Study on Dynamic Soil Structure Interaction of Bridge: A Review

Gajendra Ahir[1], Sanket S. Sanghai[2]

M. Tech Scholar[1], Assistant Professor[2]

Department of Civil Engineering

G. H. Raisoni College of Engineering, Nagpur, India

Abstract

On this paper, the idea of dynamic soil-structure interaction changed into added, and their results were discussed. One of a kind bridge model turned into tested beneath the DSSI effect and their result became analyzed for the effective design of the shape. The various dynamic version was a examine based totally on parameter on SSI conduct via the various pupil is tabulated. Evaluation technique for the collective reaction of the shape, foundation, and underlying soil became generalized in the paper. The usage of FEMPL model soil character changed into delivered to assess the dynamic soil-shape interplay. The study on numerous bridge models shows the differential within the influence of soil in seismic effect to bridge to numerous elements of the bridge just like the deck, abutments, piers, basis, and so forth.

Keywords: Dynamic Soil structure interaction, Dynamic loading, Static loading, Viscoelastic impedance

Introduction

Nearly all structures of civil engineering have some str uctural elements that have direct contact with the soil medium.Therefore; an analysis should also be carried o ut taking into account soil behavior under such behavio r.A superstructure analysis model should be verified wi th the correct soil foundation response.In general, struc tures are analyzed on the suggestion that a base is form ed by the fixed support. The soil supporting the mecha nism may not provide the structure with full fixity. Thi s causes our assumption as inefficient and theoretical o f fixed support. The structural response may not correspond with the practical response taking into account to fixed support.The effect of soil structure interaction, typicall y based on analysis, may actually reduce the dynamic s tructural response compared to the fixed based system response, depending on the soil and structure of the bui lding dynamic characteristics.

The responses to the structure due earthquake shaking are affected due to 3 structures: the structure, the inspiration and soil underlying and surrounding the muse. Soil shape interaction analysis evaluates those responses to a specific floor motion. The primary idea at the back of the provisions is that the soil-structure gadget may be replaced with an equal constant-base version with a longer length and usually a larger damping ratio. Whilst a shape is subjected to an earthquake excitation, it interacts with the inspiration and the soil, and hence modifications the movement of the ground. Soil-structure interaction widely may be divided into phenomena: a) kinematic interplay and b) inertial interaction. Earthquake ground motion causes soil displacement referred to as loose-field movement. But, the inspiration embedded into the soil will now not follow the unfastened discipline movement. This lack of ability of the inspiration to match the loose area motion reasons the kinematic interaction. On the other hand, the mass of the superstructure transmits the inertial force to the soil, inflicting similarly deformation within the soil, which is termed as inertial interplay.

Literature and Methodology

Indrajit Choudhary et.al, 2017 proposed the two-general solution for pier well interaction considering the well foundation as a i) rigid and ii) flexible structure. The study shows the time period of the pier in fundamental mode computed through the expression derived [1]. Dynamic soil structure interaction (DSSI) was investigated between the well and pier to carried out the behavior of the rigid caissons foundation which is embedded in soil for the earthquake forces. And demonstrated the fixed based assumption for the pier for the DSSI analysis presented on two mathematical model a) a simplified model and b) a generalized solution. It also endures the cognizance scenario analysis if liquefaction occurs in the soil. But the stiffness formulation has partial embedment to the foundation.

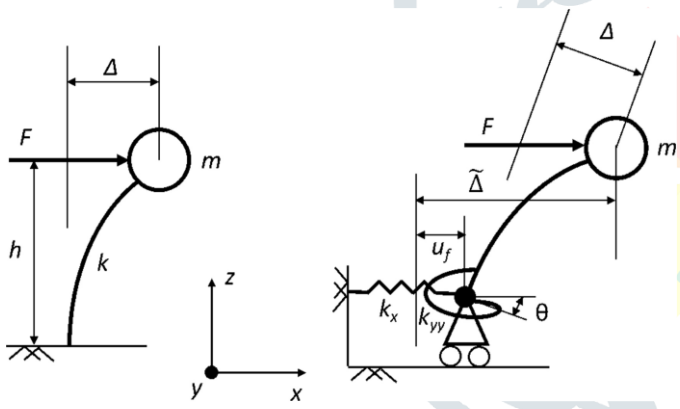

Fig. Schematic representation of structure-soil system

(Source: Vishwajit Anand et.al, 2018)

