FLEXURAL FATIGUE ANALYSIS OF FLY ASH AND PP FIBRES ADMIXED CONCRETE PAVEMENT FOR SINGLE AND COMPOSITE SECTION

Sagar Kamble[1]; Dr. H. S. Jagadessh[2]

[1]Research Scholar; Department of Civil Engineering;
BMS College of Engineering; [2]Professor; Department of Civil Engineering; BMS College of Engineering

Abstract. Fly Ash is one of the residues produced from nuclear energy stations. Fly Ash can be utilized as a minimal expense mineral admixture in concrete. Polypropylene fiber is a light weight engineered fiber, it forestalls break arrangement and gives support to the substantial design. In the present study, Fly Ash and Polypropylene fibers are used to examine the strength of the concrete. 30 % of the cement is replaced by Fly Ash in the concrete mix containing Fly Ash. In the concrete mixes containing Polypropylene fiber, additional 1.5% Polypropylene fiber is added to the concrete mix for studying the changes in the strength of M40 grade of concrete. An exploratory program was done on single and composite sections to investigate their strength properties by compressive strength test, flexural strength test and flexural fatigue test. Specimens are cured for a period of 7 days and 28 days before performing tests on them. It is concluded from the study that composite concrete sections can withstand higher number of load repetitions compared to conventional concrete.

Keywords:Fly Ash, Polypropylene Fiber, Compressive strength, Flexural strength, Fatigue test.

1 INTODUCTION

Composite section is a combined section of concrete (2-layer section) in which bottom 50% of the depth is by PQC and the remaining 50% of the depth of the concrete is with the different ingredient. Leaving the waste materials to the environment straight forwardly can cause natural issue. Consequently, the reuse of waste material has been underscored. Waste can be utilized to create new items or can be utilized as admixtures with the goal that common assets are utilized all the more productively and the climate is shielded from squander stores. These mechanical squanders are unloaded in the close by land and the normal richness of the dirt is ruined. Fly Ash is the finely separated mineral build upcoming about because of the ignition of ground or powdered coal in electric force producing warm plant. Fly Ash is a useful mineral admixture for concrete. It impacts numerous properties of cement in both new and solidified state. In addition, use of waste materials in concrete and substantial industry lessens the ecological issues of force plants and diminishes power age costs. Concrete with fly Ash lessens the porousness of concrete and thick calcium silicate hydrate (C–S–H). Exploration shows that adding fly Ash to concrete, as a halfway substitution of concrete (30%), will profit both the new and solidified states. While in the new express, the fly Ash improves functionality. This is because of the smooth, round state of the fly Ash molecule. The minuscule circles go about as a type of metal ball that guides the progression of the substantial. Fly ash can be a cost-effective substitute for Portland cement. Fly ash is also recognized as an environmentally friendly material because it is a by-product, it requires less water than Portland cement and is easier to use in cold weather, Great workability. It Reduces crack problems, permeability, and bleeding, reduces heat of hydration, allows for a lower water-cement ratio for similar slumps when compared to no-fly-ash mixes.

The incorporation of satisfactory fibers improves rigidity and gives pliability. There are more examinations on the impacts of various strands on substantial properties. A portion of the significant impacts of fibers in concrete are: expanding the elasticity, forestalling the break advancement and expanding the durability of cement. The crucial benefit of adding fibers to concrete is known as break connecting. As of late, concrete containing various fibers has been applied in huge constructions like interstate asphalts and air terminals, gigantic establishments with enormous disfigurements and substantial front of passages. As of late to forestall breaking in the fronts of the pre-projected passages, un-built-up concrete with the strands has been utilized. Then again, the examinations have shown the compressive strength decrease in fiber cements. This decrease happens in light of the assortment of Calcium-Hydroxide in the interface of hydrated concrete and different sorts of strands, (for example, Steel, Carbon, Dacron, Polypropylene fibers, and so forth). In late many years the polypropylene fibers have been broadly utilized in businesses. Polypropylene strands are generally reasonable, simple to part into better sizes, strong in the climate of concrete grid and they don't rust. They have a moderately low modulus of versatility; generally helpless security and it is hard to get uniform scattering with Polypropylene fibers when an adequately huge volume of strands is utilized. In the current examination, the impacts of including polypropylene fibers physical and mechanical properties of cements are researched. Fatigue is quite possibly the main troubles in CC asphalt structure because of the rehashed heap of substantial traffic benefits that happen at transitional and low temperatures. There are distinctive test strategies utilized all through the world to quantify Fatigue opposition for cement concrete mix. In this investigation four-point stacking Fatigue mechanical assembly is utilized.

