Effect on Concrete by partial replacement of cement with Fly Ash & Sand with Stone Dust

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Abstract - *Concrete is one of the most widely used construction materials, but the excessive use of cement and natural sand causes' environmental pollution and depletion of natural resources. To overcome these problems, this study investigates the effect of partial replacement of cement with fly ash and sand with stone dust in concrete. Fly ash obtained from thermal power plants was used as a replacement for cement at 6%, 12%, and 18%, while stone dust from crushing plants was used as a replacement for sand at 8%, 18%, and 28% in M45, M50, and M55 grade concrete. Various tests such as slump test, compressive strength test, flexural strength test, split tensile strength test, and durability test were carried out at 7, 14, and 28 days of curing. The results showed that workability slightly decreased with an increase in stone dust content because of the presence of finer particles. However, the strength properties of concrete improved due to the pozzolanic action of fly ash and better particle packing of stone dust. The mix containing 12% fly ash and 18% stone dust exhibited optimum performance with higher compressive, flexural, and split tensile strength compared to conventional concrete. Durability results also showed improved resistance against sulphate attack. Therefore, the use of fly ash and stone dust in concrete can produce economical, durable, and environmentally sustainable construction material.*

Key Words: Fresh Concrete test, Hardened Concrete test, Durability test, Workability Split Tensile Test

1 INTRODUCTION

Concrete is a widely used construction material made of cement, sand, and aggregates. Due to environmental concerns caused by excessive use of cement and natural sand, alternative materials like fly ash and stone dust are used in concrete. Fly ash partially replaces cement, while stone dust replaces sand, helping to reduce pollution, conserve natural resources, and lower construction costs. This study evaluates the strength and performance of concrete using these sustainable materials.

1.1 Stone Dust

- Stone dust is a fine by-product obtained during the crushing of stones in crushers.
- It is commonly used as a partial replacement for natural sand in concrete and construction works.
- Due to its fine texture, stone dust fills voids between aggregates, improving the density and strength of concrete.
- It is widely used in roads, pavements, bricks, and concrete works.
- Using stone dust reduces the need for river sand, helps utilize industrial waste, lowers construction costs, and supports sustainable and eco-friendly construction practices.

1.2 Fly Ash

- Fly ash is a fine powdery material that is produced as a by-product from burning coal in thermal power plants.
- It is mainly composed of silica, alumina, and small amounts of other compounds, which make it suitable for use in construction materials.
- Due to its pozzolanic properties, fly ash reacts with calcium hydroxide in the presence of water to form compounds that improve the strength and durability of concrete.

1.3 HCL

In durability studies of concrete, HCl (Hydrochloric Acid) is used to check the acid resistance and durability of concrete. Concrete specimens are immersed in HCl solution to study the effect of acidic conditions on strength, weight loss, and surface damage. This test helps to evaluate how well concrete can resist chemical attacks in aggressive environments such as industrial areas, sewage plants, and chemical industries.

2 MATERIAL AND METHODOLOGY

2.1 Fine Aggerate (IS 2386 Part-1)

Table 1 Properties of Fine Aggerate

Properties	Sand
Sieve analysis	Zone II
Fineness modulus	2.871
Specific Gravity	2.64
Water Absorption	1.77
Bulk Density	1.62 (Loose) 1.76 (Compacted)

2.2 Coarse Aggerate (383-1987)

Table 2 Properties of Fine Aggerate

Properties	20mm	10mm
Specific Gravity	2.88	2.99
Water Absorption	1.46%	0.29%
Aggregate Impact Value	9.81%	9.33%
Aggregate Crushing Value	11.75%	9.98%
Flakiness Index	10.89%	25.26%
Elongation Index	6.84%	7.66%
Bulk Density	1.62 (Loose) 1.75(Compact)	1.53 (Loose) 1.79(Compact)

2.3 Properties of Fly ash

Table 3 Properties of fly ash

Properties	Description
Fineness	Very fine powder, similar to cement
Specific Gravity	2.1 to 2.6
Bulk Density	0.8 to 1.2 g/cm^3
Color	Grey to dark grey
Texture	Smooth and fine

2.4 Mix Design (10262-2019)

- For M 45 Grade Concrete mix

Table 4 mix proportion (per cubic meter)

water	Cement	FA	CA	Total
153.26	394.32	808.9	1197.7	2553.4
0.40	1.00	2.11	3.12	6.64

