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ORIGINAL ARTICLE

Influence of recycled materials as partial replacement of natural sand on the behavior of sustainable concrete

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Abstract: The primary goal of the current paper is to evaluate the viability of the sustainable concrete (S.C) made of waste glass sand (WGS) and waste plastic sand (WPS). This paper looks at concrete mixtures as follow: the first group (5%, 10%, and 15%) WGS as the sand replacement and Group Two (5%, 10%, and 15%) WPS as a natural sand replacement, and finally, group three HRS where, (5%, 10%, and 15%) of WSP/WGS were evaluated as sand substitutes. Tests were done on the concrete to ensure that the tested concrete's behavior was within expectations. Among these tests are the slump test, compressive strength test, indirect tensile strength test, flexural strength, and elastic modulus test. The results showed that using WGS and WPS together improved the slump of the concrete mixtures. Adding WPS or HRS to concrete mixes enhanced the mechanical properties, and Compressive strength increased, reaching a maximum of 52.05 MPa after partially substituting natural sand with WGS-10% of sand. And finally, when replacement ratios were high, the results showed that the concrete's compressive strength decreased when WGS-15% and WPS-15 % were substituted at 9.85% and 14.45% respectively.

Keywords: waste plastic sand (WPS), waste glass sand (WGS), Hybrid Recycled sand (HRS), sustainable concrete (S.C), Recycled concrete (R.C)

1 Introduction

The construction industry significantly impacts environmental degradation, as this industry saps over 55% of coarse and fine aggregates in the depletion of natural resources and a high ratio of CO_2 emissions [1, 2]. Researchers have focused on looking for other suitable materials, including recycled aggregates (RA) from demolition and construction waste, which have been researched for different cement-based materials, particularly conventional and high-strength concrete [3, 4]. Waste-based concrete and methods of manufacture have been the focus of several recent studies, with a view to the problem of waste management strategies. Many researchers have studied the mechanical properties of concrete [5, 6]. The last four decades have witnessed much work on concrete's mechanical properties, including waste and recycled material. From the authors' analysis, it can be deduced that waste is a good factor in improving concrete's mechanical properties and durability. In addition, another research study demonstrated increased concrete strength with waste particles [7- 10]. Also, this study by researchers initiated good strengths of concrete containing various waste materials because they found optimal proportions [11-13]. Therefore, Sand waste materials replace natural sand and can be used not only to improve the ductility of concrete but also to increase its strength [14-16]. Using waste enhances the properties of concrete and the performance of the concrete elements.

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Previous studies relating to the behavior of the mixtures further revealed that some aspects of the suspension concrete made from waste material had the highest load-bearing capacity compared to concrete of a similar composition without waste. Substitution of plastic waste for replacement percent sand was the best behaved in that it helped cure some of the cracks, prolonged further growth of cracks, and enhanced the tensile characteristic of the test specimens [17-19]. Considering that the plastic waste was among the replacements, they performed well, adding strength to the concrete at low replacement percentages. The resulting waste becomes one of the significant challenges we face as a society, and it needs to be sorted out. The current study assessed the Inactive reuse of waste materials in concrete mass production so that costs are reduced while the issues of waste materials are addressed [20-22]. Few papers have studied the effects of sand waste replacement on concrete's mechanical properties. See **Fig.1**. Plastic waste increases concrete quality and enhances concrete members' structural performance. The impact – performance enhancement – of the replacement is that it increased the strength of the concrete even when it had been replaced by natural sand with 10% plastic waste [23, 24]. According to the Previous studies, the use of plastic sand enhances the properties of the recycled concrete (R.C.) as well as the performance of the R.C.

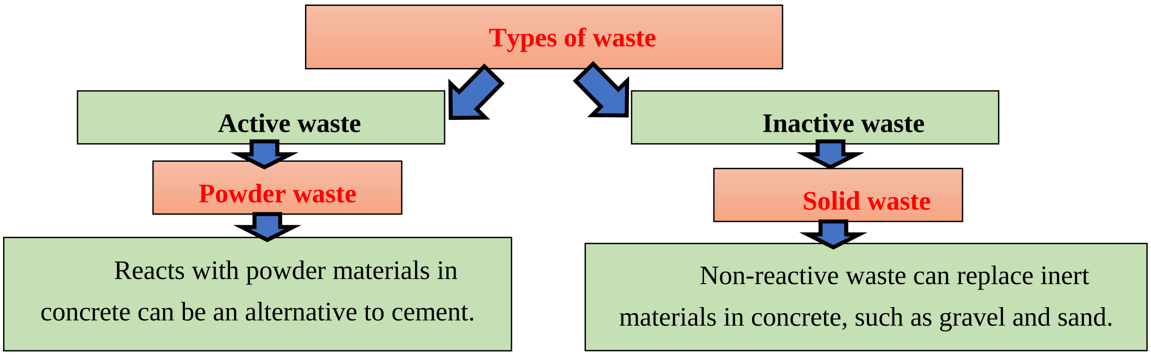

Fig.1: Classification of waste in general in terms of its use in concrete[1, 23]

On the other hand, it was found that the concrete derived from appropriate waste possessed the most significant load capacity among all the types, replacement-free, concrete mixtures. Glass Waste as a natural sand substitute performed best; The plates did not crack early and exhibited improved concrete behaviors and tensile strengths [25, 26]. Their replacement of Glass waste in the concrete has improved its strength with a low dosage replacement percentage. However, such practices are some of society's most significant problems since rubbish is becoming a common disease [27, 28]. Previous studies focused on using material waste in concrete as a powder, not an aggregate, which improved the economics of the concrete and alleviated issues related to the waste materials. [29, 30]. It was found that waste glass contributed to higher integral strength even in concrete [25, 30]. As observed by Previous studies, using glass sand enhances the workability of recycled concrete and improves its toughness and mechanical [31, 32].

The necessity of discovering alternatives to trashing waste materials has risen due to the factors that concern the diversity of trash types, which is a conclusive issue that will affect society [32, 33]. Manufacturing of concrete with trash is one such advancement. Studies have been conducted on concrete's behavior; however, some of the concrete's structural Performance was improved by using added inert waste materials like glass sand and plastic sand. It is acknowledged that such alternatives incorporate the reuse of glass and plastic waste in concrete applications [34, 35]. Even so, using recycled materials in the concrete helps in waste management by providing alternative means of disposal for plastic and glass waste. Including glass sand and plastic sand reinforces concrete technology by improving its strength, workability, and durability [36-38]. Thus, as plastering materials of concrete structures, glass and plastic can be seen as multifunctional materials for less green pollution, cleaner waste, and economical fabrication of concrete structures [39-42].

This paper seeks to assess the benefits associated with plastic, and glass waste by seeking to fill the gap in knowledge on the benefits that could be obtained through improving the properties of built structures. In the first category, plastic sand is used as a partial replacement for natural sand (0%, 5%, 10%, and 15%), while glass sand in the second category is a substitution for natural sand (0%, 5%, 10%, and 15%). The third group replaces plastic sand and glass sand at ratios of (0%, 5%, 10%, and 15%). This study aimed to investigate the developed eco concrete's slump test and mechanics properties.

2. Materials

2.1. Portland cement

Fig. 2 concludes that the cement (42.5N) used conforms to the Egyptian Standards, ESS 4756-1/2007. The chemical properties of the cement used were also investigated.

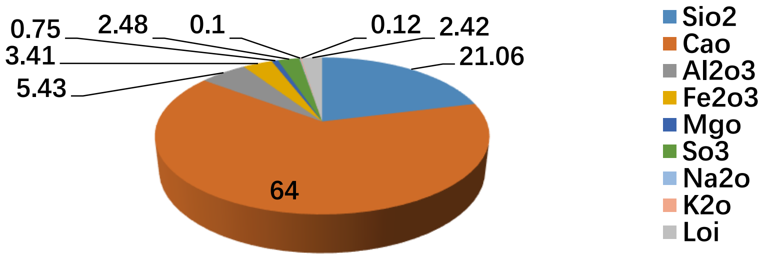

Fig. 2: Chemical of Analysis Cement Used, [111]

2. 2 Waste glass sand (WGS)

Three mixtures were prepared, and in each mix, waste glass sand (WGS) of 5%, 10%, and 15% was replaced with natural sand, previously considered waste material. The clear glass bottles used in this case study were washed, and the labels were removed. Finally, the glass bottles were ground and sieved until they attained the same smoothness as the sand, and A 4.76 mm sieve was also used for sieving the glass sand (**Fig. 3**).

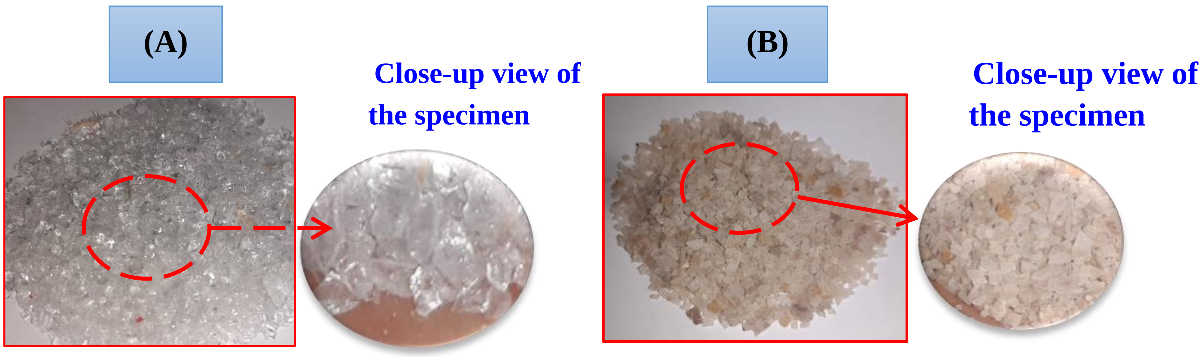

Fig. 3. (A), Waste glass sand (WGS), (B) Waste plastic sand (WPS)

2. 3 Waste plastic sand (WPS)

Natural sand was partially replaced with waste plastic sand by ratios 5%, 10%, and 15%. The old plastic was collected, washed, left to dry, and then ground. A 4.76 mm sieve was also used for sieving the plastic sand. **Fig. 3** shows the shape of the plastic sand sample used in the present study.

