

A Study on Strength & Workability of Concrete by Replacing Cement with Metakaolin & Sand with Quarry Dust

Bhavya Bharathi T¹, Sai Ramya K²

P.G. Student, Department of Civil Engineering, VVIT College, Guntur, A.P, India

Assistant professor, Department of Civil Engineering, VVIT College, Guntur, A.P, India

ABSTRACT: Concrete is widely used material for any construction work. The production of cement has been increased worldwide from 1990. Because of the emission of CO₂ gas, a lot of environmental pollution occurs. Metakaolin seems to be best cementitious material for the preparation of high performance concrete. The properties of Metakaolin are suitable for high HPC. Possible low cost and large availability in our country are the advantages to usage of Metakaolin in HPC. Day by day the demand of Construction sand has been increased. It results in Sources reduction and also an increase in Cost. So, we have to replace a suitable substitute, which is eco friendly and Low Cost quarry dust was used as an alternative to the sand to produce Concrete.

This paper dealing with partial replacement of Sand with Quarry dust and cement with Metakaolin which are having PCE (poly carboxyl ate ether) used as an admixture to produce concrete. First sand was replaced with quarry dust and found that 25% of partial replacement was beneficial to concrete with no loss of standard strength of sand. Making 25% partial replacement of sand with quarry dust as constant, 0, 2.5%, 5%, 7.5%, 10%, 12.5%, 15% Metakaolin was partially replaced in cement. Cubes and Cylinders are made to determine the Compressive & Split Tensile strength of concrete. The optimum % of replacing of Metakaolin in high strength concrete was found by using these studies.

KEYWORDS: Metakaolin, Quarry Dust, Compressive Strength & Split Tensile Strength, HPC.

I. INTRODUCTION

Concrete is most generally used material for construction in the world, and the properties of concrete subjected to changes through Technological advancement. Concrete is largest material which is second place of consumed by Human beings after food & Water according to WHO. Many types of Concrete were developed to improve the different properties of Concrete. This development should be divided into 4 stages. First one is the normal strength concrete that consists of 4 materials. They are water, cement, fine aggregate and coarse aggregates. To the Concrete Some Pozzolanic additives are added. These are the materials or admixtures which can improve the properties of concrete that are strength, durability and impermeability. Those are used either partial replacement of Portland cement (or) used as addition.

Kaolin is white & fine clay mineral which is being using in the manufacture of porcelain. Kaolinite is a mineralogical term which is related to kaolin clays. Kaolinite is a (hydrated aluminum disilicate) the common constituent of kaolin. Metakaolin improving the durability & strength of concrete to change concrete more suitable for construction. The principal reason for use of pozzolanas like metakaolin in concrete is due to its easily available nature. The use of metakaolin results in concrete significant improvement in strength. When compared to other pozzolanas, metakaolin has a large potential in concrete hence, it has been chosen for the present study.

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Quarry Dust is a byproduct which released from the crushing & cutting of Stone. So it will become as a waste material and it will also cause air pollution also. Thus, Quarry dust may be utilized in building construction as a fine aggregate, which will be reduce the cost of Construction. In this paper Quarry Dust is used as a Fine Aggregate. Super plasticizers (or) high range water reducers were used to get very high slumps in normal cement concrete with low water-to-cement ratios. Generally, the strength of concrete was inversely proportionality to the amount of water (or) water to cement ratio. To produce strong concrete, less water is added, that made the concrete mixture with low workability and difficult to mix which needs the use of super plasticizers (HI FORZA 705).

