

Use of High Volume Flyash in Concrete Pavements For Sustainable Development



Engineering

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ABSTRACT

Cement is the second largest material consumed after water. Now a day's concrete pavements are gaining popularity for its own good paving properties, as such consumption of cement is increased drastically. As cement demand increases, production also increases. Every ton of production of cement releases approximately 7% carbon dioxide to environment. In many industries, including power plants, coal is used as fuel. This generates tones of coal ash, which is very difficult to dispose off, which in turn causes pollution. Thus the production of cement and electricity contributes huge amount of carbon dioxide emissions and coal ash causing environmental pollution. Fly ash contains reactive constituents and unreactive crystalline matter. Reactive constituents reacts with lime and offers hydrated minerals to impart strength and un reactive matter gives packing effect to the concrete, filling up of pores and thus increases the strength. Here an attempt is being made to consume this pollution causing material to a utility by using it in concrete. Whenever concrete is used for pavements it should posses certain properties to suit for pavement like strength, flexure, modulus of elasticity etc. because of all these reason here an attempt is being made to design a concrete mixture for M-40 grade, by using high volume fly ash into it. After the mix design, the concrete is being evaluated for properties such as compressive strength, flexural strength etc. In the design of high volume fly ash concrete use of chemical admixtures is inevitable, and it is proposed to use the super plasticizer. The Economic design thickness and construction cost analysis were performed to know about the cost comparison of different types of pavements. From the studies we observed that at 50% replacement of fly ash maximum durability and strengths were achieved and it was proved to be economical by comparing it with Flexible pavements and controlled concrete pavements.

1. Introduction

High volume fly ash concrete (HVFA) concrete will be defined as a mix that contains at least 50% replacement of cement by fly ash or, in other words, a mix which contains at least as much fly ash as cement. HVFA can reach the same or greater design strength as normal concrete. HVFA strengths of 60 to 70 MPa are not uncommon, thus the nominal 35 MPa design strength for cast-in-place station components and 50 MPa for precast will be easily achievable. The only strength issue will be the period of time at which the strength is measured for the purposes of the contract. HVFA concrete develops strength more slowly than a traditional cement mix. For the most latitude, HVFA would prefer a 56-day strength measurement.

Literature Review

The use of fly ash in concrete has reached significant attention over the recent years due to environmental concerns regarding its disposal from one hand and significant benefits to concrete on the other, when it is used as a supplementary cementitious material. According to Sushant Upadhyaya, Dimitrios G. Goulias, Karthik Obla^[1] low fly ash contents are in some cases routinely used in concrete, high volume fly ash concrete is not so frequently used due to perceived lower early age strengths Objective of their study was to demonstrate using maturity based techniques that the beneficial effects of high in place temperature may be able to compensate for the slower rate of strength gain in HVFA concrete. Furthermore, different methods (match cured cylinders, pull out testing) estimating the early-age in-place strength of HVFA concrete were examined so as to confirm the maturity predicted strengths. The results have shown that the use of standard and field cured cylinders actually penalize estimates of concrete strength in the field. Higher in place temperatures due to the mass characteristics of structural element clearly led to increased early age strengths. According to Vanita Aggarwal (2010)^[2] the development of high volume fly ash concrete for construction with reference to its predecessors like High Strength Concrete (HSC) and High Performance Concrete (HPC). The literature available on use of fly ash in concrete has been extensively searched for getting a platform for the start of research on use of high volumes of fly ash in concrete pavements. For a variety of reasons, the concrete construction industry is not sustainable. First, it consumes huge quantities of virgin materials. Second, the principal binder in concrete is Portland cement, the production of which is a major contributor to greenhouse gas emissions that are implicated in global warming and climate change. Third, many concrete structures

suffer from lack of durability which has an adverse effect on the resource productivity of the industry. Because the high-volume fly ash concrete system addresses all three sustainability issues, its adoption will enable the concrete construction industry to become more sustainable. Helmut, R^[3] Fly ash in cement and concrete, paper describes that the use Fly Ash in Concrete has increased in last 20 years. However, less than 20 % of the Fly Ash collected was used in Cement and Concrete Industry. It is explained that one can safely use Fly Ash in Concrete in Pavements for economic & ecological benefits.

