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CAPACITY ASSESSMENT OF OLD MAJOR DISTRICT ROAD BRIDGE

Ashish Varadai[1], Meghashree.M[2]

PG Student, Department of Civil Engineering, Dayananda Sagar College of Engineering, Shavige Malleshwara Hills, Kumaraswamy Layout, Bengaluru, Karnataka 560078, India[1]

Assistant Professor, Department of Civil Engineering, Dayananda Sagar College of Engineering, Shavige Malleshwara Hills, Kumaraswamy Layout, Bengaluru, Karnataka 560078, India[2]

Abstract: This collection of research endeavors encompasses a broad spectrum of studies focused on bridge analysis and design, providing distinctive insights into diverse bridge structures and their behaviors across varying conditions. The papers delve into a wide range of topics, from evaluations of T-beam girder bridges to assessments of aging T-beam bridges' capacities, investigations into dynamic responses of high-speed vehicles on bridges, and finite element analyses of deteriorated T-girder bridges subjected to cyclic loading. Additionally, the paper on finite element failure analysis underscores the vital significance of precisely modeling support conditions within the CSi Bridge software. Collectively, these studies make substantial contributions to the realm of bridge engineering knowledge, offering valuable insights for designers, engineers, and researchers committed to enhancing the safety and integrity of diverse bridge types across a multitude of operational scenarios.

Keywords: Bridge design, Bridge analysis, , CSi Bridge, T-girder Bridges.

I. INTRODUCTION

In recent decades, the field of civil engineering has undergone significant progress, particularly with the emergence of advanced software tools that simplify the analysis and design of intricate structures. Among these tools, CSi Bridge software has emerged as a versatile and potent solution tailored for the comprehensive analysis, design, and assessment of bridge structures. This paper aims to provide an introduction to CSi Bridge software, offering insights into its capabilities, features, and applications within the domain of civil engineering.

Bridges are indispensable elements of modern infrastructure, playing a crucial role in connecting communities, facilitating transportation, and ensuring the secure movement of both vehicles and pedestrians. The intricate process of designing and maintaining bridges necessitates a profound comprehension of structural engineering principles, coupled with advanced computational resources that can effectively address the evolving challenges of the 21st century. Developed by Computers and Structures, Inc. (CSI), CSi Bridge software has firmly established itself as a pioneering software package that empowers engineers to confront these challenges.Within this paper, we delve into the salient attributes of CSi Bridge software, emphasizing its user-friendly interface, robust modeling capabilities, and all-encompassing analysis tools. We explore its versatile applications in designing a diverse array of bridge types, encompassing highway, railway, and pedestrian bridges, while discussing its role in aiding engineers to optimize structural performance while adhering to safety protocols and industry standards.

Furthermore, we scrutinize the seamless integration of CSi Bridge with Building Information Modeling (BIM) workflows, a feature that fosters streamlined collaboration among architects, engineers, and contractors, thereby enhancing project efficiency and precision. We also touch upon the software's capacity to execute dynamic analyses, addressing the pivotal aspect of a bridge's response to dynamic forces, including seismic loads and other dynamic factors.

Parametric study on reinforced concrete T-beam girder bridges:
Nishi Gupta, Amit Kumar Kaushal, Rakesh Ranjan

The paper explores a crucial aspect of India's infrastructure development, focusing on T-beam girder bridges which are prevalent on the country's highways. Undoubtedly, a nation's progress is intricately tied to its infrastructure, and highways constitute a significant component. This study, centered on a T-beam girder bridge, undertakes a thorough investigation into its structural behavior under both dead loads and live loads as stipulated by the Indian Road Congress (IRC). Utilizing linear finite element analysis via CSiBridge22 software, the research delves into the influence of key factors such as skew angle, span, span-depth ratio, loading conditions, and girder spacing on the bridge's performance. The study evaluates the impact of span length and skew angle on critical parameters like bending moment, shear force, torsional moment, and deflection. To validate the findings, manual calculations are compared with results derived from the finite element model.

The research conducts a convergence study to optimize the mesh size, revealing that the skew angle significantly affects the bridge's behavior compared to other characteristics. Notably, the mid-span bending moment and deflection decrease with an increase in skew angle, while shear force and torsional moment experience an upward trend. In essence, this study contributes valuable insights into the nuanced behavior of T-beam girder bridges, shedding light on the pivotal role of skew angles and providing essential information for the enhancement of infrastructure design and highway construction practices in India.

Analysis of RC bridge decks for selected national and international standard loadings using finite element method: Hemalatha A, Ashwin K. N, Dattatreya J.K , S.V. Dinesh

The paper provides a comprehensive comparison of the impact of different standard loadings on reinforced concrete bridge decks using finite-element analysis. The study focuses on two critical parameters: the aspect ratio (span/width) and the type of loading. Specifically, it examines both two-lane slab bridge decks spanning from 5m to 9.5m and two-lane T-beam bridge decks spanning from 7.5m to 20m. A total of 36 distinct bridge models are subjected to analysis. The investigation evaluates various crucial structural response indicators—such as deflection, longitudinal bending moment, transverse moment, shear force, and torsional moments—across different loading scenarios: IRC loading (IRC Class A and 70R loadings), AASHTO loading (HL93), and Euro standard loading (LM1). The study's findings highlight intriguing disparities in results across these loading conditions. Notably, for IRC standard loading, the maximum divergence in deflection and longitudinal bending moment ranges between 5% to 15%, while the corresponding values for AASHTO loading vary from 5% to 17%. It's observed that the Euro standard loading's maximum axle load is significantly higher (2.2 times) than IRC Class A loading's maximum axle load, consequently leading to a 1.7 to 1.8 times increase in structural response parameter values. This underscores the necessity for adopting more realistic and simplified standard loads in the future. In summary, the research underscores the need for precise standard loading regulations to ensure the accurate assessment and design of reinforced concrete bridge decks, thereby enhancing their performance and safety.

