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Analytical Study on T Beam with Phospogypsum and Steel Fiber

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Abstract

Cement concrete, the most extensively used construction material in the world provides good workability and can be moulded to any shape. Cement concrete possesses a very low tensile strength, limited ductility and little resistance to cracking. Internal micro cracks, leading to brittle failure of concrete. In this modern age, civil engineering constructions have their own structural and durability requirements, every structure has its own intended purpose and hence to meet this purpose, modification in traditional cement concrete has become mandatory. It has been found that different type of fibers added in specific percentage to concrete improves the mechanical properties, durability and serviceability of the steel structure. It is now established that one of the important properties of Steel Fiber Reinforced Concrete (SFRC) is its superior resistance to cracking and crack propagation. In this project ANSYS software was used to analyse the SFRC beams. Results obtained from the software analyses were in compared with the laboratory test results.

Keywords: Analytical, T-Beam, Phospogypsum, Steel fiber.

1. Introduction

1.1 General

Reinforced Concrete (RC) structures including residential, administrative as well as historic and transportation structures widely exist worldwide. Each of these structures has its own role and importance. These structures thus need to be conserved against sudden failures that would cause consequent human life and economic losses. In the meantime, earthquakes may abruptly occur anywhere around the globe. The effect of earthquakes on concrete structures varies, and ranges from mild responses for well- designed structures to severe responses with extensive damage in case of poorly designed structures.In addition, one of the popular RC structural systems is the moment resisting frame system. This is the case such that many moment resisting RC frames were designed in the last century or earlier and still exist worldwide. Meanwhile, such older RC frames may not satisfy the current seismic design requirements, and do not possess adequate ductility. Previous research studies attributed that to inadequate shear reinforcement in the beam-column joint region

1.2 Beam Column Joints

The behavior of reinforced concrete moment resisting frame structures in recent earthquakes all over the world has highlighted the consequences of poor performance of beam column joints. Beam column joints in a reinforced concrete moment resisting frame are crucial zones for transfer of loads effectively between the connecting elements (i.e., beams and columns) in the structure.

In the analysis of reinforced concrete moment resisting frames, the joints are generally assumed as rigid. For adequate ductility of beam column joints, use of closely spaced hoops as transverse reinforcement was recommended in the ACI-

ASCE Committee 352 report (ACI, 2002). Due to the congestion of reinforcement, casting of beam column joint will be difficult and will lead to honeycombing in concrete.

In Indian practice, the joint is usually neglected for specific design with attention being restricted to provision of sufficient anchorage for beam longitudinal reinforcement. Beam column joints have a crucial role in the structural integrity of the buildings. Thus, beam column joints must be designed to resist earthquake effects. In fact, failure due to over loading should occur in beams through large flexural cracking and plastic hinging and not in columns.

1.3 Types of Joints in Frame

The joint is defined as the portion of the column within the depth of the deepest beam that frames into the column. In a moment resisting frame, three types of joints can be identified viz. interior joint, exterior joint and corner joint.

When four beams frame into the vertical faces of a column, the joint is called as an interior joint. When one beam frames into a vertical face of the column and two other beams frame from perpendicular directions into the joint, then the joint is called as an exterior joint.

When a beam each frame into two adjacent vertical faces of a column, then the joint is called as a corner joint. The severity of forces and demands on the performance of these joints calls for greater understanding of their seismic behavior. These forces develop complex mechanisms involving bond and shear within the joint.

1.4 Types of Beam-Column Joint

- Interior Joint
- Exterior Joint
- Corner Joint

1.5 Requirement of Beam Column Joint

The essential requirements for the satisfactory performance of a joint in an RC structure can be summarized as follow: -

- A joint should exhibit a service load performance equally to or greater than that of the members it joins, that is, the failure should not occur within the joints. If at all, failure due to overloading should occur in beam through larger flexural cracking and plastic hinge formation, and not in column.
- A joint should possess a strength that corresponds at least to the most adverse load combinations that the adjoining members could possibly sustain repeatedly several times, if possible.
- The strength of the joint should not normally govern the strength of the structure, and its behavior should not hinder and development of the full strength of the adjoining members.
- Ease of fabrication and good access for placing and compacting concrete are the other significant parameter of joint design.

