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Influence of Metakaolin And Basalt Fibers on Strength of Concrete - An Experimental Approach

Sachin U[1], Bhaskar Reddy V [2], Akwil Kirijost Fernandes[3], Ibrahim Ashiq[4]

[1]Assistant professor, Dept of Civil Engineering, St Joseph Engineering College, Vamanjoor
[2]Student, Dept. of Civil Engineering, St Joseph Engineering College, Vamanjoor
[3]Student, Dept. of Civil Engineering, St Joseph Engineering College, Vamanjoor
[4]Student, Dept. of Civil Engineering, St Joseph Engineering College, Vamanjoor

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Abstract - *By the above study effect of partial replacement of cement with metakaolin onmechanical properties revels that the performance of concrete is good up to 25% replacement of metakaolin. The 12.5% replaced metakaolin with 28days curing will give more compressive strength than any percentage replacement and it is recommended to use metakaolin upto 25% without any objections as it gives strength equivalent to normal concrete strength, any way there will be gradually decrease in strength of 37.5% replaced concrete due to decrease in pozzolanic reaction. By considering all the above points can conclude that the incorporation of metakaolinupto 25% is highly recommended to reduce the pollution by decreasing the production of cement.*

Key Words: Metakaolin(MK), Basalt fibers(BF), Workability, Tensile strength, Compression test, Flexural strength, Ductility, Mechanical Property.

1.INTRODUCTION

Concrete is a composite material which is predominantly used all over the world. It is obtained by mixing cementing materials, aggregates and water in required quantities. The word "concrete" is originated from the Latin verb "concretus" which means to grow together. Because of its mechanical and durability properties together with its lower cost andproper workability, concrete is the most widely used material of construction.

During the production of ement it emits the largest amount of CO_2. In 2016, world cement production generated around 2.2 billion tons of CO_2 – equivalent to 8% of the total pollution.To reduce the consumption of cement, partial replacement of cement with some supplementary cementitious materials like Metakaolin, fly-ash, rice husk, GGBS and silica fume etc., can be used in concrete mix. In recent years, there has been a soaring interest in the exploitation of metakaolin (MK) as a supplementary cementitious material in concrete to improve its properties. For last two decades, there has been a growing interest in the use of metakaolin as a supplementary cementitious material to impart an additional performance to concrete. In this study, overall strength properties development by concrete with partial replacement ofcement with metakaolin and by incorporating 2% of basalt fibers to concrete incorporated with metakaolin can be investigated. Three replacement levels (12.5%, 25%, and 37.5%) of CK and MK by weight of cement were considered. The strength properties of the concretes will be determined at 7, 14 and 28 days.

2. LITERATURE REVIEW

i) Lou Chen, Keren Zheng and Taobing Xia (2019):

In this paper investigated the combined effect of metakaolin and lime on compressive strength of concrete by partial replacing the cement with both metakaolin and lime. The curing method used for this investigation is steam curing.The study also reveals the feasibility of reducing steam curing temperaturesby using metakaolin of high reactivity, which is of significance for mitigating steam-curing induced detrimental effects and reducing energy consumption.

ii) Pratik B. Shinde and P. Y. Pawade (2019):

In this work, concrete was made up with Pozzolanic Portland Cement (PPC) to produce control mix and further replaced by metakaolin with 5, 10, 15, 20%, respectively. The mechanical properties of concrete were assessed by means of compressive strength, flexural strength of concrete.

It shows higher results in compressive strength and flexural strength for 15% replacement of MK to cement. The values were 42.95 and 45.09 Mpa observed for 28 and 90 days. The increment was promised by incorporation of MK over plain concrete.

3. OBJECTIVES

- To identify the compressive strength, split tensile strength and flexural strength of M30 grade for 7, 14 and 28 days with manufacture sand as fine aggregate and Metakaolin as cement replacement material.
- To investigate the strength of concrete by adding basalt fibers for the concreteincorporated with metakaolin for each mix.
- To achieve the eco-friendly concrete by the addition of metakaolin and basalt fibers.
- To reduce the unit cost of concrete by the addition of metakaolin.

- To determine the basic properties of material used for the metakaolin and basalt fiber concrete.

4. MATERIALS

Cement

The cement is the important material of the concrete. The cement using for this experiment isPozzolana Portland cement.

Metakaolin

Metakaolin (MK) is a mineral admixture which confirms class-N pozzolanic specifications. (Fig. 1.). It was prepared, by heating raw kaolin at 600°C to 900°C for 6 hours and grindingin high-speed ball mill.

