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Design Optimization of Bridge Deck using Response Surface Optimization Technique

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Abstract*:* Box girder bridges have been used extensively in various parts of the world and are commonly used for highway and railway bridges, pedestrian bridges, and cable-stayed bridges. The objective of current research is to evaluate the structural characteristics of box girder bridge using techniques of FEM. The modelling and simulation of box girder bridge is done in ANSYS simulation package. The critical regions which are subjected to damage is identified. The FEA simulation results have shown that the maximum deformation is observed at the center of the box girder bridge structure. The deformation is maximum at the center of the load application region. The shear stress is obtained to be maximum at the corner support edges and regions of box girder bridge.

Key Words: Box girder bridge, FEA

1. INTRODUCTION:

Box girder bridges are commonly used for medium to long spans, and are popular for their high load-carrying capacity, resistance to torsion and bending, and aesthetic appeal. The box girder is typically made of reinforced concrete, steel, or a combination of both materials. The bridge deck is usually supported by cross beams that are placed at regular intervals along the length of the box girder. The cross beams transfer the load from the bridge deck to the box girder, which in turn distributes the load to the bridge piers or abutments. Box girder bridges can be constructed using various methods, including precast segmental construction, incremental launching, and balanced cantilever construction. The construction method used depends on the site conditions, span length, and design requirements.

Figure 1: Open trapezoidal composite box girder during construction

Box girder bridges have been used extensively in various parts of the world, including in the United States, Europe, Asia, and Australia. They are commonly used for highway and railway bridges, pedestrian bridges, and cable-stayed bridges. Box girder bridges have also been used in landmark structures such as the Second Severn Crossing in the UK, the Oresund Bridge between Denmark and Sweden, and the Stonecutters Bridge in Hong Kong. Overall, the box girder bridge is a popular and versatile bridge structure that provides a high level of safety, durability, and aesthetic appeal. Its load-carrying capacity, resistance to torsion and bending, and ability to span long distances make it a popular choice for many bridge projects.

2. LITERATURE REVIEW

Ayman et. al. [1] This article provides a comprehensive review of cable-supported bridge structures, including their history, types, design principles, and construction methods.

Gupta et. al. [2] This article focuses on long-span suspension bridges, which are among the most iconic and challenging bridge structures to design and construct. The article reviews the design principles, structural behavior, and construction techniques of these bridges.

Kaoru et. al. [3] This article provides a review of innovative bridge structures, such as cable-stayed bridges, arch bridges, and hybrid structures. The article discusses the advantages and limitations of these structures and presents case studies of their successful implementation

Khaled et. al. [4] This article reviews the state of the art in bridge inspection and maintenance, which is critical to ensuring the safety and durability of bridge structures. The article discusses the various techniques and technologies used

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in bridge inspection and maintenance, as well as the challenges and future directions in this field.

Tham et. al. [5] This article reviews the dynamic behavior of bridge structures, including the factors that affect their vibration response and the strategies used to control their vibration. The article also discusses the challenges and opportunities in the design of vibration control systems for bridges.

3. OBJECTIVE

The objective of current research is to evaluate the structural characteristics of box girder bridge using techniques of FEM. The modelling and simulation of box girder bridge is done in ANSYS simulation package.

4. METHODOLOGY

The design of box girder bridges is developed using sketch and extrude tool of design modeler. The developed model of box girder bridge is shown in figure 2.

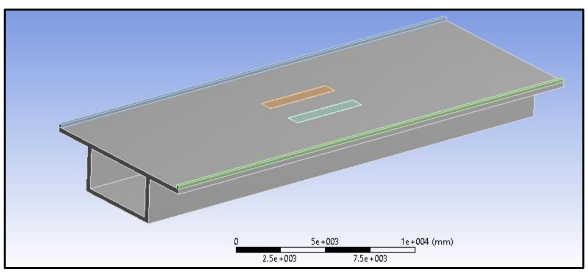

Figure 2: CAD design of box girder bridge

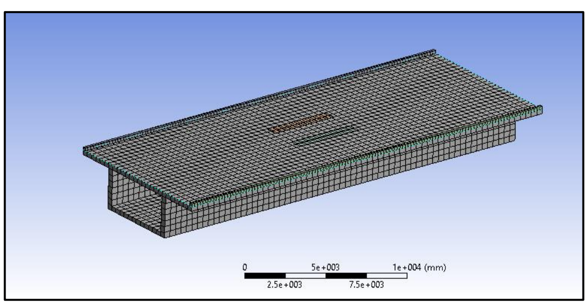

Figure 3: Meshed model of box girder bridge

The model of box girder bridge is discretized. The discretization is based on geometry type. The geometry possessed topological consistency and therefore the geometry is suited for hexahedral element type mesh. The meshing is done with fine sizing.

