Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 1, February : 2024

# PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH IN CONCRETE AND FINE AGGREGATE WITH CRUMB RUBBER

**NEERATI MOUNIKA,** PG Scholar, Dept. of Civil Engineering, Ellenki College of Engineering & Technology.
**M. SWATHI**, Assistant Professor, Department of Civil Engineering, Ellenki College of Engineering & Technology.
**B. SHARTH CHANDRA**, Assistant Professor, HOD in Department of Civil Engineering, Ellenki College of Engineering & Technology

## ABSTRACT

The focus area in the current period is solid waste management of used and waste materials. Plastic garbage, tire waste, and municipal solid waste are the most concerning of these numerous waste products. The resolution of this investigative project is to assist in the solution of tire waste solid waste management and to examine the alternative of FA to lower the rate of construction and lower environmental pollution. A possible hazard to the environment comes from the growth of nearly three crore tires thrown away annually. The greatest solution to this issue is to locate alternative aggregate for use in building. The proposed work includes an experimental investigation of the influence of crumb rubber usage as a dense waste material in concrete using changes in crumb rubber volume. According to Indian standards, several blends of crumb rubber with conventional fine aggregate were assessed based on their workability. The creation of concrete might result in less pollution entering the environment and less energy and natural resource use. Fly ash is presently produced in large quantities by thermal businesses, which has an impact on the environment and human health. In recent years, a number of researchers have demonstrated that the use of supplementary cementitious materials (SCMs) such as fly ash (FA), blast furnace slag, silica fume, metakaolin (MK), and rice husk ash (RHA), among others, not only advances the various properties of concrete—both in its fresh and hardened states—but also lowers construction costs. The feasibility of using waste from the thermal sector in place of part of the cement used in the making of concrete is investigated in this research. The project employs M30 grade concrete, which has a weight-to-cement ratio of 0.45. Fly ash may replace cement in amounts ranging from 0% to 15%, with increments of 5% based on the weight of the fine, coarse, and cement aggregates. The compressive strengths of all mixes are evaluated 7, 14, and 28 days after mixing.

**Keywords**: Crumb Rubber, Fly Ash, Cement Concrete.

## INTRODUCTION

Every year, tens of millions of tires are wasted worldwide. Tires have a lengthy lifespan and cannot biodegrade, making tire disposal a difficult process. Stockpiling, illegal disposal, and land filling have been the conventional methods of managing discarded tires, but they are all temporary fixes. Environmental issues resulting from growing and recycling in this example, using tires is an inventive concept or method. The method of recycling autos involves recycling tires. Due to wear or irreversible damage like punctures, tires that can no longer be used on automobiles. Tyre rubber is broken up or reduced in size during the cracker mill process by being passed between spinning corrugated steel drums. This technique results in the production of irregularly shaped, highly surface-area torn particles, which are known as crumb rubber.

Fly ash is less costly than fine aggregate and cement, thus we can make financial gains by substituting them with crumb rubber. We can reduce the pollution of the environment using these items. Rubber may be used in construction, as is well known, and it takes a very long time to break down.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 1, February : 2024

Contamination of the environment is therefore reduced. Fly ash, which comes from thermal plants, may be used in lieu of cement since it is less costly.

**1.1 Aim and Objective:**

The current study looks at the properties of concrete by partially replacing cement and fine aggregate with fly ash and crumb rubber. It also compares the performance of conventional concrete with fly ash and crumb rubber replaced concrete. To choose the components for mix design, preliminary testing is done on materials such as cement, fly ash, coarse aggregate, fine aggregate, and crumb rubber. The different materials used in the work are listed below, along with the test results for each. To conduct preliminary testing on the fly ash, fine aggregate, coarse aggregate, and crumb rubber. One grade of concrete mix, named M30, was produced using the IS approach of mix design as outlined in IS: 10262-2009. For M30 grade concrete, substitute fly ash for some of the cement and crumb rubber for fine aggregate at weights of 0%, 5%, 10%, and 15%. to evaluate the concrete's compressive strength after it has cured and had fly ash and crumb rubber added in lieu of cement and fine aggregate. To get the maximum strength, determine the appropriate fly ash and crumb rubber replacement ratio for grade M30 concrete. to evaluate the financial benefits of conventional concrete against concrete that has been mostly substituted with fly ash and crumb rubber.