- For M 50 Grade Concrete mix

Table 5 mix proportion (per cubic meter)

water	Cement	FA	CA	Total
153.26	437.90	766.9	1179.6	2537.4
0.35	1.00	1.75	2.69	5.79

- For M 55 Grade Concrete mix

Table 6 mix proportion (per cubic meter)

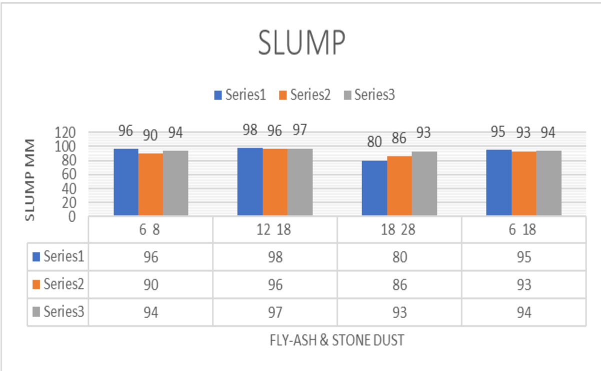
water	Cement	FA	CA	Total
153.26	414.22	784.6	1188.8	2540.9
0.37	1.00	1.89	2.87	6.13

3. RESULT

3.1 Workability

- Workability is the property of fresh concrete which determines the ease of mixing, placing, compacting, and finishing without segregation.
- Good workability ensures better strength, durability, and surface finish of concrete
- The workability of concrete is tested according to IS 1199.

Chart-1 slump value comparison



3.2 Compressive test result

- Bureau of Indian Standards suggests that the compressive strength of concrete be considered as the basis for determining all properties and studying response of concrete.
- Compressive Strength Test evaluation @ (7 Days, 14 Days and 28 Days)
- Concrete cubes are standard specimens used in the compressive strength test to determine the strength of concrete. Generally, cubes of size 150 mm × 150 mm × 150 mm are cast, cured, and tested in a Compression Testing Machine.

Where, fc=P/A
Fc= Compressive strength (N/mm^2)
P= Maximum load applied (N)
A= Area of cube specimen (mm^2)

Chart-2 Compressive test result of 7 day

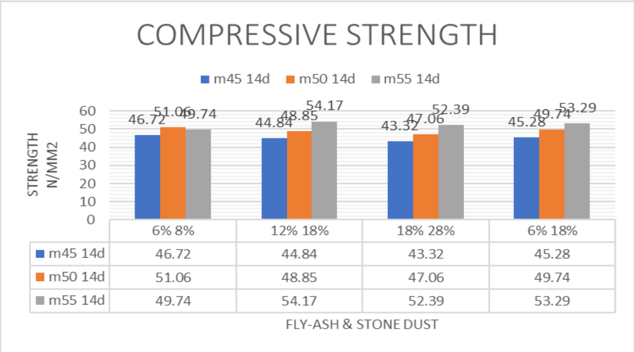


Chart-3 Compressive test result of 14 day

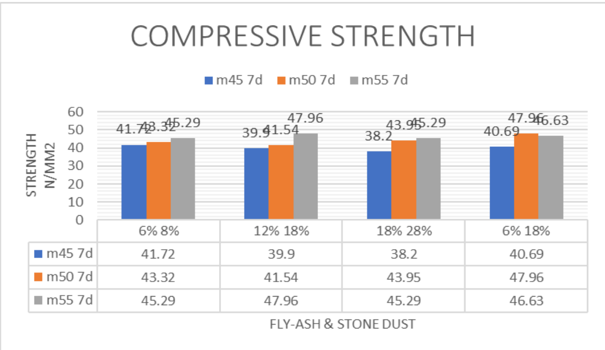
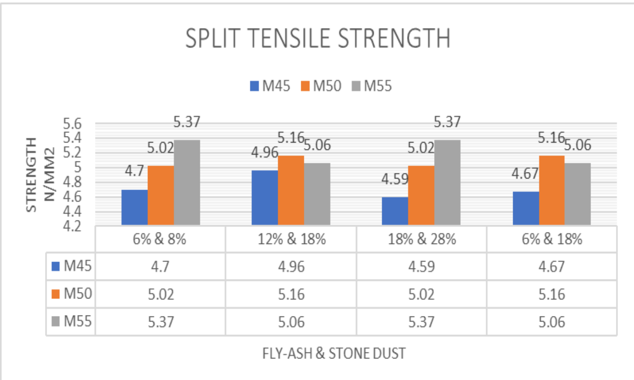


