Available online: www.ijsrmes.com
International Journal for Scientific Research in Modern Engineering and Science
Published in: Vol. 1, Issue 3, pp. 1-6, July-August 2026

A Review on Analysis of bridge Deck Performance Considering Different Types of Girder and Span Length

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Abstract

This paper presents a review of current methods used in designing the reinforcement for concrete and steel composite bridge decks that are supported by wide flange girders. It is commonly assumed that slabs are continuously supported at the midpoints of girders, without considering the influence of the girder flange's stiffness. This design approach may result in overly cautious reinforcement of the slab. The efficiency, speed and cost savings are the key components of a bridge deck construction. After reviewed, the further work is proposed to response of the bridge deck of 20m – 60m span and 15m width of the five types of bridge for IRC Class-AA loading is analysed using Ansys software. From the analysis it has been found that the model designed in this research work gives efficient results and also the results are satisfied with the standard values of IS Codes. Also, the present work, dynamic analysis with moving loads Class-AA vehicle database has been performed and compared considering with five types of bridge structure.

Keywords: *Girders, Bridge deck, Bridge Design and Steel, Reinforcement.*

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1. Introduction

A structure that allows passage over a gap while leaving the space beneath it open. The passage could be attributed to railways, roads, canals, and natural rivers, among other possibilities. At first, bridges were largely built using naturally occurring materials like stone and timber, but today, artificial materials such as cement concrete and steel are more commonly used in bridge construction. The typical design life of bridges is established to ensure a satisfactory period of service. Over its lifetime, the bridge must satisfy key fundamental criteria including structural strength, functionality, and longevity which are ensured through proper design, manufacturing, construction, and maintenance. In terms of design, this approach is grounded in the evaluation of both ultimate and serviceability limit states, which must be validated for persistent, transient, and accidental load scenarios. This paper aims to review existing work on bridge superstructure design and to shed light on the actual mechanisms at play, using a simplified model as a framework. This is done to establish a solid foundation for a more economical design approach and to support well-justified recommendations for future research.

2. Literature Review

Jeswani and Budhlani [1] analyzed the T-beam bridge using STAAD.Pro software. This analysis and design of the bridge deck and beams were carried out using software, focusing on a specific bridge model with a defined span and carriageway width. The bridge was subjected to various IRC load conditions, including IRC Class AA, IRC Class 70R, and tracked loading. to achieve the highest bending moment and shear force.

Nwofor and Nnoaham [2] concluded that the balcony function employed in this study, when applied to bridge deck analysis via the acceleration-displacement method, yielded reliable results for moments, deflections, and shear forcesproviding valuable insights for the design and detailing of bridge decks, ultimately enhancing construction efficiency.

Ajay [3], Ajay examined a single-span, two-lane bridge subjected to IRC Class AA tracked loading, analyzing its behavior by varying the span length using specialized software. The study primarily concentrated on the economic depth of a longitudinal girder across various bridge spans.

Rao [4] analyzed the simply supported RC T-beam bridge using both the rational method and the finite element method implemented in STAAD.Pro. This study found that, when compared to the Guyon Massonnet method, Courbon's Method yields average results in terms of bending moment values for longitudinal girders. The study also concludes that the bridge deck was analyzed using both the grillage analogy method and the finite element method.

Powar and Khurd [5] conducted a study on the modal and transient analysis of a bridge deck slab under moving loads, utilizing ANSYS software. The results of the modal analysis are compared with prior literature and found to be in close agreement.

The parametric study focuses on deflection, stress, and strain as the model's dimensions vary Balamurugan and Hemalatha [6] noted that a passage over an obstaclesuch as a road, railway, or pipelinemay be relevant. T-beam bridges are among the primary types of cast-in -place concrete decks. It comprises a concrete deck slab poured as a single unit atop the longitudinal girders. Typically, bridge structures are exposed to two kinds of loads, namely: stationary and moving loads.

Eom et al. [A modified precast construction method known as Turn Over (TO) was proposed to enhance construction efficiency, specifically for flipping an I-section steel girder. A full-scale 20-meter single-girder specimen and a full-scale 20-meter two-girder plate bridge specimen were employed to determine the optimal cross-section design, identify the best location for confining concrete, and assess overall structural performance.

Kanth and Prasad [8]: This paper presents a design for a small bridge. We intend to address every aspect of the redesign. This will cover the design of the new bridge, its environmental impact on the surrounding area, and the logistical aspects of the construction phase.

Kumar and Ram [9] present a study focused on the analysis and design of the superstructure for a combined road and railway bridge spanning the Krishna River, located downstream of the current bridge between Mahanadi Road in Sithanagaram and P.N. Bus Station in Vijayawada. The bridge features a through-type steel truss design, supporting two railway tracks on the lower level and a three-lane roadway on the upper level.