## II. Materials Used:

1. Cement (OPC 53 Grade)
2. Fine aggregate (F.A)
3. Coarse aggregate (C.A)
4. Fly Ash (F.L.A)
5. Crumb Rubber (C.R)

**2.1 Cement:**

Ultratech OPC 53 grade cement was used. Cement produced from single source, properties of which are tested in the laboratory is shown in table 1.

**Table 1: Properties of cement**

| S.No | Cement properties | Results | Value as per [IS: 12269-1987] |
|---|---|---|---|
| 1 | Specific gravity | 3.3 | 3.1-3.5 |
| 2 | Normal consistency | 33% | 26%-33% |
| 3 | Fineness | 5% | not exceed 10% |
| 4 | Initial setting time | 30 mins | not less than30 minutes |
| 5 | Final setting time | 150 minutes | not exceed 600 minutes |

**2.2 Fine aggregate (F.A):**

Good quality zone-II fine aggregate were used, the sieve analysis results and properties of FA used are listed in table 2.

**Table 2: Results of sieve analysis and properties of fine aggregate**

| SL.NO | IS sieve size | Cumulative e% passing | Value as per IS 383-1970 | |
|---|---|---|---|---|
| 1 | 4.75mm | 99.200 | 90-100 | |
| 2 | 2.36mm | 91.800 | 75-100 | |
| 3 | 1.18mm | 76.800 | 55-90 | |
| 4 | 600µ | 35.300 | 35-59 | gs to ZONE-II |
| 5 | 300µ | 8.300 | 8-30 | |

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 1, February : 2024

| | | | | |
|---|---|---|---|---|
| 6 | 150µ | 2.400 | 0-10 | |
| 7 | Specific gravity= 2.64 | | | |
| 8 | Bulk density=1710 Kg/m$^3$ | | | |

**2.3 Coarse aggregate (C.A):**
In this experiment, local crusher-available aggregate was employed. Ballast coarse aggregate in two size fractions, 20 mm and 25 mm, was employed. For the CA used in ballast, a variety of tests were conducted in the lab, including bulk density and specific gravity. Table 3 provides the findings.

**Table 3: Results of sieve analysis and properties of coarse aggregate**

| SL.NO | Size of sieve's | Cumulative % passing finer for ballastaggregate | lue as per IS383-1970 |
|---|---|---|---|
| 1 | 40mm | 100 | 100 |
| 2 | 20mm | 82.50 | 85-100 |
| 3 | 12.5mm | 21.80 | 25-700 |
| 4 | 10mm | 7.25 | 0-20 |
| 5 | 4.75mm | 3.06 | 0-5 |
| | Specific gravity=2.84 | | |
| | Bulk density=1480 Kg/m$^3$ | | |

**2.4 Fly Ash (F.L.A):**
It is produced from burning younger lignite or sub-bituminous coal has certain self-cementing properties in addition to pozzolanic ones. Fly ash classified as Class C hardens and gains strength when exposed to water over time. Class C fly ash does not need an activator. Class C fly ashes often include greater concentrations of sulfate (SO4) and alkali. Previously, fly ash from burning coal would only get caught in flue gasses and be discharged into the atmosphere. As a consequence, measures were implemented that cut fly ash emissions to less than 1% of total ash output and generated issues about the environment and public health. Throughout the globe, ash ponds and landfills receive more than 65% of the fly ash produced by coal-fired power stations. Good quality fly ash is used. Class F type fly ash is used.

**Figure 1: Fly Ash**

**2.5 Crumb Rubber (C.R):**
The rubber industry supplied the crumb rubber. The cutting machine is used to break apart the rubber from the tire. It is formed in various sizes. This experiment makes use of crumb rubber that is 30 grade sizes. In table 4, the characteristics of crumb rubber are listed.