1.6 Repair And Strengthening Techniques for Beam-Column Joints

A variety of techniques has been developed to strengthen the beam-column joints. These techniques can be classified into six categories, including epoxy repair, removal and replacement, RC jacketing, concrete masonry unit jacketing, glass jacketing, and application of fiber-reinforced polymer (FRP) composite.

1.7 Material Selection

1.7.1 Steel fiber

Steel fiber reinforced concrete is a composite material having fibers as the additional ingredients, dispersed uniformly at random in small percentages, i.e., between 0.3% and 2.5% by volume in plain concrete. SFRC products are manufactured by adding steel fibers to the ingredients of concrete in the mixer and by transferring the green concrete into molds. The product is then compacted and cured by the conventional methods. Figure 1 shows the steel fiber.

Figure 1 Steel fiber

Segregation or balling is one of the problems encountered during mixing and compacting SFRC. This should be avoided for uniform distribution of fibers. The energy required for mixing, conveying, placing and finishing of SFRC is slightly higher. Use of pan mixer and fiber dispenser to assist in better mixing and to reduce the formation of fiber balls is essential. Additional fines and limiting maximum size of aggregates to 20mm occasionally, cement contents of 350 kg to 550 kg per cubic meter normally needed.

Steel fibers added to concrete to improve the structural properties, particularly tensile and flexural strength. The extent of improvement in the mechanical properties achieved with SFRC over those of plain concrete depends on several factors, such as shape, size, volume, percentage and distribution of fibers.

Even though higher ratios of fibers gave increased flexural strength, workability of green SFRC was found to be adversely affected with increasing aspect ratios. Hence, aspect ratio is generally limited to an optimum value to achieve good workability and strength.

1.7.1.1 Technical Benefits

- Significantly reduced risk of cracking.
- Reduced spalling joint edges.
- Stronger joints.
- High impact resistance.
- Greater fatigue endurance.
- Reduced maintenance costs.
- Longer useful working life

1.7.1.2 Improved Strength and Durability

Steel fiber reinforced concrete is a cast able or spray able composite material of hydraulic cements, fine, or fine and coarse aggregates with discrete steel fibers of rectangular cross-section randomly dispersed throughout the matrix. Steel fibers strengthen concrete by resisting tensile cracking.

Fiber reinforced concrete has a higher flexural strength than that of unreinforced concrete and concrete reinforced with welded wire fabric. However, unlike conventional reinforcement which strengthens in one or possibly two directions Steel fibers reinforcement, greatly improving the concrete's resistance to cracking, fragmentation, spalling and fatigue.

1.7.2 Phosphogypsum

Phosphogypsum refers to the calcium sulfate hydrate formed as a byproduct of the production of fertilizer from phosphate rock. It is mainly composed of gypsum ($CaSO_4 \cdot 2H_2O$). Although gypsum is a widely used material in the construction industry, phosphogypsum is usually not used, but is stored indefinitely because of its weak radioactivity. The long-range storage is controversial. Somewhere between 100,000,000 and 280,000,000 tons are estimated to be produced annually because of the processing of phosphate rock for the production of phosphate fertilizers. Figure 2 shows the Phosphogypsum powder.

Figure 2 Phosphogypsum powder

Gypsum has been used in several forms since the beginning of civilization. Now, natural gypsum is utilized as building material (gypsum board, plaster ingredient, component of Portland cement, binder in Fast-Dry tennis court clay), in medicine, as fertilizer and soil conditioner, in hygienic products. The shortage of this product, its price or the non-existence of gypsum ores in several countries, have obliged to look for alternatives for the construction industry.
One of these alternatives is to replace gypsum by phosphogypsum, which would have the additional advantage of resolving partially the environmental problems created by fertilizer industries. Phosphogypsum can replace some of the natural components of building materials. However, it contains a higher radioactivity concentration than the natural products and its use in houses may lead to increase radiation doses to the inhabitants.

1.8 Objective

- The primary objective of the investigation is to improve the strength of the beam column joint
- To investigate the utility of steel fiber and phosphogypsum as an additive in concrete
- To study and compare the performance of conventional concrete and high strength concrete using steel fiber and phosphogypsum
- To investigate the appropriate additive percentage for steel fiber and phosphogypsum based on the strength and workability parameters.

