STUDIES ON STRENGTH PARAMETERS OF FIBRE REINFORCED CONCRETE PARTIALLY REPLACED BY RED MUD

Syed Akram Affan[1], Mohd Afroz Khan[2], Mohd Sohail Khan[3], Abdul Qavi Ul Siraj[4]

[1,2,3,4]Students, Dept of Civil Engineering, ISL Engineering College, Hyderabad, Telangana, India.

Mrs.K.Nanchari, Asst Prof, Dept of Civil Engineering, ISL Engineering College, Hyderabad, Telangana, India.

ABSTRACT: Cement is an important ingredient which helps to strengthen the concrete matrix by its binding properties. Many replacement materials such as fly ash, slag, silica fumes were experimentally investigated, and the performance of the concrete by adding such materials was proven. Red mud is one such material which is found suitable to replace cement partially. The concentration towards the replacement of cement is focused because, during the manufacturing process of cement, an enormous quantity of CO2 is liberated into the environment. Red mud is a by-product obtained during the extraction process of alumina from bauxite. The physical and chemical properties of red mud are found suitable to replace cement content in concrete. Since the fineness of red mud is lesser than that of cement, by replacing cement partially, the void is reduced, thereby increasing the compressive property of the concrete. This attempt is made to find out the adequacy and suitability of red mud as a cement replacement. This investigation is mainly focused on studying the effect of red mud with the addition of polypropylene fiber on mechanical properties.

In this research work Red mud is replaced with 5%, 10%, 15% and 20% against the cement and in addition to that hydraulic lime is added in the mix by 5% weight of cement. Then to increase the tensile strength of the concrete polypropylene fiber is added with a volume fraction of 0.15%, 0.2%, 0.25%, 0.3% and 0.35%. The mechanical property tests were conducted on the cube, cylinder, and prism specimens, and the optimum percentage of replacement was found. All test results are compared with conventional concrete (CC).

INTRODUCTION

Environmental pollution brings a lot of health hazards to all living things in this world. Depletion of raw materials due to quarrying results in paucity of construction materials. Bulk usage of river sand also causes drying of rivers and also results in lowering of the water table. High usage of Portland cement has two major drawbacks, tons of raw materials used and emission of carbon dioxide into the environment. So it is better to use industrial wastes in the

construction industry to avoid storing of industrial wastes in a large quantity. Identifying industrial wastes which have potential pozzolanic properties is also a big challenge. However, not much attention has been focused so far on the suitability of red mud utilization and their effect on strength, durability and flexural behaviour. Hence the present study emphasizes on the utilization of red mud as a partial replacement of binder in concrete.

The present research work entitled "Experimental investigation on strength and durability properties of fiber reinforced concrete using red mud" has been taken up with the following objectives:

- To evaluate mechanical properties like compressive strength, split tensile strength and flexural strength of red mud and fiber reinforced concrete.
- To study the durability properties of red mud concrete
- To investigate flexural behaviour of red mud concrete beam and functionally graded concrete beam.
- To study the behaviour of columns under axial compressive load

LITERATURE REVIEW

Maneesh Singh et al. have explained the preparation of iron rich cements using red mud. The Possibility of producing calcium sulfo alumina ferrite, calcium alumina ferrite based cements using lime + red mud + bauxite + gypsum has been investigated. The effects of composition, firing time and firing temperature on the properties of cements produced have been studied. The characteristics of the cements produced have been found to be strongly dependent on the raw mix composition and firing temperature but not so much on firing time. Some of these cements possess strength and occasionally even quite normal OPC. Then the red mud used comprises significant quantity of titania, the influence of titania on pure sulfo aluminate phase has also been considered.

Ekrem Kalkan has presented the use of red mud as a stabilization material in embankments for the preparation of clay liners. In this study, the potential usage of red mud in the preparation of stabilization material is presented. This study inspects the effects of red mud on the hydraulic conductivity, unconfined compressive strength and swelling percentage of compacted clay liners as a hydraulic barrier. From the experimental results, it is observed that higher compressive strength and lower hydraulic conductivity and swelling when compared with compacted clay with red mud and natural clay respectively. Therefore, it is determined

that red mud and cement—red mud materials can be effectively utilised for the stabilization of clay liners in embankments.

