



AN EXPERIMENTAL INVESTIGATION ON STRENGTH AND DURABILITY OF M50 GRADE OF CONCRETE USING STEEL FIBERS

PRAKASH PUNJ, BHAVESH JOSHI,

Research Scholar, Associate Professor,

Department of Civil Engineering, Mewar University, Rajasthan, India

Abstract: The utilization of high grade of concrete has become essential for high load bearing structures and in other crucial projects. M50 grade concrete is used when a high compressive strength is required, making it suitable for structures that experience heavy loads or dynamic stress, like large bridges, elevated corridors, high-rise buildings, and heavily reinforced concrete elements, due to its ability to withstand significant pressure and bending forces after 28 days of curing; essentially, it's chosen for situations where a high level of structural integrity is crucial whereas addition of steel fibre with M50 grade of concrete makes it more efficient. Using M50 grade concrete with steel Fiber is necessary when high tensile and flexural strength is required, as the steel Fibers significantly improve the concrete's ability to resist cracking, especially in situations with high impact or dynamic loading, making it ideal for applications like bridge decks, pavements exposed to heavy traffic, or structures subject to seismic activity where regular concrete might not be sufficient.

IndexTerms - Component,formatting,style,styling,insert.

1. INTRODUCTION

High strength concrete does not ensure that a durable concrete will be achieved. For a minimum strength, concrete that needs to be durable must have other characteristics specified to ensure durability. In the starting, durable concrete was made by specifying air content, minimum cement content and maximum water cement ratio. At present, performance characteristics may include permeability, de-icer scaling resistance, freeze thaw resistance, abrasion resistance or any combination of these characteristics. The end result may be a high-strength concrete, but this only comes as a by-product of requiring a durable concrete.

1.1 FIBER REINFORCED CONCRETE

Concrete is known to be relatively brittle material when subjected to normal stresses and impact loads. Concrete is also weak in tension as compared to compression. Due to these lacks of strength, concrete flexural members could not support such loads that usually occurred during their service life. In the past, concrete member reinforced with continuous bars to withstand the tensile stresses and to compensate for the lack of efficiency for the same. Besides, steel reinforcement is adopted to overcome high potentially tensile stresses and shear stresses at critical location in concrete member. Due to addition of steel reinforcement significantly increases the strength of concrete, but the development of micro cracks must be controlled to produce concrete with homogeneous tensile properties. The addition of Fiber is a solution to fill the micro cracks and to enhance flexural and tensile strength. The addition of Fiber also helps in homogeneous bonding with cement matrices. Fibers are most generally discontinuous, randomly distributed throughout the cement matrices.

1.2 FIBERS

Fibers are the small piece of reinforcing material having some dimensional characteristics. For describing a Fiber, the most important parameter is Aspect ratio. "Aspect ratio" is defined as the ratio of the length of the Fiber and equivalent diameter of Fiber. The properties of the concrete reinforced with Fiber depend upon the type of Fiber used. Fibers are used for filling the micro cracks and are act as a secondary reinforcing material. Fiber prevents the propagation of cracks originating from the internal flows and results in improving the static and dynamic properties of the matrix. In 1910, Portar observed the concept that post cracking of concrete can be improved by the introduction of Fiber in the concrete.

1.3.1 DIFFERENT TYPES OF FIBERS

Different types of Fibers which are generally used in the construction are:

1. Steel Fibers
2. Polypropylene Fibers
3. Glass-Fibers
4. Asbestos Fibers
5. Carbon Fibers
6. Organic Fibers

1.3.2 STEEL FIBERS

The method of using some Fibers to construction material dates back to the ancient times. In the ancient times, horse hair straws were used to strengthen the bricks. In 1911 Porter observed that Fiber could be used in concrete. Interests of using steel Fibers were developed during 1950. The use of steel Fibers has increased rapidly in construction of concrete structures because introduction of steel Fibers in concrete enhances the toughness, flexural strength, tensile strength and impact strength as well as restrict the failure mode of concrete. The use of concrete is limited at some places due to deficiencies like poor tensile strength, brittleness and poor resistance to impact strength, fatigue, low ductility and low durability. Also, concrete have limited strength to receive dynamic stresses caused due to explosions. Due to introduction of reinforcement or pre-stressing the steel in structural member considerable amount of brittleness can be eliminated. The problem of low tensile strength and the desired high strength still remain and it can only be improved by using some different types of secondary reinforcing materials. Steel Fibers arrest the crack which occurs generally in concrete.

