Analysis Of Short Span RC Bridges' Effects On Pushover Due To Soil Structure Interaction

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ABSTRACT

Bridges are among the most vulnerable parts of transportation networks to earthquake damage and they are one of the most important components of those networks. In addition, the effects of soil-structure interaction have a significant influence on the seismic responses of the vast majority of bridges. The purpose of this study is to conduct a dynamic analysis of the influence of Soil Structure Interaction (SSI) on a multistory reinforced concrete (RC) bridge frame that is erected on soft soil and to compare it to a foundation that is fixed. For RCC In many parts of the world, it is standard procedure to use concrete wells as a means of providing support for the bridge girders of bridges that span bodies of water such as rivers or creeks. Even after a severe earthquake has struck a structure, it is crucial that as many bridges as possible continue to operate smoothly. This is especially important for bridges that are strategically significant in terms of defence or trade. The current state of the art for the design of well foundations is still plagued with a number of uncertainties, and a simplistic pseudo static analysis of its response is the only method that is commonly used. Despite the fact that it is common knowledge that the load from the superstructure, the nature of the soil, and its stiffness all play an important role in defining a well foundation's dynamic characteristics, the current state of the art for the design of well foundations is still plagued with these factors. Pushover analysis is performed with the objective of determining how well a structure performs when modelled with either a fixed basis or a spring base system. The analysis can be carried out with either a spring base system or a fixed basis. Because the “results show that the bridge stiffness decreases due to SSI effects on the bridge support for more flexible soils types that generates large displacement, with corresponding less base shear in bridge piers and footings by an average percentage of 12 percent and 18 percent, this information is

important for structural evaluation of new bridge construction as well as for strengthening and repair works evaluation of existing bridges”.

Key words: Soil-Structure Interaction, Pushover Analysis, RC Bridge.

INTRODUCTION

When modelling and developing structures that are constructed on solid ground or rock, it is usual practise to have a stable base with no soil–foundation–structure interaction. This type of interaction is more frequently referred to as soil–structure interaction. In these kinds of circumstances, the foundations that are created most frequently are the ones that have shallow spread footings. In the past, researchers have conducted studies to study how the behaviour of bridge systems that are supported by shallow foundations changes when the structures are shaken by earthquakes. To accomplish this, the supporting soil or rock was assumed to be a homogenous material, and it was presumed that the pier column and the parts of the superstructure would have a linear elastic behaviour. To "generalise" the effect that SSI has on structures like these, more parametric tests were conducted using a broad variety of variables for the soil/rock–foundation system and the pier columns. This was done in order to determine how the effects of SSI may be "generalised." This pursuit of generality generally led to significant departures from realistic bridge designs, and as a consequence, it led to the discovery of several solutions that were conceptually reasonable but had little relevance to the practical aspects of bridge design in the real world. Consequently, this pursuit of generality led to the discovery of several solutions that were conceptually reasonable but had little relevance to the practical aspects of bridge design in the real world. In a way quite similar to that described above, Chen and Lai explored the issue of a shallow bridge foundation that was placed on a soil that was thought to be "soft." This foundation was exposed to seismic forces. Their objective was to arrive at a logical answer to the predicament via research and consideration. However, it is obvious that such a situation cannot be permitted in an actual design when a deep foundation will be used for a "soft" soil profile. This is because the deep foundation will be required to support the weight of the building. This is because a foundation of such a type will not be able to support the weight of the structure if it is built.

SSI in a made-up bridge that is supposed to be resting on a circular foundation that is only a few centimetres deep This study also shed light on the significance of the'soil' aspect of the SSI problem. The type of foundation that was selected (i.e. a shallow foundation) was manifestly unsuitable for the soil conditions, which would have practically required the use of a deep foundation that possessed much more dynamic impedance in comparison to the shallow foundation. This aspect of the SSI problem was brought to light as a result of this study. The fact that a shallow foundation was chosen as the sort of foundation to use brought to light the relevance of the'soil' component of the structure. An investigation using analytical methods into the SSI of a simple one-lumped-mass inelastic structure built in soil layers. They got at the conclusion that SSI effects would only have a noteworthy influence if the fundamental period of the inelastic structure was less than the dominant period of the seismic ground motion. This was the result that they came to.

"The effect of rocking of under-designed shallow bridge footings on reducing the seismic response and they came to the conclusion that, despite the fact that this deliberate rocking of the footing may be helpful in reducing the seismic shear force, it may have detrimental consequences for footings and bridge displacement. In other words, the rocking of the footings may cause the footings to shift and the bridge to move. The rocking response of the foundations was the focus of a study that was somewhat comparable to the one that was conducted here in order to establish compatible yielding between the soil–foundation and superstructure components of a building structure".

