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EXPERIMENTAL STUDY ON PARTIAL REPLACEMENT OF CEMENT WITH METAKAOLIN AND SAND WITH QUARRY DUST OF REINFORCED CONCRETE BEAM.

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ABSTRACT

This paper presents an investigation on the flexural behavior of High performance concrete beams produced from metakaolin, sea wage and quarry dust, M-sand is an economic alternative to the river sand. In this investigations Metakaolin, as partial cement replacement and Quarry dust, M-sand as partial fine aggregates replacement. A total of 15 specimens were considered and there reinforcement ratios are uniform were fabricated and tested. It was observed that the deflection characteristic, crack pattern, compressive strain, tensile strain, ultimate load carrying moment wise curvature of the beam the results were compared with conventional concrete beams.

Key words: Metakaolin, Quarry dust, M- sand, Flexural strength, compressive strain, and tensile strain.

INTRODUCTION

Ordinary Portland cement and water are the most commonly used building material throughout the world and they retain their status, because of demand and expansion of construction industry all over the world. Further the greatest challenge before the concrete construction industry is to serve the two pressing needs of human society, namely the protection of environment and meeting the infrastructure requirements of our growing population. The cement is the most costly and energy intensive component of concrete. The unit cost of concrete can be reduced as much as possible by partial replacement of cement with quarry dust and metakaolin.

The cement industry is one of the two primary product producers of carbon dioxide(CO_2),creating up to 5% of worldwide man –made emissions of this gas, of which 50% is from the chemical process and 40% from burning fuel. The CO_2 emission from the concrete is directly proportional to the cement content used in the concrete mix; 900 kg of CO_2 are emitted for the production of every ton of cement.

Metakaolin is in widespread use all over the world in the concrete industry. The advantages of metakaolin are not only the many concrete performance benefits, both in mechanical and durability properties, but also the environmental benefits. While the production of portland cement is associated with high CO_2 emissions. Metakaolin is a dehydroxylated form of the clay mineral kaolinite. Metakaolin can be produced by primary and secondary sources containing kaolinite are high purity kaolin deposits, kaolinite deposits or tropical soils of lower purity, paper sludge waste which contains kaolinite, oil sand tailings contains kaolinite. From the previous observations it is proved that use of waste product namely Metakaolin increased compressive and flexural strengths, increases durability. Metakaolin usage helps in developing high performance and high strength in concrete.

Quarry dust is a residue tailing or other non-voluble material after extraction and processing of rocks to form fine particle less than 4.75mm. Quarry waste, which is generally considered as a waste material, causes an environmental load due to disposal problem. The successful utilization of quarry waste as fine aggregate would turn this waste material into a valuable resource. In addition, the strain in the supply of natural sand will be reduced, and the cost of concrete production will be offset if the quarry waste is used as a partial replacement of cement. However, it should be ensured that the incorporation of quarry waste does not harm the key properties and durability of concrete at the expense of cost reduction.

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Figure-1 Metakaolin powder

Figure-2 Quarry dust

SUMMARY OF LITERATURE

An investigation by replacing cement with metakaolin, sea wage to find out the durability of concrete against sulphate attack. The effect of metakaolin addition proved to be beneficial in improving the resistance of concrete to sulphate attack. Autoclaved cured specimen had better resistance against sulphate than moist cured specimen. With regard to workability and setting time, metakaolin generally required more super plasticizer and it reduces the setting time of pastes as compared to control mixtures, replacing of cement with metakaolin10 % to 50% and 100% are 10% and 50% gives more strength compare to conventional concrete and replacing of sand with quarry dust 10% to 50% not given expected strength compare to conventional concrete so better suggestion is use normal sand only.

NEED FOR THE RESEARCH

In order to reduce the content of cement in concrete we are replacing cement with metakaolin, sea wage and sand with quarry dust, M-sand which will improve the strength and durability.

To protect the depletion of natural resources, pozzolanic material is replaced in concrete. This research is done to increase the strength of cement with metakaolin, sea wage and sand with quarry dust, (M-Sand). This research is done to construct building with high fire resistant properties.

