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EFFECT OF FIBRES ON STRENGTH CHARACTERISTICS OF CONCRETE

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Abstract:

Concrete is the mostly consumed material in the field of construction across the world. It can be easily moulded into any shape by the mixture of different materials such as cement, water, fine and coarse aggregate. In general, concrete can withstand against compression than tension. Hence to improve the tensile characteristics of concrete, different types of fibers can be incorporated to overcome strength and durability properties. Usually, fibers used in concrete are natural and artificial fibers. Among them synthetic and steel fibers are used in the present study. These two types of fibers are added in percentages of 0.5%, 1% and 1.5 % respectively by cement weight. The experimental investigation is carried out to utilize the synthetic and steel fibers in M25 grade concrete for the development of strength characteristics in terms of compression and are compared by performing destructive and non-destructive tests at curing and non-curing conditions. The optimum percentages of fibers content is determined and comparison is made between the results obtained. The results obtained are found to be satisfying the requirements.

Keywords:

Concrete; fibers; compressive strength; curing; cement

1. INTRODUCTION

Concrete Technology has become the major component in development of various infrastructure projects related to Civil Engineering aspects. Concrete is the homogeneous material for various structural projects in world from the past decades. As concrete is weak in tension and strong in compression, hence it is difficult to maintain the consistent behavior of concrete in both strength and durability areas. An alternative method adopted for improving the tensile strength parameters for concrete is by adding the various fibers such as natural and artificial fibers which is also economical. In the present study artificial fibers such as synthetic and steel fibers are considered for the strength improvement. Addition of fibers in concrete results in the development of new innovative material i.e. fiber reinforced concrete. This concrete consists of the fibers which are distributed uniformly and oriented randomly. These fibers makes the concrete to withstand against the brittle property and improves the ductility nature. Destructive and Non-destructive testing methods are used for obtaining the strength values in compression phase of concrete. Destructive testing is performed using Compression Testing Machine as per IS code 516 Part 1 Sec 1 2021 and nondestructive test is done by using Rebound Hammer Testing as per IS code 516 Part 5 Sec 4 2021 respectively.

2. LITERATURE REVIEW

Mohammed Saed Yusuf (2023) et al. have focused mainly on high strength concrete by utilizing fibers in concrete to enhance the strength parameters. The steel fibers were added in various percentages of 1%, 2%, and 3% and the compressive strength of was found to be effective at 2 % addition of fibers [11]. Ramaiah Prakash (2022) et al. had studied the effect of fibers on concrete strength [6]. Ashadul Islam (2021) et al. have compared the properties of concrete by using three different types of fibers [1]. Peng Zhang (2021) et al. have conducted impact tests, RCPT, free and thaw tests on concrete to investigate the effect of the steel fiber along with nano silica. Nano silica is considered of 3% and six steel fiber percentages are chosen by volume in range of 0–2.5%. The optimum content is found to be at 1.5 % addition of steel fibers [12]. Jevin Dobaria (2021) et al. have attempted to investigate properties of concrete with fibers like synthetic Recron 3S fibers. These strength parameters included compression, split tensile and flexural properties [4]. Sardasht S Weli (2020) et al. have presented a review on inclusion of steel fibers in concrete and its effects as well as improvements were discussed. Also concluded that application of these fibers had contributed to the increase in the strength parameters [9]. Ashfaque Ahmed Jhatial (2018) et al. have used steel fibers in M20 grade concrete at percentages of 1%, 2%, 3%, 4% and 5% and compared the results with conventional concrete and concluded that the addition of 3% had shown the optimum results [2]. Alan E Richardson and Sean Landless (2018) had reviewed the various technical research papers including steel and synthetic fibers applications in concrete for the improvement of strength and durability. The research demonstrated that the usage of these fibers had shown a remarkable impact on various properties of concrete [7]. Veronica Guerini (2018) et al. have studied the fresh and hardened properties of concrete by varying water-cement ratios utilizing fibers. From the results it was concluded that steel fibers are more affected when compared to synthetic fibers [2]. Lijina Thomas (2018) et al. have studied the influence of metallic and non-metallic fibers on stiffening and cracking behavior of UPHC. Steel fibers (0.25, 0.5, 0.75, 1%) and synthetic fibers (0.1, 0.15, 0.2%) were added to concrete and the optimum content was obtained at 0.75% and 0.15% of steel and synthetic fibers

respectively [8]. Kiranbala Devi (2013) et al. have studied the parameters of fiber reinforced concrete and compared with the normal concrete and the conclusions were drawn from the results. Addition of fibers converts the concrete into ductile nature from brittle aspects by improving the tensile characteristics [5]. Jun-Mo Yang (2012) et al. have used two types of fibers namely steel and synthetic fibers in order to study the behavior of beams of high strength concrete. Carbon, glass fiber reinforced polymer concrete are cast and tested for parameters such as load carrying capacity, cracking responses and ductility characteristics. The addition of fibers improved the properties of concrete [10].