Weiwei Huang & Shaobin Wang studied the possibility of phosphate removal from wastewater using red mud. Red mud is a waste deposit from alumina refinery and has been used as an effective adsorbents to remove phosphate from aqueous solution. In order to treat the raw red mud, Acid and acid-thermal treatments were employed. The different treatment methods like pH of solution and operating temperature on adsorption have been examined in batch experiments. From the test, it was found that higher surface area and higher adsorption capacity were observed due to activation of Red mud. The HCI treated red mud shows the maximum adsorption capacity amongst all the red mud samples. When pH value increases, the adsorption capacity of the red mud decreases. The adsorption is better at higher temperature.

Chunming Gong & Yang Nauru analysed the effect of phosphate on the hydration of alkali-activated red mud—slag cementitious material. Through micro structure studies using x-ray diffraction method and spectron electro microscope red mud materials characterisation was studied. Heat of hydration was decreased by sodium phosphate. A new phase is found to be formed in this system. The delaying mechanism is keenly recognised at this unique stage.

Ribeiro et al. studied the influence of the addition of red mud on the corrosion parameters of reinforced concrete. In this study, by measuring the conductivity of the anolyte, the chloride concentration in concrete was monitored. To prevent corrosion process, red mud was used as additive for concrete. The corrosion potential in concrete was monitored by using electrochemical measurements and the electrical resistivity in concrete was measured by using sensors fixed in concrete sample. From the results, it was found that the addition of red mud in concrete, reduces its chloride migration rate and corrosion potential.

Sneha Samal et al. reviewed the possible red mud utilization in various fields. Major achievements in utilization and treatment of red mud in India were presented. Likewise, the drawbacks of red mud utilization and treatment associated with commercial applications of red mud were also discussed. Public awareness about the application of red mud in the manufacture of bricks, construction of roads would be a significant step in utilising great amounts.

Xingjun Chen et al. investigated the possible use of red mud and fly ash in the production of foam ceramics. Mechanical strength, porosity, bulk density, water absorption tests were conducted. Micro structure properties of red mud and fly ash were also studied. The increase in mechanical strength, enhanced porosity were observed. The foam ceramic material manufactured from waste materials offer environmental benefits and economic benefits.

Ri-Xin Liu & Chi-Sun Poon investigated the utilization of red mud derived from bauxite in SCC. In this paper, the physical and chemical properties of red mud were studied. The possible use of the red mud as a pozzolanic material to exchange ash in Self-Compacting Concrete (SCC) was assessed by conducting a spread of recent and hardened properties test. The XRF and XRD results show that the compound forms within the red mud square measure principally SiO2, A12O3 and CaO at 45.76%, 40.69% and 4.98% respectively. The crystalline phases square measure principally gismondine, goosecrekite and epistilbite which belong to the zeolite family. The result indicated that both red mud and fly ash strength were the same. Meanwhile, by using the red mud instead of fly ash in SCC, the compressive strength, splitting tensile strength and elasticity modulus have enhanced. Moreover, with the addition of the red mud, the drying shrinkage decrement were observed in SCC, which might be due to the red mud's internal curing effect. Therefore, the utilization of the red mud in SCC is unquestionable.

MATERIAL PROPERTIES

In this investigation, ordinary portland cement, clean river sand from river bed is used as fine aggregate, crushed rock from quarry is used as coarse aggregate. Potable water was used in this investigation. In addition to the above core mix, hydraulic lime, red mud and polypropylene fiber are used for structural element such as beam, column and beam-column connection. High yield strength deformed bar of Fe500 grade steel was used as main, shear and transverse reinforcement. The detailed properties of each material are given in the following contents.

