Evaluation of Mechanical Properties of High Strength (M40) Fibre Reinforced Concrete using Admixtures

Gopu Ganesh Naidu, Maila Nagaraju, K.Ashok Kumar

1 Associate Professor and Head of the department, Civil Engineering, Pace institute of technology & sciences(A), Valluru, Prakasam, Andhra Pradesh, India.
2 PG Student ,Structural Engineering, Pace institute of technology & sciences(A), Valluru, Prakasam, Andhra Pradesh, India. Email: mailanagaraju@gmail.com
3 Assistant professor, Department of Civil Engineering, Pace institute of technology & sciences(A), Valluru, Prakasam, Andhra Pradesh, India.

Abstract. This research concentrates on the evaluation of mechanical properties of high strength concrete using fibers and admixtures. Now-a-days High strength concrete is used in the construction to get the more strength and durability. High strength concrete mix of M40 grade is designed by adding fibers and admixtures. Admixtures like Super plasticizer & master glenim are used to replace the cement content in the mix. Chemical admixtures are used to decrease the water content in the concrete such that its workability and compressive strength increased. Along with that as the concrete is weak in tension, to overcome that, fibers of polypropylene were used. Fibers can increase the tensile behaviour of the concrete beam. The specimens were prepared by adding the fibers and mineral admixtures to the high strength (M40) concrete and conventional concrete and tested for compressive strength, Slump cone test, Modulus of elasticity and flexural strength at 7,14, 28 & 56 days. Based on the experimental values, it is clearly identified that all the results were obtained target mean strength. Experimental data shows that using fiber content from 0.5% to 1% can increase all mechanical properties of the concrete but using more than above mentioned content will leads to decrement of strength parameters of the concrete.

Keywords: Fibers, High strength concrete, super plasticizers, Target mean strength, Green house gasses, poly propylene, Modulus of elasticity.

1. Introduction

Now-a-days concrete plays a vital role in construction & widely used in various constructions. Cement produces high amount of Green house gasses like CO$_2$ while its production, which causes harmful effects to the environment [1]. The materials used in high strength concrete are as same as normal concrete but additional to it there are some admixtures were added. To reduce the usage of concrete with same compressive and flexural strengths we use different kinds of admixtures in the mixing. By adding the mineral admixtures like, GGBS, Fly ash, Silica fume, Master Glenim etc, we can enhance the stability, workability and compressive strength of the concrete [2,3]. Some of these admixtures have very fine particles than cement. So we can easily replace cement with these admixtures and can lead to the increase of durability and reduce the porosity [5]. Fibers are used in this concrete to get the concrete strong in tension which results well in fire resistance and high compressibility [6]. Fiber reinforced concrete is a mixture of tiny discrete particles which are distributed uniformly in concrete mix and oriented transversely. The ingredients of fiber reinforced
concrete are concrete, steel, cellulose, polypropylene. The amount of fibers added to the total volume may be of 0.1% to 0.3% [7].

2. Materials and Properties

2.1. Cement

Cement is one of the major binding materials which is used in the construction. In this research we used the Ordinary Portland Cement (OPC) of 53-grade confirming to IS: 12269-2013 [11]. Several experimental tests were conducted on the taken cement to know the quality of cement as per the codal provisions of IS: 8112-1989 and get the following results.

| Property               | Test Result |
|------------------------|-------------|
| Compressive Strength(Mpa) | 47.35       |
| Fineness (%)           | 6.1         |
| Specific Gravity       | 3.02        |

2.2. Ground Granulated Blast furnace Slag (GGBS)

GGBS is used in the preparation of concrete as an admixture. Now-a-days it is popularly used as admixture rather than using as slag cement. Major constituents of blast furnace slag are Silica oxide, magnesium oxide, calcium oxide [4]. By using the GGBS in concrete it can increase the slump value, reduce the heat hydration etc.

![GGBS](image)

| Property               | GGBS | Cement |
|------------------------|------|--------|
| CaO                    | 46   | 60.1   |
| MgO                    | 1    | 2.1    |
| Al2O3                  | 10   | 15     |
| N2O                    | 0.25 | 0.45   |
| Specific Gravity       | 2.77 | 3.02   |

2.3. Poly propylene

The poly propylene fibers are used in the concrete to get increases the tensile strength of concrete [8]. Surface bleeding and aggregate settlement in case of fresh concrete are the basic reasons for the formation of cracks. To reduce these cracks we use poly propylene fiber in concrete. The poly
propylene concrete is cheap in cost [10]. The fibers are available in three different sizes i.e., 6mm, 12mm and 24mm.