3. METHODOLOGY AND EXPERIMENTAL INVESTIGATION

The experimental investigation is carried out to utilize the synthetic and steel fibers in M25 grade concrete for the development of strength characteristics. These two types of fibers are added in percentages of 0.5%, 1% and 1.5 % respectively by cement weight. Physical characteristics of materials are obtained from the tests conducted. Also destructive and non-destructive tests are performed on the concrete specimens in order to obtain the strength parameters. The strength properties are compared between curing and non-curing conditions. The specimens adopted for the entire experimental study are 84. Analysis of results are observed to derive the conclusions of the study.

4. MATERIAL USED AND PROPERTIES

Cement is of OPC 53 grade of 3.06 specific gravity considered in the study. Natural River sand of Zone-III, specific gravity 2.68 and fineness modulus 3.74 is used in the study. Crushed aggregates of 10 and 20 mm sizes of 2.76 and 2.78 specific gravity are used in the study. Potable water of pH value 7.1 is used in the present study. Synthetic fibers and steel fibers are added by weight of cement in the concrete mix of grade M25. Two fibers used in the study are shown in Figs. 1 and 2. Synthetic fibers are polypropylene fibers of waste cement bags.

Fig.1 Synthetic fibers

Fig.2 Steel fibers

The nomenclature of concrete mixes used in the present study are listed below:

1. M1- M25 grade concrete with 0 % synthetic fibers
2. M2 - M25 grade concrete with 0.5% synthetic fibers
3. M3- M25 grade concrete having 1% synthetic fibers
4. M4- M25 grade concrete with 1.5% synthetic fibers
5. M5- M25 grade concrete with 0 % steel fibers
6. M6- M25 grade concrete with 0.5 % steel fibers
7. M7- M25 grade concrete with 1% steel fibers
8. M8- M25 grade concrete with 1.5 % steel fibers

5. TEST RESULTS AND ANALYSIS

The values of strength in compression of M25 grade concrete using synthetic fibers at 7 and 28 days curing and non-curing conditions (air or ambient curing) from destructive and non-destructive testing methods are represented in Tables 1 and 3 and also their variations are shown in Figs. 3, 4 and 7. The values of strength in compression of M25 grade concrete using steel fibers at 7 and 28 days curing and non-curing conditions from destructive and non-destructive testing methods are represented in Tables 2 and 4 and also their variations are exhibited in Figs.5, 6 and 8 respectively. The results of destructive and non-destructive testing methods on all the concrete mixes are discussed in sections 5a and 5b respectively.

5a. Destructive Testing Methods

Table 1. Compressive strength of concrete of M25 grade using synthetic fibres at various curing conditions

Compressive strength (N/mm^2)				
Mix Type	**7 days Curing**	**7 days Non-Curing**	**28 days Curing**	**28 days Non-Curing**
M1	29.26	25.44	33.28	29.83
M2	32.69	28.90	44.30	34.00
M3	31.26	26.42	40.06	31.23
M4	29.80	25.10	36.43	29.02

