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"Parametric Investigation of Box Cell Bridges: Evaluating Different Sectional Profiles and Span Lengths"

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Abstract- *The self-anchoring suspension bridge plays a vital role in establishing a solid financial foundation, presenting an appealing aesthetic, providing flexibility, and ensuring acceptable load conditions. It also contributes to the overall enhancement of the bridge construction process, leading to successful execution and approval. With the increasing demand for bridge capacity and the expansion of bridge width to eight and beyond, the structural integrity of the building system becomes more crucial. Consequently, numerous changes have been made in the utilization and construction of bridges. As the width increases, the dead load also experiences a corresponding increase.*

To reduce the dead load, undesired elements are eliminated across the cross section, resulting in a negative box or honeycomb shape. As Maggid states, "By connecting two sets of two strings, a square bridge can be formed." By employing square joists instead of T-beams, one can save costs while achieving longer spans and smaller openings for the same valley width. The utilization of box beams predominates in bridge construction, and restressing has become a prevalent technique in the field. Furthermore, most decks are installed in the opposite direction.

In this particular study, the effectiveness of the Multicell Bridge Box design implementation was evaluated using five distinct box sections and two different weights. Detailed examination was conducted on cycle time, slider settings, and zoom results. The conclusions drawn from this analysis can be utilized to select the optimal components for bridge design.

Key Words: *box, beam section, bending moment, base shear, shears Force.*

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I. INTRODUCTION

A bridge is a structure that spans a wide area or distance, providing a passage for vehicles, pedestrians, or both. It serves as a connection, enabling transportation and facilitating movement across obstacles such as rivers, valleys, roads, or railways. Constructing bridges requires careful attention to safety and durability. Bridges must be designed and built to withstand their own weight, as well as the loads imposed by people and vehicles using them. They need to be resilient against factors such as corrosion, extreme weather conditions including high winds and temperature variations, and even seismic activities like earthquakes. Regular maintenance is essential to ensure their structural integrity and ensure the safety of those who rely on them. Bridges, along with roads and railways, are considered crucial assets that enable the smooth functioning of a nation's transportation infrastructure, and thus, they require continuous monitoring and upkeep.

There are several types of bridges, each with its own unique design and structural characteristics. These include:

a. Cantilever bridges: These bridges use cantilevered beams or structures projecting from fixed supports to create an overhang. They are commonly used for long-span bridges.

b. Arch bridges: These bridges have a curved design and rely on the load-bearing capability of the arch shape to distribute forces. They are known for their strength and aesthetic appeal.

c. Suspension bridges: Suspension bridges utilize a series of cables suspended from tall towers to support the bridge deck. The cables transfer the load to the towers and anchorages, allowing for longer spans.

d. Truss bridges: Truss bridges are constructed using interconnected triangular units (trusses) that provide strength and stability. They are often used for medium-span bridges.

e. Cable-stayed bridges: Cable-stayed bridges feature cables that extend directly from the towers to support the bridge deck. This design offers a balance between the arch and suspension bridge types.

Prior to the construction of a bridge, several factors must be considered. Engineers evaluate the terrain and geotechnical conditions to determine the most suitable type of bridge for the specific location. The intended purpose of the bridge, such as accommodating vehicular traffic or pedestrian use, influences the design and load requirements. Additionally, the cost of construction, including material and labor expenses, is a significant consideration to ensure feasibility and budgetary constraints are met.

A box cell bridge is a type of bridge structure that utilizes a hollow box beam as its main structural element. The box beam, commonly made of materials like concrete or reinforced concrete, forms the core of the bridge. The cross-sectional shape of the box beam is typically trapezoidal or rectangular.

Box cell bridges are commonly found in modern railroad and highway construction projects. They offer strength, durability, and versatility in design. In some cases, the box bridge may incorporate truss elements, which further enhance its load-bearing capacity and structural integrity. One popular variation of the box cell bridge is the square cell bridge.

Box sections can vary in configuration, including single-box designs, double-box designs, and multiple-box designs. Additionally, they can be continuous elements, with multiple box sections joined together to form a continuous structure.

The box cell bridge design provides several advantages. Its hollow box beam construction allows for efficient use of materials, resulting in a lightweight yet robust bridge. The design can also accommodate different load requirements and span lengths, making it suitable for various bridge applications.