Fig 1: Metakaolin

Basalt Fibers

Basalt fiber (BF) is a new kind of inorganic fiber made by the extrusion of melted basalt rock and is available in the commercial market. Basalt fiber is a material made fromextremely fine fibers of basalt, which is composed of the minerals plagioclase, pyroxene, and olivine. It is similar to fiberglass, having better mechanical properties than fiberglass, but being significantly cheaper than carbon fiber. The BF does not contain any other additives, which makes it more economical.

Diameter	17.4μm
Length	6mm
Tensile Strength	>1000Mpa
Density	>2700kg/m^3
Elastic Modulus	>90Gpa

Table 1: Physical Properties of Basalt Fibers

Fig. 2: Basalt Fibers

Manufactured Sand

Sand is used as fine aggregate in mortar and concrete. Natural river sand is the mostpreferred choice as a fine aggregate material. (Fig. 3.)

Fig. 3: Manufactured Sand

Coarse Aggregate

Next to the cement and fine aggregate coarse aggregate is another important material. Here we are using 70% of 20mm down aggregates and 30% of 12.5mm down aggregates are using.

Water

Water used for mixing and curing shall be clean and free from injurious amounts of oils, acids, alkalis, salts, sugar, organic materials or other substances that may deleterious to the concrete or steel. Portable water is generally considered satisfactory for mixing concrete.

Basic Test values for Mix Design

SL No.	Tests	Obtained Values	Respective codes
01.	Fineness test for Cement	6.80	IS: 383-1970
02.	Specific gravity for Cement	3.16	IS 2720- Part III
03.	Setting time of Cement	30min	IS: 4013 (Part VI)-1988

04.	Particle Size Distribution of Fine Aggregate	4.86	IS: 383-1970
05.	Specific Gravity of Fine Aggregate	2.73	IS: 2386 (Part III) - 1963
06.	Specific Gravity of Coarse Aggregate	2.80	IS: 2386 (Part III) -1963
07.	Particle Size Distribution of Coarse Aggregate	4.04	IS: 383-1970
08.	Water absorption test for Fine Aggregate	2 %	IS: 2386 (Part III) -1963
09.	Water absorption test for Coarse Aggregate	1.6 %	IS: 2386 (Part III) - 1963

Table 2: basic test values of mix design

5. METHODOLOGY

1. Literature review
2. collection of materials
3. testing the properties of materials
4. mix design
5. mixing and testing of concrete

6. EXPERIMENTAL RESULTS AND DISCUSSION

Compressive Strength Test Results

The variation in 7, 14 and 28days Compressive strength for all concrete mixes with different percentage of metakaolin and basalt fibers is shown below:

Table 3: Compressive Strength value on 28th day

SL No.	Percentage replacement	Failure Load (KN)	Compression Strength (N/mm^2) on 28th day
1	0	738	41
2	12.5	935	47.4
3	25	711	42
4	37.5	532	34.7

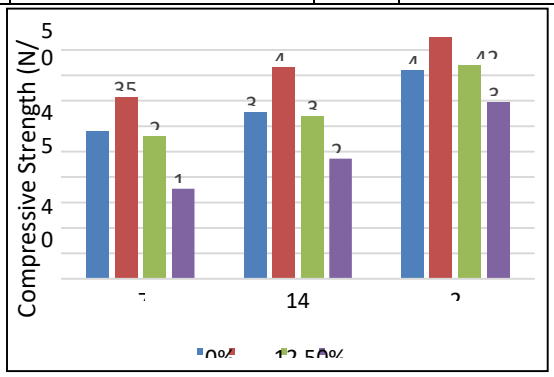

Figure 4: Compressive Strength value on 28th day

Discussions on obtained results for compressive strength

For the compressive test of metakaolin partially replaced with cement the following conclusions may be drawn:

1. From the figure 4 the early strength of the concrete for metakaolin replaced with 12.5% is more than controlled concrete strength and other percentage replacement concrete strength.
2. The same we can absorb that the strength of controlled concrete and the strength of 25% metakaolin replaced concrete is approximately equal.
3. It is also witnessed that the strength of concrete which is replaced by metakaolin with 37.5% is gradually decreased compared to other percentage replaced concrete and conventional concrete.
4. In the same the strength of conventional concrete and 25% metakaolin replaced concrete is approximately same given by 32.8 and 32Mpa respectively but anyway there will be slight increase in strength of conventional concrete.
5. From fig 6 for 28 days curing also showing the highest strength in 12.5% metakaolin replaced concrete of 47.4Mpa

Fig. 5: Testing of Specimen for Compressive Strength

Split Tensile Strength Test Results

SL No.	Percentage Replacement	Failure Load (KN)	Split Tensile Strength (N/mm^2)on 28^{th} day
1	0	228	3.5
2	12.5	190	3.8
3	25	188	4
4	37.5	171	3.6

