STUDY OF SFRC AND DESIGNING WATER TANK USING STAAD.PRO SOFTWARE

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Abstract - This paper studies the performance analysis of steel fiber reinforced concrete (SFRC) in different civil structures, especially in water retaining structures. Cement concrete has been very well used in construction globally not only because of its better engineering properties but also on account of its better ecology and environmental acceptance. However, besides various merits, concrete contains innumerable micro-cracks resulting in insufficiency like low tensile strength, limited ductility, unstable crack propagation, etc. Solution to these problems of concrete is given in this paper through various steps i.e. by studying, manufacturing process, compressive strength test, tensile strength test, flexural strength test, advantages, disadvantages, and applications of SFRC. SFRC and normal conventional concrete are compared in this paper by considering all the aspects.

It is important to supply potable water to every individual. Water is generally stored in tanks and later the stored water is supplied through pipelines. In this project, two types of water tanks i.e. underground type of rectangular water tank with 3,60,000lit capacity and overhead type of rectangular water tank with 48,000lit capacity are analyzed and designed using conventional concrete in Staad.pro software. Design details of both of the water tanks are mentioned and comparison by changing grades of concrete is carried out in this paper. It was found out that by using SFRC, nearly 20 to 30% of material will be saved in comparison to conventional concrete. The main focus is given on justifying how its better and beneficial to use SFRC.

Keywords: Compressive strength, Concrete, SFRC, Staad.pro, Steel fibers, Water tank.

1.INTRODUCTION

Cement concrete is the most extensively used construction material in the world. The reason for its extensive use is that it provides good workability and can be molded into any shape. As advancement to RCC, the concrete reinforced with randomly distributed fibers, provides an ideal two-phase composite material with enhanced resistance against cracking and better micro-crack arrest mechanism. Substantial research carried out in the field of fiber reinforced concrete (FRC) since last six decades has established that the concrete reinforced with randomly distributed fibers has several improved structural and mechanical properties. Better strengths under shear, flexure and tension; enhanced resistance against cracking, impact, fatigue and wear; and enhanced toughness and ductility, over that of the reinforced cement concrete are few of them.

In the current state of development of FRC, steel fibers have been most widely used, both safely and cheaply, for long term applications because of their easy availability at reasonable cost. These fibers can be made of different shapes which results in significant improvement in structural and mechanical properties.

Er Gaurav Goel, Er Bharat Bhushan Jindal [1] (2015) studied on suitability of steel fibre reinforced concrete for RCC water tanks. The objectives of this study were to design a circular and rectangular type of water tank of 2,00,000 liters capacity with SFRC and conventional concrete using M20 and Fe415 grades of concrete and steel. Use of SFRC in comparison to traditional reinforced concrete in various water tanks is also discussed. It is found that steel fibers can be used for crack controlling in water retaining structures and significantly reduce the permeability of concrete too. Durability study of SFRC has also well established that SFRC has better resistance to corrosion than plain cement concrete. Nearly 50% of material is saved in comparison to ordinary conventional concrete.

Himanshu Dwivedi, Dr. M.K Gupta [2] (2019) studied on analysis and design of water tank employing Staad.pro for cost optimization. To present, manual design and detailed drawings of an circular reinforced cement concrete tank, to analyse a circular water tank using the premiere analysis software Staad.pro, and to examine the cost effectiveness in terms of amount of materials for quick cost prediction of tanks were some of the objectives of this study. It was found that as the capacities increase, the amounts of materials for the structure also increases. But, a rather non-perfect proportionality result was seen, i.e., a proportional increase in the capacity would not, necessarily lead to a proportional increase in any of the materials required. It was observed that all members of the structure are safe. Staad.pro gives cumulative volume of quantity of concrete for beams and plates. Also, in case of steel Staad.pro gives cumulative weight of reinforcement steel for beams and plates only.

