechanical properties of cement mortar. A total of (234) specimens were cast and tested for compressive, tensile, and flexural strengths. These included (78) cubes, (78) brackets, and (78) prisms. The experimental work consisted of three primary phases. The first phase involved evaluating silica fume as a partial replacement for cement by (0, 8, 9, 10, 12, and 15) %. In the second phase, waste tire rubber (crumb rubber) was incorporated as a partial replacement for sand at (0, 5, 10, and 15) %. In the third phase, the optimal percentages of silica fume from Phase 1 and crumb rubber from Phase 2 were incorporated with waste plastic fibers at (0, 0.5, 0.75, and 1.0) % to determine the best-performing mixture. The results indicated that incorporating 8% silica fume, 5% waste tire rubber, and 0.75% plastic bottle fiber provided the optimal mixture. As compared to the traditional mixture, the compressive strength was reduced by 42.7%, the flexural strength reduced by 25.26%, and the splitting tensile strength reduced by 1.97%. This study highlights the probability of using waste materials for environmentally friendly buildings.

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INTRODUCTION

The cement industry is a major source of carbon dioxide (CO_2) emissions as well as a significant consumer of raw materials and energy resources. Consequently, reducing cement consumption by incorporating specific waste materials such as silica fume into concrete production can play a crucial role in addressing various environmental issues. Incorporating locally available natural materials as supplementary cementitious materials enhance the mechanical properties of the cementitious matrix while reducing construction costs [1].

Concrete is widely used in the construction; however, there are significant concerns regarding the consumption of raw materials required for traditional mixes. The growing demand for concrete products drives up construction costs. Incorporating recycled materials into concrete can reduce

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the consumption of natural resources, thereby lower construction costs and minimizing the volume of waste. Waste glass and wood ash are examples of waste-derived materials that have the potential to serve as alternative components in concrete production. Furthermore, end-of-life vehicle tires pose a significant environmental burden due to their persistence, accumulation, and disposal challenges [2, 3].

Waste plastics are another type of waste material that has been used as an aggregates, plastic fibers, and binding materials in concrete mortar mixtures [4]. Waste plastic fiber (PF) is an important component of the solid waste stream [5]. Many plastic bottles utilized for beverage containers are discarded after a single use, with the disposed bottles being sent to landfills and burned, resulting in significant environmental issues [6].

Researchers have studied the effect of use silica fume, waste tire rubber, and plastic fibers bottles (PF) as constituents of cement mortar, and their effect on its mechanical properties of cement matrix. Boiny et al. [7] investigated the effect of adding plastic fibers extracted from waste plastic bottles on the properties of cement mortar. Used several ratios of the plastic fibers proportions ranging from (0%, 0.5%, 1.0%, 1.5%, 2.0%, and 3.0%). The results indicated that the addition of fibers at a rate of 0.5% increased the splitting tensile strength while decreased the compressive strength of the cement mixture. Razali and Ishak [8] examined the possibility of replacing waste plastic fiber bottles (PF) with fine aggregate. Used three different percentages of PF, 0.5%, 1.0%, and 1.5%, with an aspect ratio of 33. The results showed a decrease in both compressive strength and splitting strength, while the flexural strength showed an increase as compared to the reference mixture. Sumanth et al. [9] investigated the characteristics of the mortar produced by partially substituting fine aggregate with waste rubber tires in ferrocement. Experimental results indicated that including crumb rubber in cement mortar caused a reduce in the flexural strength and compressive strength. Muwashee and Al-Jameel [10] studied the effect of silica fume on cement mix by examining varying proportions ranging from 0% to 8%. The results showed that the addition of 2.5% silica fume increased compressive strength by approximately 12.2% and 27.6% at 7 and 28 days of age, respectively. This improvement was attributed to the reaction between the silica fume and the calcium hydroxide present in the cement, which led to the formation of calcium silicate hydrate gel; the formation of this gel contributed to enhancing the mortar's microstructure and increasing its density and strength over time. Singh and Bansal [11] the study investigated the effect of adding silica fume on the compressive strength of cement paste. Three mix ratios, 1:3, 1:4, and 1:6, were prepared with varying silica fume contents, with the material added as a partial replacement for either cement or fine aggregate. The results showed that replacing 15% of sand with silica fume increased the compressive strength by approximately 40% after 28 days. Whereas replacing15% of cement resulted in a 28% increase in compressive. Esfandiari et al. [12] investigate the buckling resistance of the bracing. The objective was to determine the optimal percentage of substituting cement weight with fly ash and micro silica, as well as the optimum fiber content. The experimental program include fiber- free concrete and concrete reinforced with steel fibers or polypropylene fiber using six different mix proportions, including (0.3%pp + 0.8%sf, 0.4%pp + 0.4%sf, and 0.15%pp + 1.5%sf). The study found that the ideal proportions of silica fume and fly ash were 0.5% and 1.5%, respectively. These were combined with ideal ratio of the steel fibers and composite fiber, which were 1.5% and 0.15%, respectively.

Previous studies have showed that replacing cement with micro silica fume can increase the strength, while replacing sand with crumb rubber may lead to a reduction in flexural, splitting, and compressive strength. Reports also indicate that the addition of recycled plastic fibers contributes to improved tensile strength. While earlier research focused primarily on incorporating these waste materials into cement mortar individually, this study investigates their combined use specifically micro silica, crumb rubber, and recycled plastic fibers and evaluates their effects on the mechanical and physical properties of the cement mortar. This research aims to develop an eco-friendly mortar and evaluate its performance against traditional mortar, while exploring the potential of these recycled materials to enhance performance, reduce reliance on traditional constituents, and support sustainable construction practices.

