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Original Article

New Innovation in Concrete using Industrial and Agricultural Wastes

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Abstract *- Material engineers in developed countries face numerous problems regarding the disposal of industrial and agricultural wastes. Also, the cost of construction materials is increasing globally, and there is a huge gap between the demand and supply of cement throughout these countries. In this regard, this study is aimed to investigate the mechanical behavior of an innovative concrete mixture in which industrial and agricultural waste is incorporated into its components. Corn Ash was used as agricultural waste, as it burned in the uncontrolled area and used as cement replacement material by a constant percentage of 5% for all mixtures. Waste glass, Granite, and Crushed Concrete were used as industrial waste. A percentage of 10% of the fine natural aggregate as a constant percentage for all mixtures was replaced with glass waste. At the same time, a combination percentage of Granite and Crushed Concrete replaced 50% of coarse aggregate. Nine mixtures were used to investigate the mechanical behavior of concrete with various percentages of Granite and Crushed Concrete. A total of 162 samples of M40 grade concrete are cast for mechanical tests: 54 cubes for a compression test, 54 cylinders for a split tensile test, and 54 beams for the flexural test. The results indicated that the use of crushed concrete only as coarse aggregate replacement leads to a reduction in strength by about 60% of than controlled mix; this reduction was recovered by the addition of granite waste which gives the highest strength of all mixtures, 43 MPa with reduction of only 2% than controlled mix.*

Keywords *- Industrial and Agricultural waste, Waste Glass, Granite, Corn Ash, Crushed Concrete.*

1. Introduction

Since the industrial revolution, the world has faced problems regarding the disposal of industrial wastes. Over the past decades, many studies have been conducted to figure out how to utilize these wastes sustainably and safely; and one of these ideas was to make eco-friendly constructions.

As for aggregate, studies introduced alternative materials for aggregate replacement, such as waste glass, crushed concrete, and granite [1]. Many studies utilized waste glass as fine aggregates and noticed an improvement in compressive strength with a replacement percentage of 10% [2,3,4,5]. Other studies investigate the use of crushed concrete from demolished construction sites as fine and coarse aggregate with different percentages. For fine aggregate, the percentage, the studies indicate the best replacement ratio is 40% [6]. Most researchers studied crushed concrete as a coarse aggregate replacement [7,8,9]. The result indicates that the optimum percentage ranges between 20% to 30% of replacing.

Other studies investigate the utilization of more than one type of recycled aggregates in concrete. A study investigated the mechanical behavior of M25 grade concrete containing crushed concrete as coarse aggregate and glass waste with plastic as fine aggregates. The results indicated that mechanical behavior increases up to 20% of replacing [10].

Agricultural Wastes are considered the major cause of environmental pollution. Developed countries face crucial environmental problems due to the burning of agricultural waste such as ash, rice husk, and corn cob. Many studies have investigated the effect of different agricultural wastes as cement replacement materials on the mechanical behavior of concrete. They have stated that agricultural wastes should be burned in a controlled area with a temperature of more than 600°c [11]. Studies have used corn cob, rice husk, and sugar cane as agricultural wastes.

Corn cob ash; has been used alone as cement replacement material if it is burned in a controlled area till 650°c, as mentioned in [12]; they concluded that up to 10% replacement of corn ash could be used for the construction process. Also, it has been mixed with another material such as glass powder, as mentioned in [13]; they concluded that the use of 10% replacement of binary blend of corn ash and glass powder was optimum for the mechanical behavior.

Therefore, this research investigates the performance of concrete made with corn ash burned in an uncontrolled area. This study investigates the mechanical behavior of concrete with various replacement materials; corn ash as cement replacement material, waste glass as fine aggregate replacement; and crushed concrete and granite 50% coarse aggregates replacement; to produce eco-friendly concrete sustainably.

2. Materials and Methodology

2.1. Materials

Binder Materials: two materials in the study. Ordinary Portland cement with grade CEM I 42.5N following the Egyptian Standard Specification ES: 4756-1-2009 [14] was used to produce M 40 grade of concrete. Corn Ash was burned in an uncontrolled area and sieved on 75 mμ, and the Portland cement was replaced with a constant percentage of 5% in all mixes.