3 Experimental work

3.1 Details of the tested mixtures

The practical aspect presents the particulars of substituting waste glass sand (WGS) and waste plastic sand (WPS) for natural sand. Further, the details of the experimental program are illustrated in **Fig. 4**. All ten mixtures carried out in this research had different concrete mixtures. The details of the examined compositions are given in **Table 1**. Portland Cement with constant contents for all mixtures was used. Waste glass sand (WGS) and waste plastic sand (WPS) were incorporated as a partial replacement of natural sand in mixtures. Natural sand was replaced by ratios (5%, 10%, and 15%) of

WGS for the first group, by ratios (5%, 10%, and 15%) of WPS for the second group, and by ratios (5%, 10%, and 15%) of HRS for the third group.

Hybrid Recycled Sand (HRS) is a mixture of waste glass sand (WGS) and waste plastic sand (WPS), a 50%/50% blend of WGS and WPS, See **Table 1**.

For example: Hybrid Recycled sand = (50%WGS+50% WPS), Mixture 7: HRS-5%= (2.5%WGS+2.5%WPS), Mixture 8: HRS -10%= (5% WGS+5%WPS), Mixture 9: HRS -15%= (7.5% WGS+7.5%WPS).

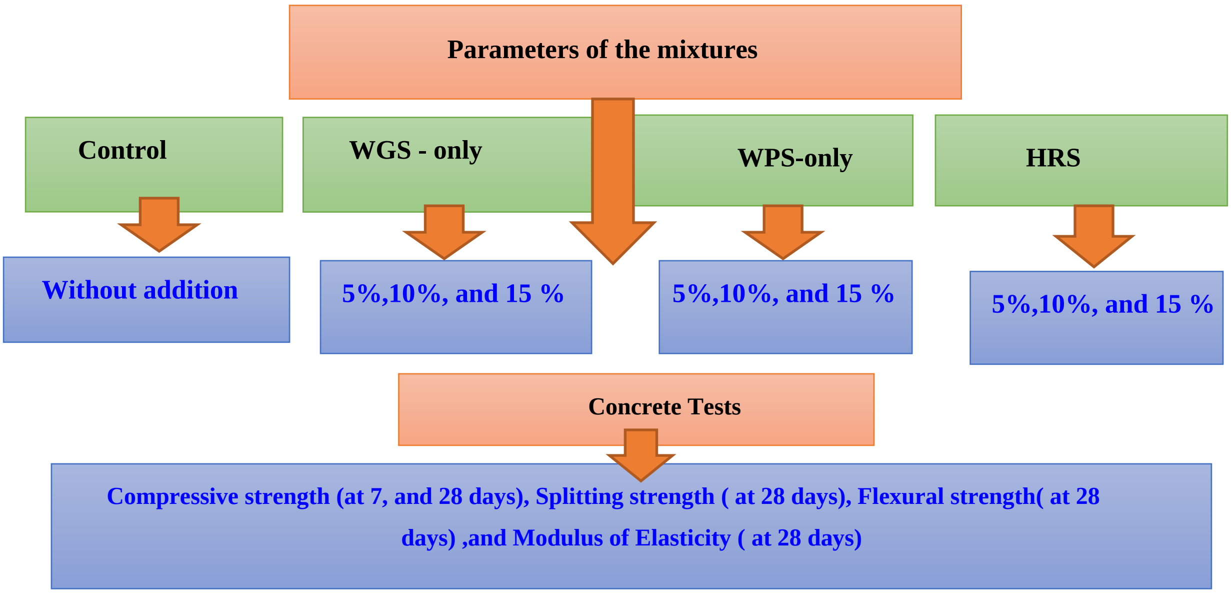

Fig. 4. Details of the experimental program

Table 1: Proportions of Concrete Mixtures (kg/m^3)

No.	G.	Mix	Cement	Natural sand	Coarse aggregate	Water (0.4 of cement)	SP (2% of cement)	WGS	WPS	*HRS
1		C 0.0%	420	735.5	1103.25	168	8.4	0	0	0
2		WGS-5%	420	698.7	1103.25	168	8.4	36.8	0	0
3	G1	WGS-10%	420	661.9	1103.25	168	8.4	73.6	0	0
4		WGS-15%	420	625.17	1103.25	168	8.4	110.33	0	0
5		WPS-5%	420	698.7	1103.25	168	8.4	0	36.8	0
6	G2	WPS-10%	420	661.9	1103.25	168	8.4	0	73.6	0
7		WPS-15%	420	625.17	1103.25	168	8.4	0	110.33	0
8		HRS -5%	420	698.7	1103.25	168	8.4	0	0	36.8
9	G3	HRS -10%	420	661.9	1103.25	168	8.4	0	0	73.6
10		HRS -15%	420	625.17	1103.25	168	8.4	0	0	110.33

*Hybrid Recycled sand = (50%WGS+50% WPS)

On the other hand, natural dolomite coarse aggregate was used as coarse aggregate in the mixes, and natural sand as fine aggregate was used in the mixes, and ratio of (coarse: fine) aggregate of 1:5. To maintain the same consistency without increasing the water content (water/binder)=0.4, the superplasticizer Sicament R2004 was applied in this research at 2% of the cement content, and It is a plasticizer and to a workability concrete admix (Conform to ASTM C 494 - Type G and BS 5075 - part 3), The ratios provided consistent and satisfactory workability and low water and binder requirements, And all mixtures exhibited slump values ranging from 60 mm to 70 mm.

3.2 Methods of Mixing and casting of concrete

The concrete was categorized into groups to evaluate their mechanical properties using the control group, the WGS replacement group I, the WPS replacement group II, and the HRS replacement group III. The specimens' design and curing condition standard was ASTM C192-02. To set the slump of these new concrete mixtures. A total of sixty samples of concrete specimens measuring 100 x 100 x 100 mm were prepared according to BS 1881-116, for seven days and twenty-eight days for compressive testing. Thirty concrete specimens were cast and cured for flexural strength tests at twenty-eight days of age. The flexural strength was measured according to ASTM C78/C78M-18. A tensile strength test followed procedures specified in ASTM 496/496M-17. The modulus of elasticity was determined by specimens of 100 mm diameter and 200 mm height after 28 days, ASTM C469/C469M-14.

4 Results of the Mixes

From **Table 2**, this section provides the analysis of the results obtained from the destructive tests to evaluate specimens of the mixtures, which were cast and cured for 7 and 28 days. Further, this section explores the Impact of WGS, WPS, and HRS on properties of concrete. **Fig. 5** gives the number of samples examined per test.

Table 2: Results of the mixtures

No.	Group		Compressive Strength (MPa)		Flexural strength At 28 days (MPa)	Splitting strength At 28 days (MPa)	Modulus of Elasticity At 28 days (MPa)
			7 day	28 days			
1		C 0.0%	33.09	50.74	6.41	6.11	34845
2	G1	WGS-5%	35.09	51.81	6.71	6.41	35884
3	G1	WGS-10%	36.21	52.05	6.85	6.55	36145
4	G1	WGS-15%	31.41	45.74	5.71	5.41	31258
5	G2	WPS-5%	33.58	50.93	6.46	6.17	35012
6	G2	WPS-10%	30.85	45.31	5.62	5.32	30589
7	G2	WPS-15%	29.53	43.41	5.31	5.01	29185
8	G3	*HRS -5%	34.46	51.08	6.52	6.22	35121
9	G3	*HRS -10%	32.54	47.24	5.91	5.61	32451
10	G3	*HRS -15%	30.07	44.32	5.47	5.19	29814

***Hybrid Recycled sand = (50%WGS+50% WPS)**

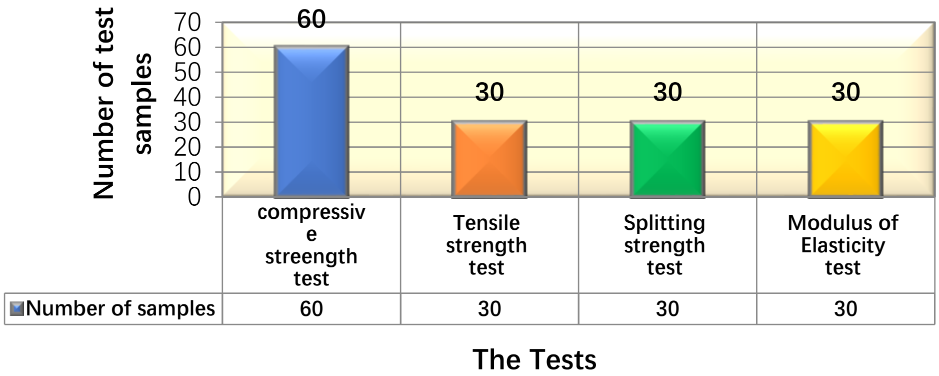

Fig. 5: The number of samples examined per test

4.1 Compressive Strength

As demonstrated in **Fig. 6**, the compressive force was evaluated at 7 and 28 days of age. **Table 2** is based on values derived from an average of three samples. The section further discusses the limitations and effects of significant factors, for example, the contribution of waste glass sand and waste plastic sand on the mechanical properties of the concrete [43, 47]. **Fig. 7** shows how adding waste glass sand and plastic sand to concrete changes its binding characteristics at 28-day age. With waste glass sand and waste plastic sand in a high-strength concrete mix, the compressive strength was enhanced by 2.11% for the mixture WGS-5%, HRS -5% mixture increased by 0.67%, and WPS-5% mixtures increased by 0.37%, as compared to the control [48-51]. Finally, the compressive strength of waste glass sand (WGS) in concrete decreased by 9.85% for WGS-15% compared to the control sample at a high replacement ratio [52, 54, 55]. This is the lowest decrease compared to other species at the same replacement ratio of natural sand, as shown in **Fig. 7**.

