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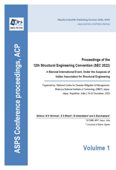

Behavioural Study of a Bridge using Isotruss Member, Box Section and Circular Tube Sections

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Abstract

It is often necessary to cross a river or any other obstacle where no bridges exist or they have been collapsed due to natural disasters. In general already prefabricated bridge elements will be used. They are mostly made out of light as well transportable and detachable parts from high quality materials which could be fast to build Bridges with different span, width and load capacity. In the present paper behavior and performance of a Bridge, using three different types of truss members, namely Isotruss member, Box section and Circular tube, have been studied. Bridge is modelled and analysed using commercial Finite Element (FE) software. The Bridge is designed for a span of 10.50 m. Live load of 4 KN/m^2 and wind load of 51.15 N, 70.34 N and 56.17 N applied as point load on Isotruss, Circular tube and Box section respectively are applied for designing the truss members. For serviceability condition stresses as well as deflections in members have been checked.

Keywords: Isotruss member, bridge, carbon fiber

1. Introduction

It is often necessary to cross a river or any other obstacle where no bridges exist or they have been collapsed due to natural disasters. In general already prefabricated bridge elements will be used. They are mostly made out of light, well transportable and detachable parts from high quality materials which could be fast built to Bridges with different span, width and load capacity. The Bridge presented here is a kind of temporary Bridge. Temporary Bridges are erected in a very short period whereby the construction time is calculated in days or hours. A temporary Bridge is in use only for some hours, days or weeks therefore can be used on a wide range of sites at different locations. In the present paper behavior and performance of a Bridge using three different types of truss member, namely Isotruss member, Box section and Circular tube have been studied.

1.1 Description of Isotruss grid structure

The patented Isotruss structure is a revolutionary composite configuration that utilizes a unique geometry with light weight composite materials to support loads in a highly efficient manner. The Isotruss structure comprises interwoven longitudinal and helical members that are composed of tows of fibers and resin [1]. The longitudinal members are parallel to the central longitudinal axis of the structure. The helical members wrap around the central longitudinal axis in a piece-wise linear fashion. The common Isotruss Structure geometry has twice as many helical members as longitudinal members. The longitudinal and helical members intersect to form joints at regular intervals circumferentially and longitudinally throughout the structure. The longitudinal members primarily resist structural axial loads. Helical members spiral around the structure, intersecting the longitudinal members at regular intervals. The helical members serve as bracing for the longitudinal members, shortening the buckling length. The helical members also resist the shear and torsion loads. The exact geometry of the structure depends on truss diameter, number of nodes around the circumference, bay length (longitudinal distance between nodes), and members diameters.

1.2 Carbon fiber

Carbon fibers (alternatively CF, graphite fiber or graphite fiber) are about 5–10 micrometers in diameter and composed mostly of carbon atoms. Carbon fibers have several advantages including high stiffness, high tensile strength, low weight, high chemical resistance, high temperature tolerance and low thermal expansion. These properties have made carbon fiber popular in Aerospace, Civil engineering, Military, and Motorsports, along with other competition sports. However, they are relatively expensive when compared with similar fibers, such as glass fibers or plastic fibers. To produce a carbon fiber, the carbon atoms are bonded together in crystals that are more or less aligned parallel to the long axis of the fiber as the crystal

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alignment gives the fiber high strength-to-volume ratio (in other words, it is strong for its size). Several thousand carbon fibers are bundled together to form a tow, which may be used by itself or woven into a fabric. Carbon fibers are usually combined with other materials to form a composite. When impregnated with a plastic resin and baked it forms carbon-fiber-reinforced polymer (often referred to as Carbon fiber) which has a very high strength-to-weight ratio, and is extremely rigid although somewhat brittle. Carbon fibers are also composited with other materials, such as graphite, to form reinforced carbon composites, which have a very high heat tolerance.

2. Analytical model of the Bridge

2.1 10.50 m span Bridge with Isotruss member

The Bridge is modeled to cross obstacle up to 10 m. Structural member used for the Bridge is Isotruss member with Carbon fiber material as shown in Fig. 1, where x is a direction along the length of bridge; y is the vertical direction while z is the direction along wind (transverse).
The Bridge is a temporary structure so the analysis is done only for Self Weight, Live load, Maximum intensity of Wind load and load combinations such as, (Live load + Self weight), (Live load + Self weight + Wind load).

