AN EXPERIMENTAL STUDY ON INFLUENCE OF METAKAOLIN AND QUARRY DUST IN CONCRTE PROPERTIES BY PARTIAL REPLACEMENT OF CEMENT AND FINE AGGREGATE

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ABSTRACT

The present study is on the partial replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate. This paper deals with the properties of concrete with varying percentage replacement of Metakaolin and Quarry Dust in M-25 grade of concrete. The mix M1, M2, M3, M4 and M5 were obtained by replacing 0%, 5%, 10%, 15% and 20% mass of cement by Metakaolin and Fine Aggregate by Quarry Dust. The test results indicated that Metakaolin and Quarry Dust used at optimum quantity tend to increase the strength of the concrete mix when compared with conventional concrete.

Keywords:- Metakaolin, Quarry Dust, Compressive Strength, Split Tensile Strength, Flexural Strength.

1. INTRODUCTION

Concrete is the most extensively used construction material. Maintenance and repairs for the concrete structures are the major problems that involved in noteworthy overheads. By using some supplementary materials which satisfies the properties of cement, we can partially replace it with cement which gives more strength when compared with conventional concrete. The addition of supplementary materials in cement has dramatically increased along with the development of concrete industries. Due to the consideration of cost saving, energy saving, environmental concerns both in terms of damage caused by the extraction of raw materials and Carbon Dioxide emission.

2. LITERATURE SURVEY

M. Fries et al.(2000):- In their experiment work the results revealed that MK mortars produce a slight heating increase when compared to a 100% Portland cement mortar, due to the high pozzolain activity of MK. With respect to the hydration heat, MK-blended mortar showed closer behaviors to silica fume than to fly ash at various percentages.

Abdul Razak et al.(2005):- In this study, Metakaolin and Silica Fumes were used as cement replacement materials at 5%, 10%, 15% by mass. The study concluded that at age 28 days and above 97% of esteemed strengths are within ±5% of actual value.

Rafat Siddique et al.(2008):- They said that the supplementary cementing material has become an integral part of high strength and high performance concrete mix designs. The partial replacement of cement with Metakaolin reduces the water penetration into concrete by capillary action. Metakaolin helps in enhancing the early age mechanical properties as well as long-term strength properties of cement paste/mortar/concrete.

S. Aiswarya et al.(2013):- This paper reviews the use of Metakaolin as supplementary cementations materials in concrete. From the recent research works using Metakaolin, it is evident that it is a very effective pozzolanic material and it effectively enhances the strength parameters of concrete.

P. Dinkar, K. Pradosh Sahoo et al.(2013):- This study presents the effect of incorporating Metakaolin on the mechanical and durability properties of high strength concrete with cement replacements of 5%, 10% and 15% were designed for target strength. Using Metakaolin as a partial replacement for cement decreased the plastic density of the mixtures.

U. Iliyas Rasoolbhai and P. Vandana Pandya(2015):- By their experiment they said that the Metakaolin has a good effect on the mechanical properties of cement by incorporating 5%, 10%, 15%, 20% Metakaolin.

A. Sunny Jagtap et al.(2017):- This study said that the strength of concrete increases with increase in Metakaolin content up to 15% replacement of cement. After that the Compressive Strength, Spit Tensile Strength of concrete will be decreased.

P. Muralinathan et al.(2018):- Metakaolin improves the pozzolanic reaction by filler effect and accelerate the hydration of cement. In this study Metakaolin blended with concrete is exposed to elevated temperatures. When these specimens are heated to an increase in temperatures like 100°C, 200°C and 300°C, there is an increase in the strength of specimens at 100°C.

3. MATERIALS USED

Cement:- The main raw material for the production of cement is clinker. Clinker is an artificial rock made by heating limestone and other raw materials in specified quantities to a very high temperature in a specially made kiln. Cement is made by finely pulverizing the clinker produced by calcining a mixture of argilaceous and calcareous materials.

Metakaolin is neither the by-product of an industrial process nor is it entirely natural. It is derived from naturally occurring mineral and is manufactured specially for cementing applications. It is the form of anhydrous calcined form of clay mineral Kaolinite. It is a cementations material used as an admixture to produce high strength. It was reported that the Metakaolin showed the best improvement on the engineering properties of concrete.

Fine Aggregates are the particles which are passing through 4.75 mm sieve and retained on 75μm sieve are called fine aggregate. The river sand conforming to zone as per IS: 383 -1987 was used. Fine Aggregate is a granular material composed of finely divided rock.

