Design and Analysis of Bridge Girders with Different Cell Using Ansys

Abstract: Bridges are a super passage or a shortcut over an obstacle that would not change the direction of the road above. The current research looks at the architecture of bridge girders for single cell, two cell, and three cell girder bridges. We developed and investigated two types of box girders: rectangular and trapezoidal girder boxes. It is a performance comparison between rectangular and trapezoidal composite box girders. The concrete properties and load analysis was in accordance with IRC 18-2000 and IRC 21-2000. A vehicle load of 13000N was given. For this analysis, an ANSYS software package is used to construct a Finite Element model. This model is then examined for parameters such as deflection and tension under the impact of a moving vehicle load, both with and without pre-stress force. The study's cornerstone is to have the best performance for a concrete box girder segment by evaluating all outcomes. Deformation, Equivalent Stress, Normal Stress, and Shear Stress were all compared. After analysing the results, a better section was chosen from among rectangular and trapezoidal sections.

Keywords: Bridge, Box Girder Bridge, Composite Bridges, Modal Analysis, Ansys.

I. Introduction

Concrete is the most widely used material in the construction industry. However, concrete does not work well in structures, which necessitates the usage of pre-pressing technology. An advanced concrete construction varies from a conventional reinforced concrete framework in that it is subjected to an initial load prior to implementation. Pressure is a compressive force added to concrete in order to overcome stresses generated by applied loads. Before and after tensioning, two methods are used to incorporate pretensioning into a concrete. A bridge is a structure used to cross a road, a body of water, a railway track, a valley, and so on. A bridge is a road that crosses a fence. The bridge's structure is determined by the bridge's or its function. The construction of the area where the bridge will be constructed is also important. It is determined by the land conditions, structural materials, construction methods, and financial conditions used in bridge construction, and other factors. Because of such rapid development and technological innovation, cost-effective and modern designer bridges have mostly replaced conventional bridges. Structural designs are designed to provide a sleek appearance or feel, as well as to be cost effective. Structural engineers discovered these two reinforced cement concrete systems to solve the issue. Girder bridges, Arch bridges, and Rigid Frame bridges are all types of bridges. In recent years, steel-construction, in-house concrete, or precast concrete bridges have been the most popular applications of composite architecture. Steel concrete composite bridges have been extensively used throughout the world due to their architectural appearance and economic importance.

Figure 1: Box Girder Bridge [4]

They are more interesting in urban areas because they can cater for lengthy periods of time without resorting to forgery. Furthermore, the weight of steel plate turning bridges and cement box turning bridges has a significant impact on seismic design. Steel plate earthquakes have significantly smaller inertia forces than concrete bridges. Steel bridge superstructures are often less disruptive than reinforced concrete superstructures during low-moderate vibration. Usually, unseated girders and defects at ties, bearings, cross plates, and expansive joints are affected. Steel plate girder bridges have usually experienced mild to moderate damage in recent earthquakes, as compared to structural concrete bridges, which have suffered serious damage.

II. TYPES OF GIRDERS

Two cross sections with types for alignment are currently used: an open area composed of a number of I-shaped cross sections with a solid transverse bracing framework and a closed portion comprising a few box brackets. Box girders have a range of main benefits and drawbacks as opposed to I-beam girders. In addition to having a strong torsional stiffness, box girders have a high corrosion tolerance since a significant portion of the steel structure, with the top and bottom flanges, is not exposed to ecological stabbing. The box girder often has a sleek appearance, which contributes to improved bridge design. The trapezoidal cross section, which is more common nowadays, has many benefits over the rectangular cross section. A narrow bottom flange is provided by the trapezoidal box girder (bathtub girder). The bending moment is centred along the abutments.

III. BOX GIRDERS

The main beams of box girder bridges are frequently hollow box formed girders. Box girders are usually made of prestressed concrete, reinforced concrete in solid cement, or steel. As seen in Figure 2, a box-girder cross section may be single cell (one box), multiple spine (split box), or multi-cell with a regular flange on the ground. (Consistent cells) The structure and pre-stressed tendons of the box girder bridge contribute to its stability.