Fig.1: Concrete filled with steel fibers
Milind V. Mohod [3] (2012) studied on performance analysis of steel fiber reinforced concrete. Objectives of this research were to study the effect of fibers on the strength of M30 grade of concrete by varying the percentage of fibers by 0.25%, 0.50%, 0.75%, 1%, 1.5%. Cubes of size 150mmX150mmX150mm were casted to check the compressive strength and beams of size 500mmX100mmX100mm were casted for checking flexural strength. The optimum fiber content while studying the compressive strength of cube was found to be 1% and it was found 0.75% for flexural strength of the beam. Also, it has been observed that with the increase in fiber content up to the optimum value, the strength of concrete also increases. Slump cone test was adopted to measure the workability of concrete. The Slump cone test results revealed that workability gets reduced with the increase in fiber content.

2. METHODOLOGY
2.1 Manufacturing of Steel Fibers and design consideration of SFRC

Steel fibers are manufactured by forcing steel strips into small pieces of steel fibers by introducing large energy. It is done by two types of failures i.e. brittle failure which occurs at low energy impact level to produce straight fibers of uniform cross section and shear failure which is associated with high energy absorption to form steel fibers of irregular cross section. Firstly, the cement, fine and coarse aggregates is poured into the mixer after that, steel fibers are used to be poured then water is poured after that this whole assembly is mixed either by hand or by using mechanical equipment. Effectiveness of steel fibers is depended on its length, diameter, aspect ratio (diameter to length ratio) and configuration.

2.2 Static Mechanical Properties
1. Compressive Strength:
Fibers do little to enhance the static compressive strength of concrete, with increases in strength ranging from essentially nil to perhaps 25%. However, as in compression, steel fibers do lead to major increases in the post cracking behavior of toughness of the composites.

2. Tensile Strength:
Fibers aligned in the direction of the tensile stress may bring about very large increases in direct tensile strength, as high as 133% for 5% of smooth, straight steel fibers. However, for more or less randomly distributed fibers, the increase in strength is much smaller.

3. Fleural Strength:
The increase in flexural strength is particularly sensitive, not only to the fiber volume, but also to the aspect ratio of the fibers. Higher aspect ratio leads to larger strength increase. Figure describes the fiber effect in terms of the combined parameter $Wl/d$, where $l/d$ is the aspect ratio and $W$ is the weight percent of fibers. It should be noted that for $Wl/d > 600$, the mix characteristics tended to be quite unsatisfactory.
4. Stress v/s Strain relations:

From the stress strain curves generated in this study, it can be observed that an increase in concrete strength increases the extent of curved portion in ascending branch and renders the drop in the descending part steeper for nonfibrous concrete and gradually flatter for SFRC.

![Stress V/S Strain curve](image)

Fig.6: Stress V/S Strain curve

2.3 Applications of SFRC

1. Pavements, tunnel lining and dome shells.
2. Shotcrete & Shotcrete containing silica fume.
3. Airport pavements & bridge deck slabs repair.
4. Offshore structures, precast products and fire protective coatings.
5. Military &commercial purpose.
6. Seismic structures, hydraulic structures and concrete sewer pipes.
7. Repair and rehabilitation.
8. Rock slope stabilization.

2.4 Advantages of SFRC

a) SFRC distributes localized stresses.
b) Reduction in maintenance, repair cost, surface permeability, and dusting.
c) Provides tough and durable surfaces.
d) They act as crack arrestor and are cost reducing.
e) Increases tensile strength, resistance to impact, freezing and thawing.
f) Reduces voids, wear, and shrinkage in the concrete.

![SFRC Reinforcement for structural elements](image)

Fig.7: SFRC Reinforcement for structural elements

2.5 PROBLEMS ON USAGE OF SFRC

The main problem in their usage is economy. That's why, only rich countries are using steel fibers in construction industry. It can adversely affect workability, especially in the case of steel fiber-reinforced concrete. Fiber-reinforced concrete is heavier than non-fiber concrete, thus there is increase in specific gravity of the concrete. Proportioning the exact number of fibers in the batch of concrete. Test have shown that a slight variation in fibers creates tremendous changes in concrete strength. Corrosion of steel fibers reduce the performance level. Risk of the appearance of steel fibers on the structures surface. The appearance of fibers affects the aesthetics of the structure.