Overall, box cell bridges offer a reliable and flexible solution for crossing obstacles such as rivers, valleys, or roadways. Their versatility in design and strength makes them a popular choice in modern bridge construction projects.

II. OBJECTIVE OF THE WORK

- Examine the shear and bending capacities of different beam sections and lengths.
- Compare the maximum bending moments, shear forces, and torsional forces at various inclination angles and color variations.
- Assess the parametric performance of prototypes of single-span, three-span, and four-span box bridges. Consider the impact of additional support on energy efficiency.

III. METHODOLOGY

A box bridge, also referred to as a box beam bridge, is primarily constructed using a hollow box beam as its main structural element. These bridges are typically composed of materials like concrete, reinforced concrete, or steel.

The term "box" in its name is derived from the bridge's design, which resembles a box-like structure. Box bridges offer several advantages as they are easily created by designers, highly functional, and have a straightforward construction and design process. They are particularly effective in supporting heavy loads from above without causing any obstruction and enable the distribution of the load over a wide area. Additionally, box bridges have minimal foundation requirements, making them suitable for sites with low soil bearing capacity. They also require less soil maintenance, and the soil treatment can be tailored according to the preferences of the civil engineer. Box bridges can be further categorized into two types:

1) Long-term analysis
2) Partial analysis.

As IRC recommendations, major vehicles will be considered traffic loads in the bridge design based on their use in various road categories.

According to IRC

1) IRC Class 70RLoading (Considered in study)
2) IRC Class AA Loading
3) IRC Class A Loading (Considered in study)
4) IRC Class B Loading

For the purpose of study only two loading for analysis are selected mainly class A and 70 R to observed the effect of configuration on bending moment, shear force and deflection.

Cases consider for Analysis

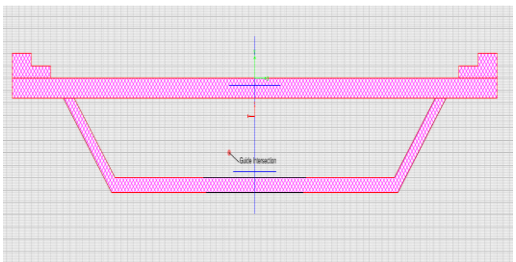
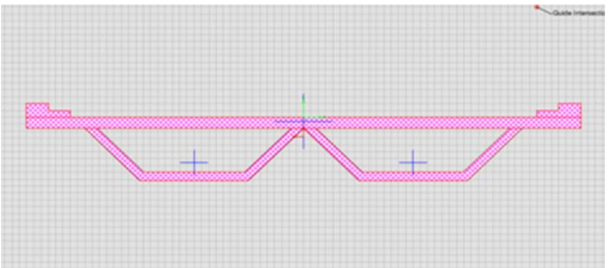
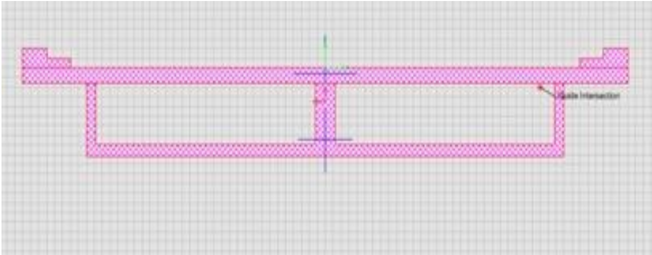


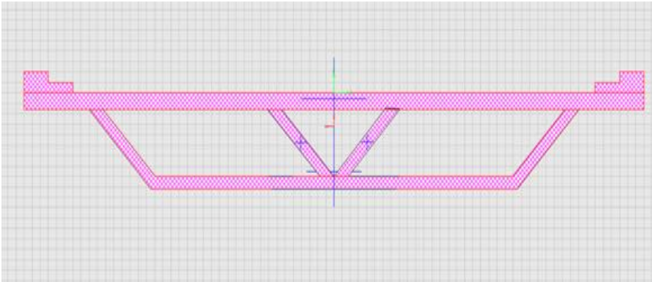
Figure 1: Case-1 (Double Box Modify To Single Box)