2.2 10.50 m Bridge with Circular tube member

The Bridge is modeled to cross obstacle up to 10 m. Structural member used for Bridge is Circular tube member with carbon fiber material.
In the second model, section used is a Circular tube member with 55 mm outer diameter and 5 mm wall thickness. Length of the individual member is 1.50 m. Fig. 1 shows the arrangement of members while Fig. 3 shows cross section of circular tube member.

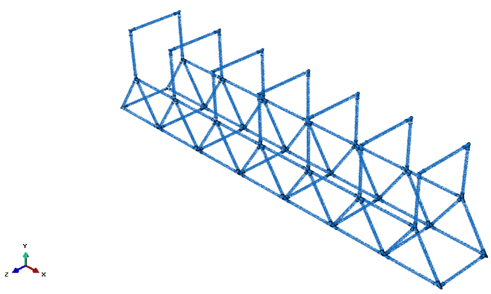

Fig. 1 3D view of Bridge with Isotruss member

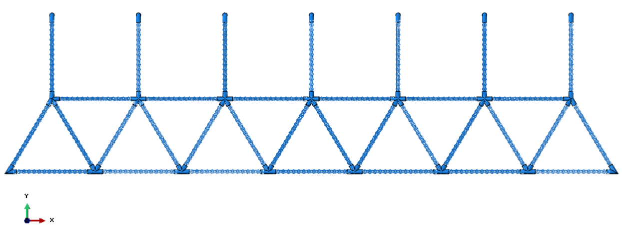

Fig. 2 Side view of Bridge with Isotruss member

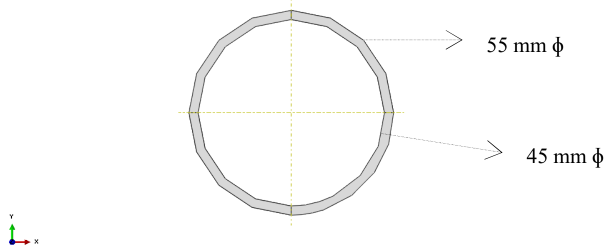

Fig. 3 Cross section of Circular tube member

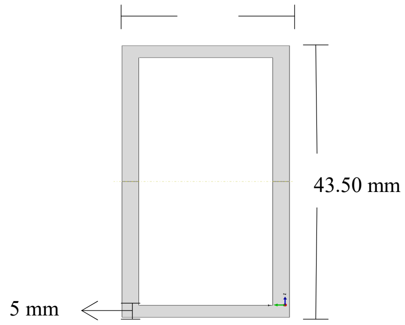

Fig. 4 Cross section of Box section member

2.3 10.50 m span Bridge with Box section member

The Bridge is modeled to cross obstacle up to 10 m.
Structural member used for the Bridge is Box section with Carbon fiber material.
In this model, section used is a Box section with a size of 30 mm x 43.50 mm and hav[illegible] thickness. Fig. 1 shows how box section members arragened in bridge and Fig. 4 shows cross section of Box section member.

3. Results

Analysis of the Bridge is done using comercial FE softwear and results are extracted in the form of deflections and maximum stresses. Analysis is done for the two load combinations, results of which are as follows,

Load combination - 1

Live load + Self weight

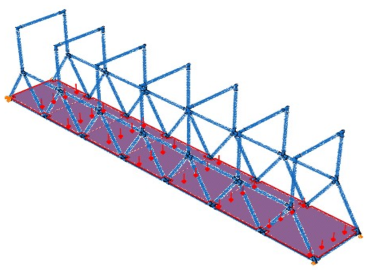

Fig. 5 Application of (Live load+ Self weight)

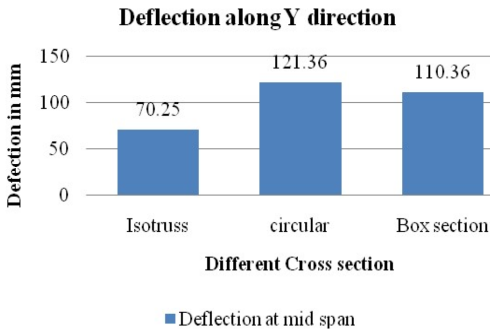

Fig. 6 Deflection in Y-direction
for (Live load + Self weight)

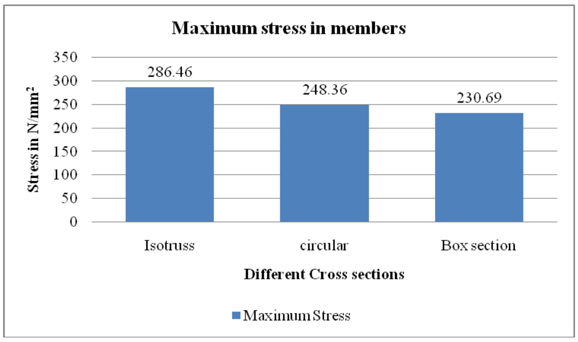

Fig. 7 Maximum Stress in member
for (Live load + Self weight)