![Fig: 2 Poly propylene](image)

| Property                        | Poly propylene |
|---------------------------------|----------------|
| Unit weight (gm/cm³)            | 0.9-0.91       |
| Tensile strength (MPa)          | 300-400        |
| Thermal conductivity (W/m/K)    | 0.12           |
| Reaction with water             | Hydrophobic    |
| Elongation at break (%)         | 100-600        |

3. Concrete Mix Proportion

Batching of concrete is done at room temperature [14]. Different percentages of fibers were mixed in the concrete like 0.5%, 1% and 1.5% and a reference mix conventional concrete is designed as per the codal provision of IS: 10262-2009 and obtained the following mix proportions.

Mix Ratio (C: FA: CA) : 1:1.2:2.3
Water Cement Ratio : 0.32

![Fig: 3 Placing and Compacting](image) ![Fig: 4 Curing](image)

4. Methodology

4.1. Workability Test

4.1.1. Slump cone Test

The slump cone test was conducted for fresh fiber reinforced concrete with mineral admixtures and for conventional concrete. Obtained results were compared and analyzed. By adding the mineral admixtures the slump values are giving good [11]. The workability of the fiber reinforced concrete with mineral admixtures increased by adding the admixtures.
4.2. **Compressive Strength**

The compressive strength of fiber reinforced concrete with mineral admixtures was finding out by conducting the compressive strength test using Compressive Testing Machine (CTM) for the different compositions of fibers and admixtures. For conducting the tests the specimens (cubes) were prepared of standard dimension 150*150*150mm \[13\]. And the test results were compared.

4.3. **Modulus of Elasticity Test**

Modulus of Elasticity of concrete is defined as the ratio of stress applied on the concrete to the respective strain caused. To get the modulus of elasticity of concrete the compression test should be done on a cylindrical concrete specimen by using a compressometer \[15\]. From the stress-strain (load-deflection) curve slope and 45% compressive strength value the modulus of elasticity value is obtained \[9\]. The cylindrical moulds were prepared and tested for 28 days as per IS: 516-1959 codal provisions.

4.4. **Flexural strength test**

For the prepared specimens the flexural strength test was conducted for both the conventional concrete and fibre reinforced concrete with mineral admixtures of different proportions. And the test results were compared \[12\]. The flexural behaviour of the concrete can be determined by using this test.

5. **Results and Discussion**

5.1. **Workability Test**

5.1.1. **Slump cone Test**

By adding mineral admixtures to the concrete we can increase the durability property of the concrete and fibers can increase the strength of the concrete. The water content of the concrete can be
decreased by adding the chemical admixtures to the concrete. The heat of hydration also decreases by adding the admixtures and fibers to the concrete.

| % Fiber | Slump values in mm |
|---------|-------------------|
| 0       | 60                |
| 0.5     | 64                |
| 1       | 71                |
| 1.5     | 78                |

5.2. Compressive Strength

Based on the compressive strength test results, it is clearly observed that the Fiber reinforced mineral admixture concrete gives the better results compared to the nominal concrete. Especially at 1% of fiber and admixtures replaced by the cement in the concrete gives more strength values compared to the remaining proportions. Experimentally proved that by adding fibers and admixtures we can improve the strength and durability of the concrete [16]. Based on the test results it is not advised to add more than 1% of admixtures and fibers to the concrete. If one add more amount of admixtures to the concrete which leads to the more amount of swelling and shrinkage.

| % Fiber | 7days | 14days | 28days | 56days |
|---------|-------|--------|--------|--------|
| 0       | 30    | 37     | 44     | 49     |
| 0.5     | 28    | 34     | 40     | 43     |
| 1       | 31    | 38.5   | 45     | 49.6   |
| 1.5     | 26    | 33     | 41     | 42     |

Fig 8: Graphical representation of Variation of Compressive strength values with various percentages of fibers
5.3. **Flexural strength test**

