

Study on Strength of Concrete with Partial Replacement of Cement with Metakaolin and Red Mud

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Abstract- Concrete is the most commonly used material for construction. The worldwide production of cement has greatly increased since 1990. Production of cement results in a lot of environmental pollution as it involves the emission of CO₂ gas. Supplementary cementitious materials (SCM) are finely ground solid materials that are used to replace a portion of the cement in a concrete mixture. These supplementary materials may be naturally occurring, manufactured or man-made waste. In this study partial replacement of cement has been done at 0%,5%,10%,15%,20% with Metakaolin and 4%,6%,8% with Red Mud. Compressive as well as flexural strength of concrete made with Metakaolin and Red Mud has been compared with conventional concrete of grade M30. The optimized strength value of concrete was achieved for both compressive as well as flexural strength at 15%Metakaolin and 6% Red Mud.

Keywords- Metakaolin, Red Mud, Ordinary Portland Cement, Compressive strength

I. INTRODUCTION

Leaving waste materials in to environment directly results to damage of natural climatic conditions, hence use of waste materials is made at most importance in present study. In construction Industry, consumption of cement is increasing day by day as well as cost is also increasing so to reduce the consumption of cement, partial replacement with Metakaolin and Red Mud was done in this study. Metakaolin is a calcined clay and easily available in Gujarat, Maharashtra & Bombay etc. Red Mud is produced from the production of Alumina from Bauxite. Bayer's process for Alumina production uses Caustic and Bauxite as the main raw material for Alumina production and generates Red mud which practically doesn't have wide industrial application and is generally dumped as a non value by product in the backyards of a Alumina Refinery called as Red Mud yard. Over the years the red mud produced were lying in the yard not without any usage. So, it is advisory to use Red Mud as partial replacement with cement as it has properties similar to cement and one of good pozzolanas. Similarly use of Metakaolin leads to Green concrete, because

during production of Metakaolin there is no emission of carbon dioxide.

II. EXPERIMENTAL PROGRAMME

2.1 Material Used:

2.1.1 Cement

Ordinary Portland cement of brand Prism and grade 43 conforming to IS 8112:1989 has been used and the properties of the cement are investigated in the laboratory. The specific gravity of cement is 3.15.

2.1.2 Fine Aggregate

The locally available river sand conforming to grading zone-III of IS 383-1970 has been used as Fine Aggregate. The various properties of fine aggregate used in present study are given in table .

Table 1.Properties of Fine Aggregate

Characteristics	Observed Values
Grading Zone	III
Fineness modulus	2.367
Specific gravity	2.61
Silt content	2%

2.1.3 Coarse Aggregate

The locally available crushed granite material has been used as coarse Aggregate. The coarse aggregate also confirms to IS 383-1970.

Table 2. Properties of Coarse Aggregate

Characteristics	Observed Values
Fineness Modulus	6.865
Specific Gravity	2.70

2.1.4 Metakaolin

Metakaolin is obtained by thermal activation of kaolin clay. Metakaolin is used in oil well cementing to improve the compressive and flexural strength of the hardened cement. Metakaolin also reduces the hardened cement permeability to liquids and gases. Hence by partially replacing Portland cement with Metakaolin not only reduces carbon dioxide emissions but also increases the servicelife of buildings. The Metakaolin was in conformity with the general requirements of pozzolana. Properties of Metakaolin are given in be Table 3.

Chemical formula of Metakaolin is $Al_2O_3 \cdot 2SiO_2 \cdot 2H_2O$.

Table 3. Chemical composition of Metakaolin

Chemicals	Percentage (%)
SiO ₂	62.62
Al ₂ O ₃	28.63
Fe ₂ O ₃	1.07
MgO	0.15
CaO	0.06
Na ₂ O	1.57
K ₂ O	3.46

2.1.5 Red Mud

Red mud is considered due to its high pH varies between 10 to 14 and discharged as high alkaline slurry. Red mud contains six major oxides named CaO, SiO₂, Fe₂O₃, Al₂O₃, TiO₂ and Na₂O and small quantities of numerous minor elements. And few of above mentioned oxides are present in cement also. Hence red mud is called as a cementitious material.