Clean drinking water, free from impurities, was used in mixing and curing according to ESS-203 [15]

Fine aggregates: two types of aggregates were used; normal aggregates and recycled aggregates. Normal aggregate was clean natural siliceous sand with sizes less than 5 mm, fineness modulus of 2.7, and a specific gravity of 2.6 t/m^3. At the same time, the recycled aggregate was waste glass with a specific gravity of 2.54 t/m^3. It has been crushed and sieved with the same sieves of fine aggregates and replaced with natural sand with a constant percentage of 10% for all mixtures.

Coarse aggregates: two types of aggregate used; normal aggregate and recycled aggregate. Normal aggregate was limestone with a specific gravity of 2.5 t/m^3 and a maximum nominal size of 10 mm. Two recycled coarse aggregates were used: crushed concrete and granite waste. Crushed concrete was collected from a local demolition site, while granite waste was collected from factories and demolition sites. These two types were used as the coarse aggregate replacement with a different percentage between 10% to 50% with an equal increment of 10%.

2.2. Methodology

Mix design has been done following BS 5328: Part2:1997. The mix proportions were 1:1.2: 2.2 with a cement content of 512 kg and a water to binder ratio of 0.4.

Trail mixes have been done to get the optimum percentage of cement replacing with corn ash. 4 different percentages have been tested, and only 5% has given the optimum value.

A total of 9 mixtures have been done, including the control one, to investigate the effect of different replacing ratios on the mechanical proprieties of the concrete. Cement was replaced by a constant percentage of 5% of corn ash (CA), and natural sand (NFA) was replaced by a constant percentage of 10% of waste glass (WG). Natural coarse aggregates (NCA) were replaced by the combination of crushed concrete (CC) and granite (G) with a total percentage of 50 % with a constant incremental of 10%. The detailed mixtures are shown in table 1.

Table 1. Mix proportion for the 9 mixtures

Mixtures	Binder material		Fine Aggregate		Coarse Aggregate		
	Cement	CA	NFA	WG	NCA	G	CC
Control	100%	0	100%	0	100%	0	0
S1	95%	5%	100%	0	100%	0	0
S2	95%	5%	90%	10%	100%	0	0
S3	95%	5%	90%	10%	50%	0	50%
S4	95%	5%	90%	10%	50%	10%	40%
S5	95%	5%	90%	10%	50%	20%	30%
S6	95%	5%	90%	10%	50%	30%	20%
S7	95%	5%	90%	10%	50%	40%	10%
S8	95%	5%	90%	10%	50%	50%	0

The dry component of the concrete was mixed, then water and Super plasticizer were added to the mix. Samples were cast and cured by submerging in water at room temperature for 7 and 28 days. A total of 54 cubes with dimensions of 10x10x10 cm, 54 cylinder with dimensions of 7.5x15 cm, and 54 beams with dimensions of 5x5x30 cm were cast.

Compressive strength, split tensile, and flexural tests were conducted on hardened concrete after 7 and 28 days. In contrast, the Slump test was conducted on fresh concrete after mixing to check its workability.

3. Results and Discussion

3.1. Slump Test

The slump test results show variation in workability ranging between 60 mm to 120 mm. The largest slump was in mix 3, which contains 50% crushed concrete, while the lowest was in the control sample and mix 8, which contains 50% granite, as shown in fig.1.

Fig. 1 Slump results

3.2. Compressive Test

Figure 2 shows the compressive test results for the 9 mixtures. The results indicate a decrease in compressive strength for the first three mixtures than the control by a reduction percentage of 45%, 57%, and 61% for mixtures S1, S2, and S3, respectively; this is due to the different addition materials, especially crushed concrete. Then the strength increased again with the addition of granite and reached its maximum value at mix8 (S8) with 50% replacing coarse aggregates with granite only.

