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INNOVATIVE DESIGN FRAMEWORK FOR T-BEAM AND SLAB BRIDGES INCORPORATING ARTIFICIAL INTELLIGENCE TECHNIQUES

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Abstract

Bridges are vital components of transportation infrastructure, facilitating movement across various geographical barriers. Traditional methods of bridge design have relied on manual calculations, but with the advent of artificial intelligence (AI) techniques, there's an opportunity to transform bridge design, particularly for T-beam and slab bridges. This study explores the integration of AI, including machine learning algorithms and optimization techniques, to enhance the efficiency and sustainability of T-beam and slab bridge design processes. The literature review showcases the significance of AI in bridge design, followed by a detailed methodology involving finite element analysis (FEM) to compare conventional and AI-driven design approaches. Results indicate significant improvements in bending moments, shear forces, and deflections for T-beam configurations, highlighting the potential of AI in optimizing bridge design parameters.

Keywords: *bridge design, artificial intelligence, T-beam bridges, slab bridges, finite element analysis, optimization.*

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1. INTRODUCTION

A bridge crosses a road, valley, or body of water without closing the route below. Every transportation system needs a bridge. Bridges of various sorts are used throughout. at 1871, Adair built the first reinforced concrete bridge, a 15-meter-span Waveney bridge at Homers Field, England. India is building more road bridges using reinforced concrete. T-beam bridges are often used for 10–25-m spans. Bridge design is difficult and demands creativity, practicality, safety, and economics. However, AI technology can transform bridge design, especially T-beam and slab bridges.

AI, including machine learning algorithms, neural networks, and optimization, offers a new bridge design strategy. Engineers may use AI to evaluate massive data sets, find complex patterns, and create optimized solutions that match performance standards. This novel design framework will improve T-beam and slab bridge design efficiency, accuracy, and sustainability. AI-based bridge design has great potential to solve infrastructure development problems. Highway and railway T-beam and slab bridges must be safe, durable, and cost-effective under various loading circumstances. Engineers can use AI-based design methods to analyze complicated datasets, simulate bridge behavior, and optimize designs for strict performance criteria.

2. LITERATURE REVIEW

Anushia K Ajay (2017) Infrastructure measures a nation's development. Infrastructure includes highways that carry people and goods. Teebeam bridges dominate highway bridges. Research around the world creates and reuses IRC codes. IRC 112-2011 replaces rules IRC 21-2000 and IRC 18-2000. Likewise, IRC 112-2011 adds limit state RCC bridge design. The range of a two-path bridge is changed to recreate IRC class AA followed stacking in VB6.0. Bridge very underlying components are parametrically concentrated on in this review. The work centers around longitudinal brace practical profundity for fluctuated ranges. T-Bar Bridge design can profit from nomograms.

L.P.Huang (2017) The heap dispersion factor (LDF) is fundamental for assessing bridges. Hardly any creators have thought about bar cross over load conveyance coefficients when bridge augmentation and strengthening. To address this, a longitudinal and cross pillar extension strategy was proposed. A Limited component (FE) model recreated bridge enlarging support. Load conveyance factors for all supports were assessed for changing cross bar position, amount, firmness, expanded width, existing bridge solidness, and interfacing framework. The outcomes show that bridge strengthening decreases side shaft LDF the most, further developing support load-conveying. Subsequent to strengthening, the support LDF rises 30%. Therefore, these jobs need strengthening. Cross shaft amount, position, and size meaningfully affect brace LDF. At the point when the expanded supports are unbendingly appended to the old braces, bar LDF is lower than

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that pivot. The LDF of every support is comparative when the primary pillars are joined to expanded inflexible or pivoted braces. Bridge extending and supporting design can profit from this review.

3. OBJECTIVE OF THE STUDY

- To validate FEM analysis and compare it to conventional methods for lengths.
- To Evaluate maximum bending moment and comparison parameters when performing FEM analysis on ordinary girders and T-beam configurations.

