# Comparative Analysis of Concrete Filled Steel Tubular Truss Bridge with Conventional Reinforced Cement Concrete Bridge

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**Abstract -** *Composite structures offer many structural benefits and hence can be used in civil engineering structures. Concrete filled steel tube (CFST) consists of inner and outer steel tubes, and concrete sandwiched in between tubes. The steel tubes and concrete work together well and integrity of steel concrete interface is maintained. Steel tubes provide a confinement effect to concrete and in turn concrete prevents the inward buckling of tubes.*
*In this study performance behavior of an innovative lightweight CFST truss bridge has been studied and the same is compared with conventional reinforced cement concrete bridge using ANSYS software. This paper aims to suggest an alternative method for the construction of bridges.*

***Key Words***: Composite structure, CFST Bridge, conventional reinforced cement concrete bridge, analysis, ANSYS,

## 1. INTRODUCTION

Concrete filled steel tubular (CFST) members utilize the advantages of both steel and concrete. They comprise of a steel hollow section of circular or rectangular shape filled with plain or reinforced concrete. They are widely used in high rise and multi storeyed buildings as columns and beam-column, and as beams in low rise industrial buildings where a robust and efficient structural system is required.

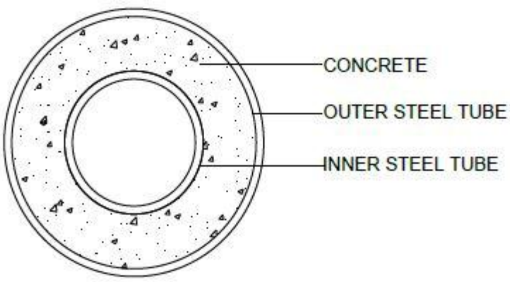


**Fig -1**: Typical CFST member

There are a number of distinct advantages related to such structural systems in both terms of structural performance and construction sequence. The inherent buckling problem related to thin-walled steel tubes is either prevented or delayed due to the presence of concrete core. Furthermore, the performance of concrete in-filled is improved due to confinement effect exerted by the steel shell. The steel lies at the outer perimeter where it performs most effectively in tension and bending. It also provides the greatest stiffness as the material lies farthest from the centroid. This, combined with the steel's much greater modulus of elasticity, provides the greatest contribution to the moment of inertia. The concrete core gives the greater contribution to resisting axial compression.

The main objective of this study is as follows.

1. To study the performance behavior of CFST bridge.
2. To compare the behavior of CFST bridge with that of conventional reinforced cement concrete bridge.

## 2. SOFTWARE USED

ANSYS R15.0.

## 3. MODELING OF BRIDGE

## 2.1 Dimensions of Bridge

General details or dimensions:

- Span : 15m
- Carriage way : 7.5m
- Thickness of slab : 0.2m
- Thickness of wearing coat: 0.08m
- Reinforcement details of the deck slab:

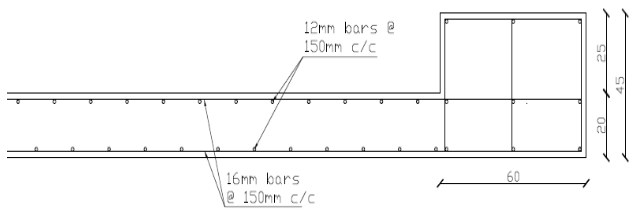


**Fig -2**: Reinforcement details of deck slab for ordinary steel and CFST Bridge.

### 2.2 Two Models have to be Analysed

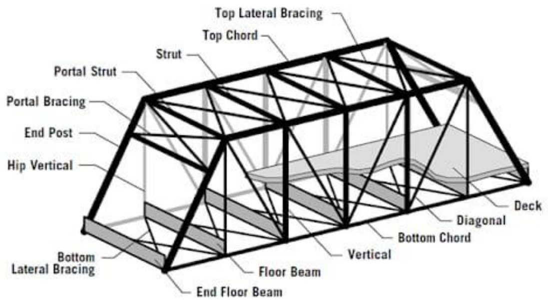


**Fig -3**: Different components of a truss bridge

1. Conventional reinforced cement concrete(RCC) bridge

Description of bridge:

- Span of bridge :15m
- Clear width of roadway :7.5m
- Thickness of slab :0.2m
- Wearing coat thickness :0.08m
- Width of longitudinal girder :0.3m