II. LITERATURE REVIEW

2.1 Literature Review on Metakaolin

- **A.V.S. Sai Kumar, Krishna Rao.B**(March 2014) investigated on the Concrete strength with replacement of cement with Quarry dust and Metakaolin partially. The replacement was done in order of 0%, 5%, 10%, 15% and 20% with Cement by Metakaolin. The Concrete mix with M30 grade was prepared for experimental investigation. Cubes and Cylinders were tested for Compressive, Split tensile, flexural Strength of concrete respectively. The tests were performed after 7, 28 and 90 days of curing specimens. The decrease in Compressive Strength was observed by the replacement of 25% cement with Quarry dust. It was clear that up to 10% of Metakaolin addition the Strength is increased. After 10% the Strength is decreased.
- **BinduBiju, Imran H** (Dec 2016) are investigated on cement replacement with Metakaolin partially in high HPC. In this study is they prepare a High Performance Concrete mix for the M70 grade. The replacement was taken in an order of 0, 2.5, 5, 7.5, 10 and 12.5% to cement with Metakaolin. The Compressive Strengths for MHPC 2.5, 5, 7.5, 10, 12.5 are determined. Up to 10% of Metakaolin the Compressive Strength increases. After 10% the Strength decreases from results.
- **J.Thivya, M.Arivukkarasi**(April 2016) investigated on replacing of cement with Metakaolin and fine aggregate with Granite Powder partially. The Metakaolin to be added was 0%, 5%, 10%, 15%, 25% by in the place of cement and Granite powder is 0%, 10%, 15%, 20%, and 25% in the place of Sand. The Compressive strength, flexural Strength & split tensile tests are conducted at 7, 14 & 28 days of curing. Finally, Compressive Strength increased 8.5% compared with conventional concrete in 15% Metakaolin and 20% Granite Powder replacement. Split Tensile Strength increases when 20% of Metakaolin and 25% of Granite Powder is added. The flexural Strength increases around 24.5%.

2.2 Literature Review on Quarry Dust

- **G.Balamurugan, Dr.P.perumal**(Dec 2013) investigated on sand replacement by quarry dust. In this study the difference of strength of concrete is determined with the replacing of sand by quarry dust from 0% to 100% in the order of increase of 10%. M20 and M25 grade of concrete mixtures were taken to keep the constant slump of 60mm. The compressive strength of concrete cubes at 7 & 28 days were obtained. This result given that quarry dust should be used in concrete mixtures as a better replaceable material for natural river sand that gives highest strength at the replacement of 50%.
- **S.N.Raman, M.F.M.Zain, H.B.Mahmud, K.S.Tan** (May 2015) were investigated on Quarry Dust as partial replaceable material for sand in Concrete mix. In this study 28 days' compressive strength is find out for the quarry dust replacement and without quarry dust also for comparison purposes. Results obtained indicate that the strength of compression is less for quarry dust replaced concrete. So, the results of study indicate the quarry dust can be used as replacement material to sand partially, in the presence of silica fume to produce concrete with good compressive strength.

III MATERIALS & TESTS ON CONCRETE

Cement: KCP 53 grade OPC as per IS 2720 part3:1980 was used in this study. It was fresh and free from lumps. The Specific Gravity of Cement was 3.15.

Coarse aggregate: Crushed stone aggregates of 20 mm size were used for the overall experimental study and having Specific Gravity of 2.64 as per IS 383-1970 was used.

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Fine Aggregate: The Fine Aggregate which was passing through IS sieve of 4.75mm were used. It was confirming to grading zone-ii of IS 383-1970 and Specific Gravity obtained was 2.64.

Metakaolin: Metakaolin is a calcined form of the mineral clay Kaolinite. Metakaolin powder of particle size is smaller than the particles of cement, but not as small as silica fume. Minerals which are high in Kaolinite are called as china clay (or) Kaolin, which are generally used in manufacture of porcelain. Metakaolin is an Aluminum Silicate with dihydroxylation. Specific gravity of highly reactive Metakaolin is about 2.5. Metakaolin is the beneficial like an admixture in concrete and cement applications. Metakaolin from the Company Astra chemicals, Chennai has been used in this paper.



Fig: Metakaolin Powder

Quarry Dust: Crushed rock aggregate by quarrying generate considerable volumes of quarry fines, which is termed “Quarry dust”. Quarry dust can be defined as residue, tailing or other non-volatile waste material after the extraction and processing of rocks to form fine particles less than 4.75mm.