2. METHODOLOGY

Figure 3 shows the methodology of the study.

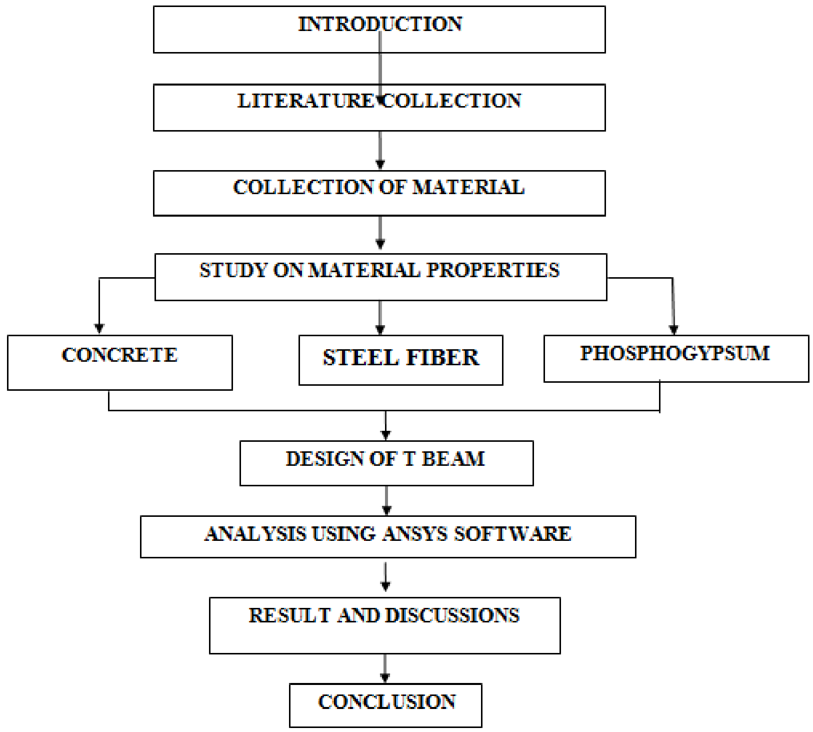

Figure 3 Methodology

3. ABOUTANSYS

a. ANSYS

ANSYS develops and markets finite element analysis software used to simulate engineering problems. The software creates simulated computer models of structures, electronics, or machine components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes. ANSYS is used to determine how a product will function with different specifications, without building test products or conducting crash tests.

i. Uses of ANSYS

- It develops and markets engineering simulation software. Ansys software is used to design products and semiconductors, as well as to create simulations that test a product's durability, temperature distribution, fluid movements, and electromagnetic properties.
- ANSYS develops and markets finite element analysis software used to simulate engineering problems. The software creates simulated computer models of structures, electronics, or machine components to simulate strength, toughness, elasticity, temperature distribution, electromagnetism, fluid flow, and other attributes.

b. FEA

The finite element method (FEM) is a numerical method for solving problems of engineering and mathematical physics. Typical problem areas of interest include structural analysis, heat transfer, fluid flow, mass transport, and electromagnetic potential. The analytical solution of these problems generally require the solution to boundary value problems for partial differential equations.

The finite element method formulation of the problem results in a system of algebraic equations. The method approximates the unknown function over the domain. To solve the problem, it subdivides a large system into smaller, simpler parts that are called finite elements.

The simple equations that model these finite elements are then assembled into a larger system of equations that models the entire problem. FEM then uses vibrational methods from the calculus of variations to approximate a solution by minimizing an associated error function.

4. ANALYTICAL RESULT

a. Graphical and Numerical Result of the Beam

Figure 4 shows the beam geometry.

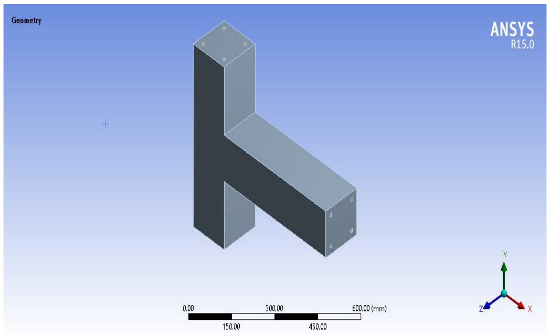

Figure 4 Beam Geometry

Figure 5 shows the beam meshing model.

