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Design and Field Execution Process of Tee Beam Bridge by Using CSI Bridge Software

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Abstract: This A Bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley.

Bridges range in length from a few meters to several kilometers. They are among the largest structures built by man. The demands on design and on materials are very high. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. The structure also must resist various natural occurrences, including earthquakes, strong winds, and changes in temperature. Most bridges have a concrete, steel, or wood framework and an asphalt or concrete road way on which people and vehicles travel.

Our Kakinada has been a part of smart city programme; many renovations and development of new structures are being done. Under this programme many bridges are being reconstructed. As a part of this the one lane road bridge at Pratap Nagar, Kakinada is being upgraded into two lane road over bridge. This Project is an on-going work of two-lane road over bridge with a T-beam Reinforced Concrete Deck slab with 12m wide and 36m long having 5 spans with equal distribution of 7.2m length. In this project work we are going to design and analyse the two-lane road over bridge by using manual calculations and computational work with Bridge Software.

Keywords: Bridge, Earthquakes, Strong winds, Roadway, Railway, Pedestrians, Canal, Pipeline, Asphalt, T-beam, Reinforced Concrete, Deck slab.

I. INTRODUCTION

A Bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley.

Bridges range in length from a few meters to several kilometers. They are among the largest structures built by man. The demands on design and on materials are very high. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. The structure also must resist various natural occurrences, including earthquakes, strong winds, and changes in temperature. Most bridges have a concrete, steel, or wood framework and an asphalt or concrete road way on which people and vehicles travel.

The T-beam Bridge is by far the Most commonly adopted type in the span range of 10 to 25 M. The structure is so named because the main longitudinal girders are designed as T-beams integral with part of the deck slab, which is cast monolithically with the girders. Simply supported T-beam span of over 30 M are rare as the dead load then becomes too heavy.

A. Reinforced Concrete Tee Beam Bridge

The reinforced concrete slab type deck is generally used for small spans. This type of super structure is economical for spans up to 8m. Slab deck is simpler for construction due to easier fabrication of form work and reinforcements and placement of concrete. In the case of reinforced concrete tee beam and slab deck, the slab spans in two directions since it is supported on main girder and cross girder in equal intervals.

A typical tee beam deck slab generally comprises the longitudinal girder, continuous deck slab between tee beams and cross girders to provide lateral stability to the bridge deck. The longitudinal girders are placed at an interval of 2 to 2.5m and cross girders are placed at an interval of 4 to 5m.

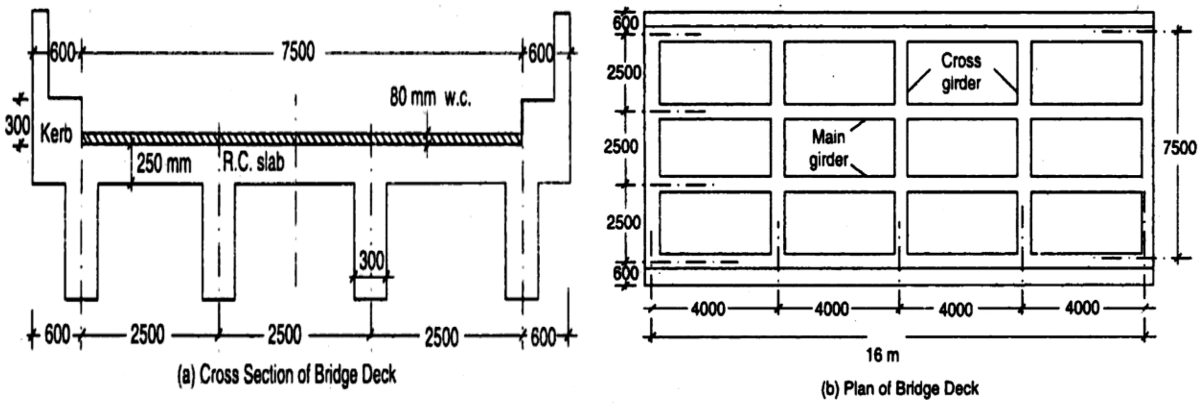

Fig: 1 T-Beam and Deck Slab Bridge

II. LITERATURE REVIEW

Iman Mohseni, Et al, in (2018), his work is on Shear and reaction distribution in skew multi-cell box-beam bridges. He studied about skewness effect on live load reactions at piers and shear forces of continuous multi-cell box-girder concrete bridges (MCB). Two MCB bridges were selected for the research, one bridge with two-span and the other with three- span. The selected bridges were modelled using finite element methods and analyzed to obtained bridge responses. Finite element method using CSI bridge software was used to investigate the bridge responses.