2.0 Fly ash utilization Scenario

Disposal of fly ash is a major environmental issue. If buried in ground, every ton of fly ash requires 1 sq.km. of land. Between now and 2015, fly ash availability in India is expected to more than double to about 200 million tons. Land filling for this quantity would render a large area of land permanently and useable. That is why it is a good idea to use fly ash in cement for concrete making. It is not an idea simply to dispose of fly ash. Researches has proved a mass of evidence to prove that mixture of fly ash in cement in given proportion results in better governing qualities, strengths, finish etc. it also makes a lot of economic sense to both the clients and construction contractors. A major use of fly ash is to replace Portland cement in concrete. India is way behind the other countries in this regard. For instance, Japan utilizes around 94% of its 6.2 million tons of fly ash for concrete compared to only 4% in India. Ministry of Environment and forests have issued a notification making it compulsory to use at least 25% fly ash for manufacturing clay bricks or tiles of blocks within a radius of 100kms from a coal or lignite based thermal plant. It is also being made mandatory for every construction agency engaged in construction of building within a range of 50kms to 100kms from a coal or thermal plant.

2.1 Present Investigation.



In this study Class-F fly ash is used obtained from Raichur thermal power station, Shaktinagar.

Table 1 Chemical Composition of Fly ash*

Composition of Raichur Fly Ash (F-A1) %	
Al ₂ O ₃	31.23
SiO ₂	61.12
CaO	0.66
MgO	0.75
SO ₃	0.53
Fe ₂ O ₃	1.5
Na ₂ O	1.35
K ₂ O	0.84
TiO ₂	1.83

*As furnished by Raichur Thermal Power Station

Table 2 Details of Mix Proportion as per IS10262-1982

Mix *	M1	M2
Fly ash %	0	50
Water / binder ratio	0.37	0.39
Super plasticizer %	0	0
Cement kg/m ³	405	209.5
Fly ash kg/m ³	0	209.5
Fine aggregate kg/m ³	750	568
Coarse aggregate type-I kg/m ³	720.25	785.50
Coarse aggregate type-II kg/m ³	354.75	386.30
Water kg/m ³	150	163.50
Slump-mm	10	0.15
Compaction factor	0.79	0.82
Mix proportion	1:1.85:2.65	1:1.36:2.80

*M₁-Controlled M₄₀ mix

M₂- 50% Fly ash HVFA Concrete

Table 3 Compressive Strength for M1 & M2 mix

Sl. No	Number of days of curing	M1 N/mm ²	M2 N/mm ²
1	3	21.99	17.89
2	7	34.22	24.31
3	28	49.23	32.59
4	56	--	49.12
5	90	---	49.93

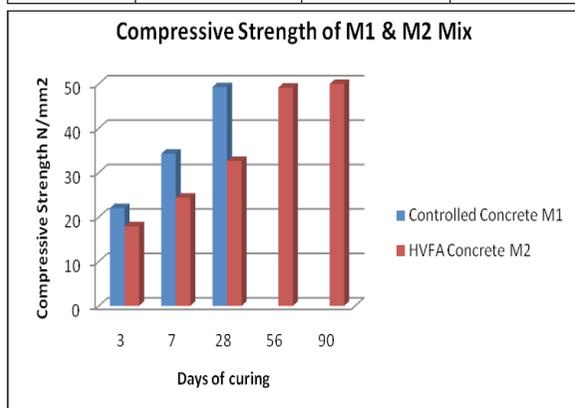


Table 4 Flexural Strength for M1 & M2 mix

Sl. No	Number of days	M1, Beams	M2, Beams
		fc _r N/mm ²	fc _r N/mm ²
1	28	4.768	3.248
2	56	---	4.872
3	90	---	5.072