Water: Fresh & clean tap water was used for casting of cubes and cylinders in this present study.

Super plasticizer: Hi-Forza 705 super plasticizer was used in this paper is prepared from poly carboxylate ether chemical and was obtained from B&B Specialties India Pvt. Ltd., Vijayawada.

Tests on Concrete

Slump Cone Test: The concrete slump test is a test which measures the workability of fresh concrete. More specifically, it measures the consistency of the concrete in that specific batch. This test is performed to check the consistency of fresh concrete. Consistency is a term very closely related to workability

Compression Test: This test is most common & important test conducted on Hardened concrete. The compression test is carried out on cubical specimen; the cube specimen is of size 150mm×150mm×150mm. The aggregate size of 20mm will be used to make concrete mixes.

Split Tensile Test: A method of determining the tensile strength of the concrete using a cylinder which splits across the vertical diameter. The size of cylindrical specimen is 150mm diameter and 300mm height.

Mix Design: M₅₀ grade concrete was prepared according to IS: 10262-2009. The material proportion was 1: 1.930:2.722 & the water cement ratio was taken as 0.35.

IV. EXPERIMENTAL RESULTS

4.1: Preparation of Trial Mixes

Based on the concrete mix design IS 10262 (2009) method seven trial mixes were prepared with different water cement ratios with different percentage of admixtures casting 6 cubes for each mix and were tested at 7 and 28 days. If we observed in the table, Cube strength is good for all mixes and greater than target strength (58.2 Mpa). But slump is achieved @ w/c of 0.35, admixture percentage of 0.9. So, M7 mix is chosen for reference mix.

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Table1: Quantities per cubic meter for trial mixes (M50)

Mi x No	W/ C Ratio	Ce ment(kg)	Sand	Coars e Aggregate	Admi xture (%)	Average cube Strengt h @7 days.	Average cube Strength@2 8 days.	Slump (mm)
M1	0.31	430	782.25	1135.97	0.7	38.35	59	No
M2	0.31	430	781.39	1134.72	0.9	37.895	58.3	10
M3	0.33	410	795.639	1138.316	0.7	39.78	61.2	No
M4	0.33	410	916.75	1311.65	0.9	39	60	20
M5	0.35	410	793.21	1118.14	0.5	37.7	58	50
M6	0.35	410	792.44	1117.204	0.7	38.35	59	65
M7	0.35	410	791.68	1116.05	0.9	38.285	58.9	75

Table2: Slump results

The Slump values are decreasing from the increasing of Quarry Dust and Metakaolin percentage. It was observed in the below table.

% of Quarry Dust	5	10	15	20	25	30
Slump (mm)	72	70	67	62	58	53
%of Metakaolin(25 % QD)	2.5	5	7.5	10	12.5	15
Slump (mm)	50	45	42	40	35	32

4.2: Compressive Strength Test Results

The Compressive Strength test was conducted at 7, 14 & 28 days. The tests were conducted on cubes (150mmx150mmx150mm) and cylinders (150mm in diameter & 300mm in height). Standard Compression testing machine was used for the testing and the results are tabulated below.

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Table3: Compressive Strength Results for Cubes & Cylinders with different % of QD