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EXPERIMENTAL INVESTIGATION

In this study 3 mixes are taken (M1and M2and M3) and the material used are Ordinary Portland Cement (53 Grade), metakaolin, Sea wage, M- Sand, quarry dust, coarse aggregate and water. The tested for their chemical characteristics of materials as per the relevant standards. Table 1Shows the various designation of mixes and Table-2&3&4 Shows the characteristics of metakaolin and quarry dust and Table-5 Shows the properties of cement.

Table-1 Design of Mixes

MIX	DESIGNATION OF CONCRETE
Conventional Concrete	M1
Replace cement with metakaolin concrete	M2
Replace sand with quarry dust	M3

CHEMICAL CHARACTERSTICS OF MATERIALS

Table-2 Chemical characteristics of metakaolin

Metakaolin chemical composition	Weight
$SiO_2+Al_2O_3+Fe_2O_3$	>97.0
Sculpture Trioxide(SO_3)	<0.50
Alkalis(Na_2O,k_2O)	<0.50
Loss on ignition	<1.00

Table-3 Chemical composition of metakaolin

Constituents	Values
SiO_2	58.03%
Al_2O_3	36.32%
Fe_2O_3	0.95%
TiO_2	1.30%
CaO	0.06%
MgO	0.36%
Na_2O	0.12%
K_2O	0.00%
Loi	2.85%

Table-4 Chemical composition of quarry dust

Item	Quarry rock dust
SiO_2	62.48
Al_2O_3	18.72
Fe_2O	6.54

Table-5 Properties of cement

S.No	Properties of cement	Results
1	Specific gravity	3.15
2	Standard consistency	3Fig1%
3	Initial setting time	33min

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COMPRESSIVE STRENGTH

The compressive strength of concrete was determined at 7, 14 &28days of curing. Tests were carried out on 150x150x150mm size cubes. A 2000 kN capacity standard compression testing machine was used to conduct the test. The result are presented Table 6&Table 7

Table-6 Compressive strength of for different conventional concrete mixes

S.No	Days	Percentage of metakaolin	Compressive strength (N/mm^2)
M1	7	0%	19.58
M1	14	0%	32.48
M1	28	0%	53.22
M2	7	3%	13.57
M2	7	6%	16.71
M2	7	9%	23.31
M2	7	12%	23.74
M2	14	3%	28.32
M2	14	6%	34.15
M2	14	9%	45.27
M2	14	12%	46.11
M2	28	3%	41.31
M2	28	6%	45.51
M2	28	9%	51.20
M2	28	12%	55.20
M3	7	3%	15.57
M3	14	6%	38.21
M3	28	12%	53.82

Figure-3 Compressive strength test

SPLIT TENSILE STRENGTH

Split tensile strength was determined for 7, 14&28 days. The test was carried out on cylinder specimens 150mm diameter and length 300mm using 2000kN capacity compression testing machine the results are presented in Tables 8&9&10 and the figure-3 Shows the experimental split tensile test.

Table-8 Split tensile strength of for different conventional concrete mixes

S.No	Days	Split tensile strength (N/mm^2)
M1	7	2.77
M1	14	3.64
M1	28	4.28
M2	7	2.77
M2	14	4.87
M2	28	4.78
M3	7	2.77
M3	14	3.95
M3	28	4.78

Figure-3 Split tensile test

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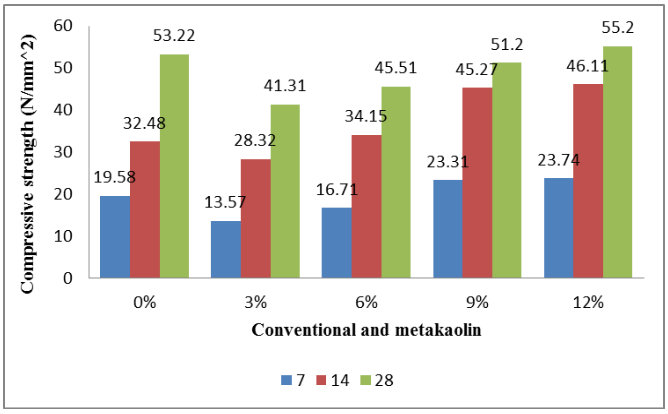

Figure-4 Comparison of 7, 14&28 days compressive strength of normal concrete and metakaolin concrete

