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### A STUDY ON STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF CEMENT WITH FLY ASH IN ADDITION WITH STEEL FIBER AND COCONUT FIBER

**Mohd Khawaja Hussain\*, Prof. Syed Arfath**

\* PG Student, Department Of Civil Engineering, Khaja Banda Nawaz College Of Engineering,  
Kalaburagi, Karnataka, India

Assistant Professor, Department Of Civil Engineering, Khaja Banda Nawaz College Of Engineering,  
Kalaburagi, Karnataka, India

#### ABSTRACT

This paper shows the results of a study undertaken to enhance the property of Fly Ash concrete with steel and coconut fiber. The aim of this experiment is to study the behavior of Fly Ash content with Steel Fibers and Coconut Fibers on the properties of concrete. In this investigation the M-20 Grade of concrete with water-cement ratio of 0.45 having a mix proportion of 1:1.5394:2.6910 to determine the compressive strength, split tensile strength and flexural strength. In this study the cement is been replaced with three percentages of Fly Ash by weight 10%, 20% and 30%. Three percentages of Steel Fibers and Coconut Fibers 0%, 1% and 2% were used having a length of 50mm. The results which are obtained are compared with the control specimen. The optimum dosage of adding Fly Ash and Steel Fibers is obtained to be 20% and 2% and the optimum dosage of adding Fly Ash and Coconut Fibers is obtained to be 20% and 1%. A steel fiber gives better results as compared to that of coconut fibers. Tests were conducted on beams with the optimum dosage obtained and are compared with the Identical Reinforced Concrete Beam.

**KEYWORDS:** Fly Ash, Steel Fiber, Coconut Fiber, Compressive Strength, Split Tensile strength, Flexural Strength of prisms and Beams.

#### INTRODUCTION

Concrete is now the most widely used construction material as it can be cast to any form and shape at site very easily. Cement concrete has established itself as the most preferred material. Fly ash is the fine powder produced as a product from the combustion of pulverized coal. The disposal is one of the main reason of fly ash. As dumping of fly ash as a waste material may cause severe environmental problems. The quantity of fly ash produced from the thermal power stations in India is approximately 80 millions tons per year. But its percentage of utilization is less than 10%. Mainly more amount of fly ash produced is class F type. Fly ash is generally used as a replacement of cement, as an admixture in concrete, and manufacturing cement. By using fly ash as an admixture in concrete instead of dumping it as a waste material can be great beneficial for the lowering the water demand of concrete for similar workability which also reduces bleeding and lowers the evolution of heat.

The concrete containing fly ash as partial replacement of cement possesses problems on delayed early strength. But concrete containing fly ash as partial replacement of fine aggregate will possess no delayed early strength.

Er. Balvir Singh and Dr. Jaspal Singh [1], shows an experimental investigation to study the properties of concrete in which Fly ash is varied as 0%, 3%, 6% and 12% variation and the Steel fibers varied as 0%, 0.75%, 1%, 1.25% and 1.5%. Falah A. Almottiri [4], shows the Fly Ash concrete which is reinforced with Steel Fiber, Fly Ash percentage is increased upto 30% for 10% interval and Steel Fiber upto 1.5% having an interval of 0.5%. By the use of Steel Fiber it shows the increase in the structural properties mainly for flexural, tensile strength for Fly ash based concrete. Tarun Sama, Dilip Lalwani, Ayush Shukla and Sofi A [5], studied the behavior of M-40 Grade Concrete cement is replaced with two percentages 40% and 60%, and Steel Fiber with four percentages 0%, 1%, 1.5% and 2%. The optimum optimum percentage obtained for overall strength of adding fly ash with steel fibers was determined to be 40% and 2%. Saravana Raja Mohan, K., P. Jayabalan and A. Rajaraman [3], shows the Fly Ash concrete composites with

natural fiber i.e. Coconut Fiber, cement is replaced with five percentages 10%, 15%, 20%, 25% and 30% with class C fly ash and four percentages of coconut fibers is 0.15%, 0.30%, 0.45% and 0.60% having 40mm length were used. The test results obtained shows the replacement of 43 grade OPC with fly ash shows an increase in compressive strength, splitting tensile strength and flexural strength and also the modulus of elasticity.