Table 4: Split Tensile Strength value on 28^{th} day

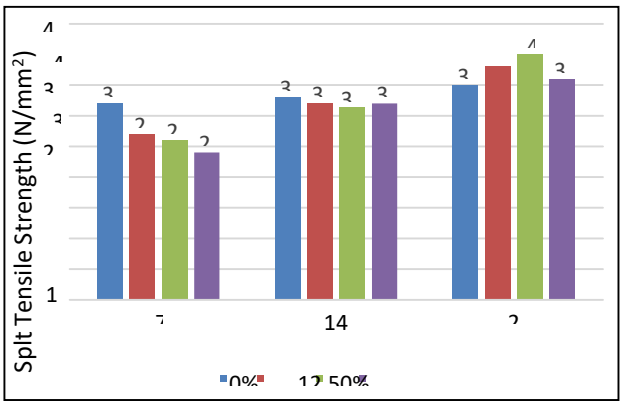

Fig. 6: Split Tensile Strength on 7^{th}, 14^{th} and 28^{th}day

Discussions on obtained results for Split Tensile Strength

For the Split tensile test of concrete partially replaced with metakaolin the following conclusions can be drawn:

1. At the 7 days testing of concrete the optimum strength is obtained for conventional concrete and it is also showing that as percentage of replacement increases the tensile strength will be gradually decreases.
2. Figure 12 shows that plain concrete split after the tensile test into two halves, which is an indicator of brittle behaviour of unreinforced concrete.
3. While the concrete with 2% of basalt fibers is more resistant to large cracks and only tiny surface cracks on the length of the specimens appeared. This implies that concrete with basalt fibers play a significant role to make the concrete capable of resisting crack propagation and tensile forces.

Fig. 7: Testing of Specimen for Split Tensile Strength

7. CONCLUSIONS

1. By the above study effect of partial replacement of cement with metakaolin on mechanical properties revels that the performance of concrete is good up to 25% replacement of metakaolin.

2. The 12.5% replaced metakaolin with 28days curing will give more compressive strength than any percentage replacement and it is

recommended to use metakaolin upto 25% without any objections as it gives strength equivalent to normal concrete strength, any way there will be gradually decrease in strength of 37.5% replaced concrete due to decrease in pozzolanic reaction.

3. In split tensile test the strength of concrete with 25% replacement showing high strength as curing period increases, where as 12.5% replaced metakaolin concrete showing the same strength equal to conventional concrete, the 37.5% replaced metakaolin concrete showing high strength in 7 days curing further decreases as curing period increases due to decreases in pozzolanic activity.

4. The crack pattern and crack width has been reduced by using basalt fibers, but there isno any increase or decrease in strength.

5. For flexure strength can replace upto 25% to get strength that we got by conventional concrete. It is preferable to replace upto 12.5% to get more strength than conventional concrete.

6. As the percentage replacement level increases the deflection slightly decreases, the 0% and 12.5% showing more deflection values than 25% and 37.5% replacement.

7. The mix proportion of 1:1.6:2.22 with 0.35 w/c ratio giving high strength by considering 50mm slump for M30 grade concrete.

8. By considering all the above points can conclude that the incorporation of metakaolinupto 25% is highly recommended to reduce the pollution by decreasing the production of cement.

REFERENCES

1. Lou Chen, Keren Zheng, Taobing Xia .et (2019): "Mechanical property, Sorptivity and microstructure of steam-cured concrete incorporated with the combination of metakaolin-limestone". Case Studies in Construction Materials, Elsevier, volume 11, ISSN -2214-5095.

   https://doi.org/10.1016/j.cscm.2019.e00267 .

2. Pratik B. Shinde, P. Y. Pawade ,et.. (2019): "Mixed Influence of Metakaolin (MK) and Steel Fiber on Mechanical Properties of Concrete". Smart Technologies for Energy, Environmentand Sustainable Development, springer. ISSN 2522-5022, ISBN978-981-13-6147-0. Page 381-390.

   https://doi.org/10.1007/978-981-13-6148-7 .

3. B. Jeevitha and Neethu Urs, (2019): "Study on Mechanical Properties of Cement Concrete for Partial Replacement of Coarse Aggregate by Shredded Plastic and Cement by Fly Ash and Metakaolin". Sustainable Construction and Building Materials, Page-177-189.

   https://doi.org/10.1007/978-981-13-3317-0_16 .

4. Jin Tang a, Shuaifei Wei, et..(2019): "Synergistic effect of metakaolin and limestone on the hydration properties of Portland cement". Construction and Building Materials 223, Page-177-184.

   https://doi.org/10.1016/j.conbuildmat.2019.06.059 .