Cement

The most common cement used is an Ordinary Portland Cement (OPC) of grade 53, confirming to IS 12269 -1987. (Reaffirmed 2004) The brand of cement used in this study is Ultra Tech OPC 53 Grade and the following physical properties of the tests were carried out for the cement used.

S. No	Physical properties of Cement	Result	As per 12269-1987
1	Specific Gravity	3.13	3.10 — 3.15
2	Standard consistency (%)	30%	30-35
3	Initial setting time	33 minutes	30 minimum
4	Final Setting Time	385 minutes	600 maximum
5	Compressive strength 7 days (MPa)	41.50	43 MPa
6	Compressive strength 28 days Mpa	58.83	53 Mpa
7	Fineness *(%)*	3%	Minimum 22
8	Soundness, Lechatlier, mm	1.00	Maximum 10

Fine Aggregate

The materials lie from 4.75 mm to 150 microns sieve are called as fine aggregate. The Natural river sand collected from krishna river bed near Karur is used for the present work. Sieve analysis has been conducted. Fineness modulus of natural river sand is 3.44. Natural sand confirming to standards IS 383-1970 and lies in zone II is used in the present study.

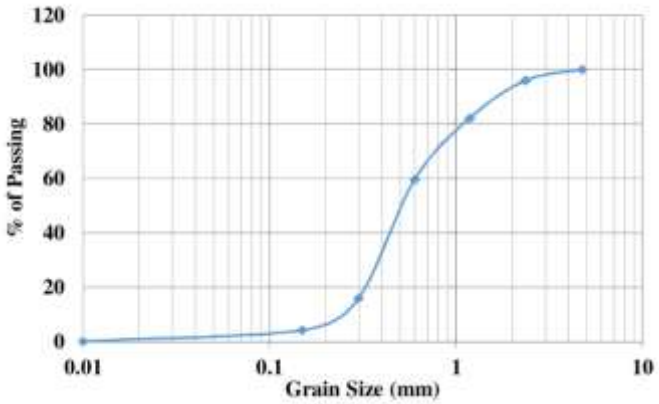

Figure 3.1 Particle Size Distributions in Fine Aggregate

Coarse Aggregate

The size of metal used is 20mm graded metal as coarse aggregate. The gradation to be satisfied to 20mm metal as per IS 383-1970. The materials are collected from the crusher at Erode for this research work.

Water

Water is an important ingredient of concrete, which reacts with cement. Water should be free

from oil, acid, alkalis, clay and loam or any other vegetable matter for concrete preparation. To prepare the concrete, water is added to the mixture of fine aggregates, coarse aggregates with

cement and the quality of water must be very good. Water should have the pH value of 7.00 plus (or) minus 1.00. Fresh portable water free from acid, organic substance is used for mixing concrete and curing in all the experimental investigation.

Red Mud

Red mud is a waste product which is derived from the treatment of aluminium ore. The composition of red mud depends on the composition of its original ore, however the main constituents are oxides of different metals of iron oxide, which provides the material its characteristic colour. At present, there is no usage of red mud has been identified and hence it is stored in large quantity nearer to the treatment plants. Red Mud is produced during the Bayer process for alumina production. Red Mud becomes an insoluble component after bauxite ingestion with sodium hydroxide at elevated high temperatureand pressure. It is a mixture of compounds originally present in the parent mineral, bauxite, and of compounds formed or introduced during the Bayer cycle. Specific gravity of red mud is 2.55.

Figure 3.2 Red mud used **for investigation**

Hydraulic Lime

Hydrated Lime or lime is generally Calcium Hydroxide with chemical formula $Ca(OH)_2$ Hydrated Lime is colourless crystal and are in the form of white powder. When this white powder is mixed with water, it dissolves in water and produces Calcium ions and hydroxyl ions which helps in increasing the pH of the solution. Hydrated Lime is in dry powder form which is obtained by mixing hot lime with a sufficient quantity of water to satisfy the hot lime's natural attraction for moisture. Hydrated Lime is added in sump water to

increase the pH level. In Gypsum-based mud system, to maintain a fluid pH of 10—11, Hydrated Lime is added.

