"Structural Analysis and Design Optimization of Steel I-Girder Bridges Using CSI Bridge Software."

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How to Cite this Article:
Ratnakar, D. (2026). "Structural Analysis and Design Optimization of Steel I-Girder Bridges Using CSI Bridge Software.". International Journal of Creative and Open Research in Engineering and Management, <i>02</i>(6). https://doi.org/10.55041/ijcope.v2i6.355

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ABSTRACT: Bridges play a vital role in modern transportation infrastructure and are essential components of road networks. With the continuous increase in traffic volume, bridges are subjected to repeated loading, which can lead to structural deterioration over time. Therefore, understanding the interaction between vehicles and bridge structures is crucial for ensuring their safety, durability, and serviceability. The primary objective of bridge engineering is to efficiently utilize structural materials and design methods to achieve optimal performance and economy.

This study presents the analysis and design of a steel I-girder bridge and introduces a comprehensive design methodology developed during the research. The work focuses on evaluating the current design practices and comparing the provisions outlined in the Indian Roads Congress (IRC) specifications with those of the American Association of State Highway and Transportation Officials (AASHTO). The comparative assessment highlights the similarities and differences between the two design standards for steel I-girder bridges.

The bridge model was developed and analyzed using CSI Bridge software, which provides a parametric, object-based modeling environment for bridge engineering applications. The software enables efficient creation of analytical bridge models while integrating material properties, geometric configurations, loading conditions, and design parameters within a unified framework. This object-oriented approach simplifies the modeling process and enhances the accuracy and efficiency of bridge analysis and design.

Keywords: Steel I-Girder Bridge, Structural Analysis, Bridge Design, CSI Bridge Software, IRC Specifications, AASHTO Standards, Parametric Modeling.

INTODUCTION: Bridge is a structure which permits the section of people on foot or vehicles worked over anyhindrance or water body. There are several bridge designs that serve an appropriate purpose.Depending on the behavior of bridge

There are various types of bridges :-

1. Timber bridge
2. Concrete bridge
3. Steel bridge
4. Composite bridge

Bridge has mainly two sections the superstructure and the substructure. The superstructure hasdeck slab, I-Girder and shear connectors though substructure has of the footer, stem and the cap.Composite construction consists of two unique materials which are strongly bound to form asolitary unit.

"Composite" implies that the concrete portion of the deck is associated with the steel portion of the bridge by shear connectors [iv]. Shear connectors are fundamentally fixed on steel beams and then they are embodied in the concrete slab. Shear connectors can be associated by welding, or utilizing nut and bolts [v].A steel beam which is assembled composite by utilizing the shear connectors and concrete which is more strong and stiff as compared to beam.

Figure Composite bridge

Various types of bridges:

• Arch bridges
• Rigid frame bridges
• Cable stayed bridges
• Truss bridge
• Girder bridge

OBJECTIVE:

1. To review the modelling of the bridge using CSI-BRIDGE 2000(software) and establishan object-based modelling approach. It assigns bridge composition as an assembly ofobjects.
2. Application of load and its combination to further analyse the bending moment and shearforce. Software gives different building code (AASTHO, IRC), by using that vehicle,wind, seismic loading can be calculated.
3. To determine all the variables of design, construction and material relative to the basicstructural calculations.

LITERATURE REVIEW:

Yingli gao, Liang Huang (2008) [16] Significant research has been done that, under adverse weather conditions the friction coefficient of the pavement decreases and finally leads to thawing. In order to prevent these various methods like scavenging with artificial and mechanical, with scattering snow melting agent, with heating cable method. The disadvantages are that it has low efficiency, waste of man power and can easily harm the pavement. It can easily erode the pavement material due to snow melting material. It doesn't meet the current demand of energy conservation. The authors have proposed that the steel pipes used in the phase change functional provide reinforcement which improves the strength of the bridge deck. The sections with steel pipes and PCM (Phase Change Materials) thaw ice more easily and hence improving the anti-freezing and anti-sliding capabilities of bridge deck

Ibrahim S.I. Harba (2009) [17] In this the author indicated that for skew bridges maximum live load, bending moment and deflection decreases while maximum shear, torsion and support reaction increases.