MATERIALS AND METHODS

Materials

Cement

In this study, Ordinary Portland Cement (OPC) of Type I ("Sinjar"), manufactured in Iraq, was used. The chemical and physical properties of the cement, which comply with Iraqi Standard Specification (IQS) No. 5/2015 [13], are presented in Tables 1 and 2, respectively.

Fine aggregate (sand)

Sand used in the experimental study was locally sourced and passed through a No. 4 sieve. Its particle size distribution was evaluated by sieve analysis in accordance with the Iraqi Standard Specification (IQS 45/2015) [14], the results are shown in Table 3. Additionally, physical properties of the fine aggregate were determined in accordance with ASTM C128-22 [15] and ASTM C566-04 [16] and the corresponding results are presented in Table 4.

Water

Potable water complying with the Iraqi Standard Specification IQS: 1703/ 1992 [17].

Table 1. Chemical properties of cement

Chemical Compounds	Result	Limits of Iraqi Specification [13]
SiO_2	19.6	-
Al_2O_3	5.2	-
Fe_2O_3	3.13	-
Cao	65.1	-
MgO	1.83	≤ 5%
So_3	2.19	≤ 2.5% if C3A≤ 5% ≤2.8% if C3A≤ 5%
Free lime	0.86	0.66-1.02
Loss on ignition	0.17	≤ 4%
Insoluble residue	0.84	≤ 1.5
Solid solution	16.25	-
C_2S	5.78	-
C_3S	66.83	-
C_3A	8.48	-
C_4AF	9.53	-
L.S.F	100.62	-

Table 4. Physical properties of fine aggregates

Physical properties	Sand properties
Saturated surface dry specific gravity	2.62
Absorption	2.45%
Surface moisture	1.54%
unit weight (Compact)	1825 kg/m^3
Fineness Modulus	2.60

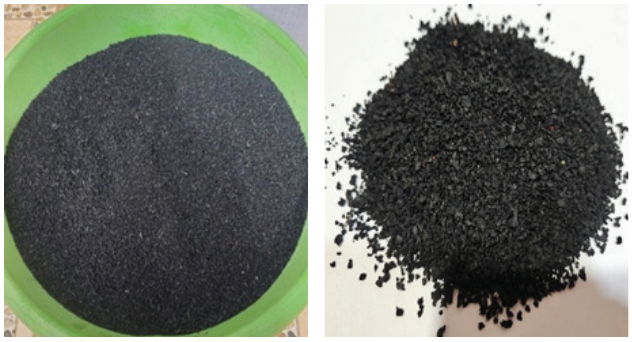

Figure 1. Crumb rubber.

Waste tire rubber

The crumb rubber (CR) was produced from end-of-life tires by a mechanical recycling process. The tires were processed by removing metal components and fibers, followed by the mechanical shredding and size reduction to obtain the required crumb rubber granules, as shown in Figure 1. The particle size of the crumb rubber used in this study ranged from 0.025 to 3.6 mm.

Waste plastic fiber bottle (PF)

Recycled Plastic fibers (PF) made from locally sourced polyethylene terephthalate (PET) bottles were added to the mortar mix. Before processing, the plastic bottles were washed with water to clean of dust and other impurities. The top and bottom sections of the bottle were then removed, and the remaining cylindrical shape was formed

Table 2. Physical properties of cement

Properties	Results	Iraqi Specification Limits [13]
Initial setting time of cement	120 min.	≥ 60
Final setting time of cement	300 min.	≤ 600
Standard ductility	0.296	---
Fineness sieve No. 170(%)	2.2	≤ 10
Compressive strength at three days	20 MPa	≥ 15
Compressive strength at seven days	30.6 MPa	≥ 23

Table 3. Sieve analysis of fine aggregate

Size of Sieve	Wight (gm)	% Retained	% Retained Cumulative	% Passing	Limits of Iraqi Specification [14]
No.4	48	4.80	4.80	95.20	90-100
No.8	82	8.20	13.00	87.00	75-100
No.16	86	8.60	21.60	78.40	55-90
No.30	205	20.50	42.10	57.90	35-59
No.50	408	40.80	82.90	17.10	8-30
No.100	140	14.00	96.90	3.10	0-10

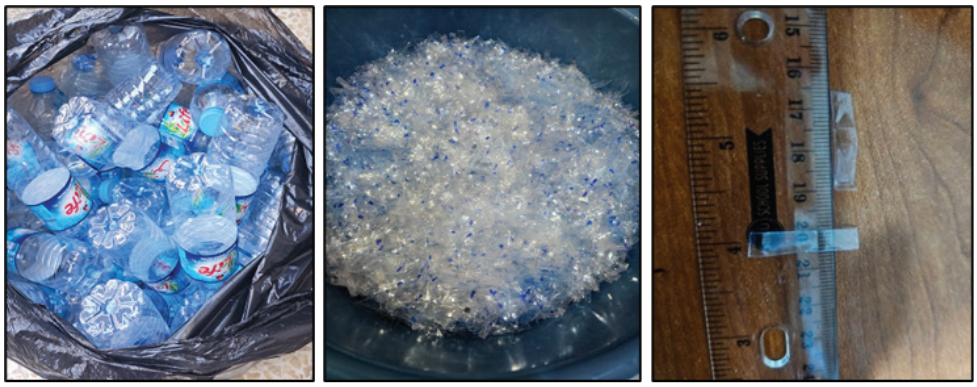

Figure 2. Production of fibers from plastic waste.