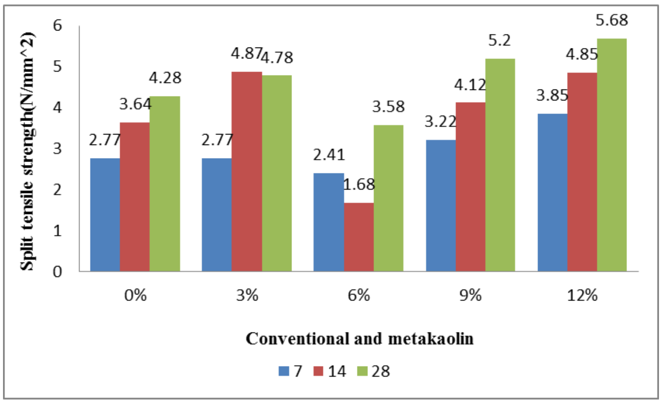

Figure-5 Comparison of 7, 14&28days split tensile strength of normal concrete and metakaolin concrete

DETAILS OF SPECIMENS

A total of 23 reinforced concrete (RC) beams were cast for flexural test. All the beams were rectangular in cross section and designed as under reinforced beams. Three beams were conventional concrete and (denoted with **CC**)and Two beams were 9%+1% metakaolin concrete, sea wage, Two beams were 19%+1% metakaolin concrete, sea wage, Two beams were 29%+1% metakaolin and sea wage, Two beams were 49%+1% metakaolin and sea wage, Two beams were 99%+1% metakaolin and sea wage and Two beams were 9%+1% quarry dust and M-sand, Two beams were 19%+1% quarry dust and M-sand, Two beams were 29%+1% quarry dust and M-sand, Two beams were 49%+1% quarry dust and M-sand and Two beams were 99%+1% quarry dust and M-sand .the beam dimensions were also sufficiently large to simulate a real structural element. The yield strength fy for tension steel bars were 415 N/mm^2, Top reinforcement 8m bars and bottom reinforcement10mm bars respectively. Pure bending region 150mm.

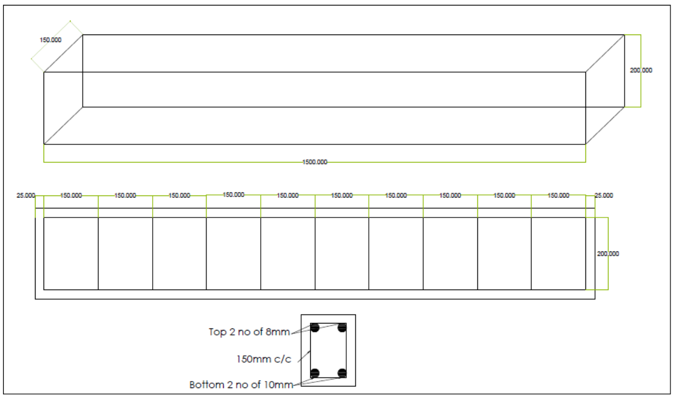

Figure-6 Typical reinforcement detailing for the beam test

EXPERIMENTAL AND TESTING

The beam was loaded under two point loading in order to keep the bending movement constant and predominating at the middle one third regions. Two steel columns were erected over a girder placed on rigid footing. The column head placed with an arrangement on two sides simply supported and two plates and a pin at the centre. The beam was placed on those supports with exactly 1500mm distance from the centre to centre of pin. At 1/3 points two roundbars of dia 30mm were placed over them. Exactly atthe centre between two round rods on the girder a hydraulic jack was placed. The top of the hydraulijack was fixed with a proving ring with dial gauge of capacity of 50T.The load was applied manuallythrough hydraulic jack. The increment of loading waskept as 2 divisions of dial gauge (2kN) in the proving ring. To record the load precisely a proving ring wasused. The load is applied measured for every 2 kN. The deflection of the beam at the point of loadingduring test was measured such as 2kN, 4kN, and 6Kn respectively figure 6 and 7.

Figure-7 Experimental test setup

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FAILURE PATTERN

All the beams exhibit a reasonably ductile performance as failure results from the yielding of high performance concrete followed by the crushing of concrete. At about 33% of the ultimate load, well flexural cracks appeared at the bottom of the specimen. With further increase in the load, regularly spaced vertical cracks were observed and they extended from the bottom of the specimen towards the top fiber. The failure occurs in the tensile zone following the appearance of one macro crack in pure bending region. The load was increased up to ultimate stage. After the attainment of ultimate load, the load was maintained till failure due to the confinement effect provided by high performance concrete.

