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ANALYSIS OF SOIL-BRIDGE INTERACTION MODELING IN SEISMIC-ISOLATED BRIDGE

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ABSTRACT

This response is a superposition of the pile foundation's own response to the excitation in the absence of the superstructure's kinematic response. The soil response analysis is one of the most important aspects of earthquake engineering. This study determines the amount of ground motion that will take place at the surface of the soil in the event that there is no structure present. Building bridges that are resistant to the effects of earthquakes, it is common practise to ignore the implications of soil-structure interaction (SSI) as well as the contribution of higher modes of vibration. These reductions are determined under the assumption that the flexibility of the isolation system and the distinct vibration modes are responsible for controlling the seismic behaviour of the bridge. The research will include estimating the seismologic aspects of the area, as well as defining and modelling the soil profile and its dynamic properties. In addition, when the seismic waves pass through the soil deposits, they take into account the many reflections and refractions that will take place at the interfaces between the soil layers.

Keywords: *Soil-Bridge , Interaction , Modeling , Seismic-Isolated , Bridges*

INTRODUCTION

Soil Structure Interaction

The seismic SSI problem may primarily be broken down into two different parts. The first consideration is how the soil behaves as seismic waves travel across it and reach deeper layers. A common assumption is that the second response is the coupled foundation-superstructure response, which is a superposition of the pile foundation's own response to the excitation in the absence of the superstructure's kinematic response and the impact of the foundation's additional flexibility on the superstructure's inertial response. This response is a superposition of the pile foundation's own response to the excitation in the absence of the superstructure's kinematic response.

The soil response analysis is one of the most important aspects of earthquake engineering. This study determines the amount of ground motion that will take place at the surface of the soil in the event that there is no structure present. This is referred to as the "free field response." The research will include estimating the seismologic aspects of the area, as well as defining and modelling the soil profile and its dynamic properties. Additionally, the inquiry will focus on determining and modelling the soil profile. In addition, when the seismic waves pass through the soil deposits, they take into account the many reflections and refractions that will take place at the interfaces between the soil layers. The validity of the findings still significantly depends on how precisely dynamic soil characteristics are approximated, which is still a tough issue despite the breakthroughs that have been made in situ testing. While there are computer programmes that are specifically designed for this purpose, the validity of the results is still heavily dependent on these programmes. In this study, rather than doing a soil amplification analysis, the considered accelerograms were used directly to excite the structure and the springs, which were used to mimic the foundation. This was done in place of the traditional practise of conducting the analysis.

Importance of Soil-Bridge Interaction Modeling In Seismic-Isolated Bridges

When building bridges that are resistant to the effects of earthquakes, it is common practise to ignore the implications of soil-structure interaction (SSI) as well as the contribution of higher modes of vibration. These reductions are determined under the assumption that the flexibility of the isolation system and the distinct vibration modes are responsible for controlling the seismic behaviour of the bridge. There has not been a lot of research done on how SSI affects the performance of seismically isolated bridges and structures (Chaudhary, Vlassis, Todorovska, Dasgupta), although there has been some. As a consequence of this, there is a need for further research to be conducted in this area so that design engineers may develop more accurate structural models of seismically isolated bridges. This might lead to a more precise evaluation of the seismic response shown by the structures. As a result, the purpose of this research is to analyse the effect that these simplifications have on the performance of seismically isolated bridges.

RC Bridge

Over the course of many years, the presentation and seismic analysis of extension structures have advanced significantly, directly linked to the rapid growth of computerised modelling. Significant advancements were made in both static and dynamic analysis of extension frameworks upon the creation of restricted component procedures. Flexible research methods were previously used for span underlying assessment, which is insufficient for inelastic activity. In any case, nonlinear unique analysis becomes essential for the basic assessment of bridges, but it takes a very long time. Because it is labor-intensive and inexpensive, nonlinear static examination, or "sucker," is the perfect inelastic seismic conduct device for underpinning bridge assessments.