Amin Rahmani et.al, 2016 study show the evaluation of sub structuring method for seismic soil structure interaction of bridges. It is practical approach which separates the bridge system into bridge superstructure (includes bridge deck and piers) and substructure (includes soil pile group and embankment) etc. While considering SSI effect the model was simulated using the sets of nonlinear springs. Spectral ground motion was recorded at the ground level during the 1979 Imperial valley earthquake and 2010 EI Mayer Cucapah earthquake. The method was validated on evaluation of continuum model of two-span bridge and its extension to three span bridge [2]. And their analysis results for ground motions revealed the weaknesses of sub structuring method. The secant stiffness which was derived was not adequately represented in the MRO at its support. He concluded that SSI numerical simulation aid the advancement in engineering practice for bridge system design.

Manthos P et.al, 2018 has developed the Finite Element Perfectly matched layer to compute the characteristic of structure considering the DSSI [3]. They said that DSSI affects the model characteristics due to flexible support conditions and dissipation of energy in the soil. To demonstrate the methodology Euro protease test structure was used. And has computed the rational Krylov (CoRK) Eigen solver to solve the non-linear Eigen problem of SSI system. It results in the development of a mixed formulation of PML model to retain both displacements and stresses as the independent variable. This model can be used to influence the dynamic SSI on experimental identification of modal characteristics with potential applications.

Callisto L. at.el, 2013 it illustrates the behavior of the seismic soil structure interaction developed in the early stage of bridge design. It includes a series of 2D plane numerical analyses [4]. For carrying out the tests nonlinear dynamic analyses were carried in the time domain for effect of two records. There was misleading in description of foundations response in which viscoelastic impedance (which involves inclined layering, slopes, varying water levels, etc.). It made three different approach for the soil liquefaction safety in which one approach particularly interest the involvement of undisturbed sample of gravels and advanced laboratory tests. So, it results implicitly the dynamic loading condition that accounts the soil-structure interaction analysis.

Yan XU and Shide HU, 2011 showed that a practical cable stayed bridge for the study of seismic behavior of the bridge under strong earthquakes [5]. The was 730m long main span with two high rise towers over 200m in

height. Their results showed that tower is more vulnerable to pulse-like earthquake and may develop plasticity. Under specific-site viscous dampers had not the same effect during pulse-like earthquakes. And hence, reoptimization of dampers parameters or reconsideration of device which generates energy dissipation will be considered if strong seismic forces are likely to occur.

Gian Michele C. et.al, 2011 adopted the newly conceptual designs in high seismic areas where same have already proved the success but not for the long span cable stayed bridge. This paper illustrates the seismic design for strong input from both conceptual designs as well from design point of view.It shows the interaction of the soil to structure after such seismic impact how the characteristic like liquefaction occurs. Within proposed approach, structural reaction was ensured through passive dissipation devices with configuration for such kind of bridge. This approach gained the confidence in this innovative approach for seismic protection to structure by means of bridging morphological and economic growth of entire structure those prone to natural hazard like earthquake.

Syrea Dhar et.al, 2016 has simulated the sequential steps of the dynamic soil structure interaction of a integrated bridge structure OpenSeesSP source code has been used. Author has developed the soil foundation-structure model to calculate linear and nonlinear wave propagation of soil. DEEPSOIL software was used to conduct the 1D response analyses on linear-nonlinear soil behavior in a time domain. To evaluate the free field soil, soil-pile foundation and full soil foundation bridge system was carried out in 2D numerical analyses. And there effect shows the nonlinearity on structural response has significant when it is subjected to high intensity ground motion. So depending on the structure consideration mentioned in natural vibration characteristics may result in inaccurate over under conservative sides.

Sudanna Borjigin et.al, 2018 performed the dynamic response analysis on nonlinear interactive vehicle bridge system under strong earthquake. Seismic design codes in most countries do not follow for Highway Bridge which shows the simultaneous procedure of live loads and earthquake loads. It is important to explain the effects of moving vehicles on seismic response of bridge.

