Study on Partial Replacement of Cement by Activated Clay, Fly ash and Nylon Fiber

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Abstract. This paper deals with the effect of cement replacement by activated clay. The increased use of concrete creates an impact on the environment because of the emission of greenhouse gases. Also, the high usage of cement in concrete increase the carbon foot print level, leading to global warming. Concrete being the second largest utilized material after water and researches are aiming to reduce its consumption. This paper focuses on the reduction of the cement usage by replacing it with activated clay. Clay being abundantly available is used as an alternate to cement since it possesses pozzolanic nature. To enhance the properties of clay it was chemically activated before being used in the mix. On the other hand, the efficiency of Fiber Reinforced Concrete-FRC is far superior to the plain concrete. To improve the mechanical properties of concrete Nylons fibers are used in the mix. Nylon fibers has high strength to weight ratio and good abrasion resistance. This paper studies the effective replacement of cement with activated clay by 50% and the same was partially replaced with 2.5% and 5% of fly ash and nylon fiber. The mechanical properties such as compressive strength, split tensile strength and flexural strength were tested after 28 days of curing. The test results indicate that there is a significant increase in the compressive and flexural strength whereas a decline was observed in tensile strength.

1. Introduction

India being a developing nation its infrastructure sector growth is rapid and it contributes to the economic development. Infrastructure growth is assessed by the cement industry and its growth. But the manufacture of cement requires huge energy and the installation of cement manufacturing plant requires high cost. At the same time the increased usage of cement leads to the production of greenhouse gases. Further the availability of raw materials is also a major concern thereby increasing the demand of alternative material. To cope up with this, researchers Freeda et al [1], Devi et al [2], Jayesh Kumar et al [3] replaced cement by Fly ash and they find that the replacement significantly increases the compression strength by 5-10%. In this test, we used activated clay as the major replacement for cement. Freeda et al [1] used the fly ash as replacement up to 30% and he concluded that the compression strength increases in the ratio of 1:6. Devi et al[2] used fly ash 30% and glass powder 15% as the replacement of cement and fine aggregate respectively and found that the strength increased by nearly 7%. According to the test conducted by Jayesh et al [3] the increase in content of fly ash decreases the...
strength. Many researchers concluded that the optimum replacement of cement by Fly ash is 15%. In this work we replaced 50% of cement by including activated clay, fly ash and Nylon fiber.

2. Materials

2.1. Fine Aggregate
Natural sand obtained from local river source is used as fine aggregate. Before mixing, the sand was air dried and free from foreign material. The grading of fine aggregate conforms to Zone III of IS 383 – 1970 [4]. The physical properties are tabulated in Table 1 which conforms to IS: 2386-1&3 [5].

| Physical Properties of Fine Aggregates |
|---------------------------------------|
| Physical Properties | Test Result |
| Size | 4.75 mm |
| Specific Gravity | 2.35 |
| Water absorption | 0.80% |

2.2. Coarse Aggregate
Gravel of size 20 mm was used as coarse aggregate. The physical properties of coarse aggregate are tabulated in Table 2 which conforms to IS: 2386-3&4 [5].

| Physical Properties of Coarse Aggregates |
|-----------------------------------------|
| Physical Properties | Test Result |
| Size | 20 mm |
| Specific Gravity | 2.70 |
| Water Absorption | 0.12% |
| Aggregate Impact value | 11.01% |

2.3. Cement
Cement 53 Grade OPC conforming to IS 12269 – 1987 [6] was used. The physical properties are tabulated in Table 3.

| Physical Properties of Cement |
|------------------------------|
| Properties | Specific Gravity | Fineness |
| Value | 3.06 | 325m²/kg |

2.4. Fly ash
To utilize Fly ash as a Pozzolana in Cement concrete and Cement Mortar, Bureau of Indian Standard (BIS) has formulated IS: 3812 Part - 1 2003[7]. As per the specification fly ash was added and its physical properties are listed in Table 4.

| Physical properties of Fly ash |
|-------------------------------|
| Physical properties | Test result |
| Specific Gravity | 2.07 |
| Fineness | 290 m²/Kg |
2.5. Activation of Clay
Activated clay is formed when it is wet and dry for making blocks. The Clay was taken from the nearby lake. A sufficient amount was taken and was sieved through 600 microns sieve. To activate 50g of clay 25ml of refined water is blended and warmed through oven at 60 degree Celsius for 5 minutes. At that point it was blended with 0.25 molarity of NaOH arrangement which is likewise warmed for 5 minutes at 90 degree Celsius.