The following are the main fundamental rezones that were identified during the harm review of the extension rezones caused by late earthquakes: an incorrect estimate of the seismic shear esteem of the dock segment limit; a large seismic development of the scaffold deck that can add extra time and offer to connect the wharf in the event that the scaffold base disconnects; an assessment that neglected to consider inelastic primary activities and related concepts of flexibility. Due to plastic pivot that was made in span dock in various areas and levels in view of the seismic force worth and generally span solidity components, which was consistently embraced for seismic plan of bridges prior to 1970, all of the underlying deficiencies result in inelastic disappointment methods of bridges. The sucker inspection was described in references as a nonlinear static process that imparted static sidelong forces to the structure. Absolute base shear is clearly relative, and top uprooting of the structure is a symptom of disappointment, with the structure's limit bend reproducing the mode of disappointment. Conflicting assessments on the role of underlying inelasticity on seismic demand were found in a substantial number of previous tests on bridges that recalled SSI as well as inelasticity for span dock.

OBJECTIVES OF THE STUDY

1. To study on Importance of Soil-BridgeInteraction Modeling in Seismic-Isolated Bridges
2. To study on Soil Structure Interaction

RESEARCH METHOD

Problem Related To Useful Utilization of SSI For Building Structures

Problems related with the useful utilization of SSI for building structures are established in an unfortunate understanding of essential SSI standards. Soil-structure interaction points are by and large not instructed in graduate quake designing courses, so most specialists endeavoring SSI practically speaking should gain proficiency with the subject all alone. Tragically, practice is upset by a writing that is frequently challenging to understand, and codes and standards that contain restricted direction. Most articles depend vigorously on the utilization of wave conditions in a few aspects and complex number juggling to plan arrangements and express outcomes. Also, classification is frequently conflicting, and pragmatic instances of SSI applications are scanty. This brings about the current circumstance where soil-structure interaction is only occasionally applied, and when it is, displaying conventions shift broadly and are not thoroughly thought out all of the time.

Liquefaction designing is one of the difficult regions in geotechnical tremor designing. Particularly after metropolitan regions struck by large tremors which made significant harm in structures due liquefaction, it has been understood that more exertion ought to be given to understand the interaction between underlying execution and geotechnical angles.

VALIDATION OF THE PROGRAM

Geometry and Boundary Condition

A three layered model as displayed are utilized to address the soilpile framework in the event of single heap and gathering heap individually. The soil and heap were displayed utilizing eight-hub hexahedral components called block component. Every hub has three levels of opportunity that is interpretation u x in x, interpretation u y in y bearing and interpretation u z in z heading. The soil is thought to be Clay, the heaps are made of cement and have square cross area with each side 0.5 m. The length of heap 10m with heap slimness proportion of 20 (aspects and properties same as in literature).The material properties of the heap and soil are given in Table 1.

Table 1. Soil Properties

Material Properties	Modulus of Elasticity (KN/m^2)	Poisson's Ratio	Yield Strain
Clay	11.78×10^3	0.4	0.0002
Concrete	25×10^6	0.2	0.0035

In this thesis aspect ratio is taken as 1.0 (Logan, 2002) after looking into the constraints on maximum number of elements with minimum computational time.

Boundary Condition

To show the soil-structure cooperation issues utilizing the limited component technique the unbounded area must be shortened to a space of limited size as the size of a limited component is limited. The limit condition will be different for static and dynamic examination.

Static Analysis

In a static examination, a counterfeit limit is presented adequately far away from the structure to shorten a limited area of the unbounded space. The limited space and this limited piece of the unbounded area structure a computational area to be demonstrated utilizing limited components. Since the relocations decline with the rising separation from the structure, straightforward limit conditions, for example, Dirichlet limit condition can be implemented on the shortened limit. This straightforward procedure of shortening the unbounded area has been shown to be adequately exact for statics (Cook et al., 2002).

Elastic Response Spectrum and Acceleration-Displacement Spectrum, ADRS Format

The transformation of the limit bend to the limit range requires that the flexible reaction or plan range is plotted in speed increase removal design, ADRS, instead of speed increase period design, Figure . The ADRS range is additionally indicated as the interest range. This has been the main improvement of the CSM technique, by Mahaney et al. (1993).