Analysis of single and Multi-span Slab Bridges using CSi Bridge Software: Supreetha YL, Suraj Shet, Sagar S

Bridges hold an indispensable role in the transportation system, serving as essential components that everyone relies upon. However, their reliability hinges on the recognition and mitigation of potential structural deficiencies. The methodology chosen for structural analysis plays a pivotal role in understanding and ensuring a bridge's stability. The decision between static and dynamic analysis methods is influenced by a multitude of factors, including the analysis purpose, structure's significance, available analysis techniques, bridge type, and soil conditions, including soil-structure interaction. Addressing this concern, this paper undertakes the task of analyzing single and multi-span RC Slab Bridges utilizing both static and dynamic analysis approaches. Notably, the utilization of CSI Bridge software facilitates the analysis of Reinforced Concrete slab Bridges. By employing this software, the study contributes valuable insights into the behavior of these structures under varying loading conditions, offering essential information for optimizing the design and maintenance of slab bridges.

Pushover analysis of reinforced concrete bridge pier designed as per irc-6 codal provision: Farhan and Tasleem

The increasing concern among structural engineers regarding the seismic vulnerability of existing bridges has spurred focused attention on seismic evaluation. This evaluation stands as the initial step towards minimizing the potential loss of both human lives and property. Notably, many of India's reinforced concrete bridges were originally designed in accordance with earlier building codes, which often lacked provisions for significant seismic forces and lateral loads. Consequently, assessing the damage incurred by these pre-existing bridges has emerged as a necessity. This research paper concentrates on employing the nonlinear static (pushover) method to conduct seismic analysis on an RCC Bridge. This method holds conceptual clarity, ease of modeling, and swift computation as its distinctive features. Over the past decade, significant advancements in pushover analysis techniques have been witnessed, leading to their incorporation into international seismic analysis codes and guidelines. The study focuses on bridge piers that experience the combination of dead load, live load, and seismic loading, all aligned with IRC-6 2012 design specifications. The primary objective of this research lies in gauging the seismic performance of a representative reinforced concrete bridge pier, designed in accordance with Indian codes, using the displacement-based pushover analysis technique. By doing so, this study contributes to a better understanding of the seismic behavior of such structures and the efficacy of current design practices in ensuring their safety and resilience.

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Dynamic analysis of Reinforced Concrete Bridges Under Seismic Excitation: Nitin Jain1 and Vinay Kumar Singh

Bridge engineers, like their structural counterparts, bear the responsibility of adhering to design standards, ensuring structural safety, and maintaining user comfort. Guided by modern mechanics and empirical knowledge of construction materials and geometry, they employ innovation to efficiently utilize resources and technologies. In the context of roadway networks, bridges hold a pivotal role as vulnerable elements, particularly in seismic events. This paper delves into the seismic vulnerability of bridges, focusing on dynamic analysis of reinforced concrete bridges with distinct girder systems—T-beam and I girder. The study accounts for seismic zone IV, hard soil type, and vehicular loads per IRC guidelines, employing response spectrum analysis through CSi Bridge software. Comparing the girder systems based on axial force, shear, moment, and torsion, the analysis seeks to optimize bridge models. In essence, the research contributes insights into seismic performance, facilitating informed design choices for robust and resilient bridges.

Analysis of Girder Bridge with IRC and IRS Loadings – A Comparative Study: P.Veerabhadra Rao

The prominence of I-girders in freeway and bridge systems arises from their structural effectiveness, heightened stability, serviceability, construction economy, and appealing aesthetics. This paper undertakes a comparative analysis of a single span RCC Girder Bridge subjected to IRC loadings and a PSC Girder Bridge under IRS loadings. The analysis employs MIDAS Civil software and STAAD-Pro software, providing insights into the behavior of the Girder Bridges through analysis results. Additionally, the study delves into the percentage variations of bending moment and shear force as derived from the analysis outcomes. Overall, this research contributes to a better understanding of the performance characteristics of RCC and PSC Girder Bridges under distinct loadings, thereby informing design decisions for efficient and reliable bridge systems.

Evaluation of dynamic loads on a skew box girder continuous bridge Part I: Field test and modal analysis:Demeke B. Ashebo, Tommy H.T. Chana, and Ling Yua.

