INVESTIGATION ON MECHANICAL PROPERTIES OF CONCRETE USING DIFFERENT RECYCLED AGGREGATES

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ABSTRACT

The experiment's fly-ash concrete utilized just fly ash for its fine and coarse particles. The mix design adhered to the IS method for M40 grade concrete and included 43 grade ordinary Portland cement. We created aggregates from fly ash by mixing it with cement and water. We measured the impact and crushing values of fine and coarse fly ash aggregates.The test used a water-cement ratio of 0.45 to evaluate fly ash aggregates at 0%, 10%, 20%, 30%, 40%, and 50% of the overall weight. We made bridges, pipes, and concrete blocks using these six-fly ash aggregate ratios. Later, we contrasted the outcomes with control concrete in terms of flexural, split tensile, compressive, and durability strengths.Learn all about the history of fly ash aggregate concrete's compressive strength changes in this in-depth study. After varying the curing times, we also checked the flexural and split tensile strengths of every concrete mixture. The results shed light on the properties of fly ash aggregate concrete's performance, suggesting it could be a greener substitute for conventional concrete mixes.

INTRODUCTION

Many studies have looked at fly ash, with the main focus being on its ability to replace cement. However, the creation of synthetic aggregates from fly ash is a significant step towards its widespread use in concrete. The potential for this method's widespread application has recently garnered attention due to its positive effects on pollution reduction and resource conservation. Concrete relies on inert fillers called aggregates to increase its volume, strength, and mass during production. Conventional crushed aggregates have caused the loss of natural resources, prompting the quest for substitute building materials.

There are major environmental concerns about thermal power plants, which generate over 70% of India's electricity. Due to the particle emissions it produces, fly ash disposal exacerbates soil deterioration, water contamination, and air pollution. Coal from India is notoriously difficult to dispose of due to its poor quality and high ash content. The cement industry produces fly ash, a byproduct that could find more beneficial applications rather than ending up in landfills.

Because of its negative effects on the environment, using fly ash from thermal plants is an important step toward using sustainable building materials made from industrial waste. There are environmental and economic benefits to using fly ash in building projects at the same time. It is possible to generate artificial coarse aggregates with a spherical shape and low energy using a pelletizer and cold holding procedures. While there has been some scholarly interest in synthetic aggregate manufacture, it has not yet achieved mainstream application in India. Natural resource availability, starting manufacturing costs, and energy needed for curing are some potential factors. However, the use of techniques such as cold holding eliminates the need for curing energy.

LITERATUREREVIEW

The results and applications of research on fly ash aggregates

Multiple trials using fly ash aggregates as a partial replacement for traditional aggregates in concrete have shown promising results. The Structural Engineering Research Center (SERC) in Chennai discovered that combining fly ash with aggregates results in extremely lightweight materials. Concrete blocks manufactured using fly ash aggregate have the potential to achieve compressive strengths of 20 MPa, according to the researchers. This makes them an excellent choice for masonry projects. Using the correct mortar, they claimed, you can get concrete strengths of 40 MPa and even higher strengths with less fly ash. Dr. J.B. Behera and colleagues studied the properties of sintered fly ash aggregates to see if they may partially replace stone aggregates. Sintered fly ash concrete, according to their research, is both lighter and as strong as conventional concrete created from whole materials. Lightweight concrete using sintered fly ash aggregates showed low water absorption, excellent compressive strength, and outstanding workability, according to research by Gao Li-Xiong and colleagues from the China Building Materials Academy. Mehmet Gesoglu and colleagues increased the compressive strengths of the concrete they made to 20–50 MPa by finely grinding the fly ash aggregates, which made the components more elastic. Haydar Arsian and Gokhan Baykal looked at many engineering properties of pelletized fly ash aggregates, such as their shear strength, specific gravity, ability to hold water, particle size distribution, and surface properties. Their findings suggest a wide variety of structural engineering applications for these aggregates.

