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The effect of varying span on Design of Medium span Reinforced Concrete T-beam Bridge Deck

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ABSTRACT

Bridge is a structure providing passageway over an obstacle without closing the way beneath. T-beam Bridge is mainly used by designer for small and medium span bridge. Reinforced Concrete is mostly used for highway bridge construction because of its durability, rigidity, economy, ease of construction and ease with pleasing appearance.

This paper describes the design of 4-lane Reinforced Concrete T-beam Bridge deck considering IRC Class-AA tracked loading with span varying from 25 to 40m. After computing manually and STAAD Pro analysis software, it is observed that dead load bending moment with increasing span increases almost square of span.

Keywords*: Bridge, cross girder, longitudinal girder, medium span, Reinforced Concrete Bridge, T-beam Bridge deck.*

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I. INTRODUCTION

A Bridge is a structure providing passage (i.e. a road, railway, canal, pedestrians or pipeline) over an obstacle (i.e. a river, road, rail or valley) without closing the way beneath.

According to the construction material, Superstructure of Bridge are classified as timber, masonry, iron, steel, reinforced concrete, pre-stressed concrete, composite or Aluminum Bridge.

Reinforced concrete is a composite material in compressive load is taken by Concrete and tensile load is taken by Reinforcement or Steel only. Reinforced concrete is well suited for the construction of highway bridges in the medium span range. Reinforced Concrete Bridge is a bridge with reinforced concrete spans and concrete or reinforced-concrete abutments. The types of Reinforced Concrete Bridge are slab bridge, T-beam bridge, hollow girder bridge, balanced cantilever bridge, rigid frame bridge, arch bridge and bow string girder bridge.

In T-beam bridge, the main longitudinal girders are designed as T-beams integral with part of the deck slab, which is cast monolithically with the girders.

Major components of T-beam Bridge

The RC T-beam superstructure consists of the following major components are:

i) **Cantilever slab portion:** Cantilever slab portion are carries the kerb, handrails, footpath or crash barriers, if provided and a part of the carriageway. The critical section for bending moment is the vertical section at the junction of the cantilever portion and the end longitudinal girder.

ii) **Cross girders or diaphragms, intermediate and end ones:** Cross girders are provided mostly to stiffen the girders and to reduce torsion in the exterior girders. These are essential over the supports to prevent lateral spread of the girders at the bearings. Another purpose of the cross girders are to balance three deflections of the girders carrying heavy loading with those of the girders with less loading.

iii) **Deck slab:** Deck slab is the roadway, or the pedestrian walkway, surface of a bridge. Deck slab is one structural element of the superstructure of a bridge. The deck may be constructed of concrete, steel, open grating, or wood. The concrete deck may be an integral part of the bridge structure (T-beam structure) or it may be supported with I-beams or steel girders.

iv) **Footpaths:** Footpath is a type of thoroughfare that is intended for use only by pedestrians and not other forms of traffic such as motorized vehicles, cycles, and horses.

v) **Longitudinal girders, considered in design to be of T-section:** Longitudinal girders are provided with straight T-ribs when cross girders are not used. When multiple cross girders are used, the rib is made thinner and the bottom of T-rib is widened to an extent sufficient accommodate the tensile reinforcing bars.

vi) **Wearing coat:** Wearing coat is provided over concrete bridge decks to protect the structural concrete from the direct wearing effect of the traffic and also to provide cross camber required for the surface drainage.

The thickness of the wearing coat is kept uniform and the top of the deck is adjusted to facilitate the cross camber for surface drainage.

II. METHODOLOGY

A. Bridge Description

In this paper, all the varying span of 4-lane T-beam bridge deck of span 25m to 40m are designed with 5m increments. The design data for all 4-lane T-beam bridge deck are vehicles live load type: IRC class AA tracked load, thickness of wearing coat = 80mm, width and depth of kerb = 600mm x 300mm. The M30 grade concrete and Fe415 grade High Yield Strength Deformed (HYSD) bars are considered materials for all Reinforced concrete bridges.