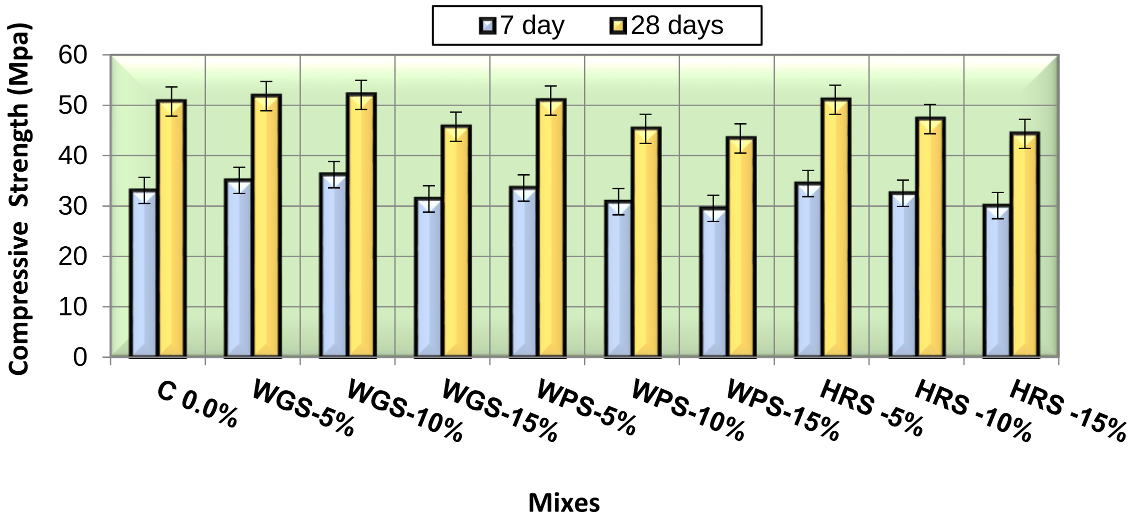

Fig. 6. Compressive strength at 7 and 28 days of all the mixtures

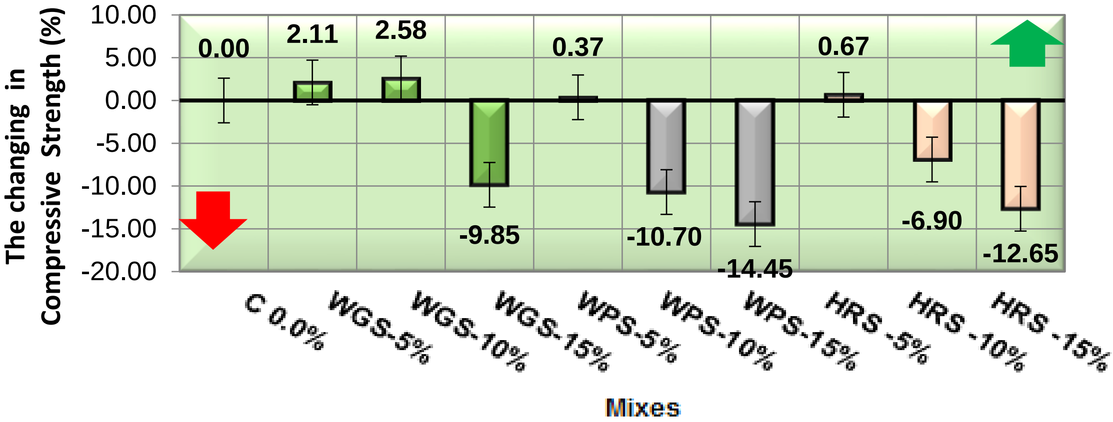

Fig. 7. The changing in Compressive Strength (%)

The plastic sand waste mixture recorded the lowest increase by 0.37% of the control mix and the highest decrease rate compared to the rest of the mixture groups, which recorded 14.45% [55-57]. **Fig. 8** shows the concrete cubes' failure shape after the compressive strength test. Several specimens possess differing failure shapes. The addition of waste glass sand or hybrid recycled sand (HRS) resulted in low-effect Cube failure, and thus, the samples collapsed accurately [57-59]. The findings indicate superior performance for WGS compared to WPS. This is because the crystalline structure of glass differs from the porous structure of plastic.

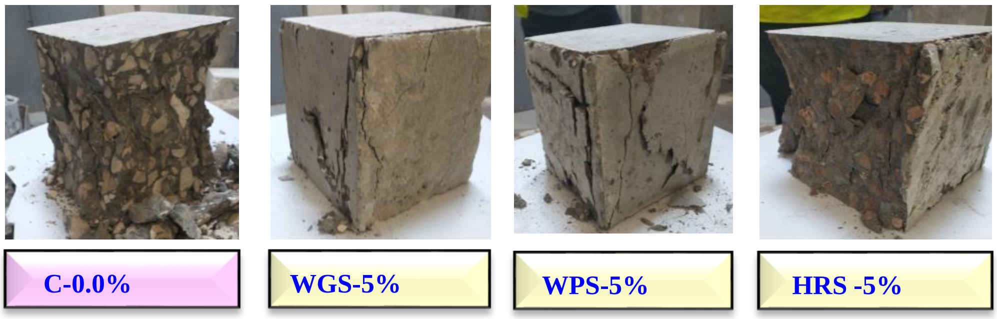

Fig. 8: Failure shape after testing for cubes

Concrete cubes behavior under compression at 28 days is almost Similar to cubes at replacement WGS and WPS with natural sand, see **Fig.8**. Concerning this, the types of breakdown were utterly unchanged in sets of samples with low replacement for waste glass sand, waste plastic sand and Hybrid Recycled sand (HRS)This is what explains the existence of cohesion in the structure of the cube This failure was only appropriate at low replacement rates such as (WGS-5%, WPS-5%, and HRS -5%) [60-62].

4. 2 Flexural Strength

The flexural test of mixes C 0.0%, WGS-5%, WGS-10%, and WGS-15% recorded 6.41, 6.71, 6.85, and 5.71 MPa, respectively. While among concrete mixes, WPS-5%, WPS-10%, and WPS-15% the flexural test 6.46, 5.62, and 5.31 MPa, respectively [63-65]. Using WGS -10%, it was observed that there is an optimum enhancement of concrete flexural strength to the extent of 6.86% for strengths in such a way that, when compared to the control mix, the maximum increase ratio was reached. It was illustrated in **Fig. 9**, [65, 66]. WGS rather than WPS enhanced flexural behavior more than recycled WPS [67-69]. It is likely because glass is originally sand, and when recycled to replace sand, it returns to its original state before manufacturing. However, the difference between WGS and natural sand is due to the glass's crystalline form and distinct external and internal structures, and it is still considered sand. Still, it has undergone several processes to improve its structural properties, which pushed for greater bonding with the concrete, which was indicated to be one of the factors enhancing the bond between the concrete matrix and fiber bulk density interphase, See **Fig.10**. On the other hand, using HRS at 5% and 10% was a better alternative for flexural strength than WPS replacement. When high replacement ratios were used, the decreases were 10.92%, 17.16%, and 14.66% for WGS -15%, WPS -15%, and HRS -15% from the control concrete mix. The lowest decrease value was recorded in WGS, followed by HRS, and finally, WPS recorded the highest decrease percentage [70-72].

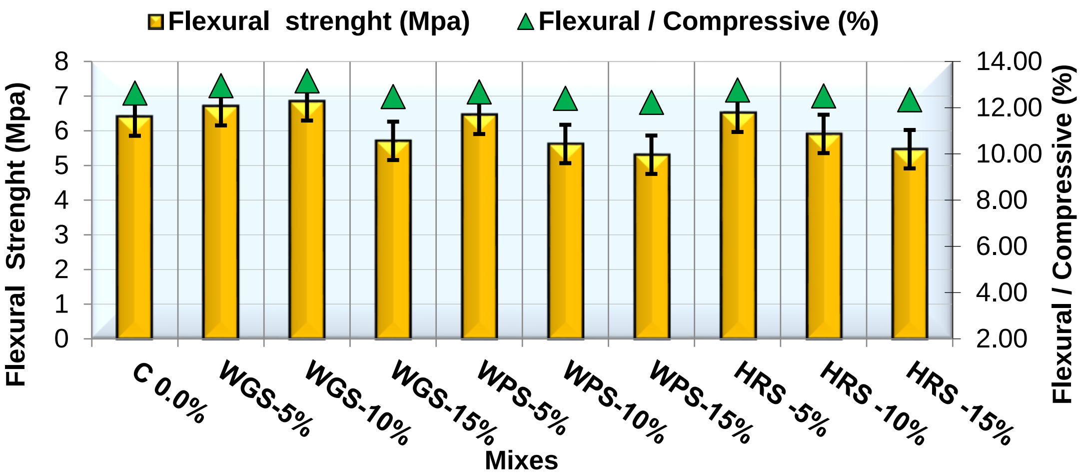

Fig. 9. Flexural Strength of the mixtures (Three loading points during the test)

The reason held within the explanation for the phenomenon of silicate sand did not yield any trends that were above – and indeed many are slightly less than – what had been anticipated [73-75]. It was because of the grinding process of the glass waste material until it was as soft as sand, See **Fig.10**, [75-77]. As a result, the produced fine aggregate became cracked in a structure internal to the aggregate, completely changing the contours and the internal structure of natural sand. Maybe the way this was produced affected, in a significant way, the resistance that was achieved. The outer hardness of the grains of sand belonging to natural sand has the contrary hardness that was broken due to the manufacturing process of sand from glass waste [78, 79].

Fig. 9 compares the flexural to compressive strength ratios (F/C) and flexural strengths of mixes with and without replacement. The amount or kind of sand replacement almost impacts the F/C ratio. However, incorporating recycled WGS and HRS considerably improved the ductility of concrete and lessened the failure mode under flexural loading: this finding is consistent with the literature, See **Fig. 10**[80-82].

