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# **A Study on Strength of Concrete With Partial Replacement Of Cement With Quarry Dust And Metakaolin**

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**Abstract:** Concrete a composite material made from cement, water, fine aggregate and coarse aggregate. But present researchers are in interest of finding new cement materials by waste materials or waste products produced from industries which are harmful to environment. The present paper deals with partial replacement of cement with quarry dust and metakaolin which are having silica used as admixture for making concrete. First quarry dust is made partial replacement of cement and found that 25% of partial replacement is beneficial to concrete without loss of standard strength of cement. Making 25% partial replacement of cement with quarry dust as constant, 2.5%, 5.0%, 7.5%, 10.0%, 12.5% metakaolin was made in partial replacement of cement and results were found that quarry dust and metakaolin usage in partial replacement to cement can be made.

**Keywords:** concrete, metakaolin, quarry dust, partial replacement, waste materials, crushing loads.

## **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. Quarry dust a waste obtained from quarrying process is used as partial replacement to cement and metakaolin a pozzolonic material also used after identifying the optimum usage of quarry dust in partial replacement of cement. Cement, at the time of production produces equal amounts of CO<sub>2</sub>. Hence the partial replacement of cement can be made practice to optimize the cement content effects the production of cement and CO<sub>2</sub> content production.

## **II. LITERATURE REVIEW ON METAKAOLIN**

Aiswarya S, Prince Arulraj G, Dilip C in 2013 examined a review on use of metakaolin in concrete. This paper reviews the use of metakaolin as supplementary cementations material 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.

A. Sadr Momtazi, Ranjbar. M. M, Balalaei. F, Nemati. R examined the effect of Iran's metakaolin in enhancing the concrete compressive strength. This paper presents the performance of metakaolin (NCCM) on compressive strength and durability of concrete. Fired (Calcinated) NCCM has a very good pozzolanic, which could be partially replaced with Portland cement. It can decrease permeability, increase compressive strength and concrete durability. In this study, four different type of metakaolin which one of them was made in UK and the others were from different part of Iran were used. The results indicate that the replacing NCCM up to 20% has noticeable effect on compressive strength in comparing with mixture without metakaolin.

B. B. Patil, P. D. Kumbhar examined that “ Strength and Durability Properties of High Performance Concrete incorporating High Reactivity Metakaolin” the present paper deals with the study of properties namely workability, compressive strength and durability of M60 grade HPC mixes incorporating different percentages of high reactivity metakaolin by weight of cement along with some suitable super plasticizer. The results of the study indicate that the workability and strength properties of HPC mixes improved by incorporating HRM up to a desirable content of 7.5% by weight of cement. HPC mixes have also indicated better resistance to the attacks of chemicals such as chlorides and sulfates when the HPC mixes were exposed to theses chemical for 180 days period.

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Beulah M. Asst Professor, Prahallada M. C. Professor, Effect Of Replacement Of Cement By Metakalion On The Properties Of High Performance Concrete Subjected To Hydrochloric Acid Attack. This paper presents an experimental investigation on the effect of partial replacement of cement by metakalion by various percentages 0%, 10%, 20%, and 30% on the properties of high performance concrete, when it is subjected to hydrochloric acid attack. The results were compared with reference mix. Test results indicate that use of replacement cement by metakalion in HPC has improved performance of concrete up to 10%.

Nova John in 2013 examined the Strength properties of metakaolin admixed Concrete. This paper presents the results of an experimental investigations carried out to find the suitability of metakaolin in production of concrete. In the present work, the results of a study carried out to investigate the effects of Metakaolin on strength of concrete are presented. The referral concrete M30 was made using 53grade OPC and the other mixes were prepared by replacing part of OPC with Metakaolin. The replacement levels were 5%, 10%, 15% up to 20 % (by weight) for Metakaolin. The various results which indicate the effect of replacement of cement by metakaolin on concrete are presented in this paper to draw useful conclusions. The results were compared with reference mix. Test results indicate that use of replacement cement by metakalion in concrete has improved performance of concrete up to 15%.

Sanjay N. Patil, Anil K. Gupta, Subhash S. Deshpande is examined the Metakaolin- Pozzolanic Material for Cement in High Strength Concrete. This paper deals with the use of Metakaolin which is having good pozzolanic activity and is a good material for the production high strength concrete, which is getting popularity because of its positive effect on various properties of concrete.