**Figure 2: Crumb Rubber**

**Table 4: Properties of crumb rubber**

| Parameters | Unit | Standard Specs |
|---|---|---|
| Acetone Extraction | % | 5-10 |
| Ash content | % | 4 max |
| Bulk Density | gm/cc | 0.30-0.45 |
| Sieve analysis passing through 4mm sieve | % | 99 |
| Sieve analysis passing through 2mm sieve | % | 1 |

**2.6 Water:**
In the current experiment, specimens were cast and cured using portable water.

**Table 5: Chemical composition of cement and Fly Ash**

| Constituents | Cement in % | Fly Ash in % |
|---|---|---|
| Silica | 21.25 | 59.94 |
| Aluminum oxide | 4.33 | 22.87 |
| Iron oxide | 1.87 | 4.67 |
| Titanium dioxide | 0.13 | 0.94 |
| Calcium oxide | 64.30 | 3.08 |
| Magnesium oxide | 1.81 | 1.55 |
| Sulfur trioxide | 3.70 | 0.35 |
| Potassium oxide | 0.71 | 2.19 |
| Sodium oxide | 0.17 | 0.62 |
| l.o.i | 1.50 | 3.34 |

## III. DESIGN OF CONCRETE MIX

**3.1 Concrete Mix Design by IS Method:** The Indian standardizing body IS 10262-2009 has documentation on the mix design approach. This approach may be used to both medium and high strength materials. The IS method of mix design was used to generate the M30 grade of concrete mix.

**3.1.1 Concrete mix proportions**

Cement = 450kg/$m^3$
Water = 197.16 liters
Fine aggregates = 758.26kg/$m^3$
Coarse aggregate = 1000.38kg/$m^3$
Water – cement ratio = 0.45

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 1, February : 2024

**Table 6: Proportions of ingredients for M30 grade**

| Water | Cement | F.A | C.A |
|---|---|---|---|
| 197.16 | 450 | 758.26 | 1000.38 |
| 0.45 | 1 | 1.68 | 2.22 |

### 3.2 Calculation of quantity of materials required:

Table 7 below lists the computed amounts of minerals for M30 grade concrete by fly ash and crumb rubber substitution at 0%, 5%, 10%, and 15% by weight of cement.

**Table 7: Quantity of materials mandatory for M30 grade of concrete for fly ash andcrumb rubber replacement**

| radeof concrete | specimen | % age of replacement | Cementin Kg | Fly ash in Kg | F.A in Kg | Crumb rubber in Kg | C.A in Kg | water |
|---|---|---|---|---|---|---|---|---|
| M30 | 4 cubes | 0% | 6.08 | 0 | 10.2 | 0 | 13.504 | 2.64 |
| | 4 cubes | 5% | 5.168 | 1.152 | 9.68 | 0.51 | 13.504 | 2.64 |
| | 4 cubes | 10% | 5.168 | 1.152 | 9.18 | 1.02 | 13.504 | 2.64 |
| | 4 cubes | 15% | 5.168 | 1.152 | 8.67 | 1.53 | 13.504 | 2.64 |

### 3.3 Casting and Curing:

150 mm x 150 mm x 150 mm standard-sized molds were used to cast the cubes. The inside surface of the molds is treated with cutting oil. Three layers, each about one-third the height of the molds, are used to fill the molds. Using a tampering rod, give the mold's entry cross section 25 steady blows to crush each layer. After the molds are filled and crushed, their top surface is leveled, and they are then left for a whole day. After the molds are removed, the cubes are then stored in water.

**Figure 3: Casted Cubes**

### 3.4 Curing

Clean, impure-free water is required for the first curing process of the specimens. There's an addition of water each week. After the curing period is up, all of the specimens are taken out and left in storage for a day to dry. The test should be carried out after the specimen's surface has been cleaned.

