INVESTIGATION ON PERFORMANCE OF RECYCLED AGGREGATE BLOCK

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Abstract -*Waste management is a vital issue the world is experiencing. Glass waste and iron-ore ash are non-degradable and harmful to the earth at disposal as landfills. Concrete block is a masonry unit used for various construction purposes. Production of these units involves the emission of CO2 on the extraction of natural resources, which affects the environment. Alternate materials substitute for natural aggregates to maintain a greener environment. This review paper presents the manufacturing process of concrete block with the partial replacement of fine aggregate with glass waste and partial replacement of cement with iron ash. The main aim is to produce concrete blocks without compromising the strength, durability and comfort, and elegance of materials. Performance study includes the strength characteristics, and quality of concrete to obtain a cost-effective product.*

***Key Words*: Concrete block, greener environment, iron-ore tailings, glass waste, ultrasonic pulse velocity.**

1. INTRODUCTION

Technologies are changing with time as the world is progressing. Development in technologies is enabling businesses to process in various dimensions. India is a rapidly developing country. The development of infrastructure is in danger. As technology advances, so do the forms and techniques of development. IS: 2185 (Part 1): 2005 gives the information about hollow concrete blocks. Having a closed or open cavity these hollow concrete blocks can be used to build load-bearing and non-load-bearing walls. Environmental concerns and health dangers associated with the construction industry have been brought to the attention of both the government and environmental groups. Aggregates, sand, clinker, and fuel in the form of resources are all utilized by the cement and concrete industry. The large portion of waste generated from industries and agricultural works is a result of fuel combustion, slag, fly ash, and large-scale manufacture of a range of products. These wastes, which are produced in large quantities, can cause contamination and dispersion of substances such as manganese, mercury, etc, if not disposed of properly, particularly when deposited in dumps, mines, and bodies of water. Their use in concrete production is a prime illustration of parallel recycling and reusing. Growth in the human population and the challenges of globalization cause the scarcity of raw materials needed in the construction industry. The task of converting industrial waste into useful construction material is a challenge to engineers of this generation. A structured recycling program helps people to obtain recycled construction materials [7]. The cement industry makes up around 6% of all CO^2 emissions in the environment. The primary goal of this research is to investigate the effects of partial cement substitution with iron-ore tailings. The flotation process produces a coarse tailing consisting primarily of SiO2 with minor concentrations of iron oxide, hydroxide, and kaolinite, with an average particle size of 150 microns. In terms of mineralogy, the majority of coarse tailings are quartz with minor concentrations of hematite and goethite. The primary goal of this research is to investigate the effects of partial substitution of cement with iron ash and partial replacement of fine aggregate with glass waste on the characteristics of concrete blocks.

1.1 Objectives

- To study the characteristics of recycled materials (Glass).
- To study the performance of concrete block.
- To study the cost analysis.

1.2 Literature Review

For the specimens, the researchers just used Portland Pozzolanic Cement (Type IP), which is widely used in the field today. They were manually crushed and sieved after cleaning to achieve particle size consistency. The researchers used a Class-A mix (1:2:4 ratio) of cement, sand, and gravel. Recycled bottles were crushed and used to replace some percent of sand (25%, 50%, 75%, and 100%), and a control combination was also available. On the 7th, 14th, 21st, and 28th days of curing, three specimens were selected from each mixture 6”x12” cylindrical molds and examined for compressive strength using UTM. Crushed samples were sieved according to ASTM standards to ensure that the cullet size was less than 2.0mm but more than 0.0625mm. The study is more concerned with the impact of using recycled bottles as fine aggregates than with the characteristics of the aggregate.

The water-cement ratio is reduced when recycled glass bottles are used as an alternative fine aggregate in concrete mix, depending on the amount present in the mix. The use of recycled bottles as fine aggregate reduces the concrete's unit weight. The use of recycled bottles as a fine aggregate substitute for structural components like as columns, beams and suspended slabs is not recommended.

When fine aggregate is replaced with 10% glass waste, the compressive strength at 7 days is shown to rise by approximately 47.75 percent on average. However, at the same replacement level, the increase in compressive strength at 28 days is just 3.30%. When waste glass is used as a fine aggregate substitute, 28 day's strength is observed to increase moderately up to 20% replacement level.

