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Experimental Study on Replacement of Cement with Metakaolin Using M-Sand with Steel Fiber of M70 Grade of Concrete

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Abstract: ***Due to rapid development in urban area, use of high strength concrete in construction industry is increasing rapidly. Mineral admixture such as Ground Granulated Slag (GGBS), metakaolin, silica fume and Alccofine are become unavoidable in high strength concrete because of the effect in hardened concrete properties. Replacing the ordinary Portland cement (OPC) by mineral admixture is retaining the natural resources for future generation. In present scenareio, the complete replacement of river sand by manufactured sand is almost mandatory due to scarcity of the river sand.Super-plasticizers are used to improve the workability of concrete at low water-cement ratio and increases the compressive strength by reducing it. In urban infrastructure development, the high strength concrete is mandatory to reduce the size of structural member, and to increase the utility space to carry heavier load. In this study M70 grade concrete mix was designed with polycarboxylate ether(PCE) based super-plasticizer. The compressive strength, Flexural strength and split tensile strength at various curing periods such as 7,14 and 28 days. From the experimental test Results it observed that, all the mixes were achieved the target mean strength, among these the manufactured sand has achieved the strength parameter such as split tensile and flexural strength also slightly increased comparatively. The obtained values at the age of 24 days are within the permissible limit as per the codal provisions and the concrete with manufactured sand shows slightly higher value than concrete with river sand.***

Keywords: Flyash, Glenium8233, Flexural and split tensile test, Manufactured Sand

1. Introduction

Recently High strength concrete is a new term which used for concrete mixture and it gives the process of high workability. High modulus of elasticity. High strength. High density. High dimensional stability. Resistance to chemical attack and low permeability.

There is a little controversy between the terms high-strength and high performance concrete. High strength concrete is also, a high performance concrete but it as a few more attributes is specially designed. Therefore, logical to describe by the more widely embracing term "high strength concrete"(HSC).

It may be recalled that in normal concrete, relatively low strength and elastic modulus are the result of high heterogeneous nature of structure of the material, particularly the porous and the weak transition zone, many desirable properties can be improved many fold. By densification and strengthening of the transition zone. Which exists at the cement paste- aggregates interface.

A subsequently reduction of quantity of mixing water is the fundamental step of making HSC. The transaction zone will greatly improve by the reduction of the water-cement ratio to less than 0.3% reduction in water-cement ratio will result in high strength concrete.

To improve the quality of transition zone, use of silica fume is also found to be necessary. The best fly ash, GGBS, metakaolin, may be used for other nominal benefits. In spite of the fact that these pozzolanic material increases the water demand, their benefits will outweigh the disadvantage. The whole problem lies in using very low water-cement ratio, consistent with high workability at the time of placing and compacting.

Adopting water-cement ratio in the range of 0.25 to 0.35% and getting a high slump is possible only with the use of super plasticizer. Therefore, use of super plasticizer is a key material in making HSC. The associate problem is the selection of super plasticizer and that of cement so that they are compatible and retain the slump and rheological properties for sufficiently long time till concrete is placed and compacted.

2. Objective

The study is focused on,

1) Study the applicability of experimental investigation process of M 70 grade of concrete.
2) Evaluate the strength of cement replaced by10%, 20%, 30%, & 40% metakaolin using M-sand with steel fibers in concrete mix.
3) Scrutinize the strength value of compression strength, split tensile & flexural strength of concrete.
4) Examine the concrete specimen at which percentage of replacement it shows the maximum strength.

The main objective of this project is to determine the mechanical properties of a High Strength Concrete. For the different percentage replacement of metakaolin for cement content and complete replacement of Msand for fine aggregate.

3. Materials and Methodology

Ordinary Portland cement (OPC) is by far the most important type of cement. All the discussions that we have done. There was only one grade of OPC which was governed by IS 269-1976. After 1987 higher grade cement introduced in India. The OPC is classified in three grades. Namely 33 grade, 43 grade and 53 grade depending upon the strength of the cement at 28 days when tested as per IS 4031-1988. If the 28 days is not less than 33N/mm², it is called 43 grade cement, and if the strength not less than 53N/mm², it is called 53 grade cement. But the actual strength obtain by these cements at the factory are much higher than the BIS specifications.