2 MATERIALS AND METHOD

2.1 CEMENT

Cement used in this work is Ordinary Portland Cement (OPC) of Grade 53.

Table 1. Basic Tests on Cement

Properties	Result
Specific gravity	3.15 g/cm3
Normal consistency	27%
Initial setting of time	35 min
Final setting of time	300 min

2.2 COARSE AGGREGATES

The aggregate which is retained over IS Sieve 4.75 mm is termed as coarse aggregate. Coarse aggregate having the size of 20 mm& 10 mm down are used in this work. The aggregates are washed to the remove dust and dirt and are dried to surface dry condition.

Table 2. Basic Tests on Coarse Aggregates

Test	Results
Los Angeles Abrasion Test	17.8%
Aggregate Crushing Value	21.45%
Aggregate Impact Value	16.10%
Combined Flakiness and Elongation Index	0.2%
Water Absorption	0.5%
Specific Gravity	2.67

2.3 FINE AGGREGATES

The aggregates most of which pass through 4.75 mm IS sieve are termed as fine aggregates. In this experimental program, fine aggregate was locally procured and conformed to IS: 383- 1970.

Table 3. Basic Tests on Fine Aggregates

Property	Values
Specific gravity (g/cm3)	2.65
Water Absorption (%)	2.5%
Moisture content (%)	Nil
Fine particles less than 0.075 mm (%)	13.4

2.4 Fly Ash

Fly ash, otherwise called pummelled fuel ash in the UK, is a coal ignition item that comprises of the particulates (fine particles of consumed fuel) that are driven out of coal-terminated boilers along with the pipe gases. Ash that tumbles to the underside of the evaporator's burning chamber is called base ash. In present day coal-terminated force plants, ash is for the most part caught by electrostatic precipitators or other molecule filtration hardware before the vent gases arrive at the smokestacks. Along with base ash eliminated from the underside of the kettle, it's known as coal debris.

Table 4. Physical Properties of Fly Ash.

Physical properties	Result
Liquid Limit	23.8%
Plastic Limit	13.13%
Plastic index	10.75%
Specific gravity	2.66 g/cm3

2.5 Polypropylene Fiber(PP)

Polypropylene fiber (PP) is the primary sound system ordinary polymer to have arrived at modern significance. It is a thermo-plastic, implying that it gets flexible or form capable at a specific raised temperature and hardens after cooling. PP has a place with the gathering of polypropylene and is incompletely glasslike and non-polar. It has comparable properties as polyethylene, yet it is more enthusiastically and more warmth safe. It is a white rough material with a high substance obstruction. Polypropylene is the second-most broadly delivered item plastic (after polyethylene) and it is regularly utilized for item bundling and naming.

Table 5. Properties of Polypropylene Fiber

Properties	Result
Specific gravity	0.91 g/cm3
Abrasion resistance	Good
Chemical resistance	Generally excellent
Elongation (%)	40-100

2.6 MIX PROPORTION

Mix design is done as per IRC 44:2017. The super plasticizer dosage is adopted as 0.5 % of total weight of cement.

Table 6. Mix Proportion of M40 Grade of Concrete

Material	Quantity (Kg)
Cement	392
Fine aggregate(kg/m3)- (M-sand)	665
Coarse aggregate (kg/m3)-20 mm (60%)	724
Coarse aggregate (kg/m3)-10 mm (40%)	483
Water	149 (ltr)
Super plasticizer	1.96 (ltr)
W/C ratio	0.38
Mix proportion-1:1.70:3.07	

2.7 CASTING OF SPECIMEN

In the present study, cubes of size 150mm*150mm*150mm and beams of size 100mm*100mm*500mm of M-40 grade of Normal Pavement Quality Concrete (PQC) are casted. At first, dry mixing of materials is carried out followed by adding water and proper mixing of materials for 2 to 3 minutes. Mix is then transferred to moulds and compacted to remove possible voids present. After casting, test specimens are demoulded after 24 hours and kept in water tank for 28 days curing process.

