**AN EXPERIMENTAL INVESTIGATION ON EFFECT OF PARTIAL REPLACEMENT OF OF CEMENT WITH RED MUD, FLY ASH AND POLYPROPYLENE FIBER**

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**Abastract:** The main objective of this experimental investigation is to find out the effect of replacement of cement by red mud in M25 grade of concrete. The different percentage replacement of cement by redmud adopted in the experimentation are (5%, 10%, 15% and 20%) and Fly ash (Class F) is added as supplementary cementitious material (20%) And also addition of optimum percentage of polypropylene fiber by volume fraction in different percentage are (0.5%, 1%, 1.5% and 2%).To study the workability characteristics of Polypropylene fiber reinforced concrete (PPFRC) and redmud PPFRC,To check the compressive, split tensile and Flexural strength, of M25 grade concrete by replacing cement by redmud (5%, 10%, 15% and 20%) and flay ash (20%), and optimum percentage of polypropylene fiber is added to concrete mix.

***Keywords:*** *Cement,redmud,flyash,Polypropylene fiber reinforced concrete.*

**INTRODUCTION**

**1.1 GENERAL**

Kolli.Ramujee (2013),In this study, the results of the Strength properties of Polypropylene fiber reinforced concrete have been presented. The compressive strength, splitting tensile strength of concrete samples made with different fibers amounts varies from 0%,0.5%,1% 1.5% and 2.0% were studied. The samples with added Polypropylene fibers of 1.5 % showed better results in comparison with the others. Shwetha et al. (2015) Use of fly ash as partial replacement of cement along with glass fibres as additional reinforcement, satisfies the various structural properties of concrete.Vinit et. al.(2015),This study investigates the experimental result carried out to determine workability and compressive strength of concrete at different replacement of PPC. M-25 grade of concrete (1:1.53:3) at w/c of 0.42 was designed as per IS-10262-2009.Mahadeva et.al (2017) The present investigation has therefore been carried out with agricultural waste materials like Rice Husk Ash (RHA) which was mixed with soil to study improvement of weak sub grade in terms of compaction and strength characteristics. Silica produced from rice husk ashes have investigated successfully as a pozolanic material in soil stabilization.Due to various construction development projects undertaken all over the world there is a substantial increase in the production of waste materials rice husk. Which create disposal problems. Rice husk waste is produced inlarge quantity in rice husk mills and is disposed in open land. Therefore use of rice husk in foundation of buildings and in road constructions to improve bearing capacity of soil and to reduce the area of open land needed for its disposal and to preserve environment through resource conservation.Concrete is a second highest using material on earth. It is a combination of cement, fine aggregate, coarse aggregate, and water. Every year approximately 4000 million metric tonnes of cement produced throughout the world. Out of that India is producing more than 270 million metric tons, and it is the second highest contributor form worldwide. Carbon dioxide is a major atmospheric pollutant emission from cement production industries, because one ton of clinker produces one tonne CO2 emission into the atmosphere. To control the pollution due to cement production, some of the industrial by-products like Redmud, Fly ash, GGBS, others are used as secondary cementitious materials Conventionally concrete is mixture of cement, aggregates and water. Properties of aggregate affect the durability and performance of concrete. Leaving the industrial by product to the environment directly can cause environmental problem. Hence the re-use of waste material has been