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Experimental study on behaviour of fiber reinforced concrete and fly ash for rigid Pavements

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ABSTRACT

A pavement being a layered structure on which vehicles travel serves mainly two purposes, i.e. firstly to provide a comfortable and durable surface for vehicles and secondly to reduce stresses on underlying soils. It has been found over past years that concrete pavement has some deficiencies as low tensile strength, low post cracking capacity, brittleness and low ductility, limited fatigue life, thereby becoming not capable of accommodating large deformations, low impact strength. Apart from it Cement concrete pavements are characterized by brittle failure and complete loss of loading capacity, once failure is initiated. Thereby it is very essential to research about of an alternative material which satisfies required facilities. In this research, Micro fibers and flyash have been used instead of cement in different proportions for preparation of fiber fly ash pavements and its properties have been verified on casting cubes of it. An attempt is made by performing experimental tests to verify their tensile and compressive strengths which have been compared with normal PPC blocks to highlight the differences in both the cases.

Key words : *Concrete, Fiber flyash pavements, Strength.*

Introduction

Pavement is the only way for movement of traffic. Some of them are rigid and some are flexible. As we know rigid pavements are mostly used but concrete pavement is also growing rapidly. Flexible pavements need regular or periodic maintenance which cause increasing in maintenance cost whereas concrete pavement has less maintenance but high construction cost. Another benefit of concrete is its good abrasion resistance. Airport runways, curves, gradients, tolls, high traffic roads, rotary, flyovers are usually damaged pavements due to less resistance to stresses. Economic factor endure concrete pavement construction. Busy road need high resistance roads which only done by concrete pavement. Concrete has good visibility mode at night. Depending on the design traffic, soil condition and design period etc, the initial construction cost of concrete road is usually 15% to 25% more expensive than asphalt road. However, concrete road offer long term value because of their long life expectancies and minimal maintenance requirements. The average age of concrete road is about 1.5 to 2 times greater than the service life of asphalt roads. In addition to longer service life, the concrete roads carry considerably more traffic. On a life cycle cost analysis, concrete roads offer long term benefits with longer service life and low maintenance cost. It has been estimated that nearly 50% in maintenance expenditure could be saved if the entire NH system was concreted. Further, construction of roads in concrete result in conservation of materials as the typical thickness of concrete pavement, for heavily trafficked highway,

is about 400 mm as against 600 to 10000 mm for a flexible pavement. Concrete is sensible to tensile stresses during heavy loads. Its brittle properties do not allow it to resist small moments and cause cracks easily. Currently, many materials are mixed with concrete to reduce its brittleness. Micro fibers, admixtures, flyash, slag, silica flakes, plastics etc are used which are found easily from the market.These material give more strength, durability, good compaction, less or high setting time, workability etc. We used flyash and fibers material in combined form. Techno–economic superiority of the cement concrete road is now well established. A considerable R & D effort has gone into several aspects of concrete pavements or roads and runways. This is particularly so in the areas of strengthening and repair, design and evaluation, improvement of concrete as a paving material by incorporation of innovative & cost effective material and techniques used for road construction in the country. Nowadays a major use of cementious materials such as fly ash silica fumes, slag, recycled aggregates in concrete resulted in significant decrease in the use of valuable natural resources and lowering of fuel consumption through reduced transport and production processes as well as to reduce CO_2 emissions. Use of cement fly ash fiber reinforced concrete in place of plain cement concrete will not only allow substantial savings in the consumption of cement, but also provide an economic and useful avenue for disposal of fly ash, which is now a recognized national problem, along with improved performance characteristics in terms of durability and low maintenance requirement. It has been hereby suggested that by adopting proper mix proportioning methods of available methods, for the same design strength more economical mixes can be produced with cement-flyash fiber concrete as compared to plain cement concrete. In this paper, we did tests and checked its compressive as well as tensile stress. Additionally, comparison with plain concrete.

Methodology/Planning

We performed compressive test and tensile strength test to check effect.

