Compressive Property of Steel Fiber Concrete with Mineral Admixture for M35 Grade

Ashish Lodhi¹, Prof. Anubhav Rai², Prof. Y.K. Bajpai³

^{1, 2, 3}Department of Civil engineering, Gyan Ganga Institute of Technology & Science, India

ABSTRACT: In the present work we fabricated tested and compare of two different types of concrete (M35 Grade) samples, one is having steel fiber of 3% and another one has Metakaolin and steel fiber both. Experiment shows very good relation of mineral admixture and steel fiber with concrete strength against compressive force. We used different proportion of steel fiber and also mineral admixture and cured it at two different levels of 7 days and 28 days later, it increases its compressive strength, and also the requirement of cement is decreased with increase in proportion of fiber and mineral admixture. Prepared samples were tested for compressive strength on a machine having 2000 KN rated capacity. This experiment shows a great enhancement in compressive strength of concrete and is also shown graphically

1. Introduction

Now a day's human requirement is much higher than shelter, with the advancement of human societies, structure has to be more confined in space occupation, spacious and stronger than before. Modern structures are developed not only with pleasant appearance but also for long life and durability. Advance technology in civil engineering and in architecture helps designers and engineers to make a promise between appearance and strength. Apart from nature's impact like in form of tycoons, flood and earthquake; structures also withstand in atmospheric condition like downpour, humidity and large variation in temperature according to climate. In the present work we also experimented with steel fibers and other ingredients (Metakaolin). Sample with different concentration and different size of fiber, were prepared and tested for the compressive strength against conventional concrete.

Data from the performed experiment were recorded and compressive strength related analysis have been done. Our main object of the work is to improve the compressive strength of the concrete without much changing in fabrication and casting process.

2. Materials

Locally available Ordinary Portland cement of grade 43 was used in the present work. The cement had a specific gravity of 3.15. Locally available dry aggregate was used in the concrete mixes. The

maximum nominal size of the coarse aggregate was 20 mm and 10 mm, its specific gravity for coarse aggregates 20 mm size was 2.82 and coarse aggregates 10 mm specific gravity 2.90. The specific gravity of the fine aggregate (sand) was 2.65, and its fineness modulus was 2.57.

Steel fibers with Hooked end & Flat crimped were used in the mixes. The steel fibers had a length of 50mm and a diameter of 0.75mm (an aspect ratio of 100). The density of the fibers was 7.65 g/cm³ and the young's modulus was 210 GPa.

Metakaolin (MK) is a reactive alumino-silicate pozzolan formed by burning purified kaolin or kaolinite clays at a specific temperature range and by grinding it to a high fineness. Metakaolin can be combined with calcium hydroxide to form hydrates. This contributes to improving properties of mortar and concrete. The reaction capacity of Metakaolin depends mainly on its mineral composition, on the raw kaolin source and on the conditions of production. Chemically, Metakaolin encompasses as main components oxides as SiO₂, Al₂O₃ and in smaller quantities the oxides Fe₂O₃, TiO₂, Na₂O and K₂O. The efficiency of metakaolin as a mineral admixture in cement and concrete is governed by high contents of SiO₂ and Al₂O₃

The pozzolanic activity of Metakaolin is its ability to combine with calcium hydroxide to form cementitious compounds. This reactivity of the Metakaolin is predominantly governed by the type and amount of mineral compounds in the kaolin and by the calcination conditions.

The pozzolanic activity of commercial Metakaolin is in the range of 610-1150 (mg CaO/g), there by considerably exceeding the pozzolanic activity of silica fume 427 (mg CaO/g). Strength properties of paste and mortar are strongly influenced by kind, shape, size and spatial dispersion of hydrations products and by the pore characteristics. Partial replacement of Ordinary Portland Cement by Metakaolin was applied mid 1960s to improve the durability of concrete dams in Brazil. Since those days, the use of Metakaolin in cement and concrete has increased significantly. Metakaolin used in the cement and concrete industry. At present, Metakaolin is not only used in Ordinary Portland Cement and in normal concrete but also in high performance mortar and concrete

Purified water that was clear and free of organic, chemical and physical impurities was used during the mixing and curing of the concrete specimens.

3. Sample Preparation

The mix proportion of 1: 1.77: 3.21 using I.S. Code 10262:2009 methods with water cement ratio 0.45 to different concrete mix by weight is determined to achieve the compressive characteristic strength of 35 N/mm², was considered for this work.