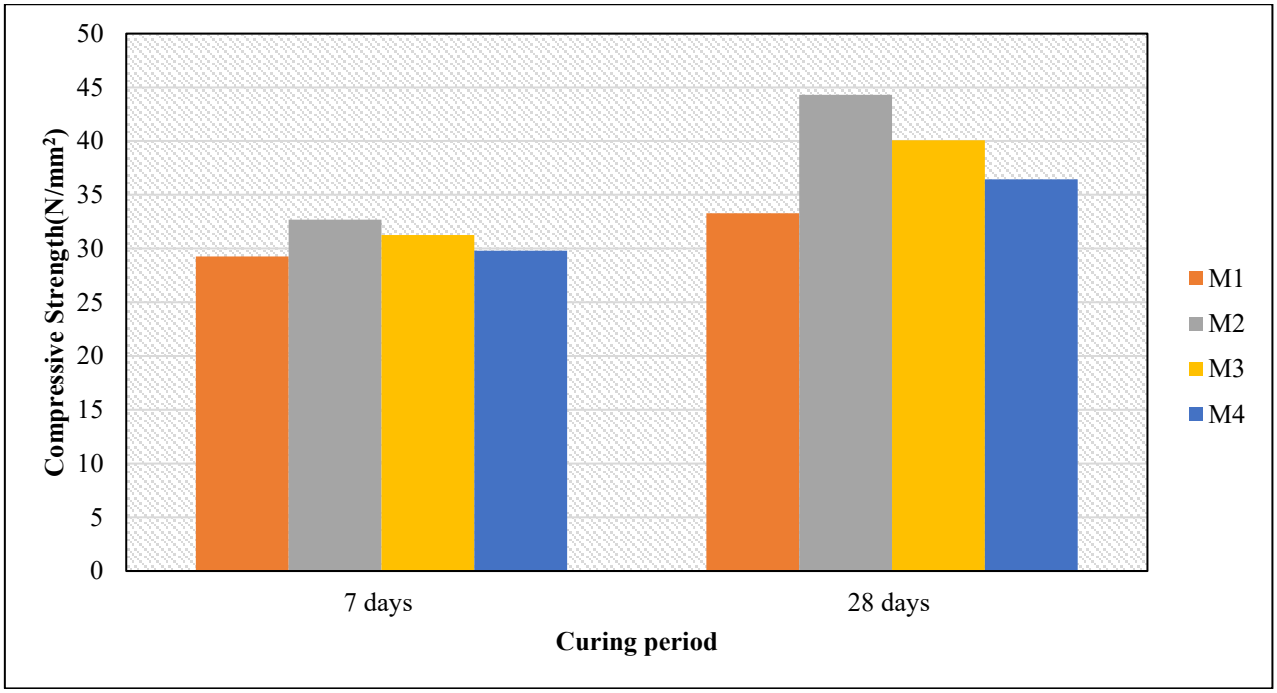

Fig.3 Comparison of compressive strength of M25 grade concrete with and without synthetic fibres at 7 and 28 days of curing

