



**INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI  
SHORT ABSTRACT OF THESIS**

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Programme of Study : Ph.D.

Thesis Title: Suitability of Numerical Modelling Approach of an Integral Bridge for Strengthening of RC Pile Foundation Using SSI

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Thesis Submitted to the Department/ Center : Department of Civil Engineering

Date of completion of Thesis Viva-Voce Exam : 23<sup>rd</sup> November, 2018

Key words for description of Thesis Work : Integral Bridge, Soil-structure Interaction, Soil continuum, Foundation retrofitting

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**SHORT ABSTRACT**

Integral Abutment Bridges (IABs) have become widely popular in the recent years due to the absence of bearings at the junction of bridge deck and bridge abutment. That leads to a reduction in the overall maintenance cost of the bridge. However, the monolithic action of deck-abutment junction changes the behaviour of the overall bridge under temperature loading and earthquake shaking. In an integral abutment bridge, bearings may be absent at the locations of the piers also. Then, the bridge is known as a fully integral bridge. In such a bridge, the behaviour of the bridge tends to follow frame-type action with all the junctions of the deck and the vertical members acting as monolithic units. Although, past studies have been carried out on behaviour under temperature variation for both the types of bridges, detailed investigations of seismic behaviour of the bridge with different modelling approaches of soil-structure interaction, have not been carried out. Also, the pile foundations below bridges have been observed to undergo failure during past earthquakes and this necessitates further investigations. All these provide the motivation for the current study.

In the present study, a multi-span RC integral bridge on RC pile foundation is first modelled using an open source program, *OpenSees*, with stratified foundation soil. For modelling Soil-Structure Interaction (SSI), two approaches are implemented separately, namely (a) soil domain approach in which the soil is modelled as a continuum, and (b) spring-dashpot approach in which the lateral strength and stiffness of the soil are modelled considering Beam on Dynamic Winkler Foundation concept. Based on the site details (the real bridge site is located in California, USA, from which the bridge characteristics have been taken), seven ground motions are selected from a strong ground motion database by matching of mean displacement spectrum for all the ground motions with a target spectrum. Under the selected site-specific ground motions, nonlinear time history analyses are carried out for different models with changes in boundary conditions at the bottom of the piers, presence or absence of backfill soil and the two different SSI modelling approaches. The variations in the deformation at bridge deck level and section level response of the piers are observed. As compared to the soil domain approach, the spring-dashpot approach is observed to

provide conservative estimates of forces and moments, and possibly can be recommended for implementation in seismic design.

For an integral bridge, the overall length of the bridge tends to play a major role in the response under temperature loading. The same parameter is expected to significantly influence the overall bridge response during earthquake shaking. In the second part of the study, the overall length of the same integral bridge is changed and nonlinear time history analysis is carried out under site specific ground motions using the spring-dashpot model for different types of foundation soil. With increase in overall length, inelasticity is observed in the response of pier and pile foundation for certain soils. Consequently, one of the retrofitting methods for pile foundation, i.e., through installation of new piles encased in jet grout, is implemented on the pile groups below abutments and the piers in two separate stages. The numerical modelling of the encasement method is carried out using suitable spring-dashpots to model the soil and the grout around the new piles. For certain soils, the response of the bridge gets significantly improved through reduction of nonlinear behaviour of the components, after applying the retrofitting method.

In a summary, the present thesis tends to provide insight into the seismic behaviour of an integral bridge with RC pile foundation from the aspects of different numerical modelling approaches, influence of overall length and improvement in the response of pile foundation through encasement method of retrofitting.