It has been possible to upgrade the quality of cement by using high quality limestone, modern equipment's, closer on line control of constituents, maintaining better particle size distribution, finer grinding and better packing. Generally use of high grade cements offer many advantage for making stronger concrete. Altrough they are little costlier than low grade cement, they offer 10-20% saving in cement consumption and also they are offer many other hidden benefits. One of the most important benefits is the faster rate of development of strength. In the modern construction actives, high grade cements have become so popular that 33grade cement is almost out of the market.

The manufacture of OPC is decreasing all over the world in view of the popularity of blended cement on account of lower energy consumption, environmental pollution economic and other technical reasons. In advanced western countries the use of OPC as come down to about 40 percent off the cement production. In India for the year 1998-1999 out of the total cement production i.e., 10% in years to come the use of OPC may still come down, but all the same the OPC will remain as an important type for general construction.

In India, Portland cement was first manufactured in 1904 near madras, by the south India industrial Ltd. But this venture failed. Between 1912 and 1913, the Indian cement Co. Ltd., was established in porbander(Gujarat) and by 1914 those company was able to deliver about 1000tons of Portland cement. By 1918 three factories were established. Together they were they were able to produce about 85000 tons of cement per year. During the first five year plan(1951-1956) cement production in India rose from 2.69 million tons to 4.60 million tons. By 1969 the total production of cement in India was 13.2 million tons and India was then occupying the 9th place in the world, with the USSR producing 89.4 million tones and the USA producing 70.5 million tons.

Prior to the manufacture of Portland cement in India, it was imported from UK and only a few reinforced concrete structures were built with imported cement. A three storied structure built at Byculla, Bombay is one of the oldest RCC structures using Portland cement in India. A concrete masonry building on mount road madras (1903), the har-ki-pahari bridge at Haridwar (1908) and the cotton Dopt Bombay, than one of the largest of its kind in the world (1922) are some of the oldest concrete structures in India.

Here the replacement of cement with metakaolin by different percentage of 10%, 20%, 30% up to 40% taking the reference of several research papers.

The strength of concrete mix propotion is determined of 1: 1.13: 2.10 by using ordinary portland cement and metakaolin as the partial replacement of cement.

The replacement of cement by different percentage of metakaolin according to the mix propotion 1: 1.13 :2.10 . The different samples are done.
The concrete mix will be tested for following strengths.
1) Compressive strength after 7, 14 and 28 days
2) Split tensile strength after 7, 14, 28 days.

Steel Fibers
Crimped Steel Fibers are low carbon, cold drawn steel fibers designed to provide concrete with temperature and shrinkage crack control, enhanced flexural reinforcement, improved shear strength and increase the crack resistance of concrete. Crimped Steel Fiber complies with ASTM C1116, Standard specification for Fiber Reinforced. These steel macro-fibers will also improve impact, shatter, fatigue and abrasion resistance while increasing toughness of concrete. Dosage rates will vary depending upon the reinforcing requrements and can range from 25 to 100 ibs/yd³ (15to 60kg/m³).

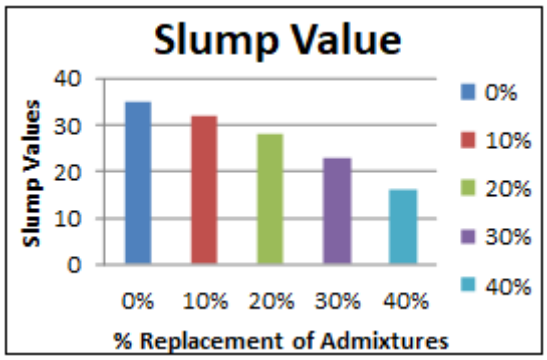
Mix design
The HSC is defined as higher concrete whose characteristic strength ranges from 50 and above. Hence for my work I'm considering M70 grade concrete. The mix design for M70 grade concrete is carried out using the Indian standard code 10262:2009. For which the water cement ratio is kept as the least value of 0.3 for the slump value is assumed as 100mm, the fine aggregate of Zone II, coarse aggregate of 20mm size and below.