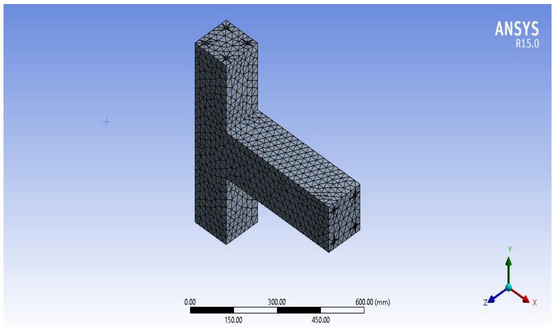

Figure 5 Beam Meshing Model

Figure 6 shows the Fixed support 1.

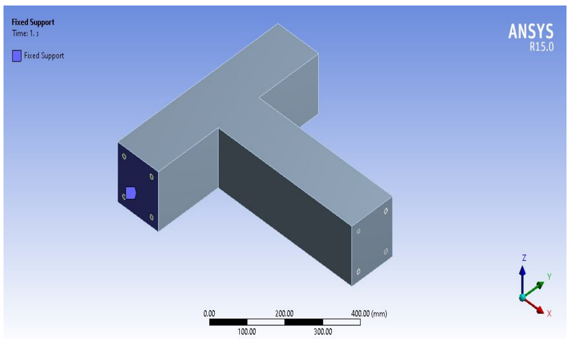

Figure 6 Fixed Support 1

Figure 7 shows the Fixed support 2.

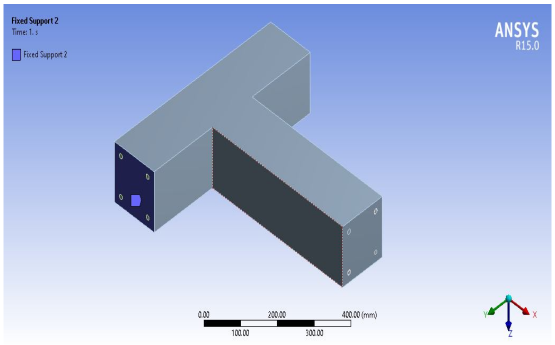

Figure 7 Fixed Support 2

Figure 8 shows the force applied on beam.

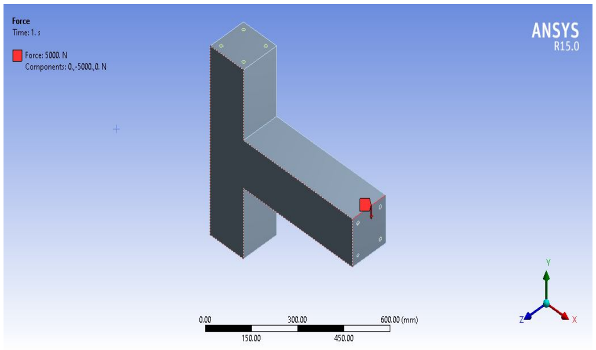

Figure 8 Force Applied on Beam

The beam is design and analysis of specified dimension. Concrete (M30 grade), Phosphogypsum and 1% of steel fiber are applied on beam. The analysis based on gradually load acting on the beam.

In this result calculated in the T-beam analysis result on minimum to maximum values calculated in this T-beam. Result calculated T-beam minimum of the load in 5KN, then find the result are deformation (0.23001 mm), Stress (23.262 MPa) & Safety factor (0.0003) other values calculated in maximum of the load in 50KN, then find the result are deformation (2.3001 mm), Stress (236.1 MPa) & Safety factor (0.0031). The min to max is a better result conclusion on T-beam in 1% of steel fiber. Figure 9 shows the total deformation of steel fiber 1%

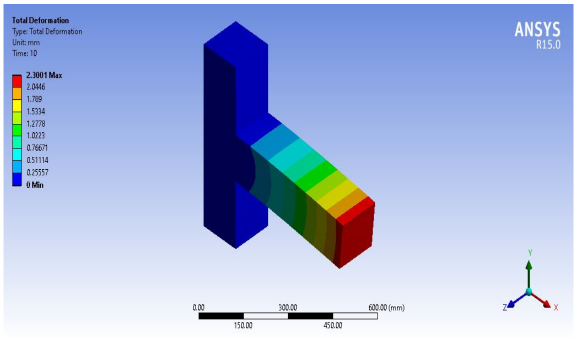

Figure 9 Total Deformation of Steel Fiber 1%

Figure 10 shows the stress of steel fiber 1%.