This paper details a comprehensive study aimed at evaluating dynamic loads on an existing continuous skew box girder bridge. The study encompasses a range of critical components, including the experimental procedure, the deployment of a data acquisition system, calibration testing, modal analysis, and the analysis of load distribution in the transversal direction. To calibrate the measurements, a three-axle heavy truck was utilized to induce both static and dynamic bending moments on the bridge, with a focus on establishing the correlation between measured strain and bending moments. The investigation into the bridge's dynamic behaviours relied on both experimental and theoretical modal analyses. Furthermore, the study explored the impact of skewness, or the angle of skew, on the bridge's static and dynamic characteristics, as well as its influence on load distribution for both the calibration truck and regular in-service vehicles. Surprisingly, the findings demonstrated that within the skew angle range of 0° to 30°, skewness had a negligible effect on both the static and dynamic behaviours of the bridge. Experimental study of the load-deformation behaviour of the precast post-tensioned continuous girder for straddle monorail: Full-scale load test under service and ultimate loading conditions: Athasit Sirisonthi, Suniti Suparp, Panuwat Joyklad, Qudeer Hussain, and Phongthorn Julphunthong.

This study reports the findings of an experimental investigation carried out on a newly designed Full-scale Precast Post-tensioned Continuous (FPPC) girder intended for a straddle monorail system, specifically the Yellow Line and Pink Line Monorail in Bangkok, Thailand. This innovative FPPC girder offers several advantages, including its lightweight nature, cost-effectiveness, and ease of rapid construction. The girder comprises three reinforced concrete (RC) hollow haunched girders, four piers or supports, two pier segments, four wet joints, and four bearings at each support. Construction took place at the Sino-Thai Engineering and Construction Public Company Limited (STECON) casting yard in Thailand. The girder underwent testing under various loading conditions, including service and ultimate loadingscenarios, with both types applied as two-point loadings.

Dynamic Response Evaluation of Long-Span Reinforced Arch Bridges Subjected to Near- and Far-Field Ground Motions: Iman Mohseni, Hamidreza Alinejad Lashkariani, Junsuk Kang, Thomas H.-K. Kang

This study delves into the structural performance evaluation of reinforced concrete (RC) arch bridges subjected to intense ground motion events. Employing a comprehensive three-dimensional finite element model of a 400 m RC arch bridge with composite superstructure and double RC piers, the research assesses its behavior under the influence of strong earthquakes. By applying two sets of ground motion records that simulate near-field and far-field motions, the inelastic behavior of concrete elements is examined through seismic time history analysis. The study employs the concept of Demand to Capacity Ratios (DCR) to gauge the dynamic performance of the structure, highlighting the significance of capacity distribution of force and bending moment within the RC arch, springings, and piers of the bridge. Notably, the findings underscore the transformative impact of near-field and far-field earthquake loads on various characteristics of the bridge, ultimately influencing its structural performance.

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Performance evaluation and rating of bridges under uncertain structuralparameters using integrated load test: G K Sahu, R K Garg and Ram Kumar

This paper addresses the issue of structural deterioration in existing bridges caused by factors like material aging, changing environmental conditions, and impact from heavy vehicles. Traditional field testing remains irreplaceable in assessing bridge performance under live loads, despite discrepancies between observed field responses and analytical models. To bridge this gap, the paper proposes an approach that uses field response data to calibrate analytical models, aiming to closely align analytical predictions with field behaviour. The study presents an integrated load test technique, exemplified through the load rating development and damage detection of an RCC Slab Bridge near Hapur on NH 24 in Uttar Pradesh, India. This technique serves as a valuable tool for enhancing accuracy in assessing load-carrying capacities and identifying potential damages in existing bridge structures.

Parametric Evaluation on Reinforced Concrete Solid Slab Bridges by Staad-Pro Software: Abhishek Niranjan, Rajeev Singh Parihar, Abhay Kumar Jha, Barun Kumar, Rajesh Misra

The art and science of structural planning and analysis encompass a harmonious blend of economy, elegance, and robustness. In today's fiercely competitive market, achieving structural excellence demands meticulous analysis as the foundation of sound planning. Leveraging software tools offers the advantage of reducing labor and effort, which prompted the pursuit of this objective in the present study. The study focuses on the assessment and design of a solid-deck slab bridge, employing both STAAD-Pro software and manual processes to accommodate various loading conditions. Furthermore, STAAD-Pro, executing multiple load combinations, verifies the analysis outcomes across shear, bending moment, axial force, and deflection. The pinnacle of design moments arises from the amalgamation of diverse loading scenarios, ultimately striving for an efficient and reliable bridge design.

Design of a prestressed concrete bridge and analysis by CSI bridge: Sameer Malhotra This paper discusses the application of prestressed concrete for large spans and swift construction, focusing on prestressed girder design using the Morice-Little method as per IRC specifications. The method's essence involves segmenting the effective width into eight parts, analyzing loadings and deflections at nine standard positions. The design process is illustrated through a bridge girder example. Additionally, the study highlights the transformative role of computer applications, specifically the CSi Bridge software developed by Computers and Structures Inc., in bridge design, construction, and maintenance. The software's analytical capabilities, akin to SAP2000, offer a step-by-step approach for efficient design, making it a crucial tool in the bridge engineering industry.