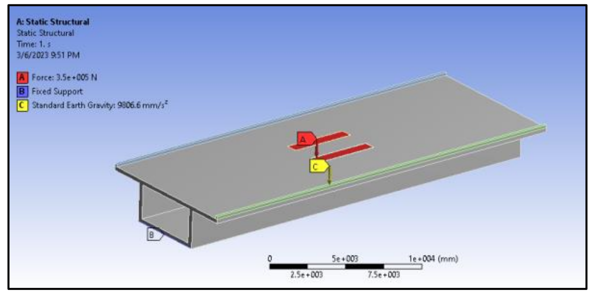

Figure 4: Applied loads and boundary conditions

The structural loads and boundary conditions are applied based on IRC loading condition. The loading condition involves applying fixed support at the free ends and downward force of high magnitude on two different surfaces as shown in red colored region. The standard earth gravity is applied on the structure.

5. RESULTS AND DISCUSSION

The FEA simulation is run to determine the deformation, normal stress, shear stress. These parameters enabled to determine the critical regions of high stresses and deformation.

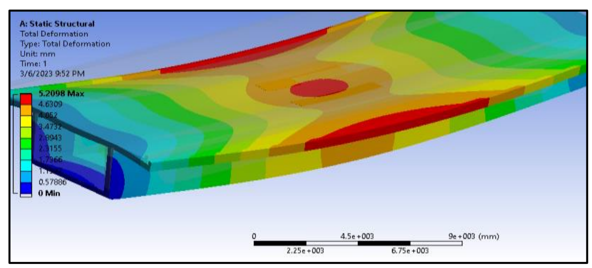

Figure 5: Total deformation

The maximum deformation is obtained at the center of the bridge structure wherein the magnitude is more than 4.6309mm and this deformation reduces along the length of the bridge structure. The deformation at other regions is 2.8mm.

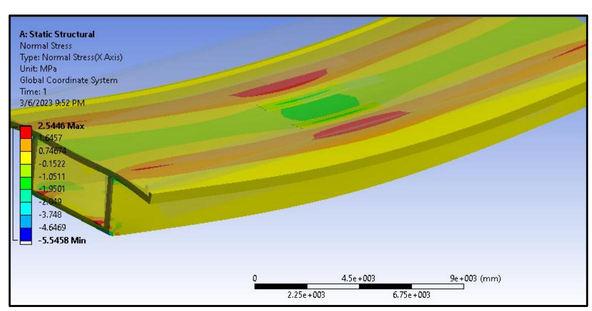

Figure 6: Normal stress

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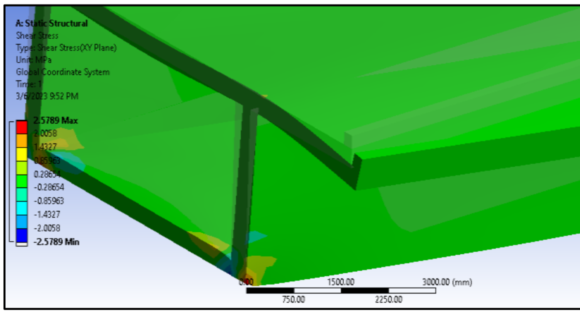

Figure 7: Shear stress (xy plane)

The shear stress across vertical plane is shown in figure 7 above. The shear stress is maximum at the corners of 2.0058MPa. The shear stress is almost uniform at other regions wherein the magnitude of stress is .28MPa.

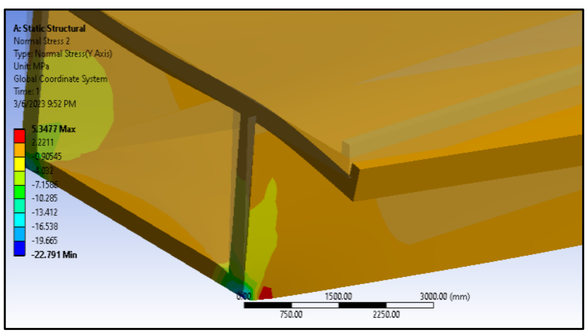

Figure 8: Normal stress

The normal stress distribution plot is obtained for box girder bridge structure as shown in figure 8 above. The maximum normal stress is obtained at the corner of box girder bridge where the magnitude of stress is more than 2.22MPa. The normal stress is lower at other regions as shown in yellow colored region wherein the magnitude is .905MPa.

6. CONCLUSION

The use of FEA simulation tool i.e. ANSYS enabled to determine the structural characteristics of box girder bridge structure on the basis of stress and deformation. The critical regions which are subjected to damage is identified. The FEA simulation results have shown that the maximum deformation is observed at the center of the box girder bridge structure. The deformation is maximum at the center of the load application region. The shear stress is obtained to be maximum at the corner support edges and regions of box girder bridge.

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