

Study on Concrete Properties by Partially Replacing Cement by Metakaolin and Fine Aggregate by Laterite Soil

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ABSTRACT: Ordinary Portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on way of utilizing either industrial or Agricultural waste, as a source of raw materials for industry. This waste utilization would not only be economical, but may also result in foreign exchange income and environmental pollution control. Industrial wastes, such as blast furnace slag, Metakaolin, fly ash and silica fume are being used as supplementary cement replacement materials. An attempt has been made in determining the compressive strength of M20 grade concrete by partially replacing cement by Metakaolin and river sand by laterite soil and it was found out to be 6 – 9% higher than controlled concrete (zero replacement).

KEYWORDS: Compressive strength, Laterite soil, Metakaolin, Ordinary Portland cement.

I. INTRODUCTION

Concrete is the most commonly used construction material in the world. It is basically composed of two components paste and aggregate. The paste contains cement and water and sometimes other cementitious and chemical admixtures, whereas the aggregate contains sand and gravel or crushed stone. The paste binds the aggregates together. The aggregates are relatively inert filler materials which occupy 70% to 80% of the concrete and can therefore be expected to have influence on its properties. The proportion of these components, the paste and the aggregate is controlled by the strength and durability of the desired concrete, the workability of the fresh concrete and the cost of the concrete. Ordinary Portland cement is recognized as a major construction material throughout the world. Researchers all over the world today are focusing on ways of utilizing either industrial or Agricultural waste, as a source of raw materials for industry. This waste, utilization would not only be economical, but may also result in foreign exchange earnings and environmental pollution control. Industrial wastes, such as blast furnace slag, Metakaolin, fly ash and silica fume are being used as supplementary cement replacement materials. Therefore it is possible to use Metakaolin as cement replacement material to improve quality such as mortar, concrete pavers, concrete roof tiles and soil cement interlocking block. The objective of the present work is determine the compressive strength of M20 grade concrete by partially replacing cement by Metakaolin and river sand by laterite soil with 0%, 5%, 10%, 15%, 20% and 25% replacement by weight and cubes are tested for 7, 14 and 28 days.

II. MATERIALS

A. CEMENT

Portland cement is the most common type of cement in general usage. It is a basic ingredient of concrete, mortar and plaster. Of the various ingredients used in concrete, cement is the most energetically and expensive.

B. WATER

Combining water with a cementitious material forms a cement paste by the process of hydration. The cement paste glues the aggregate together, fills voids within it, and makes it flow more freely. Lower water to concrete ratio yields a

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Vol. 6, Issue 2, February 2017

stronger, more durable concrete, while more water gives a free-flowing concrete with a higher slump. Impure water used to make concrete can cause problems when setting or in causing premature failure of the structure.

C. **METAKAOLIN**

Metakaolin is a Dehydroxylated form of the clay mineral Kaolinite. Stone that are rich in kaolinite are known as China clay or kaolin, traditionally used in the manufacture of porcelain. The particle size of Metakaolin is smaller than the cement particles. Considering to having twice the reactivity of most other Pozzolans, Metakaolin is a valuable admixture for concrete/cement applications. Replacing of Portland cement with 8 to 20% by its weight, Metakaolin powder produces a concrete mix, which exhibits favourable engineering properties, including the filler effect, the acceleration of OPC hydration, and the Pozzolanic reaction. The filler effect is immediate, while the effect of Pozzolanic reaction occurs between 3 to 14 days.

D. **LATERITE**

Laterite is a highly weathered material rich in secondary oxides of Iron, Aluminium or both. It is nearly devoid of base and primary silicates but may contain large amount of quartz, and Kaolinite. Laterite has been used for wall construction around the world; it is cheap, environmentally friendly and abundantly available building material in the tropical region. They observed that the restriction of laterite building to rural areas is due to lack of accepted standard design parameters for the effective structural application of laterized concrete. They described concrete as a mixture of laterite (as fine aggregate), granite or gravel (coarse aggregate), cement and water in a chosen weight proportion, mixed by means that are available and equally allowed to undergo curing processes.