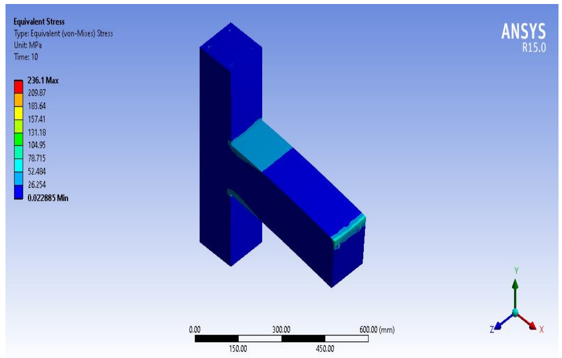

Figure 10 Stress of Steel Fiber 1%

The total deformation of steel fiber 1% it's a range of minimum to maximum values. So, analysis of in this T-beam they type total deformation value in minimum values is 0 to maximum value is 2.3901. They maximum deformation is higher deformed in the T Beam.

The stress of steel fiber 1% it's a range of minimum to maximum values. So, analysis of in this T-beam they type stress value in minimum values is 0.022885 to maximum value is 236.1. They maximum stress is higher in the T Beam.

Figure 11 shows the strain of steel fiber 1%.

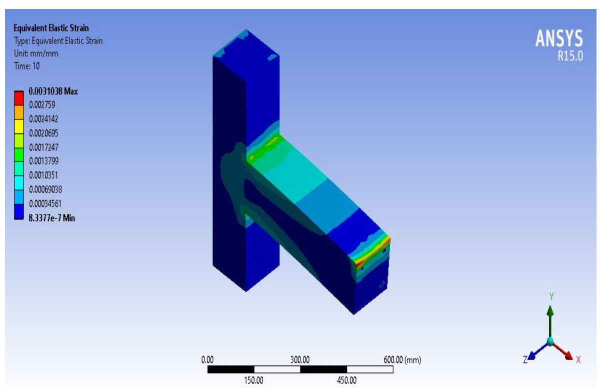

Figure 11 Strain of Steel Fiber 1%

The strain of steel fiber 1% it's a range of minimum to maximum values. So, analysis of in this T-beam they type strain value in minimum values is 8.3377e-7 to maximum value is 0.0031038. They maximum strain is higher in the T Beam.

The beam is design and analysis of specified dimension. Concrete (M30 grade), Phosphogypsum and 2% of steel fiber are applied on beam. The analysis based on gradually load acting on the beam. To predict the deformation, stress, & strain, its detail mention in the above table. In this result calculated in the T-beam analysis result on minimum to maximum values calculated in this T-beam.

Result calculated T-beam minimum of the load in 5KN, then find the result are deformation (0.22746 mm), Stress (23.393 MPa) & Safety factor (0.0003) other values calculated in maximum of the load in 50KN, then find the result are deformation (2.2746 mm), Stress (233.78 MPa) & Safety factor (0.003). The min to max is a better result conclusion on T-beam in 2% of steel fiber. Figure 12 shows the total deformation of steel fiber 2%.