emphasized. Some of the waste products are redmud, GGBS, Fly Ash, steel fibers, polypropylene fibers etc. Each waste material has its own specific effect on fresh and hard concrete properties. The waste materials used in concrete is economical and also solves some of the disposal problems. The soft soil is identified to be clay of high plasticity (CH) according to IS Soil Classification System. It has very low CBR-value (1.46) and unconfined compressive stress (70 KN/m2). The soil is required to be stabilized before doing any construction work.Treatment with RHA shows a general decrease in the MDD and increase in OMC with increase in the RHA content.There is also an improvement in the unsoaked CBR (106% at 10% RHA content) compared with the CBR of the natural soil.A similar trend is obtained for UCS. The UCS value is at its peak at 10% RHA (90.6% improved).For maximum improvement in strength, soil stabilization using 10% RHA content with 6% cement is recommended as optimum amount for practical purposes. Sabarish et al. (2017) A study indicated the feasibility that the the cement can be replaced by fly ash accordingly in the range of 0 to 40% by weight of cement for M25 and M40 grade of concrete[10].Murumi and Gupta (2019) A study presented viable limits of fly ash utilization in concrete in which it was found that potential utilization of higher fly ash percentage increases with decreasing strength level of concrete and viability of utilization of higher fly ash percentage decreases with decrease in water-reducing potential of chemical admixture[11]. Mahadeva et.al (2020) The results obtained show us an increase in flexural strength in beam specimens retro-fitted with TRM. And coir textile wrapped specimens gave comparable results in comparison to glass textile wrapped counterpart. Chemical treatment of coir fibres also proved to be effective with increased strength over untreated coir fibres. The use of natural fibres is hence proved to be feasible at a fraction of the cost of the synthetic fibre textiles used. Rajiv et.al. (2020), In this study is to determine the Mechanical properties of Self-Compacting Concrete by partially replacing GGBFS as cementatious material and Natural River Sand with Copper slag in different percentages (0%, 10%, 20%, 30%, 40%, and 50%) for M40 grade concrete. The examinations are done by embracing water powder proportion of 0.4, functionality tests, for example, droop stream, V-pipe, L-box tests are directed according to EFNARC rules at crisp state. Mechanical properties, for example, Compressive quality, split elasticity, flexural quality, Young's modulus tests was directed. It is indicated that ideal substitution level characteristic waterway sand by copper slag was seen as 40%. Rudraswamy et al. (2020)Tthe effect on shrinkage of concrete with five different fibre materials for reinforcing plain concrete was investigated. Shrinkage values are indicated in terms of total length of crack and the total area of the crack. The study indicated that, irrespective of the material of fibre used for reinforcing concrete, hybridized concrete consistently shows better results relative to single aspect ratio fibre reinforcement [12]. Redmud accelerates the heat of hydration of concrete and redmud leads to strength enhancement in early ages. Increases in the quantity of red mud in concrete reduces the workability and also increases the strength of concrete. The chemical composition of red mud and its particle size improves the durability property of concrete. It offers more capable to arrest the chloride ions and other ions diffusion into the concrete. Redmud minimizes the micro cracks, voids present in concrete by its particles size and bonding nature with other materials up to certain percentage of redmud used in concrete.