After conducting the flexural strength test it is observed that the conventional concrete gives less flexural strength values compared to the fiber reinforced mineral admixed concrete. Flexural strength test also gives good results at 1% adding of the fiber and admixtures to the concrete. The concrete get more strength when fibers are added to it compared to the normal concrete. If fibers and admixtures content increases more than 1% in the concrete which gives less strength values, because the chemical admixtures content increases in the concrete which leads to the reactions in the concrete mix which may cause decrease the strength of the concrete.

| % Fiber | 7days | 14days | 28days | 56days |
|---------|-------|--------|--------|--------|
| 0       | 3.4   | 4.1    | 4.4    | 4.9    |
| 0.5     | 3.1   | 3.7    | 4.1    | 4.3    |
| 1       | 3.5   | 4.15   | 4.5    | 5.1    |
| 1.5     | 3.1   | 3.8    | 4.15   | 4.26   |

*Fig 9: Graphical representation of Variation of Flexural strength values with various percentages of fibers*

6. **Conclusions**

From the experimental results the following conclusions were drawn.

- Plasticizers have the capacity to increase the workability by reducing the w/c ratio and which helps in gaining the high strength concrete.
- It is observed that the target mean strengths are achieved when fibers and admixtures were added to the concrete.
- High target mean strengths are achieved when 1% fiber content is added to the concrete mix.
- If further increase in fiber content which leads to the decrease in strength parameters.
- By using the mineral admixtures in the concrete the slump values are more than compared to the conventional concrete. And which can decrease the heat of hydration.
- The compressive strength, flexural strength and slump values of the fiber reinforced concrete with mineral admixtures gives best results up to 1% of fiber content beyond that gives less results.
- Based on the above discussion it is advised that up to 1% adding fibers to the mineral admixture concrete is preferable, more than that is not preferable.
References

[1] Tara Rahmani, Bahnam Kiani, Farzanesh sami, “Durability of Glass, Polypropylene and Steel Fiber Reinforced” Concrete, ACI Journal, Vol.83, 374-382

[2] A.A.Ramezanianpourab, M.Esmaeilić, S.A.GhahariahM.H. Najufic laboratory Study on the effect of polypropylene fibre on durability, physical and mechanical characteristics of concrete for application in sleepers, Volume 44, July 2013

[3] O.KayallM.NHaqueBZhu, Study on cement and concrete composites some characteristics of high strength fiber reinforced lightweight aggregate, concrete mati .Volume 25, issue 2, February

[4] Xincheng Pu and Chong Wang Contribution of silica fume to the strength and flow ability of 150MPa superhigh strength flowable concrete, 2000, journal no.2 845-52.

[5] SaeidKakooei The corrosion investigation of rebar embedded in the fibers reinforced concrete”, Construction and Building materials 35 (2012) pp:564-570.

[6] Gopu Ganesh Naidu, Kannella Edukonda “Mechanical Properties of Concrete by Replacing Cement with Eggshell powder and Fly ash”. International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-4, February 2020, DOI: 10.35940/ijitee.D1715.029420

[7] Dinakar “Effects of metakaolin content on the properties of high strength concrete”, international journal of concrete structures and materials,207(3):215-23.

[8] patil “Strength and durability property of high performance concrete incorporating high resistivity metakaolin”, international journal of modern engineering research 2012,2(3):1099-104.

[9] Permul and soundararajan Analysis on mix design of high strength concrete (M100), IJET, Volume 05 Issue 06 June-2018.

[10] Dr. Aignesberger “Micro silica by-product to get the better performance than ordinary Portland cement when compared”,

[11] KolliRamujee A study on strength properties of polypropylene fiber reinforced concrete Polypropylene fibers, compressive strength, split tensile strength. Vol.2, Issue 8, Appears on pages:3409-3412, August 2013.S

[12] ZiadBayasi and jack Zeng workability A study on air entrainment; compression; fiber reinforced concrete; flexural strength; impact; permeability; polypropylene fiber;; Materials Research.Volume:90, issue:6, Appears on pages:605-610, 1993.

[13] UmeshSharma “Use of M sand in high strength concrete and high performance concrete”, Indian Journal of science and technology, 28, ipl1063, October 2013.

[14] IS:456-2000. Code of practice for plain and reinforced concrete, Bureau of Indian Standards, New Delhi.

[15] IS:10262-2009. Code of practice for concrete mix design proportioning. Bureau of Indian Standard.

[16] M.S.Shetty, Concrete Technology, 3rd Edition, S.Chand & Company Limited, Delhi, 1992