"Studies that focused on locating shallow-seated instabilities (SSI) in bridges established on shallow foundations, either through field investigations or by analysis of recorded seismic vibrations have been extremely limited. These studies can be divided into two categories: those that used field investigations, and those that analysed recorded seismic vibrations. On a five-span continuous base-isolated bridge that was subjected to low levels of seismic motion (peak ground acceleration (PGA) varied between 0.01 and 0.03 g), the researchers utilised system identification techniques to analyse the structure's response. They arrived at the decision that the effect of the SSI on the bridge was insignificant as compared to the seismic activity that was detected. The results of their empirical investigation of soil–structure interaction in 10 instrumented bridges under a number of recorded earthquakes in California by comparing the free field seismic acceleration with the one recorded on top of the bridge foundations". This investigation was carried out in California. The state of California was the location where this inquiry took place. On the Richter scale, earthquakes with magnitudes ranging from 0.006 to 0.077 were strong enough to cause damage to five of the ten bridges that were built on spread foundations. These bridges were rattled by the earthquakes. After doing their research, they came to the realisation that SSI is not always beneficial for bridges, and that there are instances in which it may be extremely detrimental to the structure. There is no practical conclusion that can be drawn from these studies because the level of seismic activity that was observed during these occurrences was significantly less than the design threshold. As a result, there is no conclusion that can be drawn from these studies that can be applied in any way.

Conducting a proper analysis of the data that was gathered in the field is the most effective way for appreciating the SSI affects on bridges. This data was gained in the field. On the other hand, the significance of analytical studies should not be minimised because these studies provide answers that are accessible at a cost that is not prohibitively expensive and cover a wide variety of aspects that cannot realistically be addressed in field investigations. These sorts of studies also provide useful recommendations for improving the equipment and field observations that are utilised in the field. These hints may be used to enhance and improve the instruments and field observations. As a result of this, "an effort was made in this study to investigate the seismic performance of a class of bridge that was designed based on the current design practises for both the foundation and the bridge sub-structure components”. The purpose of this investigation was to determine how well the bridge would fare in the event of a seismic event. This was done in order to have a better idea of how well the bridge would hold up during a seismic activity.

OBJECTIVE

1. To investigate the top displacement and base shear/moment demands of different bridge pier heights, taking into account the entire weight of the immersed component of the well, for a variety of soil types and seismic zones.
2. To study Soil structure interaction effects on pushover analysis of short span rc bridges.

RESEARCH METHODOLOGY

SSI modelling, which stands for modelling of soil structure interaction?

These springs have a stiffness in space that is not dependent on frequency, which makes them a good model for the soil that is around the foundation of the pier. While the thorough “dynamic analysis is being carried out in the time domain, the Newmark” technique is utilised to carry out the study in its entirety.

When doing this comparison, the effects of SSI on the base shear force and top displacement are disregarded in order to focus solely on the reaction of the corresponding bridge. This is done so that the impact of SSI may be evaluated about its potential impact on the push over “analysis of the currently existing Piers Bridge. In addition, a parametric analysis is carried out to analyze the influences of soil flexibility on soft soil properties, medium soil properties, and hard soil values as basis lines of comparison. These are the soft, medium, and hard soil values”.

Consider, for instance, the typical two-span bridge with a continuous deck that is shown in Figure 3. The abutments and piers of the bridge are composed of reinforced concrete to provide the substructure of the bridge. For the sake of this discussion, let's assume that the structure is composed of “a series of line, column, and beam components. The following assumptions are assumed in order to carry out a pushover research on existing bridges while simultaneously taking into account the impact of soil-structure interaction”:

1) The soil that is used to support the foundation of the pier is represented as if it were a set of springs that were operating “in the vertical, horizontal, and rotating directions”.
2) The foundation is symbolised by stiff components that are coupled to soil springs and have frequency-independent coefficients.