The exact quantity of materials for each mix was calculated using weigh batching. The parameters varied were percentage of fiber content.

The constituent of materials used for making the concrete were tested and the results are furnished in Table 1. The cement, fine aggregate, coarse aggregate steel fiber and Metakaolin were tested prior to the experiments and checked for conformity with relevant Indian standards.

Material	Discription	
Cement	Type- OPC 43 grade	
Fine Agg.	River sand falling on zone II	
	having a Fineness modulus	
	of 2.57	
Coarse Agg.	20mm and 10 mm nominal	
	size aggregate,	
Steel fiber	0.5mm, Tensile strength	
	minimum 345MPa	
Metakaolin	Specific gravity 2.5, mean	
	grain size(µm) 2.54, Specific	
	area cm ² /gm 150000-180000,	
	colour white	
Fiber Length	50mm ,aspect ratio 100	
Mix ratio	1:1.77:3.21	
w/c ratio	0.45	

Table 1: Details of Constituent Materials

4. Test Procedure

Designed are mixed by hand mixing on a clean cemented surface. To measure all ingredients i.e. cement, sand, coarse aggregates (20 mm and 10 mm), Steel fiber and Metakaolin we use weighed machine. The coarse aggregate (of 20mm and 10mm size), sand and cement and Metakaolin and steel fiber were mixed properly and mixing continued until uniformity was achieved by turning the mixture from one side to another side for many time until the color of the mixture is uniform. Assemble it all into a heap and make a hollow in the middle.

Add the water slowly into the hallow and mix in the material while turn the mixture again and again and make into a heap again, add more water and keep turning and mixture turned over again from side to side until it appeared uniform in color for about 3 minutes and we obtain the proper consistency after that material is filled into mould.

The standard tamping bar is also used for compacting the sample in the mould. The number of stroke of the bars is distributed in a uniform manner over the cross section of the mould. The number of stroke per layer required to produce the specified conditions is 35.

After Compaction by tamping bar vibration table was used to vibrate by means of an electric machine until the specific condition of minimum voids.

Moulds of dimension of 150mm×150mm×150mm was used for sample casting. After 24 hr, each specimen was removed from the mould and cured under water at $32\pm2^{\circ}$ C until testing at age of 7 and 28 days. All specimens were cured in the same water tank to ensure uniform curing conditions.

The tests for measuring the compressive strength of the concrete specimens was carried out using Compressive Strength testing machine with a load at a constant rate within range per sec.

5. Cube Compressive Strength

Compressive strengths of the cubes (having steel fiber only) were tested for 7- days and 28- days and the test results are given Table 2. The maximum average compressive strength was 46.25 N/mm² at 28 days, obtained for a mix of fiber length of 50mm and fiber content of 3.0% by weight and the increase in strength over plain concrete was found to be 7%.

Compressive strengths of the cubes having both material Steel fiber and Metakaolin were tested for 7- days and 28- days and the test results are given *Table*.

% of Steel Fiber	Compressive strength (in N/mm ²)	
	After	After 28-
	7- days	days
0	31.22	43.78
1.0	30.81	43.91
2.0	31.63	44.81
3.0	32.96	46.25

Table 2: Result of cube compressive Strength

The maximum average compressive strength was 51.40 N/mm^2 at 28 days, obtained for a mix of fiber length of 50mm and steel fiber content of 3% and

Metakaolin content of 19% by weight and the increase in strength over plain concrete was found to be 7%



Figure1: Compressive strength of concrete and different % of steel fiber

Table 3: Result of cube compressive Strengt	h
---	---

% of	%	Compressiv (in N/n	e strength nm2)
Steel Fiber	Metakaoli n	After 7- days	After 28- days
1	10	34.96	48.71
2	10	35.28	49.65
3	10	36.07	51.40



Figure2: Compressive strength of concrete and different % of steel fiber and 10% of Metakaolin

Table 4: Comparison between Result of cube
compressive Strength

		0	
	Compressive Strength in		
% of Steel	N/i	N/mm ²	
Fiber	Without	With 10%	
	Metakaolin	Metakaolin	
1	43.91	48.71	
2	44.81	49.65	
3	46.25	51.40	



Figure 3: Comparison between Compressive strength of concrete having only steel fiber and with steel fiber and Metakaolin

CONCLUSIONS

The experiment shows that the effect of steel fiber can still be a promising work as there is always a need to overcome the problem of brittleness of concrete. The following conclusions could be drawn from the present investigation.