For casting concrete specimens with Fly Ash admixture and Polypropylene fiber, procedure remains same but ingredient that is Fly Ash/Polypropylene is added to the present basic materials of the concrete mix in appropriate quantity. The mix is then be put in mould and compacted.

Composite sections of Fly Ash admixed concrete/Polypropylene fiber admixed concrete with PQC of M-40 grade concrete are casted. First, half depth of the cubes that is 75 mm and beams that is 50 mm is filled with normal PQC mix in three layers and compacted. It should not be disturbed for 30 minutes. After the initial setting period of concrete, immediately the second half depth of the cubes and beams are filled with Fly ash admixed concrete or Polypropylene fiber concrete in three layers and compacted. After 24 hours, moulds are demoulded and kept in water tank for 28 days curing process.

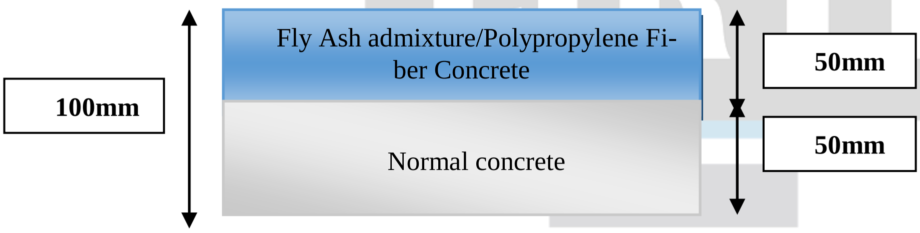

Fig. 1. Concrete composite section

Fig. 2 Concrete Beam Specimen

3 RESULTS

3.1 COMPRESSIVE TEST

For cube compression testing of concrete, 150mm*150mm*150mm cubes are casted. All the cubes are tested in saturated condition, once after wiping out the surface moisture. For each mix combination, three cubes were tested at the age of 7 days and 28 days of curing as per IS Code.

Table. 7 Compressive strength test results

Type of Concrete	AVERAGE COMPRESSIVE STRENGTH (MPa)	
	At 7 DAYS	AT 28 DAYS
Normal Concrete (PQC)	30.04	46.22
Fly Ash Admized Concrete (FA)	33.89	52.14
Polypropylene Admixed Concrete (PP)	34.85	53.62
Composite Section of Fly Ash with PQC (PQC+FA)	33.06	50.86
Composite Section of Polypropylene with PQC (PQC+PP)	33.46	51.48
Composite Section of Fly Ash with Polypropylene (FA+PP)	35.25	54.23

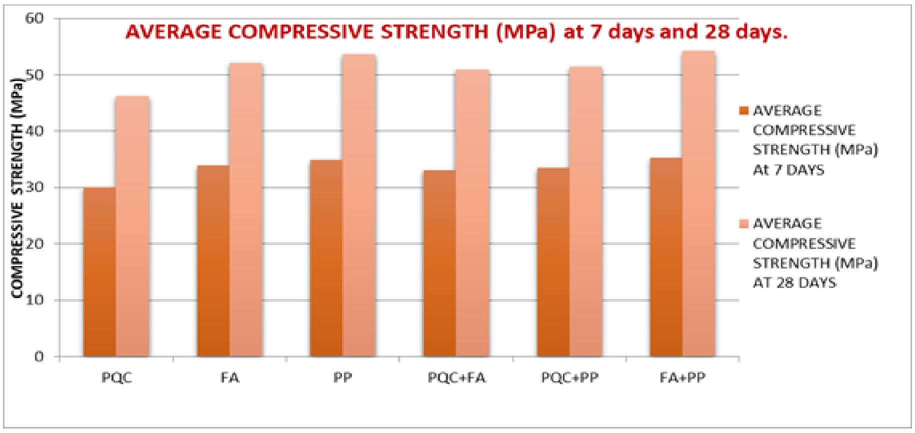

Fig. 3 Comparison of Compressive Strengths

3.2 FLEXURAL STRENGTH

Prism of size 100mmx100mmx500mm is casted as per IS 516:1959 and cured for 7 days and 28 days. Three-point loading was done; results are tabulated for 7 & 28 days.