Quarry Dust is a by-product of the crushing process which is a concentrated material to use as aggregates for concreting purpose, especially as fine aggregates. In quarrying activities, the rock has been crushed into various sizes. After the quarry blasting the dust generated is called quarry dust.

Coarse Aggregates are the particles which are passing through 80 mm sieve and retained on 4.75mm sieve are called fine aggregate. Coarse Aggregate is a granular material composed of coarsely divided rock.

4. CHEMICAL COMPOSITIONS

Table 1:- Chemical Composition of Cement

Chemicals	Cement
CaO	63.9%
SiO_2	21%
Al_2O_3	5.2%
MgO	3.9%
SO_3	2.4%
Fe_2O_3	2.3%
Na_2O	0.5%
K_2O	0.5%

Table 2:- Chemical Composition of Metakaolin

Chemicals	Metakaolin
SiO_2	51.2%
Al_2O_3	45.3%
Fe_2O_3	0.60%
LOI	0.51%
TiO_2	0.36%
Na_2O	0.21%
K_2O	0.16%
MgO	0.15%
CaO	0.06%

5. EXPERIMENTAL PROGRAM

5.1 Casting of Specimens:-

The test program considered the cast and testing of concrete specimens of cube (150mm) and cylinder (150x300mm) and prism. The specimen was cast M25 grade concrete using OPC, Natural River sand and crushed stone (20mm - 4.75mm) with Metakaolin and Quarry Dust. Each three numbers of specimens made to take the average value. The Specimens demoulded after 24hrs. The specimens were allowed to the curing periods.

5.2 Testing of Specimen:-

Testing of specimen was shown in Fig 3.1, 3.2, 3.3. The Compressive Strength, Split Tensile Strength and Flexure Strength of test values were presented in table 3, 4, and 5.

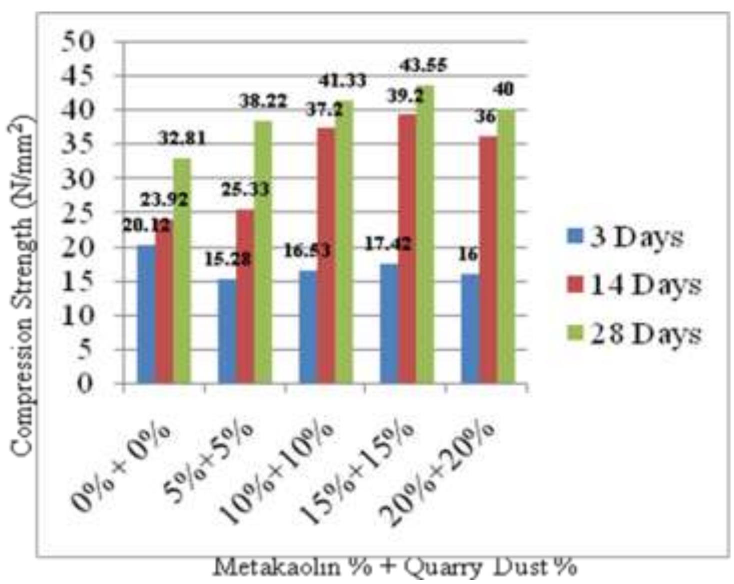
5.2.1 Compressive Strength:-

For each mix the cubes were casted (3days, 7days and 28days) and tested using Compression Testing Machine (CTM). The specimen placed on the platform of the CTM. The load applied gradually until the failure stage. The ultimate load noted and calculated the compressive strength of corresponding specimen.

Fig1:- Testing of Cubes

Table 1:- Compressive Strength in MPa

Replacement with Metakaolin in Cement (%)	Replacement with Quarry Dust in Fine aggregate (%)	3 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
0	0	20.12	23.92	32.81
5	5	15.28	25.33	38.22
10	10	16.23	37.20	41.33
15	15	17.42	39.20	43.55
20	20	16.00	36.00	40.00