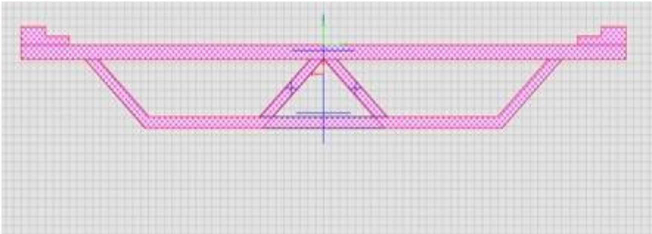
Case-2 (Double Box Cell of 45 Degree)



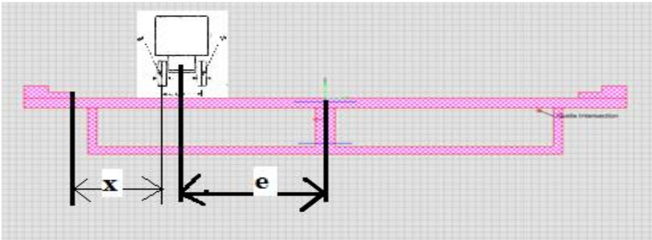
Case-3 (Double Box Cell 90 Degree)



Case-4 (Double Box Cell of (Inverted) Triangle)



Case-5 (Double Box Cell of Strap Type)