The focus on this investigation is to enhance the concepts that by use of steel fiber and coconut fiber in fly ash concrete. By this to increase the ductility, strength as well as to improve the durability of overall concrete. The fibers which are used i.e. steel fiber and coconut fiber are randomly dispersed throughout the concrete. The fibers helps to stop the internal widening of cracks and fly ash helps as an admixture for the improvement in the concrete properties. The effect of each one of the steel and coconut fibers on the mechanical properties of fly ash is studied under this investigation.

## EXPERIMENTAL PROGRAMME

### Materials Used

In present work various materials is used with their respective properties namely: OPC 53 Grade cement. Fly Ash, Steel Fiber, Coconut Fiber, Fine aggregates: Natural sand, Coarse aggregate, water.

**a. Cement:** Ordinary Portland cement of 53 grade conforming to IS: 12269-1987 is used in this investigation. The physical properties of the cement obtained on conducting appropriate tests as per IS: 12269-1987.

**b. Fly Ash:** Fly Ash used in this work is from Raichur Thermal Power Plant. The physical properties were: Specific gravity= 2.3 .

**c. Natural Sand:** Locally available clean river sand passing through sieve size 4.75mm which is retained on 150micron IS sieve is used. The sieve analysis test is done as per IS: 383-1970. The natural sand is of Zone II , Fineness Modulus= 2.84, specific gravity= 2.63.

**d. Coarse aggregate:** Coarse aggregate which is used was locally available in 20mm downsize crushed aggregate (20mm IS Sieve). The sieve analysis test is done as per IS: 383-1970. Fineness Modulus= 5.12, Specific gravity= 2.7.

**e. Steel Fiber:** The steel fiber used in this investigation is a hook end type fiber. The length of the fiber used in this experiment is 50mm and the diameter of the fiber is 1mm.

**f. Coconut Fiber:** Coconut fiber is also known as coir. The treated coconut fiber used in this investigation is of length 50mm.

**g. Water :** Clean water used for this investigation is a potable tap water. The water in the campus is of the potable standard of pH= 7.5 are used.

### Mix proportion

Concrete Mix design of M20 grade was designed conforming to IS: 10262-2009. The trial mixes were attempted to achieve workable concrete mix. Cubes of standard size 150x150x150mm, cylinders of size 150mm diameter and 300mm height, prisms of size 500x100x100mm were casted.

**Table1: Design parameters per cubic meter :**

Cement	425.73kg
Fine aggregate	655.3829kg
Coarse aggregate	1145.6235kg
W/C ratio	0.45
Water	191.58 litres

In this investigation, In first variation, cement is replaced by 10% Fly Ash in addition with Steel Fiber 0%, 1%, and 2%. In second variation, cement is replaced by 20% Fly Ash in addition with Steel Fiber 0%, 1%, and 2%. In third variation, cement is replaced by 30% Fly Ash in addition with Steel Fiber 0%, 1%, and 2%. In fourth variation, cement is replaced by 10% Fly Ash in addition with Coconut Fiber 0%, 1%, and 2%. In fifth variation, cement is replaced by

20% Fly Ash in addition with Coconut Fiber 0%, 1%, and 2%. In sixth variation, cement is replaced by 30% Fly Ash in addition with Coconut Fiber 0%, 1%, and 2%.  
The Mix proportion were 1: 1.5280: 2.670

**Properties Of Fresh Concrete**

Concrete mixes were checked for workability through slump test. It was observed that the slump flow increases as the Fly Ash content increases. All concrete mixes was homogenous and cohesive in nature also slump had shear type of failure. Based on this, 75mm slump is taken in Mix design of Concrete.

**Hardened Concrete Properties**

Compressive strength, Split tensile strength and Flexural strength (Modulus of rupture) of different mixes were determined.