Table 5. Physical properties of waste plastic fiber [18]

Property	Material Descriptions
Category	Polyethylene Terephthalate (PET)
Absorption of water	0.0
* Density (kg/m^3)	1372
Length of fiber (mm)	25.0
Width of fiber (mm)	5.0
Thickness of fiber (mm)	0.155
Aspect Ratio	25.59

Table 6. Physical properties of silica fume (SF)

Property	Value
Color	Gray
Physical State	Powder
Bulk Density	500 to 700 kg/m^3
Specific Gravity	2.1 to 2.4
Retained on a 45-micron sieve	Maximum 10%
Specific Surface Area	Minimum 15 m^2/g

into a sheet, as illustrated in Figure 2. These sheets were cut into narrow strips to produce the plastic fibers. Their physical properties and dimensions are listed in Table 5 [18].

Silica fume

Silica fume (SF) obtained from local markets was used as a supplementary cementitious material in this study. It is a byproduct of the production of silicon metal and ferrosilicon alloys. The physical properties of the silica fume are presented in Table 6. The material's pozzolanic activity index, determined through testing, was 109% a value that satisfies the acceptance criteria specified in ASTM C1240-20 standard [19].

Methods

A set of 234 specimens was cast and subsequently tested to determine their compressive, tensile, and flexural strengths. These included 78 cubes (70×70×70 mm), 78 prisms (40×40×160 mm), and 78 brackets. The experimental work consisted of three primary phases. The first phase involved studying the use of silica fume (SF) as a partial replacement weight of cement by (0, 8, 9, 10, 12, and 15) %. In the second phase, waste rubber (crumb rubber (CR)) was incorporated as a partial replacement weight of sand at replacement levels of (0, 5, 10, and 15) %. Note that the mix with 0% crumb rubber is identical to the mix with 0% silica fume. In the third phase, the optimal percentages of silica fume from Phase 1 and crumb rubber from Phase 2 were incorporated with waste plastic fibers (PF) at a volumetric ratio of (0, 0.5, 0.75, and 1.0) % to determine the best-performing mixture. Figure 3 shows the research methodology (Table 7-9).

Table 7. Mix proportion for silica fume (SF) mortar

Mix Code	Cement (gm)	% Replacement of (SF)	Silica Fume Content (gm)	Sand (gm)	Water (gm)
Traditional Mix	2500	0	0	4765	1175
SF 1	2300	8	200	4765	1175
SF 2	2275	9	225	4765	1175
SF 3	2250	10	250	4765	1175
SF 4	2200	12	300	4765	1175
SF 5	2125	15	375	4765	1175