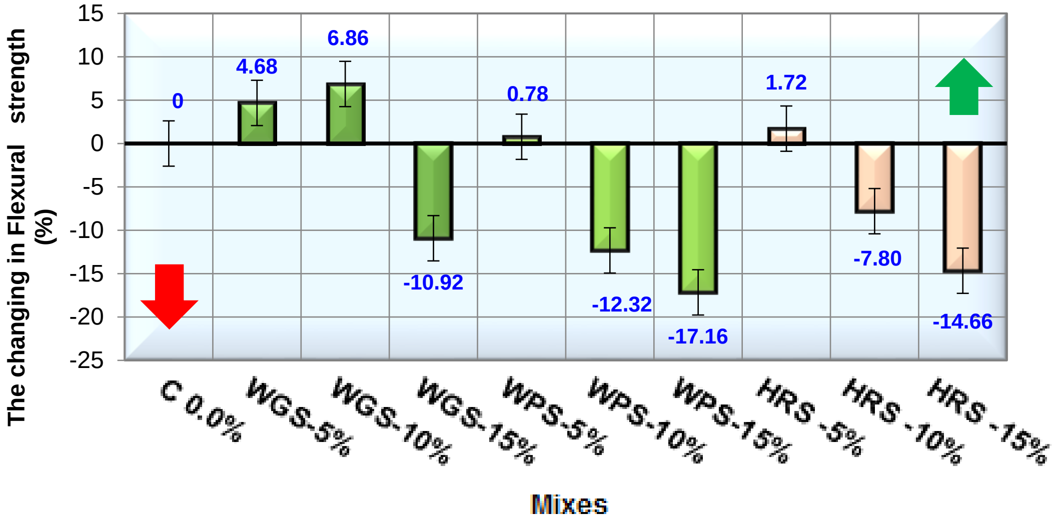

Fig. 10. The changing in flexural Strength (%)

4.2.1 Relationship between flexural strength, and compressive strength

This section will focus on the correlation between the compressive and flexural strength. The best-fit curve to verify this relationship is given in **Fig. 11** below:

$$Y = 0.1629x - 1.7628 \quad (1)$$

Where X is compressive strength in MPa. The goodness of the fit of the equation is tested using R2 at 0.9872. Y is also in MPa as the splitting strength.

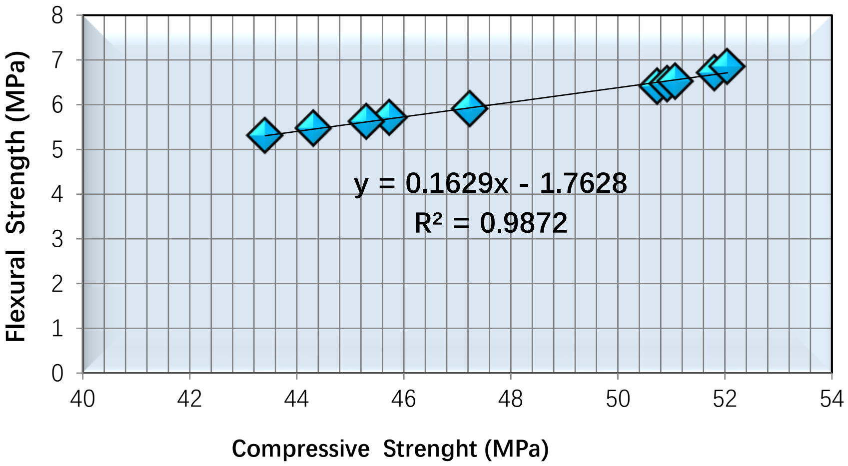

Fig. 11. Correlation between Flexural and compressive strength

Fig. 11 demonstrates the correlation between the samples' compressive and flexural strength. Each mixture of concrete leads to the derivation of this relation, considering the different results due to the various combinations. Therefore, it is logical that each mix will make a distinct relationship pattern to yield the most accurate results [83-85]. In this case, the presented line has a relatively higher degree of accuracy on the graph than those presented above, with fewer variations around the magnitude of strength. Therefore, R^2 explains it and gives a lower prediction of R, which can be stated using the splitting strength of the concrete specimen, which is likely to be the highest strength that can be conceived, See **Fig. 12**. It strengthens this approach by providing evidence that the properties develop as one goes in depth, as there is an increasing trend in concrete splitting and compressive strength [86-88].

4.3 Splitting Strength

The splitting strength of concrete indicates its resistance to cracking or fracture when subjected to external forces. This property becomes increasingly crucial in concrete structures exposed to excessive loads or adverse environmental conditions [89, 90]. Various factors affect splitting strength: the kind of cement, the water-to-cement ratio, the concrete mixture, and the production technology (**Fig. 13**). Splitting strength increased with the waste glass sand (WGS) and waste plastic sand (WPS) when replaced at a ratio of 5% of natural sand [91, 92].

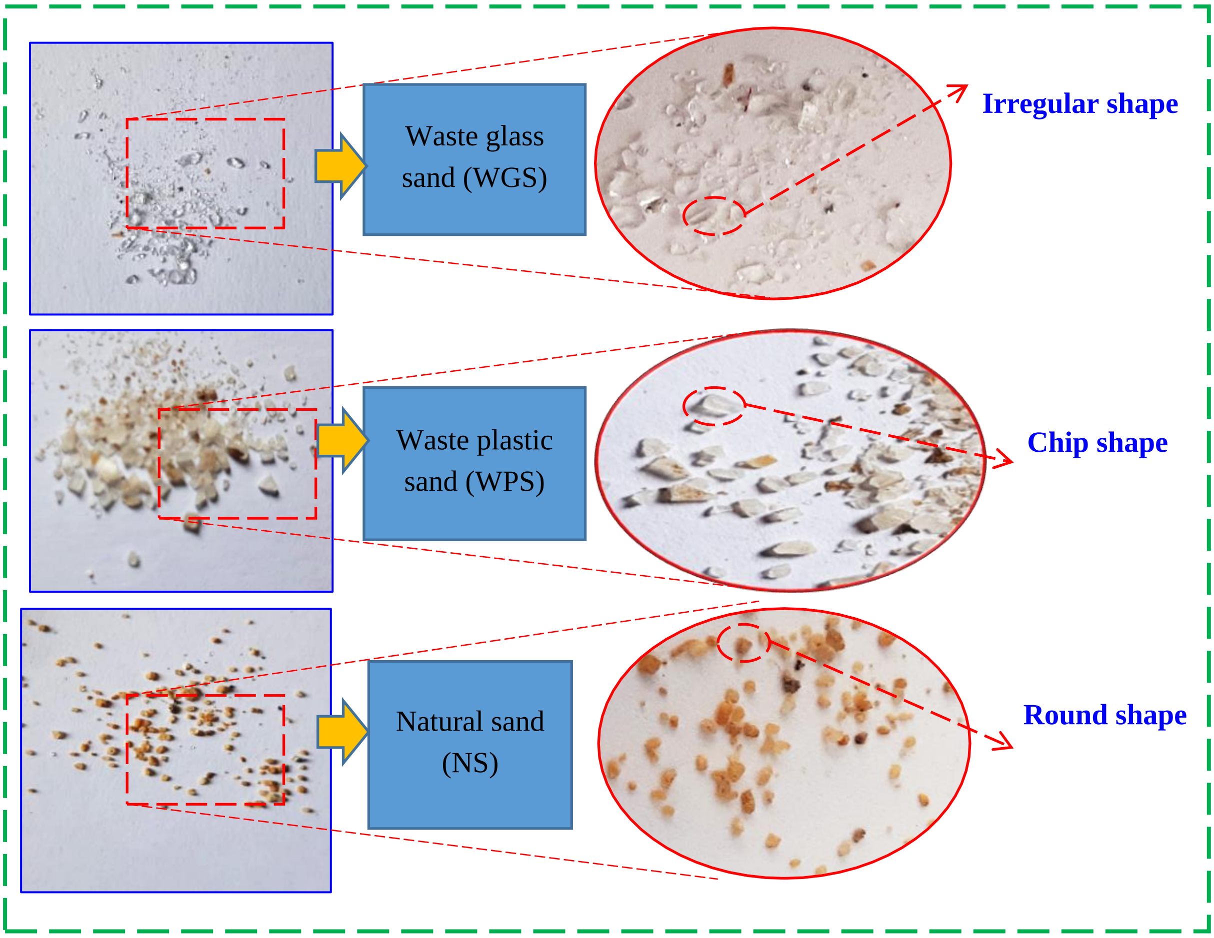

Fig. 12. Magnified images of the sample's structure (WGS, WPS, and NS)

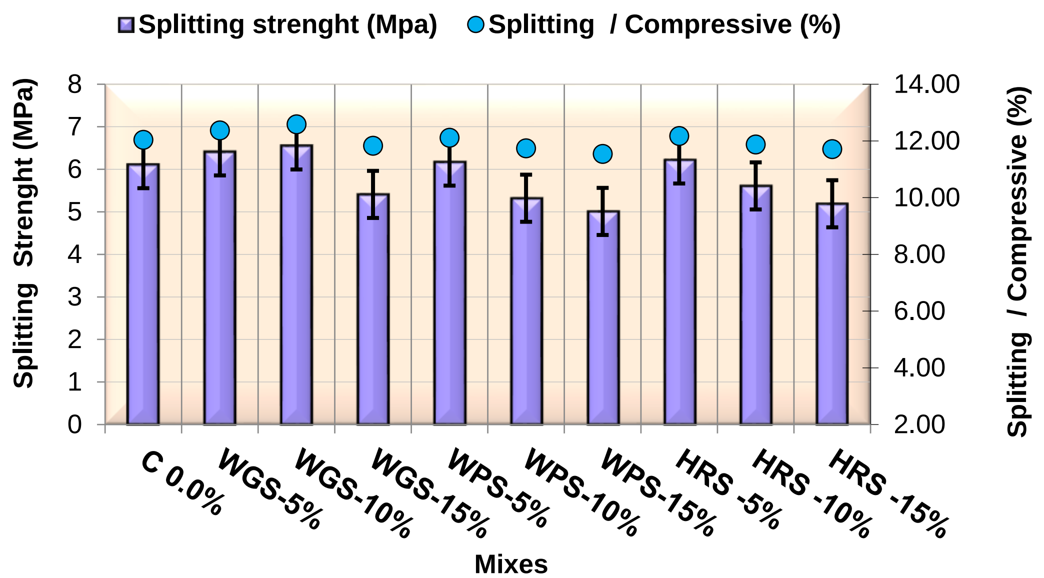

Fig. 13: Splitting strength, and splitting / compressive (%) of mixtures

For instance, WGS-10% improved the splitting strength of concrete to 7.20%. On the other hand, WGS-5% replacement saw an increase of about 4.91%. The tensile strength is improved as the replacement ratio increases and is considered the maximum effective increase when replacement WGS-10%. As presented in **Fig 14**, WPS-15% experienced a low of about 18.00%, the highest low. On the other hand, Tensile/compressive strength increased, and indirect strength rose and came within the expected range. It took the same resistance behavior at any type of sand replacement [93, 94].