- Cement = 525.5 Kg
- Water = 140 Kg (0.3)
- Fine Aggregate = 595 Kg
- Coarse Aggregate = 1105 Kg
- Admixture = 9.33(2% of cementitious material)

The proportion for the mix is **1:1.13:2.10**

Experiential Investigation
The fresh property test that is considered is the slump cone test. The result obtained for the slump cone test is:-

Slump Values of different mixes	
Concrete Mix	Slump Value (MM)
0%	35
10%	32
20%	28
30%	23
40%	16



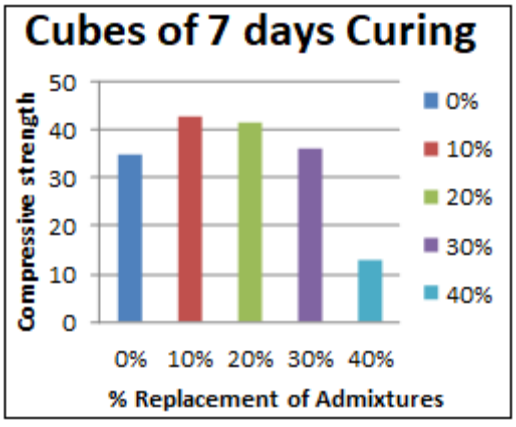
The casting of the specimens for my work is of different types and is of different quantities of the ingredients. The specimens casted are cubes cylinders and beams. The specimens are casted for different proportions of the mix quantities. The replacement of the fly ash to that of cement is in a percentage of 0%, 10%, 20%, 30% and 40%. The fine aggregate is completely replaced by Msand. The cubes casted are of 150 x 150 x 150mm in dimension. The cylinders are of 150mm in diameter and 300mm in length. The beams are of 100m x 100mm x 500mm, these beams are casted with the steel reinforcement of 8mm diameter. Only the beams are to be tested for 28days curing period. The cubes and cylinders are kept for curing for the duration of 7, 14 and 28 days in water.

Experimental Results

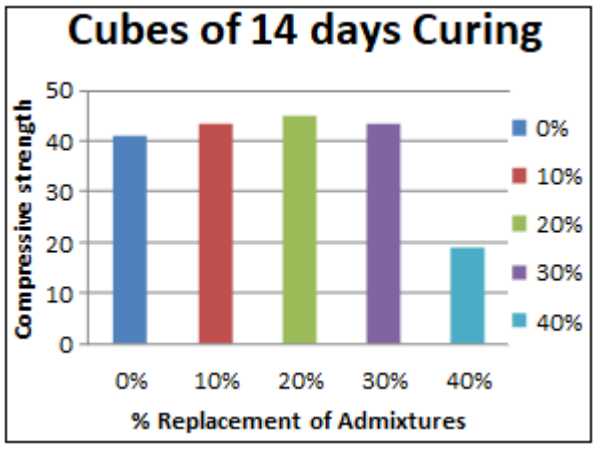
The strength test that are considered for are Compressive strength, split tensile and the flexural strength test.

Compressive Strength Test:-

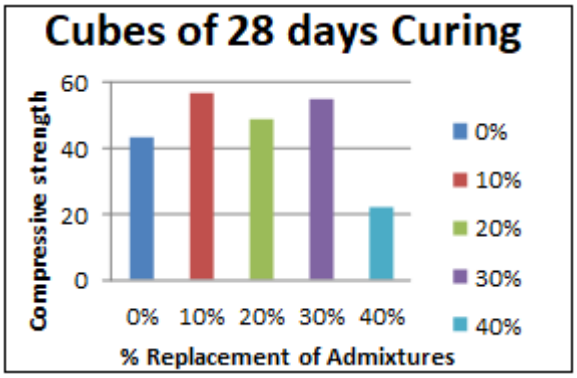
Compressive strength of cubes after 7 days curing		
% replacement of admixture	Average Ultimate Load (KN)	Compressive Strength (N/mm^2)
0%	786.6	34.96
10%	965	42.88
20%	933.3	41.48
30%	813.33	36.14
40%	295	13.11



Compressive strength of cubes after 14 days curing		
% replacement of admixture	Average Ultimate Load (KN)	Compressive Strength (N/mm^2)
0%	966.6	42.96
10%	1275	56.6
20%	1100	48.8
30%	1228.3	54.59
40%	495	22.2

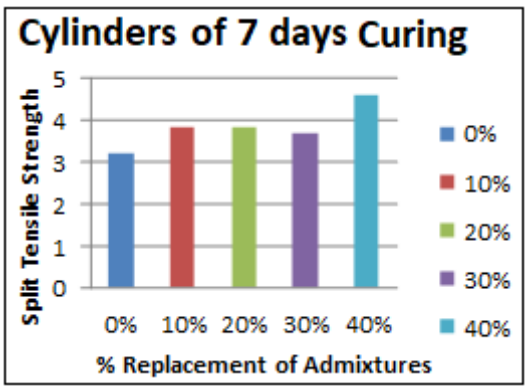


Compressive strength of cubes after 28 days curing		
% replacement of admixture	Average Ultimate Load (KN)	Compressive Strength (N/mm^2)
0%	921.66	40.96
10%	978.3	43.48
20%	1008.3	44.81
30%	976.6	43.40
40%	425	18.8