Table 4. Chemical composition of Red Mud

Chemicals	Percentage (%)
Fe ₂ O ₃	38.3
SiO ₂	11.4
Al ₂ O ₃	21.6
CaO	1.47
Na ₂ O	6.87

2.1.6 Super Plasticizer

The super plasticizer used in the present study was Cico super plast which is based on specially selected high molecular weight organic polymers. Super plasticizer is

chemical admixtures used in high grade of concrete mainly to reduce water content without affecting the strength of concrete and it is also used to increase workability.

2.1.7 Water

Clean fresh water, which is free from concentration of acid and organic substances, has been used for mixing the concrete.

2.2. Casting

The moulds used for cubes and beams were of steel having an internal dimension of 150 mm x 150 mm for cube and 100 mm x 100 mm x 500 mm for beam. The cement, coarse and fine aggregate and superplasticizer were mixed thoroughly with the help of mechanical mixer. 28days. The specimens were cast in well lubricated moulds. Concrete wereplaced on themould and compacted thereafter and theywere left at room temperature for 24hrs before being transferred into the curing tank.

III. RESULTS

TABLE FOR COMPRESSIVE STRENGTH

Table 5. Variation of Metakaolin

Metakaolin %	Average Compressive Strength at 28 Days(N/mm ²)
0	37.33
5	38.24
10	41.76
15	43.70
20	42.57

Variation of Compressive Strength For Different Fractions of Metakaolin

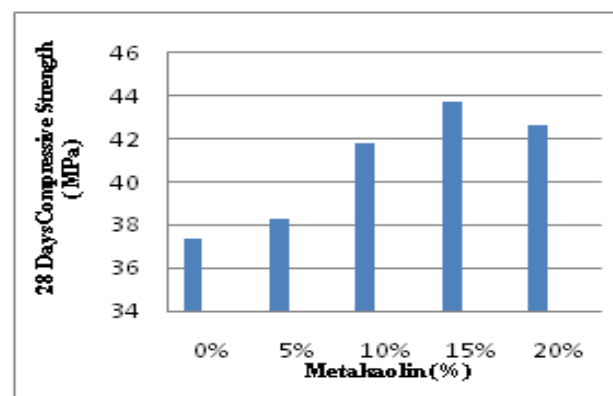


Figure 1

Table 6. Variation of Metakaolin + Red Mud

Metakaolin and RedMud %	Average Compressive Strength at 28 Days (N/mm ²)
15% Metakaolin+4% Red Mud	43.89
15% Metakaolin+6% Red Mud	45.67
15% Metakaolin+8% Red Mud	45.02

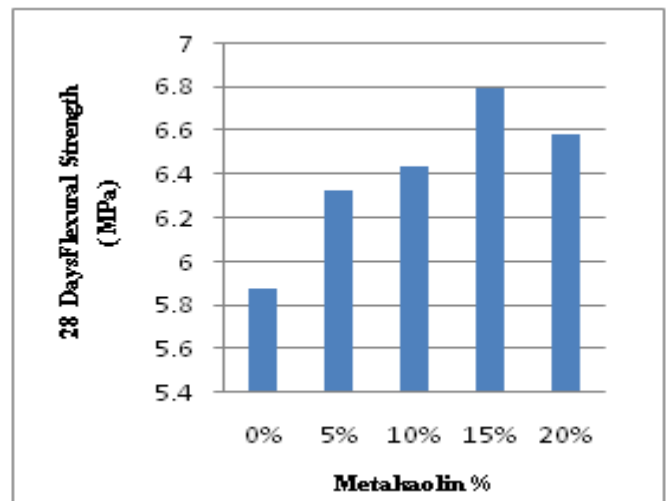


Figure 3

Variation of Compressive Strength For Different Fractions of Metakaolin and Red Mud