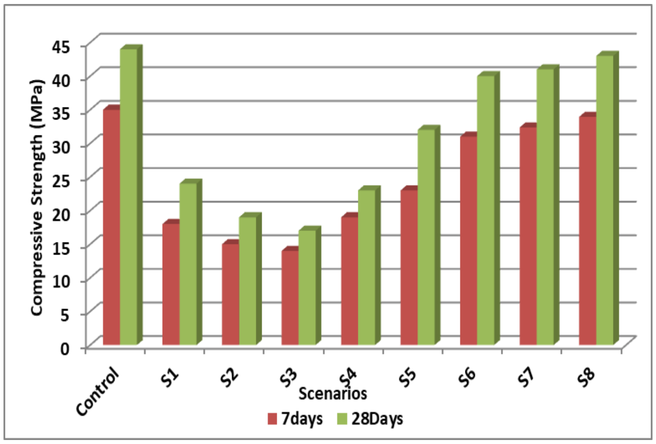

Fig. 2 Compressive test results

3.3. Split tensile Test

Figure 3 shows the tensile test results for the 9 mixtures. The results indicate that tensile strength changes the same as compressive strength. The tensile strength decreased for the first three mixtures more than the control by 3%, 34%, and 38% for mixtures S1, S2, and S3, respectively, due to the different addition materials. Then the strength begins to increase with the addition of granite and reaches its maximum value at mix8 (S8) with 50% replacing coarse aggregates with granite only.

3.4. Flexural Test

Figure 4 shows the flexural test results for the 9 mixtures. The flexural strength decreased for the first mix by 11% more than the control mix this due addition of corn ash. Then the strength begins to increase with the addition of fine and coarse aggregate until it reaches its maximum value at mix8 (S8) with 50% replacing coarse aggregates with granite only.

4. Conclusion

This study aimed to investigate the mechanical behavior of an innovative concrete mixture in which industrial and agricultural waste was incorporated into its components. This was accomplished through 9 mixtures, and the results lead to the following conclusion:

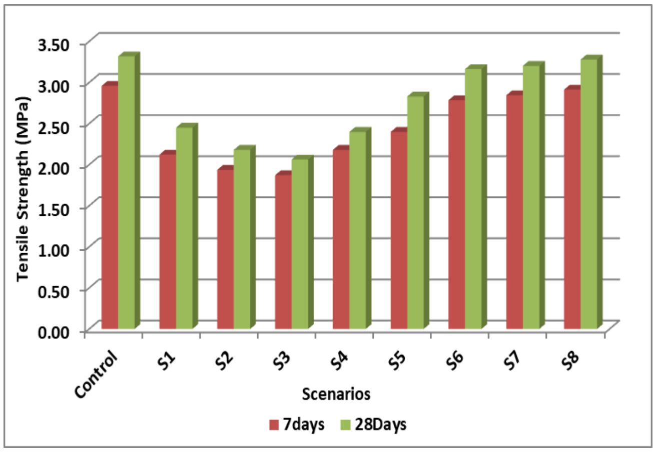

Fig. 3 Split Tensile test results

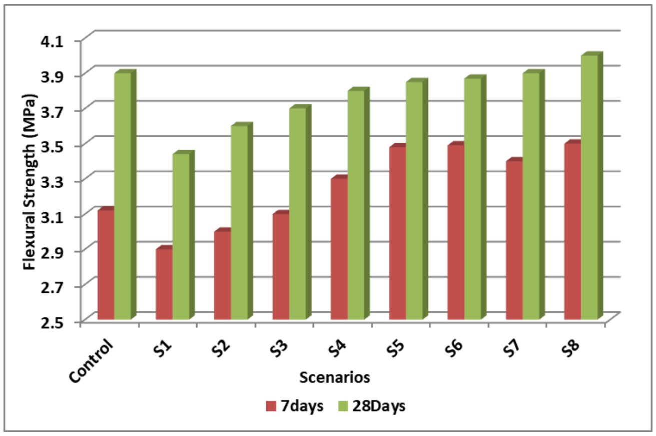

Fig. 4 Flexural test results

Crushed concrete only as coarse aggregate replacement reduces strength by about 60%. This reduction is recovered by adding granite waste, which gives all mixtures the highest strength, 43 MPa, reducing only 2% to the controlled mix.

There is a possibility of producing eco-friendly concrete with multiple industrial and agricultural wastes that could be used in the construction process.

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References

[1] A. M. Salman, Mutiu Akinpelu, et al., "Evaluation of Variations of Coarse Aggregate Types on Hardened Properties of Concrete," *Journal of Materials and Engineering Structures*, vol. 8, pp. 301-311, 2021.

