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Strength and Durability Properties of Concrete Made with RCA and Silca Fume

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ABSTRACT

Recycled material Concrete, also known as RCA, is a kind of concrete that is manufactured by substituting recycled material for natural aggregate, either in part or during the whole production process. According to the results, a reduction in the workability of concrete was caused by an increase in the quantity of recycled aggregate that included silica fume. Due to pozzolanic processes, the initial strength of bottom ash concrete was found to be lower when compared to the control mix. However, as the concrete aged, a considerable increase in strength was noted. Over the course of 28 days, the optimal dose that was seen was 10% GBA (Ground Bottom Ash) + 5% SF (Silica Fume) + 25% RCA. This combination demonstrated a greater level of strength in comparison to the control mix.In addition to this, it was discovered that an increase in the quantity of RCA led to an improvement in the resistance to acid and alkalinity assaults. It was found that the compressive and tensile strength of RCA was not significantly affected by its use up to a certain limit. In addition, the concrete exhibited good features when it was formulated with the optimal dose of 25% RCA and 5% SF as a substitute for cement.

Keywords: *-RCA, NCA, GBA, Silica fume, Compressive strength, Tensile strength, Flexural strength, Durability.*

1. INTRODUCTION

In today's fast-paced world, the concrete industry’s heavy dependence on natural resources presents significant environmental hurdles that simply cannot be ignored. It’s absolutely crucial that we tackle this pressing issue by cutting down on the use of cement and natural aggregates in the production of concrete. The escalating demand in the construction industry, coupled with the dwindling availability of resources such as coarse aggregates, sands, and cements, accentuates the urgency for sustainable practices. Recycling aggregates, therefore, emerges as a pivotal initiative, addressing the pressing need for environmentally responsible construction methods. The versatile application of coal combustion products is evident across the building materials sector, civil engineering, road construction, underground coal mining, and re-cultivation and recovery projects in open-cast mining. Beyond serving as substitutes for natural resources, their incorporation into various projects contributes significantly to resource conservation. Moreover, the integration of coal combustion products helps curtail energy demand and mitigates greenhouse gas emissions associated with the mining and manufacturing processes they replace. Key examples of these products encompass fly ash, bottom ash, boiler slag, and flue gas desulfurization materials.”

2. Literature reviews

According to **Gonzalez et al. (2007),** it was found that recycled aggregate concrete (RAC) tends to soak up more water compared to traditional concrete. This is mainly because of the adhered mortar and the higher porosity found in recycled aggregates. In addition, it was discovered that adding silica fume to both recycled aggregate concrete and traditional concrete led to an increase in water absorption. This change may stem from alterations in the pore structure and the highly reactive qualities of the silica fume, which can significantly affect the moisture retention properties of the concrete.

Topcu et al. (2004) conducted an investigation revealing that the specific gravity of Waste Concrete Aggregates (WCA) is indeed lower than that of conventional crushed aggregates. The decrease in specific gravity can be mainly linked to the adhered mortar on the surface of the recycled aggregates, which boasts a density that is lower than that of natural aggregate particles.

3. Materials and Methodology

3.1 Cement

Ordinary Portland cement (OPC) from a single lot was used throughout the course of the investigation. The physical properties of the cement as determined from various tests 30 conforming to Indian Standard IS: 1489-1991(Part-1) are listed in Table 3.1. All the tests were carried out as per recommendations of IS: 4031-1988. Cement was carefully stored to prevent deterioration in its properties due to contact with the moisture.

3.2Fine aggregate

Fine aggregate comprised river sand, possessing a specific gravity of 2.61 and a fineness modulus of 2.84. It falls under zone II of grading.

3.3 Course Aggregate

Coarse aggregate consisted of crushed angular granite sourced locally. It exhibited a specific gravity of 2.66, a flakiness index of 4.57%, and an elongation index of 3.86.

3.4 Bottom Ash

This research makes use of bottom ash from cement manufacturers located in the surrounding area. The bottom ash that we employed in this investigation was of two different sorts.

3.5 Admixture

Water-reducing and set-retarding admixtures are permitted in order to increase the workability of the concrete.Super plasticizer Geleniumhky 8765 was used for the workability.

4. Result and Discussion on Experimental Tests

4.1 Workability of Concrete Mixes

Workability is considered to be that property of plastic concrete which indicates its ability to be mixed, handled, transported and most importantly, placed with a minimum loss of homogeneity. There should be no sign of any segregation or bleeding in a workable concrete. The workability of all the mixes of concrete used in this work was controlled by conducting slump test, test apparatus was shown in Fig3.1.