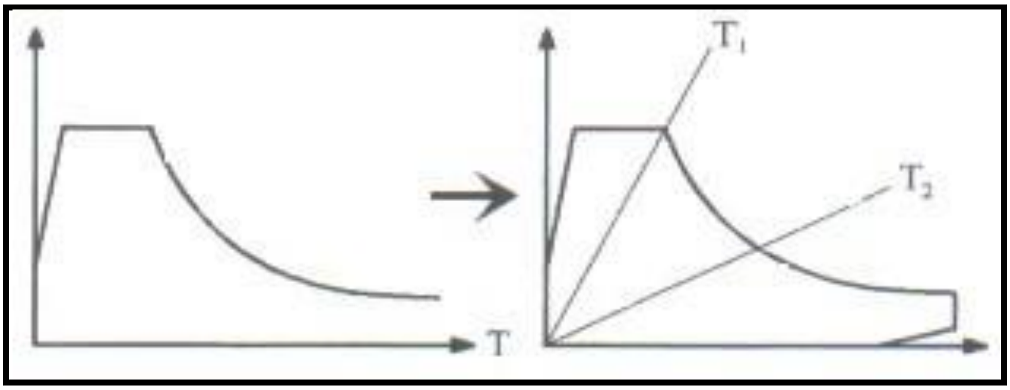

Figure 1 Conversion of elastic spectrum to ADRS spectrum

DATA ANALYSIS

PUSHOVER ANALYSIS OF SDOF SYSTEMS

Insight into Modelling

SDOF frameworks with normal vibration times of Tn = 0.1, 0.3, 0.5, 0.8, 1 and 2 seconds and a damping proportion ζ of 5% were displayed in the LUSAS FEA bundle utilizing the joint component, JNT3. The frameworks will be meant as SDOF 0.1, SDOF 0.3, SDOF 0.5, SDOF 0.8, SDOF 1 and SDOF 2 individually. The actual model of the frameworks is displayed in Figure 6.1(a). The versatile opposition of every framework to removal was given by a massless spring k, expected to have just levels of opportunity in the x-course along these lines permitting interpretation to happen. The mass m was glorified as being lumped at hub 2 of the component, Figure 1(b). Rayleigh damping addressed by solidness and mass corresponding grids to decouple the condition of movement to work on the arrangement cycle, was utilized.

For the inelastic investigations the yield strength of every framework was thought to be 0.25 of the greatest flexible power determined from direct unique examinations utilizing the Kocaeli and El Centro ground movements, that is a strength decrease element of $R\mu = 4$. It is noticed that the yield qualities of the SDOF frameworks for the two ground movements are of various greatness. The EPP and EPSH hysteretic models, Figure 4.9, characterized in Chapter 3 have been utilized in these investigations.

PUSHOVER ANALYSIS OF A 2-DOF SYSTEM

Having depicted the way of behaving of the SDOF framework, this segment will explore the seismic reaction of a two-level of-opportunity framework, 2-DOF, to the two ground movements recently utilized, using the traditional pushover investigation strategies portrayed in Chapter. These are the N2 technique, the Displacement Coefficient Method, DCM, and the Modal Pushover Analysis, MPA. The review will endeavor to evaluate the productivity of every strategy with regards to computing significant seismic requests like objective uprooting, flexibility, and reestablishing force.

- **Modeling**

The 2-DOF system was created by connecting in series two SDOF 0.5 systems used in the SDOF study. The theoretical model is presented in Figure 2. The same modeling assumptions were considered as in the case of the SDOF systems.

- **Modes of Vibration**

A natural frequency analysis was performed in order to obtain the two natural translational modes of vibration for this model. These are shown in Table 4.25. The natural mode shapes of the system are presented normalised, so that the right-end node mode shape is unity.

Nonlinear Dynamic Analyses

The model was exposed to nonlinear unique investigations to give a benchmark to the pushover examination results. The relocation time accounts of the framework are displayed in Figures 3 and 4 for the Kocaeli ground movement and the El Centro ground movement individually. Figures 5 and 6 show the complete applied force-relocation reactions for the Kocaeli ground movement and for the El Centro ground movement individually.

The outcomes show that the hubs of the framework dislodge in a way that checks the primary mode supposition of pushover examination. From the dislodging time chronicles for both ground movements, it very well may be seen that the framework yielded at roughly similar time moments. Moreover, the framework is uprooted for all time under both ground movements however with not a similar measure of extremely durable distortion. Also, noticing the two power uprooting reactions created from the two individual excitations the two hubs of the framework support about a similar measure of stacking for a similar ground movement. This happens at various time moments.