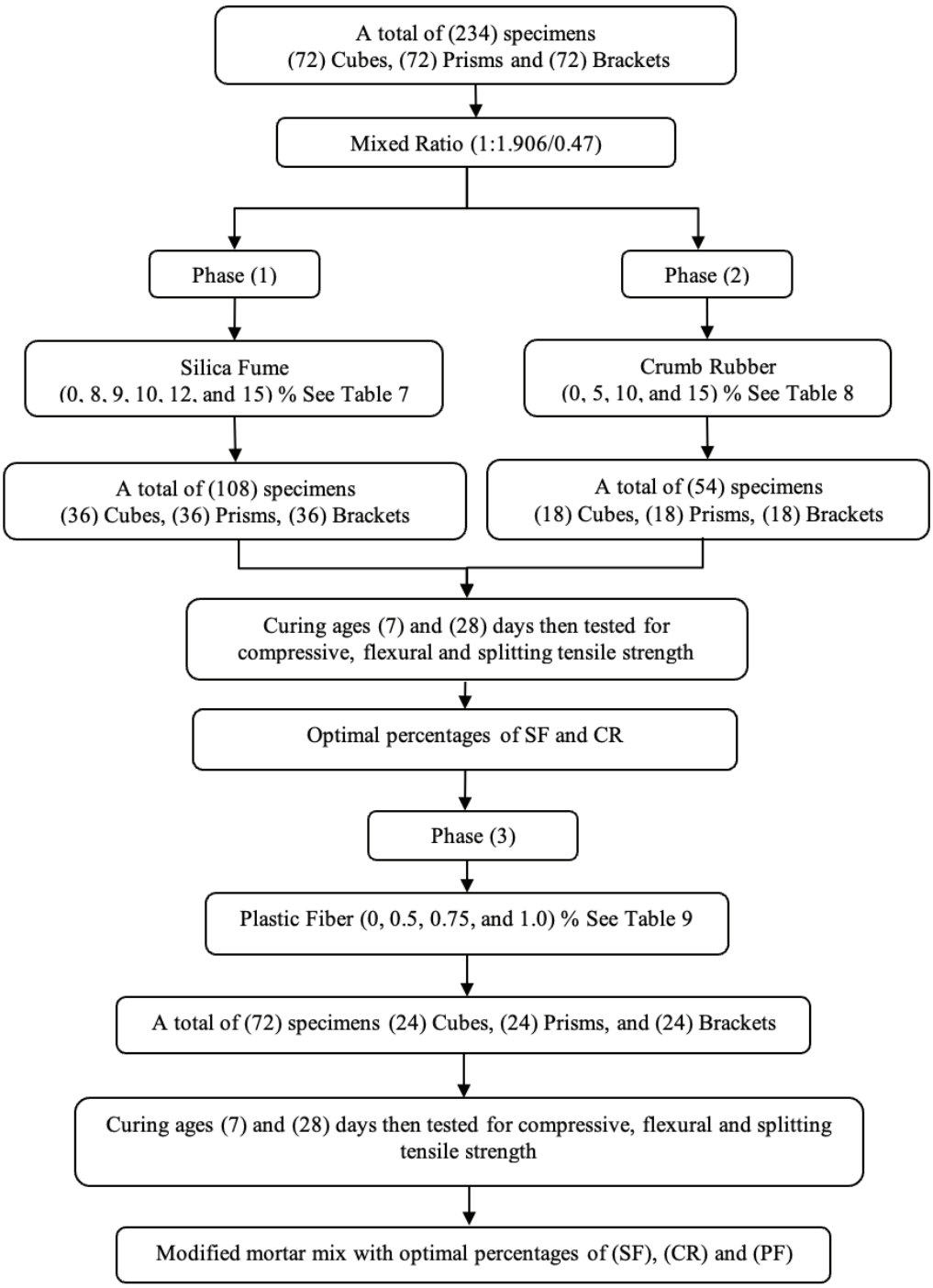

Figure 3. Research methodology.

Table 8. Mix proportion for crumb rubber mortar

Mix Code	Cement (gm)	Sand (gm)	% of replacement Sand with Tire	CR Content (gm)	Water (gm)
Traditional Mix	2500	4765	0	0	1175
CR 1	2500	4527	5	238	1175
CR 2	2500	4288	10	477	1175
CR 3	2500	4050	15	715	1175

Table 9. Mix proportion for addition plastic fiber to mortar

Index	Cement (gm)	Silica Fume (gm)	Sand (gm)	CR Content (gm)	Water (gm)	% of plastic Fiber	PF Content (gm)
Traditional Mix	2500	0	4765	0	1175	0	0
Control Mix	2300	200	4527	238	1175	0	0
PF 1	2300	200	4527	238	1175	0.5	45
PF 2	2300	200	4527	238	1175	0.75	68
PF 3	2300	200	4527	238	1175	1	90

Mixing procedure

Initially, mix the dry materials for three minutes; then, add water and mix for an additional three minutes until a paste is homogeneous. After that, the prepared mix was used to pour the molds. The molds included six cubes (70×70×70 mm) to test the compressive strength according to ASTM C109 [20], six prisms (40×40×160 mm) to test the flexural strength according to ASTM C348 [21], and six brackets to test the splitting tensile strength based on ASTM C307 [22], as illustrated in Figure 4a. After casting, the specimens were stored at normal temperature for one day, then demolded and cured by being placed in a water tank according to ASTM C192[23], as shown in Figure 4b. After that, the samples were tested at ages 7 and 28 days to determine the optimal eco-friendly mortar.

RESULTS AND DISCUSSION

Mechanical Properties of Traditional and Eco-Friendly Mortar

Test result of silica fume replacement

Table 10 presents the test results for different ratios of silica fume (SF) along the compressive strength, flexural strength, and splitting tensile strength values measured at ages 7 and 28 days. Figures 5 and 6 illustrate the relationships between the silica fume replacement ratio and the corresponding strength values; The results show that increasing the silica fume content and curing age generally enhanced strength of the cement mortar.

Figures 5 and Figure 6 show a steady increase in the compressive strength with increasing percent of silica content. However, the greatest improvements were observed up to



a. Casting the Specimens



b. Demolding and Curing the Specimens

Figure 4. Mixing process: a. Caste of specimen, b. Demolding and curing the specimens.

Table 10. Test results for cement mortar with silica at 7 & 28 days

Index	% Cement Replacement with (SF)	Compressive Strength (MPa)		Flexural Strength (MPa)		Splitting Tensile Strength (MPa)	
		7 days	28 days	7 days	28 days	7 days	28 days
Traditional Mix	0	33.59	43.48	8.65	9.54	3.34	3.54
SF1	8	35.64	46.33	8.71	9.89	3.51	4.28
SF2	9	35.52	45.22	8.70	9.72	3.45	4.14
SF3	10	33.93	44.75	8.72	9.65	3.43	4.12
SF4	12	33.77	43.75	8.69	9.69	3.41	3.63
SF5	15	33.69	43.65	8.66	9.56	3.36	3.57

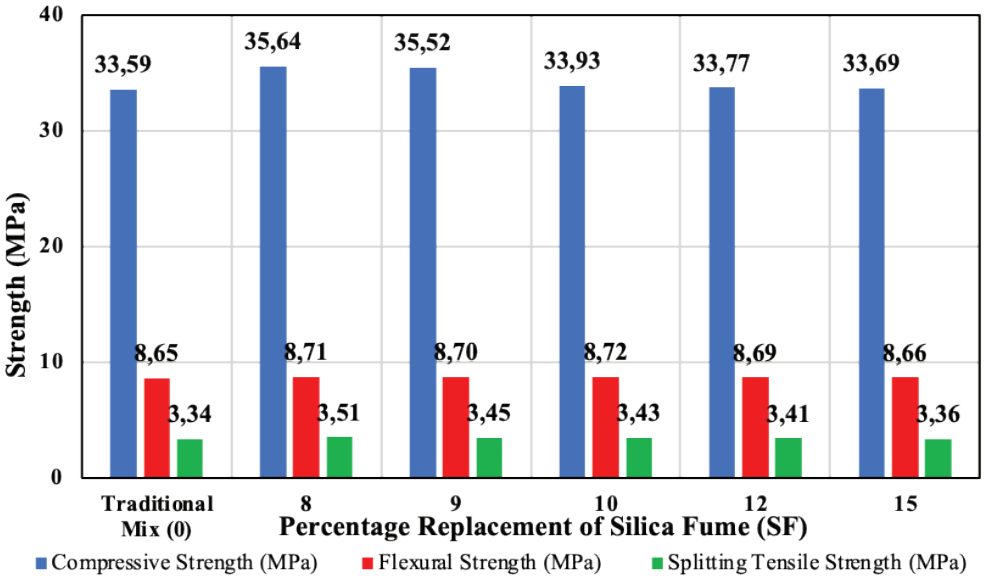

Figure 5. Test results for the cement mortar with silica at 7 days.

