ANALYSIS OF T–BEAM BRIDGE DECK SLAB

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Received 17 May 2016, Accepted 20 May 2016, Available online 02 July 2016

Abstract

Generally, structures are subjected to two types of load: static and dynamic. However, the majority of civil engineering structures are designed with the assumption that all applied loads are static. The effect of dynamic load is not considered because the structure is rarely subjected to dynamic loads; more so, its consideration in analysis makes the solution more complicated and time consuming. This feature of neglecting the dynamic forces may sometimes become the causes of disaster, particularly in the case of earthquake. Therefore it is proposed to do “dynamic analysis of bridge deck” for various span of bridge by varying number of longitudinal girders. The detailed study is carried out for “T-Beam Bridge”, for various span 16m, 20m, 24m and 28m under IRC class AA loading condition.

Keywords: Dynamic, Natural frequency, Earthquake.

1. INTRODUCTION

A Bridge is a structure providing passage over an obstacle without closing the way beneath. The required passage may be for a road, a railway, pedestrians, a canal or a pipeline. The obstacle to be crossed may be a river, a road, railway or a valley. Bridges range in length from a few meter to several kilometer. They are among the largest structures built by man. The demands on design and on materials are very high. A bridge must be strong enough to support its own weight as well as the weight of the people and vehicles that use it. The structure also must resist various natural occurrences, including earthquakes, strong winds, and changes in temperature. Most bridges have a concrete, steel, or wood framework.
and an asphalt or concrete roadway on which people and vehicles travel. Designs of bridges vary depending on the function of the bridge, the nature of the terrain where the bridge is constructed and anchored, the material used to make it, and the funds available to build it.

The T-beam Bridge is by far the most commonly adopted type in the span range of 10 to 25 m. The structure is so named because the main longitudinal girders are designed as T-beams integral with part of the deck slab, which is cast monolithically with the girders. Simply supported T-beam span of over 30 m are rare as the dead load then becomes too heavy.

2. DYNAMIC RESPONSE ANALYSIS

2.1 Indian Road Congress Bridge Loading Standards

Highway Bridge decks have to be designed to withstand the live loads specified by the Indian Roads Congress. The different categories of loadings were first formulated in 1958 and they have not changed in the subsequent revisions of 1964, 1966 and 2000.

2.2 IRC Class AA Tracked Vehicle

Two different types of vehicles are specified under this category grouped as tracked and wheeled vehicles. The IRC Class AA tracked vehicle (simulating an army tank) of 700 kN and a wheeled vehicle (heavy duty army truck) of 400 kN.

All the bridges located on National Highways and State Highways have to be designed for this heavy loading. These loadings are also adopted for bridges located within certain specified municipal localities and along specified highways.

2.3 Dynamic Response Of Bridge

Moving loads on bridge decks causes the super structure comprising beams and slabs to deflect from its equilibrium position relatively quick. The mass and the inherent elasticity of the structure tends to restore the bridge deck to its equilibrium position the causing a series of vibration due to the motion of the vehicle on the bridge deck.

The dynamic response of a bridge deck to a moving load depends on mass, stiffness, damping properties of the bridge and dynamic properties of the moving loads resulting in vibrations either at the natural frequency or at the frequency of the applied excited forces.

3. ANALYSIS OF DYNAMIC RESPONSE OF BRIDGE DECK

3.1 Methodology

- Analysis of T-BEAM Bridge is carried out by the Rational method for different spans.
- Analysis of Rational method will be done by using IRC Codes.
- Analysis is done for IRC Class AA tracked vehicle loading.
- Analysis of T-BEAM Bridge is carried out by using an EXCEL sheet for different spans.
- Analysis of dynamic response of bridge deck.
- Comparison of dynamic response of bridge deck, deflections and natural frequencies.
3.2 Rational Method Of Analysis Of Bridge

A typical tee beam deck slab generally comprises the longitudinal girder, continuous deck slab between the tee beams and cross girders to provide lateral rigidity to the bridge deck. It is known that the bridge loads are transmitted from the deck to the superstructure and then to the supporting substructure elements. It is rather difficult to imagine how these loads get transferred. If a vehicle is moving on the top of a particular beam, it is reasonable to say that, this particular beam is resisting the vehicle or truckload. However, this beam is not alone; it is connected to adjacent members through the slab and cross girders. This connectivity allows different members to work together in resisting loads. The supporting girders share the live load in varying proportions depending on the flexural stiffness of the deck and the position of the live load on the deck. The distribution of live load among the longitudinal girders can be estimated by any of the following rational methods.