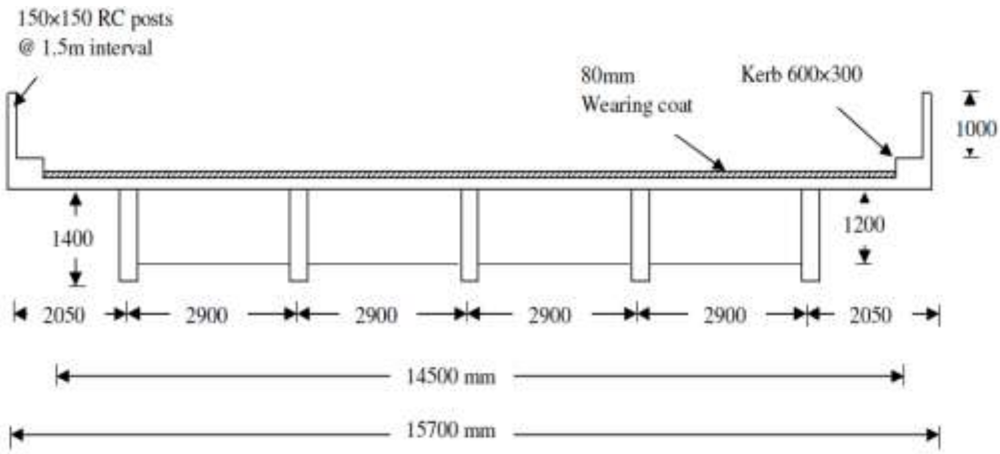

Figure 1: Cross-section of bridge deck

B. Methods

The design and analyses of all the varying span of 4-lane T-beam bridge deck of span 25m to 40m are designed with 5m increments are done by STAAD.Pro and manually considering as per Indian Standard IS: 456-2000, IRC: 6-2000 and IRC: 21-2000. This conventional method is extensively used with design steps as specified in various text books on bridge engineering (Victor 2007, Krishna Raju 2004, and Rajagopalan 2006).

III. RESULTS AND DISCUSSION

In this paper, four cases are considered for design of 4-lane RC T-beam bridge deck with varying span 25m to 40m with 5m increments.

A. Data Summary for RC T-beam bridge deck

This part explained the data adopted for all the four cases of 4-lane RC T-beam bridges with clear carriageway width of 14.5 m which is used in the parametric study in STAAD analysis as well as conventional method of design and analysis on design of RC T- beam bridges. For all the four cases of bridges M 30 grade of concrete material and Fe 415 grade of steel are provided.

Table- 1: Summary of data considered for four cases

Span (m)	Slab thickness t (mm)	Overall depth of Longitudinal Girder (mm)	No. of L.G.	c/c Distance of L.G. (m)	Overall depth of Cross Girder (mm)	No. of C.G.	c/c Distance of C.G. (m)
25	200	1600	5	2.9	1400	7	4.17
30	200	2000	5	2.9	1800	7	5
35	200	2200	5	2.9	2000	9	4.375
40	200	2500	5	2.9	2300	9	5

The above thickness of slab and section for cross girders and longitudinal girders have been adopted after design of the bridge decks using the EXCEL spreadsheet developed in the study. For the above sectional properties, the bridges were analysed in STAAD.Pro and the results obtained are described below.

B. Summary of data for Design loads

Table-2: Comparison of design Shear force from both the methods

Span (m)	STAAD. Pro analysis			Conventional method of Analysis		
	DLSF (KN)	LLSF (KN)	Total SF (KN)	DLSF (KN)	LLSF (KN)	Total SF (KN)
25	397.3	400.11	797.41	447.148	462	909.148
30	530.78	421.4	952.18	527.808	467.9741	995.7821
35	646.87	437.07	1083.94	608.468	472.2414	1080.709
40	785.7	440.1	1225.8	689.128	475.4418	1164.57

The summary results of Design dead load, live load and total load, as obtained from STAAD analysis are presented Table-2. Using the conventional method of design developed as an EXCEL spreadsheet program, the support reactions have also been computed.