Chart-4 Compressive test result of 28 day



3.3 Split Tensile test result

- Concrete cylinders were cast to determine split tensile strength. 28 days split tensile strength of concrete was determined and results of test shown below in tabular form.
- The load is applied gradually until the cylinder splits into two halves due to tensile stress developed along the vertical diameter.
- Cylinders of size 150 mm diameter and 300 mm length are used. The test is conducted after curing periods such as 7 days and 28 days

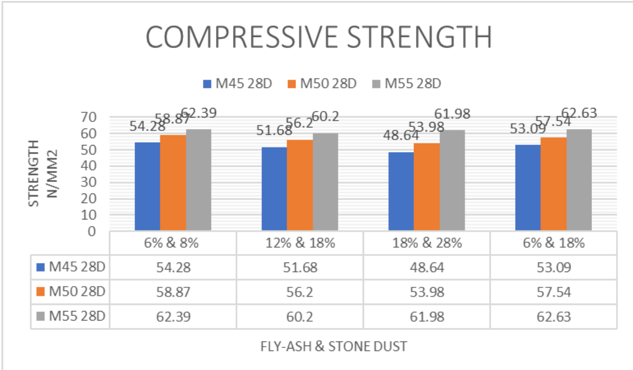
ft=2P/3.14DL

P= Maximum load applied (N)

D= Diameter of cylinder (mm)

L= Length of cylinder (mm)

Chart-5 Split Tensile test result of 14 day



3.4 Durability test result

- Durability of concrete is the ability of concrete to resist weathering action, chemical attack, abrasion, and other harmful effects while maintaining its strength and stability for a long period of time.
- In durability testing, Hydrochloric Acid (HCl) solution is used to study the resistance of concrete against acid attack.
- Concrete specimens are immersed in HCl solution for 28 days, and the changes in weight, surface condition, and compressive strength are observed to evaluate the chemical resistance and long-term performance of concrete.
- The durability requirements are specified in IS 456

Chart-6 Durability test result for M 45

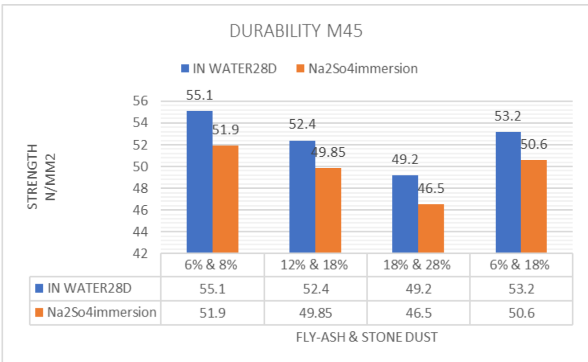
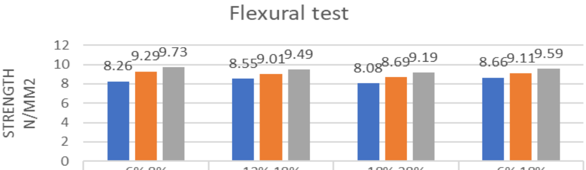
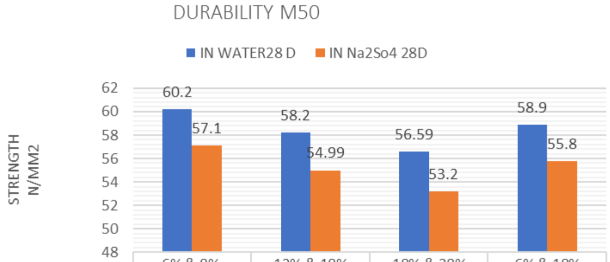


Chart-7 Durability test result for M 50



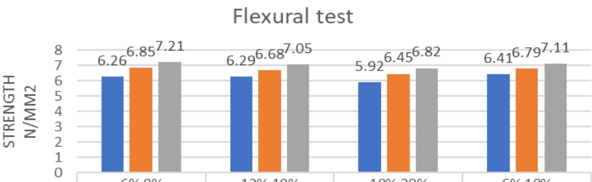
	6% 8%	12% 18%	18% 28%	6% 18%
m45 28d	8.26	8.55	8.08	8.66
m50 28d	9.29	9.01	8.69	9.11
m55 28d	9.73	9.49	9.19	9.59

