

Mechanical Properties of Self Compacting Concrete by Replacing Cement with Metakaolin in Concrete for M30 Grade

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ABSTRACT: Self-compacting concrete [SCC] is capable of moving under its own weight, filling the formwork completely without creating any mechanical vibration, it is more effective for seismic loads. The M30 grade concrete was selected and IS method was used for mix design. It is mainly adopted in complicated reinforcement structures for pile and raft foundation and retaining wall in construction areas. The use of metakaolin [MK] in this project to achieve the strength in earlier days when compared to conventional concrete techniques. The different mixes of metakaolin addition (0%, 10%, 15%, 20%) is made to determine which has the high performance in this SCC. Metakaolin has the properties as compared to cement so metakaolin was replaced with cement. A small amount of metakaolin to concrete may significantly boost its compressive strength. In comparison to metakaolin 10% and 15%, metakaolin 20% possessed the highest Flexural strength, Split tensile strength Compressive strength.

KEY WORDS: Metakaolin, cement, Replacement

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I. INTRODUCTION

Numerous studies are being conducted worldwide to investigate every potential use case and feature of SCC. SCC is seen as a future concrete that will match all performance expectations while retaining all the benefits of concrete, such as high strength and features, less labour required, speedy construction, and durability. Metakaolin gives more strength and durability than cement. In terms of production, metakaolin differs from other compounds like blast furnace slag, silica fumes & fly ash because it is created from high-purity clay and calcined at temperatures between 700 and 800 degrees Celsius. MK is developed by calcining pure kaolin clay at temperatures between 600° and 900° Celsius, which removes chemically bound water and breaks down the crystalline structure and metakaolin is an ultrafine pozzolana.

II. SCOPE

One of the products of the cement's hydration reaction is calcium hydroxide [Ca(OH)₂]. Extra Calcium Silicate Hydrate gel is produced when metakaolin is used in part place of cement and communicates with calcium hydroxide. The sole element responsible for the strength development of cement and cement-based concrete is Calcium Silicate Hydrate Gel. Generally easily accessible extremely reactive metakaolin functions as a considerably reactive pozzolanic in concrete. Metakaolin has been shown to improve the qualities of concrete when added as an alternative cementing element. The process of calcining pure kaolin clay at temperature between 600 and 900 degrees Celsius results in metakaolin, an ultrafine pozzolana that splits down the crystal structure and discharges water that has been chemically bonded. Experiments have shown that the mechanical, permeability, and durability qualities of concrete mixtures with high reactivity Metakaolin are on par with those including other mineral admixtures. Further, using these materials is ecologically conscious since it reduces the amount of CO₂ released into the atmosphere by using less Portland cement.

III. LITERATURE REVIEW

S. Yasin Mousavi et.al, (2012) has examined the fresh and hardened properties of the metakaolin-containing self-compacting concrete. It was discovered that the MK concentrations, which vary from 0% to 20% by weight of cement, may be generated with three different water/binder (W/B) ratios: 0.32, 0.38, and 0.45. 10% MK seems to be a good replacement when considering the strengthened properties, youthfulness, and economic performance of MK concrete..

V. Voukia, et.al, (2015) has identified the Metakaolin Self-Compacting Concrete's Durability. Comparing to the open pore system, the capillary pore system seems to gain more from the replacement material MK. The permeability of near-surface water is not being improved by higher replacement levels by MK. In general, Metakaolin SCC has less gas permeability than the standard concrete combination.

Dr. Prema Kumar (2015) has examined the impact of using fly ash and MK to partially replacing the cement in self-compacting concrete. There is no negative impact on the workability qualities of SCC when cement has been substituted with a mixture of fly ash and metakaolin which ranges from 8 to 34%. The compressive strength, splitting tensile strength, and flexural strength of SCC are all improved.

Dr. Rizwan A. Khan (2017) has looked into the mechanical performance and durability of self-compacting concrete implementing metakaolin and fly ash. Studies have been conducted on the cement weight dose, w/b ratio of 0.41, cement weight absorption, and penetration of SCC with different quantities of MK.

