An Experimental Study on Concrete Properties by Partial Replacement of Cement and Fine Aggregate with Metakaolin and Quarry Dust

K Haritha Valli Satya[1] |S Chandrashekar[2] |N Chaitanya Abhishek[3] |D Brahma Reddy[4] |S Vamsi Harischandraprasad[5]|Dr. Dumpa Venkateswarlu[6]

[1, 2. 3. 4]UG Students, Department of Civil Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

[5]Assistant Professor, Department of Civil Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India.

[6]Professor, Department of Civil Engineering, Godavari Institute of Engineering and Technology (A), Rajahmundry, Andhra Pradesh, India

Abstract: This paper shows that the results of an experimental study on Concrete is carried out to find out the effect of partially replacing Cement with Metakaolin and Fine aggregate with Quarry dust.The partial replacement of cement with metakaolin which are having silica used as admixture for making concrete as well as partial replacement of fine aggregate with quarry dust due to the low availability of fine aggregate. Our project deals with partial replacement at 0%, 5%, 10%, 15%, and 20% mass of Fine aggregate with Quarry dust and Cement with Metakaolin in M-25 grade of concrete.The properties of concrete like compressive strength, split tensile strength and flexural strength of concrete made with partial replacement of cement and fine aggregate with metakaolin and quarry dust is high compared to the nominal concrete.The maximum results of Compressive Strength, Split-Tensile Strength and Flexural Strength gained at 15% of the partial replacement ofCement and Fine Aggregate with Metakaolin and Quarry Dust respectively.

KEYWORDS: Compressive strength, flexural strength, metakaolin, quarry dust, split tensile strength.

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I. INTRODUCTION

Concrete is a composite material consisting of cement, fine aggregate, coarse aggregate and water in suitable proportions. Concrete is the most widely use man-made construction material in the world. The consumption of all type of aggregates has been increasing in recent years. Artificially manufactured aggregates are more expensive to produce and the other factor to be considered is the continuous extraction of natural aggregates which causes.

Advancement in utilization of wastes in concrete as admixture reduces pollutants in environment and maximizes usage of natural resources. During the production of cement Co2 is produced which cause global warming. By reducing cement consumption environment can be protected.

1.1 Scope and Need of work

The consumption of cement for construction goes to increasing with the increase of population because shelter is the main for human being. The present study deals with the utilization of Metakaolin powder by adding to cement and Quarry Dust by adding to Fine Aggregate to achieve strength.

1.2 Objectives

- To check the suitability of Metakaolin as a binding material (partially) instead of cement
- To investigate the alternative material of fine aggregate for minimizing the effect of natural sand inconstruction.
- To improve strength characteristics of concrete by adding Metakaolin and Quarry Dust.

I. LITERATURE REVIEWS

Dinkar p, et al. (2013):-This study presents the effect of incorporating Metakaolin on the mechanical and durability properties of high strength concrete for a constant water/binder ratio of 0.3 MK mixtures with cement replacementsof5%,10%and15%weredesignedfortargetstrengthandslumpof90MPa and 100 ± 25 mm. Using Metakaolin as a partial replacement for cement decreased the plastic density of themixtures.

Joseph a, et al (2017):-Investigated that the effect of metakaolin as mineral admixture in the self-compacting Concrete. Partial replacement at 0, 5, 10, 15, 20 & 25% weight of cement by metakaolin in M60 grade self-compacting concrete. The optimum amount of metakaolin was obtained as 15% in terms of compressive and split tensile strength.

M. Narmatha et al. (2016):-Cement is the most extensively used construction material. Maintenance and repair of concrete structures is a growing problem involving significant expenditure. As a result carried out worldwide, it has been made possible to process the material to satisfy more stringent performance requirements, especially long-term durability. The strength of all Metakaolin concrete mixes over shoot the strength of Ordinary Portland Cement. The increase in Metakaolin content improves the compressive strength, split tensile strength up to 15% cement replacement.

Shyam Prakash et al. (2016):-Studied on compressive strength of quarry dust as fine aggregate in concrete. From the experiment study concluded that the quarry dust can be used as a replacement for fine aggregate. It is found that 40% replacement of sand by quarry dust gives maximum result in strength compared to nominal concrete.

Venu Malagavelli et al. (2018):-Found that the fresh properties like workability is increases as the percentage of metakaolin is increases. The maximum of 10% can be replaced by cement with metakaolin. Concluded that the percentage increment in strength properties are 16.75,7.1, 7.88 in compression strength, split tensile strength, flexural strength respectively.

MATERIALSUSED

3.1 Cement

Cement is produced by a raw material called clinker. It is a binder, a substance used for construction that sets, hardens, and adheres to other materials to bind them together.

Table 1 Chemical composition of Cement

Chemicals	Cement
CaO	63.9%
SiO_2	21 I %
Al_2O_3	5.2%
MgO	3.9%
SO_3	2.4%
Fe_2O	2.3%
Na_2O	0.5%
K_2O	0.5%

3.2 Metakaolin

Metakaolin is obtained by controlled thermal heating of the clay mineral kaolinite. The size of metakaolin particle is small as compared to the cement particle. But not as fine as silica fume. It shows that the increased results of compressive and flexural strength of concrete.