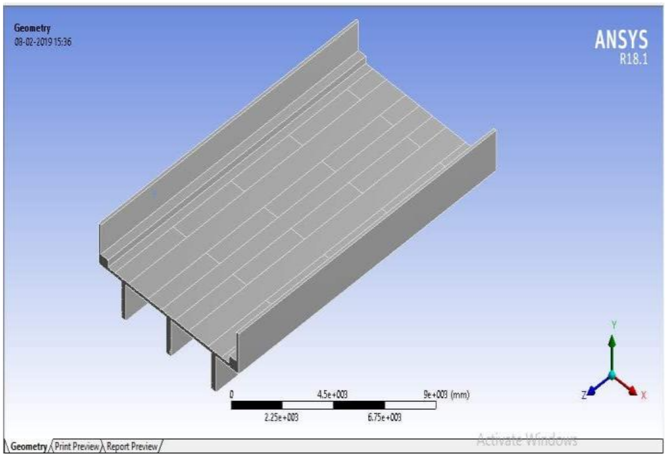


**Fig -4**: RCC bridge model

2. CFST Bridge

Dimensions of various members:

- Longitudinal Girder:

60 cm x 55cm rectangular section has been used.

- Cross Girder:

35 cm x 30 cm Rectangular section has been used.

- For Top Chord:

20m x 17.5 cm Rectangular section has been used.

- For Strut:

17.5 cm x 15 cm Rectangular section has been used.

- For Bracing:

15 cm x 12.5 cm Rectangular section has been used.

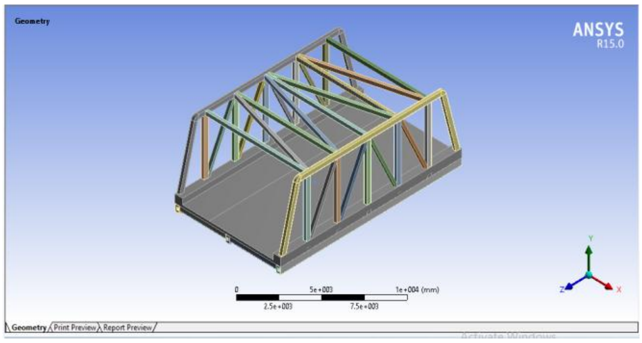


**Fig -5**: CFST truss bridge model

## 4. LOADS ON BRIDGES

The following are the various loads to be considered for the purpose of computing stresses, wherever they are applicable.

- Dead load
- Live load
- Impact load
- Longitudinal force
- Thermal force
- Wind load
- Seismic load
- Racking force
- Forces due to curvature
- Forces on parapets
- Frictional resistance of expansion bearings
- Erection forces

Here the Live Load condition selected is 70R (wheeled).

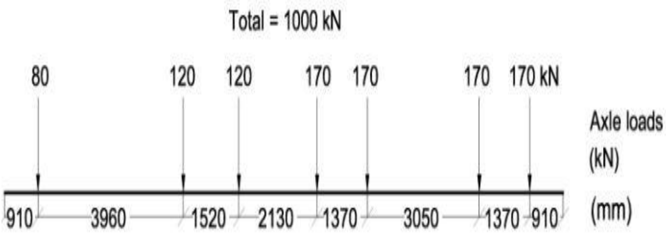


**Fig -6**: 70R loading acts on bridge

## 5. ANALYSIS RESULTS AND DISCUSSIONS

The analysis of both the bridges was done using the software ANSYS. For the analysis, the bridges were checked for different conditions such as:

- Maximum deformation
- Maximum normal stress and strain

### 5.1 Maximum Deformation

Deformation refers to any change in shape or size in an object due to:

- An applied force(the deformation energy in this case is transferred through work) or
- A change in temperature (the deformation energy in this case is transferred through heat).

As per IRC 6-2017, the maximum deformation of a bridge should not exceed 1/800 of the span length for general vehicular bridges and 1/1000 of the span length for vehicular bridges with pedestrian traffic.

Hence as per IRC 6-2017, the maximum allowed deformation for a bridge spanning 15m is found to be:

(1/1000)x15000 = 15mm

Fig.7 and Fig.8 show the deformation for ordinary RCC Bridge and CFST Bridge respectively.