**Compressive strength**

The Cubes of 150x150x150mm sizes are casted for various combined mixes. The Cubes are cured and tested for 7 and 28 days. Testing was made in 2000 KN testing machine. The average of 3 cubes for each curing and each replacement is note down to get the compressive strength of concrete.

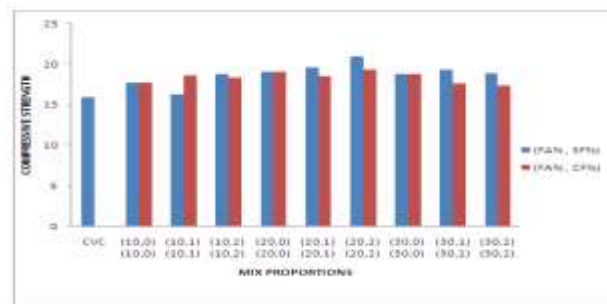


Fig 1: Comparison and Effect of curing on Compressive Strength of M-20 Grade after 7 days

Where 10, 20 and 30 represents the percentage of Fly Ash and 0, 1 and 2 represents the percentage of steel fiber and coconut fiber. Where FA is Fly Ash, SF is Steel Fiber and CF is Coconut Fiber.

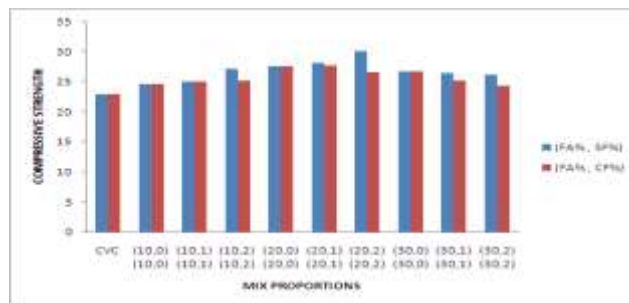


Fig 2: Comparison and Effect of curing on Compressive Strength of M-20 Grade after 28 days

Where 10, 20 and 30 represents the percentage of Fly Ash and 0, 1 and 2 represents the percentage of steel fiber and coconut fiber. Where FA is Fly Ash, SF is Steel Fiber and CF is Coconut Fiber.

The test results shows that the maximum compressive strength obtained for 7 days for a Mix containing fly ash 20% and steel fiber 2% is found to be 20.928 N/mm<sup>2</sup>, the maximum compressive strength obtained for 28 days for a Mix containing fly ash 20% and steel fiber 2% is found to be 30.011 N/mm<sup>2</sup>, and for mix containing Fly Ash and Coconut Fiber, the maximum compressive strength obtained for 7 days for a Mix containing fly ash 20% and coconut fiber 1% is found to be 19.33 N/mm<sup>2</sup> and the maximum compressive strength obtained for 28 days for a Mix containing fly ash 20% and coconut fiber 1% is found to be 27.760 N/mm<sup>2</sup>. The optimum values obtained are more than CVC.

**Split Tensile strength**

The split tensile strength is the indirect test to determine the strength of concrete. Three cylinders of size 150mm diameter and 300mm in length are casted for various percentages of Fly Ash and Steel Fiber and Coconut Fiber and cured for 28 days. Testing was made in 2000KN testing machine as per IS:516-1959. The magnitude of split tensile strength is given by  $f_{ct} = 2P/\pi dl$ , where P= applied compressive load at failure, d= Diameter of cylinder, l= Length of cylinder. Average of 3 cylinders gives the split tensile strength.

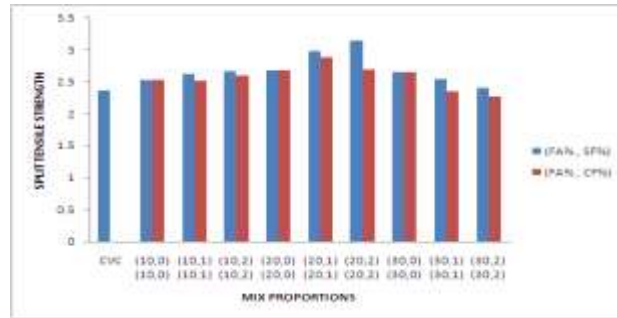


Fig 3: Comparison and Effect of curing on Split Tensile Strength of M20 Grade after 28 days

Here, 10, 20 and 30 represents the percentage of Fly Ash and 0, 1 and 2 represents the percentage of steel fiber and coconut fiber. Where FA is Fly Ash, SF is Steel Fiber and CF is Coconut Fiber.