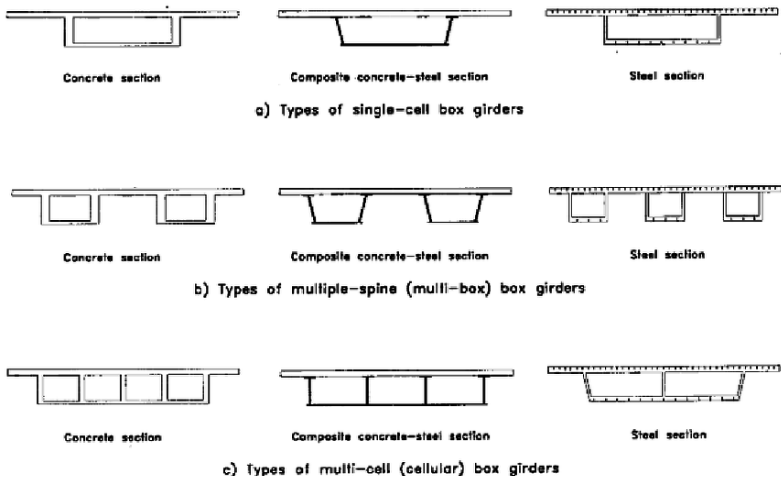

Figure 2: Types of Box girder

During the fabrication and erection processes, the segment can be fully open at the top or braced to the top flanges by a top lateral bracing device. To finish the box and cover the top gap, A concrete reinforced deck slab is added to work compositing by shear connectors with the steel portion.

IV. THE FINITE ELEMENT METHOD

A numerical method used to solve engineering and mathematical physics issues is the finite-element approach. The assessment of stresses and displacements is generally correlated with the approach to structural problems. For unknowns at a discrete number of points in a continuum, the finite element model allows approximations. The discretization of a model is the first step in this computational method of analysis. The process of splitting a body into an equal arrangement of smaller bodies or units known as components is known as discretization. These elements are linked by nodes, which are intersection points. In case of minor displacements or a linear material reaction the rigidity matrix of each part is calculated by using a scroll formulation, and the overall rigidity matrix of the whole system can be formulated using the process of direct rigidity by assembling the rigidity matrices of all the components. The global rigidity matrix represents the relation of nodal force-displacement and can be metricized by the following balance equation:

$$[F] = [K]\,[U]$$

Where, [K]= Comprehensive rigidity matrix consisting of rigidity matrices,
[U]=nodal movement vector and [F]=nodal load vector.

V. MODELLING OF BRIDGE GIRDER BOX

We build 3 varieties of single, double and triple cell girder case. Box shape in rectangular and trapezoidal two shapes.

Table 1: Dimensions of Bridge Girder Box

Types of Box Girder	Types of Cell of Girder	Length of Span (m)
Rectangular Box Girder	Single cell	25
	Double Cell	35
	Triple Cell	45
Trapezoidal Box Girder	Single cell	25
	Double Cell	35
	Triple Cell	45