Modeling and dynamic analysis of bridges designed with AASHTO and Florida I-beam girders: M A Fadul1 and H H Darwash

This study undertook a comparative assessment of the dynamic behavior of two prestressed concrete girder bridges. The first bridge was designed employing AASHTO Type III girders, while the second incorporated the newer Florida I-Beam (FIB) girders. Despite both bridges having identical dimensions, including length, width, and girder depth, variations existed in the girder arrangement. The first bridge utilized six AASHTO Type III girders, while the second employed four FIB girders. Employing a sophisticated finite element model, the study subjected both bridges to dynamic loads, conducting modal and time history analyses to discern their dynamic properties, behavior, and responses. The outcomes were instrumental in comparing the dynamic properties and deflections of the two bridges across different girders and spans. Remarkably, the finite element model revealed that even though the FIB bridge featured fewer girders, its deflections were notably lower than the corresponding values exhibited by the AASHTO bridge.

Analysis of T-beam Bridge Using Finite Element Method: R. Shreedhar, Spurti Mamadapur

T-beam bridge decks represent a prominent form of cast-in-place concrete decks, characterized by a concrete slab integrated with girders. The finite element method serves as a versatile structural analysis technique, approximating the solution of continuum mechanics problems through interconnected finite elements at nodal points. This methodology is applied to a simple span T-beam bridge, initially analyzed as a one-dimensional structure under I.R.C. loadings. The same bridge is then subjected to a three-dimensional analysis using finite element plate and beam elements through STAAD ProV8i software. Both models undergo I.R.C. Loadings to determine maximum bending moments. Remarkably, the results from the finite element model are found to be lower than those obtained through one-dimensional analysis, implying that manually calculated results under IRC loadings tend to be conservative. This research offers valuable insights into the behavior of T-beam bridges under different analysis techniques and loading scenarios.

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Investigations on simply supported concrete bridge deck slab for IRC vehicle loadings using finite element analysis: Kanchan Sen Gupta Somnath Karmakar

This study analyzes reinforced concrete bridge decks of varying span lengths (3 m to 10 m) and a consistent 12 m width, with and without a footpath, using finite element analysis. Under Indian Road Congress (IRC) load cases, both scenarios are evaluated for 88 cases. For decks with a footpath ("Condition A"), IRC bending moments align closely with FEA up to 4 m spans, with IRC values consistently 5% to 20% lower for longer spans. Without a footpath ("Condition B"), IRC moments are 4% to 30% lower. Under centered loading, IRC bending moments match FEA up to 4 m spans and are 4% to 23% lower beyond that. This research highlights bending moment behaviors and FEA-IRC agreement for certain scenarios, while disparities exist in others.

II. METHODOLOGY

Modelling in CSi Bridge:

The process of designing a bridge is a complex and multidisciplinary endeavor that requires a deep understanding of structural engineering principles, materials science, geotechnical considerations, and even aesthetics. As such, conducting a thorough literature study is an essential step in preparing a thesis report focused on bridge design. This essay delves into the significance of literature study in bridge design and its role in shaping the foundation of a comprehensive thesis report.

One of the primary objectives of the literature study is to gain insight into various types of bridges and their associated design philosophies. Different bridge types, such as beam, arch, suspension, and cable-stayed bridges, each exhibit unique structural behaviours and response mechanisms. By delving into existing literature, researchers can comprehend the merits and limitations of each bridge type and discern the factors that influence their design choices. This understanding lays the groundwork for informed decisions in selecting the appropriate bridge type for a given context.

The choice of materials plays a pivotal role in bridge design, affecting aspects such as structural integrity, durability, and cost-effectiveness. Engaging with literature allows researchers to explore the latest advancements in materials science, such as high-performance concrete, advanced steel alloys, and innovative composites. Understanding the properties and behaviour of these materials is crucial in optimizing the bridge's performance and lifespan. Beyond functional considerations, the aesthetics and environmental impact of a bridge are increasingly important aspects in modern bridge design. Engaging with literature allows researchers to explore case studies and design philosophies that balance functionality with visual appeal and environmental sustainability. This understanding guides the integration of artistic elements and ecological considerations, contributing to a holistic and harmonious bridge design.

1) The literature study also introduces researchers to advanced analysis techniques and computational tools employed in contemporary bridge design. Finite element analysis, computational fluid dynamics, and seismic response simulations are just a few examples of tools that contribute to a comprehensive understanding of a bridge's behavior under various loading conditions. Familiarity with these tools enhances the accuracy and rigor of the thesis report's analytical methodologies.

2)

1) Bridge layout line data
2) Defining lane width
3) Material Specification:
4) Defining section properties:
5) Select bridge deck section type
6) Bridge section data-Concrete Tee beam
7) Bridge bent cap data
8) Bridge object data
9) Model 3d view
10) Extruded view

In Bridge layout line data we need to specify the overall length of bridge that is 108.8 m, after that we define lane width of 3.75 m each. In material specification we assigned M20 Grade of concrete and Fe415 steel. In defining section parameters we defined different sections based on requirement. After that we need to select bridge deck section of available configurations to define all parameters of bridge. After updating the model we will get rendered view as shown.