As the ratio of IOT grow's, the workability of the mix decreases, necessitating the usage of super plasticizers. The maximum compressive strength is 40% IOT replacement, which is higher than the reference mix (NC) and other replacement percentages.

1.3 Classification of Concrete Block

The hollow concrete blocks are classified into grades:

Grade A – Load-bearing bricks having a block density greater than 1500kg/m^3.

Grade B-Load-bearing bricks with block densities ranging from 1100 to 1500 kg/m^3[15]

2. Materials

Cement: 53 grade ordinary Portland cement conforming to IS 12269.

Fine Aggregate:

- M-Sand pass IS sieve2.36mm retained on 150 micron.
- Glass powder passing IS sieve 2.36mm retained on 150 micron.

Coarse Aggregate: Passing 20mm retained on 12.5mm.

Specific Gravity of materials is determined using

IS 2720-Part 3.

Components	Specific Gravity
Cement-OPC 53 grade	3.15
Iron-ore Ash	3.0
M-Sand	2.6
Glass Waste Powder	2.31
Coarse Aggregate	2.76

Table -1: Specific Gravity of Components.

Fig 1- Recycled Glass Powder

Fig 2- Iron Ore Tailings (Ash)

2.1 Concrete Mix Proportion:

M20 grade of concrete was designed as per the IS code of practice (IS 10262(2009)) and the quantity of the constituent materials used for the mixing are given below:

Cement = 407 kg/m^3

Water= 147.7 liters

Fine Aggregate= 828.25 kg/m^3

Coarse Aggregate= 1119.01 kg/m^3

W/C ratio= 0.4

Mix Proportion - 1:1:9:2.6

0%, 5%, 10%, 15% of Iron-ore ash by weight is replaced with Cement and 30% of Glass waste powder by weight is replaced with Fine aggregates in all mix proportions mentioned below.

Concrete Mix Proportion	Mix Identity
Cement 100%	NC
Cement 100%+IOT 0%	Mix 1
Cement 95%+IOT 5%,	Mix 2
Cement 90%+IOT 10%	Mix 3
Cement 85%+IOT 15%	Mix 4

Table-2: Concrete Mix Identity

*IOT- Iron-ore tailings (Ash)

3. Results

Compressive Strength& Flexural Strength

The block specimen where tested in Compression Testing Machine as given in annexure3 after specified curing period of 28 days for different percent of IOT replacement. Mix1 (0%IOT, 30%GW), Mix2(5%IOT, 30%GW), Mix3 (10%IOT, 30%GW) and Mix4 (15%IOT, 30%GW) and for normal concrete mix. The compressive strength and Flexural Strength after respective curing periods are noted in Table:

Composition	Compressive strength (N/mm^2)	Flexural strength (N/mm^2)
NC	21.17	3.22
Mix 1	22.43	3.31
Mix 2	23.55	3.39
Mix 3	28.09	3.71
Mix 4	24.98	3.49