The results obtained shows that The maximum split tensile strength obtained for 28 days is for a Mix containing fly ash 20% and steel fiber 2% is found to be 3.15 N/mm<sup>2</sup> which is, and for mix containing Fly Ash and Coconut Fiber, the maximum split tensile strength obtained for 28 days is for a Mix containing fly ash 20% and coconut fiber 1% is found to be 2.88 N/mm<sup>2</sup>. The optimum values obtained are more than CVC.

**Flexural strength**

Three beams of size 500x100x100mm were casted and cured for 28 days for every combined replacement of Fly Ash and Steel Fiber and Coconut Fiber. Testing was done as per two point loading method. The results of various mixes are shown in tabular form as:

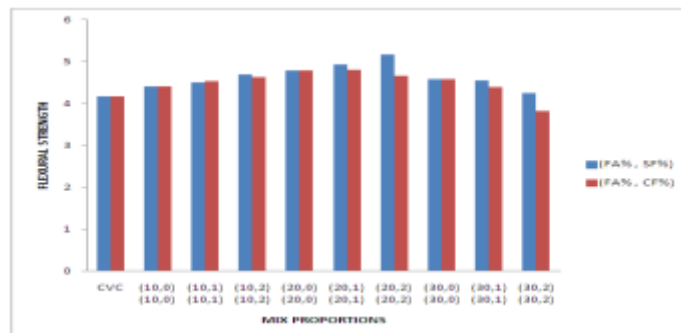


Fig 4: Comparison and Effect of curing on Flexural Strength of M20 Grade after 28 days

Here, 10, 20 and 30 represents the percentage of Fly Ash and 0, 1 and 2 represents the percentage of steel fiber and coconut fiber. Where FA is Fly Ash, SF is Steel Fiber and CF is Coconut Fiber.

The maximum flexural strength obtained for 28 days is for a Mix containing fly ash 20% and steel fiber 2% is found to be 5.16 N/mm<sup>2</sup>, and for the mix proportions containing fly ash with coconut fiber. The maximum flexural strength obtained for 28 days is for a Mix containing fly ash 20% and coconut fiber 1% is found to be 4.8 N/mm<sup>2</sup>. The optimum values obtained are more than CVC.

**Flexural Behavior of Beams****Geometry of test beams**

The dimension of beams were selected as 700x150x150mm. The testing is done under Universal testing machine under two point loading condition. The dimension is given below:

Overall length= 700mm

Effective length= 600mm

Overall Depth= 150mm

Overall Breadth= 150mm

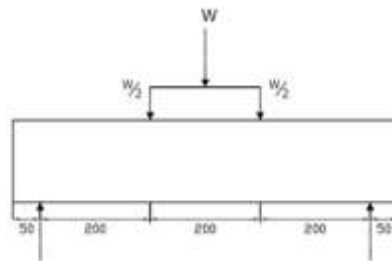
Effective Breadth= 120mm

**Details of Test Specimen****Test specimens are as follows:**

- Two Beams of grade M20 ( B1-B2 ) of span 700mm width 150mm, and depth 150mm are tested for conventional beams.
- Two Beams of grade M20 ( B3-B4 ) MIX containing Fly Ash 20% and Steel Fiber 2% of span 700mm width 150mm, and depth 150mm are tested.
- Two Beams of grade M20 ( B5-B6 ) MIX containing Fly Ash 20% and Coconut Fiber 1% of span 700mm width 150mm, and depth 150mm are tested.