## IV. RESULTS & DISCUSSIONS

**Compression test**: After seven, fourteen, and twenty-eight days of curing, the cube specimens are removed from the curing tank and placed in a laboratory setting until the surface dries. Cube specimens were subjected to a compressive strength evaluation utilizing compression testing equipment, as per IS 9013 (1978). The specimens were positioned under the compression testing apparatus in a direction perpendicular to the direction in which they were cast. A loading rate of 140 kg/sq cm/min is maintained.

Industrial Engineering Journal
ISSN: 0970-2555
Volume : 53, Issue 2, No. 1, February : 2024

**Figure 4: Compressive strength Testing Machine**

Cube compression strength (FC) = (Ultimate load)/(C/S area of specimen)

**Table 8: Test results of compressive strength**

| sh dosagein % | :rumb rubber dosage in % | M30 grade | | |
|---|---|---|---|---|
| | | ıys strengthin MPa | 14 days strength in MPa | 28 days strength in MPa |
| 0% | 0% | 21 | 26 | 30.9 |
| 5% | 5% | 13.6 | 16.8 | 24.1 |
| 10% | 10% | 8.7 | 12.6 | 16.2 |
| 15% | 15% | 6.3 | 7.7 | 10.0 |

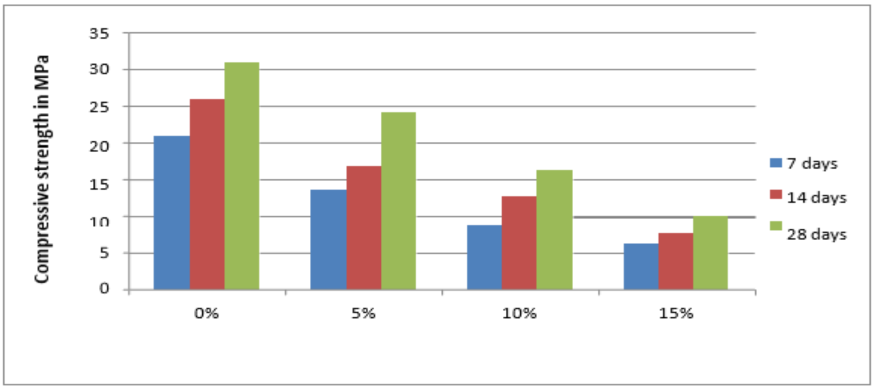


**Figure 5: Compressive strength of M30 grade concrete**

**Discussions:**

- It is found that there was 35.24% decrement in compressive strength for M30 gradeconcrete at 7 days of curing for 5% of replacement.
- It is found that there was 35.38% decrement in compressive strength for M30 grade concrete at 14 days of curing for 5% of replacement.
- It is found that there was 22.0% decrement in compressive strength for M30 gradeconcrete at 28 days of curing for 5% of replacement.
- It is found that there was 58.57% decrement in compressive strength for M30 gradeconcrete at 7 days of curing for 10% of replacement.
- It is found that there was 51.57% decrement in compressive strength for M30 gradeconcrete at

14 days of curing for 10% of replacement.

- It is found that there was 60.19% decrement in compressive strength for M30 gradeconcrete at 28 days of curing for 10% of replacement.
- It is found that there was 70.0% decrement in compressive strength for M30 gradeconcrete at 7 days of curing for 15% of replacement.
- It is found that there was 70.38% decrement in compressive strength for M30 gradeconcrete at 14 days of curing for 15% of replacement.
- It is found that there was 67.64% decrement in compressive strength for M30 gradeconcrete at 28 days of curing for 15% of replacement.