Table 1 Comparison of results between pushover analysis and nonlinear dynamic analysis for SDOF 0.1, Kocaeli

SDOF 0.1	Kocaeli					
	N2		DCM		Nonlinear Dynamic Analysis	
	$\alpha=0$	$\alpha=0.03$	$\alpha=0$	$\alpha=0.03$	$\alpha=0$	$\alpha=0.03$
Displacement (m)	0.0014	0.0014	0.0075	0.0075	0.0256	0.0085
Ductility	28	28	8.4	8.4	27.6	9.2
Reaction (kN)	178.02	180.95	178.02	217.37	185.32	317.15
Hysteretic Energy (kNm)	0.35	0.34	4.73	4.59	21.70	11.14

Table 2 Comparison of normalised results between pushover analysis and nonlinear dynamic analysis for SDOF 0.1, Kocaeli

SDOF 0.1	Kocaeli					
	N2		DCM		Nonlinear Dynamic Analysis	
	$\alpha=0$	$\alpha=0.03$	$\alpha=0$	$\alpha=0.03$	$\alpha=0$	$\alpha=0.03$
Displacement (m)	0.05	0.16	0.29	0.89	1.00	1.00
Ductility	1.01	3.04	0.30	0.91	1.00	1.00
Reaction (kN)	0.96	0.57	0.96	0.69	1.00	1.00
Hysteretic Energy (kNm)	0.02	0.03	0.22	0.41	1.00	1.00

Table 3 Comparison of results between pushover analysis and nonlinear dynamic analysis for SDOF 0.3, Kocaeli

SDOF 0.3	Kocaeli					
	N2		DCM		Nonlinear Dynamic Analysis	
	$\alpha=0$	$\alpha=0.03$	$\alpha=0$	$\alpha=0.03$	$\alpha=0$	$\alpha=0.03$
Displacement (m)	0.0256	0.0256	0.0549	0.0549	0.0474	0.0474
Ductility	7.3	7.3	6	6	5	5

Reaction (kN)	200.12	210.97	200.12	230.24	206.77	261.34
Hysteretic Energy (kNm)	13.20	12.81	36.64	35.54	34.93	35.34

Table 4 Comparison of normalised results between pushover analysis and nonlinear dynamic analysis for SDOF 0.3, Kocaeli

SDOF 0.3	Kocaeli					
	N2		DCM		Nonlinear Dynamic Analysis	
	α=0	*α=0.03*	*α=0*	*α=0.03*	*α=0*	*α=0.03*
Displacement (m)	0.54	0.54	1.16	1.16	1.00	1.00
Ductility	1.46	1.46	1.20	1.20	1.00	1.00
Reaction (kN)	0.97	0.81	0.97	0.88	1.00	1.00
Hysteretic Energy (kNm)	0.38	0.36	1.05	1.01	1.00	1.00