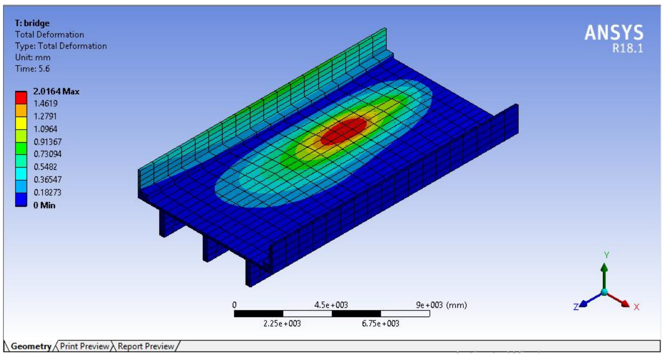


**Fig -7**: Maximum deformation for ordinary RCC Bridge

For an ordinary steel bridge, maximum deformation was observed as 2.91mm and is within the permissible limit.

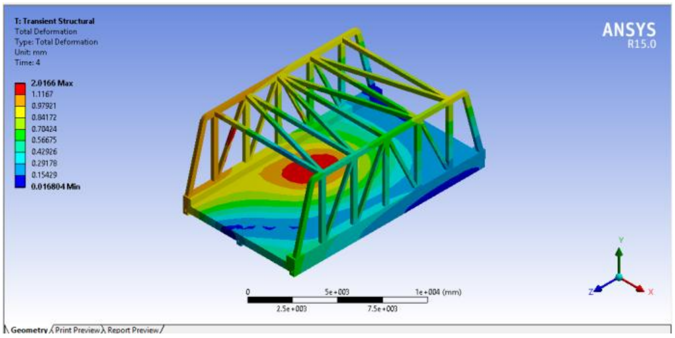


**Fig -8**: Maximum deformation for CFST Bridge.

For an ordinary steel bridge, maximum deformation was observed as 2.016mm and is within the permissible limit.
Inference:
The above deformation diagram obtained using ANSYS software indicates that maximum deformation is observed at the mid span of the bridge. This is observed because; the bridge is in a simply supported condition.

### 5.2 Maximum Normal Stress and Strain

Stress is defined as the strength of a material per unit area or unit strength. It is the force on a member divided by area, which carries the force, expressed in N/mm² or MPa.

$$\sigma = P / A$$

Where, P is the applied normal load in Newton and A is the area in mm². The maximum stress in tension or compression occurs over a section normal to the load. Normal stress is either tensile stress or compressive stress. Member's subjected to pure tension (or tensile force) is under tensile stress, while compression members (members subject to compressive force) are under compressive stress.

Compressive force will tend to shorten the member. Tension force on the other hand will tend to lengthen the member.

Fig.9 and Fig.10 show the normal stress in ordinary RCC Bridge and CFST Bridge respectively.

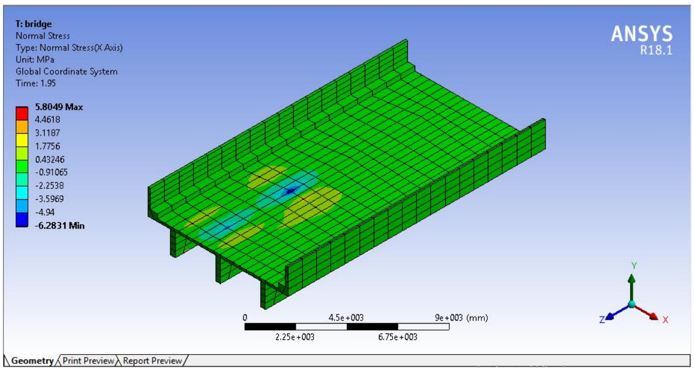


**Fig -9:** Normal stress in ordinary RCC Bridge

The normal stress observed as 5.80MPa.