III. METHODOLOGY

TESTS ON MATERIALS

i. **Cement**

Table: 1 Physical properties of Cement

Elements	Content
Specific Gravity	3.15
Fineness Modulus	6.23%
Standard Consistency	29%
Initial Setting time	40min
Final Setting time	285min

Table: 2 Chemical properties of Cement

Oxides	Percentages
CaO	62.85
SiO ₂	20.98

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 6, Issue 2, February 2017

Al ₂ O ₃	5.42
Fe ₂ O ₃	3.92
MgO	1.76
SO ₃	2.36
Na ₂ O	0.28
K ₂ O	0.53
Loss of Ignition	1.90

ii. Laterite soil

Table: 3 Properties of laterite soil

Sl No.	Properties	Test results	Reference
1	Fineness modulus	2.76	IS:2386 (Part 1)- 1963
2	Specific gravity	2.56	IS:2386 (Part 3)- 1963
3	Liquid limit	31%	IS:2720 (Part 5)- 1970
4	Plastic limit	15.13%	IS:2720 (Part 5)- 1970
5	Plastic limit	15.87%	IS:2720 (Part 5)- 1970
6	Bulk density in kg/m ³	1826	IS:2386 (Part 3)- 1963

iii. Metakaolin

Table: 4 Chemical Properties

Chemical Composition	Mass (%)
SiO ₂	52.0-54.0
Al ₂ O ₃	44.0-46.0
Fe ₂ O ₃	0.60-1.20
TiO ₂	0.65
CaO	0.09

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Vol. 6, Issue 2, February 2017

MgO	0.03
Na ₂ O	0.10
K ₂ O	0.03

Table: 5 Physical properties

SI No	Particulars	Obtained Values
1	Specific gravity	2.7
2	Standard consistency	28%

Table: 6 Physical properties of River Sand

SI No	Particulars	Obtained values
1	Specific gravity	2.70
2	Sieve analysis	2.76%
3	Water absorption	1.30%

Table: 7 Physical properties of coarse aggregate

SI No	Particulars	Obtained values
1	Specific gravity	2.70
2	Sieve analysis	2.26%
3	Water absorption	0.80%

IV. RESULTS AND DISCUSSIONS

Table: 8 Compressive strength at 28 days for different percentage of Metakaolin and laterite soil used for M30 grade concrete.

ID	Factored load KN	Compressive strength MP _a	Average Compressive strength MP _a
NCC	740	32.89	33.55
NCC	755	33.55	
NCC	770	34.22	
MK 5%	780	34.66	35.55
MK 5%	790	35.11	
MK 5%	830	36.88	

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

MK 10%	850	37.77	38.06
MK 10%	890	39.55	
MK 10%	830	36.88	
MK 15%	800	35.55	35.84
MK 15%	790	35.11	
MK 15%	830	36.88	
MK 20%	700	31.11	30.07
MK 20%	650	28.88	
MK 20%	680	30.22	
MK 25%	650	28.88	29.18
MK 25%	630	28.00	
MK 25%	690	30.66	

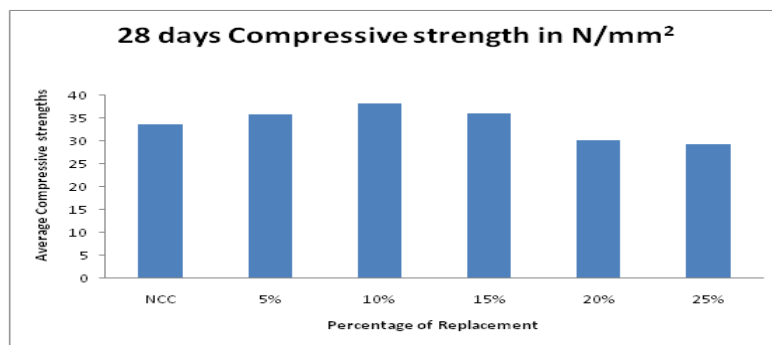


Fig 2: Shows the variation of compressive strength values for 28 days with different percentages of Metakaolin and laterite soil.