4. METHODOLOGY

We started our study by fixing the deck slab thickness. Various deck slab thicknesses were analyzed. The slab received a homogenous 41.42 kN/m^2 equivalent load. Based on this investigation, 215mm was chosen for design thickness. Following that, excel sheets were created to calculate conventional design findings. After verifying the data, we modeled and analyzed the structures using FEM. Thus, we performed FEM analysis on both configurations and recorded the findings.

The analysis problems had the following details

i. The clear spans are 20m, 24m, and 28m, ii.while the roadway width is 7.5m. iii. meter beam spacing. iv. 4 m cross beam interval. V. Deck slab thickness: 215 mm vi. Concrete grade: M25 vii. Clear cover-40 mm viii. Wearing course thickness: 75 mm

a. FEM Analysis

Grillage Similarity was utilized to depict the bridge as an organization of inflexibly coupled radiates with discrete hubs for FEM examination. This concentrate intently matches standard little range techniques. This technique strays from customary design for ranges past 60 m.

5. RESULTS AND DISCUSSIONS

All investigations utilized STAAD Ace. V8i SS6 with loads from Indian Standard codes, and Courbon's methodology was utilized for class AA wheeled vehicle stacking. Each investigation began with succeed sheets and manual calculations for approval.

a. FEM Analysis versus. Conventional Method

The outer girder bending moment values from conventional design (excel sheets) and FEM analysis on ordinary deck slab supported on girders were compared.

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Table 1: Maximum Bending moment

Span (m)	Conventional Method	FEM Analysis	Percentage Variation (%)
20	1850	1303	30
24	2240	1776	20
28	2630	2320	11.80

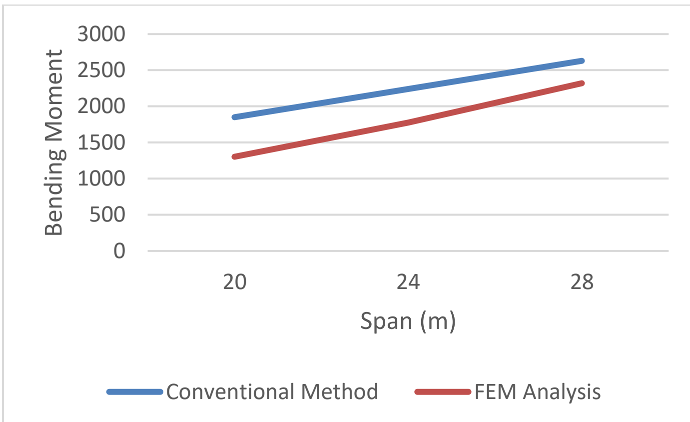

Figure 1: Graphical representation of Maximum Bending moment

b. **Comparison of Girder-supported Ordinary Deck Slab and T-beam Deck Slab Configuration**

- **Maximum Bending Moment**

Maximum Bending Moments in longitudinal girders of regular deck slab configuration are used to compare with T-beam deck slab structure.

Table 2: Maximum Bending Moment

Span (m)	Ordinary Deck Slab	T – beam Deck Slab	Percentage Variation (%)
20	3764	1635	56
24	7136	2173	70
28	12320	2920	76

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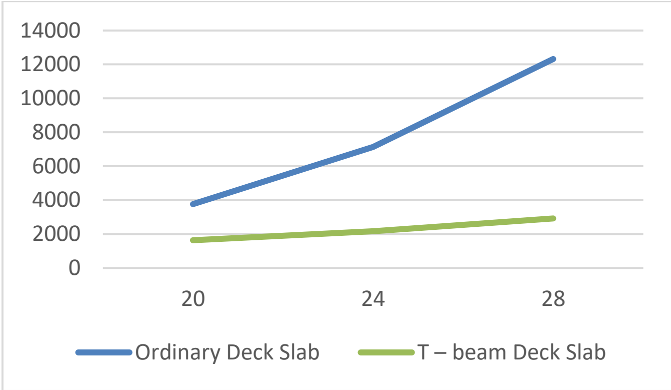

Figure 2: Graphical representation of Maximum Bending Moment

Comparing the regular deck slab configuration to the T-beam layout, maximum Bending Moment values vary from 50% to 76%.