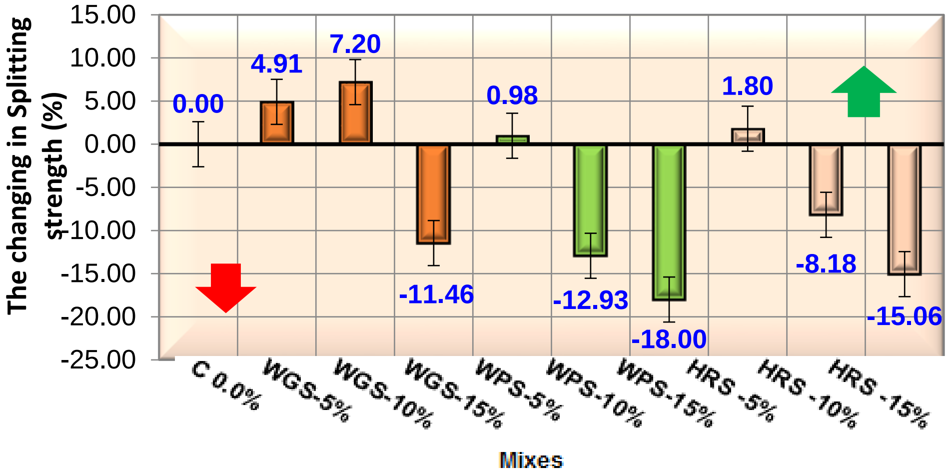

Fig. 14. The changing in Splitting Strength (%)

4.3.1 Relationship between splitting, and compressive strength

This section addresses the compressive and splitting strength. Below, a line of best fit that helps to show the relationship in the Figure graphically or mathematically is given in the form of an equation.

$$Y = 0.1623x - 2.0354 \quad (2)$$

Where X is compressive strength in MPa. The goodness of the fit of the equation is tested using R2 at 0.9873. Y is also in MPa as the splitting strength.

This is because each mix has its own compressive and splitting strength relationships based on its constituents [95, 96]. Concrete, a composite material with several proportions, seems to develop some assumptions in this theory and ardently follows just one cohesive relationship per matrix batch. Palpably, this leads to an increase in the splitting strength and compressive strength of the concrete and closure structural tests with wide projecting near ultimate loads [59, 97, 98]. See **Fig. 15**.

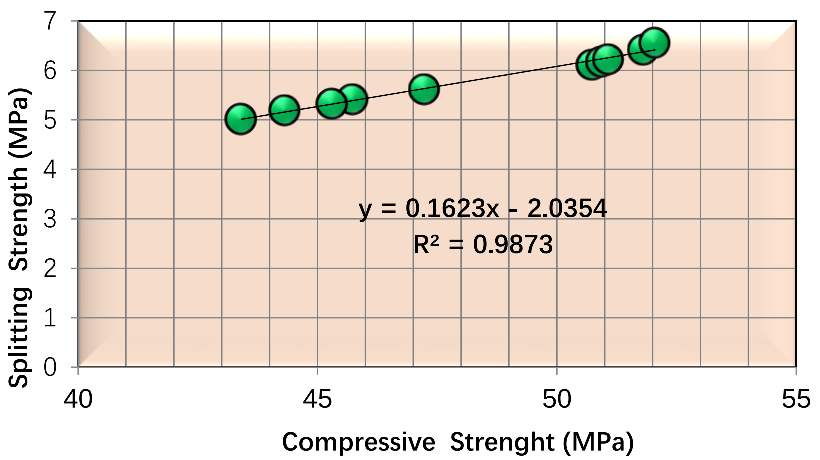

Fig. 15: Correlation between Splitting and compressive strength

4.4 Modulus of Elasticity

Because of its hardness, concrete does not have a high elastic modulus, unlike waste glass sand and plastic sand. This behavior may be attributed to high replacement ratios, which signified that the concrete was stiff. An experiment was done to determine the elastic modulus of concrete with and without waste materials. **Fig. 16** below shows how the replacement material percentage affects concrete's static modulus of elasticity [99-101]. The trend in the elastic modulus range was comparable to the three other strength results: compressive strength, flexural strength, and tensile strength. In most cases, all concrete mixes resulted in a decreased elastic modulus except for WGS-5% and WGS-10%, WPS-5% & HRS -5% combinations [102, 103].

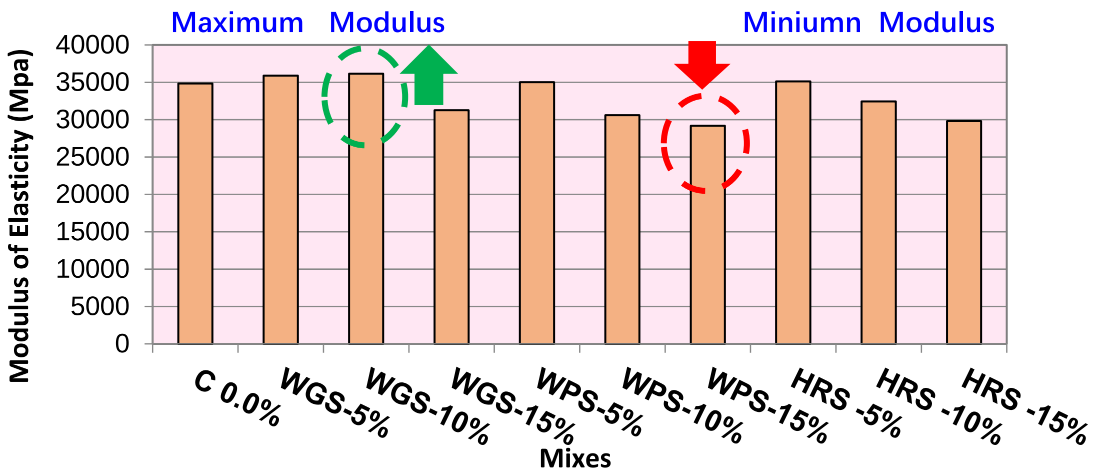

Fig. 16. Modulus of elasticity for the mixes

Compared to mixes with waste glass sand, waste plastic sand, and hybrid recycled sand, those with only waste glass sand achieved a higher elastic modulus. This may be because the compressive strength of waste plastic sand-only mixes was not so effective. Statistically, WGS-5% and WGS-10% were highlighted as promising for enhancing the elastic modulus of the concrete as well [103, 106,112]. Considering the additions of WGS-5% and WGS-10%, the modulus of elasticity increased by about 2.98% and 3.73%, respectively. Although the rest of the mixtures did not gain any elasticity, they showed a loss in the range of 6.87% to 16.24%. See **Figs. 17&18**. These changes in the modulus of elasticity were relevant for the compressive strength of the concrete at the same strain level [78, 105-110,112].

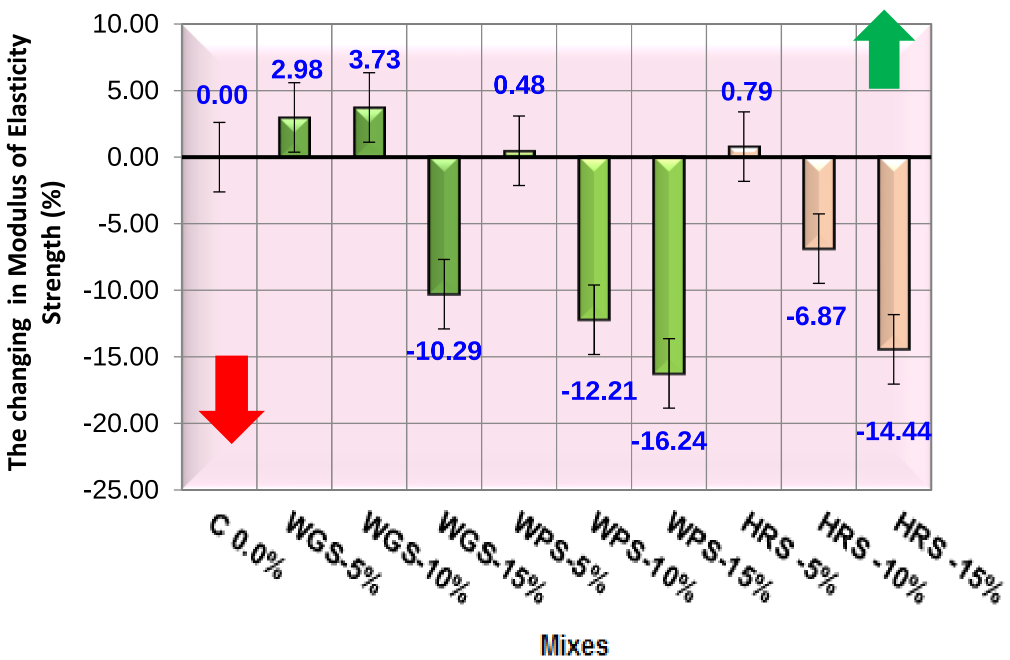

Fig. 17. The changing in the modulus of elasticity strength (%)