Tests: - Compressive strength test and tensile strength test

Compressive strength is the capability of material or structure to carry the loads on its surface without any crack or deflection. A material under compression tends to reduce the size, while in tension, size elongates. **Compressive strength of concrete cube test provides** an idea about all the characteristics of concrete. By this single test one judges that whether concreting has been done properly or not. Concrete compressive strength for general construction varies from 15 MPa to 30 MPa and higher in commercial and industrial structures. Compressive strength of concrete confide on many factors such as water-cement ratio, cement strength, quality of concrete material, and quality control during production of concrete etc. Test for compressive strength is carried out on cube or cylinder. This paper deals with an experimental study on the properties of concrete containing flyash and fibers. Flyash and fibers content used was 10%, 20% and 30% of mass basis of cement. The experiment conducted shows steel fiber addition into Portland cement concrete or Fly ash concrete. Although Fly ash replacement reduces strength properties, it improves workability, reduces drying shrinkage and increases freeze–thaw resistance of fiber reinforced concrete. The performed tests show that the behavior of Fly ash concrete is similar to that of Portland cement concrete when fly ash is added. Compressive strength formula for any material is the load applied at the point of failure to the cross-section area of the face on which load was applied.

Compressive Strength = Load / Cross-sectional Area

Compressive Strength Test of Concrete Cubes

Compressive strength test as per IS:516 and IS:456-2000. For cube test two types of specimens cubes of 15cm X 15cm × 15cm or 10 cm × 10cm × 10cm depending upon the size of aggregate are used. Mostly cubical moulds of size 15cm × 15 cm × 15 cm are commonly used. This concrete is put in the mould and tempered properly to avoid voids. After 24 hours these moulds are removed and test specimens are kept in water for curing. The top surface of these specimens should be made smooth. This is done by pouring cement paste and spreading smoothly on whole area of specimen. These specimens are tested by compression testing machine after 7 days, 14 days and 28 days curing. Load should be practiced gradually at the rate of 140 kg/cm^2 per minute till the Specimens fails. Load at the failure divided by area of specimen gives the compressive strength of cemented cube.

The capability of the concrete withstand in pull-

ing force (Tensile Stress) without broke is called Tensile Strength of concrete. The tensile strength of concrete is measured in Force per **C**ross **S**ectional area (N/Sqmm or Mpa). As above said, the concrete is good in the compressive force and poor in tension force because of its brittle nature. The concrete is composed by the mixture of different material, Cement, fine and coarse aggregates. Each material has different properties. During, the water-cement ratio gradient makes around the aggregate particles and the cement paste forms a different microstructure around the concrete. This zone is called the Interface Transits Zone. The ITZ is the weakest zone of concrete because the bond of cement paste and aggregates may be weak due to the bleeding of concrete. In compression, the load transfer from one aggregate to another aggregate and that was not required remarkable strength. At the same time, in tension, the aggregate pull away from each other and it can easily change shape in a very fine way. The tensile strength of concrete is a critical property when it is to be used in making road and runways, this test shall follow as per the ASTM C496 and IS 5816 1999. The tensile strength of concrete is mostly in the range of 10 % to 13% of its compressive strength. The concrete cube are used to find out the compressive strength of concrete but to find the tensile strength of concrete, a cylindrical specimen has to be used. The concrete specimen should be a cylindrical shape having diameter 150 mm and length 300mm. The testing machine can be able to apply the loads constantly in the range of 1.2 MPa/min to 2.4 Mpa/min. The test shall be made at the age of 7 days and 28 days. Estimate the adequate ingredients to prepare the concrete with a proper water-cement ratio. Assure that the cube mould should be free from dust and rust. Now, fill the concrete into the mould with proper compaction with the help of tamping rod. Finish the top surface smoothly by the trowel. The mould should be covered with gunny bag and place undisturbed for 24 hours at a temperature of 27 °Celsius ± 2. After 24 hours the cube specimen shall remove from the mould and put into the water for 7 or 28 days based on the test. The concrete specimen shall be taken out from the water 24 hours prior to the test and it should be in dry condition. The surfaces of the machine and the loading strip free from dust. The specimen should be weighed in Newton's. Then place the specimen centrally between the loading strips and ensure the upper platen is parallel to the bottom platen. Load applied gradually until the specimen breaks and note down the values. The same method has been executed for the other specimen.

Observation and Calculation

For Tensile strength

From Table 1 and 4, we find compressive and tensile strength of cube and cylindrical normal samples.

From Tables 2 to 4, we find compressive and tensile strength of cube and cylindrical normal samples.