Redmud is highly alkaline solid waste material produced from the alumina refinery industries. Every year more than 300 million tonnes of redmud is produces throughout world. Disposal of large quantity of red mud is very expensive and it creates contamination of neighbour lands, water bodies. Using red mud as a cementitious material in concrete is highly appreciable, because concrete is a second largest using material after water. It reduce the negative effect on environment due to redmud disposal and cement industries.

**1.2 REDMUD**

Red mud is hazardous waste generated in the bayer process alumina production (Al2O3) from bauxite ore which contains high levels of residual alkalinity and toxic heavy metal. Therefore, red mud is a hazardous waste of alumina industry. The volume of redmud which is generated in alumina processing plant depends on quality of the Bauxite ore. The alumina processing plant usually disposes the liquid redmud into the reservoirs, which causes the risk of major environmental pollution. A pozzolan is defined as the siliceous and aluminous material that in itself possesses little or no cementitious value, but that will, if in the finely divided form in the presence of moisture, chemically react with the calcium hydroxide at ordinary temperatures to form the compounds having cementitious properties.

Chemical composition of cement and red mud nearly equal hence we can replace of cement by red mud in improved hardened concrete properties.

**Table 1.1: Chemical composition of cement and redmud**

|  |  |  |
| --- | --- | --- |
| **Chemical composition** | **Cement** | **Red mud** |
| Cao | 63.6 | 35.3 |
| SiO2 | 19.49 | 18 |
| Al2O3 | 4.54 | 6.31 |
| Fe2O3 | 3.38 | 12.38 |
| Na2O | 0.13 | 2.71 |
| Mgo | 2.36 | 1.13 |
| K2O | 0.58 | 0.45 |

**1.3 USE OF FLY ASH IN CONCRETE**

Flyash is an by-product of the combustion of coal in electric power generation plants. When the coal is ignited in the combustion chamber, the carbon and other volatile materials are burned off. However, some of the mineral impurities of shale, clay, feldspars, etc., are fused in the suspension and carried out of the combustion chamber in the form of exhaust gases. As the exhaust gases cools the fused materials solidify into the spherical glassy particles called as flyash. Due to the fusion-in suspension of these flyash particles are mostly the minute solid spheres and hollow ecospheres. The sizes of the flyash particles varies but tends to be similar to slightly larger than the type I Portland cement.

The flyash is collected from the exhaust gases by electrostatic precipitators or bag filters.

Flyash is used widely as the construction material, this waste material used as landfill or for soil stabilization. It is an non combustion mineral portion of coal, generated in a coal combustion in power plant. Since the 1950s, flyash was slowly introduced to civil engineers as a valuable ingredient that can be used in concrete mix. It can improve many desirable properties of concrete in fresh and hardened stages. Today It is used in the concrete for several reasons such as improving the workability of fresh concrete, sulphate resistance, reducing of initial hydration temperature, and strength of hardened concrete.

**1.4 POLYPROPYLENE FIBRE REINFORCED CONCRETE**

Concrete is an brittle material having low tensile strength and low strain capacity that result in low resistance to cracks. In order to improve such properties, fiber reinforced concrete (FRC) has been developed. Fibers are used to improve tensile strength, impact strength and flexural strength, toughness, to change failure mode by improving post-cracking ductility and to avoid cracking. Tensile strength of composite related more to the stress at which matrix develops macro-crack, will not differ much for the most conventional fiber reinforced cementations materials. Many fiber materials in various sizes and shapes have been produced for use in FRC. Among these fibers the polypropylene fibers is one of the most successful commercial applications. The common forms of polypropylene fibers are smooth-monofilament and having triangular shape. These have some unique properties that makes them suitable for reinforcement in concrete mix. The fibers have low density, chemically inert and non-corrosive.

**1.4.1 APPLICATIONS OF POLYPROPYLENE FIBRE REINFORCED CONCRETE**

In the past several years an increasing number of constructions have been taken place with concrete containing polypropylene fibers such as foundation piles, prestressed piles, piers, highways, industrial floors, bridge decks, flotation units for walkways. It is also used for controlling shrinkage & temperature cracking. The main use of PPFRC applications includes buildings (slabs, beams, water storage tanks, pool construction, basements, cement tiles and plastering, foundations, drainage etc..), bridges, industrial floorings, hydraulic structures, highway pavements blast resistance, sewage and waste management and other applications include plaster to reduce plastic shrinkage cracking, increase abrasion resistance, increase freeze and thaw durability, control plastic settlement cracking etc.

**2. MATERIAL**

**2.1 CEMENT**

In this experimental work. Ordinary Portland Cement (OPC) 53 grade conforming to IS: 8112-1989 was used. The cement used was Birla cement from the local distributors.

**Table 2.1:** Properties of cement

|  |  |  |
| --- | --- | --- |
| **Properties of Cement** | **Test Results** | **Standard Values** |
| Specific gravity | 3.15 | 2.9-3.16 |
| Fineness | 10% | - |
| Normal consistency | 32 % | 24%-32% |
| Initial setting time | 35 min | Not less than 30 min |

**2.2 REDMUD**

Red is an industrial waste produced by aluminium industries and Redmud is collected from “Hindalco Industries Limited, Belgaum, Karnataka”.