T-beam deck chunk configuration has a tiny expansion in greatest Bowing Moment with length contrasted with customary configuration. Because of absence of outlining. Thus, joint stress concentrations are low because of the monolithic deck section and support structure, decreasing Bowing Moments.

- **Maximum Shear Force**

The sort of reinforcing and pre-stress needed to keep the bridge in service depend on shear forces. Thus, Shear Force fluctuation was noticed and investigated to determine the optimal arrangement.

Table 3: Maximum Shear Force

Span (m)	Ordinary Deck Slab	T – beam Deck Slab	Percentage Variation (%)
20	370	328	11
24	400	380	6
28	445	430	3

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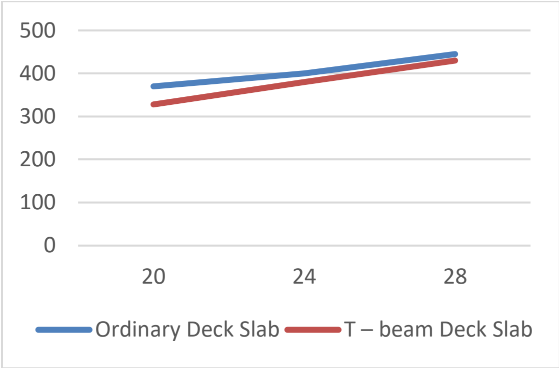

Figure 3: Graphical representation of Maximum Shear Force

When contrasted with T-beam arrangement, typical deck chunk configuration has higher shear force per meter run that diminishes with length and shifts from 3% to 11%. The graph reveals no significant shear force difference across configurations. Both systems have a comparable load transmission mechanism, therefore shear forces across surfaces vary within a tolerable range.

- **Deflection**

Since deflection is a key serviceability metric, both ordinary and T-Beam deck slab configurations were observed to see how span length affected deflection.

Table 4: Maximum deflection moment

Span (m)	Ordinary Deck Slab	T – beam Deck Slab
20	0.680	7.5
24	0.800	15.7
28	0.990	32.5

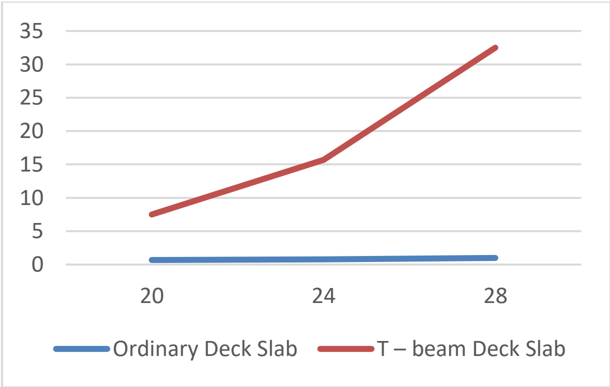

Figure 4: Graphical representation of Maximum Deflection moment

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The configurations differ in deflection by 91% to 97%. The shortfall of cross braces, which operate as shear stress scattering components in standard deck piece configurations, makes T-Beam deck chunk deflection develop dramatically with length. However, T-beam deflection values fall within IRC serviceability restrictions of 45mm in RCC bridge design. A 50mm limit is confirmed by American Standards utilized by Iowa Department of Transportation.

6. CONCLUSION

Compared to deck slab architecture, T-beam configuration allows us to keep most design parameters within serviceability, deflection, and shear constraints. Joints and cross girders that increase bridge loadings are eliminated. Pre/post tensioning the T-beam deck slab improves performance. Applying pre-stressing force and calculating jacking force are easier. If prestressing is considered in the design/construction process, we must create a composite design. Due to its more exposed components, the standard deck slab configuration causes long-term maintenance and serviceability difficulties. The T-Beam deck slab arrangement makes this problem easier to solve.

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