Results

The compressive strength values of the cube speci-

Table 1. Compressive strength of concrete block

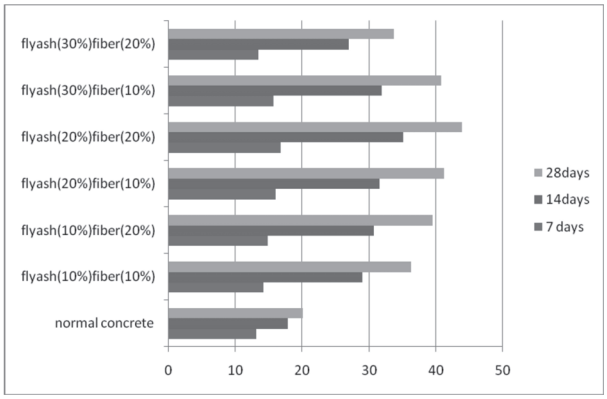
Sample	Compressive strength in 7 days (N/mm^2)	Compressive strength in 14 days (N/mm^2)	Compressive strength in 28 days (N/mm^2)
1	12.5	18.1	19.6
2	13.1	17.8	20.1
3	11.3	17.5	19.1

Table 2. Compressive Load of Flyash-Fiber Reinforced Concrete

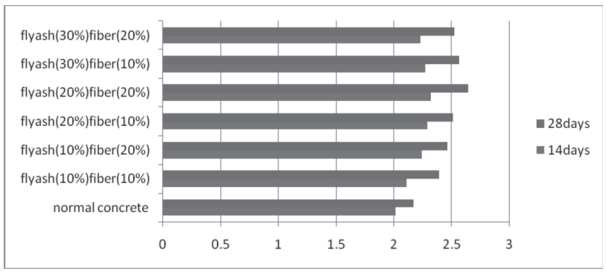
Fly ash	Steel fiber	Compressive strength in 7 days (N/mm^2)	Compressive strength in 14 days (N/mm^2)	Compressive strength in 28 days (N/mm^2)
10%	10%	14.14	28.92	36.3
10%	20%	14.78	30.67	39.44
20%	10%	15.96	31.54	41.23
20%	20%	16.78	35.09	43.87
30%	10%	15.65	31.87	40.75
30%	20%	13.46	26.92	33.65

Table 3. Compressive Strength of Flyash-Fiber Reinforced Concrete

Fly ash	Steel fiber	Compressive load in 7 days (KN)	Compressive load in 14 days (KN)	Compressive load in 28 days (KN)
10%	10%	318	650.7	816.7
10%	20%	332	690.0	887.4
20%	10%	359.1	709.65	927.6
20%	20%	377.5	789.5	987.07
30%	10%	352.12	717.023	916.87
30%	20%	302.85	605.7	757.12



Graph 1. Compressive Strength



Graph 2. Tensile Strength

mens at the age of 7, 14 and 28 days. From the Table 1 ,2 and 3 it is observed that the compressive strength of concrete increases when increase in fiber content and flyash but after increase in flyash compressive strength decreases at 7, 14 and 28 days. From the graph 1 it is observed that maximum compressive strength is attained when both flyash and fiber content are 20% and gradually then decreases. In Tensile strength, the test cylinders were tested for their tensile strength values at the age of 14 and 28 days. From the Tables 3, 4, and 5 it is observed that tensile strength of concrete increases when increase in fiber content and flyash but after increase in flyash tensile strength decreases at 14 and 28 days. From the graph 2 it is observed that maximum tensile strength is attained when both flyash and fiber content are 20% and gradually then decreases.

Table 4. Tensile Strength of Concrete Block

Sample	Tensile strength after 14 days (N/mm^2)	Tensile strength after 28 days (N/mm^2)
1	2.01	2.17
2	1.9	2.08
3	2.05	2.22

Conclusion

From results, we found compressive and tensile strength of normal concrete and concretehaving FRC with flyash are greater. Fiber reinforced concrete with flyash is more durable, high strength, resist shrinkage and resist the thermal expansion compared to the normal concrete.

Table 5. Tensile Strength of Flyash-Fiber Reinforced Concrete

Fly ash	Steel fiber	Tensile strength in 14 days (N/mm^2)	Tensile strength in 28 days (N/mm^2)
10%	10%	2.11	2.39
10%	20%	2.24	2.46
20%	10%	2.29	2.51
20%	20%	2.32	2.64
30%	10%	2.27	2.56
30%	20%	2.23	2.52

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