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Experimental Study on Special Concrete by Replacement of Aggregates with ‘Quarry Dust’ and ‘Broken Glass’

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ABSTRACT: Conservation of natural resources and preservation of environment is the essentially of any development. The problem arising from continuous technological and industrial development is the disposal of waste material. If some of the waste materials are found suitable in concrete making, not only cost of construction can be cut down, but also safe disposal of waste materials can be achieved. So in the present paper, an attempt has been made to assess the suitability of quarry dust and waste broken glass in concrete making. In the laboratory quarry dust has been tried as fine aggregate in place of sand and broken glass has been used as partial substitute to conventional coarse aggregate in concrete making. Cubes, cylinders and prisms were cast and tested for compressive strength, split tensile strength and flexural strength after a curing period of 28 days.

I.INTRODUCTION

Raw material used in concrete constitutes a significant portion of the concrete mixes. Sand and gravel is the most commonly used fine and coarse aggregates. The resources of these materials are unsustainable in the long run and they are getting exhausted. During the last few decades the aggregates consumption increased rapidly due to urbanization and industrialization. Being a developing country, India is also facing such a problem. Therefore, it is important to find a way to introduce alternate raw materials from the other sources. We are introduced raw material like fine aggregate fully replaced by quarry dust & coarse aggregate partially replaced by broken glasses. Advances in concrete technology result in alternate construction materials as a substitute to traditional like cement, sand, aggregates, bricks, blocks, timber, paint, ceramics etc, published literature indicates that some wastes have been used in concrete. It is concluded from the available literature that, all over the world, in all the areas such as industrial by-products, domestic wastes, agricultural waste etc., trails are ongoing to obtain alternate or substitute raw materials for making new concrete.

In the last decade, construction industry has been conducted research on the utilization of waste products in concrete. Some of waste products are fly ash, rice husk, saw dust, discarded tires, plastic, glass rock, steel slugs, stone dust and ceramic. Each waste product has its specific effect on properties of fresh and hard concrete. The use of waste products in concrete not only makes it economical but also solves some of the disposal problems. The utilization of Quarry rock dust which can be called as manufactured sand has been accepted as a building material in the industrially advanced countries of the west for the past three decades.

Glass is a 100% recyclable material with high performances and unique aesthetic properties which make it suitable for wide-spread uses. Besides, the current recycling state and legislative forces pose great pressures on glass recycling and reusing. The use of glass as aggregates in concrete has great potential for future high quality concrete development. Some solutions have been formed to alleviate ASR, but these solutions have some limitations which made it still particularly important to investigate the utilisation of glass in concrete. These limitations include the long-term inspecting of the effectiveness of ASR suppressants; the effectiveness of the combined use of ASR suppressants; the effective dosage of suppressants in mitigating ASR. Waste glasses are used as aggregates for concrete. However the

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applications are limited due to the damaging expansion in the concrete caused by ASR between high-alkali pore water in cement paste and reactive silica in the waste glasses.

II. EXPERIMENTAL PROGRAMME

General

The aim of the experimental programme is to compare the strength of conventional concrete made with broken glass, used as coarse aggregate [1-2]. The basic test carried out on materials used for casting concrete samples are discussed in this chapter, followed by a brief description about mix design and curing procedure adopted.

III. MATERIALS

Cement

Ordinary Portland cement of 43 grade conforming to bureau of Indian standard (IS 12269: 1987) is used in the investigation [3-4]. Cement is a fine, grey powder. It is mixed with water and materials such as sand gravel and crushed stone to make concrete.

Fine Aggregate

Quarry Rock Dust : The basic tests on quarry dust were conducted as per IS-383-1987 and its specific gravity was around 1.95 [5]. Wet sieving of quarry dust through a 90 micron sieve was found to be 78% and the corresponding bulking value of quarry dust was 34.13%.

Quarry dust is made while blasting, crushing, and screening coarse aggregate [6-7]. Quarry dust has rough, sharp and angular particles, and as such causes a gain in strength due to better interlocking and a concomitant loss in workability. The use of quarry dust sometimes causes an increase in the quantity of cement required to maintain workability. The quarry dust contained more fines smaller than the 200 μm sieve than the river sand (about 20% for quarry dust compared with 5% for river sand). Quarry Rock Dust can be defined as residue, tailing or other non-volatile waste material after the extraction and processing of rocks to form fine particles less than 4.75mm [8].

Coarse Aggregate

Crushed granite coarse aggregate conforming to IS 383-1987 of size 20 mm and down having a specific gravity of 2.6 was used [9]. The loose and compacted bulk density values of coarse aggregate were 1483 and 1680 kg/m³, respectively, for different grade of concrete.

Waste Broken Glass

A highly transparent material produced by melting a mixture of silica, soda, ash and CaCO₃ at high temperature, and then by cooling the melted mixture for solidification without crystallization is known as glass [10].

A clean dry glass powder is useful as a substitute for portland cement in concrete. The finely ground glass having a particle size finer than 38 micro metre contain a high amount of amorphous silica, which exhibits a pozzolanic behavior. Hence, the use of ground glass in concrete can be advantageous with respect to hardened properties and durability. Moreover, using waste glass as fine aggregate would produce better workability in concrete, provided its geometry is almost spherical and preferable to produce a workable mixture [11-12].