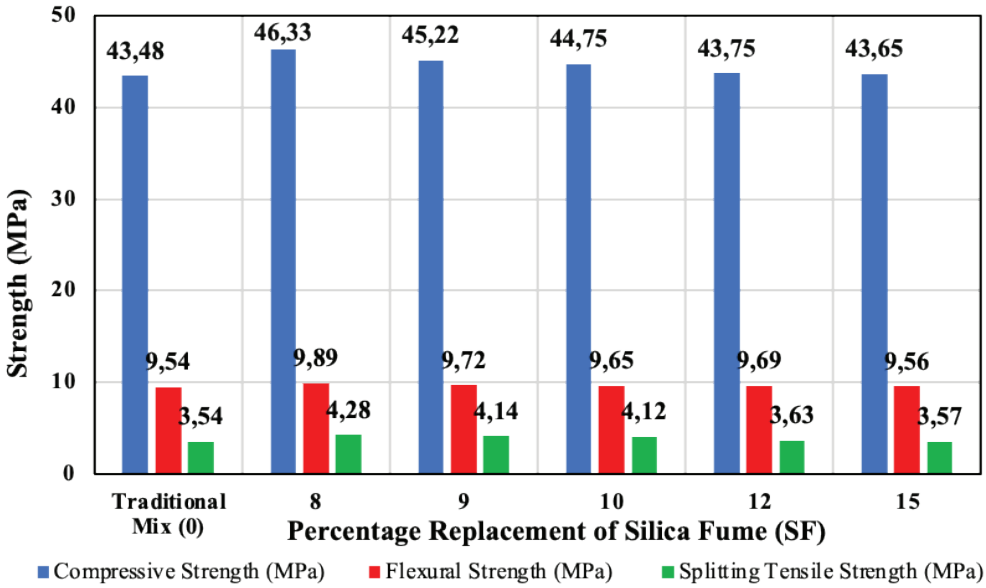

Figure 6. Test results for the cement mortar with silica at 28 days.

10% replacement. These results agree with [24]. At 28 days, the compressive strength was more than traditional mix by 6.6% at 8% replacement, 4.0% at 9%, and 2.9% at 10%. After this range, the improvement was slight, with increases 0.6% and 0.4% recorded at replacement ratio of 12% and 15%, respectively. A similar behavior was observed at the curing ages of 7 days. The increase in the compression is attributed to the fine silica fume powder operating as a micro filler, filling the voids between cement particles and reducing the porosity of the cement paste; however, excessive amounts may not contribute significantly to strength enhancement [25-27].

The same observation was detected in flexural strength. The greatest improvements were found to be between 8% and 10% silica fume replacement. Beyond this range, the effect diminished. These results align with previous studies [28] and [29], which demonstrated that silica fume enhances the flexural strength of mortar.

Although the changes were not as great as those in compressive and flexural strength, splitting tensile strength also increased with increased silica fume content and longer curing times. As before, the range of 8%–10% replacement exhibited the best results, further silica fume addition had little effect after this. According to previous research [25, 30, 31], silica fume enhance tensile strength, but the advantages gradually diminish.

The results show that the optimal amount of silica fume to improve strength is between 8 and 10%. Using a larger amount achieves no additional benefits, and may even lead to negative side effects, including increased water demand and the potential for the material to bunch up. An 8% replacement trial mix was found to be successful in improving the performance of eco-friendly mortar.

Test result of the crumb rubber replacement

Table 11, Figures 7 and Figure 8 present test results illustrating the effect of crumb rubber (CR) on the compression, flexural strength, and splitting tensile strengths of cement mortar at 7 and 28 days.

Table 11. Test results for cement mortar with crumb rubber at 7 & 28 days

Index	% Replacement of Sand with (CR)	Compressive Strength (MPa)		Flexural Strength (MPa)		Splitting Tensile Strength (MPa)	
		7 days	28 days	7 days	28 days	7 days	28 days
Traditional Mix	0	33.59	43.48	8.65	9.54	3.34	3.54
CR1	5	24.10	28.32	6.63	8.58	2.91	3.20
CR2	10	17.04	22.82	5.75	7.13	1.67	2.53
CR3	15	14.28	18.57	4.77	6.14	1.58	2.10

