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Analysis of Bridge Deck Slab Using Code Provisions of Irc6-2014 by Grillage Analogy Method

KEYWORDS

bridge deck slab, grillage analogy method, finite element method, IRC-6-2014 code

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ABSTRACT *The simplest form of bridge is the single-span beam or slab which is simply supported at its ends. In spite of the increase in computing power, bridge deck analysis methods have not changed to the same extent, and grillage analysis remains the standard procedure for most bridges deck. The grillage analogy method for analyzing bridge superstructures has been in use for quite some time. An attempt is made in this paper to provide guidance on grillage idealization of the structure, together with the relevant background information. Guidance is provided on the mesh layout. The bridge deck is analyzed by both grillage analogy as well as by finite element method. Bridge deck analysis by grillage method is also compared for normal meshing, coarse meshing and fine meshing. Though finite element method gives lesser values for bending moment in deck as compared to grillage analysis, the later method seems to be easy to use and comprehend.*

INTRODUCTION

Many methods are used in analyzing bridges such as grillage and finite element methods. Generally, grillage analysis is the most common method used in bridge analysis. In this method the deck is represented by an equivalent grillage of beams. The finer grillage mesh, provide more accurate results. It was found that the results obtained from grillage analysis compared with experiments and more rigorous methods are accurate enough for design purposes. If the load is concentrated on an area which is much smaller than the grillage mesh, the concentration of moments and torque cannot be given by this method and the influence charts described in Puncher can be used. The orientation of the longitudinal members should be always parallel to the free edges while the orientation of transverse members can be either parallel to the supports or orthogonal to the longitudinal beams. The other method used in modeling the bridges is the finite element method.

FINITE ELEMENT ANALYSIS:

Finite elements, referred to as finite elements, connected together at a number of nodes. The finite elements method was first applied to problems of plane stress, using triangular and rectangular element. The method has since been extended and we can now use triangular and rectangular elements in plate bending, tetrahedron and hexahedron in three-dimensional stress analysis, and curved elements in singly or doubly curved shell problems.

Finite element needs more time and efforts in modelling than the grillage. The results obtained from the finite element method depend on the mesh size but by using optimization of the mesh the results of this method are considered more accurate than grillage. The finite element method is a well-known tool for the solution of complicated structural engineering problems, as it is capable of accommodating many complexities in the solution. In this method, the actual continuum is replaced by an equivalent idealized structure composed of discrete elements, referred to as finite elements, connected together at a number of nodes. The availability of sophisticated computers over the last three decades has enabled engineers to take up challenging tasks and solve intractable problems of earlier years. Nowadays rapid decrease in hardware cost has enabled every engineering firm to use a desk top computer or micro processor. Moreover they are ideal for engineering design because they easily provide an immediate access and do not have the system jargon associated with large computer system. It is to be expected that software to be sold or leased and the hardware supplied with software. After the initial phase, where only principles of gravity and statics were enunciated resulting in ambiguity in applying to structural problem, Mathematicians took over from around 1400 A. D. and presented a variety of formulations and solutions. Purely, as exercise in basic science, around 1700A.D. these formulations and solutions found practical significance in applications to structures.

GRILLAGE ANALYSIS:

This method of analysis using grillage analogy, based on stiffness matrix approach, was made amenable to computer programming by Lightfoot and Sawko. When the complete field of slab, pseudo-slab and slab on girders decks are considered, grillage analogy seems to be completely universal with the exception of Finite Element and Finite Strip methods which will always be cost wise heavy for a structure as simple as a slab bridge.

When a bridge deck is analyzed by the method of Grillage Analogy, there are essentially five steps to be followed for obtaining design responses :

(a)Idealization of physical deck into equivalent grillage
(b)Evaluation of equivalent elastic inertia of members of grillage
(c)Application and transfer of loads to various nodes of grillage
(d)Determination of force responses and design envelopes and
(e) Interpretation of results.

NUMBER AND SPACING OF GRID LINES:

Wherever possible, an odd number of longitudinal and transverse grid lines are to be adopted. The minimum number of longitudinal grid lines may be three and the minimum number of transverse grid lines per span may be five. The ratio of spacing of transverse grid lines of those of longitudinal grid lines may be chosen between 1.0 and 2.0. This ratio usually reflects the span to width ratio of the bridge. Thus, for a short span and wide bridge, it should be close to 1.0 and for long span and narrow bridge, this ratio may be kept closer to 2.0.Gridlines are usually uniformly placed, but their spacing can

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be varied, if required, depending upon the situation. For example, closer transverse grid lines should be adopted near a continuous support as the longitudinal moment gradient is steep at such locations. It may be noted that in the grillage analysis, an increase in number of grid lines consequently increases the accuracy of computation, but the effort involved is also more and soon it becomes a case of diminishing return. In a continuous girder bridge, more than one longitudinal physical beam can be represented by one grid line. For slab bridges, the grid lines need not be closer than two to three times the depth of slab. Following points give a summary of the guidelines to convert an actual bridge deck into a grid for grillage analysis:

(a) Grid lines are placed along the centre line of the existing beams, if any and along the centre line of left over slab, as in the case of T-girder decking.

(b) Longitudinal grid lines at either edge be placed at 0.3D from the edge for slab bridges, where D is the depth of the deck.

(c)Grid lines should be placed along lines joining bearings.

(d)A minimum of five grid lines are generally adopted in each direction.

(e) Grid lines are ordinarily taken at right angles.

(f) Grid lines in general should coincide with the CG of the section. Some shift, if it simplifies the idealisation, can be made.

(g) Over continuous supports, closer transverse grids may be adopted. This is so because the change is more depending upon the bending moment profile.

(h) For better results, the side ratios i.e. the ratio of the grid spacing in the longitudinal and transverse directions should preferably lie between 1.0 to 2.0.

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