Partial Replacement Of Coarse Aggregate By Waste Ceramic Tile And Cement By Coal Dust

Fathima S N[1], Alfya N[2], Anand Ashok[3], Aakash A S[4], Lakshmi Chandran[5]
[1, 2, 3, 4] Dept of Civil Engineering
[5]Assistant professor, Dept of Civil Engineering
[1, 2, 3, 4, 5] Musaliar College of Engineering

Abstract- *The use of natural materials in construction has increased a lot due to growth and innovation in the building industry. Also, when buildings are demolished, we create a lot more waste. Here, in this project the aim is to find experimentally the effect of partial replacement of coarse aggregate by ceramic tiles and cement by coal dust in concrete. First we have to find out the optimum compressive strength of concrete specimen by the partial replacement of ceramic tiles as coarse aggregate. Then, we have to replace coal dust as cement with various proportions. 0%, 10%, 20%, 30%..... of coarse aggregate were substituted with ceramic waste broken tiles and 0%, 5%,10%,15%,20%.....by coal dust. The concrete grade of M30 was developed. The specimen is casted and cured, then compressive strength, tensile strength and flexural strength are tested.*

Keywords- Crushed Ceramic Tiles, Compressive strength, Flexural strength, Split-tensile strength, Coal dust.

I. INTRODUCTION

Concrete usage is soaring globally, driven by infrastructure growth and building expansion. To enhance sustainability, crushed tiles are used to partially replace traditional aggregates, reducing waste and environmental impact. Researchers focus on innovative methods like substituting coarse aggregate with repurposed ceramic tiles to create eco-friendly concrete mixes.

With concrete demand projected to nearly triple by 2050, finding alternatives to natural aggregates is crucial for sustainable development. Coal bottom ash, a by-product of coal-fired power plants, is increasingly used in concrete production to reduce environmental impact and waste. Experimentation aims to optimize concrete strength by replacing traditional materials with ceramic tiles and coal dust additives.

Researchers conduct experiments to determine the effects of substituting coarse aggregate with ceramic tiles and cement with coal dust in concrete mixes. Testing involves developing M30 grade concrete specimens and assessing compressive, tensile, and flexural strengths to optimize material usage and sustainability.

II. LITERATURE REVIEW

Manikandan et al..,(2023) prepared concrete by replacing coarse aggregate by waste tile considering maximum size of particle 20mm. The percentage of tiles ranged from 0% to 25% and a proportion of cement was substituted with flyash

Priyanka Kusum et ..,(2021) studied M25 grade concrete with replacement of the coarse aggregate by 30 %by ceramic aggregate. The workability of concrete was assessed. Compressive strength initially improved with up to 30% replacement, but beyond that, it decreased as the mix became less cohesive and workable.

Anurag Singh et al..,(2021) The research findings suggest that higher substitutions of cement with coal ash in concrete production. While workability slightly decreased with higher coal ash content due to increased water demand, replacements of 10% to 15% of cement with coal ash showed better compressive strength compared to 100% ordinary Portland cement. However, compressive strength declined as coal ash replacement surpassed 15%.

Sumit Gaikwad et al..,(2019) The study found that a mixture of waste paper sludge and Activated Charcoal Powder can effectively substitute cement in concrete production. This combination notably improved compressive, flexural, and split tensile strengths in various proportions, offering increased durability, especially with 10% PS and 1% ACP. Additionally, it was observed to be more cost-effective for bulk construction when compared physical

III. MATERIALS AND METHODOLOGY

3.1 MATERIALS USED

3.1.1 Ordinary Portland Cement

Ordinary Portland Cement (OPC) is a common type of cement used in construction, made primarily from limestone and clay. It's versatile, durable, and widely used in various construction projects worldwide. OPC 53 grade cement is preferred here.

Table 1: Physical properties of cement

Sl no	Properties	Result
1	Fineness	7%
2	Consistency	30
3	Initial Setting Time	More than 30 minutes
4	Final Setting Time	Less than 60 minutes

3.1.2 Fine aggregate

Fine aggregate passing through a 2.36mm sieve consists of small sand and silt particles used in construction, filling voids in concrete mixes to enhance cohesion and strength.

Table 2: Physical properties of fine aggregate

Sl no	Properties	Result
1	Fineness modulus	4.96%
2	Specific gravity	2.51

3.1.3 Coarse aggregate

A 20mm size coarse aggregate comprises larger particles used in construction to reinforce concrete mixes.

Table 3: Physical properties of coarse aggregate

Sl no.	Properties	Result
1	Fineness modulus	5.98
2	Specific gravity	2.81

3.1.4 Waste ceramic tiles

Waste ceramic tiles can enhance concrete by substituting conventional aggregates, offering a sustainable solution for recycling construction waste.