Table 8. Flexural Strength Test Results

Type of Concrete	AVERAGE FLEXURAL STRENGTH (MPa)	
	At 7 DAYS	AT 28 DAYS
Normal Concrete (PQC)	3.14	4.83
Fly Ash Admixed Concrete (FA)	4.09	6.29
Polypropylene Admixed Concrete (PP)	4.19	6.44
Composite Section of Fly Ash with PQC (PQC+FA)	3.80	5.85
Composite Section of Polypropylene with PQC (PQC+PP)	3.98	6.13
Composite Section of Fly Ash with Polypropylene (FA+PP)	4.60	7.07

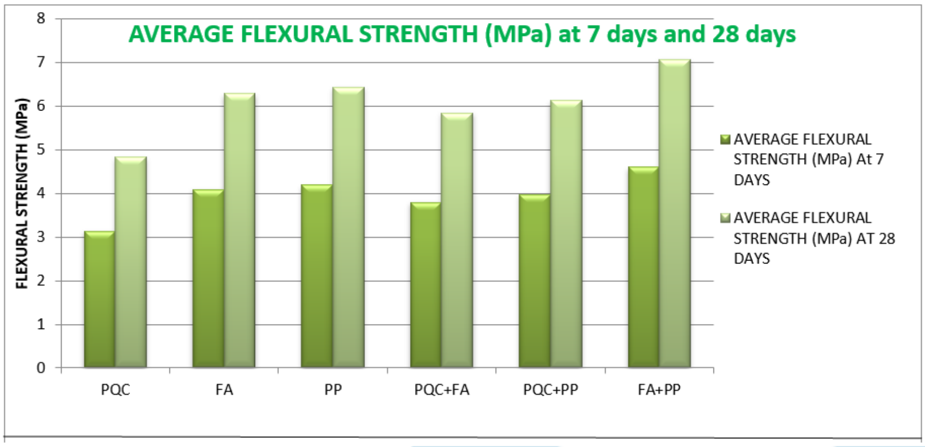

Fig. 4. Comparison of flexural strengths

3.3 FATIGUE STRENGTH

Fatigue test specimens are tested under one-third point loading with frequency of loading as 3Hz. At a particular stress level amplitude of the fatigue loading was maintained constant throughout the testing. Minimum stress in fatigue loading was maintained at 1% of maximum stress. Minimum stress was used mainly to prevent any possible movement of specimens at support during testing. The specimens failed due to single propagation of single vertical crack through the depth of the section. The nature of failure was brittle. For these specimens the number of fatigue cycles at the instant of appearance of crack was considered as fatigue life.

The Fatigue test is carried out on the conventional mix to determine the Number of Repetitions (N). The conventional concrete mix is compared with other concrete mixes. Repetitions are found out for each mix for different stress ratio of 0.65, 0.75 and 0.85 and each mix is compared with the IRC 58 stress ratio values. Graphs pertaining to this are shown.

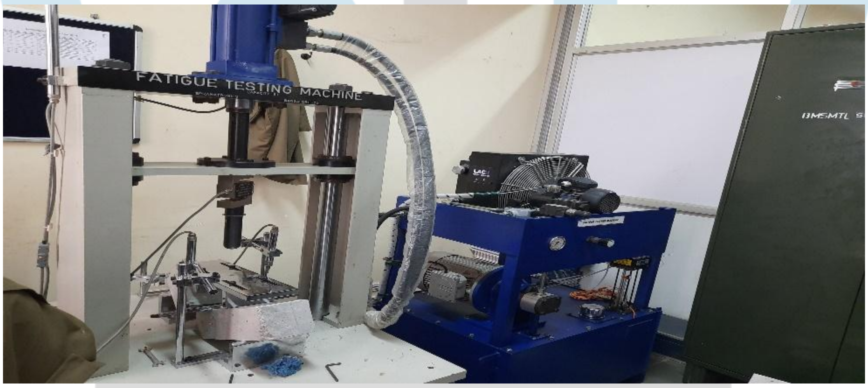

Fig. 5. Fatigue Test Set Up

Fig. 6 Specimen for Fatigue Test

Table 9 Number of repetition (N) for different stress ratios (0.65, 0.75, and 0.85) for both single and composite sections