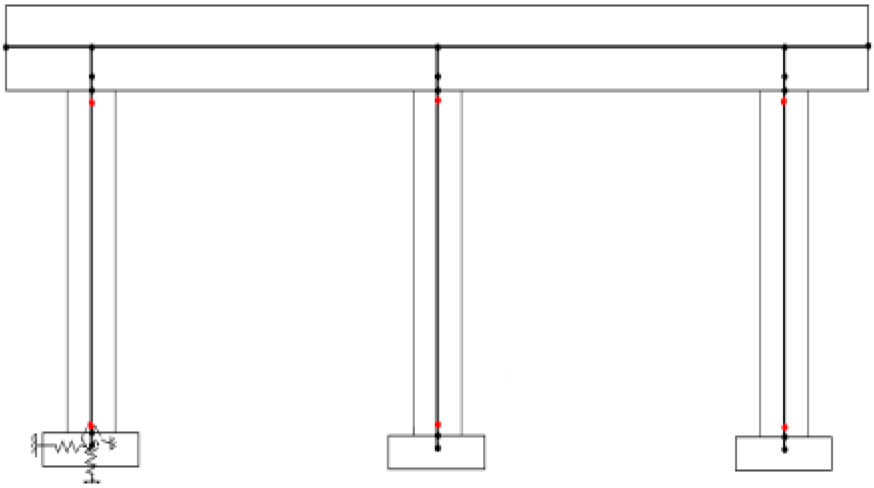


Figure 1: Model in mathematics of the Al-Fahs Bridge in Riyadh, Saudi Arabia

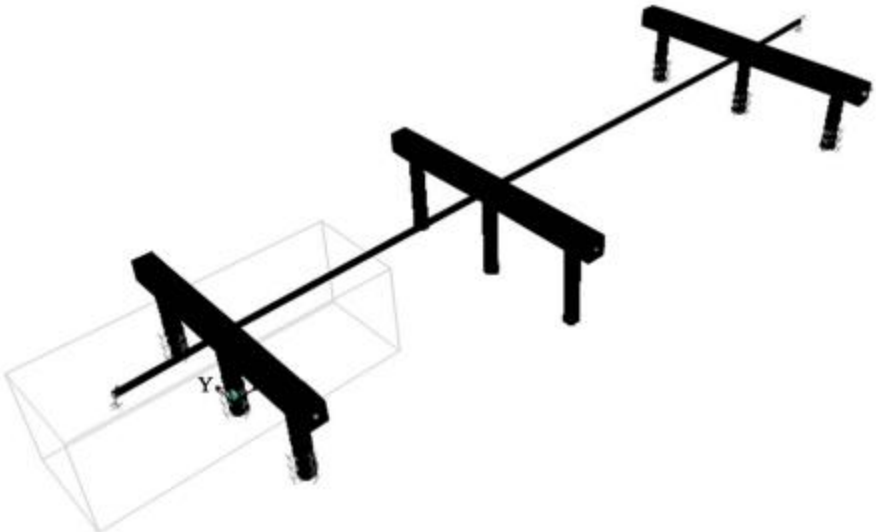


Figure 2: The Al-Fahs Bridge as modelled in 3D by SAP2000 using the finite element method,

The mathematical model of the bridge system that can be seen illustrated in Figures 1 and 2 is the product of the assumptions that were made in the paragraphs that came before it. The measurements of the foundation were not changed in any manner, and the spring stiffness was computed based on the assumption that these dimensions remained unchanged. This is a crucial point to keep in mind because it was the assumption that guided the determination of the spring stiffness. This assumption, which was used in earlier studies despite the fact that it is illogical, was debunked in the most recent study, “and the size of the footings was established based on the carrying capacity of each soil type”. In addition to this, the spring stiffness that is associated with each different type of soil was analysed. This assumption has been used in the past because it is more plausible than others that have been considered.

Soil Idealization

The basic categorization criteria that may be used to clay soil properties are outlined in Table 2, which can be found below. The model of the soil that is utilised to support the foundation of the pier is handled as springs, and these springs are meant to function in the vertical direction, as well as in the horizontal direction, as well as in the rotating direction. “Three springs, two for movement in global horizontal directions and one for movement in the vertical direction, are attached below the footings of the bridge in” order to facilitate movement. In addition, springs that rotate along the same three axes that are perpendicular to each other have been attached. As a direct consequence of this, springs including all six degrees of freedom have been attached to the bottom of the piers. A schematic illustration of such an idealisation is shown in Figure 2, which was created for the goal of making the concept more easily understandable. In order to accurately describe the foundation, we make use of stiff components that are then “connected to soil springs that have frequency-independent coefficients”.

The springs' degree of stiffness has been the subject of research of a thorough kind, with the objective of finding out how stiff they are. As can be seen in Table 1 of the present work, it has been hypothesised that closed form formulae may be utilised to characterise the stiffness of similar soil springs. This has been demonstrated. These expressions have been included into the investigation at hand, and Table 2 provides a tabulation of the values that have been derived from the investigation thus far. Shear modulus values are specific to each kind of soil and can vary greatly from type to type (G).