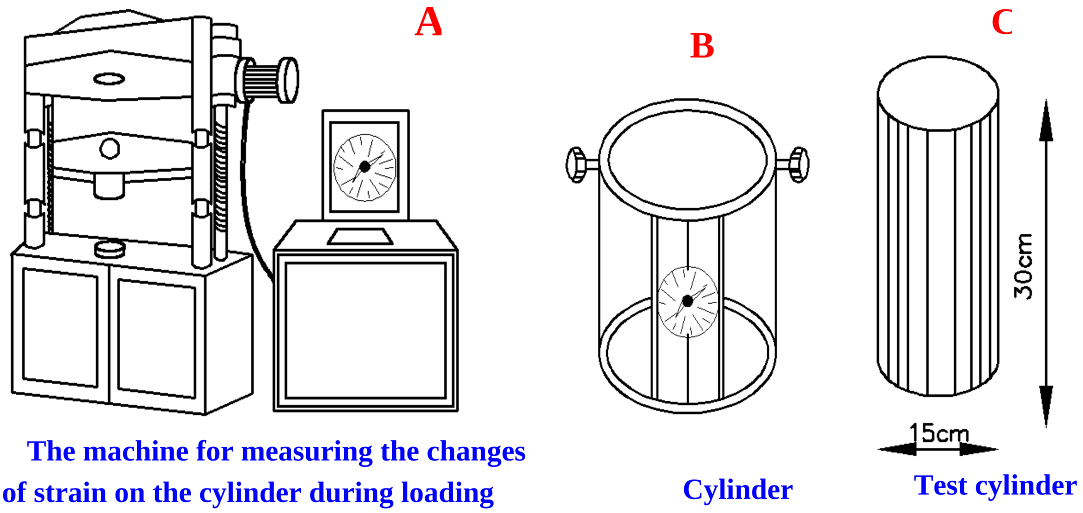

Fig. 18. A, B, and C, Machine of the Modulus of elasticity, cylinder frame, and test cylinder

5 Conclusions

From the experiments that were conducted in this study, the following conclusions can be made:

Waste glass and plastic sand in a high-strength concrete mix enhanced the compressive strength by 2.11% for the WGS-5 % mixture, HRS-5 % mixture increased by 0.67%, and WPS-5% mixture increased by 0.37%, compared to the control at a low sand replacement ratio.

The plastic sand waste mixture recorded the lowest increase by 0.37% of the control mix and the highest decrease rate compared to the rest of the mixture groups, which recorded 14.45%.

The flexural test of mixes C 0.0%, WGS-5%, WGS-10%, and WGS-15% recorded 6.41, 6.71, 6.85, and 5.71 MPa, respectively. While among concrete mixes, WPS-5%, WPS-10%, and WPS-15% the flexural test 6.46, 5.62, and 5.31 MPa, respectively.

WGS-10% improved the splitting strength of concrete to 7.20%. The splitting strength improves as the replacement ratio increases and is considered the maximum effective increase when replacing WGS-10%.

The trend in the elastic modulus range was comparable to the three other strength results: compressive strength, flexural strength, and tensile strength. In most cases, all concrete mixes resulted in a decreased elastic modulus except for WGS-5% and WGS-10%, WPS-5% & HRS -5% combinations.

The findings indicate superior performance for WGS compared to WPS. This is because the crystalline structure of glass differs from the porous structure of plastic.

6. Recommendations for future research

Through the study of this paper, some critical recommendations were reached, including the following:

Studies of WPS and WGS in non-load-bearing concrete with high replacement ratios (Higher than 20% of natural sand), by studying the mechanical properties.

Studying on the cast concrete reinforced elements from the mixes that yielded promising results in this study, and analyzing the behavior.

Studying Conduct long-term tests on optimum mixes in this study. It can help achieve higher results.

CRediT authorship contribution statement

Radwa Defalla Abdel Hafez: Investigation, Formal analysis, Writing – original draft.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

References

[1] García G., et al., Systematic review on the use of waste foundry sand as a partial replacement of natural sand in concrete. Construction and Building Materials, 2024; 430: 136460. https://doi.org/10.1016/j.conbuildmat.2024.136460

[2] Tamanna N., R. Tuladhar, N. Sivakugan, Performance of recycled waste glass sand as partial replacement of sand in concrete. Construction and Building Materials, 2020; 239: 117804. https://doi.org/10.1016/j.conbuildmat.2019.117804.

[3] Ismail Z.Z. ,E.A. Al-Hashmi, Use of waste plastic in concrete mixture as aggregate replacement. Waste management, 2008; 28(11): p. 2041-2047. https://doi.org/10.1016/j.wasman.2007.08.023.

[4] Muhedin D.A. , R.K. Ibrahim, Effect of waste glass powder as partial replacement of cement & sand in concrete. Case Studies in Construction Materials, 2023; 19: e02512. https://doi.org/10.14445/23488352/IJCE-V4I12P103.

[5] Thorneycroft J., et al., Performance of structural concrete with recycled plastic waste as a partial replacement for sand. Construction and Building Materials, 2018; 161: 63-69. https://doi.org/10.1016/j.conbuildmat.2017.11.127.

[6] Tan K.H. , H. Du, Use of waste glass as sand in mortar: Part I–Fresh, mechanical and durability properties. Cement and Concrete Composites, 2013; 35(1): 109-117. https://doi.org/10.1016/j.cemconcomp. 2012.08.028.

[7] Ibrahim K., The effect of using waste glass [WG] as partial replacement of sand on concrete. IOSR Journal of Mechanical and Civil Engineering, 2017; 14(2): 41-45. https://doi.org/: 10.9790/1684-1402024145.

[8] Mustafa M.A.-T., et al. Effect of partial replacement of sand by plastic waste on impact resistance of concrete: experiment and simulation. in Structures. 2019; Elsevier. https://doi.org/10.1016/j.istruc.2019. 06.008.

[9] Steyn Z., et al., Concrete containing waste recycled glass, plastic and rubber as sand replacement. Construction and Building Materials, 2021; 269: 121242. https://doi.org/10.1016/j.conbuildmat.2020.121242.

[10] Sharma R. ,P.P. Bansal, Use of different forms of waste plastic in concrete–a review. Journal of cleaner production, 2016; 112: 473-482. https://doi.org/10.1016/j.jclepro.2015.08.042.

[11] Oliveira L.A.P.d., J.C. Gomes, P. Santos, Mechanical and durability properties of concrete with ground waste glass sand. Artigo em encontro cientifico internacional, 2008; https://doi.org/10400.6/588.

[12] Suleman S. , S. Needhidasan, Utilization of manufactured sand as fine aggregates in electronic plastic waste concrete of M30 mix. Materials Today: Proceedings, 2020; 33: 1192-1197. https://doi.org/10.1016/j.matpr.2020.08.043.

[13] Olofinnade O.M., et al., Strength and microstructure of eco-concrete produced using waste glass as partial and complete replacement for sand. Cogent Engineering, 2018; 5(1): 1483860. https://doi.org/10.1080/23311916.2018.1483860.

[14] Almeshal I., et al., Eco-friendly concrete containing recycled plastic as partial replacement for sand. Journal of Materials Research and Technology, 2020; 9(3): 4631-4643. https://doi.org/10.1016/j.jmrt.2020.02.090.

[15] Jani Y. and W. Hogland, Waste glass in the production of cement and concrete–A review. Journal of environmental chemical engineering, 2014; 2(3): 1767-1775. https://doi.org/10.1016/j.jece.2014.03.016.

[16] Hama S.M. , N.N. Hilal, Fresh properties of self-compacting concrete with plastic waste as partial replacement of sand. International Journal of Sustainable Built Environment, 2017; 6(2): 299-308. https://doi.org/10.1016/j.ijsbe.2017.01.001.

[17] Tejaswi S.S., et al., Experimental investigation of waste glass powder as partial replacement of cement and sand in concrete. IUP Journal of Structural Engineering, 2015; 8(4): 14. https://doi.org/10.13189/cea.2018.060304.

[18] Rai B., et al., Study of waste plastic mix concrete with plasticizer. International Scholarly Research Notices, 2012; 2012(1): 469272. https://doi.org/10.5402/2012/469272.

[19] Taha B. , G. Nounu, Properties of concrete contains mixed colour waste recycled glass as sand and cement replacement. Construction and Building Materials, 2008; 22(5): 713-720. https://doi.org/10.1016/j.conbuildmat.2007.01.019.

[20] Ismail Z.Z. , E.A. Al-Hashmi, Recycling of waste glass as a partial replacement for fine aggregate in concrete. Waste management, 2009; 29(2): 655-659. https://doi.org/10.1016/j.wasman.2008.08.012.

[21] Marzouk O.Y., R. Dheilly, M. Queneudec, Valorization of post-consumer waste plastic in cementitious concrete composites. Waste management, 2007; 27(2): 310-318. https://doi.org/10.1016/j.wa sman.2006. 0

3.012.

[22] Shekhawat B.S. , D.V. Aggarwal, Utilisation of waste glass powder in concrete–A Literature Review. International Journal of Innovative Research in Science, Engineering and Technology, 2014; 3(7). https://doi.org/10.3850/978-981-07-6059-5_090.

[23] Rashad A.M., Recycled waste glass as fine aggregate replacement in cementitious materials based on Portland cement. Construction and building materials, 2014; 72: 340-357. https://doi.org/10.1016/j.conbuildmat.2014.08.092.

[24] Shinu N.M.T. , S. Needhidasan, An experimental study of replacing conventional coarse aggregate with E-waste plastic for M40 grade concrete using river sand. Materials Today: Proceedings, 2020; 22: 633-638. https://doi.org/ 10.1016/j.matpr.2019.09.033.

[25] Limbachiya M.C., Bulk engineering and durability properties of washed glass sand concrete. Construction and Building Materials, 2009; 23(2): 1078-1083. https://doi.org/10.1016/j.conbuildmat.2008.05.022.

[26] Akinyele J. , A. Ajede, The use of granulated plastic waste in structural concrete. African Journal of Science, Technology, Innovation and Development, 2018; 10(2): 169-175. https://doi.org/10.1080/20421338.2017.1414111.