Figure 3.3 **Hydraulic** lime used for **investigation**

Polypropylene Fiber

In the recent years, synthetic fibers have been used mostly for reinforcing cementitious materials. Polypropylene (PP) fibers have low elastic modulus and poor physiochemical bonding with cement paste, it is quite seeming that the load carrying capacity of a structure under flexural loading is considerably increased. Considerable improvements in strain capacity, toughness, impact resistance, Crack control of concrete can be obtained through the use of polypropylene fibers.

The modulus of elasticity of both the monofilament and the fibrillated polypropylene is usually about 3500 N/mm^2, and the tensile strength is about 560 to 770 N/mm^2. The bundles of polypropylene fibers added to concrete are separated into millions of individual strands due to the abrasion action of the aggregates. The fibers are distributed throughout the entire mix, providing support to concrete in all possible directions.

Figure 3.4 Polypropylene fiber used **in this investigation**

Superplasticizer

Role of superplasticizer in PP fiber is very important because it increases the workability of concrete. CERA PLAST 300 is used. It is brown in colour and available in liquid form. The specific gravity of this superplasticizer is 1.2.

MIX DESIGN

Mix design is the process of selecting the quantities of ingredients of concrete and determining the proportions by which the concrete produce as economically as possible and satisfies the job requirements. The important phase of the concrete is proportioning of the ingredients such as cement, fine aggregates, coarse aggregates to ensure the quality and economy of concrete. There are many methods of design of concrete available of which Indian standard method of mix design is used in this work.

Generally the compressive strength of concrete is the main property which is generally considered as quality of concrete. So, the mix design is carried out for the particular compressive strength of concrete, and workability of concrete. So that, the fresh concrete may be mixed properly, placing the concrete and compact properly. The purpose of mix proportion is to produce the required properties in both plastic and hardened concrete. A mix design for M25 grade concrete is designed as per IS 10262-2009 and IS 456-2000.

There are 3 steps which interrelated to each other in proportioning of concrete mixes.

1. Selection of suitable materials such as cement, fine aggregates and coarse aggregates.
2. Finding the relating quantities of the materials at low cost which can give good results, strength and durability properties.
3. The careful quality checkup at each and every phase of making the concrete.

MIX PROPORTION

A concrete mix was designed as per IS 10262 — 2009 to achieve a concrete grade of M25. The mix proportion adopted as per design was 1:1.54:2.67. Water cement ratio of 0.45 was used constantly for all the mix. Various mix identifications were followed.

Quantities of ingredients in M25 grade Concrete

Unit	Cement **(kg/m^3)**	Fine Aggregates **(kg/ m^3)**	Coarse Aggregate **(kg/ m^3)**	**Wat er** (kg/ **m^3**)	Superplasticizer (kg/ **m^3**)
Cubic meter	425.7	656.9	1139.67	191•6	weight of cement
Ratio	1	1.54	2.67	0.45	

RESULTS AND DISCUSSION

The mechanical properties of concrete after 28 days curing have been studied using casting specimen of all mixes with various percentage of replacement red mud and hydraulic lime and using addition of polypropylene fiber of different volume fraction of 0.15%, 0.2%, 0.25%, 0.3% and 0.35% respectively. The mechanical property tests are conducted on cube specimen to find out compression strength, in cylinder specimen to find out split tensile strength, in cylinder specimen to find out modulus of elasticity and in prism specimen to find out modulus of rupture after 28 days curing. The effect of replacement of red mud, addition of polypropylene fiber on the concrete have been discussed below.