**Table 2: Details of Test Beams**

Beam dimension (mm)	Reinforcement		Tensile reinforcement ratio (%)
	Compression	Tension	
150x150x700mm	2#8	2#10	0.87%
150x150x700mm	2#8	2#10	0.87%
150x150x700mm	2#8	2#10	0.87%



ALL DIMENSIONS ARE IN MM

**Fig5: Loading Arrangement For Testing Of All Beams****Test setup and testing procedure**

The testing is done in Universal testing machine. All beams were tested under two point loading method. One dial gauge was placed at the centre of beam to note the deflection at mid span. The loading was done at the rate of 400kg/min which is placed centrally over the channel section ISMC 250. The First Crack load and Ultimate Crack load and their corresponding deflections were recorded.

**RESULTS AND DISCUSSION****Crack pattern**

All 6 beams were failed in flexural. As the load increases, the crack started from bending zone at the mid span of beam. The cracks at the mid span opened widely near failure. At failure, Flexural cracks were observed.



Fig 6: Crack Pattern Of Test Beam

**Experimental results**

All the beams were studied for bending under flexural mode. Structural parameters such as cracking load, service loads, ultimate loads and their corresponding deflections were investigated. Also, experimental moments of cracking and ultimate loads is calculated and compared with the theoretical moments (IS: 456-2000).

Table 3: Average Experimental results of test beams

Beam No.	Ast	Experimental Values					
		Pcr	Avg Pcr	$\Delta_{cr}$	Pu	Avg Pu	$\Delta_u$
B1	0.87%	110	112.5	1.0	165	162.50	1.9
B2	0.87%	115		1.2	160		1.8
B3	0.87%	121.6	124.55	0.7	189.30	190.75	1.8
B4	0.87%	127.5		0.8	192.20		2.0
B5	0.87%	95	102.5	1.0	176.10	173.85	2.8
B6	0.87%	110		1.2	171.60		2.6

Here Pcr = Cracking load, and Pu = Ultimate load and their corresponding deflections  $\Delta_{cr}$  and  $\Delta_u$  respectively.

