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Study On Recycled Waste Glass Fine Aggregate Concrete

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Abstract: *Glass recycling has the potential to reduce the amount of waste in landfills, natural resources and cost savings. Based on the economic considerations, recycling of waste glass is considered as an alternative material for fine aggregate in concrete. The use of waste glass recycled in the production of concrete is very useful to achieve the goal of sustainable construction. The article presents M 20 grade concrete using recycled waste glass as an alternative to conventional aggregate of river fine sand. The physical properties of recycled waste glass fine aggregate are compared with conventional fine aggregate of river sand. Laboratory tests have been conducted to determine the compressive strength, splitting tensile strength, flexural strength and modulus of elasticity of concrete with the recycling glass waste as fine aggregate and compared with the conventional mixing concrete made of river sand as fine aggregate. The study indicated that recycled waste glass can effectively be used as fine aggregate without substantial change in strength.*

Keywords: *Compressive Strength; Flexural Strength; Modulus of Elasticity; Recycled Waste Glass Fine Aggregate (RWGFA) and Splitting Tensile Strength.*

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I. Introduction

1.1 Introduction

Sustainable waste management is necessarily required for natural resources conservation. The productive use of recycled materials in concrete manufacturing is increasing now-a-days. When waste glasses are used in making concrete products, the production cost of concrete is getting reduced. The use of recycled waste glass fine aggregate in concrete has great potential for future in concrete development. Recycling of this waste glass by converting it to aggregate components could save landfill space and reduce the demand for extraction of natural resources. There has been an increasing significant interest in the development of concrete production with recycled waste glass as fine aggregate is effectively used. An increase in the percentage of natural aggregates replaced with recycled waste glass leads to reduction in the unit weight of concrete. At the same time, the recycling is necessary for environmental protection. Fine and Coarse aggregate constitutes about 70 to 75% of its total volume of a concrete production. The global consumption of river sand is very high, due to the enormous use of concrete. In this situation the good quality of river sand is demand for concrete production. Also deepening of the river courses causing bank slides and disturb the underground water stratum and etc., [1]. Some of the alternative materials have been used already for making concrete. There are copper slag, manufacturing sand, slag, quarry dust, sea sand and rice husk dust. In this research, recycled waste glass is effectively used as fine aggregate for concrete production.

1.2 Objective of this project

In this research experimental work, suitability of use of recycled waste glass as fine aggregate in concrete is experimentally carried out with the following objectives.

i) To study the chemical properties of recycled waste glass.
ii) To study the mechanical properties such as compressive strength, splitting tensile strength and flexural strength of concrete using recycled waste glass as fine aggregate and the results are compared with conventional concrete.
iii) To study the modulus of elasticity of concrete using recycled waste glass fine aggregate and the results are compared with conventional concrete.

II. Experimental Work

2.1 Cement

OPC 43 grade cement is used and it is conforming to IS 12269 – 1987 [2]. The physical properties of cement are tabulated in Table 2.1.

Table: 2.1 Physical Properties of Cement

Sl.No	Property	Result
1.	Specific Gravity	3.15
2.	Fineness	2%
3.	Standard Consistency	29%
4.	Initial Setting Time	60 minutes
5.	Final setting Time	600 minutes
6.	Compressive Strength	43 MPa

2.2 Recycled Waste Glass as Fine Aggregate

In this research white colour clear glass is used as fine aggregate for making concrete. The glass is washed to remove the impurities then it is crushed and melted. After that it is screened into required size for immediate use. In this research the size of the recycled waste glass size of 3 mm and down 3 mm is used. The sample of recycled waste glass fine aggregate is shown in Figure 2.1.

Fig: 2.1 Recycled Waste Glass as Fine Aggregate (RWGFA)

The properties of recycled waste glass fine aggregate are given in Table 2.2. The Scanning Electron Micrograph (SEM) images of recycled waste glass fine aggregates are shown in Fig.2.2, Fig.2.3 and Fig.2.4. An X –Ray Fluorescence (XRF) is used to determine the chemical composition of the recycled waste glass. The chemical composition of recycled waste glass fine aggregate are given in Table 2.2.

Table: 2.2 Properties of Recycled Waste Glass as Fine Aggregate (RWGFA)

S.No	Property	Result
1.	Specific Gravity	2.56
2.	Size of the Aggregate	3 mm and down

The specific gravity of RWGFA is nearly same as natural river sand and the size of RWGFA is 3mm and down.