Author has used MATLAB software to solve vehicle bridge interaction (VBI) program to intergarte commercial FEA package. So as to get the effect on vehicle dynamics or seismic responses for the bridge to know the clarified results. Method shows the large longitudinal displacement at the top of the pier and causes plastic deformation at the bottom. Moving vehicles reduces the acceleration responses at top of pier and bearings of relative displacement. Because of it vehicles behaves like a dampers for the bridge, and probably specific ground motion at lower level than original was excited to in phase Vehicle Bridge. The other mode level dissipates seismic energy which could dissipate bridge components and bearing displacements. Author explains that assumption such as fixed base cannot represent SSI effect. But in addition soil uncertainty may leads to change in dynamic behavior of system.

Biplab Das et.al, 2016 has discussed effect of various soil types on the piled rafted foundation incorporating the dynamic soil structure interaction. An adaptation of such conventional design at base level for superstructure and pile head remains unchanged. Such interaction affects largely fundamental frequency and column-piles design forces. This observe examines the impact of shear energy of soil in seismic layout of based via pile draft foundation embedded in tender clay. Super structure is modeled as lumped mass stick model and piled raft slab is modeled as inflexible plate. Pile is modeled as Euler–Bernoulli beam detail and resistance using linear Winkler springs connected to the pile. Dynamic review is experienced in anticipate area to count their responses. Monte Carlo simulation way of doing thing is secondhand for probabilistic considered opinion of the integral frequency and forces at column and reactor attributing a immense range of parametric conversion of continue preventative soil piled raft terrific Shape gadget. They have recognized

at shows that the crucial frequency and forces in notice and pile modifications appreciably seeing of co untried variability.

Summary and Conclusion

The review of the current study applied in dynamic soil structure analysis leads to the properly calculate the force of technique, there portion is inadequate to approach under both influence like static and dynamic loadings. Many of not proposed the design on soil mass as visco-plastic, visco-elastic and elastic-plastic in interaction analyses. To pound nonlinear soil-structure interaction analysis, incremental iterative stratagem is stay to be the virtually suitable and commander one. The finite element approach has dependable to be a very convenient method for studying soil-structure interaction effect mutually rigor. In specific, the technique becomes convenient to involve the effect of material nonlinearity, non-homogeneity and interface modeling of soil and foundation.

References

Chowdhury, Indrajit, et al. "Dynamic soil structure interaction of bridge piers supported on well foundation." Soil Dynamics and Earthquake Engineering 97 (2017): 251-265.

Rahmani, Amin, et al. "Evaluation of sub structuring method for seismic soil-structure interaction analysis of bridges." Soil Dynamics and Earthquake Engineering 90 (2016): 112-127.

Papadopoulos, Manthos, et al. "Modal characteristics of structures considering dynamic soil-structure interaction effects." Soil Dynamics and Earthquake Engineering 105 (2018): 114-118.

Callisto, Luigi, Sebastiano Rampello, and Giulia MB Viggiani. "Soil–structure interaction for the seismic design of the Messina Strait Bridge." Soil Dynamics and Earthquake Engineering 52 (2013): 103-115.

Xu, Yan, and Shide Hu. "Seismic design of high-rise towers for cable-stayed bridges under strong earthquakes." Frontiers of Architecture and Civil Engineering in China 5.4 (2011): 451-457.

Calvi, Gian Michele, et al. "Seismic Design of cable-stayed bridges. The South Crossing Bridge in Guayaquil, Ecuador."

Yamaguchi Eiki, et al. "Dynamic Response Analysis of Bridge under Seismic Loading Including Collision."

Standard, British.

"Euro code 8: Design of structures for earthquake resistance." Part 1 (2005): 1998-1.

Das, Biplab, Rajib Saha, and Sumanta Haldar. "Effect of in-situ variability of soil on seismic design of piled raft supported structure incorporating dynamicsoil-structure-interaction." *Soil Dynamics and Earthquake Engineering* 84 (2016): 251-268.

Borjigin, Sudanna, et al. "Nonlinear dynamic response analysis of vehicle–bridge interactive system under strong earthquakes." *Engineering Structures* 176 (2018): 500-521.

Wu, Ruo-Yang, and Chris P. Pantelides. "Seismic evaluation of repaired multi-column bridge bent using static and dynamic analysis." *Construction and Building Materials* 208 (2019): 792-807.

Wu, Ruo-Yang, and Chris P. Pantelides. "Seismic evaluation of repaired multi-column bridge bent using static and dynamic analysis." *Construction and Building Materials* 208 (2019): 792-807.

Anand, Vishwajit, and SR Satish Kumar. "Seismic Soil-structure Interaction: A State-of-the-Art Review." *Structures*. Elsevier, 2018.