CEMENT:

Because of its role in setting and hardening to join various materials, cement is a crucial binder in the construction industry. Both of these characteristics work together to create a building material that is both sturdy and durable. Construction uses concrete, a cement-based building material, for foundations, walls, bridges, and pavements. Buildings rely on cement for its binding capabilities, which make them

more stable and long-lasting.

FINEAGGREGATE:

We used sand from a nearby source to make sure it was free of organic debris and other contaminants for our study. The results of the sieve study, in compliance with IS 383-1970, confirmed that the sand is Zone-II. Wellgraded Zone-II sand is optimal for making mortar and concrete.

The tests conducted on the fine aggregate yielded the following results:

Surface area density: 2.3

Fineness Modulus: 3.06

These qualities are important for assessing the sand's suitability for usage in concrete production. The specific

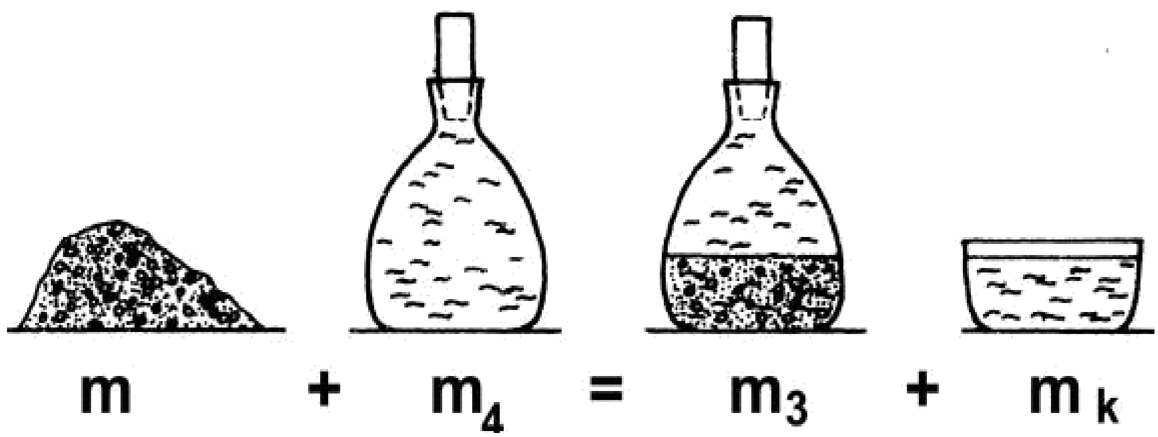


Fig.:4.1Derivationoftheformulafordensitydetermined Pycnometricmethod

Determination of Setting Time

By measuring how deep a needle can go into a standard-consistency cement paste until the reading reaches a certain point, we can determine how long cement takes to set. This test provides important information about how long the cement remains workable before setting.

Setting up the lab

The ideal temperature and relative humidity for a laboratory setting is 20 ± 2 °C and 65%. Under these circumstances, testing will always yield the same results.

The consistency test is a standard.

The conventional plunger penetration test determines the consistency of cement paste. We use trial penetrations with varying water contents, expressed as a percentage of the cement mass, to ascertain the water required to achieve this consistency.

Equipment

We conduct this test using the Vicat device, which includes a plunger. Important details are as follows:

• The plunger, which is a right cylinder with a diameter of 10.00 ± 0.05 mm and an effective length of 50 ± 1 mm, is constructed from non-corrodible metal.

PROCEDURE:

i. Take2kgof aggregate. Samplelargerthan 10mm

ii. Washthesamplethoroughlyto removefinerparticle anddust.

iii. Place the sample in a wire basket and immerse it in distilled water

SPLIT TENSILESTRENGTHTEST:

We conducted a split tensile strength test on the concrete, using cylinders that met IS 516-1959's standard dimensions of 150 mm in diameter and 300 mm in height. We placed the specimens carefully on a 200-ton compression testing machine (CTM) to ensure they were on a level surface. Next, we continuously loaded the cylinder until it broke, and then calculated the compressive strength by noting the highest load.