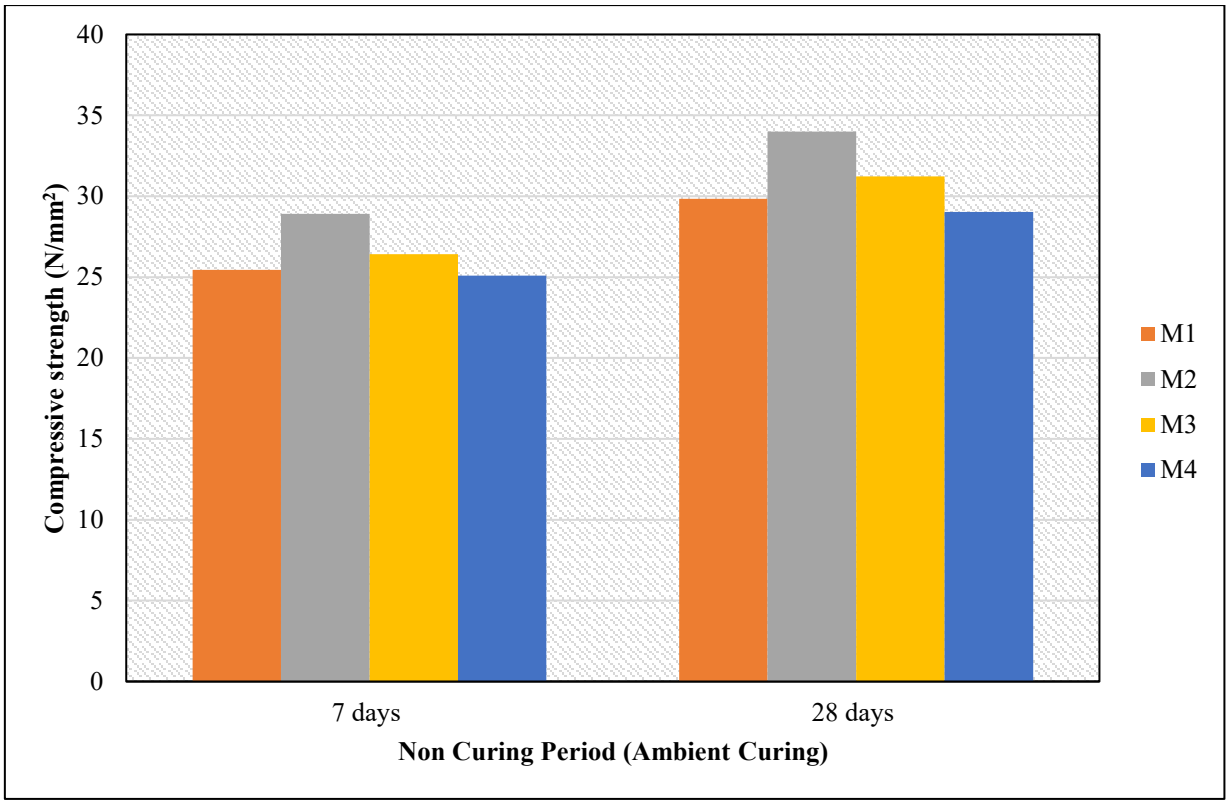

Fig.4 Comparison of compressive strength of M25 grade concrete with and without synthetic fibres at 7 and 28 days of non-curing conditions (Ambient curing)

Table 2. Values of compressive strength of M25 grade concrete with and without steel fibres at 7 and 28 days of curing and non-curing conditions

Compressive strength (N/mm²)				
Mix Type	**7 days Curing**	**7 days Non-Curing**	**28 days Curing**	**28 days Non-Curing**
M5	29.26	25.44	33.28	29.83
M6	31.66	27.43	42.73	32.62
M7	34.67	31.56	45.32	36.84
M8	30.51	26.22	39.65	31.45

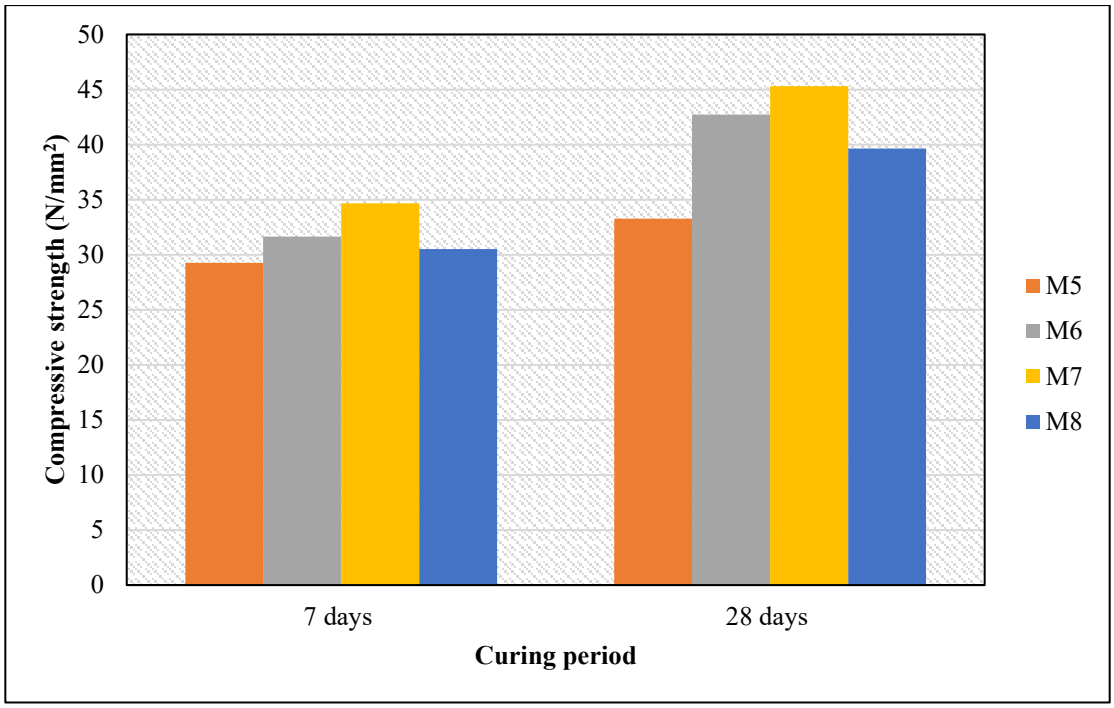

Fig.5 Comparison of compressive strength of concrete of M25 grade using steel fibres at various curing conditions