Prajwal Raj, Et al, in (2017), his work is on Structural behaviour of box Girder Bridge using numerical application and modelling. He analyzed the structural behaviour of post tensioned box Girder Bridge using the software application. The objective of this study is to know its structural behaviour and to decide which code of practice is better (between IRC and AASHTO) by comparing the results, also to know about the modelling pattern of the software and to know about the structural behaviour of single cell and four cell box girders under IRC and AASHTO loading.

Pengzhen Lu, Et al, in (2012), his work is on Analysis of a T-Frame Bridge. His work presents a spatial grillage model for analysis of such bridges. The proposed model is validated by comparison with results obtained from field testing. It is shown that analysis of T-frame bridges may be conveniently performed using the spatial grillage model. The static and dynamic behaviors of a rigid T-frame bridge were investigated analytically and experimentally.

III. METHODOLOGY

A. *General Guidelines For Analysis And Design Of A Bridge Structure*

Procedure for preparation of General Arrangement Drawing of a Bridge:

1) First of all, the required formation level is found out. On knowing this the permissible structural depth is established. This is done after taking into account the following two things:
   a) Minimum vertical clearance required taking into account the difference between the affluxes high flood level and the soffit of the deck.
   b) Thickness of wearing coat required below the formation level.

2) Considering the depth of foundations, the height of deck above the bed level and low water level, average depth of water during construction season, the type of bridge, span lengths, type of foundations, cross section of the deck, method of construction and loading sequence.
3) Trial cross sections of the deck, sizes of various elements of the substructure and superstructure are decided upon and drawn to arrive at the preliminary general arrangement of the bridge. Various trials lead to a structural form with optimum placements of its load masses. Relative proportions and sizes of certain members as well as their shapes are decided upon and drawn to a certain scale on this drawing. The type of bearing to be used along with their locations depending the support system is also established. The main basis of the general arrangement drawing of a bridge structure is a quick preliminary analysis and design of the member sections. This is essential for forming the basis of the detailed to be carried later on depending upon the requirements of the project.

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B. General Procedure For Design Of Superstructure Of A Bridge

1) Analyze and design the transverse-deck-slab and its cantilever portions, unless the superstructure is purely longitudinally reinforced solid slab with no cantilevering portions. This is necessitated so as to decide the top flange thickness of the deck section which is essential to work out the deck section properties for the subsequent longitudinal design.
2) Compute the dead load and live load bending moments at each critical section.
3) In order to determine the maximum and minimum live load effects that a particular longitudinal can receive, carry out the transverse load distribution for live load placed in various lanes.
4) This may be done by Courbon's method, little and Morice's method, Hendry and Jaeger methods.
5) Alternatively, use may be made to the Plane-Grid method which involves using one of the many standard computer programs (. e.g. CSI Bridge Program). The Plan Grid method is basically a finite element method. Though time consuming in writing the input data, it is nevertheless very useful for the purpose of analysis. For wide and multi-cell boxes and transverse live load distribution may be studied by the finite element method but it is time consuming.
6) Design against bending of critical sections, in reinforced or in prestressed concrete as the case may be. Work out dead load and live load shear forces at each critical section in the longitudinal of the deck and design the sections and reinforcements for effects of torsion and shear, if required.

C. Transverse Distribution Of Loads

Analysis based on the elastic theory is recommended to find the distribution in the transverse direction of the bending Moment in the direction movement in the direction of the span. For the analysis, the structure May be idealized in one of the following ways:

1) A system of interconnected beams forming a rigid.
2) An orthotropic plate.
3) An assemblage of thin plate elements or thin plate elements and beams.

For the computation of the bending Moment due to live load, the distribution of the live loads between longitudinal has to be determined. When there are only two longitudinal girders, the reactions on the longitudinal can be found by assuming supports of the deck slab as unyielding. With three or more longitudinal girders, the load distribution is estimated using any one of the above rational methods.