Rahul Sharma, et al. (2017) has taken a look at the effects of MK and copper slag on the durability of the SCC. Six of the concrete mixes contained variable amounts of CS, ranging from 0% to 100%, along with compatible percentages of 60% OPC, 30% FA, and 10% MK. Ordinary Portland cement (OPC) made up 60% of the seven extra mixes, FA made up 40%, and CS made up 0%. Investigations on the durability of SCC with CS serving as fine aggregate and MK serving as a partial replacement have been performed.

IV. OBJECTIVES

- The contribution of MK on the physical properties of SCC has been investigated using an experimental program.
- To the compressive strengths of the concrete mix have been improved by the addition of metakaolin.
- During 7 & 28 days of hydrate the split tensile ,compressive, flexural strength tests are going to be used to verify the mechanical properties of the concretes

V. METHODOLOGY

- Generating the SCC for M30 grade concrete by exchanging metakaolin mix design for cement.concrete
- Casting concrete cubes , cylinder, prism and cured for 7 and 28 days in total.
- To analysis the M30 mixed proportions.
- To analysis the result of fresh properties test and hardened properties test.

VI. MIX PROPORTION

S.No	Materials	0% Replaced	10% Replaced	15% Replaced	20% Replaced
1	Cement	407 kg/m ³	366.3 kg/m ³	345.95 kg/m ³	325.6kg/m ³
2	Metakaolin	-	40.7 kg/m ³	61.05 kg/m ³	81.4 kg/m ³
3	Fine aggregate	808 kg/m ³	808 kg/m ³	808 kg/m ³	808 kg/m ³
4	Coarse aggregate	1116 kg/m ³	1116 kg/m ³	1116 kg/m ³	1116 kg/m ³
5	Water	155 kg/m ³	155 kg/m ³	155 kg/m ³	155 kg/m ³
6	Superplasticizer	4.07 kg/m ³	4.07 kg/m ³	4.07 kg/m ³	4.07 kg/m ³

Mix Proportion Ratio = 1 : 1.98 : 2.74

VII. FRESH PROPERTIES TEST RESULTS

S.No	Materials	0% Replaced	10% Replaced	15% Replaced	20% Replaced
1	T50cm Slump flow test	3.79 sec	3.98 sec	4.6 sec	5.15 sec
2	V-funnel test	9 sec	10.2 sec	11 sec	11.3 sec
3	L-box test	0.83 sec	0.84 sec	0.9 sec	0.93 sec
4	U-box test	25.4 sec	27.2 sec	28 sec	28.2 sec

VIII. HARDENED PROPERTIES TEST RESULTS

S.No	Materials	Days	0% Replaced	10% Replaced	15% Replaced	20% Replaced
1	Compressive strength test	7	23.34 N/mm ²	24.41 N/mm ²	25.83 N/mm ²	26.57 N/mm ²
		28	38.24 N/mm ²	39.22 N/mm ²	39.74 N/mm ²	41.42 N/mm ²
2	Split tensile strength test	7	2.6 N/mm ²	3.0 N/mm ²	3.1 N/mm ²	3.3 N/mm ²
		28	3.7 N/mm ²	4.2 N/mm ²	4.4 N/mm ²	4.6 N/mm ²
3	Flexural strength test	7	5.1 N/mm ²	5.1 N/mm ²	5.2 N/mm ²	5.4 N/mm ²
		28	9.2 N/mm ²	9.3 N/mm ²	9.3 N/mm ²	9.5 N/mm ²