Table 1 Soil characteristics considered

Soil Types	N value	C (kN/m^2)	φ (degree)	γ_{sat} (kN/m^3)	C_c	e_0
Soft	10	18.5	0.0	17.0	0.189	0.90
Medium	20	36.8	0.0	18.5	0.135	0.72
Hard (Baseline)	45	220.0	0.0	21.0	0.093	0.58

“Where N is the result of the SPT test, C is the cohesion value, is the angle of soil internal friction, sat is the soil density, Cc is the compression index of soil, and e0 is the starting energy (initial void ratio of soil)”.

Table 2: Expressed in closed form are the values for the stiffness of comparable soil spring.

Degrees of freedom	Stiffness of equivalent soil spring
Vertical	$\left[2GL/(1-v)\right](0.73+1.54\chi^{0.75})$ with $\chi = A_b/4L^2$
Horizontal (transversal direction)	$\left[2GL/(2-v)\right](2.0+2.50\chi^{0.85})$ with $\chi = A_b/4L^2$
Horizontal (longitudinal direction)	$\left[2GL/(2-v)\right](2.0+2.50\chi^{0.85})-\left[0.2/(0.75-v)\right]GL\left[1-(B/L)\right]$
Rocking (about the longitudinal axis)	$\left[G/(1-v)\right]I_{bx}^{0.75}(L/B)^{0.25}\left[2.4+0.5(B/L)\right]$
Rocking (about the transversal axis)	$\left[3G/(1-v)\right]I_{by}^{0.75}(L/B)^{0.15}$
Torsion	$3.5GI_{bz}^{0.75}(B/L)^{0.4}(I_{bz}/B^4)^{0.2}$

"Moment of inertia of the foundation area with regard to the longitudinal, lateral, and vertical axes, respectively: Ibx, Iby, and Ibz. Have been measured with the help of the empirical formula G = 120 N 0.8 t/ft2, which can also be written as G = 12,916,692.48 N 0.8 MPa". The surface area of the foundation is denoted by the letter Ab, and the width and length of a rectangular foundation are denoted by the It has been assumed that Poisson's ratio (v) of soil is equal to 0.5 for all of the various types of soil in order to calculate the stiffness of the corresponding soil springs. This was done so that the soil spring stiffness could be calculated. During this portion of the discussion, the term "N" will refer to the total number of blows that will be delivered to the soil in the course of the standard penetration test (SPT), and "v" will be considered to be equal to 0.5. Table 4 illustrates that there is a significant discrepancy in the values of the spring stiffness that may be related to variations in the size of the footing. These differences can be seen across all of the spring stiffness measurements. This is not only something that should be expected, but it will also have an influence on the conclusions that are drawn from the inquiry when the SSI effect is taken into consideration.

It was concluded that the process of creating the mass and stiffness matrices for the model of the bridge would be best accomplished through the use of the finite element technique. In order to create reactions that was brought on by genuine ground vibrations, the "Newmark step-by-step direct integration method was utilized".

Effects of SSI Waves on the Pushover Analysis of the Bridge Pier

"Due to the inability to define the modification of bridge response during inelastic action, which is reflecting on the displacement capacity curve of bridge, it is obvious that the elastic analysis procedures used in the past for structural assessment of short span bridge behaviour are insufficient and inadequate. These procedures were used in the past for structural assessment of short span bridge behavior". In order to analyse the impact that SSI has on the pushover outcomes of bridges built on a variety of soil types, a numerical research is now being carried out. The Pushover analysis is a form of "nonlinear static analysis techniques that can be used to determine the dynamic characteristics and peak ground footing base shear corresponding to top pier displacement that is called a displacement curve of structures, to estimate available plastic rotational capacities to ensure satisfactory seismic performance.

These techniques can be used to determine the dynamic characteristics and peak ground footing base shear corresponding to top pier displacement that is called displacement curve of structures". Nevertheless, actual seismic analysis is still the approach that provides the most accurate predictions of the seismic characteristics of structures.

The structural assessment and the prediction of true and more practical processes of bridge collapse will both benefit from the estimation of the evolution of plastic hinges, which will be advantageous in the future. It is possible for these to become simpler to analyse than time history analyses, which take a significantly greater amount of time and effort in simulation and modelling compared to pushover analyses, which have an accepted level of accuracy as it was verified in. This is in addition to the various types of results and seismic data that were discussed above. It is presumable that the dampening of the bridges is five percent of the crucial value for each and every mode of vibration. The soil that surrounds the pier may be divided into three separate types: hard, medium, and soft. Each of these categories has its own unique characteristics. The qualities that each of these distinct soils held are outlined in Table 3, which can be seen here. On the basis of this, the "Pushover analysis with soil structure interaction will be more" useful in demonstrating how the structure would behave by identifying the various mechanisms of failure and the possibility for progressive collapse. This can be done by interacting with the soil beneath the structure.