- The maximum compressive strength of specimen after 28 days is 51.40 N/mm² with 3% of fibers and 10% of Metakaolin.
- 2. An increase of 11% in compressive strength is observed if 10% Metakaolin added with 3% of Steel fiber in to the mix as compare with only 3% of steel fiber.
- 3. An increase of 18% in compressive strength is observed if 10% Metakaolin added with 3% of Steel fiber in to the mix as compare with normal M-35 grade concrete without any additives.
- 18. Indian standard code of practice for plain and reinforced concrete IS: 456-2000, Bureau of Indian Standard, New Delhi.
- Indian Standard methods of tests for strength of concrete IS: 516-1959, Bureau of Indian Standards, New Delhi.

REFERENCE

- J.M. Justice and K. E. Kurtis, "Influence of Metakaolin Surface Area on Properties of Cement-Based Materials" Journal of Materials in Civil Engineering © ASCE/ September 2007.
- H. M. Khater, "Influence of Metakaolin on Resistivity of Cement Mortar to Magnesium Chloride Solution" Journal of Materials in Civil Engineering © ASCE/ September 2011.
- L. G. Sorelli, A. Meda and G. A. Plizzari, "Bending and Uniaxial Tensile Tests on Concrete Reinforced with Hybrid Steel Fibers," Journal of Materials in Civil Engineering © ASCE/ September/October 2005
- S. S Potgieter-Vermaak and J. H. Potgieter, "Metakaolin as an Extender in South Africian Cement," Journal of Materials in Civil Engineering," Volume 18, No.4, August 1, 2006 © ASCE,2006.
- Erhan Guneyisi, Mehmet Gesoglu, Kaism Mermerdas, "Strength Deterioration of Plain and Metakaolin Concrete in Aggressive Sulfate Environments." Journal of Materials in Civil Engineering ,Volume 22, No.4, April 1, 2010 © ASCE.
- Job Thomas and Ananth Ramaswamy, "Mechanical Properties of Steel fiber-Reinforced Concrete". Journal of Materials in Civil Engineering," Volume 19, Issue 5 May 2007.
- Francesco Bencardino¹; Lidia Rizzuti²; Giuseppe Spadea³; and Ramnath N. Swamy⁴, "Stress-Strain Behaviour of Steel Fiber-Reinforced Concrete in Compression" Journal of Material in Civil Engineering Volume 20, Issue 3,March 2008.
- 8. Muthuswamy, K.R and Thirugunanam ,G.S, "Mechanical properties of hybrid fiber reinforced high performance concrete" The Indian concrete journal, April 2013.
- Muthuswamy, K.R and Thirugunanam, G.S, "Flexural behavior of high performance hybrid fiber reinforced concrete beams, The Indian concrete journal, April2013
- Ghughal,Y.Mand Bhalchandras,S.A., "Performance of steel fiber reinforced high strength silica fumes concrete". Civil Engineering and Construction Review, October 2009,pp32-34
- 11. Mehta P. and Aitcin (1995), "Development in the application of high performance concrete", Chapter 17 University of Memphis
- A.M.Alhozaimy, P. Soroushian & F. Mirza (1996), "Mechanical properties of polypropylene fiber reinforced concrete and the effect of pozzolanic materials".
- Fahad A. Kandari, et.al,(2011)"influnce of fly ash on behavior of Fibers Reinforced Concrete Structures", Journal of applied sciences, 11(17):3185-3191.
- Falah A. Almottiri (2011), "Physical Properties of Steel Fiber Reinforced Cement Composites Made with Fly Ash", Jordan Journal of Civil Engineering, Volume 5, No. 2.
- 15. Chih-Ta Tsai, Lung-Sheng Li, Chien-Chih Chang, Chao-Lung Hwang (2009), "Durability design and application of Steel Fiber reinforced Concrete in Taiwan", the Arabian Journal for Science and Engineering, Volume 34, Number 1B
- 16. Indian standard code of practice for specification for coarse and fine aggregate from natural sources of concrete IS: 383-1970, Bureau of Indian standards, New Delhi.
- Indian standard code of practice for recommended guidelines for concrete mix design IS: 10262-2009, Bureau of Indian standards, New Delhi.
- 20. Santhakumar, A.R., Concrete Technology, Oxford press, New Delhi, 2005
- 21. Gambhir M.L., Concrete Technology, McGraw Hill Education (India) Private Limited, New Delhi, 2013.