Compressive Strength

The test results of Red Mud and Hydraulic Lime Modified Concrete with fibers is shown in Figure 4.1

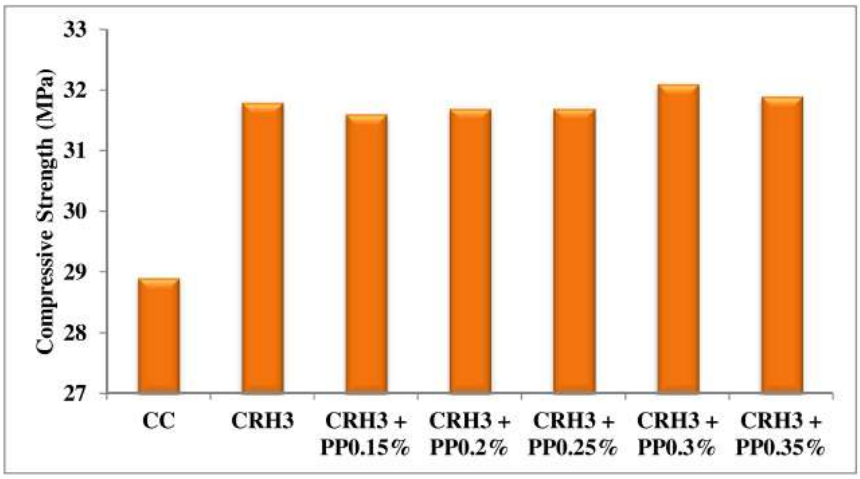

Figure 4.1 Compressive Strength for Red Mud and Hydraulic Lime Modified Concrete with fibers

On analysing the compressive strength of modified concrete with hydraulic lime with addition of polypropylene fiber, it was found that modified concrete with hydraulic lime with addition of 0.3% polypropylene fiber has the higher compressive strength of 32.1 MPa which is 16.56% higher than the conventional concrete..

Split Tensile Strength

The mechanical property test results of Red Mud and HydraulicLime Modified Concrete with fibers .. The test results of Red Mud and Hydraulic Lime Modified Concrete with fibers is shown in Figure 4.2.On analysing the split tensile strength of modified concrete with hydraulic lime with addition of polypropylene fiber, it was found that modified concrete with hydraulic lime with addition of 0.3% polypropylene fiber has the higher split tensile strength of 2.66 MPa which is 18.1% higher than the conventional concrete.

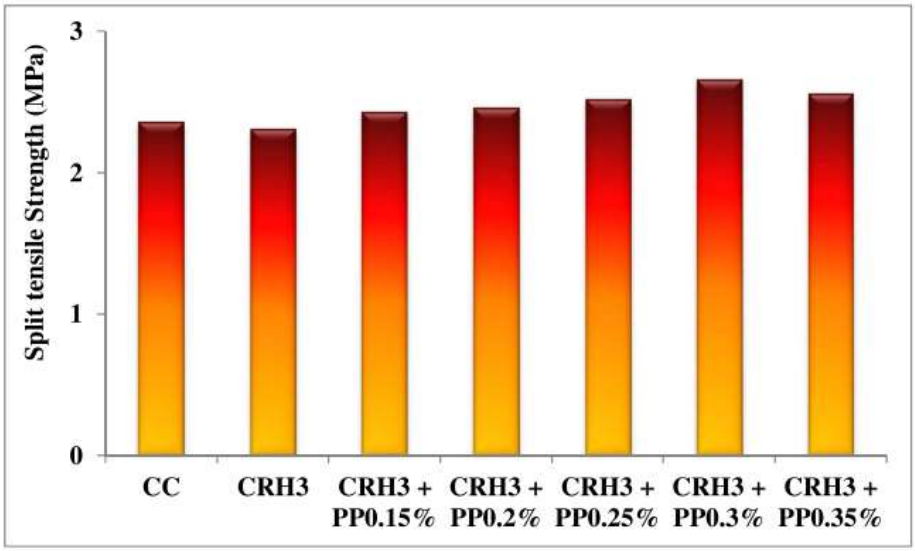

Figure 4.2 Split Tensile Strength for Red Mud and Hydraulic Lime Modified Concrete with fibers

Modulus of Rupture

The mechanical property test results of Red Mud and Hydraulic Lime Modified Concrete with fibers is shown in Table. The test results of Red Mud and Hydraulic Lime Modified Concrete with fibers is shown in Figure 4.3. On analysing the modulus of rupture of modified concrete with hydraulic lime with addition of polypropylene fiber, it was found that modified concrete with hydraulic lime with addition of 0.3% polypropylene fiber has the higher modulus of rupture of 3.86 MPa which is 13.25% higher than the conventional concrete.