By using any one of the above Methods, the Maximum reactions factors for intermediate and end longitudinal girders are obtained. The bending Moments and shears are then computed for these critical values of reaction factors. The above three Methods make simplifying assumptions relating to the structure and loading. These assumptions introduce errors but Make these Methods amenable to calculators and graphs. In relative comparison to this the grillage Method of analysis, pioneered by Lightfoot and Sawka requires lesser simplifying assumptions.

D. Proposed Methodology

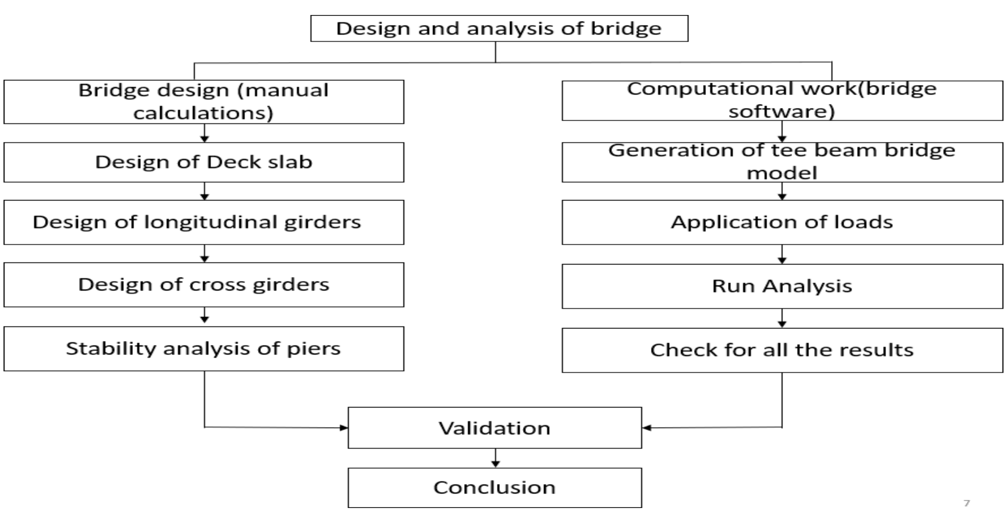

Fig: 5 Methodology of Analysis and Design of Reinforced Concrete T-Beam Bridge

IV. DESIGN OF REINFORCED CONCRETE T- BEAM BRIDGE

In this chapter the manual calculation of Reinforced Concrete T- beam Bridge was detailed as per the standard load considerations from IRC: 6-2000. The deck slab is design using the standard drawings issued by IRC and the sub structure was analyzed using the details of Pratap Nagar Bridge which were collected from Smart City Corporation of India limited, Kakinada.

A. Load Considerations

The various loads to which the bridge is subjected to are

- Dead loads.
- Live loads.
- Wind loads.
- Seismic loads.

1) Dead Loads: Unit weight for Dead Loads has been considered by adopting unit weights as per IRC 6:2000 (Standard Specifications and Code of Practice for Road Bridges, Section II-Loads and Stress)
2) Super Imposed Dead load: Wearing coat and Crash Barrier loads are taken as 2.0kN/m2 and 7.75kN/m.
3) Vehicular Live Load: As per IRC: 6-2000 deck the superstructure is analyzed for the following vehicles and whichever produces the severest effect has been considered in the design. Following combinations are adopted.

- One Lane of Class AA loading.
- Two Lanes of Class A loading.

4) Durability and Maintenance Requirements:

Concrete Grades and Reinforcement

Concrete	:	For RC Deck Slab (M30 Grade).
Reinforcement	:	HYSD bars (Fe415) conforming to IS: 1786.
Clear Cover	:	Minimum clear cover of 4mm to reinforcement has been adopted.

Drainage Provision: Deck slab is provided with 2.5% camber and drainage spouts with 5m c/c are adopted.

V. COMPUTATIONAL WORK OF BRIDGE

In this chapter the details of Reinforced Concrete T- beam deck slab bridge are analyzed using the CSI Bridge software. The bridge software will make use of Finite Element Method to run the analysis. The materials adopted are M30 grade concrete and HYSD reinforcement. The parametric study is carried out to study the shear force and bending moment in various spans.

A. Steps Involved In Computational Work

1) Give layout and lane details
2) Generate the model of the bridge by giving components details
3) Apply the desired live load condition
4) Give the dead load details
5) Run analysis
6) Check results

B. Generation Of Bridge Model

The bridge model is generated after giving the material properties and the frame properties.