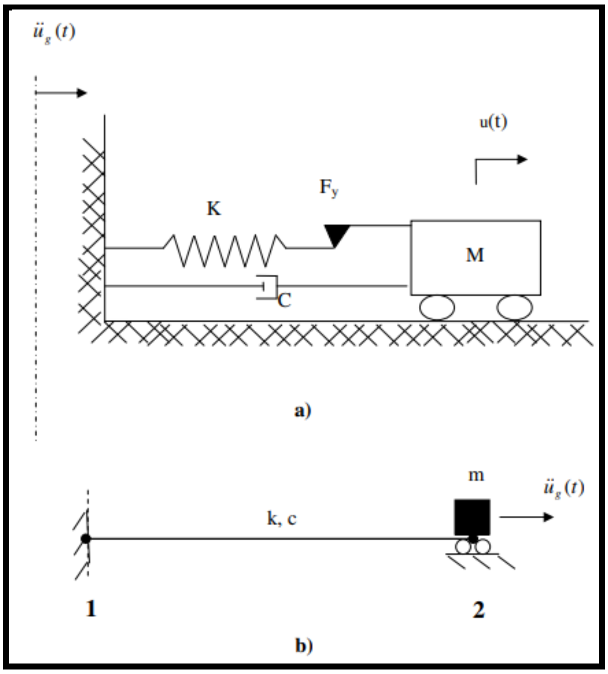

Figure 4.2 SDOF model a) Physical model b) FE model

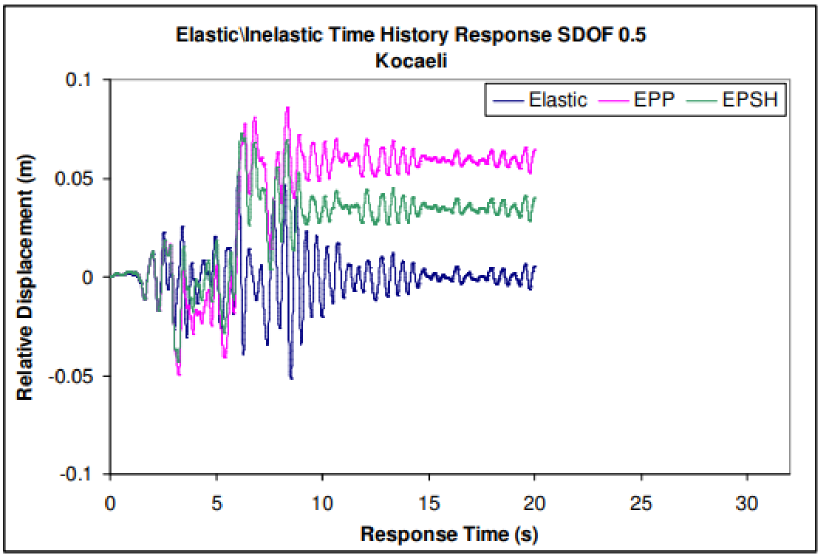

Figure 4.3 Displacement Time-Histories of SDOF 0.5 for the Kocaeli ground motion

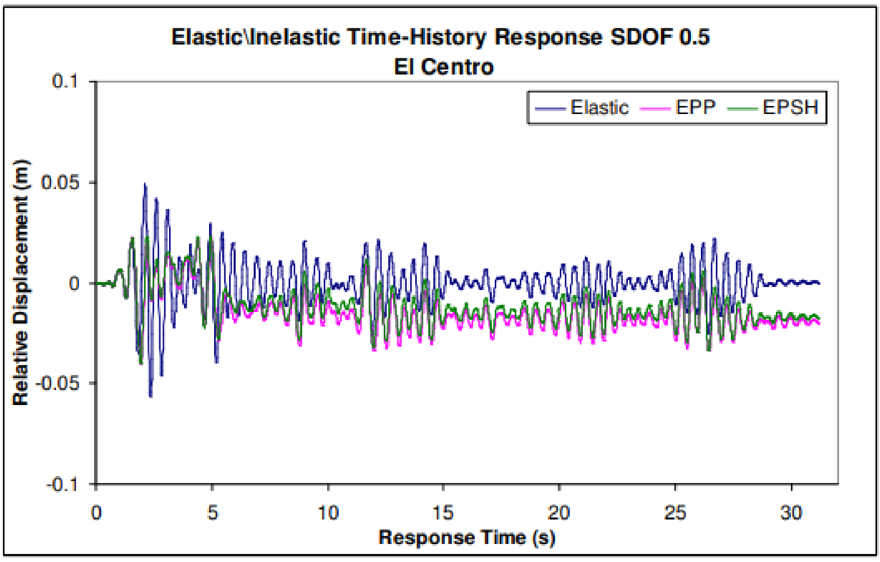

Figure 4.4 Displacement Time-Histories of SDOF 0.5 for the El Centro ground motion

CONCLUSION

This examination gave some essential data on the utilization, and precision of the different pushover investigation techniques in the seismic appraisal and plan of structures. The examination included the accompanying viewpoints: The fundamental idea of pushover examination was made sense of, and the different pushover investigation strategies were depicted. An exhaustive survey of past discoveries on pushover examination was given. Pushover investigations were led on six SDOF frameworks and a 2-DOF framework for two ground movements of various nature. The viability of the N2, DCM and MPA techniques in foreseeing significant seismic requests, for example, most extreme relocations, response power and flexibility and hysteretic energy was examined. Pushover investigations were consequently performed on a four-story built up substantial edge intended to EC8. The viability of the N2, DCM and MPA techniques in foreseeing most extreme relocations across the floor levels, the base shear and the flexibility was evaluated

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