Afterwards, we carefully placed the test specimen in the center of the machine using packing strips and loading pieces to ensure appropriate alignment along its length. After positioning the jig in the machine, we checked to ensure that the specimen was perfectly centered. Cubic specimens had their molded faces subjected to the stress in order to guarantee that the fracture plane crossed the troweled surface. While loading cylinder specimens, it was essential to maintain a parallel relationship between the upper and bottom platens. This painstaking preparation was necessary to obtain reliable results from the split tensile strength test.

RATEOFLOADING:

Careful application of load is required for accurate results in the compressive strength test of concrete specimens. After adjusting the loading rate, it should stay constant until the specimen breaks. The loading rate may drop in manually operated machines as the specimen approaches failure; operators must then modify the controls to maintain a loading rate as close to the prescribed rate as possible. Write down the highest load that was applied during the test. It is crucial to carefully examine the fractured concrete for any unusual characteristics linked to the type of failure after it has occurred. Make a note of these specifics for when you need them. Compressive strength measurements done on concrete specimens in accordance with these guidelines will provide reliable findings.

Calculation:

The split tensile strength is calculated as loading condition such that the load is applied on topand bottom of the cylinder on its lateral surface, to the area equal to the lateral surface area of thecylinder.

The split tensile strength = $(2P/\pi dl)$

N/mm2Where,

P= average load in
N,d=diameter of cylinder
in mm,l=lengthof cylinder
in mm.

FLEXURALSTRENGTHTEST:

Flexural strength testing procedure from IS516-1959:

Placing the specimen in testing machine:

FigNo4.12 Testing Square prism for flexural strength

3. SULPHATE TEST Procedure:

We used a number of systematic procedures to assess the durability of concrete in high-sulfate settings as part of the research on its resistance to sulfate attacks. We tested concrete cubes immersed in sulfate solutions containing 5% sodium sulfate (NaSO3) and 5% magnesium sulfate (MgSO3) by weight of water against control cubes not exposed to the sulfate water to measure the reduction in compressive strength. As part of thWe prepared the sample by soaking 150-mm-diameter concrete cubes in water for 28 days, allowing them to dry for one day before immWe immersed the concrete cubes in a solution containing 5% NaSO and 5% MgSO for 90 days to maintain a constant sulfate solution content. Following their immersion, we removed the cubes from the sulfate solutions and dried them to remove any residual debris and water. After that, tThen, we tested them for compressive strength using the guidelines outlined in IS 516-1959. Mehta and Burrows (2001), this accelerated test method for determining the loss of compressive strength is a useful way to evaluate the sulfate resistance of concrete. The study aimed to investigate the effects of sulfur dioxide exposure on concrete's structural integrity by tracking these processes. This would provide insight into the durability of concrete in sulfate-rich settings.

MATERIALPROPERTIES:

A. CEMENT:

TABLE5.1:Test results on the cement

S. No	Test	Results	IS Code Used	Acceptable Limit
1	Specific Gravity of Cement	3.160	IS:2386:1963	3.0 to 3.2
2	Standard Consistency of Cement	6 mm at 34% w/c	IS:4031:1996	w/c ratio 28% - 35%
3	Initial and Final Setting Time	45 mins and 10 hours	IS:4031:1988	Minimum 30 mins and should not exceed 10 hours
4	Fineness of Cement	3.00%	IS:4031:1988	< 10%