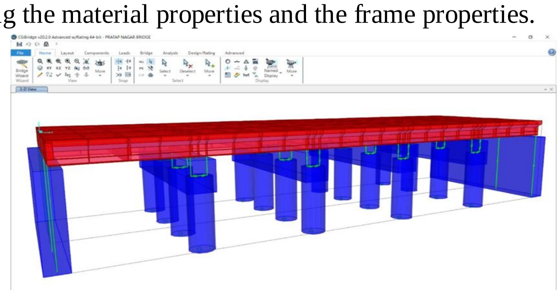

Figure 14: Bridge model

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C. Application Of Live Load

Loads are taken into consideration, according to IRC:6 – 2000, Here, IRC Class AA Loading is taken.

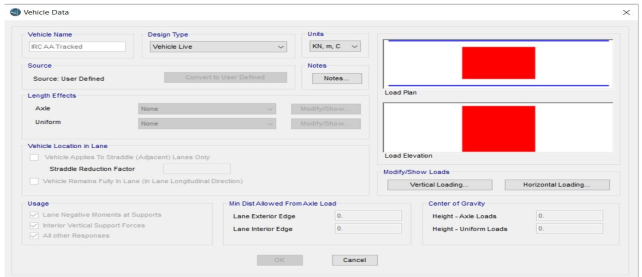


Figure 15: Application of IRC Class AA Loading

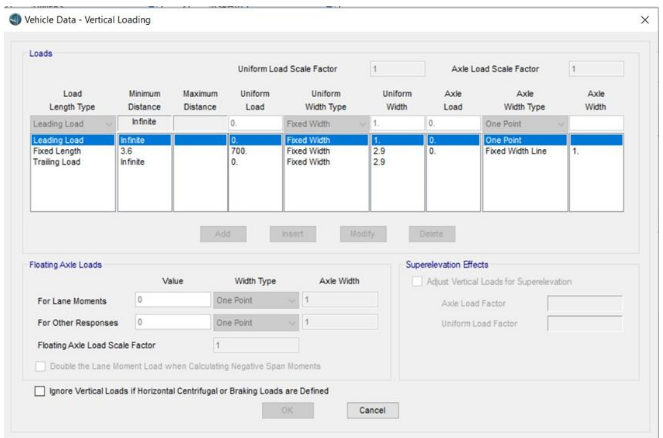
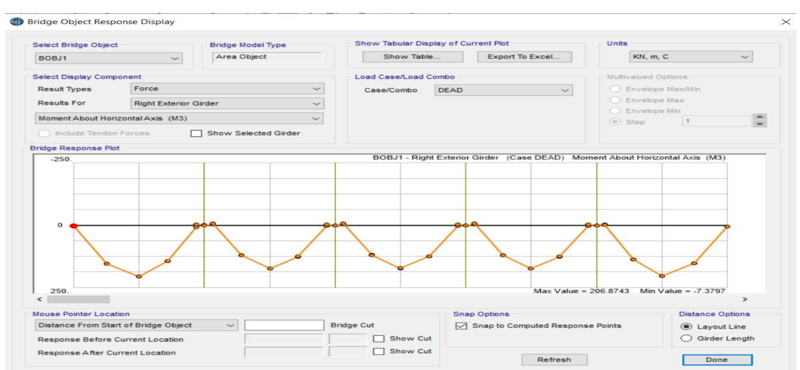


Figure 16: Vertical loading due to IRC Class AA loading

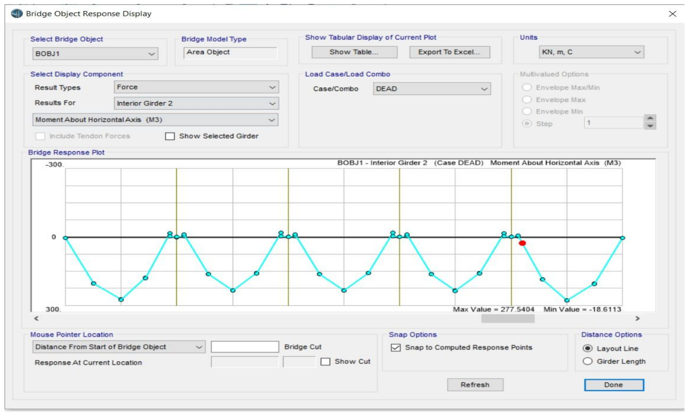
VI. RESULTS AND DISCUSSION

The Reinforced Concrete T beam bridge is 36m long with 5 equally distributed spans of each 7.2m. It is having two external girders and two internals girders. The maximum bending moment is observed in the external spans of the bridge. The maximum bending moment in the outer girder due to dead load in the external spans (span 1 and span 5) is 206.87 kN-m and the maximum bending moment in the outer girder due to dead load in the internal spans (span 2, span 3 and span 4) is 174.06 kN-m.