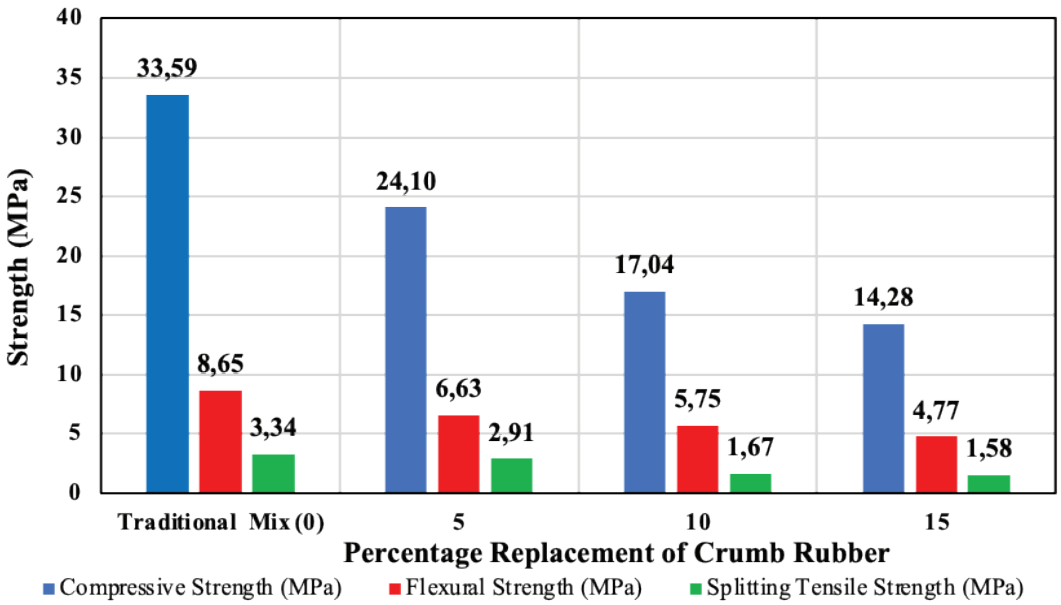

Figure 7. Test results for the mortar with crumb rubber at 7 days.

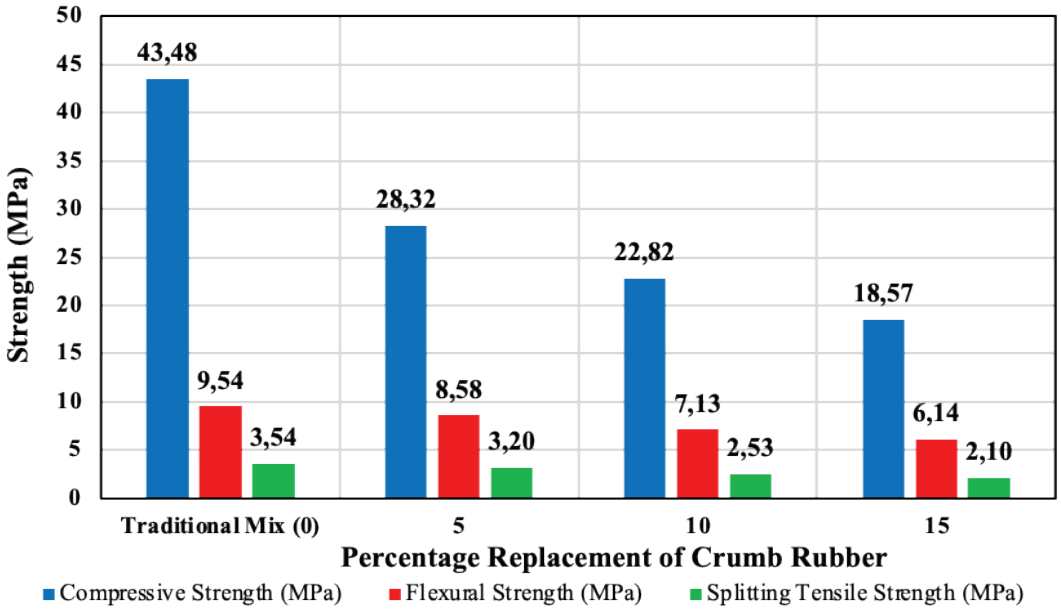

Figure 8. Test results for mortar with crumb rubber at 28 days.

The compressive strength declined with the increasing replacement ratio of crumb rubber with sand. This trend aligns with previous findings [32, 33]. At 7 days of ages, compressive strength decreased by 28.25%, 49.24%, and 57.45% compared to the traditional mix at rubber (CR) levels of 5%, 10%, and 15%, respectively; the corresponding reduction rates at 28 days were 34.87%, 47.51%, and 57.29%. This decrease in strength can be attributed to the weak interfacial bond between the rubber particles and the cementitious mix, which facilitates micro-crack formation and accelerates crack propagation under loading [34].

Increasing the replacement ratio of rubber with sand leads to a decrease in flexural strength. At 28 days, the percentage decrease was lower than the traditional specimens by 10%, 25.2%, and 35.6% for 5%, 10%, and 15% rubber replacement. Several factors contributed to this reduction, including the weak adhesion between rubber particles and cement mix, the non-homogenous distribution for rubber particles inside mortar, and the hydrophobic nature of the rubber particles. These properties can lead to air entrapment during mixing, caused an increased air content and reduce the dense of mortar matrix [35, 36].

A same pattern was observed in splitting strength, which decreased when rubber ratio increased. The reduction in splitting strength at 28 days was 9.6%, 28.5%, and 40.6% compared to the traditional mortar at rubber replacement of 5%, 10%, & 15%, respectively. This reduction is attributed to the loss of bonding material within the cementitious matrix resulting from the incorporation of crumb rubber. However, the reduction in tensile strength was less than compressive strength, because the rubber bridged cracks and limited their progression [35, 37].

The optimum strength was obtained with 5% of rubber replacement with sand. A trial mix with this percentage was conducted to confirm the results.