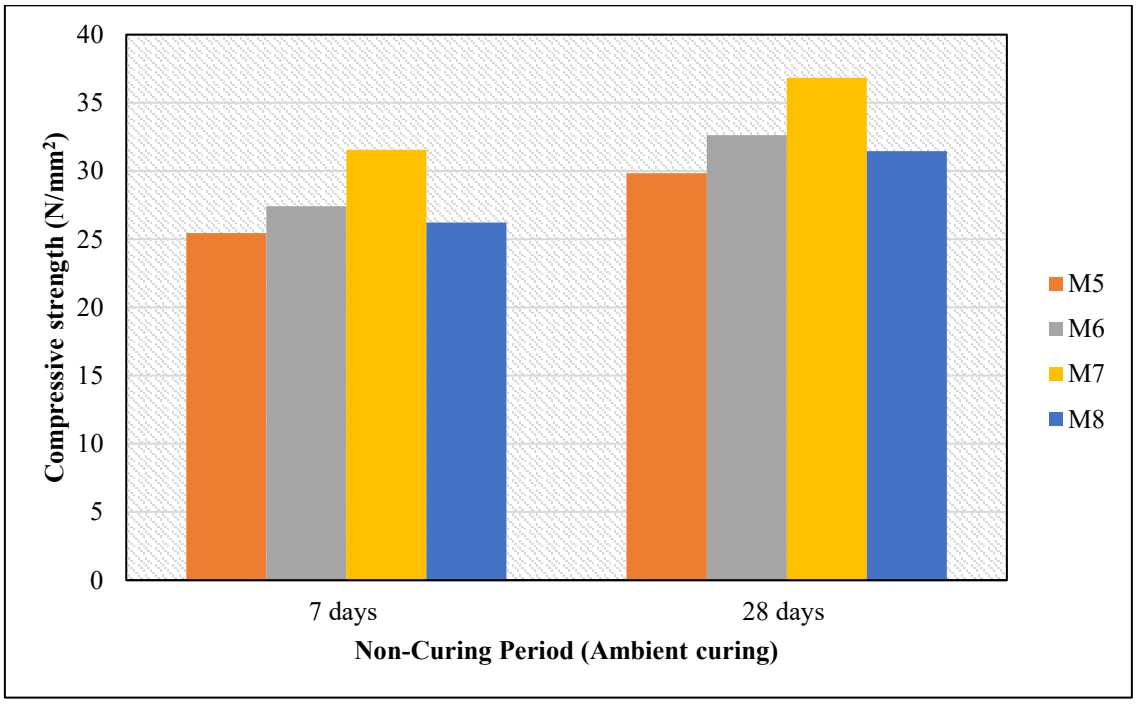

Fig.6 Comparison of compressive strength of concrete of M25 grade using steel fibres at ambient curing condition

From Figs.3 and 4, it concluded that the maximum percentage increase in compressive strength of M25 grade concrete at 28 days curing are 33.11, 20.37 and 9.47 % for 0.5,1 and 1.5 % addition of synthetic fibers respectively. Similarly, the increase in percentage of compressive strength of M25 grade at 28 days curing are 28.39, 36.17 and 19.14 % for 0.5,1 and 1.5 % of steel fibers respectively are observed clearly form Figs. 5 and 6. Considering the strength values regarding non-curing conditions, the concrete with 0.5 % synthetic fibers has exhibited more when compared to other mixes. Similarly, the concrete with 1% steel fibers has shown higher values of compressive strength than the other concrete mixes.

5b. Non-Destructive Testing Methods

Rebound Hammer Test is conducted on the concrete specimens to obtain the compressive strength values and then comparison is done between the concrete mixes with and without addition of fibers which are tabulated in Tables 3 and 4.