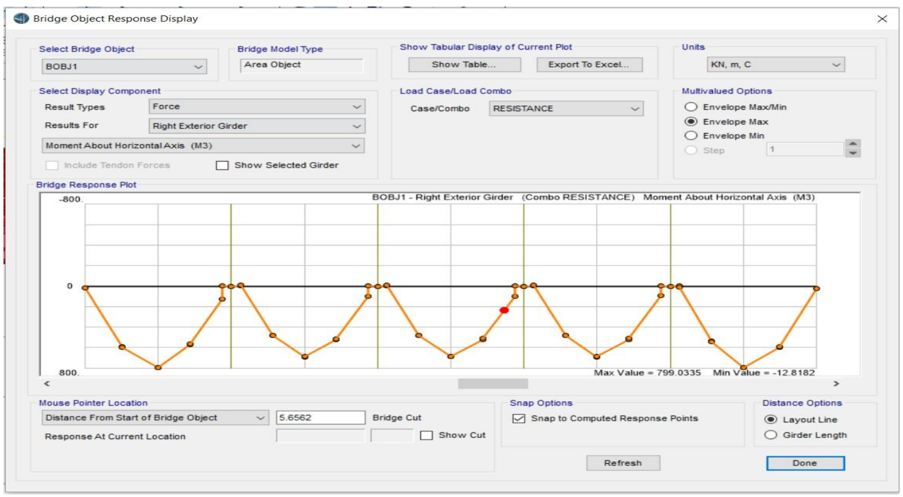
Graph 1: Bending moment in the external girder due to dead load

The maximum bending moment in the internal girder due to dead load in the external spans (span 1 and span 5) is 277.54 kN-m and the maximum bending moment in the internal girder due to dead load in the internal spans (span 2, span 3 and span 4) is 235.28 kN-m.



Graph 2: Bending moment in the internal girder due to dead load

The maximum bending moment in the outer girder due to live load in the external spans (span 1 and span 5) is 779.03 kN-m and the maximum bending moment in the outer girder due to live load in the internal spans (span 2, span 3 and span 4) is 690.71 kN-m.

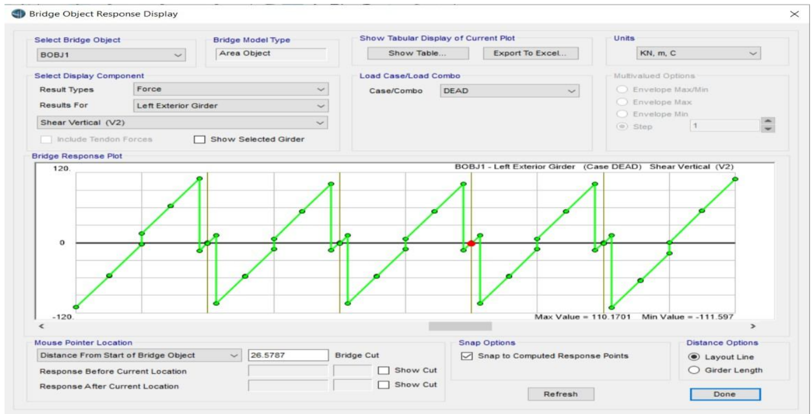


Graph 3: Bending moment in the external girder due to live load

The maximum bending moment in the internal girder due to live load in the external spans (span 1 and span 5) is 1276.7 kN-m and the maximum bending moment in the internal girder due to live load in the internal spans (span 2, span 3 and span 4) is 1108.68 kN-m.