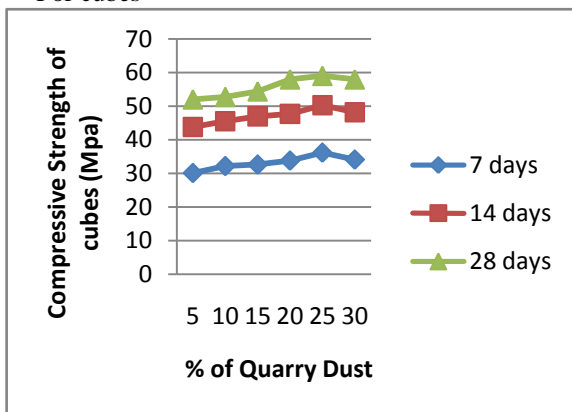
% of Quarry Dust	Compressive Strength					
	Cubes			Cylinders		
	7 days	14 days	28 days	7 days	14 days	28 days
Conventional Concrete	35.85	49.6	58.956	28.72	39.72	47.108
5	30.07	43.8	51.99	24.29	35.25	41.62
10	32.14	45.47	52.73	25.77	36.44	42.36
15	32.59	46.96	54.36	26.07	37.62	43.55
20	33.77	47.69	57.92	26.95	38.22	46.36
25	36.14	50.217	58.962	28.146	39.703	46.96
30	34.07	48.14	57.92	27.407	38.51	43.79

Quarry dust was added to the concrete with the increasing order of 5%, 10%, 15%, 20%, 25% & 30% respectively. The compressive strength was increased up to 25% thereafter, the strength was reduced. Thus, 25% of QD is the optimum value.

Graph1: Variation of Compressive strength

Graph2: Variation of Compressive Strength for

For cubes



Cylinders

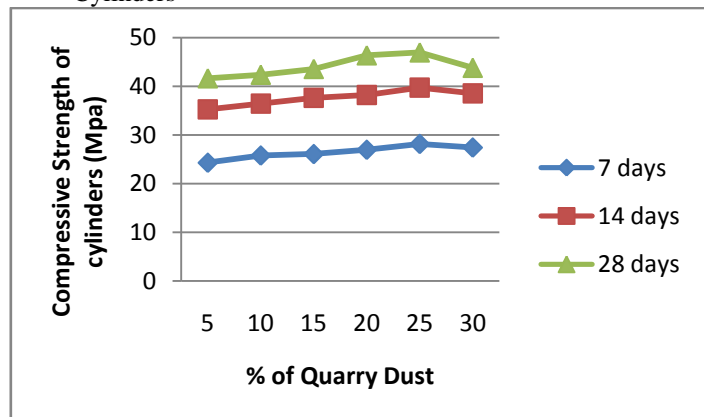


Table4: Compressive Strength Results for cubes & Cylinders with different % of Metakaolin

% of Metakaolin	Compressive Strength (N/mm ²)			
	Cubes		Cylinders	
	7 days	28 days	7 days	28 days
2.5	37.628	59.257	32.586	49.478
5	38.814	59.848	33.184	50.068
7.5	39.703	60.835	33.629	50.513
10	39.851	61.33	33.777	51.407
12.5	40.296	62.517	34.962	52.296
15	39.553	61.626	34.073	51.258

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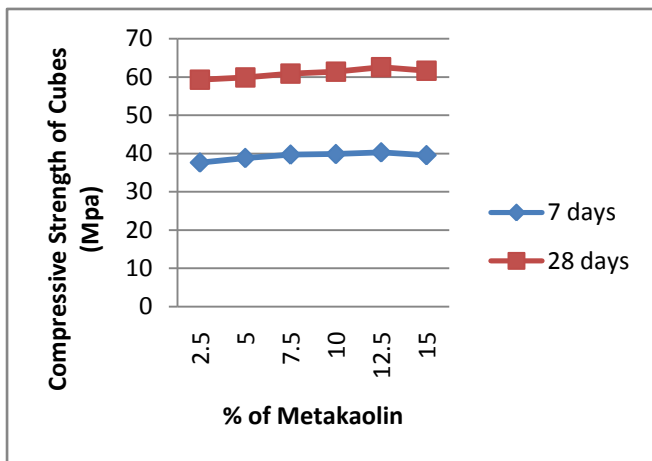
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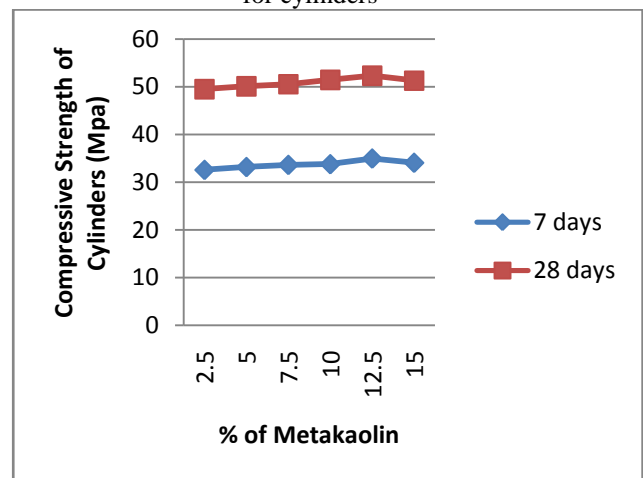
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Metakaolin was added to the concrete with the increasing order of 2.5%, 5%, 7.5%, 10%, 12.5% & 15%, respectively and keeping the QD % as constant (25%). The compressive strength was increased up to 12.5% thereafter, the strength was reduced. Thus, 12.5% of Metakaolin was taken as optimum value. The variation of Strength for cubes & Cylinders are same. But compare with cubes, the cylinders got less strength.