Kamatagi [10] conducted a study on a simple-span T-beam bridge using STAAD.Pro. The study shows that the maximum bending moment occurs under loading conditions for class 70R vehicles. Following the results, the T-beam bridge was designed using both methods, i.e., (IRC21 & IRC112). It was observed that the results from the finite element method were lower than those obtained using the working stress method.

Ahmed [11] analyzed the T-beam girder according to IRC specifications and demonstrated that the results from the FEM method were more economical compared to those from one-dimensional analysis. A comparison of T-beam and Box Girder designs for spans up to 25 meters Lu et al. [12] proposed a spatial grillage model for analyzing a T-frame bridge. The static and dynamic analysis results from the spatial grillage model of the T-frame bridge are compared with those derived from field testing.

Abbasi and Pahwa [13] compiled and computed a range of dynamic and static characteristics for a cable-suspended bridge structure. Simulations demonstrate that most of the displacement in a cable suspension bridge is caused by heavy traffic, not wind pressure.

Dzolev et al. [14] provided text appears to be incomplete or corrupted. Please provide a valid sentence or passage for paraphrasing. This paper presents an analysis of a reinforced concrete girder bridge designed in accordance with EN 1998-2, focusing on the ductility attained at plastic hinges under the target displacement corresponding to the designed seismic action. The study considers both confined and unconfined concrete cross sections, with and without the influence of geometric nonlinearity.

Kulkarni and Karadi [15] conducted a seismic evaluation case study for an existing reinforced concrete bridge using nonlinear static (pushover) analysis. For this study, a four-span reinforced concrete bridge located on SH-12 in Karnataka, India, was chosen. The bridge was analyzed using nonlinear static (pushover) analysis based on the FEMA 356 guidelines and Auto hinges, employing the ATC 40 capacity spectrum method, with SAP2000 software used for the analysis.

Karthiga et al. [16] provided text appears to be incomplete or corrupted. Please provide a valid sentence or passage for paraphrasing. This paper offers a linear analysis of the substructure of rail over bridges, accounting for IRS 25 t railway loading, and of road over bridges, considering IRC class-A loading. Roads over bridges are bridges that allow the roadway to pass over them.

Li et al. [17] provided text appears to be incomplete or corrupted. Please provide a valid sentence or passage for paraphrasing. This paper investigates the seismic responses of corrosion-damaged RC bridges subjected to spatially varying ground motions. The analysis takes into account the chloride-induced corrosion damage to the bridge. Using the time-variant chloride corrosion current density, the level of reinforcement corrosion in the bridge piers is assessed.

Cao and Yuan [18] examine pushover analysis of bridges featuring elevated pile foundations, noting that the inelastic effects of the second mode must not be overlooked. Generalized pushover analysis cannot be used directly under this condition. A revised generalized pushover method is developed to estimate seismic demands for bridges featuring elevated pile foundation systems.

Paolacci et al. [19] were intended for gravity loads and typically included plain steel bars. As a result, most bridges lack seismic detailing, making their structural performance generally insufficient during earthquake ground motions.

Rahai et al. [20] assessed the erratic performance of two prestressed concrete bridge models using the capability spectrum method (CSM) and the displacement constant method (DCM). The displacement-controlled pushover analysis was used to assess the structural capacity.

Al-Sarraf et. al. [21] provided text appears to be incomplete or corrupted. [22] analyzed anisotropic platesthose with varying elastic properties and geometries across different directionsusing a model composed of four side beams featuring both flexural and torsional rigidity, plus two diagonal beams with flexural rigidity only.

Monteiro et al. [22] provided text appears to be incomplete or corrupted. Please provide a valid sentence or passage for paraphrasing. This paper aims to revisit that issue from the perspective of modeling type. At present, the majority of structural seismic analyses are conducted using either fiber-based or plastic hinge models.

Onyia [23] demonstrates that finite element solutions for the bridge deck problem align reasonably well with those derived using the method of distribution coefficients, with a maximum mean difference of less than 0.4%.

Mahmood and Al-Ghabsha [24] employed the finite element method to model the cross section of the prism, complemented by appropriately selected Fourier series to capture the prism’s longitudinal behavior, ensuring compliance with simply supported boundary conditions at its ends.

3. Conclusion

Limited work has been conducted on determining the dynamic response of bridges. Bending, tension, deformation, etc. Moving loads on a bridge have a more significant impact on the deck slab. It is challenging to pinpoint the impact of the key parameters that influence the response. Because of vibrations, changes in stress, strain, and deflection take place. Therefore, understanding the dynamic behavior of the deck slab is crucial. In this study, we identify how stresses, strains, deflection, and frequency vary as the span length, bridge deck type, or girder configuration changes. Ansys software supports all kinds of analysis. The load carried by IRC Class AA vehicles moving across the deck in a direction parallel to the span. The damping effects in both the bridge and the vehicle are disregarded. It is assumed that the vehicle will stay in contact with the deck. To make it useful for future analysis of bridge deck slabs. The design of bridges must account for dynamic response, as it plays a crucial role in achieving a bridge structure free from vibration and disturbance.

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