Table 3. Rebound compressive strength of concrete of M25 grade using synthetic fibers at various curing conditions

Compressive strength (N/mm^2)				
Mix Type	**7 days Curing**	**7 days Non-Curing**	**28 days Curing**	**28 days Non-Curing**
M1	26.54	22.52	32.63	26.74
M2	28.20	23.34	36.42	30.23
M3	26.50	21.72	33.00	28.67
M4	23.65	20.84	29.66	27.13

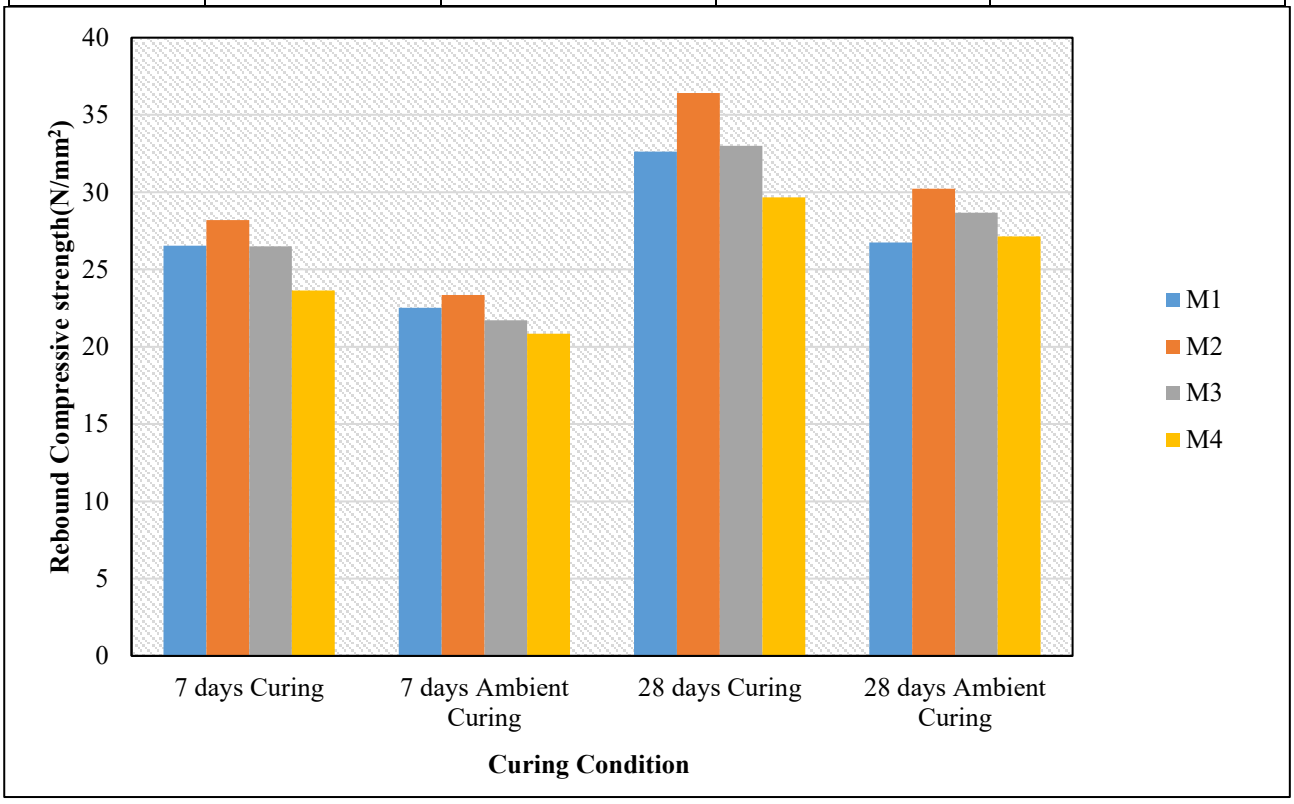

Fig.7 Variation of Rebound compressive strength of concrete of M25 grade using synthetic fibers at various curing conditions

Table 4. Rebound compressive strength of concrete of M25 grade using steel fibers at various curing conditions

Compressive strength (N/mm^2)				
Mix Type	**7 days Curing**	**7 days Non-Curing**	**28 days Curing**	**28 days Non-Curing**