Vikas Srivastava, Rakesh Kumar and V.C. Agarwal in 2012 examined the Effect on mechanical properties of concrete by inclusion of metakaolin reported that metakaolin inclusion increases the compressive, tensile, flexural and bend strength and modulus of elasticity of concrete considerably; however, the workability is slightly compromised. This paper presents the review of investigations carried out to find the suitability of metakaolin in production of concrete.

Venkata Sairam Kumar N, Dr. B. Panduranga Rao, Krishna Sai M.L.N examined that the experimental studies on partial replacement of cement with quarry dust. The aim of the experiment is to find the maximum content of quarry dust partial replacement of cement in concrete. The percentages of quarry dust partial replacement of cement in concrete are 0, 10%, 15%, 20%, 25%, 30%, 35%, and 40%. M20, M30 and M40 grade concrete cubes of 150x150x150mm size were cast for conducting compressive strength test. From the experimental studies 25% of partial replacement of cement with quarry dust improved hardened concrete properties.

Tasnia Hoque, Muhammad Harunur Rashid, MD. Rokon Hasan, EBNA FORHAD MONDOL in 2013 examined the Influence of Stone Dust as Partially Replacing Material of Cement and Sand on some Mechanical Properties of Mortar. In this paper an investigative experiment is reported on the mechanical properties of mortar modified by stone dust as replacing material of both fine aggregate and cement. An endeavour has been made to evaluate the appropriateness of stone dust as construction materials. Properties of mortar are investigated with the replacement of 25% and 50% of fine aggregate and also 5% of cement by stone dust.

M. Si-Ahmed, A. Belakrouf, and S. Kenai examined that "Influence of Metakaolin on the Performance of Mortars and Concretes". The experimental results have shown that the rates of Substitutions of 10 and 15% metakaolin increases the compressive strength and flexural strength at both early age and long term. The durability and the permeability were also improved by reducing the coefficient of sorptivity.

Jiping BAI, Stan WILD, Albinas GAILIUS in 2004 examined the accelerating Early Strength Development of Concrete Using Metakaolin and quarry dust. This paper reports strength development, particularly at early curing ages, to evaluate the effectiveness of NCCM as an accelerating admixture. The Portland cement concrete covering five different addition levels of NCCM (1%-5%) to binder and with four water to cement ratios of 0.3, 0.4, 0.5 and 0.6 (0.4 and 0.5 for PC 60 % – PFA 40 % concrete) were cured in water up to 28 days. The compressive strengths were evaluated at 1, 3, 7, 14 and 28 days. The compressive strength development of the concrete at various curing times is compared with control concrete (PC only). It is found that NCCM contributes significantly to early strength development as an accelerating admixture for PC and PC-PFA concrete.

### III. MATERIALS AND METHODOLOGY

#### A. Cement:

Portland pozzolana cement conforming to IS: 269-1976 and IS: 7031-1968 was used in this study. The cement is of 53grade and the tests conducted on cement are tabulated in Table No.1

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Table. No: 1 Properties of cement:

S. No	Property	Test results
1	Normal consistency	29%
2	Specific gravity	3.13
3	Initial setting time	92 minutes
4	Final setting time	195 minutes
5	Compressive strength at 3days 7days 28days	27.40 N/mm <sup>2</sup> 29.23 N/mm <sup>2</sup> 41.62 N/mm <sup>2</sup>

### B. Metakaolin

Metakaolin is brought from Vadodara having 50%-55% of SiO<sub>2</sub> and specific gravity of 1.9 is used all through the study.

Table. No: 2 Physical properties of metakaolin

Properties	Value
Density (gm/cm <sup>3</sup> )	2.17
Bulk density (gm/cm <sup>3</sup> )	1.26
Particle shape	Spherical
Colour	Grey
Specific gravity	2.1

Table. No: 3 Chemical composition of metakaolin

Constituents	Values
Silica	53%
Alumina	43%
Iron Oxide	0.5%
Calcium Oxide	0.1%
Sulphate	0.1%
Sodium Oxide	0.05%
Potassium Oxide	0.4%

### C. Quarry dust:

Quarry dust is collected from local stone crushing units was used. It was initially dry in condition when collected and was sieved by IS: 90 micron sieve before mixing in concrete.