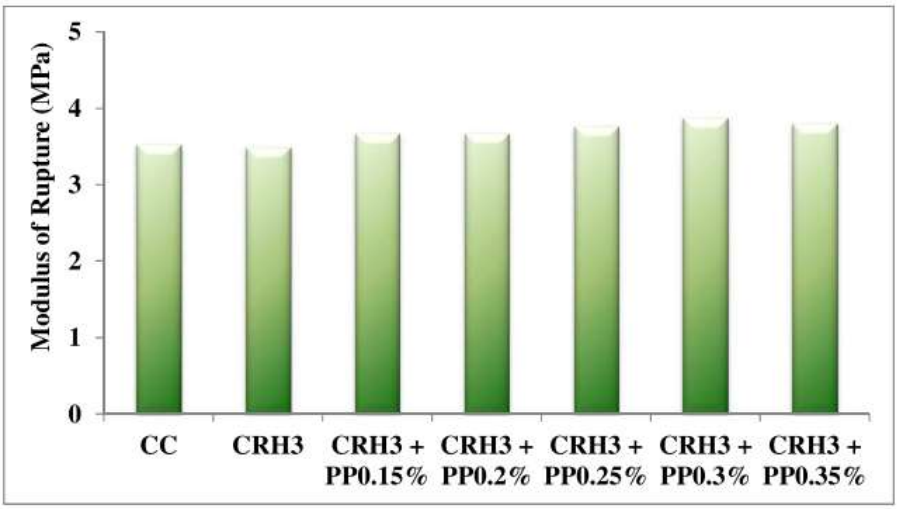

Figure 4.3 Modulus of Rupture for Red Mud and Hydraulic Lime Modified Concrete with fibers

CONCLUSION

From the mechanical property test results, the following conclusions have been arrived:

On analyzing the mechanical properties, it is found that the partial replacement of cement by red mud, hydraulic lime and addition of polypropylene fiber influences the strength characteristics of concrete.

Modified concrete cube with red mud and hydraulic lime (CRH3) has the highest compressive strength of 31.8 Mpa, which is 7.96% higher than the conventional concrete.

Modified concrete with hydraulic lime with the addition of 0.3% polypropylene fiber has higher strength than the conventional concrete.

From the mechanical property results it was found that CRH3+PP0.3% specimens gave better results when compared to other mixes.

REFERENCES

1 IS:10086 1982, 'Indian Standard specification for moulds for use in tests of cement and concrete', V Reprint, Bureau of Indian Standard, New Delhi.

2 IS:10262 2009, 'Indian Standard recommended guide lines for concrete mix design', V print, Bureau of Indian Standard, New Delhi.

3 IS:12269 1987, 'Indian Standard Specification for 53 Grade Ordinary Portland Cement', II reprint, Bureau of Indian Standard, New Delhi.

4 IS:2386 (Part II) 1996, 'Indian Standard Methods of test for aggregates for concrete, deterious materials and organic impurities', VIII reprint, Bureau of Indian Standard, New Delhi.

5 IS:2386 (Part III)-1997, 'Indian Standard Methods of test for aggregates for concrete: Specific gravity, density, voids, absorption and bulking', VIII reprint, Bureau of Indian Standard, New Delhi.

6 IS:2386 (Part IV)-1996, 'Indian Standard Methods of test for aggregates for concrete: Mechanical properties', IX reprint, Bureau of Indian Standard, New Delhi.

7 IS:2386 (Part V)-1996, 'Indian Standard Methods of test for aggregates for concrete: Soundness', VIII reprint, Bureau of Indian Standard, New Delhi.