**Table 2.2:** Properties of redmud

|  |  |  |
| --- | --- | --- |
| **SL. No.** | **Properties** | **Test Result** |
| 1 | Specific Gravity | 2.98 |
| 2 | Fineness | 2600 sq.cm/gm |
| 3 | PH | 11.8 |

**2.3 FLY ASH**

It is a by-product of thermal power station which is obtained during the combustion of coal in thermal power plant. The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolanic in nature, and contains less than 20% lime (CaO).

**Table 2.3:** Properties of fly ash

|  |  |
| --- | --- |
| **Properties of Fly Ash** | **Test Results** |
| Specific gravity | 2.52 |
| Fineness | 30% |
| Normal consistency | 24% |
| Initial setting time | 30 min |

**2.4 FINE AGGREGATE**

Locally available M sand belonging to zone II of IS 383-1970 was used for the project work.

**Table 3.4:** Properties of fine aggregates

|  |  |  |
| --- | --- | --- |
| **Properties** | **Test Results** | **Standard Values** |
| Specific gravity | 2.65 | 2.4-2.9 |
| Water absorption | 1% | **-** |
| Sieve analysis | Zone II | **-** |

**2.5 COARSE AGGREGATE**

Locally available Crushed aggregates (size<20mm) confirming to IS 383-1970 are used in this dissertation.

**Table 3.5:** Properties of coarse aggregates

|  |  |  |
| --- | --- | --- |
| **Properties** | **Test Results** | **Standard Values** |
| Specific gravity | 2.63 | 2.6-2.8 |
| Water absorption | 0.4 % | 0.1% - 2.0% |
| Impact test | 18.64 % | Not more than 30% |

**2.6 POLYPROPYLENE FIBER**

Polypropylene fiber, also known as polypropylene or PP, is a synthetic fiber, transformed from 85% propylene, and used in a variety of applications. It is used in many different industries, but one of the most popular is the manufacturing of carpet yarns. For example, most of the economical carpets for light domestic use are made from this fiber. The fiber is thermoplastic, resilient, light weight and resistant to mildew and many different chemicals.

**Table 4.6:** Properties of popypropylene fibers

|  |  |
| --- | --- |
| **Properties** | **Test Results** |
| Density (Kg/m3) | 900 |
| Length (mm) | 12 |
| Diameter (Micron) | 34 |
| Tensile Strength (MPa) | 1750 |
| Specific Gravity (Kg/m3) | 2.68 |

**2.7 Concrete mix proportion:**

Cement = 329 Kg/ m3

Water = 148 Lt/ m3

Fine aggregate = 845 Kg/ m3

Coarse aggregate = 1106.4 Kg/m3

Chemical admixture = 6.58 Kg/m3

w/c ratio = 0.45

**Mix Ratio = 1: 2.57: 3.36**

**3. Results and discussions**

**3.1 SLUMP TEST RESULTS**

**3.1.1 SLUMP TEST FOR POLYPROPYLENE FIBER REINFORCED CONCRETE (PPFRC)**

Slump test was conducted for polypropylene fiber reinforced concrete (PPFRC). The concrete mix is prepared by adding polypropylene fibers at different percentages from 0.5% to 2.0% in 0.5% intervals. Slump test results of PPFRC are tabulated in table 4.1.

**Table 3.1: Slump test results for PPFRC**

|  |  |  |
| --- | --- | --- |
| **Sl No** | **% OF PPF** | **Slump in (MM)** |
| 1 | 0 | 94.5 |
| 2 | 0.5 | 91.2 |
| 3 | 1 | 88.4 |
| 4 | 1.5 | 84.1 |
| 5 | 2.0 | 80.8 |

**Fig 3.1: Slump test results for PPFRC**

**3.2.2 SLUMP TEST RESULTS FOR REDMUD PPFRC**

Slump test was conducted for redmud polypropylene fiber reinforced concrete. The concrete mix is prepared by replacing cement with redmud at different percentages from 5% to 20% in 5% intervals and flyash is also replaced for cement in 20%. Optimum percentage of polypropylene fiber 1.5% is also added. Slump test results of PPFRC are tabulated in table 4.2.