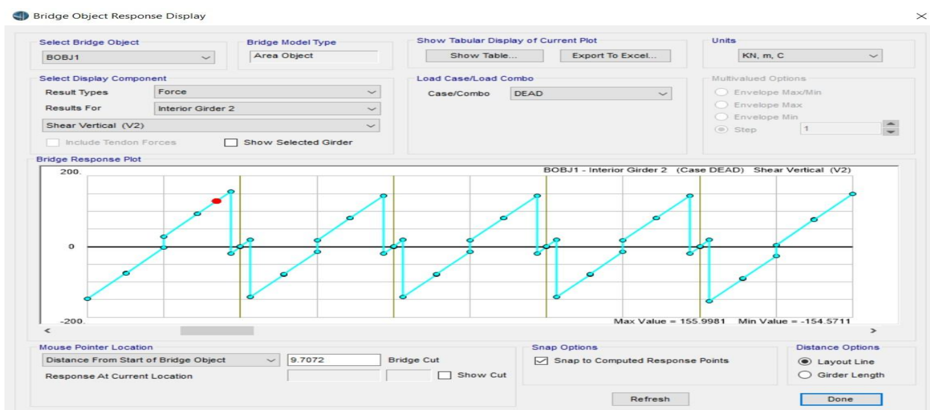
Graph 4: Bending moment in the internal girder due to live load

The maximum shear force is observed in the external spans of the bridge. The maximum shear force in the outer girder due to dead load in the external spans (span 1 and span 5) is 110.17 kN and the maximum shear force in the outer girder due to dead load in the internal spans (span 2, span 3 and span 4) is 101.33 kN.



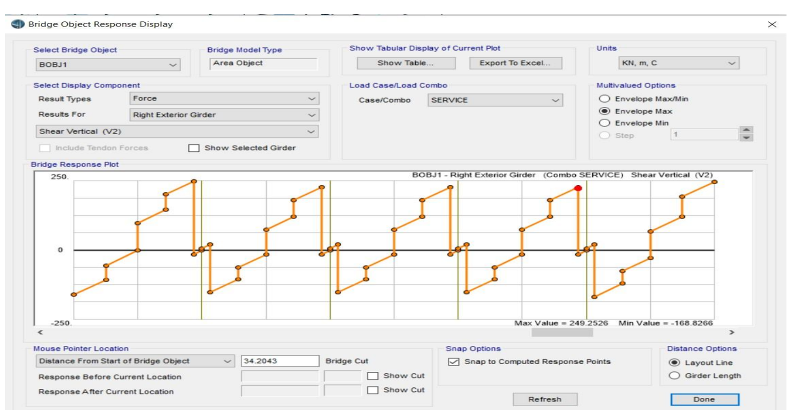
Graph 5: Shear force in the external girder due to dead load

The maximum shear force in the internal girder due to dead load in the external spans (span 1 and span 5) is 155.99 kN and the maximum shear force in the internal girder due to dead load in the internal spans (span 2, span 3 and span 4) is 142.50 kN.



Graph 6: Shear force in the internal girder due to dead load

The maximum shear force in the outer girder due to live load in the external spans (span 1 and span 5) is 249.25 kN and the maximum shear force in the outer girder due to live load in the internal spans (span 2, span 3 and span 4) is 228.00 kN.



Graph 7: Shear force in the external girder due to live load

VII. VALIDATION OF RESULTS

A. Maximum Bending Moment And Shear Force By Using Courbon's Method

Table 3: Maximum Bending Moment and Shear Force by using Courbon's Method:

Bending moment	DL	LL	TOTAL	UNITS
Outer girder	276.8	882.42	1159.22	kN-m
Inner girder	276.8	1120.35	1397.15	kN-m
Shear Force	DL	LL	TOTAL	UNITS
Outer girder	130.421	275.224	405.645	kN
Inner girder	130.421	387.823	518.244	kN