Test result of adding waste plastic fiber bottle

Table 12, Figures 9 and Figure10 present test results showing the effect of waste fiber bottle (PF) on each strength of the cement mortar made with 8% silica fume replacing

Table 12. Test results for mortar with (PF) at ages 7 and 28 days

Index	% Addition of PET	Compressive Strength (MPa)		Flexural Strength (MPa)		Splitting Tensile Strength (MPa)	
		7 days	28 days	7 days	28 days	7 days	28 days
Tradition Mix	---	33.59	43.48	8.65	9.54	3.34	3.54
Control Mix	0	26.42	32.52	6.82	7.45	3.07	3.33
PF1	0.5	19.75	24.69	6.57	7.05	3.16	3.39
PF2	0.75	20.32	24.90	6.62	7.13	3.22	3.47
PF3	1	19.27	22.89	6.39	6.80	3.10	3.37

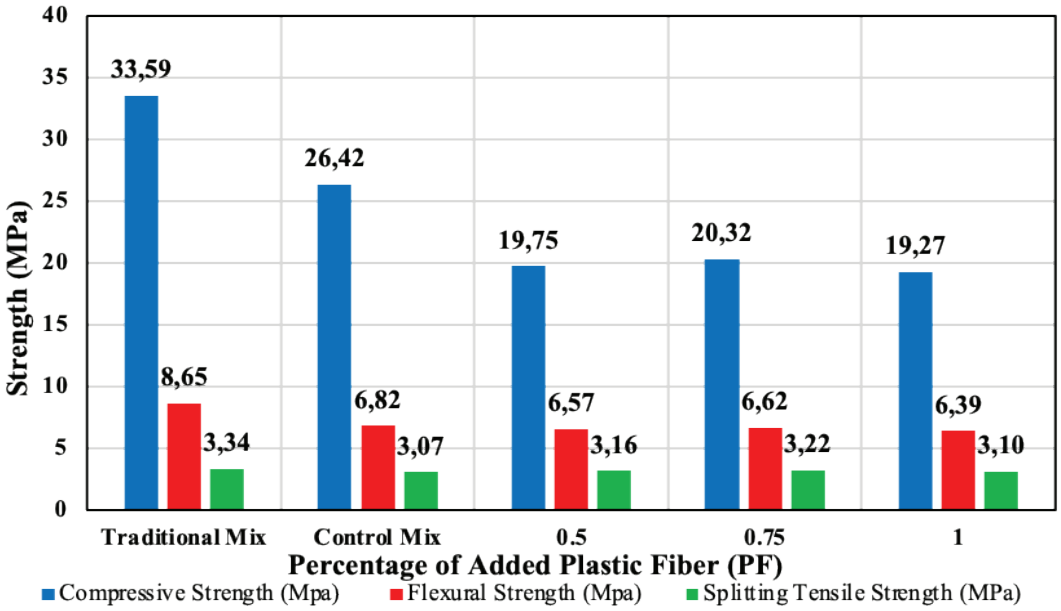

Figure 9. Test results for mortar with plastic fiber at 7 days.

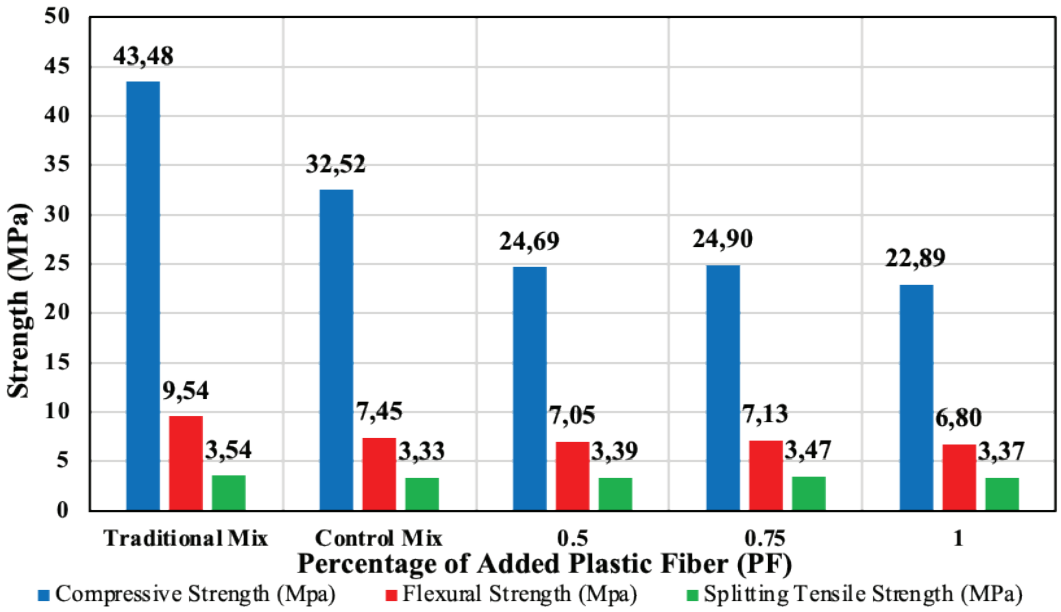

Figure 10. Test results for mortar with plastic fiber at 28 days.

cement and 5% crumb rubber replacing sand at 7 and 28 days. Figure 11 show eco- friendly specimens after tested.

Incorporating recycled plastic fibers at various volumetric ratios caused a reduction in the compressive strength of mortar. This result aligns with previous studies [38, 39]. At 28 days, their reductions in strength were 24%, 23.4%, and 29.6% as compared to the control mortar for plastic fiber contents of 0.5%, 0.75%, & 1.0%, respectively. The specimens containing 0.75% fibers showed the smallest reduction in compressive strength. This was due to increased void content associated with fiber incorporation and the weak interfacial bond between the plastic fibers and the paste [40].