Graph3: Variation of Compressive strength for cubes



Graph4: Variation of Compressive strength for cylinders



Split Tensile Strength Test Results

The Split Tensile Test was conducted on the cylinder of diameter 150mm and height 300mm. The values obtained are tabulated below.

Table5: Split Tensile Strength for different % of QD

% of Quarry Dust	Split Tensile Strength @ 28 days
Conventional Concrete	3.819
5	3.53
10	3.53
15	3.67
20	3.819
25	3.96
30	3.81

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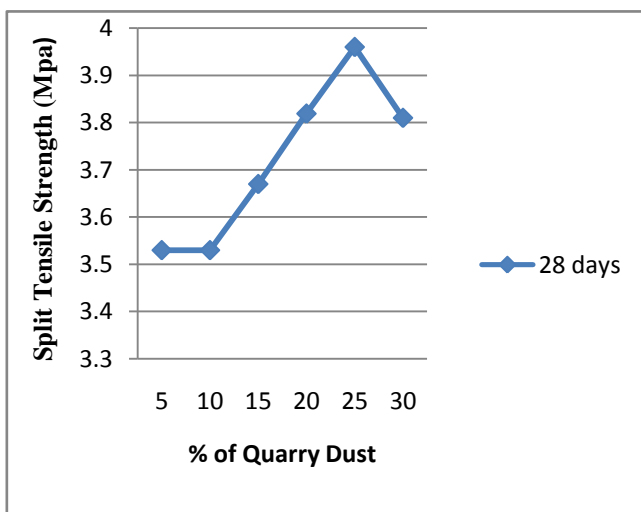
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Table6: Split Tensile Strength for different % of Metakaolin

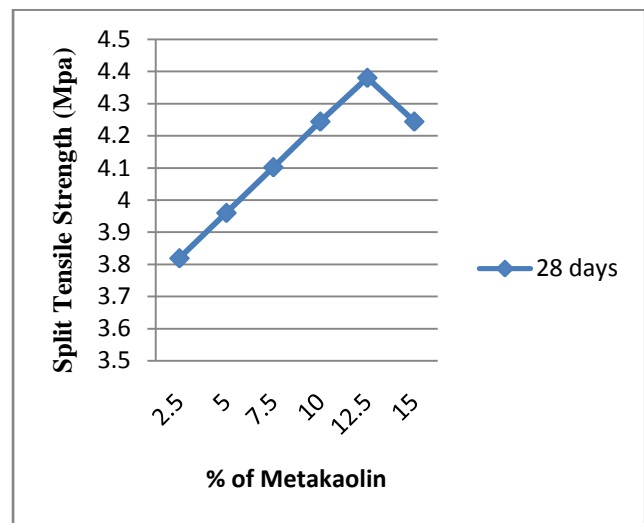
% of Metakaolin	Split Tensile Strength @ 28 days
2.5	3.819
5	3.96
7.5	4.102
10	4.244
12.5	4.38
15	4.244

Metakaolin was added to the concrete with the increasing order of 2.5%, 5%, 7.5%, 10%, 12.5% &15%, respectively and keeping the QD % as constant (25%).. The compressive strength was increased up to 12.5% thereafter, the strength was reduced. Thus, 12.5% of Metakaolin was taken as optimum value.