Table 3. The values of the different types of soil's stiffness in relation to the various footing dimensions.

Stiffness of equivalent soil spring	Type of soils		
	Soft	Medium	Hard
	Footing dim. 30 * 30 ft	Footing dim. 25 * 25 ft	Footing dim. 15 * 15 ft
Vertical (kip/ft)	42,897	130,586	1,089,276
Horizontal (transversal direction) (kip/ft)	32,335	93,119	905,725
Horizontal (longitudinal direction) (kip/ft)	32,335	93,119	905,725
Rocking (about the longitudinal) (kip.ft)	7,689,516	12,130,288	17,914,003
Rocking (about the transversal) (kip.ft)	8,361,189	13,548,574	19,255,865
Torsion (kip.ft)	396,725	835,256	1,697,930

The pushover loading was not a simple lateral force, but rather was connected to the mode forms of the structure. The equivalent lateral seismic load was found to be proportional to the mode shape that was stated, the angular frequency of that mode, and the mass that was tributary to the node where the force was applied. It is possible to compute it using the Equation.

$$F_{ij} = d_{ij} \times \varpi_j^2 \times m_i \quad (1)$$

Where: i is (number of node), and j is (number of mode).

F_{ij} is the force at node (i) in the (j) mode of vibration;

d_{ij} is The displacement of node (i) in the (j) vibration mode at the angular circular frequency of ωj; mi is the mass tributary to the node (i).

The manual or the software tutorial will provide clarification on the pushover approach by discussing it in depth and verifying it. The generation of "equivalent static loads at each time step of pushover analysis corresponding to structures whose modes" have been described is the responsibility of SAP2000. The controlling displacement that was prescribed was more than the predicted probable ultimate displacement at the moment where it was being monitored. The structure was overworked to the point that it exceeded its full capacity, which resulted in a breakdown on a global scale. The pushover deflection and creative plastic hinges that were applied in the longitudinal direction of the bridge study case are depicted in Figure 3, which may be seen here. These were installed in parts of the footing and pier that had a weaker rigidity than the rest of the structure.

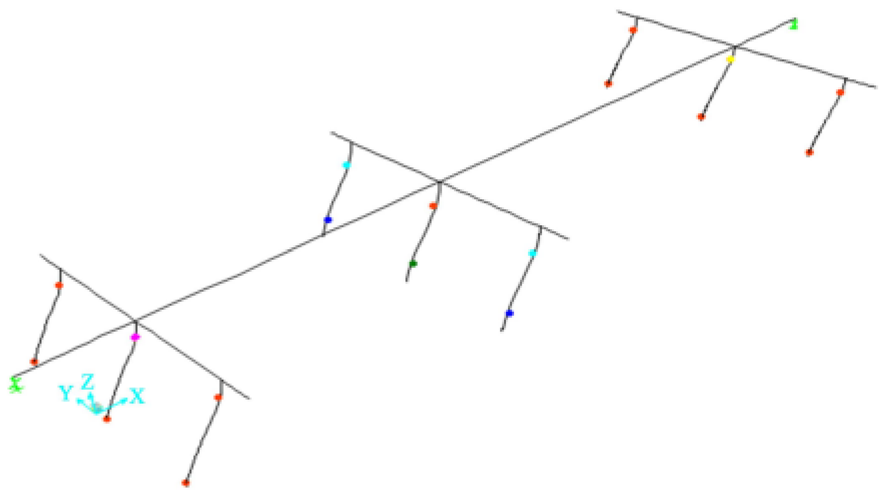


Figure 3. In the longitudinal direction of the Al-Fahs Bridge, the production of plastic hinges for the pushover analysis;

Seismic demands are analysed using lateral loads that slowly increase at each time step as part of the process of pushover analysis, which incorporates numerical analysis. This is something that may be performed through analysis, and it is done so until either a particular displacement is reached or the structure collapses, whichever occurs first. The load modes remain unchanged until one of these events takes place. Forces and displacements, which together are referred to as equivalent seismic loads, are able to be managed by employing the relevant control techniques, which can either be control methods for force or control methods for displacement. The force control approach has two basic downsides, in contrast to the displacement control method's three primary problems. After inelasticity has formed in the structure, it is difficult to adjust the force vector increment at each phase of the increment analysis using the force control technique. This is the approach's first and most significant shortcoming. The fact that the method of force control is more expensive is the second disadvantage of using it. The second possible disadvantage is the chance that the maximum lateral force may be reached, causing the analysis iteration to be terminated before the maximum displacement has been calculated. This is a drawback since the precision of the results is diminished as a result.