B. COARSEAGGREGATES:

Table5.2: test results on coarse aggregates

S. No	Test	Results	IS Code Used	Acceptable Limit
1	Fineness Modulus	6.5	IS:2386:1963	6.0 to 8.0 mm
2	Specific Gravity	2.90	IS:2386:1963	2.0 to 3.1
3	Porosity	46.83%	IS:2386:1963	Not greater than 100%
4	Voids Ratio	0.8855	IS:2386:1963	Any value
5	Bulk Density	1.50 g/cc	IS:2386:1963	-
6	Aggregate Impact Value	37.5	IS:2386:1963	Less than 45%
7	Aggregate Crushing Value	26.6%	IS:2386:1963	Less than 45%

C.FINEAGGREGATES:

Table5.3:test results on the fine aggregates

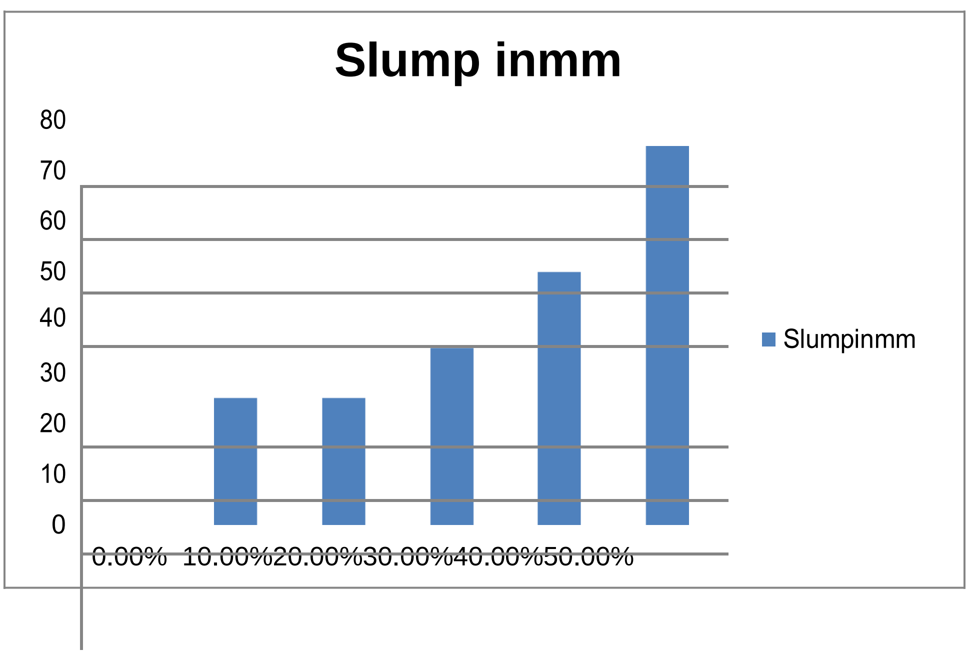
S. No	Test	Result	IS Code Used	Acceptable Limits
1	Fineness Modulus	4.305	IS:2386:1963	Not more than 3.2 mm
2	Specific Gravity	2.43	IS:2386:1963	2.0 to 3.1
3	Porosity	36.6%	IS:2386:1963	Not greater than 100%
4	Voids Ratio	0.577	IS:2386:1963	Any value
5	Bulk Density	1.5424	IS:2386:1963	-
6	Bulking of Sand	3.0%	IS:2386:1963	Less than 10%