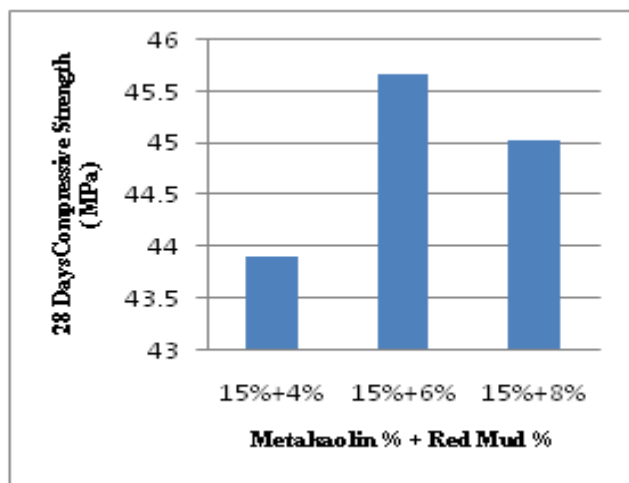


Figure 2

Table 8. Variation of Metakaolin + Red Mud

Metakaolin and Red Mud %	Average Flexural Strength at 28 Days (N/mm ²)
15% Metakaolin+4% Red Mud	6.36
15% Metakaolin+6% Red Mud	6.85
15% Metakaolin+8% Red Mud	6.52

Variation of Flexural Strength For Different Fractions of Metakaolin and Red Mud

TABLE FOR FLEXURAL STRENGTH:

Table 7. Variation of Metakaolin

Metakaolin %	Average Flexural Strength at 28 Days (N/mm ²)
0	5.88
5	6.32
10	6.43
15	6.79
20	6.58

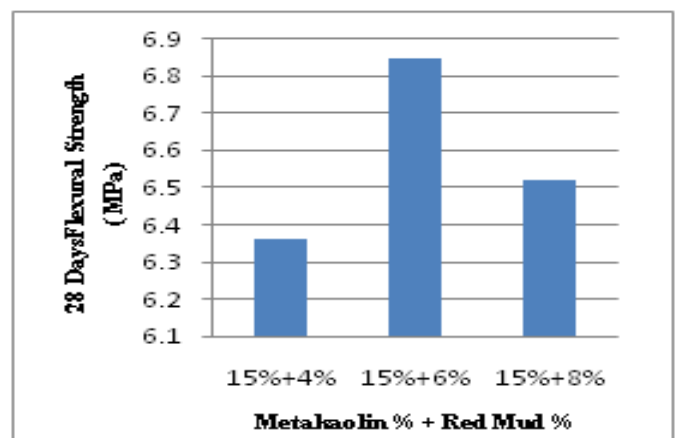


Figure 4

Variation of Flexural Strength For Different Fractions of Metakaolin

IV. CONCLUSIONS

1. Metakaolin reduces the setting time of mixture as compared to normal mixture and it generally required more super plasticizer.
2. The replacement of cement with 10% Metakaolin and 6% Red Mud, give better results better for strength as shown in figure 2 and figure 4
3. The increase in metakaolin content improves the compressive strength, and Flexural Strength upto 15% replacement.
4. The choice of selecting Red Mud as a replacement material not only increases the strength, but also protects the environment as it is one of the source for causing environmental pollution.
5. It has been found that compressive and flexural strength have their maximum values for 15% Metakaolin replacement. The compressive strength is increased by 22.34%, flexural strength by 15.47% when compared to their nominal strength. For any further increase in Metakaolin the strength decrease gradually.
6. When Red Mud is added with 15% Metakaolin dosage, maximum strengths are obtained at 6% of Red Mud. The compressive strength is increased by 23.01% and flexural strength by 16.49% when compared to their nominal strength.
7. From the test results, it is clear that the strength of the specimens increases for the replacements 15% Metakaolin and 6% Red Mud and then the strength of the specimens starts decreasing. Hence, the percentage of cement replacement by red mud is determined to be 15%.

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