[2] M. G. Raja, and M. K. M. Ramalingam, "Experimental Study on Partial Replacement of Fine Aggregate by Granite Powder in Concrete," *International Journal of Innovative Science and Research Technology*, vol. 2, 2016.

[3] J. Premalatha, and R. Srinivasan, "Properties of Concrete with Waste Glass Powder (Gp) as a Fine Aggregate Replacement," *International Journal of Recent Technology and Engineering*, vol. 8, no. 2, pp. 2308-2314, 2019. *Crossref*, http://doi.org/10.35940/ijrte.B1258.0982S1119

[4] A. R. Patil, and M. Tushar Saxena, "Recycling of Waste Glass as Partial Replacement of Sand in Concrete-Effects on Compressive Strength," *International Research Journal of Engineering and Technology*, pp. 1778-1788, 2008.

[5] Ghadeer Jabbar Kassed, and Sura Kareem Ali, "Reuse of Glass Waste as a Partial Replacement to Fine Aggregates in Concrete," *Journal of Engineering*, vol. 27, no. 8, pp. 43-58, 2021. *Crossref*, http://doi.org/10.31026/j.eng.2021.08.04

[6] V. Devi, P. Saraswat, et al., "Effect of M Sand and Demolished Concrete Aggregates as a Replacement of Natural Fine Aggregates in Mix Design, *SSRG International Journal of Civil Engineering*, vol. 9, no. 4, pp. 15-19, 2022. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V9I4P103

[7] Reema, S. Ram Kishore, et al., "Partial Replacement of Coarse Aggregates with Demolition Waste in Construction," *Mukt Shabd Journal*, vol. 9, no. 6, pp. 474-482, 2020. [Online]. Available: http://shabdbooks.com/gallery/49-june2020.pdf

[8] M. Monish, V. Srivastava, et al., "Demolished Waste as Coarse Aggregate in Concrete," *Journal of Academia and Industrial Research*, vol. 1, no. 9, pp. 40, 2013.

[9] P. Saravanakumar, D. Manoj, and S. Jagan, "Properties of Concrete Having Treated Recycled Coarse Aggregate and Slag," *Journal of Construction*, vol. 20, no. 2, pp. 249-258, 202. *Crossref*, http://doi.org/10.7764/RDLC.20.2.249

[10] Saravanan J, ImthiyasAhamed S, et al., "Low Cost Roofing Tiles using Agricultural Wastes," *SSRG International Journal of Civil Engineering*, vol. 4, no. 3, pp. 58-62, 2017. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V4I3P115

[11] A. A. Serbanoiu, C. M. Gradinaru, et al., "Corn Cob Ash versus Sunflower Stalk Ash, Two Sustainable," *Materials Basel*, 2022.

[12] K. Singh, J. Singh, and S. Kumar, "Evaluation of Corn Cob Ash as Partial Replacement of Cement in Concrete," *Agricultural Research*, vol. 55, no. 4, pp. 737, 2018. *Crossref*, http://doi.org/10.5958/2395-146x.2018.00133.3

[13] N. Bheel and A. Adesina, "Influence of Binary Blend of Corn Cob Ash and Glass Powder as Partial Replacement of Cement in Concrete," *Silicon*, pp. 1647-1654, 2020. *Crossref*, http://doi.org/10.1007/s12633-020-00557-4

[14] E.S.S.4756-1/2009, Portland Cement, Ordinary and Rapid Hardening, Egyptian Standard Specification E.S.S. 4756-1, Egypt: Ministry of Industry, vol. 1, 2009.

[15] "Egyptian Code of Practics 203, Basics of Design and Regulations of Construction of Reinforced Concrete Structures," *Egypt: Egyptian Ministry of Housing*, 2017.

[16] D. B. Nirmala, M. S. Sunil, R. Prasad, and S. Raviraj, "Feasibility Study on Mechanical Properties of Concrete using Construction Waste as the Partial Replacement of Coarse and Fine Aggregates, *SSRG International Journal of Civil Engineering*, vol. 9, no. 3, pp. 24-29, 2022. *Crossref*, https://doi.org/10.14445/23488352/IJCE-V9I3P103