Graph 1:- Compressive Strength values for Cubes

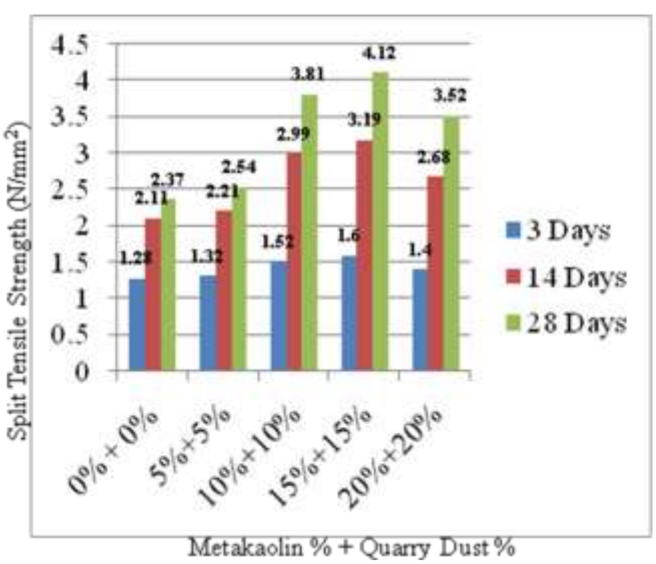
5.2.2 Split Tensile Strength:-

For each mix the cylinders were casted and tested in CTM. The specimen placed perpendicular to normal axis on the platform of the CTM. The load applied gradually until the failure stage.

Fig 2:- Testing of Cylinders

Table 2:- Split Tensile Strength in MPa

Replacement with Metakaolin in Cement (%)	Replacement with Quarry Dust in Fine aggregate (%)	3 days (N/mm²)	14 days (N/mm²)	28 days (N/mm²)
0	0	1.28	2.11	2.37
5	5	1.32	2.21	2.54
10	10	1.52	2.99	3.81
15	15	1.60	3.19	4.12
20	20	1.40	2.68	3.70



Graph 2:- Split Tensile Strength values for Cylinders

5.2.3 Flexural Strength:-

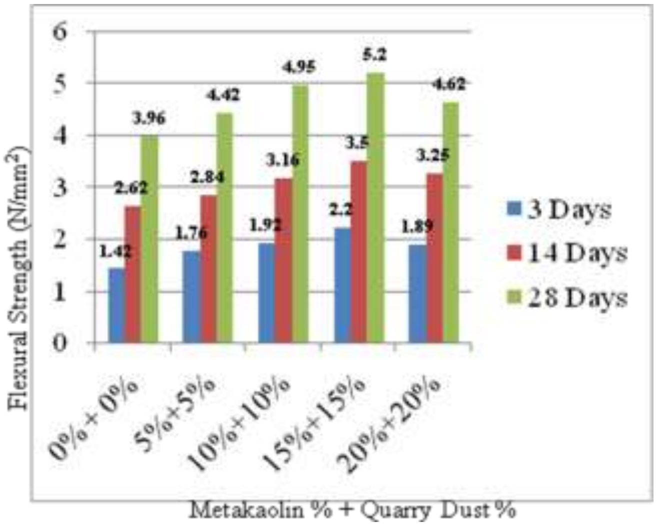
For each mix the prisms were casted and tested in Flexural Testing Machine (FTM). The specimen of prism placed horizontally on the platform of the FTM. The ultimate load noted and calculated the flexural strength of corresponding specimen.

Fig 3:- Testing of Prisms

Table 3:- Flexural Strength of Concrete Prisms

Replacement with Metakaolin in Cement (%)	Replacement with Quarry Dust in Fine aggregate (%)	3 days (N/mm²)	14 days (N/mm²)	28 days (N/mm²)
0	0	1.42	2.62	3.96
5	5	1.76	2.84	4.20
10	10	1.92	3.16	495
15	15	2.20	3.50	5.20
20	20	1.86	3.25	4.62

Graph 3:- Flexural Strength values for Cylinders



Graph 2:- Split Tensile Strength values for Cylinders

6. CONCLUSIONS

Based on the Experimental Results and subsequent discussions the conclusions are summarized below:

1. The Compressive Strength, Split-Tensile Strength and Flexural Strength has been increased by partial replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate.
2. The maximum values of Compressive Strength, Split-Tensile Strength and Flexural Strength obtained at 15% of the partial replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate.
3. At 15% replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate the Compressive Strength (43.55 N/mm^2) is increased up to 26.34% when compared to Conventional Concrete (34.47 N/mm^2).
4. At 15% replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate the Split-Tensile Strength (4.12 N/mm^2) is increased up to 73.84% when compared to Conventional Concrete (2.37 N/mm^2).
5. At 15% replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate the Flexural Strength (5.20 N/mm^2) is increased up to 31.31% when compared to Conventional Concrete (3.96 N/mm^2).

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