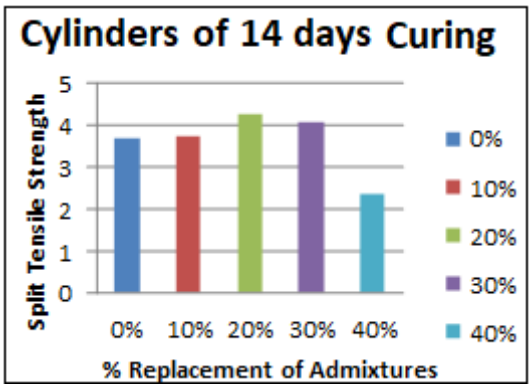


Split tensile strength

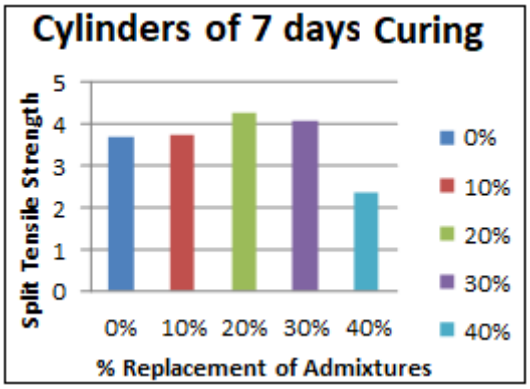
Compressive strength of cylinders after 7 days curing		
% Replacement of admixture	Average Ultimate Load (KN)	Compressive Strength (N/mm^2)
0%	146.67	3.2
10%	173.3	3.85
20%	173.3	3.85
30%	128.3	3.78
40%	206.6	4.59



Compressive strength of cylinders after 14 days curing		
% replacement of admixture	Average Ultimate Load (KN)	Compressive Strength (N/mm^2)
0%	168.3	3.7
10%	168.3	3.74
20%	193.3	4.29
30%	183.3	4.07
40%	107	2.377

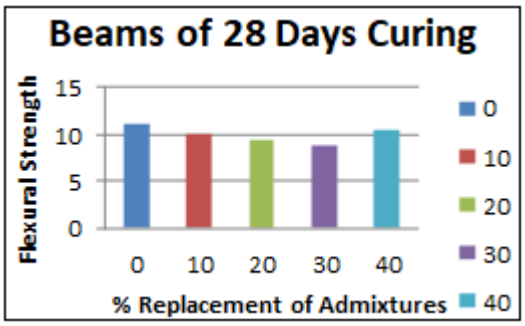


Compressive strength of cylinders after 28 days curing		
% replacement of admixture	Average Ultimate Load (KN)	Compressive Strength (N/mm^2)
0%	123.3	2.7
10%	225	5
20%	186.6	4.34
30%	175	3.88
40%	76.6	1.703



Flexural strength test:

Flexural Strength of the Beam		
% Replacement of Admixtures	Average Ultimate Load (KN)	Flexural Strength (N/mm^2)
0 %	92	11.2
10 %	88.33	9.99
20 %	78.33	9.39
30 %	73.33	8.7
40 %	87.33	10.47



4. Conclusion

Based on the present experimental investigation the following conclusions can be drawn

The purpose of introducing complete replacement of natural sand by manufacture sand is to increase the strength and performance of the concrete. And also, the strength properties of concrete can be enhanced by introducing the steel fibers.

By doing this project we can reduce the consumption of cement by 40% than conventional concrete, at this proportion concrete will give maximum strength.

In this project, the fine aggregate completely replaced by M-sand it reduces the cost saving and it is econo

Form above tests it can be concluded that 10% of metakaolin and 100 % replacement of Msand for Cement and Fine Aggregate replacement gave the better strength in case of cubes and cylinders. But in case of beams as the reinforcement was included the strength was withstood for the 40% replacement of flyash for cement and 100% replacement of Msand for fine aggregate.

5. Future Scope

For the future study on my research paper, the durability tests on the concrete can be determined for the same above considered materials or for the different materials. The strength properties of the same materials for the different grade of concrete or for higher curing period can be considered.

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