Table-3: Compressive Strength & Flexural Strength for 28days

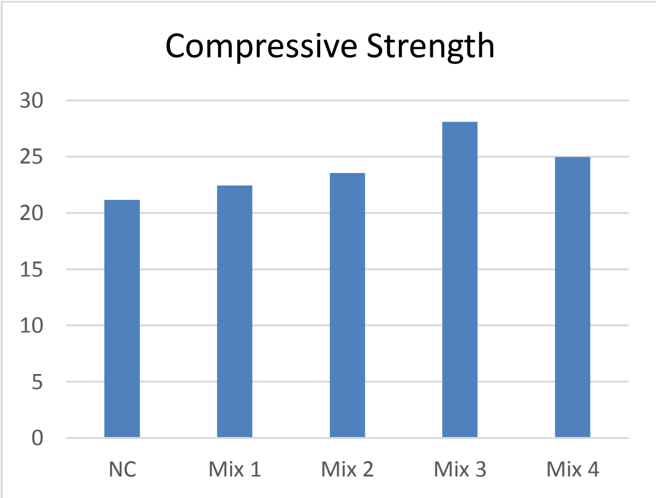

Fig 3.1 Compressive Strength of different mix

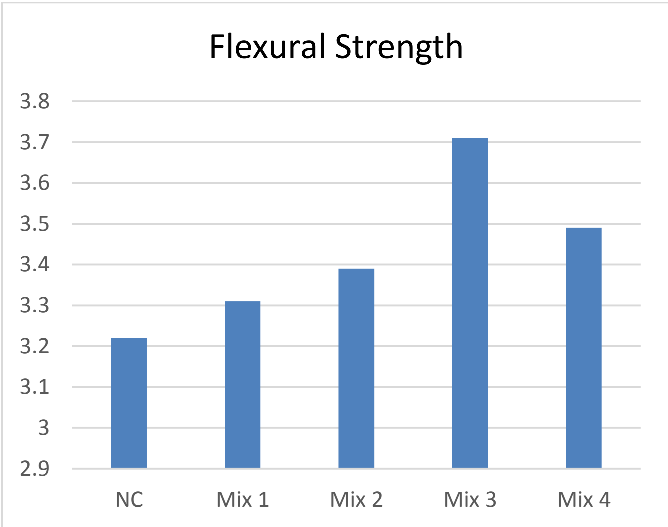

Fig 3.2 Flexural Strength of different mix

Ultrasonic Pulse Velocity

The UPV direct method is used to examine the quality of concrete according to IS: 13311(Part-1)-1992. The time it takes for an ultrasonic pulse to travel through the concrete being tested is measured using this method. When the concrete quality is good in terms od density, consistency, homogeneity, and other factors, a higher velocity is achieved. The basic formula for calculating pulse velocity is as follows:

$$\text{Pulse velocity}=\frac{\text{Path length}}{\text{Travel time}}$$

Composition	Pulse velocity(km/s)	Grading
NC	4.25	GOOD
Mix 1	4.40	GOOD
Mix 2	4.33	GOOD
Mix 3	4.42	GOOD
Mix 4	4.42	GOOD

Table-4: Interpretations of Present UPV Results

Derivation of Modulus of Elasticity from UPV Data

The dynamic Young's Modulus of Elasticity (E) can be calculated using pulse velocity and dynamic Poisson's Ratio (μ) using the IS: 13311-Part 1-1992.

$$E= [\rho(1+\mu)\ (1-2\mu)/(1-\mu)] \times V^2$$

E= Young's Modulus in N/mm^2

ρ= Density on Concrete in kg/m^3

μ= Poisson's Ratio = 0.15

V= Pulse Velocity in m/s

The E-values calculated using the above equation is given below:

Type of mix	Pulse velocity(m/s)	E-value MPa
NC	4250	410550.00
Mix 1	4400	440041.41
Mix 2	4330	426151.46
Mix 3	4420	444050.88
Mix 4	4410	442043.87

Table-5: E-value obtained from UPV Results

Cost Analysis

From the above results it is to be concluded that Mix3 (10% IOT + 30% GW) has obtained more strength than NC and to compare the cost between conventional M20 concrete block to Mix 3 Cost Analysis is done:

	MIX 3		
Material	**Weight(kg)**	**Cost/kg (Rs)**	**Overall cost (Rs)**
Cement	4.7	7.6	35.72
Fine Aggregate	6.95	1.3	9.04
Coarse aggregate	13.61	1.1	14.97
		Total	**59.73**

Table-6: Cost Analysis for Concrete Mix3

	NC		
Material	**Weight(kg)**	**Cost/kg (Rs)**	**Overall cost (Rs)**
Cement	5.23	7.6	39.748
Fine Aggregate	9.94	1.3	12.922
Coarse aggregate	13.61	1.1	14.971
		Total	**67.641**

Table-7: Cost Analysis for Reference Mix NC

4. CONCLUSIONS

The following conclusion are drawn from tests conducted on materials to examine characteristics and testing on hardened concrete to determine strength properties such as compressive and flexural.:

1. With increase in percentage of IOT workability of the mix is reduces
2. Replacement of 10% IOT with 30% of recycled glass waste gives maximum compressive strength and flexural strength which is more than reference mix (NC) and other replacement mix percentages.
3. Mix 3 (10% IOT) replacement shows higher resistance to elastic deformation than reference mix (NC).

4. From the cost analysis IOT and recycled glass waste replacements reduces the price of the concrete brick by 10% approximately.

5. Further research on Mix 3 can be carried to use it for load bearing structures.

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