1.3.3 ADVANTAGES OF FIBER REINFORCED CONCRETE (FRC)

The randomly distributed Fiber throughout the concrete can overcome cracks and control shrinkage more effectively. Fibers have outstanding energy absorption Capacity and strength. Generally, the reinforcement of concrete through Fibers is not a substitution and conventional steel reinforcement. Fibers are less efficient in resisting tensile stresses as compared to conventional steel reinforcement. Due to closed spacing Fibers are better in controlling cracks and shrinkage. It is clear that conventional steel reinforcements are used to increase the load carrying capacity and Fibers are used for controlling crack. Due to these differences, there are particular applications that Fibers reinforce are advance than conventional steel reinforcement. These include:

1. Fibers can be utilized as a primary reinforcement in which the conventional steel reinforcement cannot be utilized.
2. Fibers can be materials to resist locally high loads or deformations, which applies in structures like precast piles, precast walls, blast resistant structures or sewer tunnel and linings.
3. Steel bars and wire mesh required necessary labor and material costs for structure concrete. The inclusions of randomly distributed short Fibers as an alternative will significantly reduce labor costs and material costs, increases construction and project time.

2.1 MIX DESIGN

Concrete mix was designed as per IS 10262-2009 and the design procedure was as follows:

1. Determine the mean target strength f_t from the specified characteristics compressive strength at 28- day fck and the level of quality control. $f_t = f_{ck} + 1.65 S$, where S is the standard deviation obtained from the IS 10262-2009.
2. Adopt the water cement ratio for the desired mean target strength using the Table 5 of IS 456 and water cement ratio so chosen is checked against the limiting water cement ratio.
3. Select the water content, for the required workability and maximum size of aggregates (for aggregates in saturated surface dry condition) using table 2 of IS 10262-2009.
4. Calculate the cement content from the water- cement ratio and the final water content as arrived after adjustment. Check the cement against the minimum cement content from the requirements of the durability, and greater of the two values is adopted.
5. Determine the proportion of coarse and fine aggregates in total aggregate by absolute volume corresponding to the adjusted water cement ratio from IS 10262 2009.
6. From the quantities of water and cement per unit volume of concrete and the proportion of fine and coarse aggregates already determined in step 5 above, calculate the content of coarse and fine aggregates per unit volume of concrete from the following relations: $V = [W + C/Sc + fa/P Sfa] \times 1/1000$ Where V= Absolute volume of concrete = Gross volume (1 m³) minus the volume of entrapped air SCSC = Specific gravity of cement W = Mass of water per cubic meter of concrete, kg C= Mass of

cement per cubic meter of concrete, kg P= Ratio of fine aggregates to total aggregate by volume Fa, Ca = total Masses of fine and coarse aggregate, per cubic meter of concrete respectively kg, and Sfa , Sca = Specific gravities of saturated surface dry fine and coarse aggregates, respectively.

7. Determine the concrete mix proportions for the first trial mix. 8. Prepare the concrete using the calculated proportions and cast three cubes of 100 mm size and test them after 28-days moist curing and check for the strength.

9. Prepare trial mixes with suitable adjustment till the final mix proportions are arrived at

Table 3.10 combination of binders studied

Mix Name	OPC%	Steel Fiber%
M1	100	0
M2	90	0
M3	85	0
M4	80	0
M5	90	0.5
M6	90	0.75
M7	90	1
M8	85	0.5
M9	85	0.75
M10	85	1
M11	80	0.5
M12	80	0.75
M13	80	1
M14	100	0.5
M15	100	0.75
M16	100	1