**Table 3.2: Slump test results for redmud PPFRC**

|  |  |  |
| --- | --- | --- |
| **Sl No** | **Mix Designation** | **Slump in mm** |
| 1 | RM 0 | 94.5 |
| 2 | RM 5 | 89.2 |
| 3 | RM 10 | 85.4 |
| 4 | RM 15 | 83.1 |
| 5 | RM 20 | 79.8 |

**Fig 3.2: Slump test results for redmud PPFRC**

**3.3 COMPRESSIVE STRENGTH TEST RESULTS**

**3.3.1 COMPRESSIVE STRENGTH TEST FOR PPFRC**

Compressive strength test was conducted for polypropylene fiber reinforced concrete (PPFRC). The concrete mix is prepared by adding polypropylene fibers at different percentages from 0.5% to 2.0% in 0.5% intervals. The compressive strength tests are conducted on 7, 14 and 28 days of curing and results are compared with conventional concrete. Compressive strength of PPFRC are tabulated in table 4.3.

**Table 3.3: Compressive strength for PPFRC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl No | % of PPF | Compressive strength in Mpa | | |
| 7 days | 14 days | 28 days |
| 1 | 0 | 20.86 | 25.25 | 31.95 |
| 2 | 0.5 | 21.32 | 27.58 | 33.82 |
| 3 | 1 | 23.35 | 28.8 | 34.25 |
| 4 | 1.5 | 25.15 | 30.12 | 36.28 |
| 5 | 2 | 23.89 | 29.02 | 34.22 |

**Fig 3.3: Compressive strength of PPFRC**

**3.3.2 COMPRESSIVE STRENGTH TEST FOR REDMUD PPFRC**

Compressive strength test conducted for redmud polypropylene fiber reinforced concrete. The concrete mix is prepared by replacing cement with redmud at different percentages from 5% to 20% in 5% intervals and flyash is also replaced for cement in 20%. Optimum percentage of polypropylene fiber 1.5% from table 7.3 is also added. The compressive strength test are conducted on 7, 14 and 28 days of curing and compared with conventional concrete. The results are tabulated in table 4.4.

**Table 3.4: Compressive strength for redmud PPFRC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl No | % of Fly Ash + % of PPF + % of RM | 7 days | 14 days | 28 days |
|  |
| 1 | 0% | 20.86 | 25.25 | 31.95 |  |
| 2 | 20%+1.5%+5% | 22.25 | 28.2 | 34.98 |  |
| 3 | 20%+1.5%+10% | 23.55 | 29.54 | 36.88 |  |
| 4 | 20%+1.5%+15% | 24.85 | 31.25 | 38.85 |  |
| 5 | 20%+1.5%+20% | 22.7 | 29.36 | 37.54 |  |

**Fig 3.4: Compressive strength of REDMUD PPFRC**

**3.3.3 Discussion,s on compressive strength test results**

* The compressive strength values for polypropylene fiber reinforced concrete are increased upto 1.5% polypropylene fiber addition. For 2% polypropylene fiber addition compressive strength starts decreasing.
* It is observed that 17.05% increase in compressive strength for 7 days, 17.02% increase in compressive strength for 14 days and 11.93% increase in compressive strength in 28 days for 1.5% of polypropylene fiber addition compared to conventional concrete mix.
* The compressive strength results for redmud PPFRC are increased upto 15% replacement of cement by redmud after 15% compressive strength starts decreasing.
* The 15% replacement of redmud gives 16.05% higher compressive strength than the conventional concrete for 7 days, 19.2% higher compressive strength for 14 days and 18.01% higher compressive strength for 28 days.
* The maximum compressive strength is achieved for 15% redmud replacement, 20% flyash replacement and 1.5% of polypropylene fiber addition.