Eccentricity of Vehicle along Moving Path

IV. RESULTSAND DISCUSSION

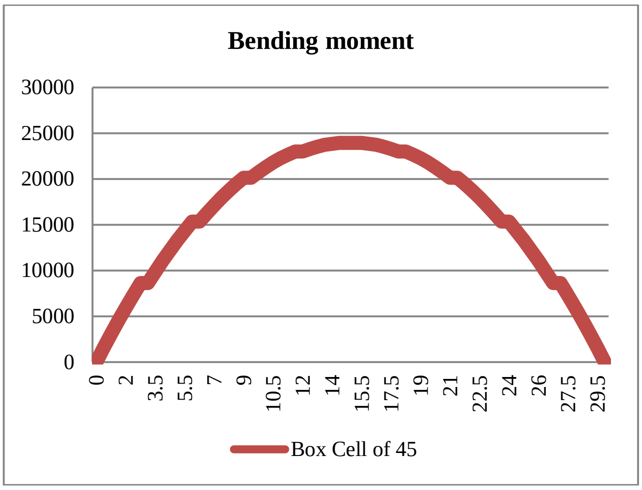


Figure 1. Bending Moment Diagram for Box Cell of 45

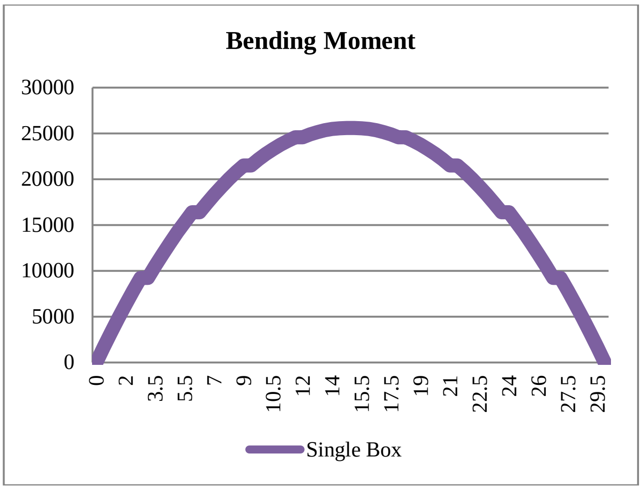


Fig. 2 Bending Moment Diagram for Double Box Cell Modified Single Box

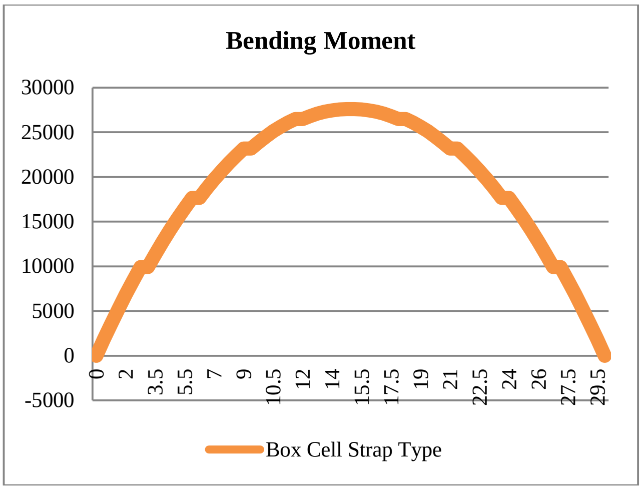


Fig. 3 Bending Moment Diagram for Box Cell Strap Type

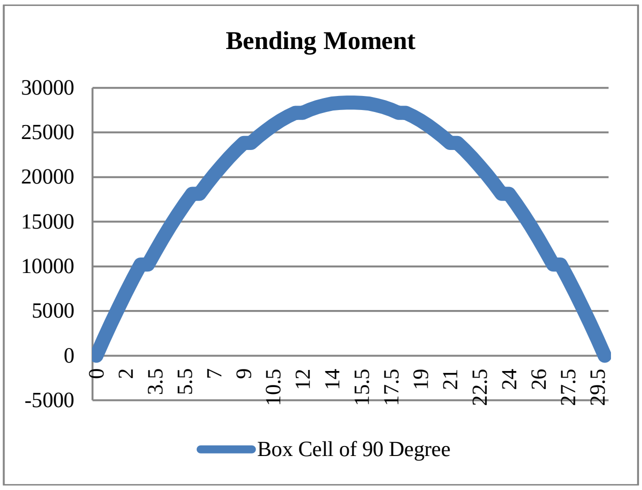


Fig. 4 Bending Moment Diagram for Box Cell of 90 Degree

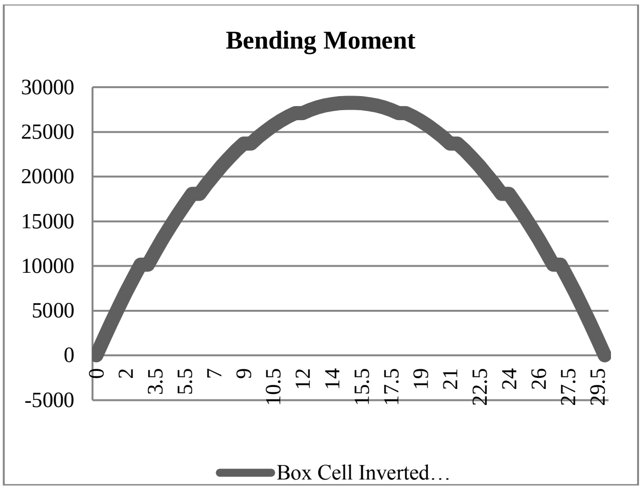


Fig. 5 Bending Moment Diagram for Double Box Cell Inverted Triangle

V. CONCLUSIONS

Conclusion of Bending Moment Results:

After analyzing the bending moment results for various box cell angles, it can be concluded that a 90-degree box cell exhibits the highest bending moment, while a 45-degree box cell experiences the lowest bending moment. This finding is supported by the graph and tables that display the bending moment results. As expected, the bending moment is zero at the support, indicating a balanced distribution of forces, and reaches its maximum value at the center of the bridge. These observations highlight the importance of considering the box cell angle in designing box beam bridges to ensure optimal structural performance.

Conclusion of Shear Force Results:

The examination of shear force results for different box cell angles reveals that a 90-degree box cell experiences the highest shear force, whereas a 45-degree box cell exhibits the lowest shear force. As anticipated, the shear force is zero at the support, indicating a point of no shear stress, and reaches its maximum value at the support with a positive value and a negative value at the left support. This variation in shear force across the box beam emphasizes the significance of accounting for the box cell angle when evaluating the structural behavior and stability of box bridges.

Conclusion of Bending Moments Results Due to Vehicle Load and Different Loadings:

By considering different vehicle loadings, such as IRC-A Path 2.7 and Load Class-70R Path 1.65, the maximum bending moments can be determined. The analysis indicates that the vehicle load IRC-A Path 2.7 results in a maximum bending moment value of 5691.9269 KM-M, while the vehicle load Load Class-70R Path 1.65 yields a maximum bending moment value of 2734.9767 KN-M. These findings illustrate the varying effects of different vehicle loads on the bending moments experienced by the box beam bridge. It emphasizes the need for accurate load calculations and considerations in bridge design to ensure structural integrity and safety under varying traffic conditions.

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