M5	26.54	22.52	32.63	26.74
M6	24.26	21.10	35.33	25.42
M7	29.54	24.45	37.60	29.76
M8	28.32	20.54	33.14	24.93

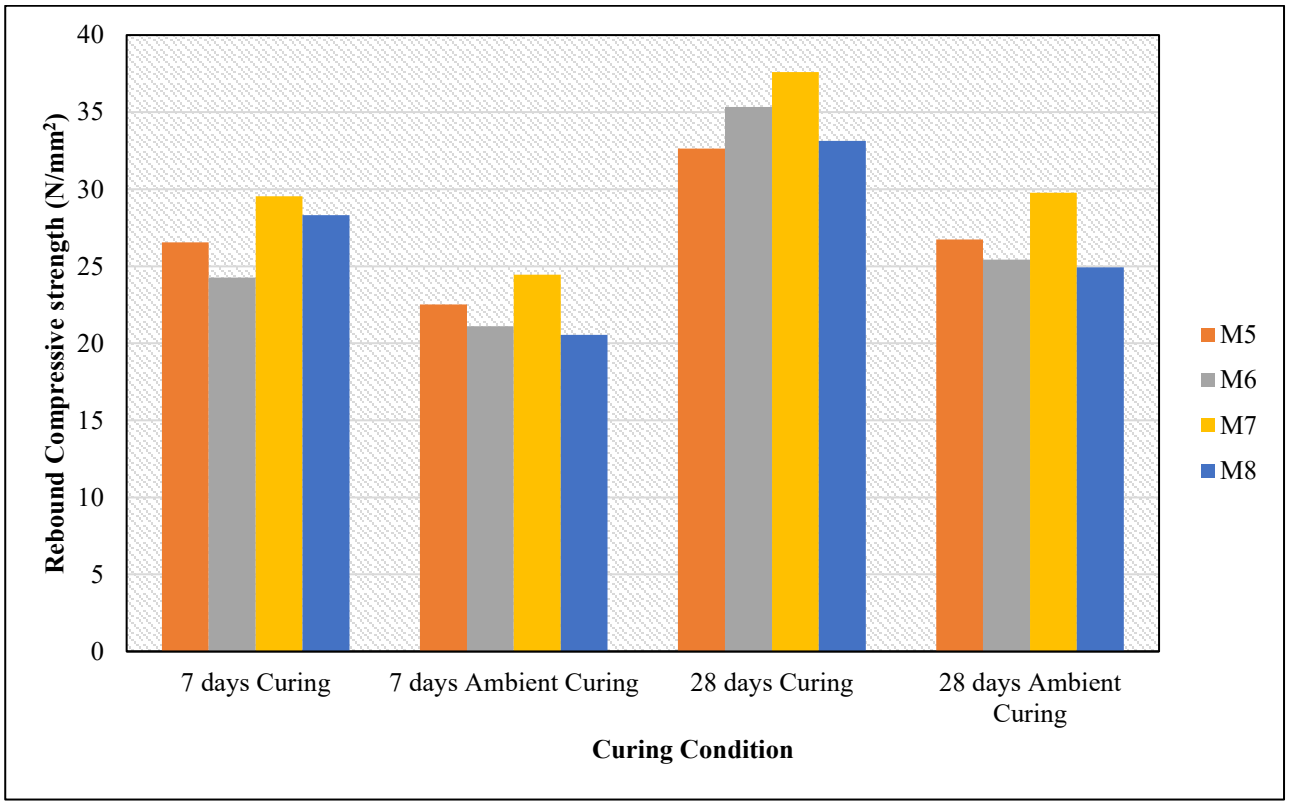

Fig.8 Variation of Rebound compressive strength of concrete of M25 grade using steel fibers at various curing conditions

From Figs.7 and 8, the percentage increase in Rebound compressive strength of M25 grade concrete at 28 days curing is maximum by 11.6 % at 0.5 % utilization of synthetic fibers. Similarly, percentage increase in compressive strength of M25 grade concrete at 28 days curing is 15.23 % for 1 % addition of steel fibers.

6. CONCLUSIONS

The important aspects obtained from the tests results using fibers under curing and non-curing conditions:

1. Among steel and synthetic fibers, steel fibers has shown higher effectiveness in compressive strength when compared to conventional concrete and concrete with synthetic fibers under both curing conditions.
2. Addition of synthetic fibers at 0.5 % by weight of cement has shown the more strength values of concrete for both destructive and non-destructive testing methods under curing and non-curing conditions.
3. Steel fibers at 1 % by weight of cement has attained higher compressive strength values for both destructive and non-destructive testing methods under curing and non-curing conditions.
4. Among synthetic and steel fibres, steel fibre exhibits more efficiency in improvement of compressive strength when compared to synthetic fibres made from reused cement bags. The effect of synthetic fibre in concrete is less due to its low shear modulus in the phase of compression.

5. Utilization of synthetic fibers from waste cement bags has developed a new sustainable ecofriendly concrete in the modern era of construction technology along with steel fibers.

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