Since of this, the strategy that controls displacement has been chosen for this research because it is deemed to be the most appropriate choice among the available options. It is common practise to make use of SAP2000, a nonlinear finite element programme software analysis instrument, in order to keep an eye on a bridge's mass centre. This application was utilised for the purpose of keeping track of a goal displacement that was established at a monitored location.

“After the pushover study has been finished, a static pushover curve and a capacity spectrum of the structure may be produced for each load situation. Both of these may be determined using the pushover study. The shape of the pushover curve was determined by plotting the displacement at the monitored location against the base shear. The base shear may be thought of as the entire force reaction exerted on all of the supports in each global direction”.

The curve of the capacity spectrum as it extends down the longitudinal axis is seen in figure 4. This number was calculated using the results of the “finite element model software (print screen). On the spectrum region, the capacity spectrum and the demand spectrum were displayed by utilising the spectral acceleration vs. spectral displacement coordinates. The blue line illustrates the single demand spectrum with variable damping, whereas the red lines demonstrate the demand spectrum with varying damping ratios. The capacity curves of the study case bridge are depicted in figure 6 in both the longitudinal and transversal directions, as appropriate. When hard soil effects are present and the damping coefficient is held constant, the capacity spectrum graph illustrates the relationship between the top displacements of bridge piers and the maximum base shear force that corresponds to peak pier displacement. This relationship holds true even when peak pier displacement occurs”.

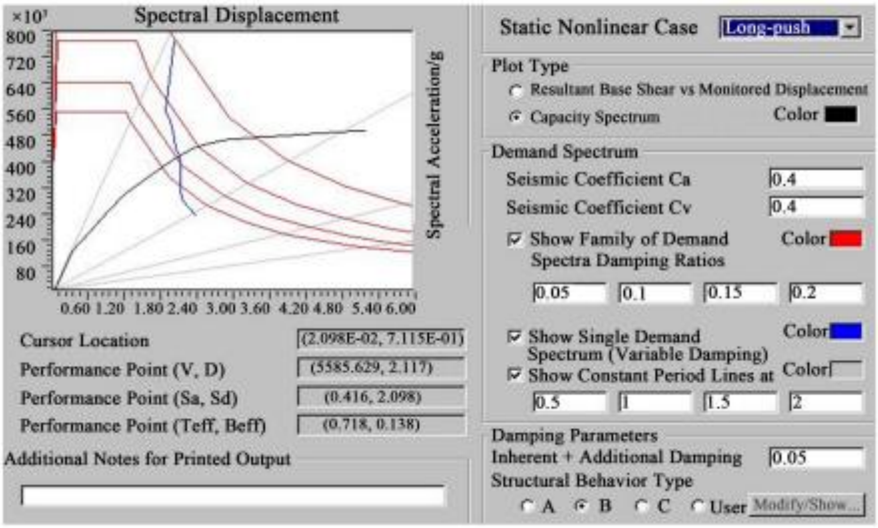


Figure 4. Spectrum of displacement capacity in the direction of the longitudinal axis of the Al-Fahs bridge;