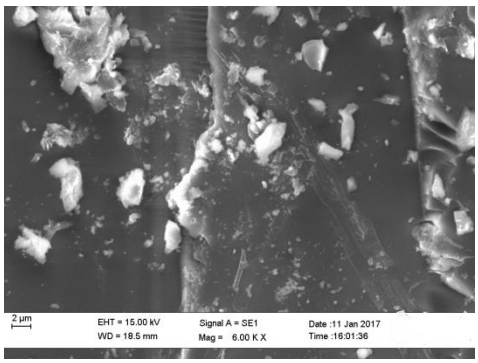

Fig: 2.2 SEM Images of Recycled Waste Glass as Fine Aggregate (RWGFA)

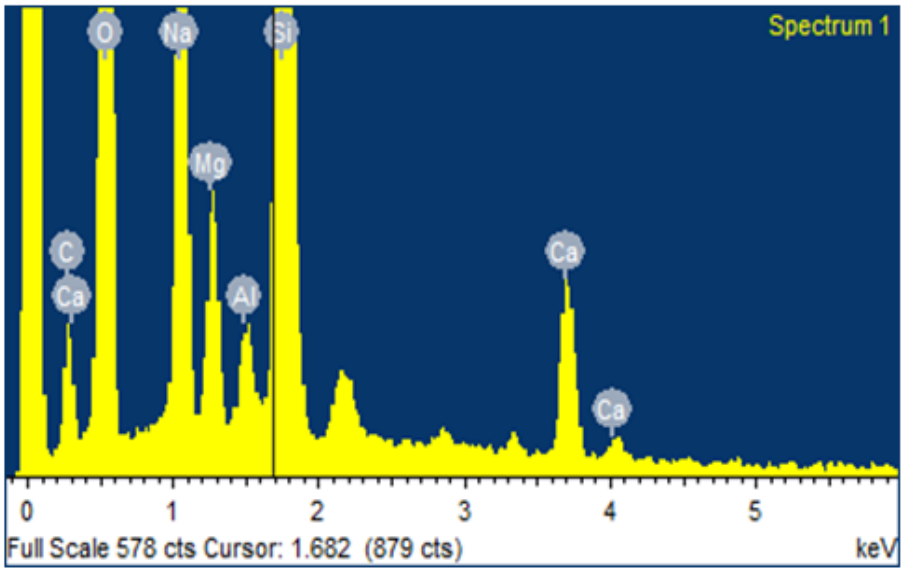

Fig: 2.3 SEM Images of Recycled Waste Glass as Fine Aggregate (RWGFA)

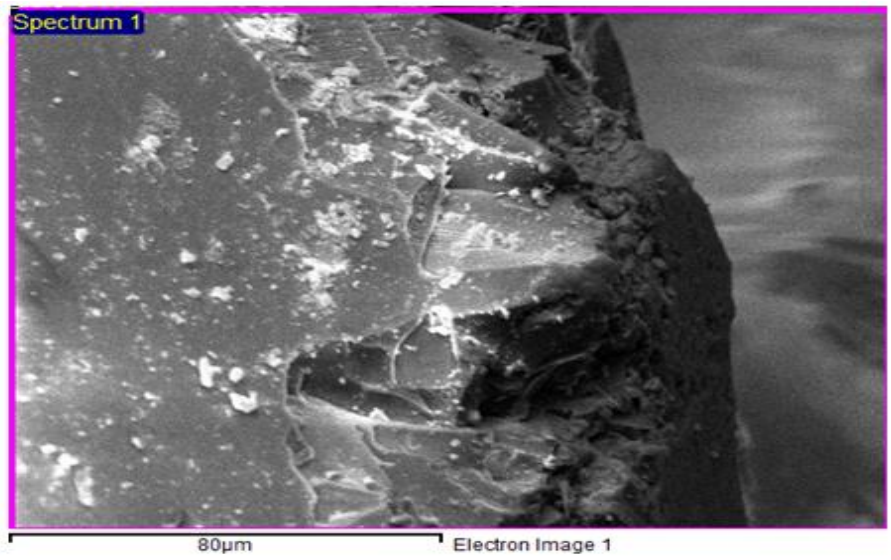

Fig: 2.4 SEM Images of Recycled Waste Glass as Fine Aggregate (RWGFA)

Table:2.3 Chemical Constituents of Recycled Waste Glass as Fine Aggregate (RWGFA)

Constituent	SiO_2	$CaCo_3$	Na	MgO	Ca	Al_2O_3
In Percentage	78.01	7.83	8.60	1.81	3.02	0.61

The natural sand posses a nearly same amount of silica and higher percentage (nearly 10%) of alumina when compared to RWGFA. The calcium and sodium content in river sand are minimum (less then 3%) when compared to RWGCA.