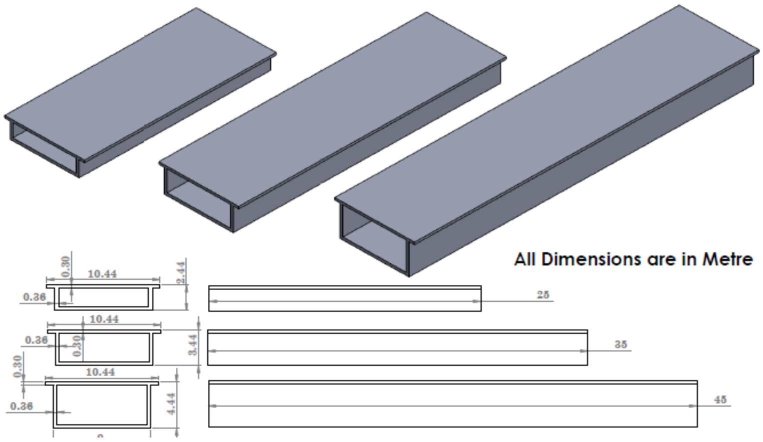

Figure 3: 3d Model of Single cell Rectangular box girder

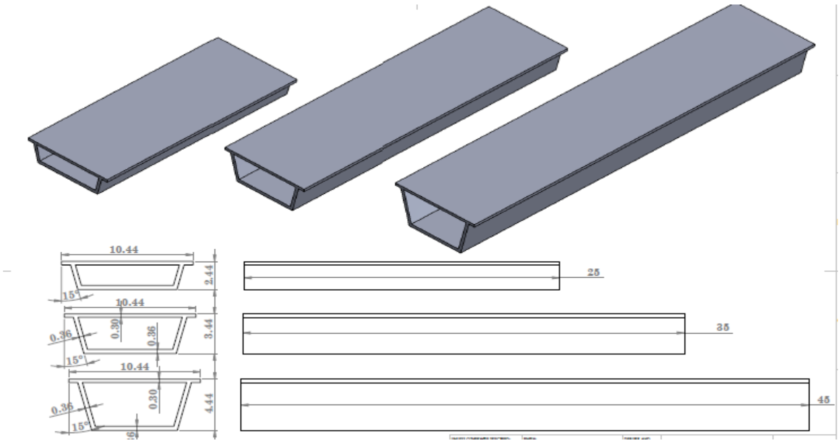

Figure 4: 3d Model of Single cell Trapezoidal box girder

VI. LOADING CONDITIONS OF BRIDGE GIRDER BOX

We applying 13000N moving vehicle load on top surface of bridge girder box using Ansys for analysing its deformation and stress.