[27] Shayan A. , A. Xu, Value-added utilisation of waste glass in concrete. Cement and concrete research, 2004; 34(1): 81-89. https://doi.org/10.1016/S0008-8846(03)00251-5.

[28] Rajawat S.P.S., B.S. Rajput, G. Jain, Concrete strength analysis using waste plastic as a partial replacement for sand. Materials Today: Proceedings, 2022; 62: 6824-6831. https://doi.org/10.1016/j.matpr.2022.04.961.

[29] Zeybek Ö., et al., Influence of replacing cement with waste glass on mechanical properties of concrete. Materials, 2022; 15(21): 7513. https://doi.org/10.3390/ma15217513.

[30] Al-Tayeb, M.M., et al., Ultimate failure resistance of concrete with partial replacements of sand by waste plastic of vehicles under impact load. International Journal of Sustainable Built Environment, 2017; 6(2): 610-616. https://doi.org/10.1016/j.ijsbe.2017.12.008.

[31] Johnston C., Waste glass as coarse aggregate for concrete. Journal of Testing and Evaluation, 1974; 2(5): 344-350. https://doi.org/10.13074/jent.2013.12.132059.

[32] Bahoria B., D. Parbat, P. Nagarnaik, XRD analysis of natural sand, quarry dust, waste plastic (ldpe) to be used as a fine aggregate in concrete. Materials Today: Proceedings, 2018; 5(1): 1432-1438. https://doi.org/10.1016/j.matpr.2017.11.230.

[33] Ramdani S., et al., Physical and mechanical performance of concrete made with waste rubber aggregate, glass powder and silica sand powder. Journal of Building Engineering, 2019; 21: 302-311. https://doi.org/10.1016/j.jobe.2018.11.003.

[34] Dong W., W. Li, Z. Tao, A comprehensive review on performance of cementitious and geopolymeric concretes with recycled waste glass as powder, sand or cullet. Resources, Conservation and Recycling, 2021; 172: 105664. https://doi.org/10.1016/j.resconrec.2021.105664.

[35] Patil P.S., et al., Innovative techniques of waste plastic used in concrete mixture. International Journal of Research in Engineering and Technology, 2014; 3(9): 29-32. https://doi.org/10.15623/ijret.2014.0321008.

[36] Siddique R., J. Khatib, and I. Kaur, Use of recycled plastic in concrete: A review. Waste management, 2008; 28(10): 1835-1852. https://doi.org/10.1016/j.wasman.2007.09.011.

[37] Jiao Y., et al., Mechanical and fracture properties of ultra-high performance concrete (UHPC) containing waste glass sand as partial replacement material. Journal of Cleaner Production, 2020; 277: 123501. https://doi.org/10.1016/j.jclepro.2020.123501.

[38] Al-Hadithi A.I. ,N.N. Hilal, The possibility of enhancing some properties of self-compacting concrete by adding waste plastic fibers. Journal of Building Engineering, 2016; 8: 20-28. https://doi.org/10.1016/j.jobe.2016.06.011.

[39] Turgut P. , E. Yahlizade, Research into concrete blocks with waste glass. International Journal of Civil and Environmental Engineering, 2009; 3(3): 86-192.

[40] Babafemi A.J., et al., Engineering properties of concrete with waste recycled plastic: A review. Sustainability, 2018; 10(11): 3875. https://doi.org/ 10.3390/su10113875.

[41] Aliabdo A.A., M. Abd Elmoaty, A.Y. Aboshama, Utilization of waste glass powder in the production of cement and concrete. Construction and Building Materials, 2016; 124: 866-877. https://doi.org/10.1016/j.conbuildmat.2016.08.016.

[42] Kandasamy R. , R. Murugesan, Fibre reinforced concrete using domestic waste plastics as fibres. ARPN Journal of Engineering and Applied Sciences, 2011; 6(3): 75-82.

[43] Bahoria B., et al. Effect of replacement of natural sand by quarry dust and waste plastic on compressive & split tensile strength of M20 concrete. in Proceedings of the International Conference on Engineering (NUiCONE 2013), Ahmedabad, India. 2013.

[44] Shao Y., et al., Studies on concrete containing ground waste glass. Cement and concrete research, 2000; 30(1): 91-100. https://doi.org/10.1016/S0008-8846(99)00213-6.

[45] Bahoria B., et al. Sustainable utilization of Quarry dust and waste plastic fibers as a sand replacement in

conventional concrete. in Proceedings of the International Conference on Sustainable Civil Infrastructure, ICSCI, Hyderabad, India. 2014.
[46] Bahadur R. , A.K. Parashar, An investigation of waste glass powder with the substitution of sand on concrete mix. Materials Today: Proceedings, 2023. https://doi.org/10.1016/j.matpr.2023.02.123.
[47] Safarizki H. , L. Gunawan. Effectiveness of glass powder as a partial replacement of sand in concrete mixtures. in Journal of Physics: Conference Series. 2020. IOP Publishing. https://doi.org/10.1088/1742-65 96/1625/1/012025.
[48] Bahoria B., D. Parbat, P. Nagarnaik, Characterization study of natural sand, quarry dust, waste plastic (ldpe) to be used as a fine aggregate in concrete. International Journal of Civil Engineering and Technology, 2017; 8(3).
[49] Kim I.S., S.Y. Choi, E.I. Yang, Evaluation of durability of concrete substituted heavyweight waste glass as fine aggregate. Construction and Building Materials, 2018; 184: 269-277. https://doi.org/10.1016/j.conbuil dmat.2018.06.221.
[50] Wang T., et al., Sustainable utilisation of low-grade and contaminated waste glass fines as a partial sand replacement in structural concrete. Case Studies in Construction Materials, 2022; 16: e00794. https://doi. o rg/10.1016/j.cscm.2021.e00794.
[51] Wang Y., et al., Effective utilization of waste glass as cementitious powder and construction sand in mortar. Materials, 2020; 13(3): 707. https://doi.org/10.3390/ma13030707.
[52] Ammash H.K., M.S. Muhammed, A.H. Nahhab, Using of waste glass as fine aggregate in concrete. Al-Qadisiya Journal For Engineering Sciences, 2009; 2(2): 206-214.
[53] Gopi K.S. , T. Srinivas. Feasibility study of recycled plastic waste as fine aggregate in concrete. in E3S web of conferences. 2020. EDP Sciences. https://doi.org/10.1051/e3sconf/202018401084.
[54] Hameed A.M. , B.A.F. Ahmed, Employment the plastic waste to produce the light weight concrete. Energy Procedia, 2019; 157: 30-38. https://doi.org/10.1016/j.egypro.2018.11.160.
[55] Almesfer N. , J. Ingham, Effect of waste glass on the properties of concrete. Journal of Materials in Civil Engineering, 2014; 26(11): 06014022. https://doi.org/10.1061/(ASCE)MT.1943-5533.0001077.
[56] Gautam S., V. Srivastava, V. Agarwal, Use of glass wastes as fine aggregate in Concrete. J. Acad. Indus. Res, 2012; 1(6): 320-322.
[57] Hossain M., P. Bhowmik, K. Shaad, Use of waste plastic aggregation in concrete as a constituent material. Progressive Agriculture, 2016; 27(3): 383-391. https://doi.org/ 10.3329/pa.v27i3.30835.
[58] Walczak P., et al., Utilization of waste glass in autoclaved aerated concrete. Procedia Engineering, 2015; 122: 302-309. https://doi.org/10.1016/j.proeng.2015.10.040.
[59] Batayneh M., I. Marie, I. Asi, Use of selected waste materials in concrete mixes. Waste management, 2007; 27(12): 1870-1876. https://doi.org/10.1016/j.wasman.2006.07.026.
[60] Belmokaddem M., et al., Mechanical and physical properties and morphology of concrete containing plastic waste as aggregate. Construction and Building Materials, 2020; 257: 119559. https://doi.org/10. 101 6/j.conbuildmat.2020.119559.
[61] Manjunath B.A., Partial replacement of E-plastic waste as coarse-aggregate in concrete. Procedia Environmental Sciences, 2016; 35: 731-739. https://doi.org/10.1016/j.proenv.2016.07.079.
[62] Saikia N. , J. De Brito, Use of plastic waste as aggregate in cement mortar and concrete preparation: A review. Construction and Building Materials, 2012; 34: 385-401. ttps://doi.org/10.1016/j.conbuil dmat. 201 2.02.066.
[63] Saribiyik M., A. Piskin, A. Saribiyik, The effects of waste glass powder usage on polymer concrete properties. Construction and building materials, 2013; 47: 840-844. https://doi.org/10.1016/j.conbuildma t. 2013.05.023.
[64] Su Q. , J. Xu, Mechanical properties of concrete containing glass sand and rice husk ash. Construction and Building Materials, 2023; 393: 132053. https://doi.org/ 10.1016/j.conbuildmat.2023.132053.
[65] Vanitha S., V. Natarajan, M. Praba, Utilisation of waste plastics as a partial replacement of coarse aggregate in concrete blocks. Indian journal of science and technology, 2015; 8(12): 1. https://doi.org/10. 1 7485/ijst/2015/v8i12/54462.
[66] Jain A., et al., Utilization of shredded waste plastic bags to improve impact and abrasion resistance of concrete. Environment, Development and Sustainability, 2020; 22: 337-362. https://doi.org/10.1007/s1066 8-018-0204-1.
[67] Harrison E., A. Berenjian, M. Seifan, Recycling of waste glass as aggregate in cement-based materials. Environmental Science and Ecotechnology, 2020; 4: 100064. https://doi.org/ 10.1016/j.ese.2020.100064.
[68] Seghiri M., et al., The possibility of making a composite material from waste plastic. Energy Procedia, 2017; 119: 163-169. https://doi.org/10.1016/j.egypro.2017.07.065.
[69] Nodehi M. , V. Mohamad Taghvaee, Sustainable concrete for circular economy: a review on use of waste glass. Glass Structures & Engineering, 2022; 7(1): 3-22. https://doi.org/10.1007/s40940-021-00155-9.
[70] Du H. , K.H. Tan, Concrete with recycled glass as fine aggregates. ACI Mater. J, 2014; 111(1): 47-58.