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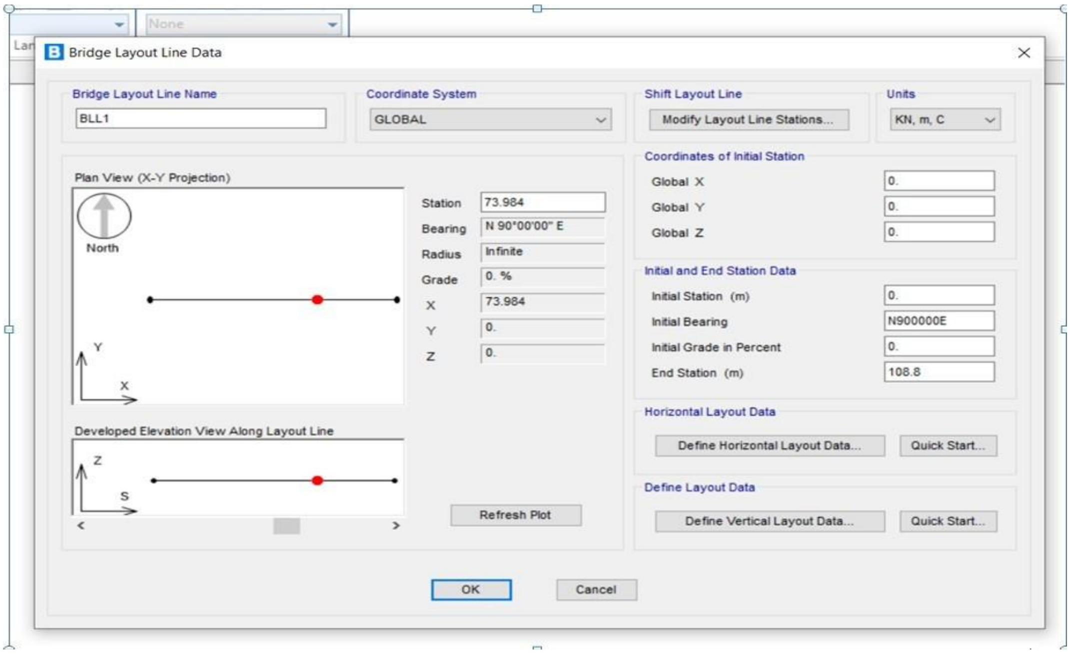
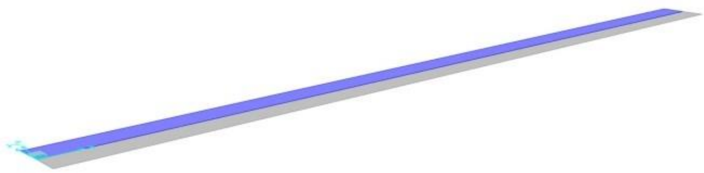
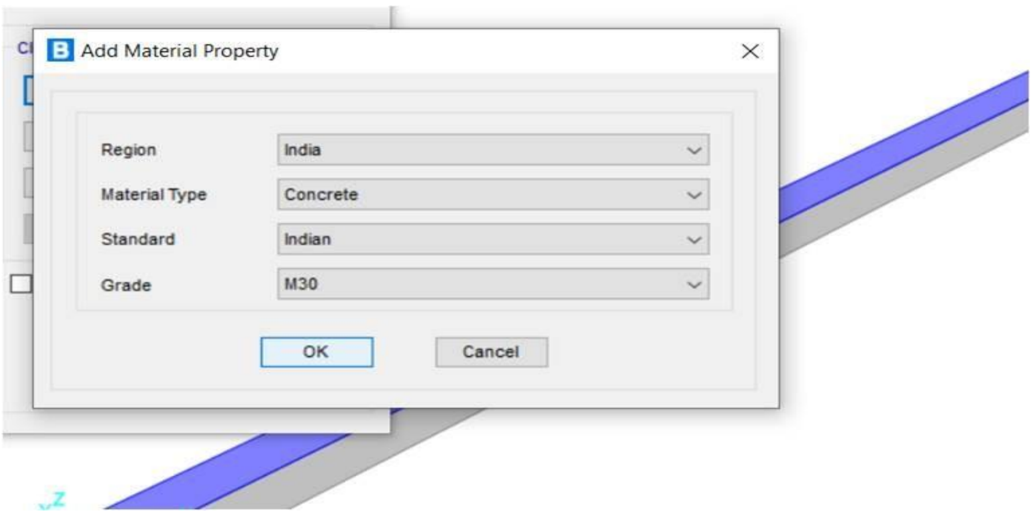
1) Bridge layout line data:



2) Defining lane width:



3) Material specification:



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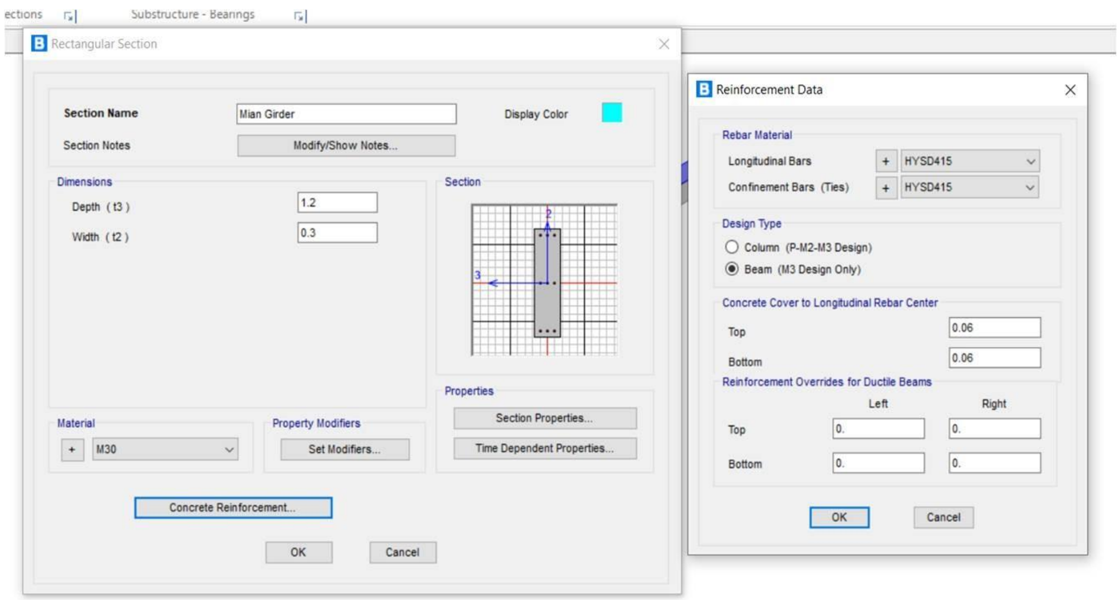
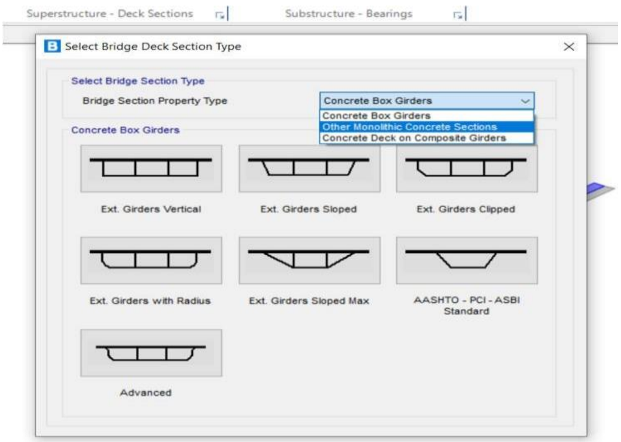
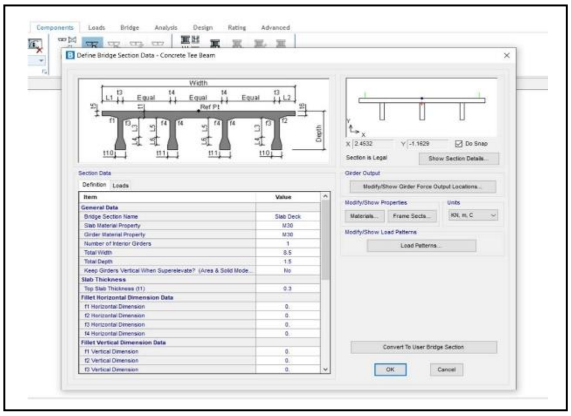
4) Defining section properties



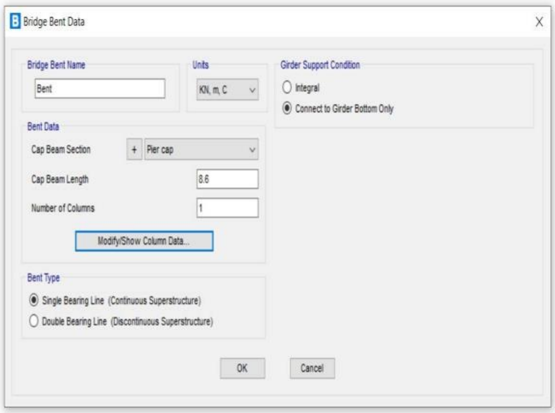
5) Select bridge deck section type



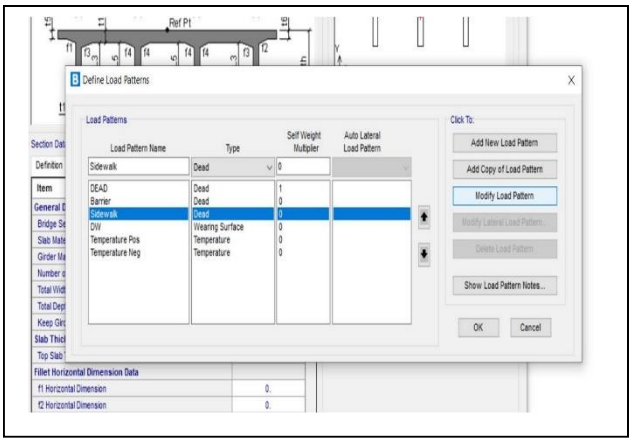
6) Bridge section data-Concrete Tee beam