Stress Ratio SR	Number of repetitions to failure 'N'						
	IRC 58	Normal Concrete	Fly Ash Admixed Concrete	Polypropylene Admixed Concrete	Composite Section of Fly Ash with PQC	Composite Section of Polypropylene with PQC	Composite Section of Fly Ash with Polypropylene
0.65	$7.7x10^3$	$8.769x10^4$	$9.725x10^4$	$9.354x10^4$	$1.953x10^5$	$9.531x10^4$	$9.224x10^4$
0.75	477	$3.949x10^4$	$4.824x10^4$	$4.358x10^4$	$5.912x10^4$	$4.712x10^4$	$4.024x10^4$
0.85	30	$8.564x10^3$	$1.642x10^4$	$1.358x10^4$	$2.154x10^4$	$1.578x10^4$	$1.128x10^4$

Table 10 Number of repetition (N) for different stress ratios in log values

Stress Ratio SR	Number of repetitions to failure 'N'						
	IRC 58	Normal Concrete	Fly Ash Admixed Concrete	Polypropylene Admixed Concrete	Composite Section of Fly Ash with PQC	Composite Section of Polypropylene with PQC	Composite Section of Fly Ash with Polypropylene
0.65	3.886	4.942	4.983	4.970	5.290	4.979	4.964
0.75	2.679	4.596	4.683	4.639	4.771	4.673	4.604
0.85	1.477	3.93	4.21	4.13	4.33	4.198	4.052