Table 2 Chemical Composition of Metakaolin

Chemicals	Metakaolin
SiO_2	51.2%
Al_2O_3	45.3%
Fe_2O	0.60%
LOI	0.51%
TiO_2	0.36%
Na_2O	0.21%
K_2O	0.16%
MgO	0.15%
CaO	0.06%

3.3 Coarse aggregate

The aggregates which tends to retain in 4.75 mm IS sieve is termed as coarse aggregates. Coarse aggregates makes the more economical the mix.

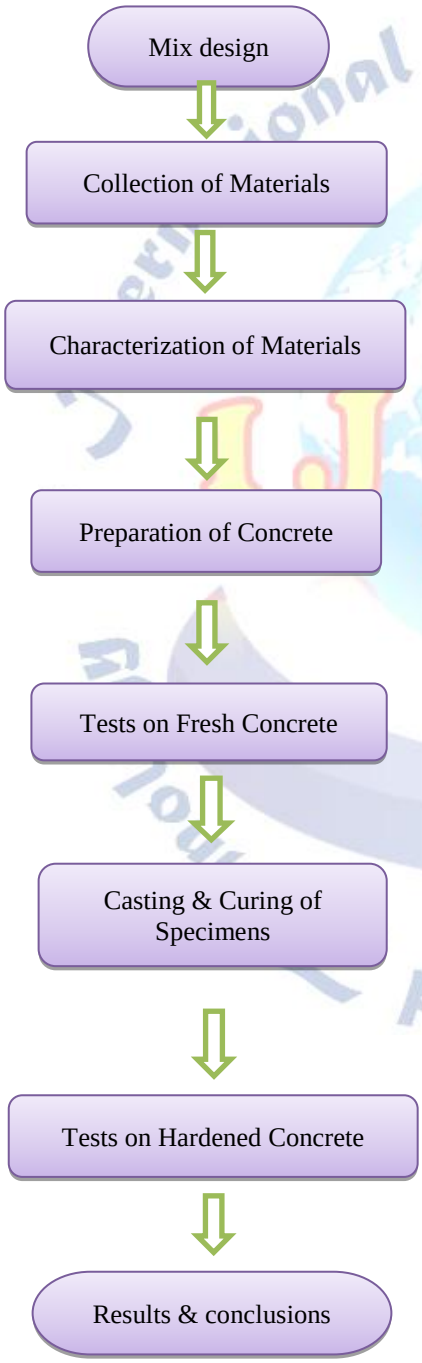
3.4 Fine aggregate

The aggregates which passes through the 4.75 mm IS sieve is termed as fine aggregate. It gives required strength and density to the concrete.

3.5 Quarry dust

The Rock has been crushed into various sizes in quarrying. The dust is produced during the quarrying is called as quarry dust.

METHODOLOGY



The concrete mix is designed for M25 grade and the obtained mix proportion is 1:1.44:2.37 with water - cement ratio of 0.4. All the required materials Like Cement, Fine Aggregate, Coarse Aggregate, Metakaolin and Quarry dust are collected and delivered to the laboratory.Tests were conducted on the raw materials to determine their properties and suitability for the experiment.The concrete cubes are casted and used as test specimens to obtain the compressive strength, split tensile strength and flexural strength of concrete. The test results of both the concretes are compared and presented in the following tables and graphs, based on the results conclusions are forwarded.

EXPERIMENTS CONDUCTED

COMPRESSIVE STRENGTH TEST:

Compressive strength test was carried out on 150*150*150mm size cubes. Cubes were prepared for 7, 14 and 28 days of curing and tested with UTM. The specimens were loaded at a constant strain rate until failure. The compressive strength is decreased with an increase in the percentage of metakaolin and quarry dust in cement and fine aggregate.

SPILTTENSILESTRENGTHTEST:

The tensile strength of concrete is obtained by applying a compressive force along the length of the concrete cylinder. The test was carried out on the specimen of dimensions of 150 mm in diameter and 300 mm in length. Cylinder specimens were prepared for 7, 14 and 28 days of curing and tested with UTM

Resultant split tensile strength $ft = \frac{2P}{\pi DL}$

P = Load at which specimen breaks

Replacement with Metakaolin in cement %	Replacement with Quarry dust in fine aggregate%	COMPRESSIVE STRENGTHVALUES		
		7days	14days	28days
0%	0%	20.54	21.16	22.14
5%	5%	27.55	29.54	32.81
10%	10%	29.72	31.81	34.18
15%	15%	31.61	35.49	42.81
20%	20%	27.56	30.20	34.18

FLEXURALSTRENGTHTEST:

Flexural strength is one measure of the tensile strength of concrete. It is a measure of unreinforced concrete beam to resist failure in bending. It is measured by loading 150*150mm concrete beams with a span at least 3 times the depth. The flexural strength is expressed as modulus of rupture.