7) Bridge bent cap



8) Defining load pattern



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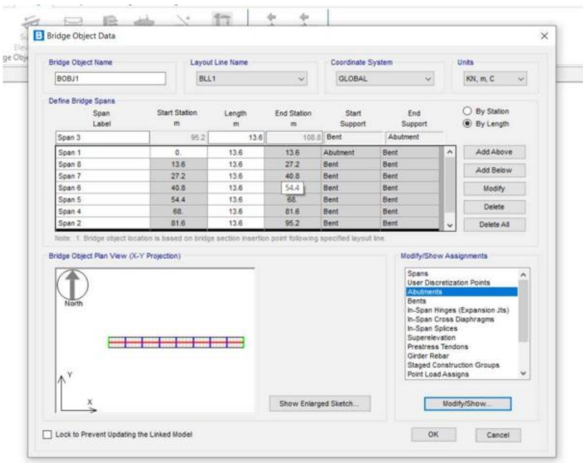
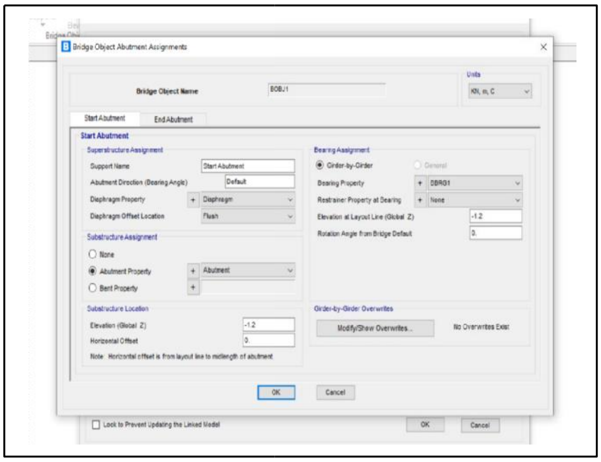
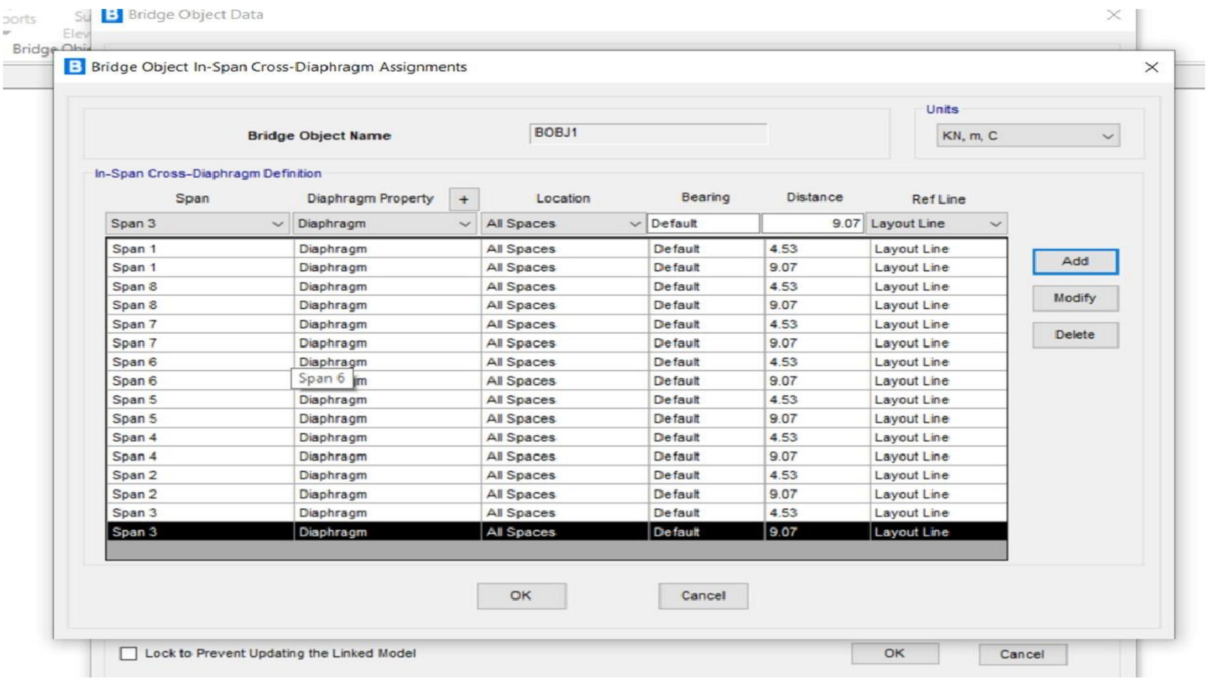
9) Bridge object data



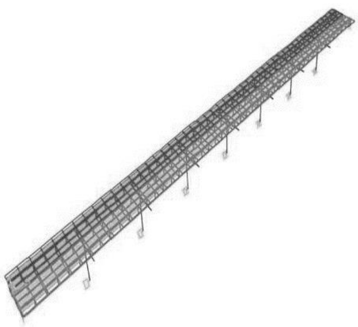
10) Bridge Object Abutment Assignment



11) in span Cross Diaphragm Assignment



12) FEM Mode



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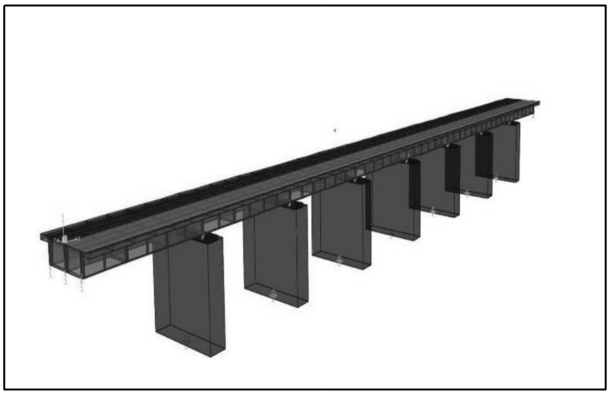
13) Rendered View



Loading and Analysis:

After defining bridge object data, software will automatically generate the model load cases as per model specification requirements, we have to define vehicle class and speed to which vehicle need to be passed over bridge. For seismic analysis we need to define seismic function with available data input such as soil type, zone, reduction factor, and importance factor.