LOAD AND DEFLECTION

Conventional concrete beam specimen and metakaolin and quarry dust concrete (10% to50% and 100% metakaolin concrete and 10% to 50% and 100% quarry dust concrete) which was tested for their flexural behaviors and the average result are plat in to the graph are shown in Figure 8 and 9.

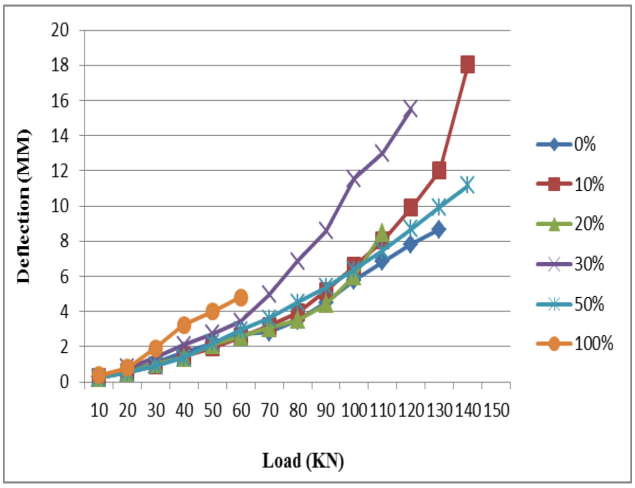

Figure-8 Load-Deflection curve for conventional and metakaolin concrete 28 days

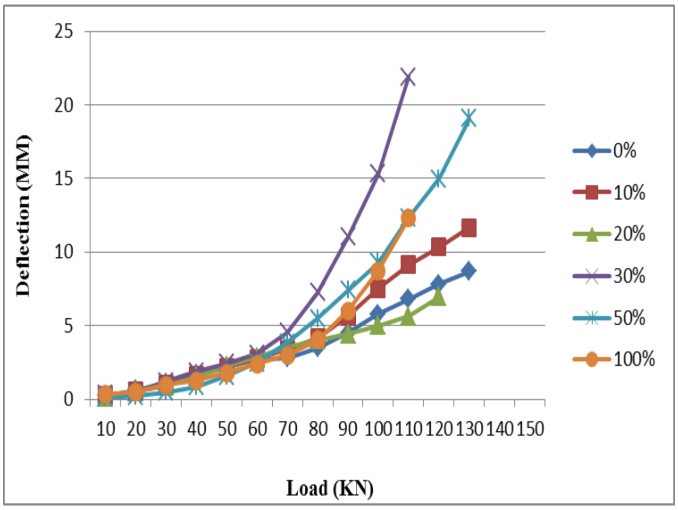

Figure-9 Load- Deflection curve for conventional and quarry dust concrete 28 days

CONCLUSION

The tests on beams carried out in this study describe the possible of use of high performance concrete using 10% to 50% and 100% of cement with metakaolin, sea wage and 10% to 50% and 100% of sand with quarry dust, M-sand. The results of the experimental study reported here, the following conclusions can be drawn

Partial replacement of cement by Metakaolin, sea wage and Quarry Dust and M- sand by sand in concrete mixes would lead to considerable saving in consumption of cement and sand.

The ultimate load carrying capacity of High performance concrete beam using 10%to 50% Metakaolin, sea wage by cement and 10%to50% Quarry Dust, M-sand by sand is found to be initial 36kN and ultimate load140kN, at the age of 28 days of curing. This shows that there is increase in load carrying capacity by 8.33%, and 26.67 %, compared with Conventional concrete Beam.

The advantages of introducing high performance concrete by using 10% to 50% of cement with Metakaolin, sea wage and 10% to 50% of sand with Quarry Dust, M- sand the slowing down the first crack appearance and the presence of smaller deflection, compared with Conventional concrete Beam.

Using of 50% metakaolin replaced with cement concrete is more preferable than 50% quarry dust replaced sand concrete due to 8% increase in ultimate load and 58.03 lesser deflection

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