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Study of Temperature Variations in High Volume Fly Ash Concrete Pavement Slab

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Abstract: HVFAC has excellent workability, low heat of hydration, adequate early-age and high later-age strengths, reduced drying shrinkage, reduced micro cracking, excellent durability characteristics while being more economical and environment-friendly when compared to conventional concrete. Due to its superior performance and engineering properties the development of HVFAC has opened new doors to sustainability of modern concrete construction. The high-volume fly ash concrete system addresses all the sustainability issues, its adoption will enable the concrete construction industry to become more sustainable. At high levels problems may be encountered with extended set times and slow strength development, leading to low early-age strengths and delays in the rate of construction. These drawbacks are overcomed by using fibers. The fibres are distributed uniformly in concrete has better properties to resist internal stresses due to shrinkage. Steel fiber which improves specific material properties of the concrete, impact resistance, flexural strength, toughness, fatigue resistance, and ductility is used. The present technology of making flexible pavements is increasingly becoming unsustainable because of rising life cycle costs and could be suitably replaced with high volume fly ash based concrete roads. Temperature distribution in pavement slab is dependent on material properties and on ambient conditions. Temperature distribution across the thickness of concrete pavement is an important factor for the design of rigid pavements. This paper is a study of the temperature differences in a pavement slab which contains more than 50percent of fly ash content. The different percentage replacement of fly ash includes 60percent, 65percent and 7percent in addition with and without steel fiber for each percentage. From the results obtained from the mechanical strength tests the mix with 60percent fly ash with steel fiber had the maximum strength. Slab will be casted for the mix containing 60percent fly ash with steel fiber and the difference in temperature will be observed for a period of time and the results will be discussed.

Keywords: *High Volume Fly Ash, Steel Fiber, Material Properties and Hardened Properties, Temperature Variations*

1. Introduction

Cement can be suitably replaced with low cost and so called industrial by-products like fly ash favoring environment and saving cement addresses the sustainability issues and its adoption will enable the concrete construction industry to become more sustainable. Fly ash improves the properties of both fresh and hardened concrete. In green state, fly ash added to cement concrete results in reduction of heat of hydration and increases the workability.

HVFAC has excellent workability, low heat of hydration, adequate early-age and high later-age strengths, reduced drying shrinkage, reduced micro cracking, excellent durability characteristics while being more economical and environment-friendly when compared to conventional concrete. Due to its superior performance and engineering properties the development of HVFAC has opened new doors to sustainability of modern concrete construction. The high-volume fly ash concrete system addresses all the sustainability issues, its adoption will enable the concrete construction industry to become more sustainable. Increasing the amount of fly ash in concrete is not without shortcomings. At high levels problems may be encountered with extended set times and slow strength development, leading to low early-age strengths and delays in the rate of construction. These drawbacks are overcomed by using fibers. The fibers are distributed uniformly in concrete has better properties to resist internal stresses due to shrinkage. Steel fiber which improves specific material properties of the concrete, impact resistance, flexural strength, toughness, fatigue resistance, and ductility is used. Rheological properties of fresh concrete and the strength, finishes, porosity and durability of hardened concrete are all reported to be affected by addition of fly ash. Fly ash has also been used as substitute mineral filler in asphalt paving mixtures for many years. Mineral filler in asphalt paving mixtures consists of particles, less than 0.075 mm in size, that fill the voids in a paving mix and serve to improve the cohesion of the binder (asphalt cement) and the stability of the mixture.

2. Aim and objective

This study discusses issues related in using levels of fly ash in concrete and provides guidance for the use of fly ash without compromising the construction process or the quality of the finished product. It also lessens the problem in the reduction of greenhouse gas emission and avoids landfill disposal of ash products and helps in the improvement of concrete mixture as road base materials.

3. Material properties

The properties of materials used in the concrete are discussed below:

3.1 Cement

Ordinary Portland cement of 53 grades available in local market was used.

3.2 Fly ash

Fly ash class F confining as per IS 3812-2000 is used.