Here live load of 4 kN/m^2 is applied. From results for load combination-1 it is seen Bridge with Circular tube as well as Box section shows 67% and 56% more deflection than Bridge formed by Isotruss member respectively. While stress value is 15% and 24% higher in the case Bridge formed by Isotruss member than that of Circular tube and Box section respectively but maximum stress for Isotruss member is within elastic limit of Carbon fiber i.e. less than 330 N/mm^2. Box section and Circular tube member fail in the deflection criteria. Maxmimum deflection permitted in this case is 105 mm i.e. by (span/100) criteria.

Load combination - 2

Live load + Self weight + Wind load

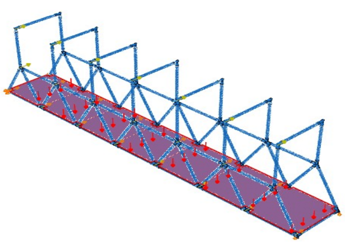

Fig. 8 Application of
(Live load + Self weight + Wind load)

Here live load of 4 kN/m^2 is applied and wind load of 51.15 N, 70.34 N and 56.17 N applied as point load on Isotruss, Circular tube and Box section respectively. From results for load combination-2 it is seen that Bridge with Circular tube as well as Box section shows 72% and 58% more deflection in Y-direction than Bridge formed by Isotruss member

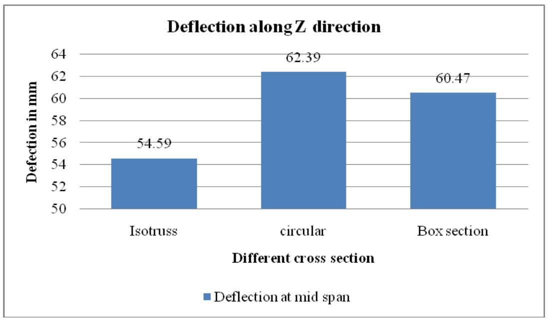

Fig. 9 Deflection in Z-direction
for load (Live load + Self weight + Wind load)

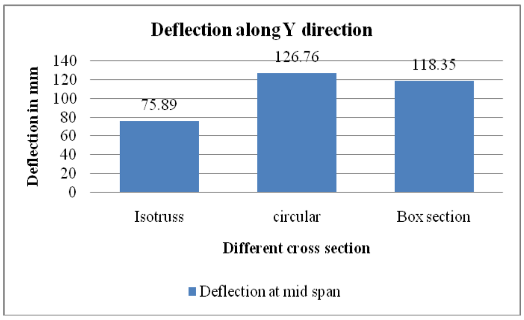

Fig. 10 Deflection in Y-direction
for (Live load + Self weight + Wind load)

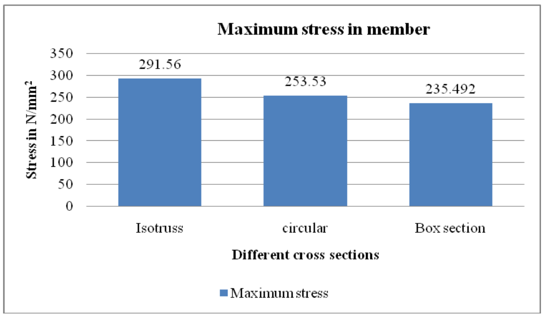

Fig. 11 Maximum stress in member
for (Live load + Self weight + Wind load)

respectively and for deflection in Z-direction Bridge formed by Circular tube shows 14% and Bridge formed by Box section shows 11% higher deflection than Isotruss member Bridge. While stress value is 18% and 26% higher in the case Bridge forming of Isotruss member than that of Circular tube and Box section respectively but maximum stress for Isotruss member is within elastic limit of Carbon fiber i.e less than 330 N/mm^2. Box section and Circular tube member fail in the deflection criteria. Maxmimum deflection permitted in this case is 105 mm i.e. by (span/100) criteria.

4. CONCLUSION

- Isotruss member is effective than Circular tube as well as Box section.
- Use of Isotruss member gives lightweight and strong structural solution.

Isotruss member can be used efficiently for Bridge applications as it is advantages.

Disclosures

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