2.3 Coarse Aggregate

Coarse aggregates used are of machine crushed stone, angular in shape passing through 20 mm IS sieve and retained on 4.75 mm IS sieve and it is conforming to IS 383-1970 [3]. The properties of coarse aggregates are given in table 2.4.

Table: 2.4 Properties of Course Aggregate

Sl.No	**Property**	**Result**
1.	Specific Gravity	2.76
2.	Fineness Modulus	7.13

2.4 Chemical Admixtures

In the production of concrete, super plasticizer is added by required quantity by the weight of the cement. Super plasticizer, Fosroc SP -430 is used. The use of chemical admixtures improves the slump loss and result in better durability and workability. In this mix SP of 0.7% weight of the cement is used.

2.5 Water

Potable, fresh and clean water which is free from organic matter is used in this concrete production.

III. Experimental Procedure

M 20 grade concrete with water cement ratio of 0.50 is designed for mix proportions by using IS Code 10262-2009 [4]. The mix proportions for conventional mix concrete is shown in Table 3.1. The same mix proportions are used with 100% replacement of recycled waste glass as fine aggregate in concrete.

Table: 3.1 Mix Proportions for M 20 Conventional Mix Concrete

Description	Cement	Fine aggregate	Coarse aggregate	Water	SP
Ratio	1	2.75	3.36	0.50	0.7%

For each mix, six cubes of size 100 × 100 × 100 mm, are caste to find the compressive strength at 7days and 28 days. Three cylinders of size 100 mm diameter and 200 mm long, three prisms of size 100 × 100 × 500 mm and three cylinders of size 150 mm diameter and 300 mm long are caste to find the splitting tensile strength, flexural strength, modulus of elasticity at 28 days respectively. The specimens are demoulded after 24 hours and cured for 28 days. After 28 days the specimens are taken out from curing tank and tested. All the above tests are carried out for conventional mix concrete and recycled waste glass as fine aggregate concrete as per IS 516-1959 [5].

IV. Results And Discussions

The mean value of compressive strength for 7 days and 28 days, splitting tensile strength and flexural strength and modulus of elasticity at 28 days for conventional mix concrete and recycled waste glass as fine aggregate concrete are tabulated in Table 4.1.

Fig.4.1, Fig.4.2, Fig.4.3 and Fig.4.4 show the crack pattern of cubes in compressive strength test, the failure pattern in splitting tensile strength test, crack pattern in flexural strength test and crack pattern in modulus of elasticity test respectively. The pattern of cracking of the recycled waste glass fine aggregate concrete is not significantly varying with the conventional mix concrete.

The compressive strength of the recycled waste glass fine aggregate concrete is 28.20 MPa and the same of conventional mix concrete is 28 MPa. The splitting tensile strength of the recycled waste glass fine aggregate concrete is 3.25 MPa and of conventional mix concrete is 3.20 MPa. The flexural strength of the recycled waste glass coarse aggregate concrete is 3.76 MPa and of conventional mix concrete is 3.70 MPa. The modulus of elasticity of the recycled waste glass coarse aggregate concrete is 2.52×10^4 MPa and of conventional mix concrete is 2.50×10^4 MPa. As far as strength properties are concerned, the results are higher than the conventional mix concrete using of river sand as fine aggregate. Recycled waste glass fine aggregate is an alternative for river sand with similar strength properties of the conventional concrete.

Table: 4.1 Strength Properties of Conventional Mix Concrete and Recycled Waste Glass Fine Aggregate Concrete

Mix	**Compressive Strength (MPa)**		**Splitting Tensile (MPa)**	**Flexural Strength (MPa)**	**Modulus of Elasticity (MPa)**
	7 days	**28 days**	**28 days**	**28 days**	**28days**
Conventional Mix	18.83	28.00	3.20	3.70	2.500×10^4
RWGFA Concrete	15.62	28.20	3.25	3.76	2.520×10^4

Fig: 4.1 Crack Patterns of Cubes after Testing

Fig: 4.2 Crack Pattern of Cylinder after Testing

Fig: 4.3 Crack Pattern of Prism after Testing

Fig: 4.4 Crack Pattern of Cylinder after Testing

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