**3.4 SPLIT TENSILE STRENGTH TEST RESULTS**

**3.4.1 SPLIT TENSILE STRENGTH TEST FOR PPFRC**

The split tensile strength test was conducted for polypropylene fiber reinforced concrete (PPFRC). The concrete mix is prepared by adding polypropylene fibers at different percentages from 0.5% to 2.0% in 0.5% intervals. The split tensile strength tests are conducted on 7, 14 and 28 days of curing and results are compared with conventional concrete. Split tensile strength of PPFRC are tabulated in table 4.5.

**Table 3.5: Split tensile strength for PPFRC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl No | Mix Designation | Split tensile strength in Mpa | | |
| 7 days | 14 days | 28 days |
| 1 | PP 0 | 2.28 | 2.82 | 3.22 |
| 2 | PP 0.5 | 2.38 | 2.94 | 3.48 |
| 3 | PP 1 | 2.54 | 3.12 | 3.67 |
| 4 | PP 1.5 | 2.84 | 3.35 | 3.85 |
| 5 | PP 2 | 2.42 | 3.02 | 3.42 |

**Fig 3.5: Split tensile strength of PPFRC**

**3.4.2 SPLIT TENSILE STRENGTH TEST FOR REDMUD PPFRC**

The split tensile strength test conducted for redmud polypropylene fiber reinforced concrete. The concrete mix is prepared by replacing cement with redmud at different percentages from 5% to 20% in 5% intervals and flyash is also replaced for cement in 20%. Optimum percentage of polypropylene fiber 1.5% from table 7.5 is also added. The split tensile strength test are conducted on 7, 14 and 28 days of curing and compared with conventional concrete. The results are tabulated in table 4.6.

**Table 3.6: Split tensile strength for redmud PPFRC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl No | % of Fly Ash+% of PPF+% of RM | 7 days | 14 days | 28 days |
|  |
| 1 | 0% | 2.28 | 2.82 | 3.22 |  |
| 2 | 20%+1.5%+5% | 2.34 | 3.02 | 3.36 |  |
| 3 | 20%+1.5%+10% | 2.52 | 3.28 | 3.54 |  |
| 4 | 20%+1.5%+15% | 2.78 | 3.48 | 3.92 |  |
| 5 | 20%+1.5%+20% | 2.38 | 3.24 | 3.61 |  |

**Fig 3.6: Split tensile strength of redmud PPFRC**

**3.4.3 Discussion on split tensile strength test results**

* The split tensile strength values for polypropylene fiber reinforced concrete are increased upto 1.5% polypropylene fiber addition. For 2% polypropylene fiber addition split tensile strength starts decreasing.
* It is observed that 19.71% increase split tensile strength for 7 days, 15.82% increase in split tensile strength at 14 days and 18.48% increase in split tensile strength in 28 days for 1.5% of polypropylene fiber addition compared to conventional concrete mix.
* The split tensile strength results for redmud PPFRC are increased upto 15% replacement of cement by redmud above 15% split tensile strength starts decreasing.
* The 15% replacement of redmud gives 17.98% higher split tensile strength than the conventional concrete for 7 days, 18.96% higher split tensile strength for 14 days and 17.85% higher split tensile strength for 28 days.
* The maximum split tensile strength is achieved for 15% redmud replacement, 20% flyash replacement and 1.5% of polypropylene fiber addition.

**3.5 FLEXURAL STRENGTH TEST RESULTS**

**3.5.1 FLEXURAL STRENGTH TEST FOR PPFRC**

The flexural strength test was conducted for polypropylene fiber reinforced concrete (PPFRC). The concrete mix is prepared by adding polypropylene fibers at different percentages from 0.5% to 2.0% in 0.5% intervals. The flexural strength tests are conducted on 7, 14 and 28 days of curing and results are compared with conventional concrete. The flexural strength of PPFRC are tabulated in table 4.7.