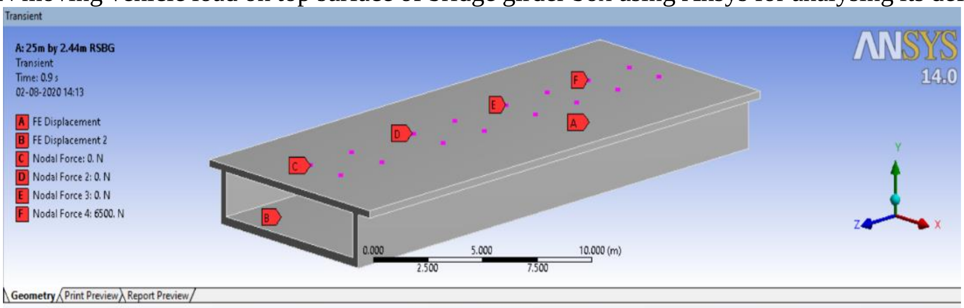

Figure 5: Loading conditions on Single Cell Bridge girder box

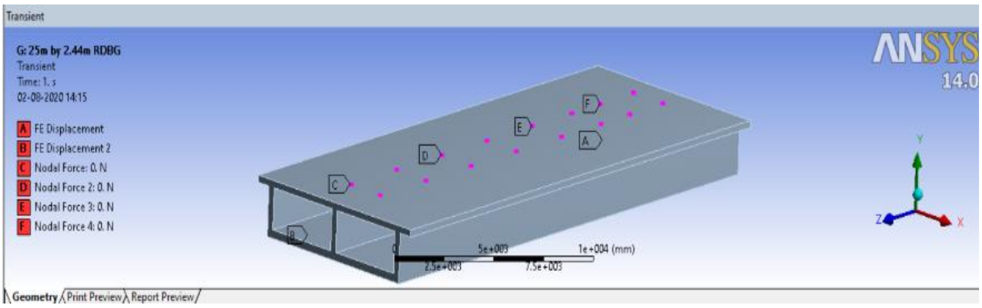

Figure 6: Loading conditions on Double Cell Bridge girder box

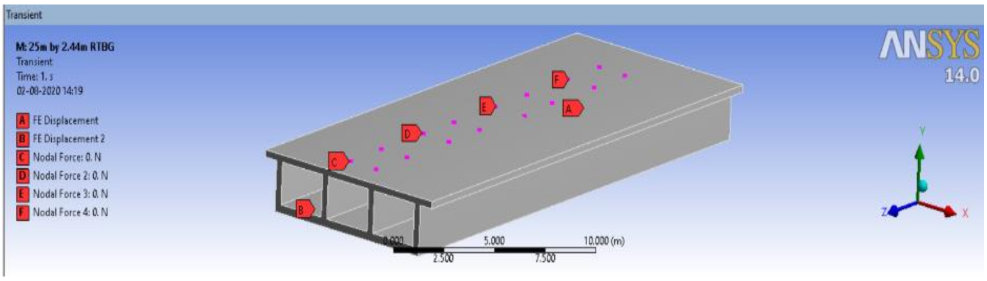

Figure 7: Loading conditions on Triple Cell Bridge girder box

VII. RESULTS AND ANALYSIS

The structural investigation of bridges for dynamic loading conditions will give us deformations and stresses values. In the present study girder box Bridge designed as rectangular and trapezoidal type are modelled and comparative analysis is made to find out magnitude of deformations due to Loading conditions. Types of girder box with shapes and cell types are described below.

