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A Study On Flexural Fatigue Characteristics Of Steel Fiber Reinforced Concrete Of M30 Grade

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ABSTRACT

In this study, the scope of research will be focused on the flexural fatigue behaviour of steel fiber reinforced concrete. The fatigue life data of SCFRC containing 0.5 %, 1.0 % and 1.5 % by volume of steel fibres have been obtained by conducting flexural fatigue tests on approximately prism specimens of size 100 x 100 x 500 mm under third point loading at stress level 0.70. In present investigation is mainly focused on the effect of steel fibers on mechanical and flexural fatigue properties on M30 concrete.Pavement concrete is mostly used for airfield runways, road surfaces, bridge decks, parking lots and industry floors. Due to passing vehicles, these structures often endure repetitive cyclic loads during their service lives, the fatigue characteristics of concrete in these structures are important performance and design parameters. It is necessary to predict the fatigue life and parameters for structures that have been endured repeated loading. Fatigue failure occurs when a concrete structure fails at less than design load after being exposed to a large number of stress cycles. Fatigue may be defined as a process of progressive and permanent internal damage in a material subjected to repeated loading.

1.0 INTRODUCTION:

In spite of large number of studies on the mechanical properties of SCFRC under statically applied loads, the literature reveals that there has been practically no study on its fatigue strength, which

otherwise is an important parameter in the design of concrete structures, like bridges and highway pavements, subjected to such type of loads. Since fatigue data of concrete is random

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and scattered in nature, it is imperative to incorporate probabilistic concepts to predict its flexural fatigue strength. Therefore, the present investigation was planned to examine the fatigue strength characteristics of SCFRC at different stress levels. It is intended to estimate the material coefficients of the fatigue equations representing S–N diagrams, thus making these equations applicable to predict the flexural fatigue strength of SCFRC. The probability of failure is proposed to be incorporated into the fatigue life data of SCFRC by developing S–N–Pf diagrams, both graphically and analytically. It is hoped that the characterization of fatigue behaviour of SCFRC will enable designers and engineers to use this innovative material with greater confidence in practical applications.

The need of large scale construction of concrete bridges, airportand highway pavements to accommodate rapidly growing traffic volume have increased the demand of high performance construction materials. The inclusion of fibres, especially steel fibres to develop SFRSCC with improved fresh and hardened properties has been a subject of interest for many researchers in the recent past. The majority of applications of SCC are in bridge decks and piers, pavements, road surfaces, rapid transportation systems, industrial yards, precast structural elements, high rise buildings, etc., wherein the fatigue loading is the predominant mode of loading. Concrete structures such as bridges, pavements and off-shore structures are normally subjected to millions of cycles of repetitive fatigue load during their service life, making fatigue strength a critical parameter in the design of these structures.

2.0 LITERATURE REVIEW:

Interest in the fatigue of concrete began with the development of highway systems and considerably increased during the 1970s at start of building off shore platforms for crude oil production in deep sea. These structures are expected to resist millions of cycles of repeated loads during their intended life. Because the flexural fatigue strength is an important parameter in the design of bridges, pavements and off shore structures, the majority of research in the literature on the fatigue of NVC as well as NVFRC has been focused to study its behaviour in flexure. Although some studies focused on other aspects of fatigue, **Zanuy et al.** studied transverse fatigue of top slab of box girder bridges and investigated the effect of fatigue degradation in the compression zone of reinforced concrete sections. S–N curves for fatigue of

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bond in reinforced concrete structures under transverse tension were developed by **Lindorf and Curbach**. Researchers looked into the flexural fatigue behaviour of NVC to investigate the effect of stress reversal, loading frequency, and aggregate type, air-content, water/cement ratio on the fatigue strength of NVC under constant and variable flexural loading. Researchers carried out extensive studies on the fatigue behaviour of NVFRC, which were mainly confined to determination of flexural fatigue strength and endurance limits for different type/volume fraction/aspect ratio of steel fibres and reported a better fatigue strength and performance of NVFRC over NVC mainly due to crack arrest property of steel fibres. Some studies focused attention on other aspectsof fibre reinforced concrete in respect of fatigue. **Wei et al.**studied the effect of fibre volume fraction, amount of silica fume and their composite action on fatigue performance of NVFRC. **Ong et al.** investigated the behaviour of steel fibre mortar overlayed concrete beams under cyclic loading whereas the behaviour of composite concrete sections reinforced with steel bars and steel fibres, and subjected to flexural cyclic loading was analysed by **Spadea and Bencardino** by means of a mechanical model. **Sim and Oh** conducted fatigue tests on bridge decks strengthened with various fibre-reinforced polymer plastics and an improved resistance to crack propagation and better stress distributions was reported. The Weibull distribution was adopted toanalyse the fatigue life of the decks.Since fatigue test data of NVC as well as NVFRC show significant scatter and is random in nature, attempts have been made to apply the probabilistic concepts and different equations have been proposed to predict its flexural fatigue strength. **Kesler,Ballinger and Oh**adopted a relationship between stress level S ($=f_{max}/f_r$) and the number of load repetitions to fatigue failure N, for determining the fatigue strength of NVC.