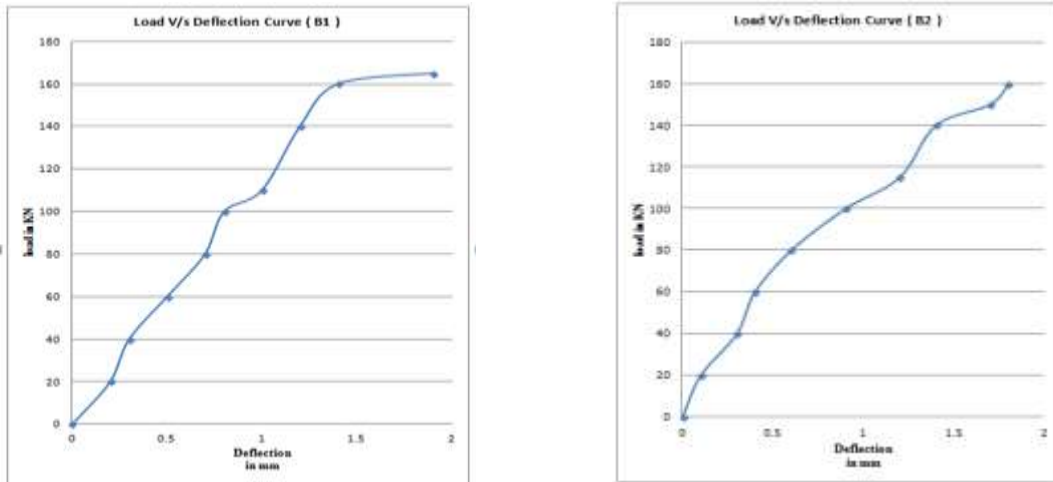


Fig 7: Average Load vs Deflections of Beams- B1,B2

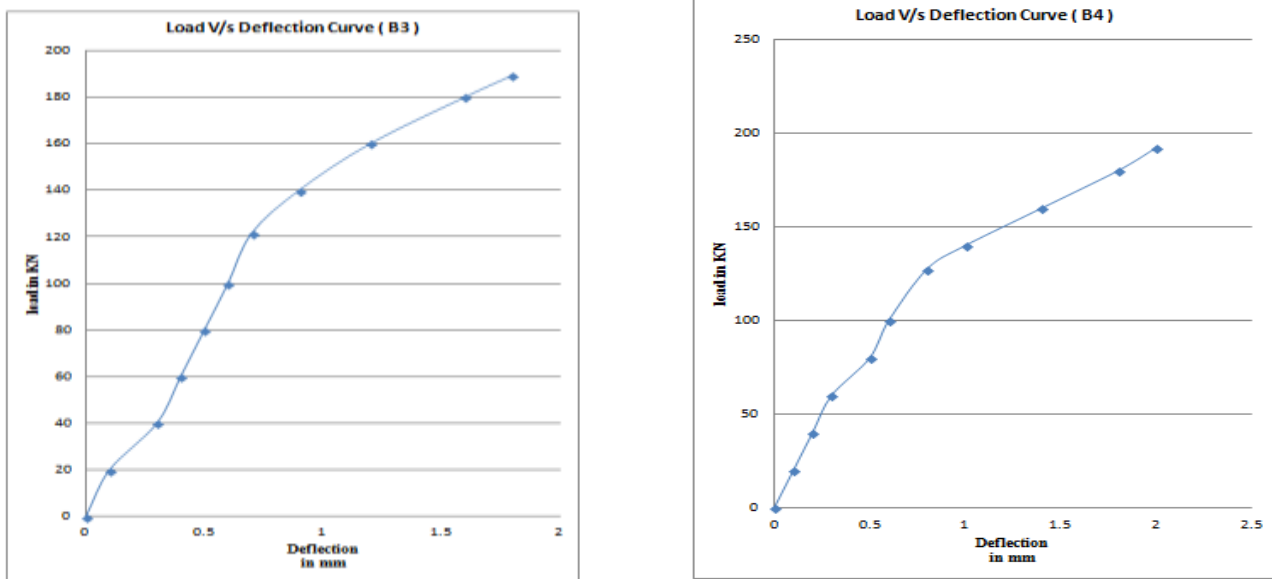


Fig 8: Load Vs Deflection of Beams –B3,B4

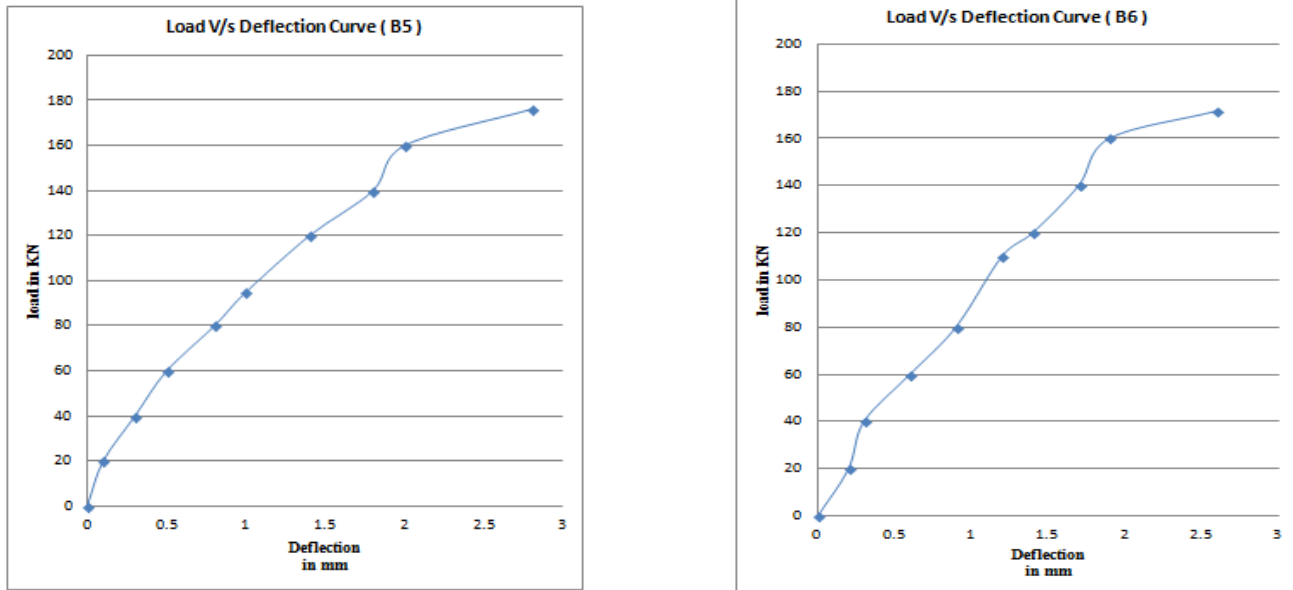


Fig 9: Load Vs Deflection of Beams –B5, B6

### Deflection

The deflection was measured at the mid span of beam and the corresponding loads were noticed. The results show the load deflection behavior of beams:

### CONCLUSIONS

- 1) The compressive strength of concrete increases as the percentage of replacement of cement is increased upto 20% in addition with steel fiber 2% further replacement there is decrease in strength of concrete.
- 2) The compressive strength of concrete increases as the percentage of replacement of cement is increased upto 20% in addition with coconut fiber 1% further replacement there is decrease in strength of concrete.
- 3) The compressive strength obtained for 7 days containing fly ash 20% and steel fiber 2% is found to be 20.928 N/mm<sup>2</sup> which is about 31.51% more than the CVC and the compressive strength obtained for 28 days containing fly ash 20% and steel fiber 2% is found to be 30.011N/mm<sup>2</sup> which is about 31.32% more than the CVC.
- 4) The compressive strength obtained for 7 days containing fly ash 20% and coconut fiber 1% is found to be 19.33 N/mm<sup>2</sup> which is about 21.46% more than the CVC and the compressive strength obtained for 28 days containing fly ash 20% and coconut fiber 1% is found to be 27.76 N/mm<sup>2</sup> which is about 17.67% more than the CVC.