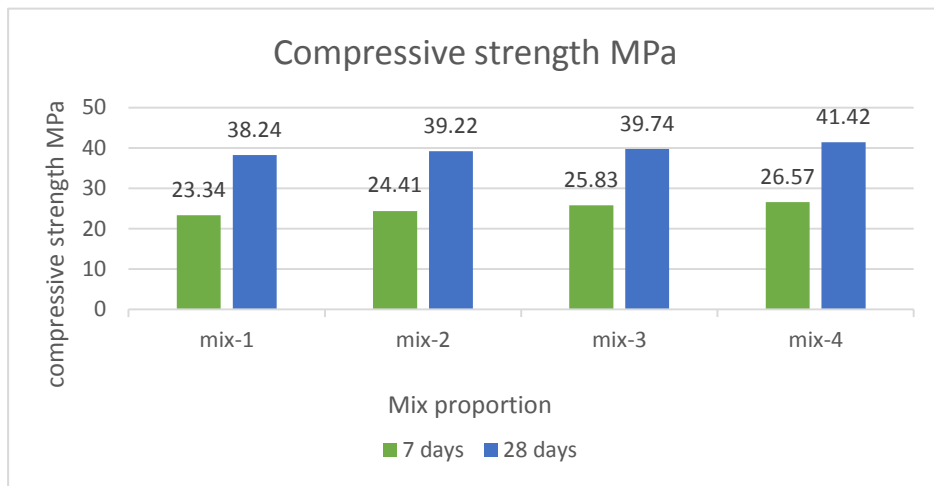


Figure1: Comparison of Compressive Strength test result

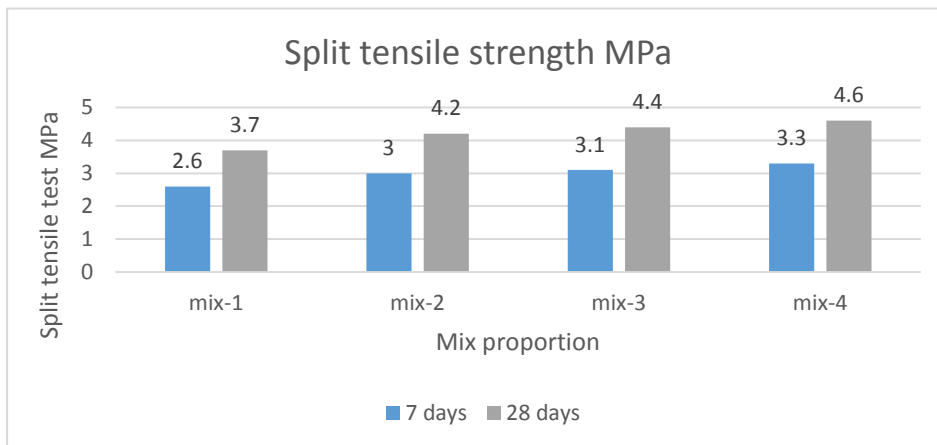


Figure2: Comparison of split tensile strength test result

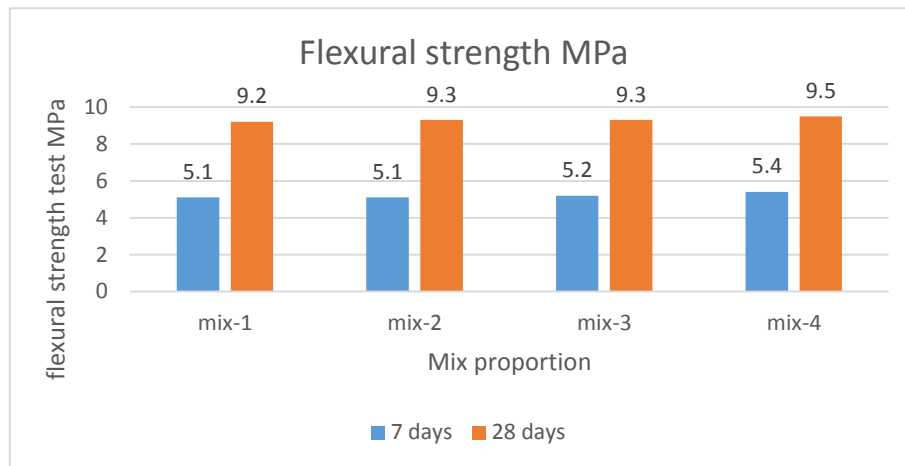


Figure3: Comparison of Flexural strength test result

IX. CONCLUSION

On the basis of the scope of search it can be concluded that:

- The following conclusions came about after the experimental program's outcomes were analyzed. The M30 grade self-compacting concrete mix proportions were developed to meet the SCC fresh qualities.
- The outcome demonstrates how metakaolin is used to generate high strength self-compacting concrete.
- The levels of metakaolin replacement that generated the maximum compressive strength when compared with PPC 53 grade without mixing were 10%, 15%, and 20%.
- In comparison with metakaolin 10% and 15%, metakaolin 20% expressed the highest potential split tensile strength, flexural strength, and compressive strength.

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