Table 4.1 Slump of all mix M1, M2, M3 and M4

Mix	Mix identify	Value (mm)
Mix1	100%OPC+0%OBA+0%SF	112
Mix2	850%OPC+10%OBA+5%SF	109
Mix3	80%OPC+10%OBA+10%SF	96
Mix4	75%OPC+10%OBA+15%SF	86

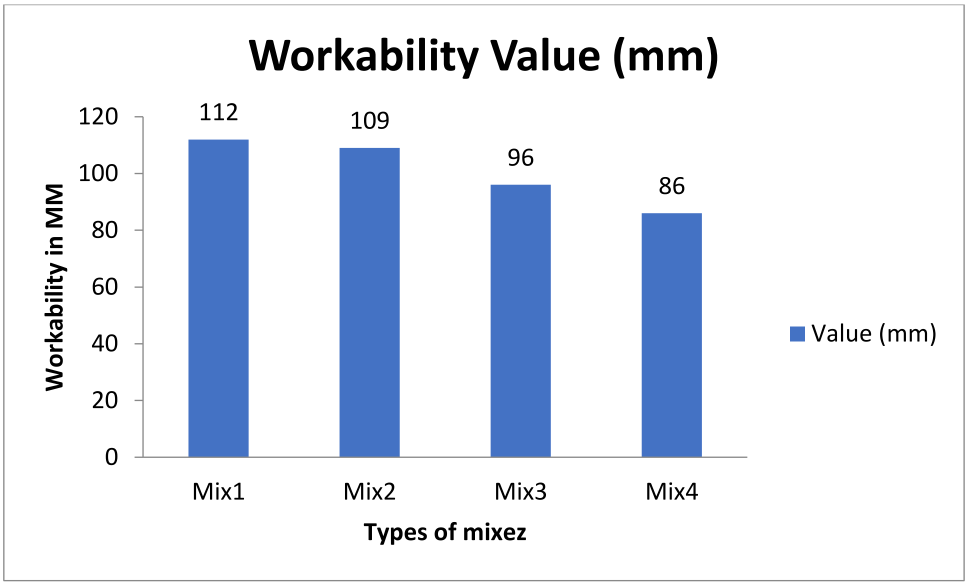

Fig. 4.1 Variation of slump value in mm

4.2 Compressive Strength

Compressive strength (CS) was obtained using a compressive testing machine (CTM), casting concrete cubes of size 150*150 *150 millimeters for all mixes labeled as Mix1, Mix2, Mix3, and Mix4. All mixes underwent continuous curing at 7 , 14 , and 28 days, respectively, following the guidelines of IS: 516. The variation in compressive strength at different time intervals is calculated and presented in the table below for concrete made with recycled concrete aggregates (RCA) and silica fume (SF) with bottom ash mixes.

Table 4.3. Compressive strength (MPa) values of all mixes at different curing ages

Mix	Mix identify	7 days	14 days	28 days
Mix1	100%OPC+0%OBA+0%SF	23.01	31.45	36.15
Mix2	850%OPC+10%OBA+5%SF	22.63	31.33	36.33
Mix3	80%OPC+10%OBA+10%SF	19.23	29.4	34.84
Mix4	75%OPC+10%OBA+15%SF	18.1	28.5	33.85