- 5) The compressive strength obtained for 28 days containing fly ash 20% and steel fiber 2% is found to be 30.011N/mm<sup>2</sup> which is about 7.80% than the compressive strength 27.67N/mm<sup>2</sup> obtained for 28 days containing fly ash 20% and coconut fiber 1%.
- 6) The split tensile strength obtained for 28 days containing fly ash 20% and steel fiber 2% is found to be 3.15 N/mm<sup>2</sup> which is about 32.91% more than the CVC. The split tensile strength obtained for 28 days containing fly ash 20% and coconut fiber 1% is found to be 2.88 N/mm<sup>2</sup> which is about 21.52% more than the CVC.
- 7) The split tensile strength obtained for 28 days containing fly ash 20% and steel fiber 2% is found to be 3.15 N/mm<sup>2</sup> which is about 8.57% more than the split tensile strength 2.88 N/mm<sup>2</sup> obtained for 28 days containing fly ash 20% and coconut fiber 1%.
- 8) The flexural strength obtained for 28 days containing fly ash 20% and steel fiber 2% is found to be 5.16 N/mm<sup>2</sup> which is about 23.97% more than the CVC. The flexural strength obtained for 28 days containing fly ash 20% and coconut fiber 1% is found to be 4.8N/mm<sup>2</sup> which is about 13.29% more than the CVC.
- 9) The flexural strength obtained for 28 days containing fly ash 20% and steel fiber 2% is found to be 5.16 N/mm<sup>2</sup> which is about 6.977% more than flexural strength 4.8N/mm<sup>2</sup> obtained for 28 days containing fly ash 20% and coconut fiber 1%.4.8N/mm<sup>2</sup>.



- 10) The load carrying capacity of CVC is less than the cement replaced with Fly ash in addition with Steel Fibers and Coconut Fibers.  
The load carrying capacity of Fly ash in addition with Steel Fibers is more than the coconut fibers.

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