Journal of Namibian Studies, 35 (2023): 168-176 ISSN: 2197-5523 (online)

Special Issue on Engineering, Technology and Sciences

An Experimental Investigation On Partial Replacement Of Fine Aggregate By Waste Glass And Coarse Aggregate By Waste Plastic

S.P. Ruksana[1], B. Ajitha[2]

[1]PG-Student (M.Tech- Structural Engineering), Department of Civil Engineering, JNTUA College of Engineering, Ananthapuramu, A.P., India.
[2]Associate Professor,Department of Civil Engineering, JNTUA College of Engineering,Ananthapuramu, A.P., India.

ruksanapalagiri@gmail.com[1], ajitha123.civil@jntu.ac.in[2]

ABSTRACT

Around the world, the utilization of concrete is increasing significantly. Due to the gradual increase in material waste caused by population growth and urbanization, research into the use of waste building materials is important. The key objective of this study is to examine how concrete behaves and how its characteristics alter when waste glass and waste plastic aggregate are used instead of natural aggregates. Solid waste management is one of the most significant environmental issues facing by the world today. The best material for recycling is glass. Therefore, using waste glass as a substitute for fine aggregate in concrete is an interesting possibility in terms of the economy of waste landfills and the conservation of natural resources. Safe disposal of plastic waste is an important environmental problem that needs to be mitigated. From this point of view, this investigation is an attempt to evaluate whether it is appropriate to use waste glass and waste plastic as a substitute for fine and coarse aggregate, which helps in the production of light-weight concrete. M60-grade concrete is used in this study. M60-grade concrete is used for reinforced concrete structures (RCC) in high-rise buildings, long-span bridges, and other structures that require high compressive strength. The construction of decisive environmental systems takes advantage of this. The spillways of dams are also constructed with M60-grade concrete. For M60 grade concrete, the fine aggregate is replaced with waste glass and the coarse aggregate is replaced with waste plastic aggregate, and the compressive strength test is conducted. The percentage by weight of waste glass with fine aggregate is 0% and 10% and waste plastic with coarse aggregate is 0%, 5%, 10%, 15%, 20%, 25%, 30% and 35%, respectively.

Keywords: concrete; waste glass; waste plastic; strength; light-weight concrete.

1. INTRODUCTION

The material that is most often used in many types of construction is concrete. The construction of buildings, foundations, pavements, bridges, motorways, runways, parking garages, dams, reservoirs, pipelines, fences and columns often involves the use of concrete. High performance and economy are requirements for modern concrete. Concrete is an incredible versatile building material, which is difficult to find its alternatives [1]. Urbanization has increased significantly due to the migration of large numbers of residents. Due to the increasing demand of the construction sector for supply of sand from conventional sources, including river beds, aquifers, fisheries and protected areas [2], industrial waste from steel, copper and coal also has certain characteristics of aggregates, making its disposal difficult and having a negative effect on the environment. This study attempts to replace natural sand with slag sand produced in the steel industry.

One of the first artificial materials was glass. Theoretically, glass is 100% recyclable; it can be endlessly recycled without any loss of quality [3]. Recycling waste glass and other industrial products has made significant progress in the construction sector. By recycling this waste and turning it into aggregate, less natural raw material has to be extracted for construction, which preserves landfill space [4]. Waste glass is used as a substitute for fine aggregate in this study because it is a safe and cost-effective alternative to fine aggregate. Safe disposal of waste plastic is an important environmental issue that needs to be addressed. This study investigates the effects of fusing waste plastic materials with concrete. Plastic can be used in concrete as a filler material and to improve the mechanical qualities of concrete [5]. This research summarized the behavior of concrete when waste glass is used instead of fine aggregate at 10% by weight and coarse aggregate as waste plastic at 5, 10, 15, 20, 25, 30, and 35% by weight. At various percentages, concrete samples were tested for compressive strength. The results are compared with a nominal M-60 grade concrete mix.

1.1. Objectives of the present study:

The main aim of the present research work is

1. To investigate the aggregate properties of waste glass and waste plastic.
2. To study the feasibility of using waste glass and waste plastic in concrete.
3. To study the impact of waste glass and waste plastic aggregate on fresh concrete.
4. To examine the effect of compressive strength on waste glass and waste plastic aggregate-based concrete in a hardened state.
5. To examine the effect of split tensile and flexural strength on waste glass and waste plastic aggregate-based concrete in a hardened state.
6. To develop a concrete mix that is economical and light in weight yet effectively satisfies all the structural requirements.

2. LITERATURE REVIEW:

Zainab Z. Ismail et al. (2008) [6]**:** Recycled waste glass was partially replaced with fine aggregate. In this study, the properties of concrete containing waste glass as a good additive to fine aggregate are investigated. The strength and properties of ASR were examined from the perspective of waste glass. Waste glass is replaced by 10%, 15%, and 20%. After 28 days, it was observed that the compressive and flexural strengths were found to be higher than normal concrete. Based on the test results, the optimum percentage of waste glass was 20%.