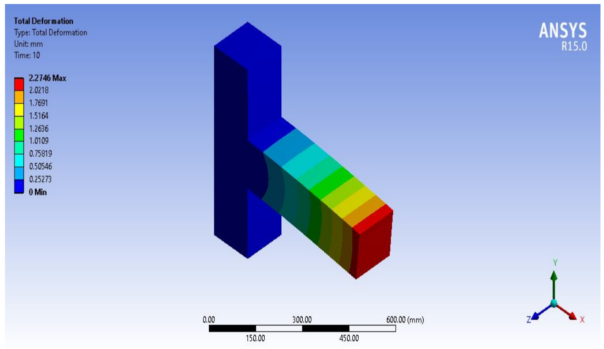

Figure 12 Total Deformation of Steel Fiber 2%

Figure 13 shows the stress of steel fiber 2%

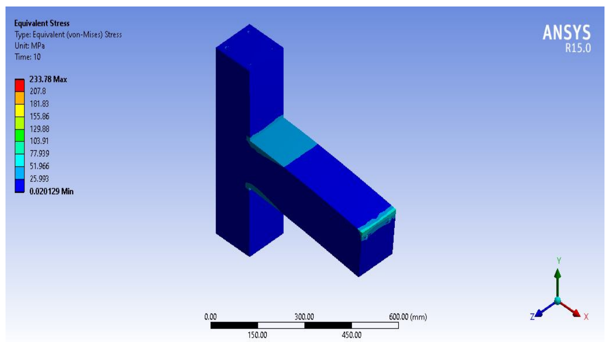

Figure 13 Stress of Steel Fiber 2%

The total deformation of steel fiber 2% it's a range of minimum to maximum values. So, analysis of in this T-beam they type total deformation value in minimum values is 0 to maximum value is 2.2746. They maximum deformation is higher deformed in the T Beam.

The stress of steel fiber 2% it's a range of minimum to maximum values. So, analysis of in this T-beam they type stress value in minimum values is 0.020129 to maximum value is 233.78. They maximum stress is higher in the T Beam.

Figure 14 shows the strain of steel fiber 2%.

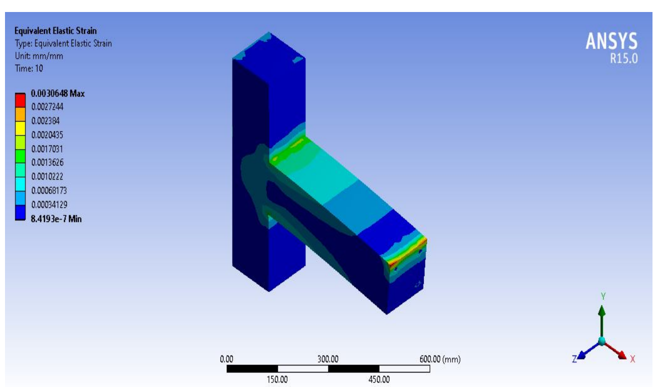

Figure 14 Strain of Steel Fiber 2%

The strain of steel fiber 2% it's a range of minimum to maximum values. So, analysis of in this T-beam they type strain value in minimum values is 8.4193e-7 to maximum value is 0.00306.48. They maximum strain is higher in the T Beam.

The beam is design and analysis of specified dimension. Concrete (M30 grade), Phosphogypsum and 3% of steel fiber are applied on beam. The analysis based on gradually load acting on the beam. To predict the deformation, stress, &

strain, its detail mention in the above table. In this result calculated in the T-beam analysis result on minimum to maximum values calculated in this T-beam.

Result calculated T-beam minimum of the load in 5KN, then find the result are deformation (0.22418mm), Stress (23.105 MPa) & Safety factor (0.0003) other values calculated in maximum of the load in 50KN, then find the result are deformation (2.2418 mm), Stress (230.9 MPa) & Safety factor (0.0030). The min to max is a better result conclusion on T-beam in 3% of steel fiber. Figure 15 shows the total deformation of steel fiber 3%.

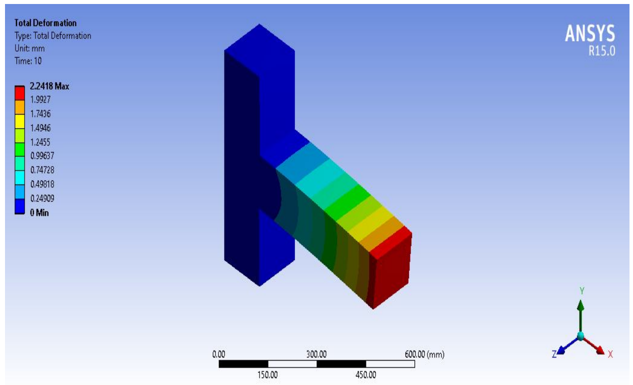

Figure15 Total Deformation of Steel Fiber 3%

The total deformation of steel fiber 3% it's a range of minimum to maximum values. So, analysis of in this T-beam they type total deformation value in minimum values is 0 to maximum value is 2.2418. They maximum deformation is higher deformed in the T Beam. Figure 16 shows the stress of steel fiber 3%.