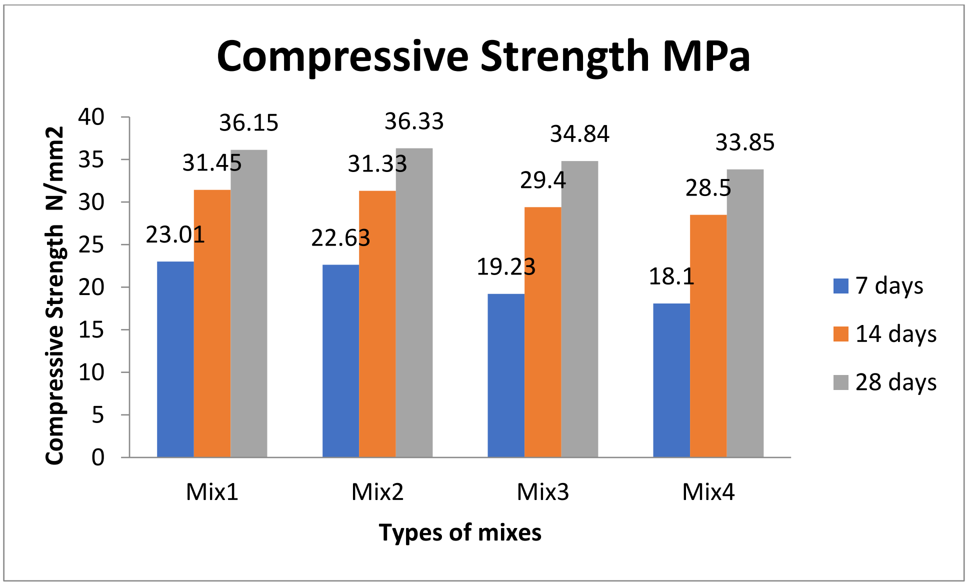

Fig. 4.1 Variation of compressive strength of concrete with age

4.3 Split Tensile Strength Test Results

The results of the splitting tensile strength tests conducted on concrete specimens of different mixes cured at different ages are presented and discussed in this section. The splitting tensile strength test was conducted at curing ages of 7, 14, 28 days.

Table 4.4. Split tensile strength test(MPa) values of all mixes at different curing ages.

Mix	Mix identify	7 days	28days	28day s
Mix1	100%OPC+0%OBA+0%SF	3.6	4.13	4.3
Mix2	80%OPC+10%OBA+5%SF	3.63	4.12	4.4
Mix3	80%OPC+10%OBA+10%SF	2.85	3.1	3.7
Mix4	75%OPC+10%OBA+15%SF	2.82	2.99	3.2