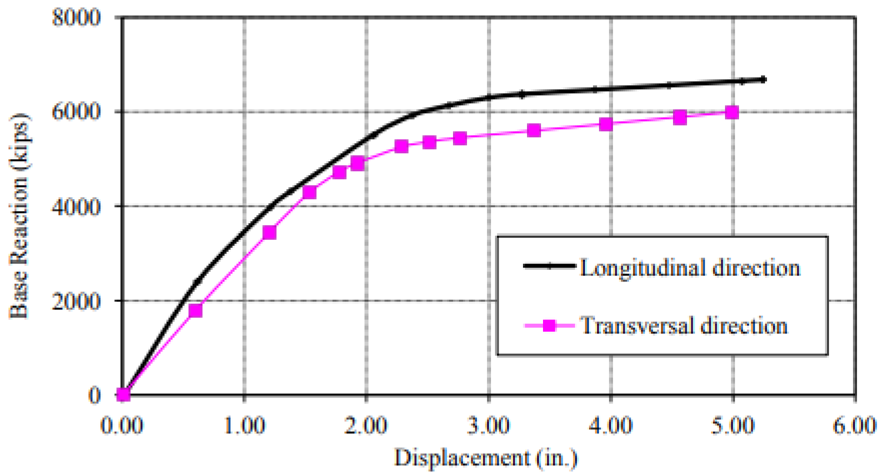


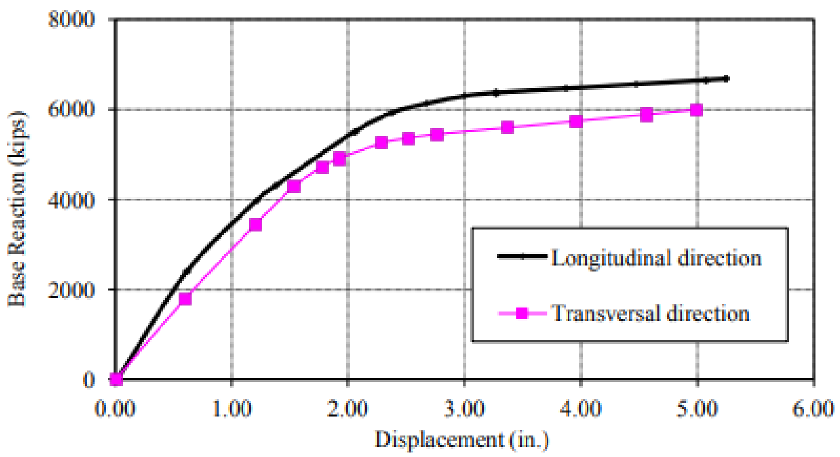
Figure 5. Pushover study of capacity spectrum curve for Al-Fahs Bridge on hard surface.

This diagram depicts the capacity spectrum curve of a static transmitter. Figure 5 depicts the pushover curve of the pier bridge in addition to the capacity spectrum of the structure. This demonstrates the greatest displacement that may be found at the specified point in respect “to the base shear, which is the overall accumulative base shear reaction of all piers in each global direction. The maximum base shear value in the longitudinal direction of the study case bridge is greater than its corresponding base shear in the transversal direction of the bridge by an average percentage” that ranges from 5 percent to 7 percent This is because the longitudinal direction of the bridge is longer than its transversal direction. This is because there is a difference in the equivalent total pier stiffness in both directions, and this difference is proportionate directly with the stiffness of the bridge. In other words, the bridge's stiffness is directly proportional to the difference. This might be due to the circular cross section of the pier, which has the same level of stiffness in both the forward and reverse orientations. The parallel and series connection of the piers, on the other hand, have an effect on the overall equivalent stiffness of the structure.

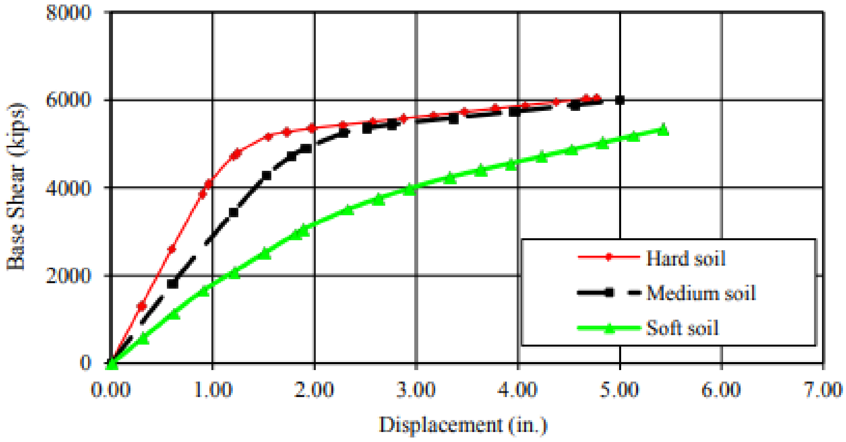
As part of this study, a pushover analysis was conducted using data from three distinct soil structures interaction situations. The first scenario served as a comparison datum and was based on the first design, which ignored SSI and was referred to as Hard Soil. This design was the basis for the first scenario. Figure 6 presents a representation of this scenario in the form of “the capacity spectrum curve of the pushover analysis for the study case (Al-Fahs Bridge). The” following are some of the factors that will be considered in the pushover analysis for the other two scenarios: SSI will be simulated by one.