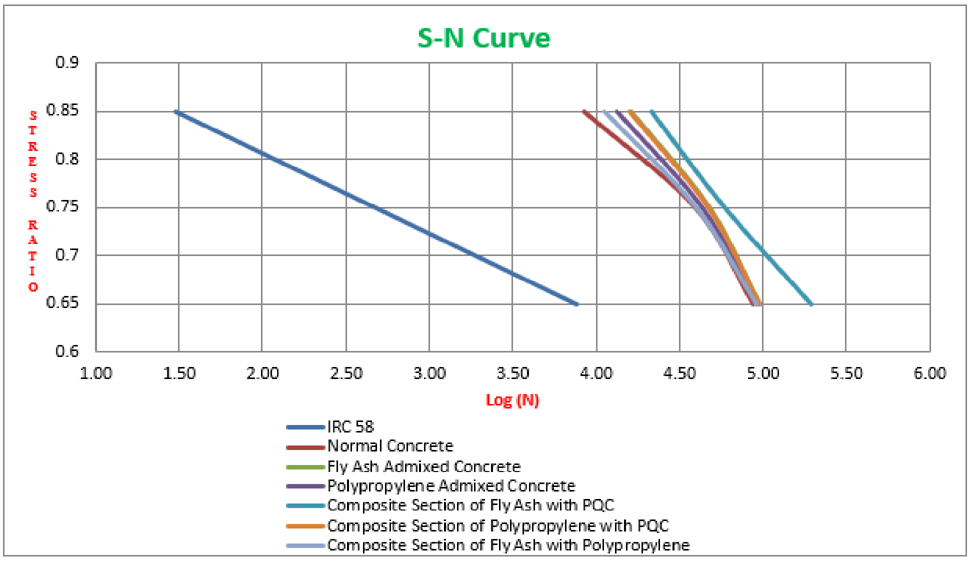

Fig. 7 S-N Curve for Different Stress Ratios and Samples

4 CONCLUSIONS

- The physical tests on Course Aggregates, Fine Aggregates, Cement, fly ash are carried out and all the test results are found to be within the specified limits as per 500-35 of MoRTH-5, IS2386(Part III)-1963, IS: 456, IS: 3812.
- The compressive strength on M40 Grade Concrete Mix of cubes size 150*150*150 mm are done for 7 days and 28 days strength yield good results.
- The compressive strength of Fly ash admixed concrete has 12.2% increase when compared with PQC at 28 days curing period.
- The compressive strength of PP admixed concrete has 16 % increase when compared with PQC at 28 days curing period.
- The compressive strength of Composite Section(FA+PQC) of Fly Ash with PQC has 11% increases in strength when compared with PQC at 28 days curing period.
- The compressive strength of Composite Section of(PP+PQC) Polypropylene with PQC has 11.58% increases in strength when compared with PQC at 28 days curing period.
- The compressive strength of Composite Section of(FA+PP) Fly Ash with Polypropylene has 11.58% increase in strength when compared with PQC at 28 days curing period
- The Flexural Strength test of concrete beams is carried out for 7 and 28 days and the results yield good strength.
- The Flexural strength at 28 days Curing when compared with (PQC) normal concrete, Fly ash admixed concrete has 30.45% increase in strength, while PP admixed 33 % increase in strength, Composite Section of(FA+PQC) Fly Ash with PQC 21.11% increase in strength, Composite Section(PP+PQC) of Polypropylene with PQC 26.91% increase in strength, Composite Section(FA+PP) of Fly Ash with Polypropylene 46.37% increase in strength.
- Fatigue test is carried out on different concrete mixes of age 28 days. The number of repetitions is higher than the mentioned values in IRC: 58-2002 for different Stress ratios.
- The fatigue life of six different compositions concrete mix, when compared to IRC 58 values, Composite Section of Fly Ash with PQC **(PQC+FA)** provided the highest fatigue life when compared to other composite sections with IRC-58 values.

References

1. E. W. Tse., D. Y. Lee., F. W. Klaiber.:Fatigue behaviourof concrete containing Fly Ash, Science direct, (2016)
2. Tarun R. Naik.: Fatigue behavior of plain concrete made with or without Fly Ash. Science direct, (2008)
3. AravindkumarB.Harwalkar., Dr.S.S. Awanti.:Fatigue behavior ofhigh-volume Fly Ash concrete under constant amplitude and compound loading. IJCIET, (2012)
4. T.C. Madhavi., T. Vardhan Reddy.: Water absorption in Fly Ash concrete. IJCIET, (2015)
5. D.G.Montgomery., D.C.Hughes., R.I.T.Williams.: Fly Ash in concrete — a microstructure study. Science direct, (2015)
6. Biaoliyinchilihuaxuyuchuanshichangningli.: Experimental investigation on the flexural behavior of steel polypropylene hybrid fiber reinforced concrete. Science direct, (2018)
7. Mohammed A. A. Sherir.: Behaviour of Engineered cementitious composites under fatigue loading. IJCIET, (2015)
8. Christopher K.Y.Leunga., Yin Nee Cheunga., Jun Zhangb.:Fatigueenhancement of concrete beam with ECC layer. Science direct, (2010)
9. JunZhanga., Christopher K.Y.Leungb., Yin Nee Cheungb.: Flexural performance of layered ECC-concrete composite beam. Science direct, (2014)
10. DanMeng.,Y.X.Zhang.,C.K.Lee.: Flexural fatigue behaviour of steel reinforced PVA-ECC beams. Science direct, (2018)
11. Poonkuzhali. R., Priya Rachel.: Experimental investigation on high volume fly ash concrete using manufactured. (2016)
12. MORTH, 'SPECIFICATION FOR ROAD AND BRIDGE WORKS', (FIFTH REVISION) – 2013, INDIAN ROAD CONGRESS.
13. IRC:58-2015 "GUIDELINES FOR THE DESIGN OF PLAIN JOINTED RIGID PAVEMENTS FOR HIGHWAYS"
14. Khanna S K, Justo C E G, Veeraragavan A. 'Highway Materials and Pavement Testing', (Fifth Edition), Nem Chand & Bros., Roorkee, India.