![Comparison in SFRC and conventional concrete](image)

Fig.8: Comparison in SFRC and conventional concrete

2.6 Design details of Overhead Water Tank using conventional concrete

1. Capacity of water reservoir = 48,000lit
2. Dimensions of Tank=6m*4m*2m
3. Volume of water reservoir = 48cubic meters
4. Grade of concrete = M30 and M35
5. Total quantity of steel required for M35 & M30=11.391KN & 27.112KN respectively
6. Beam dimension= 450*300mm
7. Column shape= Rectangular
8. Column dimension = 500mm*500mm
9. Plate thickness = 180mm
10. Clear cover as per IS 456, 2000
    - Column= 40mm
    - Beam= 30mm
    - Plate =30mm
11. Reinforcement Details:
    - Column= 6 bars of 8mm dia., Fe415 main bars @ 190mm C/C
    - Beam= 4bars of 8mm dia., Fe 415 main bars @ 300mm C/C
    - Plate= For bottom, top, and vertical plate, 10mm dia., Fe 415 main bars@ 126mmC/C
12. Load Cases:
    - Dead Load
    - Hydrostatic Pressure
    - Seismic Zone= Zone 2
Fig. 9: Design details of Overhead Water Tank

Fig. 10: 3D Rendered View

Fig. 11: Displacement and Shear force Diagram

Fig. 12: Bending Moment and Stress Distribution diagram
2.7 Design details of Underground Water Tank using conventional concrete

- Thickness of slab=0.23m
- Capacity=3,60,000 liters
- X direction=10.23m
- Y direction=6.23m
- WP=30KN/sq.m
- SP=40KN/sq.m

<table>
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<th>No. of Bays</th>
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<tr>
<td>Along Height in y direction</td>
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</tr>
<tr>
<td>Along Width in z direction</td>
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Table 1: No. of Bays and Directions

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<tr>
<td>Length</td>
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<tr>
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<td>Width</td>
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Table 2: Outer and inner dimensions of the tank

Fig.13: Design Details of Underground Water Tank

Fig.14: Isometric view of Underground Water Tank

Fig.15: 3D Rendered View
3. RESULT (BASED ON STAAD.PRO AND LITERATURE REVIEW)

1. Overall study establishes that for 48,000 lit capacities of rectangular type of overhead water tank and 3,60,000lit. capacity of rectangular type of underground water tank by using SFRC, nearly 20 to 30% of material will be saved in comparison to conventional concrete. Therefore, it clearly states that some economy will be definitely achieved if SFRC is used i.e. This saving will definitely offset the cost of inclusion of steel fibres into concrete.

2. It is obvious that if SFRC is used instead of conventional concrete that will provide economic and durable water retaining structure which will be more pleasant in aesthetic.

### Table 3: Grade & Volume of Concrete

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<th>Grade of concrete</th>
<th>Volume of concrete required</th>
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<tr>
<td>M30</td>
<td>46.4 cubic meters</td>
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<tr>
<td>M35</td>
<td>23.2 cubic meters</td>
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3. SFRC allows to lay concrete floors up to 2500sq.m without joints and is therefore easier to maintain and clean. The floor slabs can be up to 50% thinner than conventional slabs, which means that SFRC is significantly cheap.

4. After studying detail report of design of water tanks in STTAD Pro. it is observed that all members of the structure are safe. STAAD.Pro gives cumulative volume of quantity of concrete for beams and plates. Also, in case of steel it gives cumulative weight of reinforcement steel for beams and plates only.

ACKNOWLEDGEMENT

This study would not have been possible without support of the institute, Dr. D.Y. Patil college of Engineering, Akurdi, Pune. Authors are extremely grateful to guide Prof. Smita Pataskar for her time to time valuable insight and support in completing this study.

REFERENCES