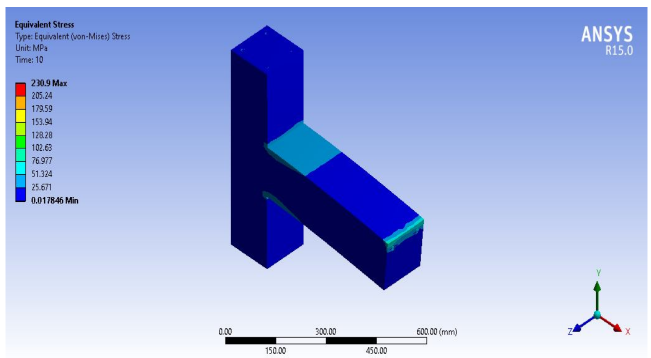

Figure 16 Stress of Steel Fiber 3%

Figure 17 shows the strain of steel fiber 3%.

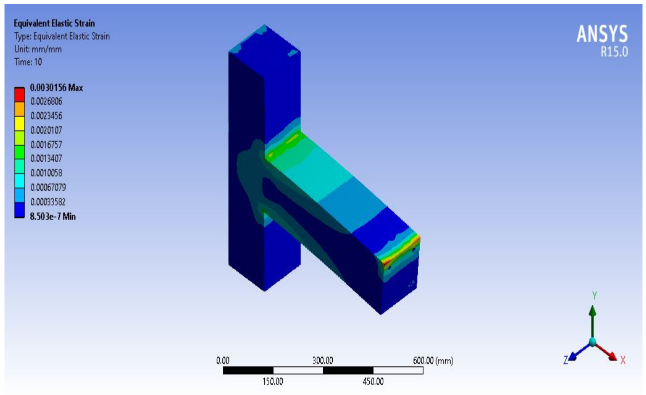

Figure 17 Strain of Steel Fiber 3%

The stress of steel fiber 3% it's a range of minimum to maximum values. So, analysis of in this T-beam they type stress value in minimum values is 0.017846 to maximum value is 230.9. They maximum stress is higher in the T Beam.
The strain of steel fiber 3% it's a range of minimum to maximum values. So, analysis of in this T-beam they type strain value in minimum values is 8.503e-7 to maximum value is 0.0030156. They maximum strain is higher in the T Beam.

5. RESULT AND DISCUSSION

The T-section beam analysis with adding steel fiber various percentages (1, 2 & 3%) and gradually load increased (5 to 50kN). It's observed deformation and stress value comparatively steel fiber 3% combination is higher strength, so both the deformation and stress value are gradually decreased compared to other combination

a. Deformation

Figure 18 shows the graphical representation of deformation.

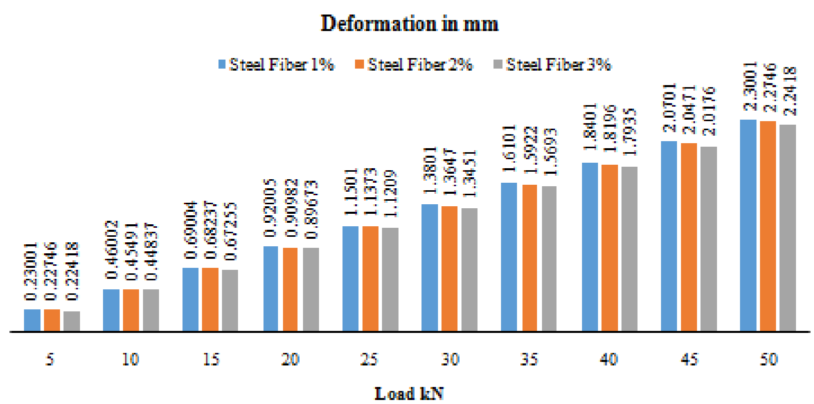

Figure 18 Graphical representation of deformation

b. Stress

Figure 19 shows the graphical representation of stress.