Table. No: 4 Physical properties of quarry dust

Property	Quarry dust	Test method
Specific gravity	2.54-2.60	[5] IS 2386 (Part III) 1963
Bulk relative density (kg/m <sup>3</sup> )	1720-1810	IS 2386 (Part III) 1963
Absorption (%)	1.20-1.50	IS 2386 (Part III) 1963
Moisture content (%)	Nil	IS 2386 (Part III) 1963
Fine particles less than 0.075mm (%)	12-15	[5] IS 2386 (Part I) 1963
Sieve analysis	Zone II	[4]IS 383 – 1970

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Table. No: 5 Chemical compositions of quarry dust

Items	Quarry rock dust (%)	Test method Test method
SiO <sub>2</sub>	62.48	[10]IS: 4032-1968
Al <sub>2</sub> O <sub>3</sub>	18.72	
Fe <sub>2</sub> O <sub>3</sub>	06.54	
CaO	04.83	
MgO	02.56	
Na <sub>2</sub> O	Nil	[10]IS: 4032-1968
K <sub>2</sub> O	03.18	
TiO <sub>2</sub>	01.21	
Loss of ignition	00.48	

**D. Fine aggregate:**

The fine aggregate used is natural sand obtained from the river Godavari conforming to grading zone-II of table 3 of IS: 10262-2009. The results of various tests on fine aggregate are given in table.

Table. No: 6 Properties of fine aggregate

S. No	Property	Value
1	Specific gravity	2.57
2	Fineness modulus	2.46
3	Bulk density: Loose Compacted	15kN/m <sup>3</sup> 16kN/m <sup>3</sup>
4	Grading	Zone-II

**E. Coarse aggregate:**

Coarse aggregate obtained from local quarry processing units has been used for this study.

Table. No: 7 Physical properties of coarse aggregate

S. No	Property	Value
1	Specific gravity	2.78
2	Fineness modulus	8.83
3	Bulk density Loose Compacted	14 kN/m <sup>3</sup> 16 kN/m <sup>3</sup>
4	Nominal maximum size	20 mm

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**F. Water:**

Ordinary potable tap water available in laboratory was used for mixing and curing of concrete.

Table. No: 8 Physical properties of water

S. No	Property	Value
1	pH	7.1
2	Taste	Agreeable
3	Appearance	Clear
4	Turbidity(NT units)	1.75

**G. Mix design procedure:**

In present study M30 grade concrete was designed as per IS: 10262-2009. The weight ratio of mix proportion is 1: 1.56: 3.13 keeping water cement ratio 0.4. It was proposed to investigate the properties of concrete, cast with partial replacement of cement with 25% of quarry dust which was made from experimental results of and further cement content is optimized with 0%, 2.5%, 5%, 7.5%, 10% and 12.5% of proportions of metakaolin proportions and cured in water.

In this experimental work, physical properties of materials used in the experimental work were determined. M30 grade of reference concrete was mixed and cured in potable water.

### IV. CASTING AND TESTING DETAILS

9 cubes, 9 cylinders, 9 beams conforming to IS: 516-1964 are casted After 24 hours the moulds were demoulded and subjected to water curing. Before testing the cubes were air dried for 2 hours. Crushing loads, split tensile strength, flexural strength were noted and average of 3 specimens was determined at 7days and 28days, 90days. The results are tabulated below

Table. No: 9 Compressive strength results

S. No	Quarry dust (%)	Average strength at 28 days(N/mm <sup>2</sup> )
1	0	41.6
2	10	40.5
3	20	41.4
4	25	42.8
5	30	38.9

Compressive strength test results of 25% partial replacement of cement with quarry dust and with addition of metakolin:

Table. No: 10 Compressive strength test results

S. No	Mix Id	Compressive strength(N/mm <sup>2</sup> )		
		7 days	28 days	90 days
1	NCC	26.35	40.62	42.21
2	NCC M0	27.42	41.6	43.80
3	NCC M2.5	28.80	42.53	44.23
4	NCC M5	29.13	43.25	46.23
5	NCC M7.5	31.33	44.45	47.02

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6	NCC M10	32.34	47.58	49.26
7	NCC M12.5	29.8	43.6	45.2