Praveen Mathew et al. (2013) [7]**:** This research is based on the use of recycled waste plastic as coarse aggregate. Different replacements were done and different tests were conducted, and it was observed that the maximum compressive strength was achieved at 20% replacement.

S. Sony Sultana et al. (2022) [8]**:** This research is based on the use of metakaolin, marble dust as a partial replacement for cement. In this study, the durability properties of concrete are investigated. M60 grade concrete is used by partially replacing cement with metakaolin 0, 5, 10, 15 and 20% by weight of cement and marble dust 0 and 10% by weight of cement and fine aggregate with slag sand respectively. Based on the test results, it was observed that the inclusion of metakaolin and marble dust strengthens the concrete.

S. Yeswanth Sai Krishnaet al. (2022) [9]: This study is based on the use of nano silica as a partial replacement of cement. In this study, M60 grade concrete is used by partial replacing cement with nano silica 0, 5, 10, 15 and 20% by weight and the durability properties of concrete are investigated.

3. EXPERIMENTAL METHODS AND MATERIALS:

3.1. Cement:

This study makes use of Ordinary Portland cement (OPC-53 grade), conforming to IS 12269-89 [10].The following are the properties and results of cement.

Table 1. Properties of Cement

Properties	Obtained results
Specific gravity	3.14

3.2. Fine aggregate:

The fine aggregate that is used in this study is slag sand, a by-product produced in molten form during the production of pig iron at high temperatures (1400-

1500°C) in a blast furnace. The following are the properties of slag sand with standard limits as per IS-456 2000[11].

Table 2. Properties of fine aggregate (slag sand)

Characteristics	Obtained values	Standard Limits
Specific Gravity	2.59	2.5-2.7
Sieve Analysis	Zone-1	Zone-1 to zone- 4
Fineness modulus	2.98	2.2 - 3.2

3.3. Coarse Aggregate:

In accordance with requirements of IS 383- 1970 [12], coarse aggregate of nominal size 20mm and 12.5mm was used. The following are the properties of coarse aggregate with standard limits as per IS-456 2000[11].

Table 3. Properties of coarse aggregate

Characteristics	Obtained values	Standard Limits
Specific Gravity	2.66	2.5-3.0
Sieve Analysis	Single sized	Single or graded
Fineness modulus	5.58	>5

3.4. Waste Glass:

Local businesses may sell broken glass, smashed bottles, or other waste glass. The STELLARK Agency in Tamil Nadu, a native resource, is where the glass powder is gathered. The chemical composition of waste glass powder is displayed.

Table 4. Chemical Composition of waste glass

Chemical	Composition (%)
Loss on ignition	0.19%
Silica	71.53%
Alumina	0.961%

Calcium	16.54%
Calcium oxide	9.27%
Magnesium Oxide	3.84%
Potassium	0.29%
Sodium	13.27%

3.5. Waste Plastic:

The waste plastic material that was employed in this study was crushed into tiny particles with a size range of 20 to 12 mm. This waste plastic material cannot be further deteriorated. The garbage produced by households is the source of the plastic that is used.

3.6. Super-plasticizer:

In this research, the admixture used for M60 grade concrete is Forsoc Conplast SP 430 dis.

4. RESULTS AND DISCUSSIONS:

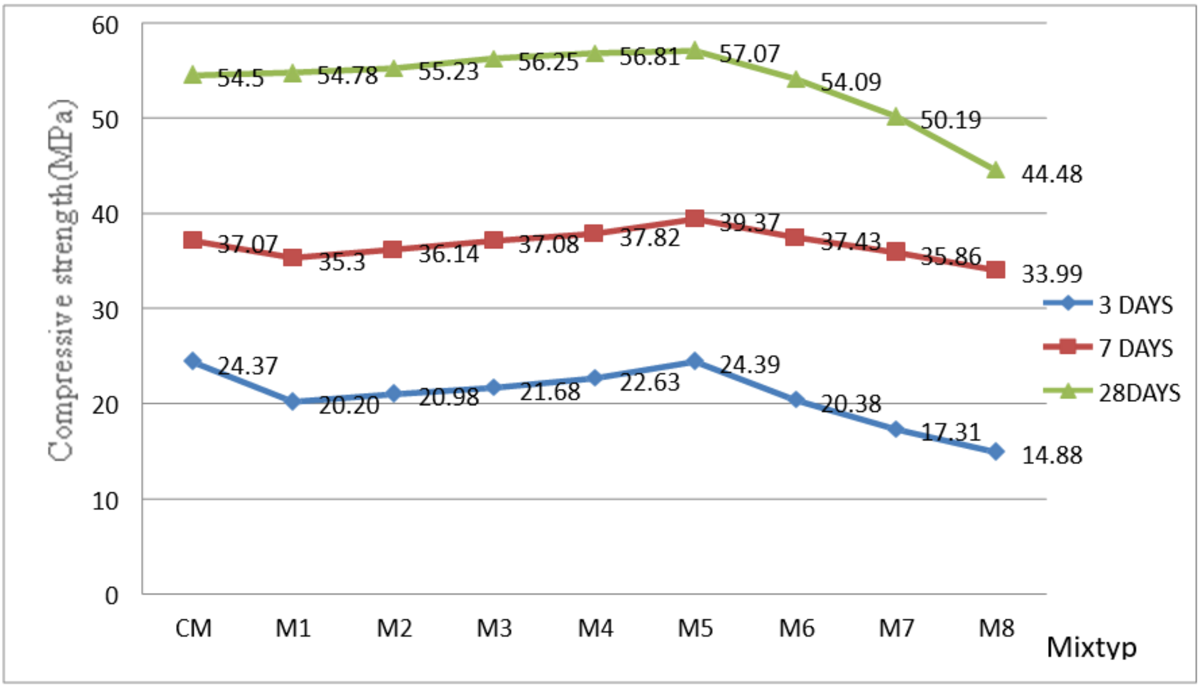
For the current study, total 9 samples were casted on average for each combination for 3, 7 and 28 days. After 24 hours, the casted moulds are de-moulded and samples are placed in water for curing. The compressive, split tensile and flexural strength tests were conducted on the samples and the obtained results are listed below.