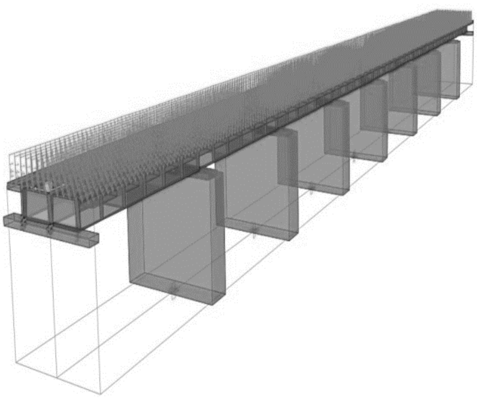


Figure 1 Railing load assignment

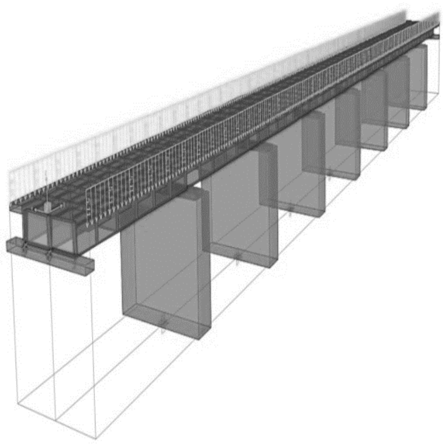


Figure 2: Wearing surface load

III. RESULTS AND DISCUSSION

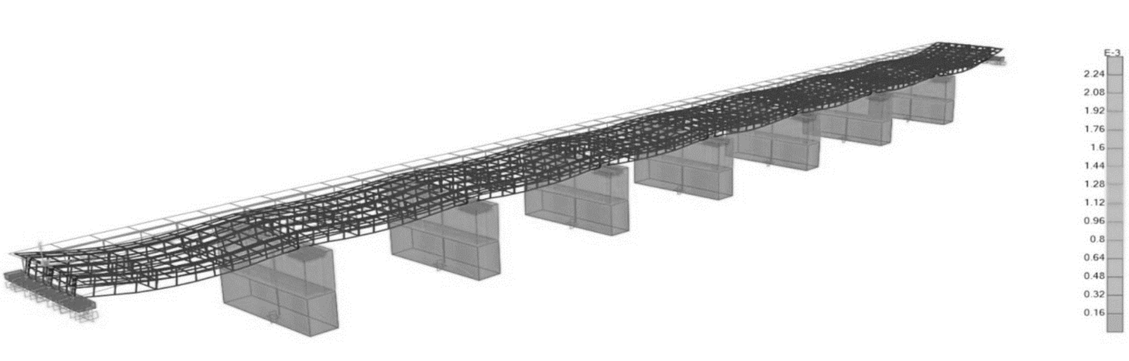


Figure 3 Deformed shape DL

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IV. CONCLUSION

The compilation of literature presented in this review encompasses a wide spectrum of studies that delve into the analysis and behavior of diverse bridge types, offering invaluable insights into their structural performance. The initial set of studies delves into load distribution and capacity assessment of various bridge forms. Seo and Kidd investigate the live-load distribution in precast concrete double-tee girder bridges, underscoring the significance of span length and width-to-length ratio. Gupta, Kaushal, and Ranjan center their study on T-beam girder bridges, spotlighting the skew angle's influence on bending moments and shear forces. Schanck and Davids introduce an innovative proxy finite element analysis method to more accurately evaluate older T-beam bridges, challenging traditional rating factors.

In a different vein, Xu and Li scrutinize the dynamic behavior of multi-span bridges under moving loads, highlighting the import of span count and coupling conditions. Zeng, Yang, and Dimitrakopoulos delve into the resonance dynamics of high-speed vehicles on curved bridges, shedding light on damping and feedback effects. Song, You, Byun, and Maekawa delve into the failure behaviors of deteriorated T-girder bridges under cyclic loading, presenting an invaluable finite element modeling technique. Lastly, Ashebo, Chana, and Yu assess dynamic loads and skewness effects on box girder bridges, underscoring the negligible influence of skew angle on bridge behavior. Agarwal, Pal, and Mehta provide a comprehensive analysis of free vibrations in box-girder bridges, considering diverse configurations and parameters.

Collectively, these studies augment our comprehension of bridge performance, design, and evaluation across varied types and scenarios, ultimately contributing to the enhancement of safety and sustainability within transportation infrastructure.

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[4]. “Dynamic behaviour of multi-span bridges under moving loads with focusing on the effect of the coupling conditions between spans”: Hongan Xu, Wen L. Li.
[5]. “Dynamic response of high speed vehicles and sustaining curved bridges under conditions of resonance”: Qing Zeng, Y.B.Yang, and Elias G. Dimitrakopoulos.
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