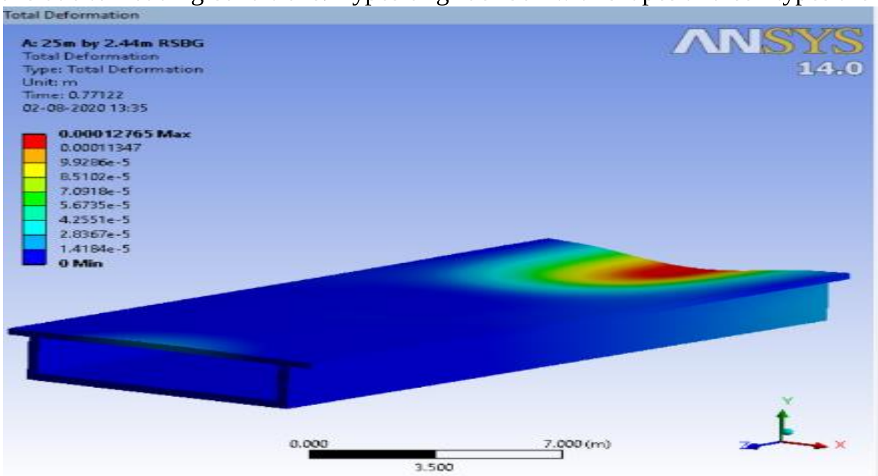

Figure 8: Deformation in single cell Girder box with length of span 25 meter

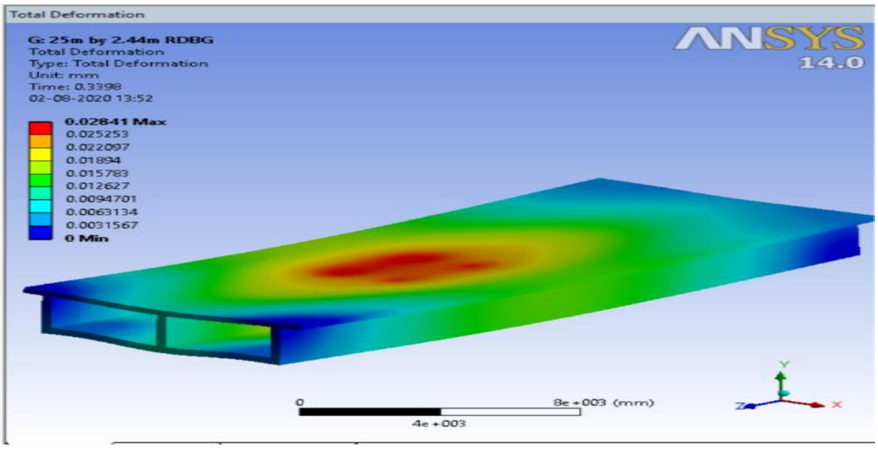

Figure 9: Deformation in Double cell Girder box with length of span 25 meter

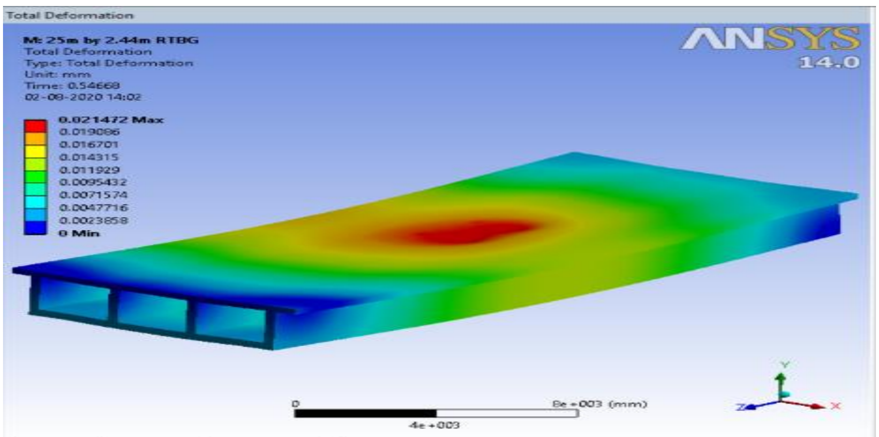

Figure 10: Deformation in Triple cell Girder box with length of span 25 meter

Table 2: Stress and Deformation of Rectangular Girder Box with length of Span 25 meter

Types of Cell of Girder	Length of Span (m)	Deformation (mm)	Stress (Pa)
Single cell	25	0.127	108500
Double Cell	25	0.029	97311
Triple Cell	25	0.021	96995

Table 3: Stress and Deformation of Rectangular Girder Box with length of Span 35 meter

Types of Cell of Girder	Length of Span (m)	Deformation (mm)	Stress (Pa)
Single cell	35	0.112	117910
Double Cell	35	0.025	29395
Triple Cell	35	0.031	57105

Table 4: Stress and Deformation of Rectangular Girder Box with length of Span 45 meter

Types of Cell of Girder	Length of Span (m)	Deformation (mm)	Stress (Pa)
Single cell	45	0.118	102820
Double Cell	45	0.043	84115
Triple Cell	45	0.032	61737