Figures 6 and 7 make a comparison between the pushover curves of the original design, which completely ignored SSI effects, and the pushover curves of two alternative soil structure interaction effects. The purpose of displaying these curves side by side is to facilitate comparison. In finite element modelling, the soil stiffness parameters of medium and soft soil are defined in the same way that they were defined in Table 4, taking into consideration the soil bearing capacity that is reflected on the bridge pier footing dimension. This is done in the same way that they were defined in Table 4. This has a direct impact on the total soil simulation stiffness values, which in turn leads to more realistic assumptions and more accurate simulations, both of which are required for generating fair comparisons and analyses of the findings. It is assumed that the damping of the bridges is equal to five percent of the critical value in each of the several modes of the investigation.

It is abundantly clear that a comparison of the responses exhibited by the various types of soil will be of great assistance in the process of researching the influence that pier flexibility has on the results of pushover bridge analysis. This is made abundantly clear by the fact that the bridge piers have varying degrees of flexibility, which makes it abundantly clear that a comparison of the responses exhibited by the various types of soil. The soil that is located in close vicinity to the pier can be categorised as either hard, medium, or soft depending on how much pressure is applied to it.



“Figure 6: The capacity spectrum curves of the Al-Fahs Bridge on the various types of soil, shown in the longitudinal direction”



"Figure 7: Spectral capacity curves of the Al-Fahs Bridge on a variety of soil types, shown in the transverse direction".

"The capacity spectrum curves of the Al-Fahs Bridge (study case) are displayed in Figures 6 and 7, respectively, and are shown to be in the longitudinal and transversal directions. These curves are shown to be in the longitudinal and transversal directions. The footing stiffness is expanding as a result of soil types with characteristics ranging from soft to medium to hard soils with greater stiffness values". This is causing the footing to become increasingly rigid. These different types of soil have a direct bearing on the total stiffness of the structure as a whole, which has grown from 25 percent to 45 percent for the bridge's rigidity. In addition, the final displacement has increased by anywhere from seven percent to twenty percent for depths ranging from five and a quarter inches to six and eleven tenths of an inch "for medium soil and soft soil, respectively. On the other hand, the total base shear has significantly decreased for soft soil by percentage 15 percent compared to hard soil at the corresponding step of the same displacement; in the longitudinal direction, as shown in Figure 6". This can be seen in the comparison between the two types of soil in the figure. This is the situation due to the fact that soft soil may be compressed more easily than hard soil can.

The behaviour of the pushover displacement capacity curve in the transversal direction of the bridge is identical to the behaviour of the pushover displacement capacity curve in the longitudinal direction of the bridge, with a smaller "percentage of base shear decreasing and displacement increasing". This is in comparison to the behaviour of the pushover displacement capacity curve in the longitudinal direction of the bridge. This behaviour may be understood with reference to Figure 7, which depicts a comparison of the bridge's stiffness in both the forward and reverse orientations. This helps to explain why the structural rezoning of soft foundations caused a larger displacement. "The stiffness in both directions under pushover loadings with lower base shear values when compared to additional types of medium and hard soils".

CONCLUSION

An investigation into the inelastic response of soil–structure systems was carried out by means of a parametric research in order to facilitate the evaluation of the effect that SSI has on the damage index of bridges. There is a significant shift in the forces that are present in the superstructure, foundation, and soil mass due to the impact of soilstructure interaction. This shift can be seen in all three of these components. In order to arrive at an exact computation of the quantities of force that were intended to be designed, it is required to take into consideration the interaction effect. The potential for a large increase in seismic base shear to be produced by the interaction of the soil with the structure of low-rise building frames that are supported by isolated footings exists. Because of this, it was thought that the base shear for the permanent base should serve as the foundation for the design. It is a well-known fact that the base shear for flexible footing is significantly less than that of the fixed basis. On the other hand, the recent study has demonstrated that there are specific scenarios in which the base shear values for flexible footing are greater than those of permanent foundation. This is because flexible footing is more adaptable to changing conditions. This is especially valid for soil that is on the softer side. The interaction that occurs between the structure and the soil should be taken into account for the purpose of calculating the design base shear; however, in the case that DDBD is used, this contact can be ignored. The core concept of pushover analysis was dissected, and the many application tactics that may be used with it were analysed in detail. It has been observed that SSI has a substantial influence on the dynamic behaviour of bridge piers, which leads to the creation of systems that are more flexible, have less damping, and experience larger total displacements of bridge piers. In this article, a user-friendly method “that can be incorporated into the preliminary design of bridges is presented. This method is also helpful for the structural assessment, strengthening, and/or rehabilitation of existing short span RC bridges. In addition, a comprehensive investigation of the relative significance of various physical parameters of the system response is presented”.

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