4.1. Results on Compressive Strength

Table 5 and Graph 1 show the compressive strength measurements at 3, 7, & 28 days of a composite mix (M-60) and different percentages of glass waste partially replacing fine aggregate and plastic waste replacing coarse aggregate. In order to study the effect of compressive strength, 81 cubes (each measuring 150x150x150 mm) are casted using different percentages of waste glass and waste plastic on the appropriate test days 3, 7 and 28.

Table 5. Compressive strength of different mixes at different ages

Mix Type	COMPRESSIVE STRENGTH (MPa)		
	3DAYS	**7DAYS**	**28 DAYS**
CM	24.37	37.07	54.5
M1	20.207	35.30	54.78
M2	20.989	36.14	55.23
M3	21.683	37.08	56.25
M4	22.63	37.82	56.81
M5	24.39	39.37	57.07
M6	20.385	37.43	54.09
M7	17.316	35.86	50.19
M8	14.882	33.99	44.48



Graph 1. Compressive strength of different mixes at different ages

5. CONCLUSION:

Based on experimental research, the compressive strength of concrete, with the addition of waste glass and waste plastic in varying quantities, were determined and tested after 3, 7, and 28 days. The conclusions drawn are as follows:

- Waste glass and waste plastic can be combined as additional resources to replace some of the fine and coarse aggregate in construction projects.
- The mechanical properties of concrete do not change significantly, when glass powder is used instead of slag sand.
- Waste plastic can be effectively disposed of by using it as coarse aggregate in concrete, which can greatly minimize environmental pollution and create green concrete. The addition of plastic reduces the unit weight of concrete; it can be used to create lightweight concrete.
- According to research, waste glass and waste plastic can be used as a substitute material for fine and coarse aggregate and can replace 10% of waste glass and 5 to 20% of waste plastic yield good results in terms of strength and quality.
- Based on results, replacing 10% of the fine aggregate with glass waste and 20% of the coarse aggregate with plastic waste increased the material's compressive strength. The maximum compressive strength obtained is 57.07N/mm^2.

6. REFERENCES:

[1] Concrete technology by M.S. Shetty-S Chand & co. 2004
[2] G.Xue et al.,Macroscopic mechanical properties and microstructure characteristics of steelslag fine aggregate concrete, J. Build. Eng. (2022)
[3] Sobolev, K., Türker, P., Soboleva, S., Iscioglu, G., 2006. Utilisation of waste glass in ECO- cement: strength properties and microstructural observations.Waste Management 27 (7), 971– 976.
[4] Rakshvir, M., Barai, S.V., 2006. Studies on recycled aggregates-based concrete. Waste Management & Research, 24 (3), 225–233.
[5] M.Niaounakis, 10: Building and Construction Applications, in: M. Niaounakis (Ed.), Biopolym. Appl. Trends, William...

[6] Zainab Z. Ismail et al. (2008) Department of Environmental Engineering, College of Engineering, University of Baghdad, Iraq

[7] Praveen Mathew et al. (2013) Civil Engineering Dept., SHIATS (formerly AAI-DU), Allahabad-211007, UP, India.

[8] S.Sony Sultana et al. (2022) Durability properties of concrete containing metakaolin, marble dust and slag sand for high strength concrete.

[9] S.Yeswanth Sai Krishna et al. (2022) Durability properties of concrete containing nano silica and slag sand for high strength concrete.

[10] Specification for 53 Grade Ordinary Portland Cement, Indian Standard Code 12269- 1989.

[11] IS: 456-2000 "Specifications for Plain and Reinforced Concrete". New Delhi, India.

[12] IS: 383-1970 "Specification for Coarse and Fine Aggregates from Natural Sources or Concrete" (Second revision).