**TABLE 3.7: Flexural strength for PPFRC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl No |  | Flexural strength in Mpa | | |
| % of PPF | 7 days | 14 days | 28 days |
| 1 | PP 0% | 2.72 | 3.24 | 3.82 |
| 2 | PP 0.5% | 2.85 | 3.32 | 3.98 |
| 3 | PP 1% | 3.24 | 3.74 | 4.21 |
| 4 | PP 1.5% | 3.57 | 4.08 | 4.62 |
| 5 | PP 2% | 3.34 | 3.85 | 4.42 |

**Fig 3.7: Flexural strength of PPFRC**

**3.5.2 FLEXURAL STRENGTH TEST FOR REDMUD PPFRC**

The flexural strength test conducted for redmud polypropylene fiber reinforced concrete. The concrete mix is prepared by replacing cement with redmud at different percentages from 5% to 20% in 5% intervals and flyash is also replaced for cement in 20%. Optimum percentage of polypropylene fiber 1.5% from table 7.7 is also added. The flexural strength test are conducted on 7, 14 and 28 days of curing and compared with conventional concrete. The results are tabulated in table 4.8.

**Table 3.8: Flexural strength for redmud PPFRC**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Sl No | % of Fly Ash+% of PPF+% of RM | 7 days | 14 days | 28 days |
|  |
| 1 | 0% | 2.72 | 3.24 | 3.82 |  |
| 2 | 20%+1.5%+5% | 2.81 | 3.36 | 3.94 |  |
| 3 | 20%+1.5%+10% | 3.14 | 3.68 | 4.12 |  |
| 4 | 20%+1.5%+15% | 3.45 | 4.02 | 4.54 |  |
| 5 | 20%+1.5%+20% | 3.22 | 3.78 | 4.24 |  |

**Fig 3.8: Flexural strength of redmud PPFRC**

**3.5.3 Discussion on flexural strength test results**

* The flexural strength values for polypropylene fiber reinforced concrete are increased upto 1.5% polypropylene fiber addition. For 2% polypropylene fiber addition flexural strength starts decreasing.
* It is observed that 23.8% increase flexural strength for 7 days, 20.58% increase in flexural strength at 14 days and 17.31% increase in flexural strength in 28 days for 1.5% of polypropylene fiber addition compared to conventional concrete mix.
* The flexural strength results for redmud PPFRC are increased upto 15% replacement of cement by redmud above 15% flexural strength starts decreasing.
* The 15% replacement of redmud gives 21.15% higher flexural strength than the conventional concrete for 7 days, 19.4% higher flexural strength for 14 days and 15.85% higher flexural strength for 28 days.
* The maximum flexural strength is achieved for 15% redmud replacement, 20% flyash replacement and 1.5% of polypropylene fiber addition.

**4. CONCLUSIONS**

In this experimental investigation, redmud and flyash are used in concrete as partial replacement for cement along with polypropylene fibers. Following conclusions can be made from the results obtained.

* Workability of concrete decreases with increase in percentage of redmud.
* Compressive strength results for polypropylene fiber reinforced concrete (PPFRC) has maximum strength at 1.5% of polypropylene fiber addition.
* Split tensile strength and flexural strength for polypropylene fiber reinforced (PPFRC) have maximum strength at 1.5% of polypropylene fiber addition.
* Optimum percentage polypropylene fibers used in concrete is 1.5% of total weight of the concrete.
* Compressive strength results of redmud polypropylene fiber reinforced concrete has maximum strength at 15% of replacement of cement by redmud and 20% of flyash as cementitious material along with 1.5% of polypropylene fibers.
* Split tensile strength and flexural strength of redmud polypropylene fiber reinforced concrete has maximum strength at 15% of replacement of cement by redmud and 20% of flyash as cementitious material along with 1.5% of polypropylene fibers.
* Optimum percentage of redmud replacement in concrete is 15%.
* Total of 35% of cement is replaced by redmud and flyash (20%+15%).
* Redmud and flyash are the industrial waste materials which can be made use in construction field, which can minimize production of cement.
* Use of industrial waste in concrete minimizes the disposal problems of industrial waste, minimizes environmental pollution and it is also economical.

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