3.3. Fine Aggregate

The locally available River sand of grade II conforming to the requirements of IS 383-1970 is used. River sand is of Specific gravity 2.74 is used in this project.

3.4 Coarse Aggregate

Coarse aggregate of size 20mm and specific gravity 2.74 is used. Locally available crushed blue granite stones conforming to graded aggregate of nominal size 12.5 mm as per IS 383 – 1970.

3.5 Super Plasticizer

A commercially available sulphonated naphthalene formaldehyde based super plasticizer "CONPLAST SP 430" was used as chemical admixture to enhance the workability of the concrete. The super plasticizer confirming to IS 9103-1999 is used.

3.6 Steel Fiber

Steel fibers are used to improve the strength properties as they are proven to be good crack arresters. Fiber content of about 1 percent by volume The Temperature Variations for a week are listed below:

A fiber in concrete generally reduces the slump by about 50mm.

3.7 Water

This is the least expensive but most important ingredient of concrete. The water, which is used for making concrete , should be clean and free from harmful impurities such as oil, alkali, acid, etc., in general, the water, which is fit for drinking should be used for making concrete.

4. Experimental investigation

In this investigation the hardened properties of high volume fly ash concrete for various percentage replacement of cement and fly ash are determined.

4.1 Mix proportions

Design procedure was formulated for high volume fly ash concrete which was relevant to Indian standard (IS 10262-2009).

Table1: *Mix ratio*

% of fly ash	% of cement	Parameter identity
60	40	M1
65	35	M2
70	30	M3

4.2 Hardened properties

In order to find the mechanical properties Compressive strength tests were conducted at 7 and 28 days of cube (150 X 150 X 150 mm) specimens. For each combination, two specimens were tested. In order to find the split tensile strength of concrete 7 and 28 days of cylinder (150 X 300 mm) specimen are cast. For each combination, two specimens were tested.

Figure1.*Compressive strength test*

Table 2: *7 days Compressive strength of high volume fly ash concrete*

S. No.	Replacement percentage		7 days Compressive strength (N/mm^2)
	Fly ash	Steel fiber	
1.	60	0	14.8
2.	60	1	23.8
3.	65	0	21.33
4.	65	1	23.33
5.	70	0	21.33
6.	70	1	24

The following chart shows the 7 days Compressive strength of high volume fly ash concrete:

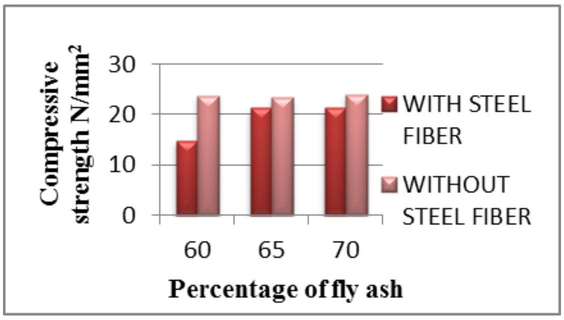

Figure 2.*Chart for 7 days Compressive strength of high volume fly ash concrete*

The following table shows the 28 days Compressive strength of high volume fly ash concrete:

Table 3: *28 days Compressive strength of high volume fly ash concrete*

S.No.	Replacement percentage		28 days Compressive strength (N/mm^2)
	Fly ash	Steel fiber	
1.	60	0	20
2.	60	1	28.9
3.	65	0	18.8
4.	65	1	24.44
5.	70	0	21.33
6.	70	1	24

The following chart shows the 28 days Compressive strength of high volume fly ash concrete:

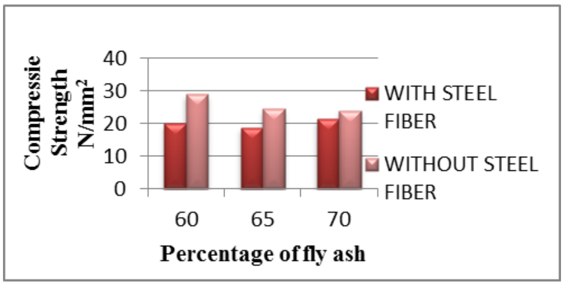

Figure 3.*Chart for 28 Days Compressive Strength of HVFAC*

Figure 4.*Split tensile strength*

The following table shows the 7 days split tensile strength of high volume fly ash concrete:

Table 4.*7 Days Split tensile strength of high volume fly ash concrete*

S. No.	Replacement percentage		7 Days Split tensile strength (N/mm^2)
	Fly ash	Steel fiber	
1.	60	0	1.48
2.	60	1	2.12
3.	65	0	2.12
4.	65	1	2.47
5.	70	0	1.7
6.	70	1	1.98

The following chart shows the 7 days split tensile strength of high volume fly ash concrete:

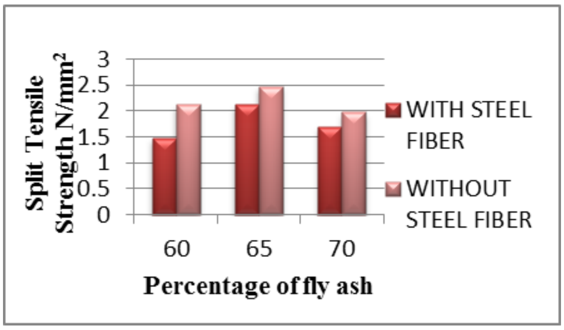

Figure 5.*Chart for 7 Days Split tensile strength of HVFAC*

The following table shows the 28 days split tensile strength of high volume fly ash concrete:

Table 5.*28 Days Split tensile strength of HVFAC*

S. No.	Replacement percentage		28 Days Split tensile strength (N/mm^2)
	Fly ash	Steel fiber	
1.	60	0	2.4
2.	60	1	2.26
3.	65	0	2.47
4.	65	1	2.6
5.	70	0	3.04
6.	70	1	3.18

The following chart shows the 28 days split tensile strength of high volume fly ash concrete:

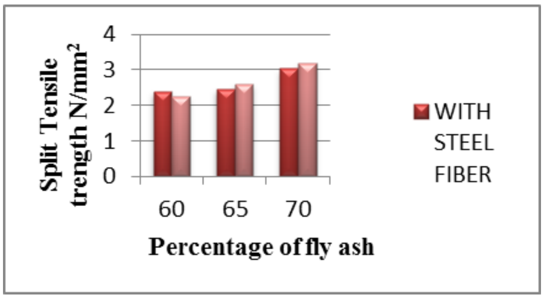

Figure 6.*Chart for 28 Days Split tensile strength of HVFAC*

4.3 Test on slab

Slab of dimension 1m x 1m x 0.15m was casted for mix containing 60% of flyash. Two specimens one with steel fiber and other without steel fiber were casted to observe the temperature variations.

Figure7.*Slab with steel fiber*

Figure 7.*Slab without steel fiber*

The Temperature Variations for a week are listed below:

Table 6.*Temperature variations in slab*

Day	10.00 AM	2.30 PM	4.30 PM
1	30.70	34.20	29.60
2	29.80	31.35	27.80
3	31.00	36.20	29.20
4	29.50	34.40	29.90
5	30.50	33.20	30.00
6	33.40	35.60	31.20
7	32.20	34.40	29.00

5. Conclusion

Based on the above experimental study, following conclusions can be drawn regarding the properties of high volume fly ash concrete:

- Hardened properties of concrete are improved when fly ash and steel fiber are added.
- From results of test conducted on compressive strength, the strength increases for addition of 60% fly ash with steel fiber.
- From the tensile test it is found that the strength increases for 70% fly ash addition with steel fiber.
- The high-volume concrete offers a holistic solution to the problem of meeting the increasing demands for concrete in the future in a sustainable manner and at a reduced or no additional cost.
- Because there is a direct link between durability and resource productivity, the increasing use of high volume concrete will help to enhance the sustainability of the concrete industry.

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