Table. No: 11 Split tensile strength test results

S. No	Mix Id	Split tensile strength(N/mm <sup>2</sup> )		
		7 days	28 days	90days
1	NCC	2.45	3.12	3.21
2	NCCM0	2.61	3.21	3.32
3	NCCM2.5	2.65	3.26	3.35
4	NCCM5	2.73	3.34	3.41
5	NCCM7.5	2.92	3.62	3.76
6	NCCM10	3.02	3.91	3.95
7	NCCM12.5	2.81	3.30	3.36

Table. No: 12 Flexural strength test results

S. No	Mix Id	Flexural strength(N/mm <sup>2</sup> )		
		7 days	28 days	90 days
1	NCC	4.41	6.05	7.12
2	NCCM0	4.63	6.28	7.23
3	NCCM2.5	4.93	6.49	7.35
4	NCCM5	5.02	6.50	7.54
5	NCCM7.5	5.23	6.64	7.75
6	NCCM10	5.34	6.93	7.85
7	NCCM12.5	5.21	6.70	7.62

## V. CONCLUSIONS

There was a change in slump for NCCM0 has increased 0.79% when compared with NCC. The slump for NCCM2.5, NCCM5, and NCCM7.5 has reduced by 1.6%, 2.4%, 0.79% when compared with NCC. The slump for NCCM10 has increased by 1.57% when compared with NCC and there was no change in slump for NCCM12.5 when compared with NCC. The compaction factor for NCCM0, NCCM2.5, NCCM5, and NCCM7.5 was reduced by 1%, 2.19%, 3.29%, and 4.39% respectively when compared with NCC mix and mix NCCM10 was increased by 1.08% when compared with NCC mix. Hence the degree of workability was found to be almost same.

The compaction factor for mix NCCM12.5 was reduced 1% respectively when compared with NCC. It was observed that the compressive strength of NCCM0, NCCM2.5, NCCM5, NCCM7.5, NCCM10, and NCCM12.5 at the age of 28 days has reached its target mean strength however it was observed that the compressive strength increased by 1.6%, 2.1%, 3.7%, 6.3%, 12.5% and 6.6% respectively when compared with NCC.

It was observed that the compressive strength of NCC at the age of 28 days reached its target mean strength however it was observed that the compressive strength reduced by 2.3% respectively when compared with NCCM0, mixes NCCM2.5, NCCM5, NCCM7.5, NCCM10 and NCCM12.5 at the age of 28 days has reached its target mean strength however it was observed that the compressive strength increased by 2.1%, 3.8%, 6.4%, 14.6% and 4.5% respectively when compared with NCCM0. It was observed that the compressive strength of NCCM12.5 has reduced by 8.36% respectively when compared with NCCM10 at the age of 28 days.

Flexural strength (At 28 days) of NCCM0, NCCM2.5, NCCM5, NCCM7.5, NCCM10 and NCCM12.5 has increased by 2%, 2.15%, 2.3%, 4.3%, 8.3% and 9.7% respectively when compared with mix NCC. Flexural strength (At 28 days) of NCC has reduced 3.66% by respectively when compared with mix NCCM0. Flexural strength (At 28 days) of mix NCCM2.5, NCCM5, NCCM7.5, NCCM10 and NCCM12.5 has increased by 3.23%, 3.38%, 5.42%, 8.88% and 6.26% respectively when compared with mix NCCM0. Flexural strength (at 28 days) of mix NCCM10 has reduced by 3.3%

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respectively when compared to NCCM12.5.

The split tensile strength(at 28 days) of mixes NCCM0, NCCM2.5 NCCM5, NCCM7.5, NCCM10 and NCCM12.5 has increased by 2.8%, 4.2%, 6.5%, 13.8%, 20% and 5.4% respectively when compared with mix NCC. The split tensile strength of mix NCC has reduced by 2.8% respectively when compared to NCCM0. The split tensile strength of mixes NCCM2.5, NCCM5, NCCM7.5, NCCM10 and NCCM12.5 (at 28 days) has increased by 1.53%, 3.89%, 11.32%, 17.9% and 2.7% respectively when compared with mix NCCM0.

The Split tensile strength of mix NCCM10 has reduced by 15.6% respectively when compared with mix NCCM12.5. Cement can be replaced with quarry dust up to 25% without much loss in compressive strength. Considerable decrease in compressive strength was observed from 25% cement replaced with quarry dust.

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