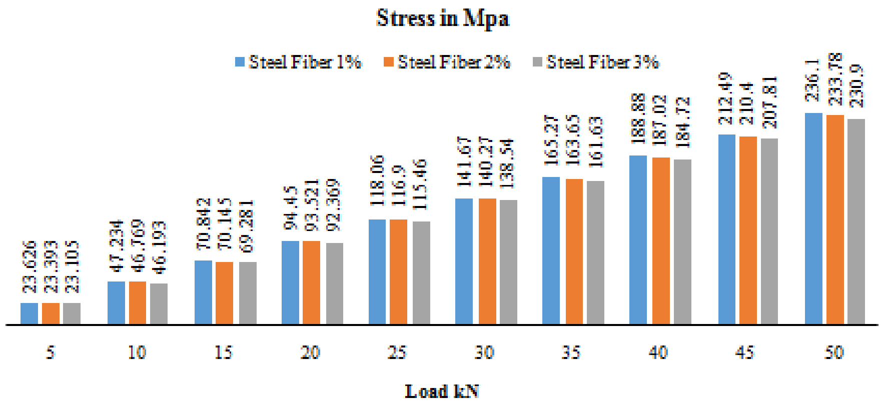

Figure 19 Graphical representation of stress

c. **Strain**

Figure 20 shows thegraphical representation of strain.

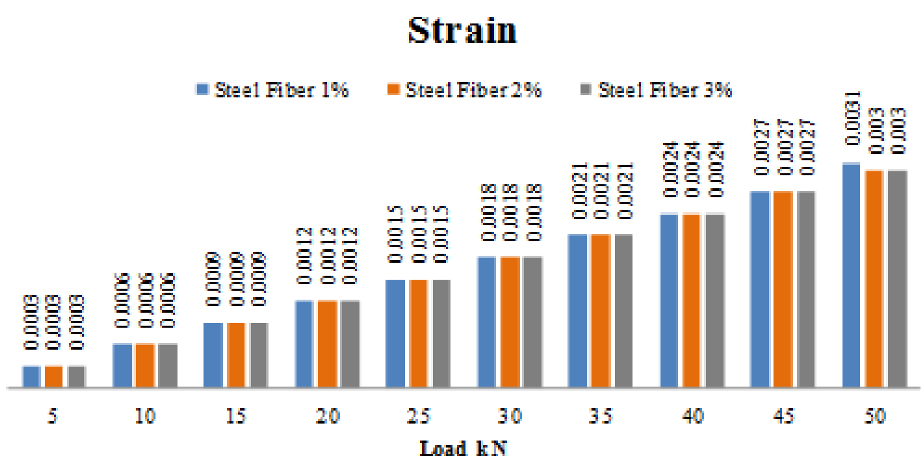

Figure 20 Graphical representation of strain

6. CONCLUSION

Beam column joint in the moment resisting frame have traditionally beam neglected in design process while the individual connected elements, that is, beam and column, have received considerable attention in design. Based on the studied dimensions of the beam–column joint and the considered defects along with the proposed steel fiber and phosphogypsum strengthening configuration subjected to incrementally monotonic static loading, the following conclusions can be drawn:

- Using steel fiber and phosphogypsum as a strengthening material led to increased ultimate capacity and decreased ductility compared to conventional T beam.
- The experimental results clearly demonstrate that steel fiber and phosphogypsum adding can enhance the structural performance of RC T beam under static loading.
- Increasing the percentage of steel fiber and phosphogypsum increase the strengths of the T beam.
- In above test results show the compare to Control specimen with steel fiber and Phosphogypsum added beam is more load carrying capacity.

The structural behavior of RCC T beam has been studied. Experimental investigation has been carried out in phase 2. From test results, important parameters have been worked out such as strength, deflection in order to assess the seismic behavior of the T beam when earthquake load acting on structure. They analysis of the (1, 2 & 3%) on T-

Beam, its observed t-beam deformation, stress and strain of the t-beam finally the 3% is a lowest value of the analysis is better on the T-beam.

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