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III. TESTS CONDUCTED

Concrete Mixes

Control mix concrete and modified with various broken glass contents as listed in Table 1 are prepared. By considering the use broken glass particles in the mixes as much as possible and achieve suitable workability was attempted and strength criteria of Grade M20 concrete mix was analyzed [13]. Water cement ratio is 0.5 and mix ratio is 1:1.33:3.35.

Table 1: Mix Specifications

Mix specification	Control mix	A ₁	A ₂	A ₃	A ₄	A ₅	A ₆
Proportion of waste broken glass	0%	5%	10%	15%	20%	25%	30%
Fine aggregate	100% replacement of quarry dust as fine aggregates						

Fresh concrete test

Slump test-Workability

Slump test is used to determine the workability of fresh concrete. Slump test as per IS: 1199 – 1959 is followed. The apparatus used for doing slump test are Slump cone and Tamping rod. Tables 2 shows the slump test results.

Compressive strength test

Cubical specimens of size 150 mm were cast for conducting compressive strength test for each mix. The compressive strength test was carried out as per IS: 516-1979. This test

was carried at the end of 28 days of curing. The compressive strength of any mix was taken as the average of strength of three cubes.

Table:2 slump test value

S.No	Proportion of waste broken glass	Slump value in mm
1	0%	89
2	5%	83
3	10%	75
4	15%	70
5	20%	64
6	25%	58
7	30%	50

Split tensile strength test

The tensile strength of the resultant mix is judged in terms of split tensile strength. For this, cylindrical specimens of size 100 mm dia × 200 mm height were cast. The test was conducted at the end of 28 days of curing and the average of three samples was taken as the representative split tensile strength of the mix.

Flexural strength test

The beam specimen was tested for flexure strength at the end of 28 days. The specimen size was 500mm x 100mm x 100mm. The specimen were submerged in clean fresh water in a curing tank and kept there until taken out just prior to test.

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IV.RESULTS

In this chapter the parameters studied on the control concrete and quarry dust and broken glass replaced concrete are discussed. The parameters such as compressive strength, splitting tensile strength and flexural strength are discussed and comparison between the control concrete and quarry dust and waste broken glass added concrete is represented.

Compressive Strength

The compressive strength for different replacement of broken glass added concrete and control concrete were tested at the end of 28 days. The values of compressive strength obtained are tabulated below.

Table 3: Compressive Strength

Mix specificatin	Proportion of waste glass	7day	14day	28day
Control mix	0%	10.74	13.70	19.83
A ₁	5%	10.50	13.60	19.70
A ₂	10%	10.10	13.15	19.30
A ₃	15%	9.86	12.97	18.20
A ₄	20%	8.10	11.0	15.9
A ₅	25%	7.65	9.26	13.12
A ₆	30%	6.80	8.45	11.76

Split Tensile Strength

The split tensile strength for different replacement of broken glass added concrete and control concrete were tested at the end of 28 days. The values of compressive strength obtained are tabulated below.

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Table 4: Tensile Strength

Mix specificatin	Proportion of waste glass	7day	14day	28day
Control mix	0%	2.86	3.68	4.95
A ₁	5%	2.74	3.64	4.92
A ₂	10%	2.56	3.55	4.80
A ₃	15%	2.40	3.15	4.55
A ₄	20%	2.10	2.96	3.40
A ₅	25%	1.90	2.54	3.10
A ₆	30%	1.65	1.96	2.84

Flexural Strength Test

The flexural strength for different replacement of broken glass added concrete and control concrete were tested at the end of 28 days. The values of compressive strength obtained are tabulated below.

Table 5: Flexural Strength

Mix specificatin	Proportion of waste glass	7day	14day	28day
Control mix	0%	1.54	2.67	3.64
A ₁	5%	1.46	2.60	3.61
A ₂	10%	1.40	2.56	3.55
A ₃	15%	1.38	2.43	3.50
A ₄	20%	1.34	2.10	3.35
A ₅	25%	1.26	1.96	3.20
A ₆	30%	1.07	1.84	2.98

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V.CONCLUSION

This study intended to find the effective ways to reutilize the quarry dust and broken glass as concrete aggregate. Analysis of the strength characteristics of concrete containing recycled waste materials gave the following results.

It has been identified that waste materials can be disposed by using them as construction materials. Hence the quarry dust and waste broken glass is suitable to replace fine and coarse aggregate. Quarry dust and waste broken glass is generated in large quantities in countries like India and this has been found as a useful replacement as fine and coarse aggregate. Hence, quarry dust and broken glass can be used as an alternate construction material to aggregates in concrete. Besides economical and strength criteria, concrete made from waste materials as aggregates, solves the disposal problem of these waste materials.

The compressive strength and split tensile strength of concrete containing broken glass aggregate is retained more or less in comparison with controlled concrete specimens. However strength noticeably decreased when the broken glass content was more than 15%. It has been concluded 15% of broken glass aggregate can be incorporated as coarse aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties respectively. But decrease in strength for 20% replacement is 20%

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