Pranathhi Reddy, Karuna S (2010) [18] In this the author has compared the behavior of normal bridge to skew bridge at different angles. Magnitude of shear force reduces withthe increase in skew angle. In case of moving loads, the shear force increases withincrease in skew angle.

Arindham Dhar, Mithil Mazumdar, Mandakini chowdhary and Somnath Karmakar (2012) [19]Significant research has been done on the mid span longitudinal moment which steadily increases with the increase in the skew angle for obtuse angles girder and decreases for the acute angle. In obtuse angled girder there is rapid increase in the torsional moment with the increase in the skew angle.

C. Topkaya, J. A. Yura, E. B. Williamson, and K. H. Frank (2012) [20]: In this the author indicates the concrete deck behaviour and the interface of steel girder at early stages The deck, due to large volume of concrete is casted in two stages, in order to control shrinkage. The measured and the predicted quantities are observed and it gives an indication that concrete act compositely with bridge at early times.

Amir Reza Ghiami Azad, Hemal Patel, Michael Engelhardt, Todd Helwig, EricWilliamson, Richard Klingner (2013) [21]: It indicates that the non-composite steel girder bridges which are continuous and post installed shear connectors and moment distribution is possible and efficient in extending the life of the bridge. By strengthening the composite by 30%, the load ratings can be increased by 60 %. By simple plastic analysis ultimate strength can be calculated.

VICTORIA E. ROŞCA*, ELENA AXINTE, CARMEN E. TELEMAN (2013) [22]:In this the author proposes the composite I beam's cost optimization. Nonlinear approach is followed for the optimization. The design of composite beams are performed by design module, cost of composite beams by cost module, search for optimal design by optimization module.

Vikash Khatri, Pramod Kumar Singh, P.R.Maiti (2013) [23]: In this the comparison of prestressing force and the total area of steel is described and the stresses in the deck slab. By anchoring tendons, shrinkage strain can be modified. Restressing force for 5girder bridge is more than that of four girder bridge. The maximum stress for five girders bridge is more than that of 4 girder bridge.

Zhou Wangbao, Jiang Lizhong, Kang Juntao, Bao Minxi (2013) [24]: In this the author the coupling effect of loads are improved by elastic methods. Critical methods are developed and are compared with traditional methods. There is linear relation between vertical loads and lateral strains. Critical bending buckling is rarely affected by the moment and length.

Y.P.Pawar, S.S.Kadam, D.D.Mohite, S.V. Lale, C.M. Deshmukh (2013) [25]: In this the author explained the moment variation in T girder. In T- section only one flange and web will be in low resistance against torsion. It explained the variation in bending moment along long span and short span due to girder's self-weight.

Ashraf Ayoub, Associate Member, ASCE, and Filip C. Filippou, Member, ASCE(2014) [26]: In this analysis of steel girders is done by inelastic beam element. BY interface model shear connector's partial interaction can be maintained. The stability characteristics are presented in a program using nonlinear analysis

Jan Bujnak , Jaroslav Odrobinak (2014) [27]: In this the author proposes the hogging area influence of the slab stiffness. The influenced flexural behaviour of non-structural parts can be ignored; minor differences are explained. The structural behaviour can be done by spatial model of composite bride approximation

Epuri Pavan Kumar, Arepally Naresh, Sri Ramoju Praveen Kumar,Amgoth Ashok(2015) [28]: In this paper it shows the comparative study of the AASHTO and IRC codes. The stress values are compared for different sections. It concluded that AASHTO code has less value than IRC code.