**Replacement concrete of 5% replacement may be an alternative to the concrete which isused in secondary structural components construction.**

- There won't be any corrosion in steel if this concrete is utilized in RCC.
- As the amount of crumb rubber in concrete increased owing to an increase in water demand, its workability reduced.
- The mechanical qualities of concrete significantly decreased when crumb rubber was added, but the durability rose. When crumb rubber is utilized to replace the mixture, the impact is greater than when fine aggregate is used in its stead.
- By pre-treating crumb rubber with modifiers, the detrimental impact of crumb rubber on mechanical strength might be reduced and even eliminated.
- Rubberized concrete loses density as its rubber component rises.
- Fly ash, when used in very tiny amounts to replace cement, reduces density.
- Crap rubber treated concrete had a substantially higher degree of toughness than control mix.
- Rubberized concrete is able to absorb more energy when loaded because of the elastic nature of rubber.
- Although the rubberized concrete mix has poor compressive strength and bond strength, its low density reduces the structure's dead load and self-weight.
- Fly ash addition is substantially more cost-effective than cement replacement.
- Using fly ash in concrete may reduce disposal costs for the coal and thermal industries and provide greener concrete for building.
- The cost study shows that reducing the cement by a certain amount lower building cost, but also reduces strength.
- Fly ash may be a creative supplemental cementitious building material, according to this study, but engineers must make wise choices.

## V. CONCLUSION

- The ideal amount is 5% for substituting cement with fly ash and fine aggregate with crumb rubber.
- As cement was increasingly replaced by fly ash and fine aggregate by crumb rubber, the workability of concrete decreased.
- The maximal compressive strength at 5% of dose is 24.1MPa for 28 days of testing after curing.
- The fabrication of secondary structural components uses the dose of 5% that produced the greatest strength.

## REFERENCES

[1] Parmar, Abhijitsinh & Joshi, Chahil & Parmar, Aditi & Patel, Urvish & Vaghasiya, Avadh. (2015). Use of Crumb Rubber as a Partial Replacement of Fine Aggregate in Conventional Concrete.

[2] A. Tamilarasan, & Muthu, A. Anbujothi & Kumar, C. Arun & J. Dhakshnamoorthy, & B. Vignesh, (2017). Experimental Study on Concrete by Partial Replacement of Fine Aggregate with Crumb Rubber. International Journal of Advanced Research Trends in Engineering and Technology

(IJARTET). 4. 140-145.
[3] Abhijitsinh Parmar, Chahil Joshi. Use of Crumb Rubber as a Partial Replacement of Fine Aggregate in Conventional Concrete. Accessed 19 Jan. 2024.
[4] Safiuddin, Md & Raman, Sudharshan N. & Zain, M. (2007). Utilization of Quarry Waste Fine Aggregate in Concrete Mixtures. Journal of Applied Sciences Research. 3. 202-208.
[5] Dhalape, Parshuram, et al. An Experimental Study on Cement Concrete with Industrial Fly Ash and Phosphogypsum. Materials Today: Proceedings, Elsevier BV, 2023, pp. 717–23.
[6] Pitroda, Dr. Jayeshkumar & Zala, Laxmansinh & Umrigar, F. (2012). Experimental Investigations on Partial Replacement of Cement with Fly Ash in Design Mix Concrete. International Journal of Advanced Engineering Technology E-ISSN 0976-3945. III. 126-129.
[7] Sathawane, Satish & Vairagade, Vikrant & Kene, Kavita. (2013). Combine Effect of Rice Husk Ash and Fly Ash on Concrete by 30% Cement Replacement. Procedia Engineering. 51. 35–44. 10.1016/j.proeng.2013.01.009.
[8] Amit mittal, M B Kaisare, Rajendra Kumar Shetti. (2017). Experimental study on use of fly ash in concrete. International journal of scientific Research. Volume 6, Issue 1.
[9] Harison, Alvin & Srivastava, Vikas & Herbert, Arpan. (2014). Effect of Fly Ash on Compressive Strength of Portland Pozzolona Cement Concrete. Journal of Academia and Industrial Research (JAIR). 2. 476-479.
[10] IS 12269-1987: Specification for 53 grade ordinary Portland cement.
[11] IS 383-1970: Specifications for coarse and fine aggregate from natural sources.
[12] IS 10262-2009: Concrete mix design for M30 grade.
[13] IS 3812-2-2033: Specifications for Fly Ash