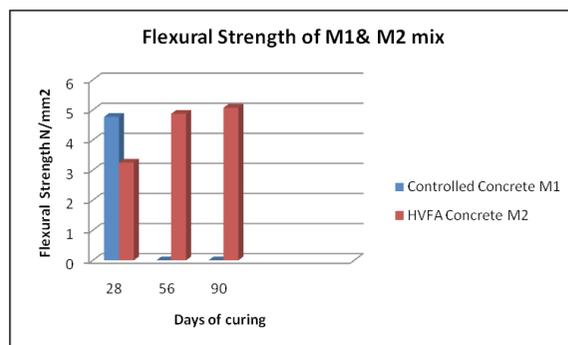
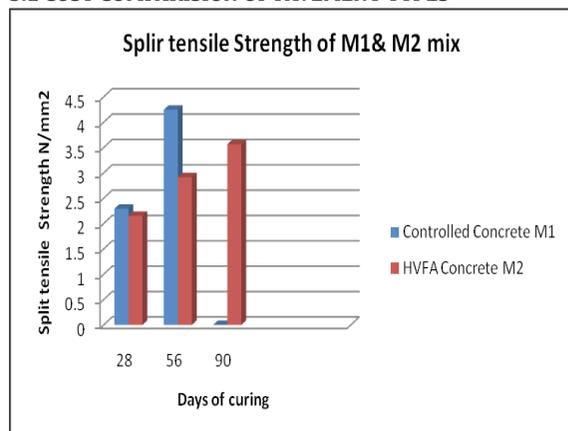


Table 5 Split Tensile Strength for M1 & M2 mix

Sl. No	Number of days of curing	M1 N/mm ²	M2 N/mm ²
1	7	2.291	2.150
2	28	4.243	2.913
3	56	--	3.564
4	90	---	4.441

3.1 COST COMPARISON OF PAVEMENT TYPES



Under similar prevailing conditions, costing for rigid pavement alternatives is arrived at for typical two lane (7.0m width) 1 km road stretch. The unit rate has been worked out based on Karnataka Public Works Department Schedule of Rates (SR) KSRRB of Bangalore circle for the year 2009-2010. Where ever rates are not available prevailing market rates are assumed.

For subgrade of 3% and traffic order of 112 msa, the total flexible pavement thickness obtained is 870mm (as per IRC 37:2001). The design thickness of various flexible component layers is shown below in Table 6.

Table 6 Flexible Pavement components

Pavement Components	Thickness, mm
Bituminous Concrete, BC	50
Dense Bituminous Macadam, DBM	120
Bituminous Macadam, BM	100
Wet Mix macadam, WMM	250
Grannular Sub Base, GSB	200
Drainage layer	150
Total	870

Initial Cost of New flexible pavement (1 Km x 2-lane 7m wide) is Rs **152.67 lakhs**.

The rigid pavement is designed as per IRC 58-2002. The CBR 3 % is considered for the design which corresponds to an effective k value of 8 kg/cm³ over 100 mm DLC as given in IRC58-2002. Cumulative Cost per Km (2-lane 7m wide) of 100 mm Dry Lean Concrete and 150 mm Drainage layer below the slab in rigid pavements are 32.00 lakhs.

Table 7 Unit cost of new pavement alternatives

Sl. No	Pavement	t cm	Concrete Quantity / Km, m ³	Rate per m ³ of concrete, Rs	cost /Km, Rs, in lakhs
1	M ₁	32	2240	4353.00	129.50
3	M ₂	31	2170	3355.00	104.80

Note: inclusive of cost of 100 mm Dry Lean Concrete and 150 mm Drainage layer below the slab in rigid pavements

4.1 CONCLUSIONS

With the results obtained from the tests conducted on High Vol-

ume Fly Ash Concrete and Controlled concrete, the following conclusions can be drawn.

The optimum dosage of super plasticizer for High Volume Fly Ash Concrete is found to be 1.25 % of the total cementitious material in concrete, which improves the workability in terms of slump and Compaction factor.

The Flexural Strength of High Volume Fly Ash Concrete increases by 6.27% at 90 days curing when compared to Controlled Concrete at 28 days curing. Hence HVFAC can be used for construction of new pavements only and not for overlay.

Due to higher flexural strength there will be reduction in thickness of pavements and hence High Volume Fly Ash Concrete pavements are more economical. It will be particularly beneficial when gain in early strength is not the criteria for pavement construction.

REFERENCE

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