B. Maximum Bending Moment And Shear Force By Using Finite Element Method

Table 4: Maximum Bending Moment and Shear Force by using Finite Element Method

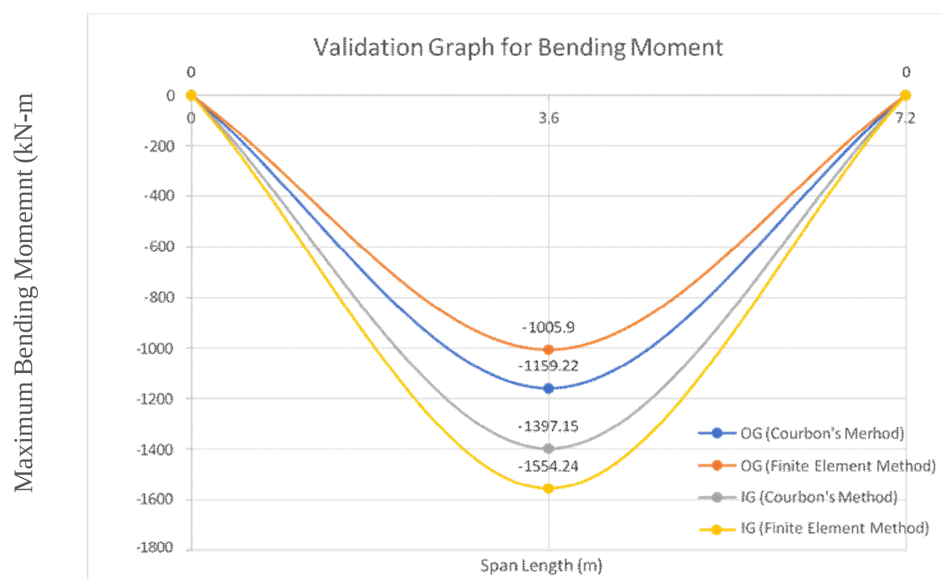
Bending moment	DL	LL	TOTAL	UNITS
Outer girder	206.87	799.03	1005.90	kN-m
Inner girder	277.54	1276.7	1554.24	kN-m
Shear Force	DL	LL	TOTAL	UNITS
Outer girder	110.17	249.25	359.42	kN
Inner girder	155.99	456.99	612.98	kN

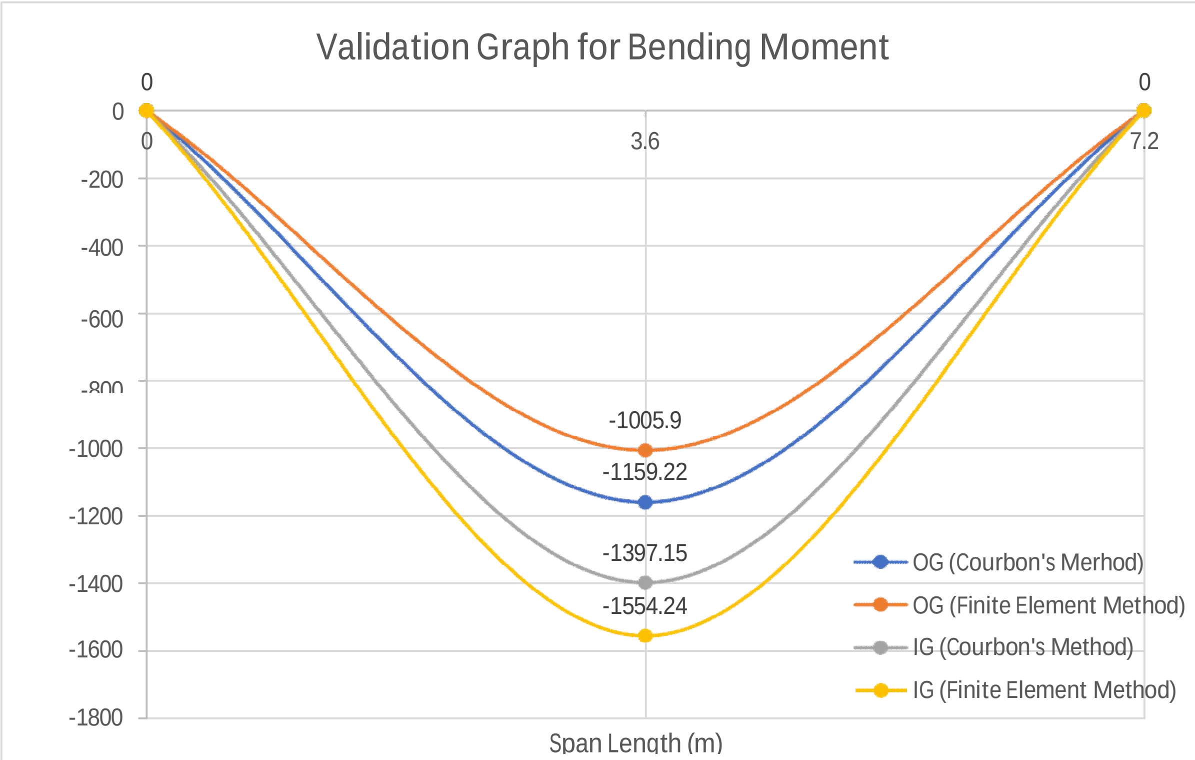
*C. **Validation Of Results***

Maximum Bending Moment:

Table 5: Validation of maximum Bending Moment

Methods	Bending moment	DL kN-m	LL kN-m	TOTAL	Percentage difference
Courbon's Method	Outer girder	276.8	882.42	1159.22	13.2 %
Finite element method	Outer girder	206.87	799.03	1005.90	
Courbon's Method	Inner girder	276.8	1120.35	1397.15	10.10 %
Finite element method	Inner girder	277.54	1276.7	1554.24	



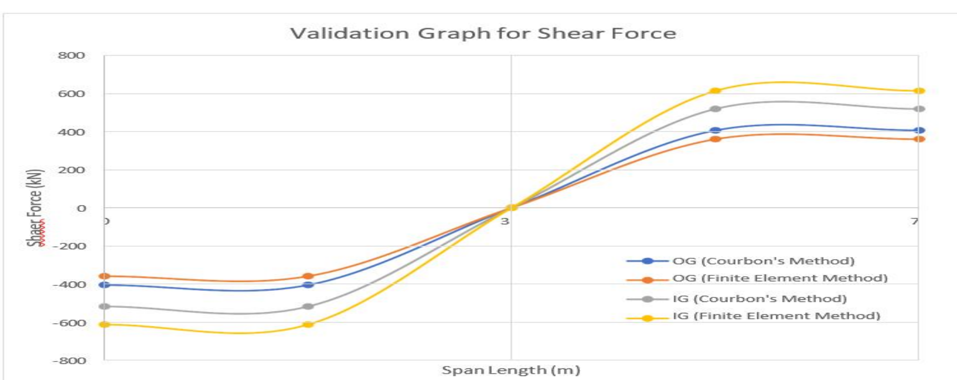


Graph 9: Validation Graph for Bending Moment

D. *Maximum Shear Force*

Table 6: Validation of maximum Shear Force

Methods	Shear Force	DL kN	LL kN	TOTAL	Percentage difference
Courbon's Method	Outer girder	130.421	275.224	405.645	11.39 %
Finite element method	Outer girder	110.17	249.25	359.42	
Courbon's Method	Inner girder	130.421	387.823	518.244	15.45 %
Finite element method	Inner girder	155.99	456.99	612.98	



Graph 10: Validation Graph for Shear Force

VIII. SUMMARY AND CONCLUSIONS

A. Summary

The general objective of this project is to Design and Analyse the reinforced concrete T- Beam Bridge. The manual design is done and the computational work is done using CSI Bridge software. The following conclusions have been drawn out.

B. Conclusions

1) The Analysis and Design of the T- Beam Bridge is safe and within the permissible limits.
2) The manual calculation of the bridge was done by Courbon's Method and the computation work was done by CSI Bridge Software for validation.
3) The values obtained by the manual calculation and computation work was within the permissible limits and its safe.
4) The maximum Bending Moment and Shear Force are obtained in the End Spans when compared with intermediate spans of the bridge.
5) The Maximum Bending Moment of 1159.22 kN-m is obtained in Outer Girders and 1397.15 kN-m is obtained in Inner Girders by using Courbon's method.
6) The Maximum Bending Moment of 1005.9 kN-m is obtained in Outer Girders and 1554.24 kN-m is obtained in Inner Girders by using CSI Bridge Software.
7) The Bending Moment obtained in the inner girders is more when compared with outer girders.
8) The values obtained by the CSI Bridge almost matches the results obtained by the Courbon's method when subjected to Class AA Tracked loading.
9) Using finite element software (CSI Bridge) results are reduced by 13.2% as compared to Courbon's Method for Bending moment and reduced by 11.39% for Shear Force in Outer Girder.
10) Using finite element software (CSI Bridge) results are increased by 10% as compared to Courbon's Method for Bending moment and increased by 15.45% for Shear Force in Inner Girder.
11) The dimensions of the pier adopted are safe as the stresses are in safe permissible limits.
12) The values obtained by the finite element analysis give more economical structure compared to conventional method.

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