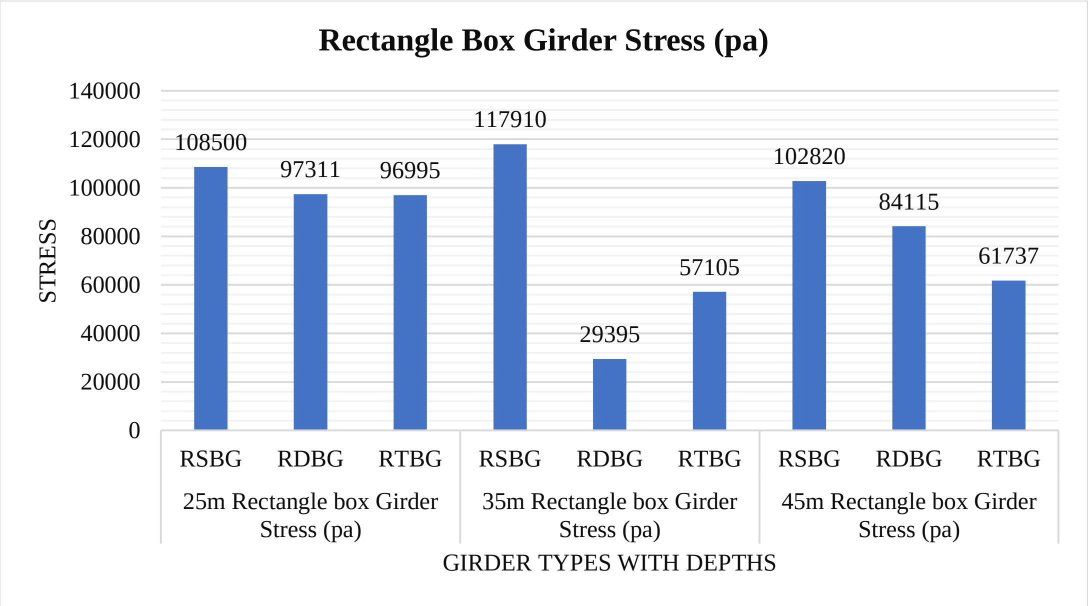

Figure 11: Stress Variations of Rectangular Girder box

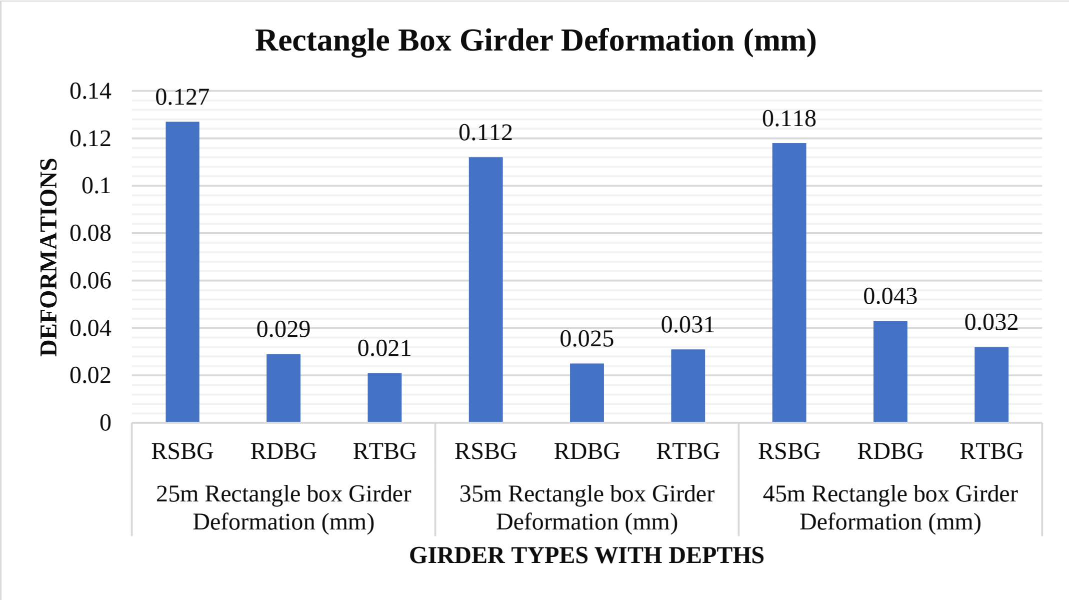

Figure 12: Deformation Variations of Rectangular Girder box

Table 5: Stress and Deformation of Trapezoidal Girder Box with length of Span 25 meter

Types of Cell of Girder	Length of Span (m)	Deformation (mm)	Stress (Pa)
Single cell	25	0.141	126880
Double Cell	25	0.025	64762
Triple Cell	25	0.017	59462

Table 6: Stress and Deformation of Trapezoidal Girder Box with length of Span 35 meter

Types of Cell of Girder	Length of Span (m)	Deformation (mm)	Stress (Pa)
Single cell	35	0.164	141480
Double Cell	35	0.004	70506
Triple Cell	35	0.023	52070

Table 7: Stress and Deformation of Trapezoidal Girder Box with length of Span 45 meter

Types of Cell of Girder	Length of Span (m)	Deformation (mm)	Stress (Pa)
Single cell	45	0.12	80063
Double Cell	45	0.045	70723
Triple Cell	45	0.034	54062