Graph5: Split Tensile Strength variation with Different % of QD



Graph6: Split Tensile Strength Variation with Different % of Metakaolin



V. CONCLUSION

The following conclusions were made by the experiments conducted on the Concrete with replacement of cement with Metakaolin and fine aggregate with Quarry dust partially.

- The Concrete's Workability was decreased with the increase in Metakaolin & Quarry dust replacement levels.
- After conducting the tests, we observed that the conventional Concrete strength is lower than the Metakaolin Concrete. But, the Quarry dust replacement at 25% only given the better result than conventional concrete.
- The concrete's compressive strength is increased by 6% than conventional concrete at Quarry dust with 25% and Metakaolin with 12.5%. The strength is decreased when the replacing is more than 12.5%. So, 12.5% is taken as optimum value.
- The concrete's Split tensile strength is increased by 14.689% than conventional concrete at Quarry dust with 25% and Metakaolin with 12.5%. The strength is decreased when the replacing is more than 12.5%. So, 12.5% is taken as optimum value.

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- Finally we concluded that the optimum % of Metakaolin in concrete was 12.5.

REFERENCES

1. A.V.S.Sai Kumar, B.Krishna Rao, A Study on Concrete strength with partial replacement of cement with Quarry dust and Metakaolin, IJSETR, Volume 3, Issue
2. O.BalaramiReddy, Ms.S.Sivakamasundari, Experimental study on replacement of cement partially with Metakaolin and Sand with Quarry dust of reinforced concrete beam, Internal Journal of Science, Engineering and Technology Research (IJSETR), Volume 5, Issue 4.
3. Bindu Biju, Imran H, Partial Replacement of Cement with Metakaolin in Highly Performed concrete, IJIRSE, Volume 5, Special Issue 14, December 2016.
4. M.Narmatha, Dr, T.Felixkala, Analyze the mechanical properties of Metakaolin using as a partial replacement of cement in concrete, SSRG-IJCE, volume 4, Issue 1, January 2017.
5. Niveditha.A, S. Manivel, Effects of partial replacement of cement with Metakaolin in Sifcon, IJEMR, Volume-4, Issue-2, April-2014, ISSN No: 2250-0758.
6. J.Thivya , M.Arivukkarasi , Compararision in partial replacement of cement by Metakaolin and the fine aggregates by the granite powder, IJAERT, Volume-4, Issue- 4, April 2016, ISSN NO 2348-8190.
7. Sanjay N.Patil, Ani K.Gupta,SubhashS.Deshpande, Metakaolin-Pozzolanic material for cement in high strength Concrete,IOSR Journal for Mechanical and Civil Engineering (IOSR-JMCE),ISSN:2278-1684,PP:46-49.
8. AiswaryaS, PrinceArulraj G, Dilip C, A Review on use of Metakaolin in the Concrete,IRACST-Engineering Science and Technology: An International Journal(ESTIJ),ISSN:2250-3498,Volume-3,No-3,June 2013.
9. Basant K Bansal,Digvijay S Chouhan, Trilokgupta and Ravi K Sharma, European Journal of Advances in Engineering and Technology ,2017 , 4(7):549-554,ISSN:2394- 658x.
10. Shelorkar Ajay P, Malode Abhishek and Loya Abhisek, Experimental Investigation on Steel Fibre Reinforced Concrete using Metakaolin,IJSCER.