REVIEW ON BEHAVIOR OF CURVED INTEGRAL BRIDGES

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Abstract: In the modern days, with the increasing traffic problems number of bridges are constructed in order to cope up with the traffic demands under the prevailing conditions and challenges. Due to these problems more number of curved bridges has been constructed. In case of curved conventional bearing type of bridges there are problems related to bearing articulation. Also the maintenance and initial cost of joints and bearings proves to be much costly. So the curved integral bridges have been introduced to overcome such restraints as they are monolithic and avoid the use of bearings and expansion joints. Also the curved integral bridges are aesthetic to view and simple in construction.

***Index Terms* – Curved Bridges, Integral Bridges, Bearings.**

I. INTRODUCTION

Curved Integral Bridges are the bridges which are curved in plan and monolithic. Such bridges have many functional and economical advantages as they are constructed without the use of bearings and expansion joints. Also due to the continuous construction the problem related to bearing articulation is avoided and it also improves the riding quality due to the absence of joints. Owing to this advancement the curved integral bridges have been popular in the counties like North America, Europe and many other parts of the world.

II. LITERATURE REVIEW

1) Yaohua Deng et al (2015) [1] carried out field monitoring program and a numerical based analysis in order to determine the behavior of curved and skewed bridge with integral abutments. The behavioral study of a newly constructed three span one lane bridge was done through field monitoring system under changing ambient conditions and was tested by a dump truck across the bridge walkway. Also parametric study was conducted to predict the behavior of such bridges under design load conditions. It was concluded that with the changes in curvature and skew there were significant changes in the stresses. Also it was found that thermal stress and its magnitude relative to the maximum stress can reach up to 3 ksi and 15% of the maximum stress, respectively.

2) Dunja Peric et al (2015) [2] assembled an entire finite element model of a three span integral bridge subjected to combined gravity and thermal loads. The substructure of bridge included the two sets of concrete piers, two abutments, and fourteen HP steel piles (seven at each abutment), having its strong axis of bending oriented parallel to the longitudinal direction of the bridge. Various load cases representing different amount of temperature increase in presence of different type of the backfill soil were simulated. The results of the analysis indicated that the effects of the amount of compaction on backfill and magnitude of thermal loading have opposite behavior on substructure elements as compared to that of superstructure.

3) Semih Erhan et al (2014) [3] compared the seismic performance of integral and conventional bridges considering the differences at their abutments. Three conventional jointed bridges were designed from the existing integral bridges having one, two and three spans and then the structural models of the integral and conventional bridges were created taking into account the nonlinear structural and dynamic soil–bridge interaction effects. The nonlinear time of the bridge models are conducted using a set of ground motions. In the analyses, the ground motions are scaled to peak ground accelerations ranging between 0.2 and 0.8 g to assess the seismic performance of integral bridges in relation to that of conventional bridges at various ground motion intensities and associated performance levels. The analyses results revealed that integral bridges have superior seismic performance compared to conventional bridges in terms of smaller inelastic rotations at piers and piles, deck displacements, pile axial forces, abutment rotations, pier column drifts and bearing displacements for the bridges under consideration.

4) Alaan G. Bloodworth et al (2012) [4] describes a method in which the results of laboratory cyclic stress-path testing within a numerical model have been used to determine the thermal cycling effects. For this samples of sand and stiff clay were tested in the tri-axial apparatus under stress paths that are typical behind an integral abutment. Both the soils showed distinct behavior, in which stiff clay attains relative little built up of lateral stress with cycles, whereas in case of sand stresses were found to be increasing continuously, exceeding at-rest pressure and finally reaching to full passive pressures. Also a numerical model was developed in order to determine the implications of these findings on soil-abutment interaction and to estimate the lateral stresses acting on the

abutment as a whole. It was found that the numerical model gave good agreement with published centrifuge and field data, indicating that the stress profile specified in some current standards is conservative.

5) Zhihui Zhu et al (2014)[5] The objective of the study was determine the effect that thermal stresses have on underlying foundation systems, such as intermediate bridge piers in integral abutment bridges. The study was conducted by instrumenting a multi-span integral abutment bridge with temperature and bridge response remote-monitoring devices. Simultaneous to the field-monitoring program, a detailed analytical study of the integral abutment bridge was undertaken considering self-weight and temperature loading.

- Following observations were obtained:

a) For superstructure temperatures cooler than the base construction temperature, rotations were induced in Pier such that the pier rotated away from the center of the bridge and vice versa.
b) The pier footings have been designed so that pressures are limited to approximately one-half of the allowable bearing capacity for the bridge site.

6) D.L. Kozak et al (2018) [6] In this study, two Integral bridges were modeled and were subjected to design-level earthquakes; one using pre stressed concrete girders, and the other using steel plate girders as the main superstructure elements. Two analysis types were conducted for each 3-span IAB in both directions i.e. transverse and longitudinal directions:

i. Static pushover analysis
ii. Dynamic analysis

The design-level shaking was provided by 20 ground motions, for a 1000-year return period hazard-level, developed for the southern Illinois city of Cairo. It was found that, yielding of piles at the abutments is a main limit state, which occurs in both the steel and concrete IABs for all dynamic analysis. Damage to the pier columns and retainers are more extreme in the concrete IAB as compared to steel IAB. The final location of consistent damage is in the retainers of the both bridge when subjected to transverse excitation.

- Recommendations:-

a) To increase abutment pile size.
b) Smaller retainer anchor bolt for Steel Integral abutment bridges.
c) Increase the size of pier column.

7) Emre Kalayci et al (2015) [7] The effect of curvature and Backfill material on response of curved Integral Bridges is investigated using results 3D finite element models (FEMs) having the structural characteristics of bridge in Vermont .The bridge models are differed by varying the degree of curvature (0^0 to 50^0) of the superstructure and backfill material properties (loose sand and dense sand), thus forming total 10 models. The influence of curvature and backfill material on IAB thermal response was determined through the comparison of longitudinal and vertical deformations of the bridge deck, abutment displacements and rotations, weak and strong axis pile moments, and backfill pressures behind abutments under the effect of thermal loading. It was found that temperature increase cause decrease in vertical displacement. The maximum vertical displacement in all cases increases with curvature. Backfill material had minimal effect on vertical deflection of bridge deck. Changes in abutment displacements and rotations with increased bridge curvature were dominated by self - weight; curvature of the bridge did not affect abutment displacements and rotations induced by thermal loading as strongly.

III SUMMARY

Following findings are observed from the review of the above papers:

- The value of thermal stress and its magnitude relative to the maximum stress can reach up to 3 ksi and 15% of the maximum stress, respectively.
- There is considerable effect on stress due to change in curvature and skew of the integral bridges.
- The effect of backfill compaction and thermal changes are inverse in case of substructure elements as compared to that of super structural elements.
- The increase in the curvature resulted in an increase in the maximum vertical deflection of bridge.
- Yielding of piles at the abutments is a main limit state, which occurs in both the steel and concrete.
- The temperature increase resulted in decrease in the vertical displacement.

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