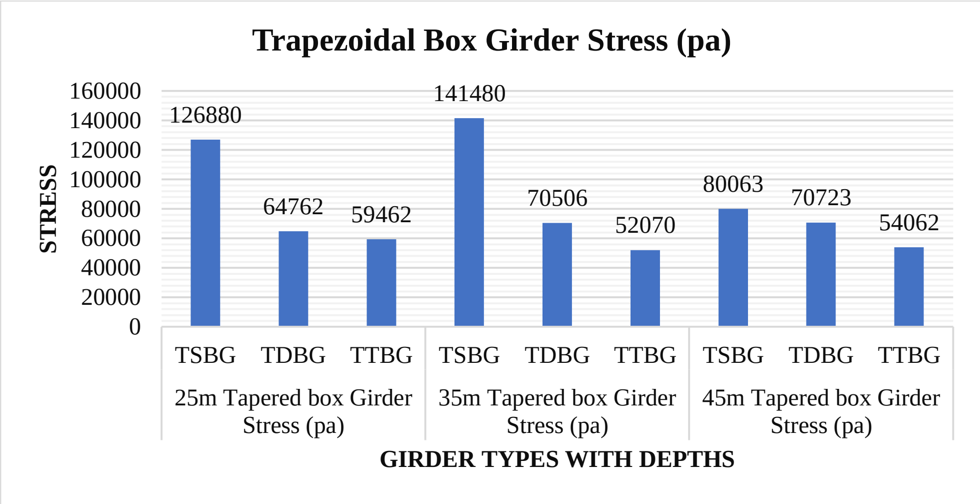

Figure 13: Stress Variations of Trapezoidal Girder box

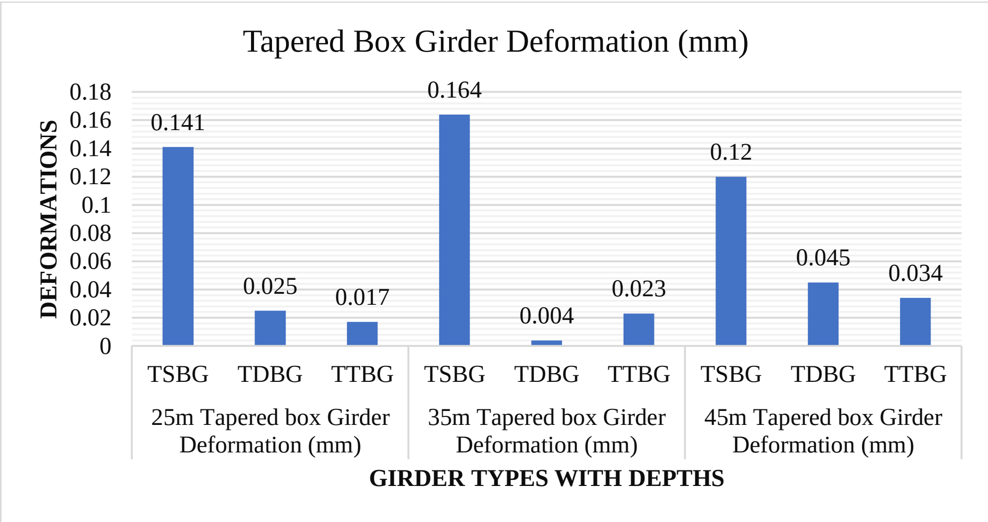

Figure 14: Deformation Variations of Trapezoidal Girder box

RSBG= Rectangular Single Bridge Girder Box
RDBG= Rectangular Double Bridge Girder Box
RTBG= Rectangular Triple Bridge Girder Box
TSBG= Trapezoidal Single Bridge Girder Box
TDBG= Trapezoidal Double Bridge Girder Box
TTBG= Trapezoidal Triple Bridge Girder Box

V. Conclusion

This research compares two types of Bridge Girder box designs, namely Rectangular and Trapezoidal with single cell, double cell, and triple cell. To decide the best fitting bridge girder in terms of structural viability, as well as which takes the least deformations and stresses in the girder period. First, the girder designs for both styles of bridges are completed and analysed using Ansys. The following findings are reached by comparing the outcomes of the study.

- Deformation decreases when we increase cell in girder box, we found maximum deformation in rectangular girder box at single cell and 25 m length of span is 0.127mm.
- Minimum deformation found in rectangular girder box with triple cell at 35 m length of span is 0.021 mm.
- Trapezoidal type girder box gives lower deformation in double cell with 35 m length of span is 0.004mm which less than the lower value of rectangular girder box. So, it is our best suitable condition and design for Bridge girder box.
- Maximum deformation found in single Girder box with 35 m length of span is 0.164mm.
- as comparison of both design i.e. rectangular and trapezoidal type bridge girder box we found better results in trapezoidal type girder box with 35m length of Span.

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