H.R.Nikhade, A.L.Dandge, A.R.Nikhade(2015) [29]: In this the author explains that with the increase in grade, moment decreases. Analysis of box girder is carried out by mathematical model

MATERIAL AND METHODOLOGY

TYPES OF LOADS

Different loads and stresses ought be considered into account while outlining the superstructure:-

1. Dead load
2. Live load
3. Dynamic load
4. Longitudinal forces due to tractive exertion of vehicles.

Detail of IRC loading:-

The designed live load might comprise of standard wheeled or tracked vehicle ortrain of vehicles for bridges. The standard vehicle or trains might be expected to parallel to the length of bridge and to possess any position which will produce maximum stresses, within the kerb to kerb width of roadway. For every vehicle ortrain all the axles of unit of vehicle shall be in position causing maximum stresses. Vehicle in adjacent lanes should be considered as headed in the direction of maximum stresses. The spaces on carriageway left uncovered by the standard train of vehicles shall not be assumed. For wind load all the structure ought to be designed for the lateral wind forces. These forces ought to be considered to act horizontally and in the direction that resultant stresses in member under consideration are maximum. The intensity of wind forces should be based on wind pressures and wind velocities which are allowed for design.

ANALYSIS OF STEEL-I-GIRDER BRIDGE

DESIGN USING CSI-BRIDGE:

Model the bridge: Start the modelling of bridge by specifying the lane width. Utilizing bridge wizard change the material properties and also entering the vehicle classes i.e. IRC class AA loading, IRC class A loading, IRC class 70 R loading using Indian codes. Mention the deck section properties. Using the bride object data enter the diaphragms along the span of the bridge at equal interval. Mention the abutments, bents, bent cap with its dimensions in the frame properties, specify where the bent assignment is being applied, it is basically applied at the end of the span. The diaphragm assignment includes a diaphragm location, property, and orientation, in span diaphragms are assigned as a part of bridge object definition. Diaphragms that occur at abutments, bents and hinged are assigned as a part of the bridge object abutment, bent and hinge assignments respectively. Load the bridge model available in CSI-Bridge. A moving load analysis can be utilized to decide the reaction of a bridge structures as a result of weight of vehicular live loads. Lanes are required if vehicular loads are to be added to a bridge model. Vehicles move in both directions along each lane of the bridge. Vehicles are consequently situated at such positions along the length and width of the lanes to produce the maximum and minimum response quantities throughout the structure. After the bridge model geometry, load patterns and load cases have been characterized, the bridge model is prepared for analysis. the result is shown graphically.

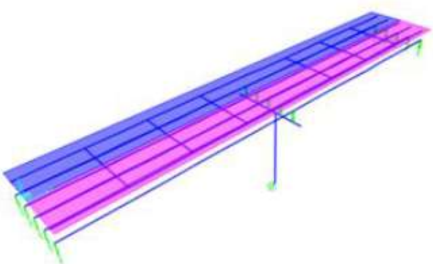

Figure Bridge Model

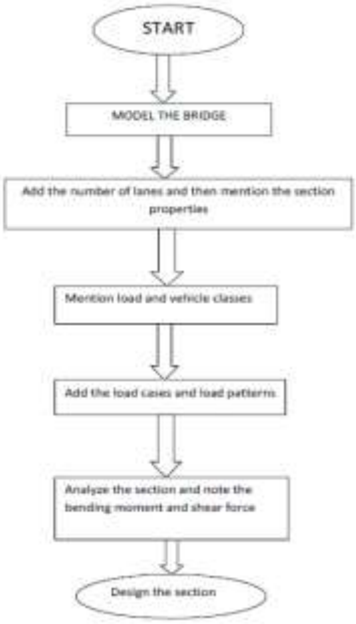

Figure Flowchart

CONCLUSIONS

In the present thesis the two span bridges were modelled using CSI-Bridge and compared with the manual calculations using different frame sections and material properties. The girder section designed for IRC class AA loading and IRC class A loading. The bending moment and shear force was compared as analysed by CSI- Bridge. Therefore, the different trial sections were taken in order to calculate the bending moments and deflections. However, some conclusions were drawn as follow. The bending moment decreases with increase in the grade of concrete in Steel I-Girder Bridges as span length increased. The excel sheets was developed for the design of medium to long Steel I-Girder Bridges (from 25 m span to 50 m span. However, the analysis and design of Steel I-Girder Bridges for any span can be obtained from mathematical models without doing lengthy calculations. The effect of grade of the concrete on the torsion was also explained for the different span length of in Steel I Girder Bridges. The values of axial force and shear force for IRC and AASTHO was also compared.

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