The systems of loading used in finding out the flexural tensions are

- Central point loading
- Third point loading

EXPERIMENTALRESULTS

The test results of the samples were compared with the respective control concrete properties and the results were presented using tables, pictures and graphs. Conclusions and recommendations were finally forwarded based on the findings and observations.

Table 1: Compressive Strength Test

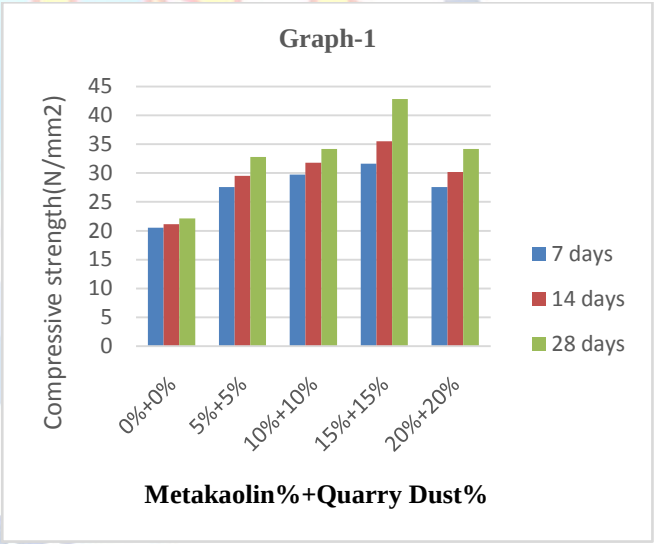


Table 2: Split Tensile Strength Test

Replacement with Metakaolin in cement %	Replacement with Quarry dust in fine aggregate%	SPLIT TENSILE STRENGTHVALUES		
		7days	14days	28days
0%	0%	1.42	1.91	2.36
5%	5%	1.56	2.01	2.45
10%	10%	1.60	2.92	3.72
15%	15%	1.71	3.36	4.19
20%	20%	1.59	2.87	3.69

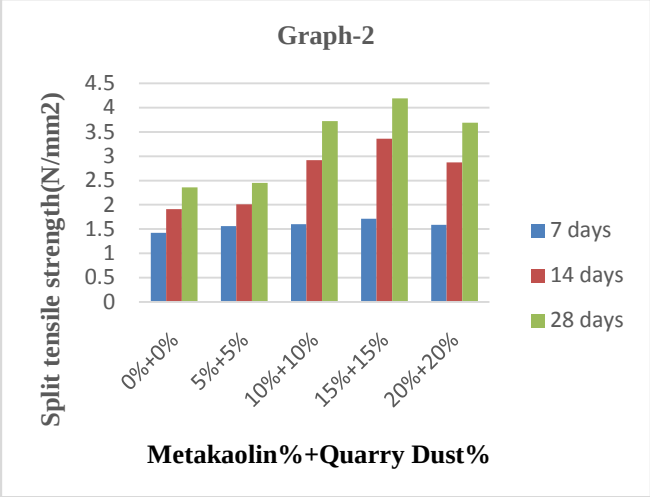
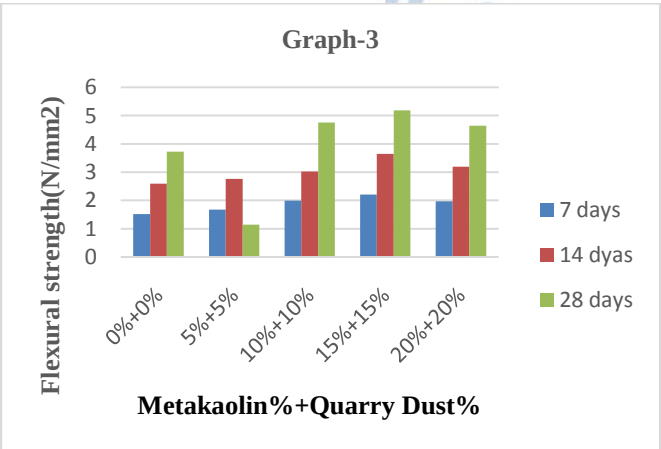


Table 3: Flexural Strength Test

Replacement with Metakaolin in cement %	Replacement with Quarry dust in fine aggregate%	FLEXURAL STRENGTHVALUES		
		7days	14days	28days
0%	0%	1.52	2.59	3.72
5%	5%	1.67	2.76	4.14
10%	10%	1.99	3.02	4.76
15%	15%	2.21	3.65	5.19
20%	20%	1.97	3.19	4.64



CONCLUSIONS

1. The Compressive Strength, Split Tensile Strength and Flexural Strength of Concrete by partial replacement of Cement and Fine AggregateMetakaolin and Quarry dust is high compared to the Nominal Concrete.
2. The maximum results of Compressive Strength, Split-Tensile Strength and Flexural Strength gained at 15% of the Concrete made with partial replacement of Cement and Fine Aggregate with Metakaolin and Quarry Dust respectively.
3. At 15% replacement of Metakaolin and Quarry Dust in Cement and Fine Aggregate the Compressive Strength, Split-Tensile Strength and Flexural Strength has increased up to 93.36%, 77.54% and 39.51%respectively.

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