Fig 3.1.4 Ceramic tiles

3.1.5 Coal dust

Coal dust can be utilized in concrete as a supplementary cementitious material, enhancing its strength and reducing environmental impact by recycling coal waste.

Fig 3.1.5 Coal dust

3.1.6 Water

Water is crucial in concrete mixes, aiding in the hydration process to bind cement and aggregates.

3.2 METHODOLOGY

3.2.1 Mix design

M30 grade mix proportions are listed in table 4.

Table 4: Quantity of materials required per cu.m for M30 grade concrete

Cement	Fine aggregate	Coarse aggregate	Water
387.5 kg/m^3	646.32 kg/m^3	1170.26 kg/m^3	186 kg/m^3

3.2.2 Experimental Progress

The experimental program involving partial replacement of coarse aggregate with ceramic tiles and cement with coal dust aims to assess the impact on concrete properties. Factors like compressive strength, durability, and workability should be analyzed to understand the effectiveness and limitations of these substitutions in practical applications. The construction industry is continuously exploring sustainable and cost-effective alternatives to traditional concrete mixtures.

This experimental program focuses on the partial replacement of coarse aggregate with ceramic tiles and cement with coal dust in concrete. The aim is to investigate the effects on key properties such as compressive strength, durability, and workability. Analyze the properties of coal dust and ceramic tiles to understand their chemical composition, particle size distribution, and physical characteristics. Determine the suitable proportions of coal dust to replace cement and ceramic tiles to replace coarse aggregate. Prepare concrete samples by substituting a portion of the coarse aggregate with waste ceramic tiles with various proportion. The optimum strength is determined.

3.2.3 Casting of specimens

Initially we have to cast conventional concrete specimens such as cube, cylinder and beams for finding the compressive strength, split tensile strength and flexural strength. These results are then compared with concrete specimens which are prepared with partial replacement of cement and coarse aggregate with coal dust and ceramic tiles respectively. The conventional concrete specimens are casted by using OPC 53 grade cement and M sand as fine aggregate. The mix calculation is carried out as M30 concrete.

6 cubes (150mm x 150mm x 150mm), 6 cylinders (150mm diameter and 300mm height)and 6 beams (100mm x 100mm x 500mm) were casted for determining 7 days and 28 days compressive strength of cubes, 7 day split tensile strength of cylinder and 7 day flexural strength of beams. Careful procedure was adopted in the batching, mixing and casting operation. Concrete is mixed manually. The proportion of each material for concrete was measured by weight. The dry ingredients are mixed and water is added slowly until the concrete is workable.

Fig 3.2.3 Casting of specimens

3.2.4 Tests for concrete

Compressive Strength Test (as per IS 516:1959)

Compressive strength is tested on 15 x 15 x 15 cm concrete cubes after 7 and 28 days of curing, applying load at 140kg/cm2 per minute until failure, and then calculating strength by dividing the load at failure by the specimen's area.

Compressive strength, **fck = P/A**

Where, P= failure load in compression in N

A= Area of cube in mm2

fck=Compressive strength in N/mm2

Split Tensile strength Test (as per IS 516:1959)

Tensile strength, tested through split tensile tests on standard cylinders measuring 15cm in diameter and 30cm in depth, is calculated using the equation:

Split Tensile Strength, **fsp = 2P / (πdl).**

Where, fsp =Split tensile strength in N/mm2
P = Maximum applied load in N
L = Length of cylinder in mm
d = Diameter of cylinder in mm

Flexural Strength Test (as per IS 516:1959)

Flexural strength, an indicator of concrete durability, is tested through beam tests on 10cm x 10cm x 50cm beams, determining the modulus of rupture, which depends on beam dimensions and loading position.

fb **=pl/bd^2**

When 'a' >13.3 cm

fb **=3Pa/b2**

When 11 <'a'< 13.3 cm

IV. RESULT

The mechanical properties such as compressive strength test, splitting tensile test and flexural strength test were performed on cubes, cylinders and beams by replacing coarse aggregate with ceramic tiles in mix proportion of M30 concrete.