The addition of waste plastic fibers has also led to decline in the flexural strength of mix as compared to the control matrix. At 7 days, flexural strength was reduced by 3.67%, 2.93%, and 6.30% for three different ratios of plastic fiber 0.5%, 0.75%, and 1.0%, respectively. The reductions in the



Figure 11. Show eco-friendly specimens after testing.

flexural strength at 28 days, were 5.37%, 4.29%, and 8.72%. These result are aligned with previous studies [41, 42]. The decrease in flexural strength was due to fiber length and random distribution throughout the mortar mix. Meddah and Bencheikh [43] noted that fiber length can influence flexural performance; their results showed that incorporating short fibers (30 mm long) caused a slight decrease in flexural strength, whereas longer fibers (50 and 60 mm long) had a negligible effect on this property.

Unlike compressive and flexural, the splitting strength increased with increasing plastic fiber content. Its increase in strength at 28 days was 1.8%, 4.2%, and 1.2% relative to the control mixture for fiber ratios of 0.5%, 0.75%, & 1.0%, respectively. The highest improvement was observed at a fiber content of 0.75%. These result are consistent with other previous studies [44, 45]. The most significant increase occurred at 0.75% fiber content. (PF) fibers significantly improve the mortar's resistance to crack propagation. The mechanism involves (PF) fibers acting as a reinforcing material that prevents the formation and propagation of cracks within the mortar [46]. This reinforcing effect is particularly significant at the 0.75% level, exhibiting a positive connection with the tensile strength of (PF) fiber.

Optimum mixture

The optimum mix was obtained with 8% silica fume replacing cement, 5% crumb rubber replacing sand, and 0.75% plastic fiber added to the mortar. The modified mortar showed mechanical strengths of (24.9 MPa (compressive), 7.13 MPa (flexural), and 3.47 MPa (tensile strength) at 28 days. Figure 10 illustrates the strength performance of the optimal mixture at 28 days is reduced compared to traditional mortar by (25.26, 42.7, and 1.97) % for flexural, compressive, and tensile strength, respectively. The modified mortar offers environmental benefits despite the reductions in strength and could be appropriate for applications that allow a lower strength, such as casting nonstructural elements and using it with ferrocement to strengthen beams, because using eco-friendly materials reduces crack

Table 13. Cost comparison

Details	Unit	Estimation of Cost and Quantities for Traditional Mortar			Estimation of Cost and Quantities for Eco-Friendly Mortar		
		Unit Price ($)	Amount	Total price ($)	Unit Price ($)	Amount	Total price ($)
Cement	Ton	105.63	0.00762	0.81	105.63	0.00762	0.81
Sand	m^3	21.2	0.0091	0.2	21.2	0.0085	0.18
Silica Fume	Kg	1.76	0	0	1.76	0.61	1.1
Waste Tire Rubber	Kg	0.71	0	0	0.71	0.726	0.511
Waste Plastic Fiber	Kg	1.76	0	0	1.76	0.206	0.36
Labors	daily	17.6	1	17.6	17.6	1	17.6
Total Cost ($)				18.61	Total Cost ($)		20.56

width as a result of plastic fiber and reduces the self-weight of the element due to the low density of these materials.

Cost comparison

The cost comparison between traditional and eco-friendly mortar are shown in Table 13. From Table 13 shows that using traditional mortar is less expensive and stronger than the eco-friendly mortar. The cost of the eco-friendly mortar was approximately 10.4% higher than that of traditional mortar. This increase can be attributed to the limited availability of specialized facilities in Iraq for processing and recycling waste materials, including silica fume, crumb rubber, and waste plastic fibers.

CONCLUSION

Silica fume improved the mechanical performance of the mortar compared to the traditional mortar. An 8% silica fume replacement level yielded the best overall performance at both 7 and 28 days. This improvement is attributed to the optimal balance between workability, cement hydration, and sufficient pozzolanic activity. Higher replacement levels may weaken the material due to reduced cement content, while a lower level may not completely utilize the benefit of silica fume. In the other hand, replacing fine aggregate with crumb rubber led to reduce in strength. In general, the strength loss increased with increasing rubber content; Where the replacement ratio with rubber by 5% recorded the lowest rate of decline among the traditional mixtures, with decline rates of 9.6%, 34.87%, and 10.0% in each of the tensile strength, compressive strength, and flexural strength, respectively. This behavior was due to the weak bond between the rubber and the mortar. Furthermore, implementing 0.75% plastic fiber in a mortar containing 8% silica fume and 5% crumb rubber improved flexural and splitting strengths compared to mortar containing silica fume and crumb rubber only; these results demonstrate the ability of plastic fibers to enhance the tensile properties of modified mortar. Based on the test results, the mechanical performance of the modified mortar is optimized by combining 8% silica fume, 5% crumb rubber, and 0.75% plastic fibers, especially regarding flexural strength and splitting tensile strength. Thereby encourages the use of waste materials in buildings. The modified mortar is appropriate for non-structural applications due to its improved tensile properties, although it doesn't exceed the strength requirements for structural applications that carry loads. Applications requiring durability and crack resistance, such as strengthening and retrofitting, can benefit greatly from its utilization.

AUTHORSHIP CONTRIBUTIONS

Authors equally contributed to this work.

DATA AVAILABILITY STATEMENT

The authors confirm that the data that supports the findings of this study are available within the article. Raw data that support the finding of this study are available from the corresponding author, upon reasonable request.

CONFLICT OF INTEREST

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

ETHICS

There are no ethical issues with the publication of this manuscript.

STATEMENT ON THE USE OF ARTIFICIAL INTELLIGENCE

Artificial intelligence was not used in the preparation of the article.

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