CONCRETETESTS

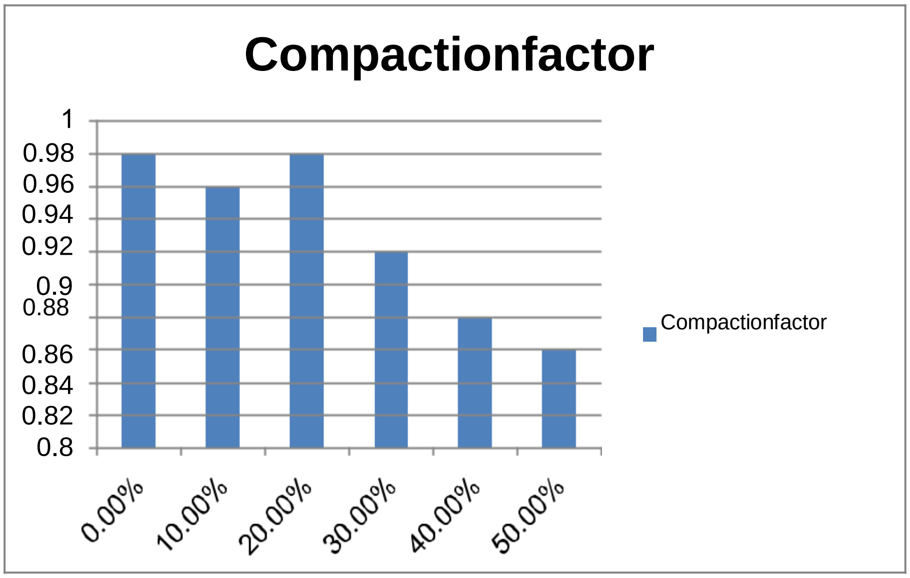
A. TESTSONFRESHCONCRETE:

1. SLUMPCONETEST:

S.no	%Replacementofflyashaggregates	Slumpinmm
1	0.00%	0
2	10.00%	25
3	20.00%	25
4	30.00%	35
5	40.00%	50
6	50.00%	75



2. COMPACTIONFACTORTEST



S. No	% Replacement of Fly Ash Aggregates	Compaction Factor
1	0.00%	0.98
2	10.00%	0.96
3	20.00%	0.98
4	30.00%	0.92
5	40.00%	0.88
6	50.00%	0.86

B. TESTSONHARDENEDCONCRETE:

1. COMPRESSIVESTRENGTH:

S. No	% Replacement of Fly Ash Aggregates	Compressive Strength of Concrete (MPa)
		7 Days
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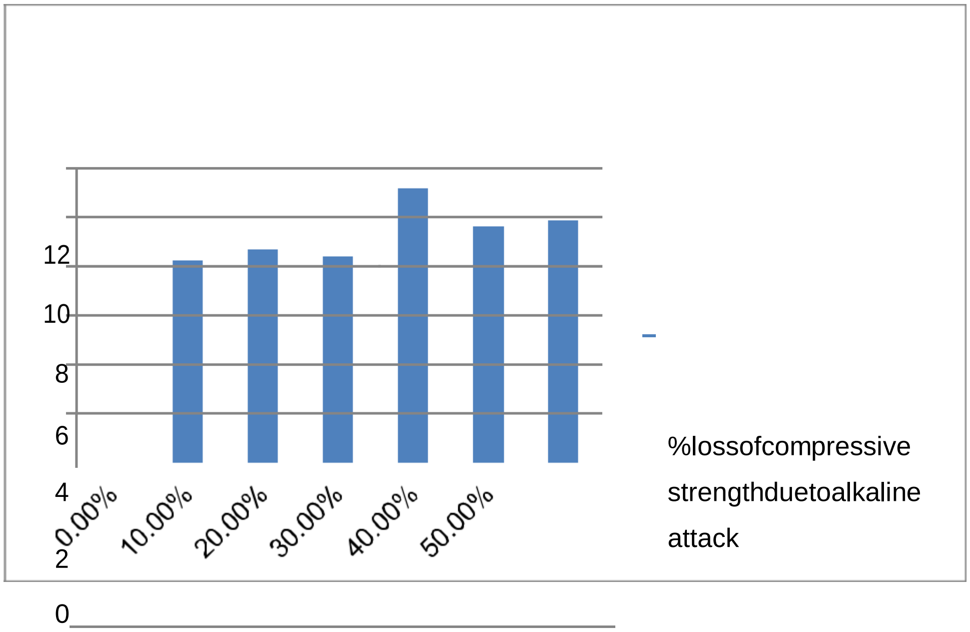
1	0.00%	23.49
2	10.00%	24.01
3	20.00%	25.34
4	30.00%	21.72
5	40.00%	20.66
6	50.00%	20.16