Mix	Cement3(Kg/m)	W/B	Fine aggregates (Kg/m ³)	Coarse aggregate (Kg/m ³)	Fiber (%)	Water (per m ³)
M1	438	0.45	692.8	1108.00	-	197
M2	394.2	0.45	687.6	1100.20	-	197
M3	372.3	0.45	684.47	1095.19	-	197
M4	350.4	0.45	627.00	1091.80	-	197
M5	394.2	0.45	687.6	1100.20	0.5	197
M6	394.2	0.45	687.6	1100.20	0.75	197
M7	394.2	0.45	687.6	1100.20	1.0	197
M8	372.3	0.45	684.47	1095.19	0.5	197
M9	372.3	0.45	684.47	1095.19	0.75	197
M10	372.3	0.45	684.47	1095.19	1.0	197
M11	350.4	0.45	627.00	1091.80	0.5	197
M12	350.4	0.45	627.00	1091.80	0.75	197
M13	350.4	0.45	627.00	1091.80	1.0	197
M14	438	0.45	692.82	1108.00	0.5	197
M15	438	0.45	692.82	1108.00	0.75	197
M16	438	0.45	692.82	1108.00	1.0	197

* RESULTS AND DISCUSSIONS

4.1 INTRODUCTION: In this chapter the results obtained such as compressive strength, flexural strength of concrete at different percentages of steel Fibers after experimental investigation have been thoroughly discussed. Properties which were examined are:

1. Workability of concrete mixes
2. Compressive strength

3. Flexural strength

Compressive strength test was conducted on a 200T Compressive Testing Machine, flexural strength test was conducted on 100 KN MTS make close Loop Actuator System. The detailed analysis and discussion of the test results as obtained from the experimental programme is presented in following sections.

4.2. WORK ABILITY OF CONCRETE MIXES: The workability of concrete mixes was obtained by slump test as per procedure given in chapter 3. W/B ratio was kept constant 0.45 for all the concrete mixes. No super plasticizer was used in any concrete mixes. The workability results of different concrete mixes were shown in Table 4.1.

Table 4.1 Workability of concrete mixes

Mix no.	Description	W/B ratio	Slump (mm)
1	100% opc	0.45	120-125
2	99.5%opc + 0.5% SF	0.45	110-120
3	99.5%opc + 0.5% SF	0.45	110-115

Table 4.1 shows that on increasing the percentage of RHA in concrete mix, the workability of concrete mix was found to decrease as compared to control mix. The addition of steel Fibers into concrete mix further decreases the workability.

4.3 COMPRESSIVE STRENGTH TEST RESULTS: In this section the results of the compressive strength conducted on concrete specimens of different mixes cured at different ages are presented and discussed. The compressive strength test was conducted at curing ages of 7, 28 and 56 days. The compressive strength test results of all the mixes at different curing ages are shown in Table

4.2. Variation of compressive strength with the time is also shown in Fig 4.1 to Fig 4.10 for different curing ages i.e at 7, 28 and 56 days.

Table 4.2 Compressive strength results of all mixes at different curing ages.

Mix No.	Description	Compressive Strength (MPa)		
		7 Days	28 Days	56 Days
M1	100%PC	39.30	45.52	50.45
M2	99.5%OPC+0.5%SF	43.65	48.84	59.80
M3	99.25%OPC+0.75%SF	42.9	48.86	59.68
M4	99%OPC+1%SF	41.56	45.66	58.71
M5	98.75%OPC+1.25%SF	41.67	45.38	57.75
M6	98.5%OPC+1.5%SF	46.82	45.40	60.62
M7	98.25%OPC+1.75%SF	45.96	52.54	55.60

It can be observed from Fig4.1 to Fig4.2 that the maximum compressive strength at 7 day was obtained for a mix containing OPC replacement with 1.5% of steel Fiber, 28-day maximum compressive strength was obtained for a mix containing OPC replacement by 1.75% of steel Fiber and 56-day maximum compressive strength was obtained for a mix containing OPC replacement by 1.5% steel Fiber fraction. At replacement of cement with steel Fiber, compressive strength of concrete mixes increases for 0.5% and 0.75% fraction of steel Fiber, but decrease for 1% fraction of steel Fiber. At 1.0% replacement with steel Fiber, compressive strength of concrete mixes decreases for all fraction at 7 and 28 days but was found to increase for all fraction at 56 days. The increase in compressive strength 1.25% steel Fiber was found to before 7, 28 and 56 days respectively. The increase in compressive strength for 1.5% steel Fiber was found for 7 days and 56 days respectively and at 1.75% of SF Results have been showed favourable for 28 days