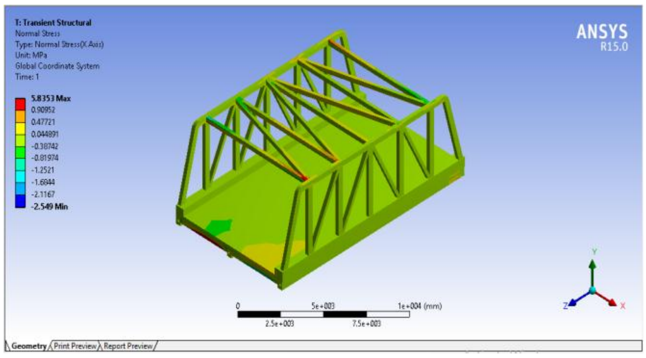


**Fig -10:** Normal stress in CFST Bridge

The normal stress observed as 5.8353MPa.

Strain, represented by the Greek letter ε, is a term used to measure the deformation or extension of a body that is subjected to a force or set of forces. *Normal strain* (also

| Type of bridge | Deformation (mm) | Normal Stress(MPa) | Normal Strain |
|---|---|---|---|
| Ordinary RCC Bridge | 2.91 | 5.80 | $2.81 \times 10^{-5}$ |
| CFST Bridge | 2.0166 | 5.8353 | $2.92\ 10^{-5}$ |

known as extensional strain) is different from *shear strain* in that normal strain is the ratio of the change in length to the original length along the *x*-, *y*-, or *z*-direction, whereas shear strain is a measure of a change in angle in an *x*-*y*, *y*-*z*, or *z*-*x* plane. Normal strain is dimensionless, whereas the unit of measure for shear strain is radians. For axially loaded 1D element, only normal strains exist. For 2D or 3D problems, strains need to be resolved into normal and shear components.

$$\varepsilon = \Delta L/L$$

Fig.11 and Fig.12 show the normal strain in ordinary steel bridge and CFST Bridge respectively.

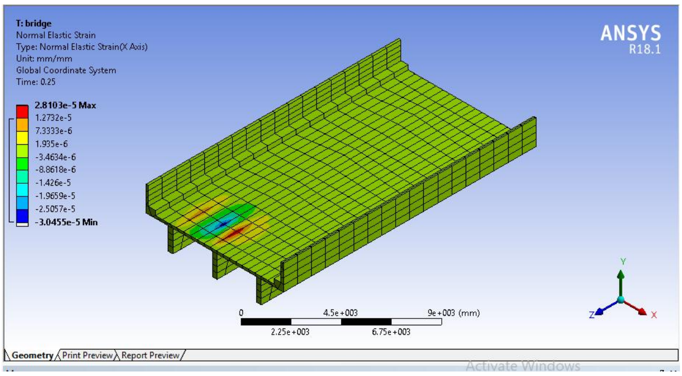


**Fig -11:** Normal stress in ordinary steel bridge

The normal strain observed as $2.81 \times 10^{-5}$

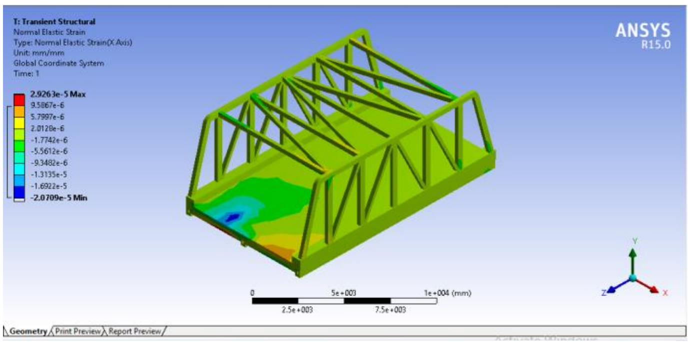


**Fig -12:** Normal strain in CFST bridge

Normal strain observed as $2.92 \times 10^{-5}$

Inference:

Both the normal stress as well as the normal strain for either of the bridges has a less value in magnitude. The lesser value suggests that, both the bridges behave well.

**Table -1:** Results of analysis

## 6. CONCLUSION

From the above analysis of both the bridges, the following conclusions are obtained:

- The deformations obtained for the bridges are within the permissible limit. Also the bridge made of CFST gives the least deformation.
- Considering the normal stress acts on the bridge, the analysis has shown that the maximum value of normal stress is just 5.85MPa, which is literally a lesser value.
- In case of normal strain, the values obtained after analysis is very less, which suggest that the structure behaves well in terms of normal strain.
- The analysis results have shown that the bridge made with CFST members behaves better as compared with the ordinary RCC Bridge.

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