The above graph indicates that the compressive strength of 28 days with various percentage of Metakaolin replacing cement and Laterite Soil to the fine aggregate in the concrete mixes. Let us consider the optimum strength gained after 28 days curing period is C10% MK + FA10% LS replacement and strength increases in percentage of Metakaolin and Laterite Soil decreases with the remaining replacement percentage of Metakaolin and Laterite Soil.

Table: 9 Split tensile strength test for 28 days Split tensile strength test for 28 days

ID	Failure load KN	Split tensile strength MPa	Average Split tensile strength MPa
NCC	355	5.02	5.02
NCC	360	5.09	
NCC	350	4.95	
MK 5%	370	5.23	5.23
MK 5%	365	5.16	
MK 5%	375	5.30	
MK 10%	425	6.01	6.01
MK 10%	435	6.15	
MK 10%	450	5.87	
MK 15%	320	4.53	4.92
MK 15%	350	4.95	

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Website: www.ijirset.com

Vol. 6, Issue 2, February 2017

MK 15%	380	5.30	3.71
MK 20%	260	3.80	
MK 20%	240	3.55	
MK 20%	260	3.80	3.61
MK 25%	250	3.60	
MK 25%	255	3.65	
MK 25%	250	3.60	

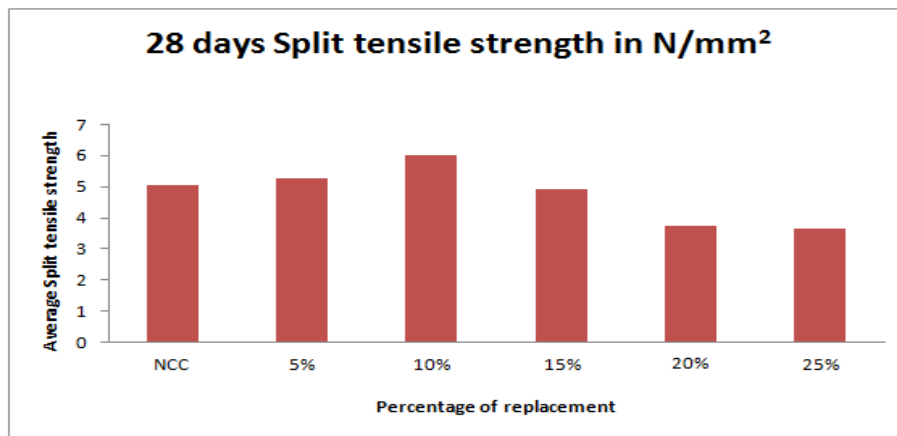


Fig 3: Graph shows the variation of split tensile strength for different percentages of Metakaolin and Laterite soil.

The above graph indicates that the split tensile strength for 28 days with various percentage of Metakaolin replaced in cement and Laterite added to the fine aggregate in the concrete mixes. Let us consider the optimum strength gained after 28 days curing period is C10%MK+FA10%LS replacement and strength increases in percentage of Metakaolin and Laterite Soil decreases with the remaining replacement percentage of Metakaolin and Laterite Soil.

V. CONCLUSION

1. At the Partial replacement of Ordinary Portland cement by Metakaolin and fine aggregate by Laterite soil results in a better compressive strength.
2. The compressive strength results of the concrete have revealed that the concrete with 10% cement replacement by Metakaolin and fine aggregate by Laterite soil have shown a compressive strength improvement at 28 days over the control concrete with the 100% Ordinary Portland Cement.
3. Partial replacement of cement by Metakaolin and fine aggregate by Laterite soil increases workability of fresh concrete; therefore use of super plasticizers is not substantial.
4. The compressive strength of concrete (M30) with sand is marginally higher (6% - 9%) when compared to the concrete with river sand.

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