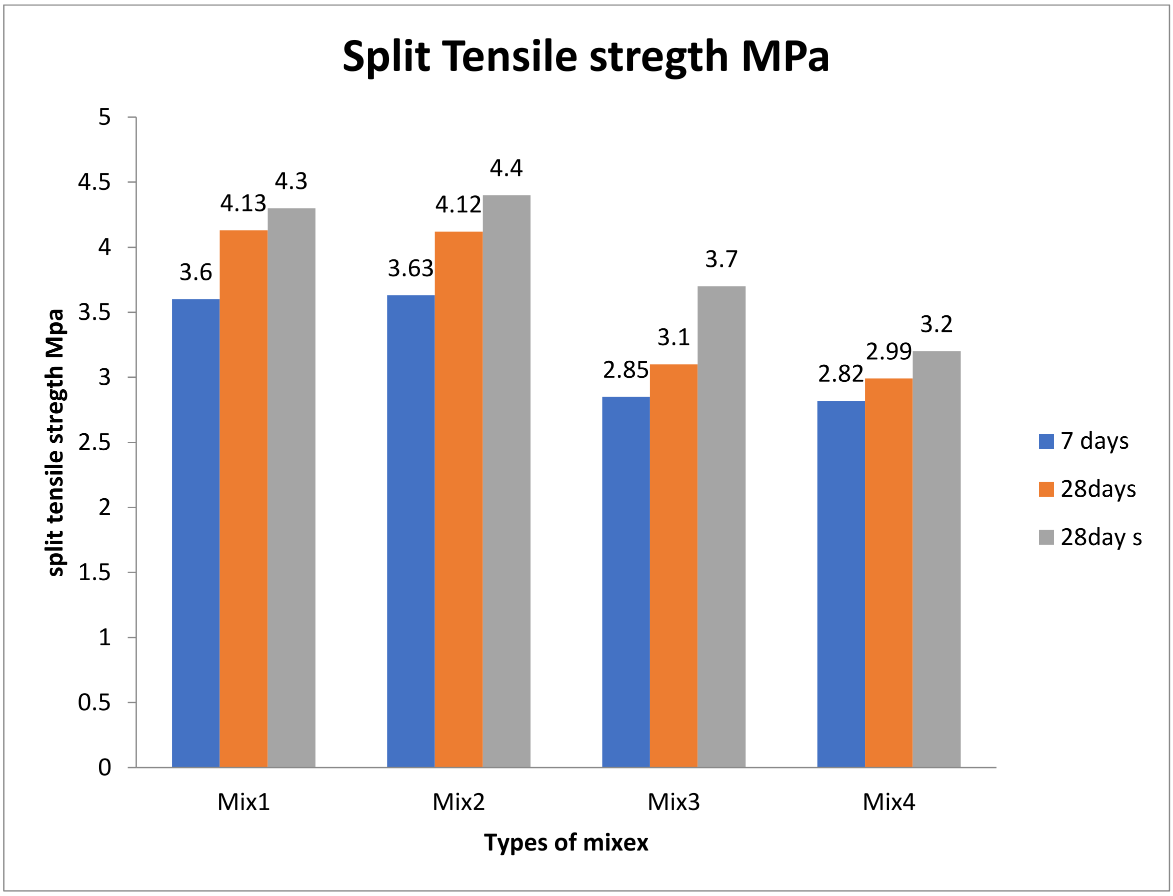

Fig. 4.2 Variation of split tensile strength of concrete with age

4.4 Flexural strength Results

In order to delve into the flexural strength of the beam specimens, a couple of point transverse load tests were conducted on the Universal Testing Machine, boasting a robust capacity of 2000 kN. Table 4.4 presents the results obtained after 28 days of curing, and it's clear as day that as the replacement of RCA increases, the flexural strength of the specimens takes a hit. It's a classic case of what goes up must come down.

Table 4.4 Flexural strength values at 28 days of curing

Mix	Mix identify	28day s
Mix1	100%OPC+0%OBA+0%SF	6.60
Mix2	80%OPC+10%OBA+5%SF	6.50
Mix3	80%OPC+10%OBA+10%SF	5.99
Mix4	75%OPC+10%OBA+15%SF	5.50

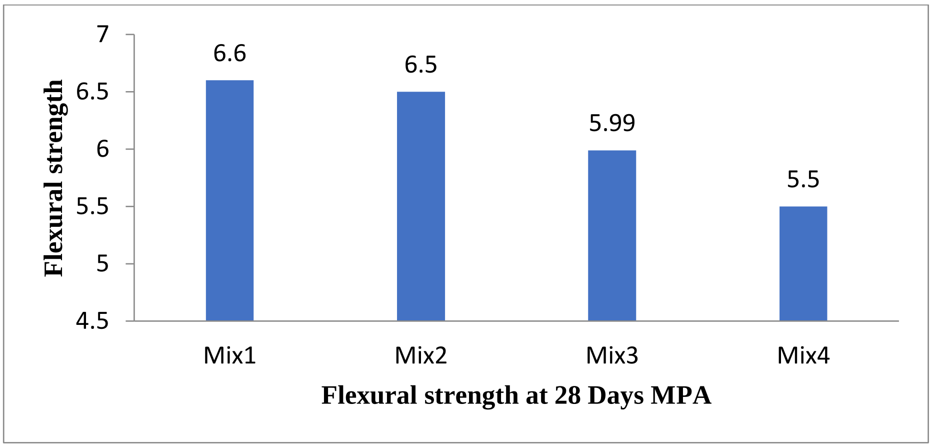

Fig. 4.3 Variation of Flexural strength of concrete with age

4.5 H_2SO_4 Attack and NaOH Test

The acid attack test is a tried-and-true method that evaluates the durability of concrete, ensuring it stands the test of time and the elements. Standard cubes measuring 15 cm were meticulously cast and lovingly cured in regular water for a full 28 days, ensuring optimal results. Once this phase was complete, the cubes were carefully extracted from the water and treated in a sulphuric acid solution, all while diligently monitoring the pH levels of the acid water with a pH meter to ensure everything was just right. The graph vividly showcases the dramatic impact of acid on strength, highlighting the transformation before and after the curing process. It's a classic tale of change and resilience, illustrating how conditions can shape outcomes in a truly remarkable way. In a similar vein, an alkalinity test was performed on cubes of identical dimensions, which were cast and cured for a full 28 days under standard curing conditions. After 28 days, the cubes were seperated from water and cured in a NaOH solution for an additional 28 days. The table presents results indicating the effects of both chemicals before and after the curing process.