Chart-8 Durability test result for M 55



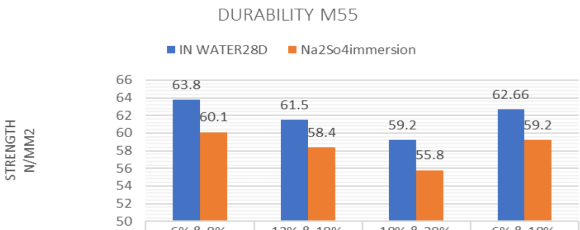
	6% & 8%	12% & 18%	18% & 28%	6% & 18%
IN WATER28 D	60.2	58.2	56.59	58.9
IN Na2So4 28D	57.1	54.99	53.2	55.8

Chart-9 Comparison of flexural strength values at 7days



	6% 8%	12% 18%	18% 28%	6% 18%
m45 7d	6.26	6.29	5.92	6.41
m50 7d	6.85	6.68	6.45	6.79
m55 7d	7.21	7.05	6.82	7.11

Chart-10 Comparison of flexural strength values at 28 days



	6% & 8%	12% & 18%	18% & 28%	6% & 18%
IN WATER28D	63.8	61.5	59.2	62.66
Na2So4immersion	60.1	58.4	55.8	59.2

ability testing with a Na2SO4 solution, the results indicate that the average strength loss in normal M45, M50, and M55 grade concrete is 5.70%, 4.6%, and 5.9% respectively.

- ✓ The ideal proportions for stone dust and fly ash are determined to be 6% and 8%

REFERECENS

1) IS 456:2000 – Plain and Reinforced Concrete – Code of Practice, Bureau of Indian Standards, New Delhi, India.
2) IS 2386:1963 (Part I to Part III) – Methods of Test for Aggregate for Concrete, Bureau of Indian Standards, New Delhi, India.
3) IS 10262:1982 – Guidelines for Concrete Mix Design, Bureau of Indian Standards, New Delhi, India.
4) IS 12269:2013 – Ordinary Portland Cement, 53 Grade – Specification.
5) IS 516:1959 – Method of Test for Strength of Concrete.
6) IS 383:1970 – Specification for Coarse and Fine Aggregates from Natural Sources for Concrete.
7) IS 5816:1999 – Splitting Tensile Strength of Concrete – Method of Test.
8) T.R. Naik, Sustainability of Concrete Construction, Practice Periodical on Structural Design and Construction, 2008.
9) Gidion Turuallo and Harun Mallisa, Using Stone Dust to Replace a Part of Sand in Concrete Mixture.
10) Mahdi Rafieizonooz, Jahangir Mirza, Mohd Razman Salim, Mohd Warid Hussin, Investigation of Coal Bottom Ash and Fly Ash in Concrete as Replacement for Sand and Cement.
11) Md Mahboob Ali and S.M. Hashmi, Strength Characteristics of Concrete with Partial Replacement of Cement by Marble Powder Dust and Sand by Stone Dust.
12) Sarvesh P.S Rajput, Experimental Study on Crushed Stone Dust as Fine Aggregate in Cement Concrete.

❖ **IS CODES**:

- IS 12269:2013 – Ordinary Portland cement, 53 Grade – Specifications (1st Revision).
- IS 10262:2009 – Concrete Mix Proportioning – Guidelines (First Revision).
- IS 456:2000 – Plain and Reinforced Concrete- Code of Practice.
- IS 7320: 1974 – Specifications for Concrete Slump Test Apparatus.
- IS 460:1962 – Specification for Test Sieves.
- IS 516:1959 – Method of Test for Strength of Concrete.
- IS 2386:1963 – Method of Testing for Aggregate

for Concrete, Part III Specific Gravity, Density, Voids, Absorption and Bulking.

- IS 383:1970 – Specification for Coarse and Fine Aggregates from Natural Sources for Concrete (Second Revision).
- IS 14858:2000 - Compression Testing Machine Used for Testing of Concrete and Mortar – Requirements.
- IS 1199:2018 – Fresh Concrete – Methods of Sampling, Testing & Analysis.
- IS 9103:1999 Concrete Admixtures – Specification.