3.0 MATERIALS

3.1 Cement:

Ordinary Portland cement of 53 grade, conforming to IS: 12269-1999 with particle size of 90µ has been used in the present investigation. The specific gravity, standard consistency were 3.12 and 32% respectively.

3.2 Fine Aggregates:

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Locally available river sand conforming to Zone-II as per IS: 383-1999 has been used. The bulk density, specific gravity, and fineness modulus of the sand were 1.41g/cc, 2.68, and 2.9.

3.3 Coarse Aggregates:

Crushed granite aggregate of maximum 16 mm size conforming to IS: 383-1999 has been used. The bulk density, specific gravity and fineness modulus of the coarse aggregate were 1.46g/cc, 2.7 and 7.1.

3.4 Fly ash:

Fly ash of Class F conforming to IS: 3812: Part-II-2003 obtained from Ramagundam thermal power plant (India) with a specific gravity of 2.18 and fineness of 6422 cm2/gm was used.

3.5 SteelFibers:

Tensile strength of steel fibers were 250 N/mm2, with an aspect ratio of 50.

3.6 Water:

Water plays a vital role in achieving the strength of concrete. For complete hydration it requires about 3/10th of its weight of water. It is practically proved that minimum water-cement ratio 0.35 is required for conventional concrete. Water participates in chemical reaction with cement and cement paste is formed and binds with coarse aggregate and fine aggregates. If more water is used, segregation and bleeding takes place, so that the concrete becomes weak, but most of the water will absorb by the fibers.

4.0 EXPERIMENTAL PROGRAM:

The investigation was aimed at studying the effect of steel fibers on compressive strength, split tensile strength, flexural strength of M30 grade of concrete. Mix proportioning of concrete will be done based on guidelines of IS 10262: 2009. To study the effect on strength of concrete the specimens will be tested for 28 days. Standard cubes (150x150x150 mm), cylinders (150 mm diameter, 300 mm height), prisms (100x100x500 mm) will be cast to investigate the behaviour on mechanical properties and flexural fatigue behaviour. Slump and Compaction factor will be done to test the effect on workability of concrete due steel fibers. The inclusion of steel fibers will be varied from 0 to 1.5% with an increment of 0.5% i.e 0, 0.5%, 0.1%, 1.5% to volume of concrete.

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Table 1 - Mix Proportions of mixes M 50 grade in kg/m^3

Cement	Fine Aggregate	Coarse Aggregate	Water
350	765	1030	175

5. RESULTS AND DISCUSSION

5.1 Workability:

Workability test is performed on the fresh concrete by slump cone and compaction factor test. Slump cone test and compaction factor were conducted as per Indian standards as explained in previous chapter. The results of slump cone and compaction factor test for M30 grade of concrete with glass fibers are shown in table 2.

Table 2 – Slump and compactor factor test values of concrete with steel fibers

Dosage of Steel fibers (%)	Slump (mm)	Compaction Factor Test
0	107	0.95
0.5	92	0.93
1	85	0.91
1.5	72	0.89

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Figure 1: Effect of steel fibers on workability

5.2 Mechanical Properties:

Compression testing machine of 2000 kN has been used for the test of compressive strength. The results of compressive strength are given in the Table 3.

Table 3 – Mechanical properties of M30 grade of concrete with glass and polypropylene fibers

Dosage of Steel fibers (%)	Compressive Strength (MPa)	Split tensile Strength (MPa)	Flexural Strength (MPa)
0	38.2	2.89	4.33
0.5	40.2	2.96	4.44
1	42.4	3.04	4.56
1.5	41.5	3.01	4.51

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Figure 2: Effect of steel fibers on Compressive strength

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Figure 2: Effect of steel fibers on Split tensile strength

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Figure 2: Effect of steel fibers on Flexural strength

Table 6: Effect on Fatigue properties of Concrete with and without Fiber

Dosage of Steel fibers (%)	APPLIED FLEXURAL LOAD (N)	FLEXURAL LOAD (N)	CYCLES TO FAILURE	STRESS RATIO
0	8484.48	12549.26	5350	0.7
0.5	8784.48	---	6450	0.7
1	8784.48	--	7510	0.7
1.5	8784.48	--	6650	0.7

Figure 2: Effect of steel fibers on Fatigue strength

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6.0 CONCLUSIONS

1. Workability of concrete is been effected by the addition of steel fibers. The effect has increased with the increment in dosage of steel fibers in concrete.

2. The compressive strength of concrete has been increased with the addition of steel fiber in M30 concrete.

3. The compressive strength of steel fiber has been increased up to 3.41% compared withM30 grade of Concrete.

4. The flexural strength of concrete has been increased with the addition of steel fiber in concrete. The flexural strength of concrete has been decreased with the 1.5% dosage.

5. Fatigue life i.e. (number of cycles at failure) increases with the addition of steel fiber and steel fiber for the stress ratio 0.7.

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