4.4 FLEXURAL STRENGTH TEST RESULTS:

In this section the results of the flexural strength test performed on concrete specimens of different mixes at different curing ages has been discussed. The flexural strength test was conducted at curing ages of 28 and 56 days. The test results of all mixes at different curing ages are shown in Table 4.3. Variation of flexural strength of all mixes cured at 28 and 56 days are shown in Fig

4.11 to Fig 4.20.

Table 4.3 Flexural strength test results of all mixes at different curing ages

Mix No.	Description	Flexural strength (MPa)	
		28 days	56 days
1	100%PC	3.78	6.84
2	99.5%OPC+0.5%SF	5.98	7.51
3	99.25%OPC+0.75%SF	5.73	7.28
4	99%OPC+1%SF	4.96	6.66
5	98.5%OPC+1.5%SF	5.17	6.29
6	98.25%OPC+1.75%SF	5.03	6.11

It can be observed from the Table 4.3 that the maximum flexural strength at 28 and 56 days of curing was obtained for a mix containing 0.5% and 0.75% Fiber fraction but decreases for 1% Fiber fraction. The increase in flexural strength for 0.5% Fibers was found to be 31.74% and 11.47% for 28 and 56 days respectively. The increase in flexural strength for 0.75% Fiber was found to be 25.13% and 7.53% for 28 and 56 days. The decrease in flexural strength for 1% Fiber was found to be 3.08% for 56 days but increase in flexural strength was 4.7%.

5. CONCLUSIONS

5.1 Introduction

In the current experimental investigation, strength reinforced with steel Fiber were examined by conducting different tests such as compressive strength test, flexural strength test. The data obtained after experimental work has been presented and discussed in Chapter-4 earlier. This chapter gives the broad conclusions that may be drawn from the investigation.

5.2 CONCLUSION

The following conclusions may be drawn from the current investigation:

- The workability of concrete mix was found to decreases as the replacement of cement by STEEL FIBRE increases.
- The workability of concrete mix also was found to decreases due to FURTHER addition of steel Fiber in to concrete mix.
- The addition of steel Fiber in to concrete mix was found to have higher strength at 0.5% Fiber content on the earlier stage but have higher strength at 0.75% Fiber content on the later stage.
 - The addition of steel Fiber to concrete mix was found to have more effect than RHA in decreasing the compressive strength.
- The addition of steel Fibers in to concrete mixes increases the flexural strength at 0.5% Fiber content t as compared to normal mixes whereas at 0.75% and 1% Fiber content decreases the flexural strength.
 - The resistance to cracking and deflection was more offered by concrete mix at replacement with all Fiber contents for 56 days.
- Mix with 99.5%OPC+0.5%SF was found to give the maximum flexural strength than all other concrete mixes for 28 and 56 days of curing.
- The addition of steel Fiber in concrete mix was found to increase IRA values but less than the control mix for replacement with all Fiber content.
- The average IRA values were found to increases at 0.5% Fiber content but decrease at 0.75% Fiber content and again increase at 1% Fiber content.
- Good correlation between strength and absorption properties of concrete was found. With increase in strength, sorptivity values decreases.
- Result shows that concrete mix containing 99.5%OPC+0.5%SF can be adjudged as the most appropriate mix for compressive strength, flexural strength

SCOPE FOR FUTURE RESEARCH:

Based on availability of different binders and their use in concrete mix, The possibility of research in following area can be evaluated. Test may be conducted on mortar also and a comparative study can be done to decide the better one in respect of strength and durability.

- Some other environmental and exposure may be taken for further study of different durability properties of concrete.
- Ternary and quaternary blended concrete may be studied to find out the best mix proportion among pozzolans with OPC.
- Flexural toughness of concrete can also be evaluated.
- Curing temperature may also be changed for investigating the samples for durability properties

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