C. Summary of data for bending moment

The Design bending moments have been obtained from STAAD analysis are presented Table-3. The Bending moments have also been computed using the conventional method of design developed as an EXCEL spreadsheet program are presented in Table-3.

Table-3: Comparison of Bending moment from conventional calculation and STAAD.Pro

Span (m)	STAAD. Pro analysis			Conventional method of Analysis		
	DLBM (KN-m)	LLBM (KN-m)	Total BM (KN-m)	DLBM (KN-m)	LLBM (KN-m)	Total BM (KN-m)
25	2176.1	2062	4238.1	2886.025	2310	5196.025
30	3513.73	2729.25	6242.98	4068.18	2807.845	6876.025
35	4834.85	3297.32	8132.17	5451.985	3305.69	8757.675
40	6762.8	3938.1	10700.9	7037.44	3803.534	10840.97

D. The variation of Bending Moment and Shear Force with span

The variation of dead load SF, live load SF, dead load BM and live load BM are shows as in Figure-2 and Figure-3. It can be found that as the span is increases varying from 25m to 40m with 5m increments, the dead load and live load shear and moment are increases.

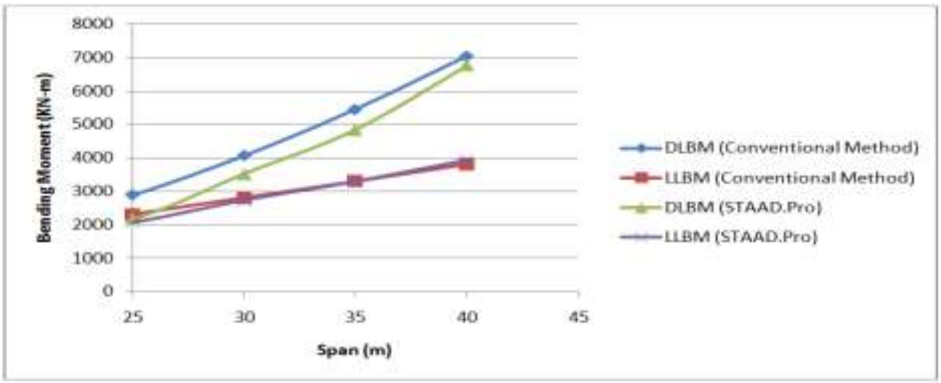

Figure 2: Variation of Bending Moment with Span by STAAD.Pro and Conventional method

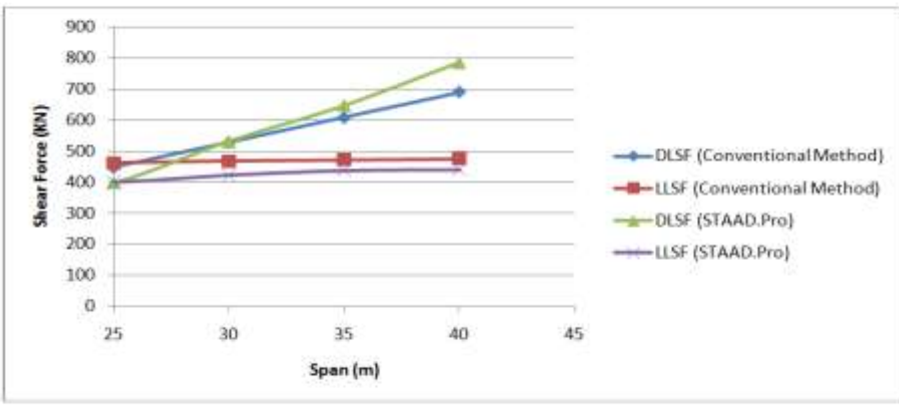

Figure 3: Variation of Shear Force with Span by STAAD.Pro and Conventional method

IV. CONCLUSION

In this paper the 4-lane Reinforced Concrete T-beam Bridge deck considering IRC Class-AA tracked loading with span varying from 25 to 40m are designed and analyses by manually and STAAD Pro software. After computing the results, following important conclusions are draw from the study:

- With increasing different spans the dead load bending moment increases almost square of the span.
- It is also true that bending moment increases in a parabolic manner with increasing span.

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