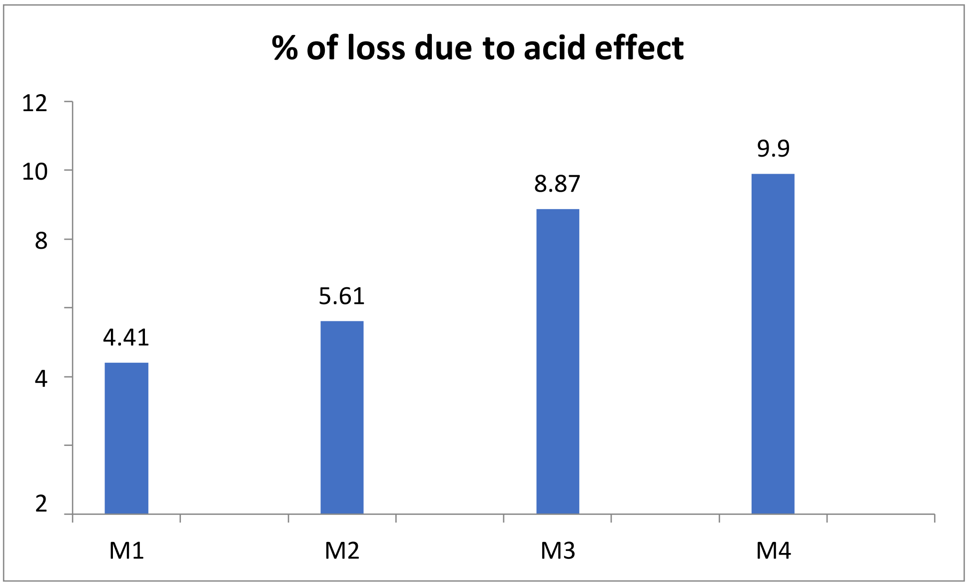

Fig: 4.5 % of loss due to acid effect

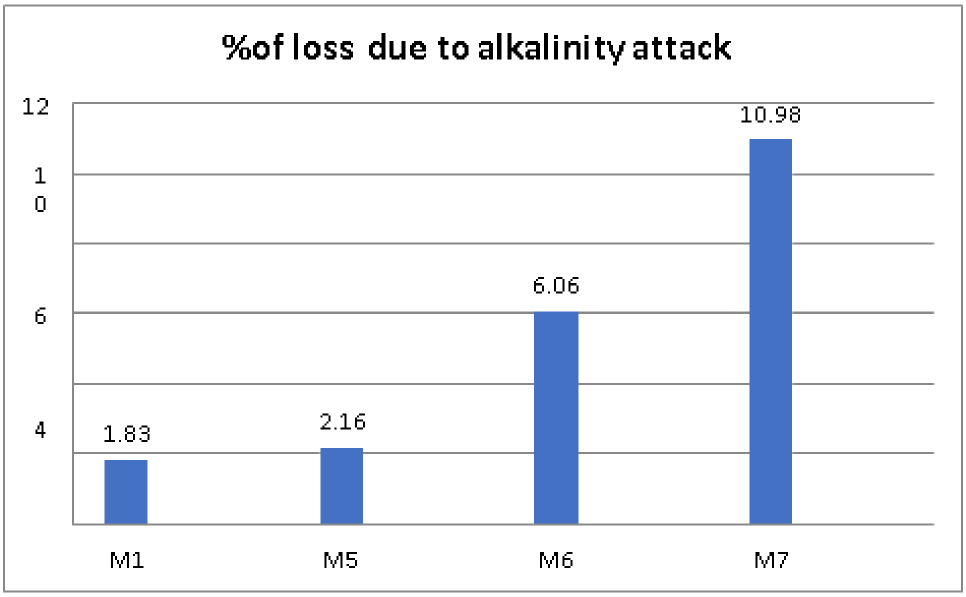

Fig: 4.6 %of loss due to alkalinity attack

5. CONCLUSIONS

5.1 Introduction

In contemporary research, the utilization of recycled aggregate, silica fume, and bottom ash in concrete has been explored to investigate alkalinity and acid resistance. The experimental data collected was thoroughly examined and discussed in Chapter 4, aiming to fulfill the outlined objectives of the present study. This chapter provides comprehensive conclusions which are as follows.

- Increasing the amount of recycled aggregate in concrete leads to a decrease in workability, which is a common challenge faced in construction projects.
- The compressive strength takes a hit as the amount of recycled aggregate in the concrete mix goes up when compared to the control mix. The ultimate compressive strength reaches its peak when utilising 25% recycled aggregate combined with 5% silica fume, showcasing the perfect blend of innovation and sustainability in construction materials.
- The increment of recycled aggregate leads to a reduction in tensile strength in concrete. Optimal strength gain at 28 days is observed with a dosage of up to 25% RCA with SF.
- The resistance to acid attack on concrete improves with an increasing percentage of recycled aggregate. Replacement levels up to 25% recycled aggregate exhibit minimal loss due to acid attack. Further increases in the percentage of RCA result in an increased effect of acid attack.
- Flexural strength decrease with increase of RCA concrete with natural aggregate.
- Alkalinity test results indicate that an increment in the replacement of recycled aggregate corresponds to an increment in the effect of alkalinity. The minimum effect of alkalinity occurs at a certain limit of recycled aggregate replacement with natural aggregate, respectively.

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