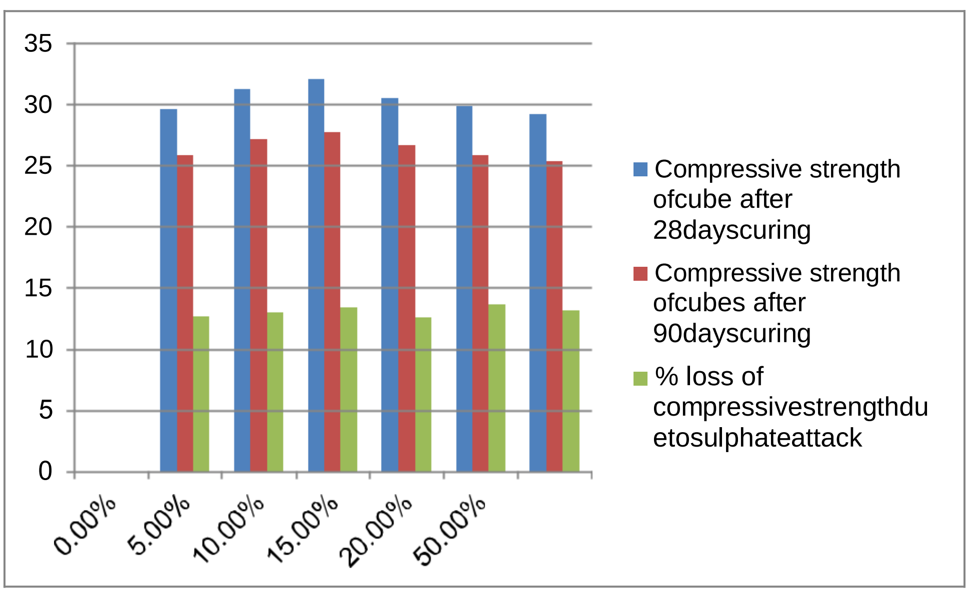
2. ALKALINEATTACK

Sl. No	% Replacement of Fly Ash Aggregates	Weight of Cube after 28 Days (grams)	Weight of Cubes after 90 Days (grams)	% Loss of Weight due to Alkaline Attack	Compressive Strength of Cube after 28 Days (MPa)	Compressive Strength of Cubes after 90 Days (MPa)	% Loss of Compressive Strength due to Alkaline Attack
1	0.00%	2286	2259	1.181	29.55	27.12	8.223
2	10.00%	2340	2306	1.452	31.19	28.48	8.688
3	20.00%	2280	2244	1.578	32.016	29.32	8.42
4	30.00%	2310	2268	1.818	30.47	27.06	11.191
5	40.00%	2296	2251	1.959	29.84	26.97	9.617
6	50.00%	2324	2276	2.065	29.20	26.32	9.86



3. SULPHATEATTACKTEST

We cleared the cement, fine aggregates, and coarse



aggregates for further investigation, finding their material qualities within the acceptable range of the IS code. While increasing the percentage of fly ash

Thanks to the experimental program, we have some solid conclusions about using fly ash aggregate in concrete.

aggregate in concrete did increase the slump cone values, it also unexpectedly made the material less workable. Based on the results, the optimal percentage of fly ash aggregate for compressive strength at 7, 28, and 56 days of curing was 20%. At 20% replacement for both curing times, cylindrical specimens reached their maximum split tensile strength after 28 days and flexural strengths after 56 days of curing, respectively. Studies on the durability of fly ash aggregate concrete revealed a rise in compressive strength and weight loss percentages with increasing percentages of fly ash aggregate. Results like these show that concrete can retain its durability up to a 20% replacement level. Finally, consider replacing some of the coarse aggregate in your M40-grade concrete with 20% fly ash aggregate for maximum strength.

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