4.1 Compressive strength of ceramic tiles aggregate concrete (N/mm2)

Mix	Replacement (%)	7 Days	28 Days
Mix 1	M30+0%CTA	17.3	30.17
Mix 2	M30+10%CTA	26.66	37.78
Mix 3	M30+20%CTA	27.44	41.54
Mix 4	M30+30%CTA	26.48	39.3

4.2 Split tensile strength of ceramic tiles aggregate concrete (N/mm2)

Mix	Replacement (%)	7 Days	28 Days
Mix 1	M30+0%CTA	1.72	2.37
Mix 2	M30+10%CTA	1.81	3.12
Mix 3	M30+20%CTA	1.83	3.14
Mix 4	M30+30%CTA	1.76	3.05

4.3 Flexural strength of ceramic tiles aggregate concrete (N/mm2)

Mix	Replacement (%)	7 Days	28 Days
Mix 1	M30+0%CTA	2.6	4.03
Mix 2	M30+10%CTA	4.75	5.58
Mix 3	M30+20%CTA	4.87	5.92
Mix 4	M30+30%CTA	4.25	4.9

The optimum strength is obtained at the mix of replacing 20% ceramic tiles as coarse aggregate. Then replace cement by coal dust with various proportions. The mechanical properties such as compressive strength test, splitting tensile test and flexural strength test were performed on cubes, cylinders and beams.

4.4 Compressive strength of replaced concrete specimen (N/mm2)

Mix	Replacement (%)	7 Days	28 Days
Mix 1	M30+0%CTA	17.3	30.17
Mix 2	M30+20%CTA+5%CD	11.3	18.32
Mix 3	M30+20%CTA+10%CD	17.77	30.44
Mix 4	M30+20%CTA+15%CD	10.55	15.13

4.5 Split tensile strength of replaced concrete (N/mm2)

Mix	Replacement (%)	7 Days	28 Days
Mix 1	M30+0%CTA	1.72	2.37
Mix 2	M30+20%CTA+5%CD	1.09	1.76
Mix 3	M30+20%CTA+10%CD	2.05	2.575
Mix 4	M30+20%CTA+15%CD	1.375	1.55

4.6 Flexural strength of replaced aggregate concrete (N/mm2)

Mix	Replacement (%)	7 Days	28 Days
Mix 1	M30+0%CTA	2.6	4.03
Mix 2	M30+20%CTA+5%CD	2.375	4.75
Mix 3	M30+20%CTA+10%CD	3.375	6.25
Mix 4	M30+20%CTA+15%CD	2.87	4.312

V. CONCLUSION

1. The altered mix affects various properties.
2. Considerations may include changes in compressive strength, workability, and durability.
3. The impact on these factors should be evaluated to determine the feasibility and practicality of such replacements in concrete applications.
4. Initially we cast specimens with conventional mix proportion of M30 grade concrete.
5. Then replace partially ceramic tiles with coarse aggregate and find out the optimum strength.
6. We got the optimum strength at the mix of replacing 20% coarse aggregate by ceramic tiles.
7. Into this optimum strength we have to replace cement with coal dust and specimens are developed.
8. The strength is then compared with the strength of the conventional concrete specimens.

9. The result concluded that there is no change in strength of replaced concrete than that of the conventional mix proportion of M30 grade concrete.
10. But in the case of ceramic tile aggregate concrete the strength increased when compared to conventional concrete specimens.

REFERENCE

[1] Ayoola A.R, Uganna M. C, Adewale, “Partial replacement of coarse aggregate with broken ceramic tiles in concrete production (2018)”, International Journal of Research Publication and Reviews.

[2] A.Priyanka Kusum, Sayed Tabish Quadri, “Partial replacement of coarse aggregate by waste ceramic tiles in concrete,(2021)”, International Research Journal of Engineering and Technology (IRJET).

[3] A.P Manikandan, P. Nandakumar, M. Balachandran,D. gowri Sankar, G.V Jayakumari, “Partial replacement of coarse aggregate by waste ceramic tiles in concrete,(2023)”,International Journal of Progressive Research in Science and Engineering.

[4] A. Rohit Varma, M. Manoj Pravalli, “A Study on partial replacement of coarse aggregate by ceramic tile aggregate and fine aggregate by marble dust to improve concrete (2022)”

[5] Akshay B.Rahane, Vrushali S.Jagtap, Papiha R. Wade, Mohammad Ismail “To enhance the strength of concrete by partial replacement of coarse aggregate with tile waste(2021)”

[6] A. Rohit Varma, M. Manoj Pravalli, “A Study on partial replacement of coarse aggregate by ceramic tile aggregate and fine aggregate by marble dust to improve concrete (2022)”

[7] Aman kumar, “Partial Replacement of Cement with Fly Ash and Cow Dung Ash by using Quarry Dust as a Fine Aggregate (2018)”

[8] Shikha pal, Anurag Singh, “Experimental Study on Partial Replacement of Cement with Coal Ash (2021)”, International Journal of Engineering and Technology.

[9] S C Bostanci, “Coal ash use as a cement replacement in concrete production 2010”,IOP Conference Series.

[10] S.Prabhakaran, “Experimental investigation on partial replacement of cement by gypsum and fine aggregate by wood ash (2022)”

[11] https://www.google.com/url