1. Courbon’s method
2. Guyon Massonet method
3. Hendry Jaeger method.

3.3 Courbon’s Method

Among the above mentioned methods, Courbon’s method is the simplest and is applicable when the following conditions are satisfied:

- The ratio of span to width of the deck is greater than 2 but less than 4
- The longitudinal girders are interconnected by at least five symmetrically spaced cross girders.

<table>
<thead>
<tr>
<th>Span (m)</th>
<th>Width of carriage way (m)</th>
<th>Effective width of the girder (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td>7.5</td>
<td>200</td>
</tr>
<tr>
<td>20</td>
<td>7.5</td>
<td>200</td>
</tr>
<tr>
<td>24</td>
<td>7.5</td>
<td>200</td>
</tr>
<tr>
<td>28</td>
<td>7.5</td>
<td>200</td>
</tr>
</tbody>
</table>

Table: 1 Dimension of deck slab

- The cross girder extends to a depth of at least 0.75 times the depth of the longitudinal girders.

The Courbon’s method is popular due to the simplicity of computations as detailed below:

![Figure: 2 Position of Live Loads for Maximum BM in Girder](http://www.ijriet.com)

When the live loads are positioned nearer to the kerb as shown below.

The center of gravity of live load acts eccentrically with the center of gravity of the girder system. Due to this eccentricity, the loads shared by each girder are increased or decreased depending upon the position of the girders. This is calculated by Courbon’s theory by a reaction factor given by

\[ R_x = \frac{\sum WX/n}{\sum I d^2} \times \frac{1}{d_x e} \]

Where, \( R_x \) = Reaction factor for the girder under consideration

\( I \) = Moment of inertia of each longitudinal girder
\( d_x \) = Distance of the girder under consideration from the central axis of the bridge
\( W \) = Total concentrated live load
\( n \) = Number of longitudinal girders
\( e \) = Eccentricity of live load with respect to the axis of the bridge.

The live load bending moments and shear forces are computed for each of the girders. The maximum design moments and shear forces are obtained by adding the live load and dead load bending moments.

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The reinforcement in the main longitudinal girders are designed for the maximum moments and shears developed in the girders.

An approximate method may be used for the computation of the bending moments and shear forces in the cross girders. The cross girders are assumed to be equally shared by the cross girders. This assumption will simplify the computation of bending moments and shear forces in the cross girders.

4. COMPARATIVE ANALYSIS OF T–BEAM GRIDER BRIDGE

On the basis of which the serviceability criteria are checked. This is followed by dynamic analysis of bridge to obtain natural frequency and time period. With the help of these dynamic parameters the natural frequency is checked. The nominal shear is checked for the effective width of the girder.

This is studied by parametric investigation and are presented in the form of Figure 3 to 8.

1) Figure 3 shows the variation of moment in a shorter span with respect to spans for various widths of the girder in the interior slab panel.

2) Figure 4 shows the variation of moment in the longer span with respect to spans for various widths of the girder in the interior slab panel.

3) Figure 5 shows the variation of shear force with respect to spans for various widths of the girder in the interior slab panel.

5) Figure 6 shows the variation of maximum deflection with respect to span for various widths of the girder in bridge deck.

6) Figure 7 shows a variation of the natural frequency of vibration with respect to span for various widths of the girder in bridge deck.

7) Figure 8 shows the variation of time period with respect to span for various widths of the girder in bridge deck.

Bending moments, shear force, deflection and natural frequency of all the spans for various widths of the girder are determined.

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Natural Frequency, Time Period for various span of bridge deck.

5. CONCLUSION

The dynamic response of bridge deck for various span and for various width of the girder in Tee-beam bridge for IRC class AA loading is analyzed using excel sheet.

From the study,

- The bending moments in longer span increases when the span increases.
- The bending moments in shorter span increases when span increase.
- The shear force in the deck slab is linearly increasing when span increase.
- The maximum bending moment in longitudinal girder increases when span increase.
- When the natural frequency of vibration on the girder decreases when span increase.
- The deflection in the Tee-beam girder increases when span increase.
- The time period in the Tee-beam girder increases when span increase.

References