[71] Al-Tayeb M.M., et al., Ultimate failure resistance of concrete with partial replacements of sand by polycarbonate plastic waste under impact load. Civil and Environmental Research, 2020; 12(2). https://do i .org/10.7176/CER/12-2-06.
[72] Kazmi D., D.J. Williams, M. Serati, Waste glass in civil engineering applications—A review. International Journal of Applied Ceramic Technology, 2020; 17(2): 529-554. https://doi.org/10.1111/ijac.13434.
[73] Sudharsan N., T. Palanisamy, S. Yaragal, Environmental sustainability of waste glass as a valuable construction material-A critical review. Ecology, Environment and Conservation, 2018; 24(Suppl): p. S331-S338.
[74] Al Bakri A.M., et al., Investigation of HDPE plastic waste aggregate on the properties of concrete. J. Asian Sci. Res, 2011; 1(7): 340-345.
[75] Balasubramanian B., et al., Experimental investigation on concrete partially replaced with waste glass powder and waste E-plastic. Construction and Building Materials, 2021; 278: 122400. https://doi.org/.1016 /j.conbuildmat.2021.122400.
[76] Lam C.S., C.S. Poon, D. Chan, Enhancing the performance of pre-cast concrete blocks by incorporating waste glass–ASR consideration. Cement and Concrete Composites, 2007; 29(8): 616-625. https://doi.org/ 10.1016/j.cemconcomp.2007.03.008.
[77] Al-Sinan M.A. , A.A. Bubshait, Using plastic sand as a construction material toward a circular economy: A review. Sustainability, 2022; 14(11): 6446. https://doi.org/10.3390/su14116446.
[78] Bahoria B., D. Parbat, P. Naganaik, Replacement of natural sand in concrete by waste products: A state of art. Journal of Environmental Research and Development, 2013; 7(4A): 1651.
[79] Mohammed, I.I., et al., Utilization of waste plastic and waste glass together as fine and coarse aggregate in concrete. Eurasian Journal of Science and Engineering, 2020; 6(2): 1-10. https://doi.org/10.23918/eajse. v6 i2p1.
[80] Metwally I.M., Investigations on the performance of concrete made with blended finely milled waste glass. Advances in structural engineering, 2007; 10(1): 47-53. https://doi.org/10.1260/136943307780150823.
[81] Ali K., et al., Effect of waste electronic plastic and silica fume on mechanical properties and thermal performance of concrete. Construction and Building Materials, 2021; 285: 122952. https://doi.org/10.1016 /j.conbuildmat.2021.122952.
[82] Tahwia A.M., et al., Properties of ultra-high performance geopolymer concrete incorporating recycled waste glass. Case Studies in Construction Materials, 2022; 17: e01393. https://doi.org/10.1016/j.c scm.202 2.e01393.
[83] Vijayakumar G., H. Vishaliny, D. Govindarajulu, Studies on glass powder as partial replacement of cement in concrete production. International Journal of Emerging Technology and Advanced Engineering, 2013; 3(2): 153-157.
[84] Bahij S., et al., Fresh and hardened properties of concrete containing different forms of plastic waste–A review. Waste Management, 2020; 113: 157-175. https://doi.org/10.1016/j.wasman.2020.05.048.
[85] Ahmad J., et al., RETRACTED ARTICLE: Effects of waste glass and waste marble on mechanical and durability performance of concrete. Scientific reports, 2021; 11(1): 21525. https://doi.org/10.1038/s41598-021-00994-0.
[86] Sharifi Y., et al., Utilization of waste glass micro-particles in producing self-consolidating concrete mixtures. international journal of concrete structures and materials, 2016; 10: 337-353. https://doi.org/10.1 007/s40069-016-0141-z.
[87] Bulut H.A. , R. Şahin, A study on mechanical properties of polymer concrete containing electronic plastic waste. Composite Structures, 2017; 178: 50-62. https://doi.org/10.1016/j.compstruct.2017.06.058.
[88] Adnan H.M. , A.O. Dawood, Recycling of plastic box waste in the concrete mixture as a percentage of fine aggregate. Construction and Building Materials, 2021; 284: 122666. https://doi.org/10.1016/j.conbuildm at .2021.122666.
[89] Yu X., et al., Performance of concrete made with steel slag and waste glass. Construction and Building Materials, 2016; 114: 737-746. https://doi.org/10.1016/j.conbuildmat.2016.03.217.
[90] Dweik H.S., M.M. Ziara, M.S. Hadidoun, Enhancing concrete strength and thermal insulation using thermoset plastic waste. International journal of polymeric materials, 2008; 57(7): 635-656. https://doi.o rg /10.1080/00914030701551089.
[91] Idir R., M. Cyr, A. Tagnit-Hamou, Use of waste glass in cement-based materials. Environnement, Ingénierie & Développement, 2010; 10. https://doi.org/ 10.4267/dechets-sciences-techniques.3132.
[92] Yun C.M., et al., Plastic Waste as Fine Aggregate for Sand Filler Replacement in Concrete, in Waste Materials in Advanced Sustainable Concrete: Reuse, Recovery and Recycle. 2022; Springer. 149-168. https ://doi.org/10.1007/978-3-030-98812-8_9.
[93] Meena A. , R. Singh, Comparative study of waste glass powder as pozzolanic material in concrete. 2012.
[94] Del Rey Castillo, E., et al., Light-weight concrete with artificial aggregate manufactured from plastic waste. Construction and Building Materials, 2020; 265: 120199. https://doi.org/10.1016/j.conbuildm at.2020. 120

199.
[95] Sawant V.G., Experimental Investigation of Waste Glass Powder as the Partial Replacement of San d in Making Concrete. Iconic Res. Eng. J, 2018; 1: 7-9.
[96] Olofinnade O., S. Chandra, P. Chakraborty, Recycling of high impact polystyrene and low-density polyethylene plastic wastes in lightweight based concrete for sustainable construction. Materials Today: Proceedings, 2021; 38: 2151-2156. https://doi.org/0.1016/j.matpr.2020.05.176.
[97] Safi B., et al., The use of plastic waste as fine aggregate in the self-compacting mortars: Effect on physical and mechanical properties. Construction and Building Materials, 2013; 43: 436-442. https://doi.org/10.101 6/j.conbuildmat.2013.02.049.
[98] Mageswari M. , D.B. Vidivelli, The use of sheet glass powder as fine aggregate replacement in concrete. The Open Civil Engineering Journal, 2010; 4(1). https://doi.org/10.2174/1874149501004010006 5.
[99] Çelik A.İ., et al., Mechanical behavior of crushed waste glass as replacement of aggregates. Materials, 2022; 15(22): 8093. https://doi.org/10.3390/ma15228093.
[100] Saxena R., et al., Impact resistance and energy absorption capacity of concrete containing plastic waste. Construction and Building Materials, 2018; 176: 415-421. https://doi.org/10.1016/j.conbuildmat. 2018.05. 019.
[101] Letelier V., et al., Combined use of waste concrete and glass as a replacement for mortar raw materials. Waste Management, 2019; 94: 107-119. https://doi.org/10.1016/j.wasman.2019.05.041.
[102] Paul S.C., B. Šavija, A.J. Babafemi, A comprehensive review on mechanical and durability properties of cement-based materials containing waste recycled glass. Journal of Cleaner Production, 2018; 198: 891-906. https://doi.org/10.1016/j.jclepro.2018.07.095.
[103] Al-Tayeb M.M., et al., Experimental and simulation study on the impact resistance of concrete to replace high amounts of fine aggregate with plastic waste. Case Studies in Construction Materials, 2022; 17: e01324. https://doi.org/10.1016/j.cscm.2022.e01324.
[104] Taher S.M., et al., Behavior of geopolymer concrete deep beams containing waste aggregate of glass and limestone as a partial replacement of natural sand. Case Studies in Construction Materials, 2021; 15: e00744. https://doi.org/10.1016/j.cscm.2021.e00744.
[105] Khan M.N.N., A.K. Saha, P.K. Sarker, Reuse of waste glass as a supplementary binder and aggregate for sustainable cement-based construction materials: A review. Journal of Building Engineering, 2020; 28: 101052. https://doi.org/0.1016/j.jobe.2019.101052.
[106] Mohajerani A., et al., Practical recycling applications of crushed waste glass in construction materials: A review. Construction and Building Materials, 2017; 156: 443-467. https://doi.org/10.1016/j.conbuildmat. 2 017.09.005.
[107] Mousa M., et al., Tensile characterization of an "Eco-friendly" UHPFRC with waste glass powder and glass sand. in Strain-Hardening Cement-Based Composites: SHCC4 4. 2018; Springer. https://doi.org/10. 1 016/j.conbuildmat.2023.131418.
[108] Hafez R.D.A., Utilization of Cement Kiln Dust and Aluminum Powder as Partial Cement Replacement in Sustainable High-Performance Concrete. Sustainable Engineering Materials 2025; 1(1): 000006, https://doi.org/10.54113/j.suem.2025.000006.
[109] ABDEL HAFEZA R. D., et al. Reinforcing the brittle resistance of high strength concrete using agricultural waste fiber. Sustainable Structures 2024; 4(3): 000058. https://doi.org/10.54113/j.su st.2024.000058.
[110] ABDEL HAFEZA R. D., et al. Behavior of eco-friendly concrete reinforced with hybrid recycled fibers. Sustainable Structures 2025; 5(1): 000064. https://doi.org/10.54113/j.sust.2025.000064.
[111] ABD EL-ALEEM, S., et al. Effect of cement kiln dust substitution on chemical and physical properties and compressive strength of Portland and slag cements. The Arabian Journal for Science and Engineering, 2005, 30.2B: 263-273.
[112] Raghda Osama Abd-Al Ftah, et al. Creating a new type of concrete by using waste electrical cable plastic and waste electrical cable rubber: as a sustainable approach. Sustainable Structures 2025; 5(4):000090. https://doi.org/10.54113/j.sust.2025.000090.