2.6. Nylon Fiber
Nylon fibers are tough, possess high tensile strength, as well as has elasticity and luster. The compressive strength, split tensile strength, flexural strength of the concrete gets increased on addition of 1% nylon fiber as shown in Figure 1

![Image of Nylon Fiber](image)

Figure 1. Nylon fiber

3. Experimental Work
The concrete was designed for the characteristic strength of 20 Mpa. The mixes were prepared by replacing 50% of activated clay in cement as shown in Figure 2. In 50% of activated clay partial replacement of fly ash and nylon fiber is added in the proportion of 2.5% and 5%. The mix proportions prepared are shown in Table 5.

| Mix | Mix Proportion |
|-----|----------------|
| % Cement replacement | Cement (gm) | FA (gm) | CA (gm) | Water (ml) | A. clay (gm) | Flash+ Nylon (gm) |
| 0 | 511 | 767 | 1533 | 128 | 0 | 0 |
| 50(47.5%- A. clay, 2.5% Fly ash+ Nylon) | 256 | 767 | 1533 | 128 | 243 | 13 |
| 50(45%- A. clay, 5% Fly ash + Nylon) | 256 | 767 | 1533 | 128 | 230 | 26 |

Table 5. Mix Design of Concrete
4. Preparation and Testing of Specimen
Totally 9 specimens were prepared for concrete mix which included conventional mix and replacement of 2.5% and 5%. Concrete cubes of size 150 x 150 x 150 mm, cylinder of size 150 x 300 mm and prism of size 100 x 100 x 500 mm were casted and cured in water. After 7 days and 28 days of curing, the cubes were taken out, air dried and tested for 7 days and 28 days of compressive strength respectively. For tensile and flexural specimens testing were done at 7 days. The compressive strength test set up is as shown in Figure 3

5. Results and Discussion

5.1. Compressive Strength
From Figure 4 it is observed that the compressive strength of concrete is increased by 5.7% by replacing 50% cement by (47.5% A. clay, 2.5% Fly ash + Nylon), 9.2% in the replacement of 50% (47.5% A. clay, 2.5% Fly ash + Nylon) after 7 days of curing and increased by 15%, in the 50% replacement of (45% A. clay, 5% Fly ash + Nylon) 21% in the 50% replacement (45% A. clay, 5% Fly ash + Nylon) after 28 days of curing.
5.2. Tensile Strength
The tensile strength of concrete with 0% replacement is 3.3N/mm\(^2\). But when the cement is replaced by 50% (47.5% A. clay, 2.5% Fly ash+ Nylon) the tensile strength gets decreased by 11% and changes to 3.02N/mm\(^2\). While replacing 50% of cement by (45% A. clay, 5% Fly ash + Nylon) the tensile strength gets decreased by 18% compared to conventional mortar after 7 days of curing as shown in Figure 5.

5.3. Flexural Strength
The flexural strength of conventional concrete is 3.54N/mm\(^2\). The flexural gets tremendously increased to 6.87 N/mm\(^2\) by replacing 50% of cement with (47.5% A. clay, 2.5% Fly ash+ Nylon). But when the 50% cement is replaced with (45% A. clay, 5% Fly ash+ Nylon) after 7 days of curing, the flexural strength gets slightly decreased and it becomes 6.1N/mm\(^2\) as shown in Figure 6.
Figure 6. Flexural Strength After 7 Days of Curing

6. Conclusion
The Compressive strength of the concrete significantly increased by nearly 21% after 28 days of curing by replacing 50% of cement with (45% A. Clay, 5% Fly ash and Nylon fiber). When comparing two mixtures, we saw that the higher amount of Fly ash and Nylon fiber makes the concrete much stronger than conventional mortar and another mixture (5% Fly ash and Nylon fiber). The tensile strength of the concrete significantly decreased with higher percentage of Fly Ash (5% Fly ash and nylon fiber) compared to conventional mortar. The flexural strength of the concrete gets higher when the cement is replaced by 47.5% A. Clay and 2.5% Fly ash and nylon fiber but when it is replaced by 45% A. Clay and 5% Nylon fiber and Fly Ash, the Flexural strength is slightly decreased. Thus, the first replacement proportion is having better flexural strength than the latter one.

7. References
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