SSI, EFFECT ON CABLE STAYED SUSPENSION HYBRID BRIDGE

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Abstract: ***The interaction of soil, foundations and structures (SFSI) depends on numerous parameters, foundation manner and properties of soil, foundation and structure. Important are the characteristics of vibration caused by Earthquake9frequency contents, peak acceleration, etc.)depending on the soil quality. A different design model for SFSI is described and analysed in this paper. Consequently, the decomposition of the soil pile structure, response is presented in steps in modelling and analysis are given. In this paper, the emphasis is on the simplified model and foundation on piles. For the modelling author used SAP2000 software***

Keywords: Soil Structure Interaction (SSI) , Soil Pile Structure Response , Modelling of Pile

I. INTRODUCTION

Seismic Soil Structure interaction is an important element in the understanding of seismic structure failure, yet it is very complex to analyse.The damage caused with foundation of bridges in earthquake(s) has emphasized the importance of understanding SSI.

Considering SSI effects allows researchers and practicing engineers to does more seismically resilient bridges.The SFSI depends on different parameters like foundation manner,properties of soil, foundation and structure, the characteristics of ground motion like frequency contents, peak acceleration etc. surrounding the soil and the structure itself.To evaluate the seismic response ofa structure at a given site dynamic properties of the combined soil structure system must be understood.

In most cases there are two different methods used for the seismic response of the complete bridge system.

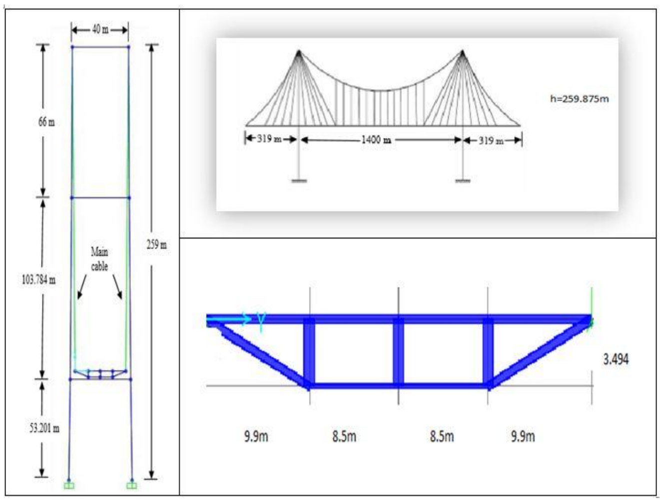
1) TheElasto Dynamic Method developed in the Nuclear Power Industry for large foundations

2) The so called P-Y method developed and practised in the Oil Industry for Pile Foundations

Both methods have restriction in use to different types of bridge foundations

- In the present study a bridge of East channel of Lingding Strait in China is considered.
- The bridge configuration consists of:::::
  - Main span = 1400 m
  - Side Span = 319 m
  - Height of Pylon,H = 259.875 m
  - The Central span consists of cable stayed portion of 788m and suspension portion of 612m; the spacing of two main cables is 34m, and cable sag to span ratio considered is 1/10 ; spacing of hangers is 18m ; stay cables are anchored to girder at 18m intervals in central span and 14m in side spans; the pylon tower considered is H type
- For modeling author used
  - M60 grade concrete & A615Gr60 grade steel
  - Girder- frame elements, with thin shell elements encasing along longitudinal direction
  - Pylon,Transverse beams-frame elements

Footing of 2m x 2m x 0.3m; Soil types considered are namely soft, medium and hard; soil is considered as link element



The various element modeled are tabulated

Members	E(MPa)	c/s Size	A(m²)
Girder	3.9 x 10^5	frame elements + thin shell encasing	1.655
Main cable CS	2.0 x 10^5	0.637 m dia	0.3167
Main Cable SS	2.0 x 10^5	0.672 m dia	0.3547
Hanger	2.0 x 10^5	6.4 x 10^{-3} m dia	0.0064
Pylon Tower	3.3 x 10^4	6m x 5 m	30.000
Trannsverse Beam	3.3 x 10^4	3.17m x 3.17m	10.0489

Modeling of soil

Modeling of soil as per FEMA 356

3 types of soil such as hard soil, medium soil and soft soil are considered for the study

The properties such as shear modulus, modulus of elasticity and poission's ratio of soil are taken from book of foundation engineering by Bowles J. E.

Soil Properties	Hard	Medium	Soft
Shear Modulus ,G (kN/m²)	30000	20000	10000
Youngs Modulus,E (kN/m²)	72000	50000	26000
Poisson's ratio, μ	0.2	0.25	0.3
Length of Pylon at bottom, L (m)	6	6	6
Width of Pylon at bottom, B (m)	5	5	5
Soil Stiffness , K_x, (kN/m)	658981	451873	232582
Soil Stiffness , K_y, (kN/m)	681648	467416	240582
Soil Stiffness , K_z, (kN/m)	565711	402283	215509
Soil Stiffness , $K_{\theta x}$, (kN/m)	2718750	1933333	1035714
Soil Stiffness , $K_{\theta y}$, (kN/m)	3571887	2540008	1360719
Soil Stiffness , $K_{\theta z}$, (kN/m)	5019213	3346142	1673071

The properties of the soil taken in study are as under

Type of soil	Shear modulus (G) KN/M²	Elastic modulus (E) KN/M²	Poission's ratio
Hard	30000	72000	0.20
Medium	20000	50000	0.25
Soft	10000	26000	0.30

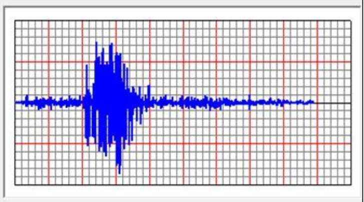
Author considered below 2 different cases To study the effects of the soil

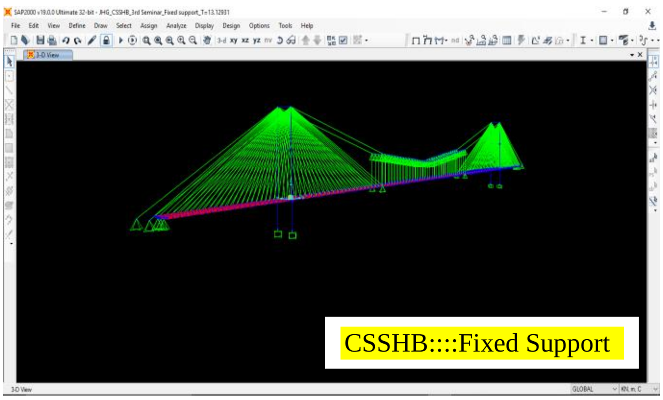
Fixed support at the base : In this case fixed support is provided at base so that translation in all directions and rotations in all directions are prevented.

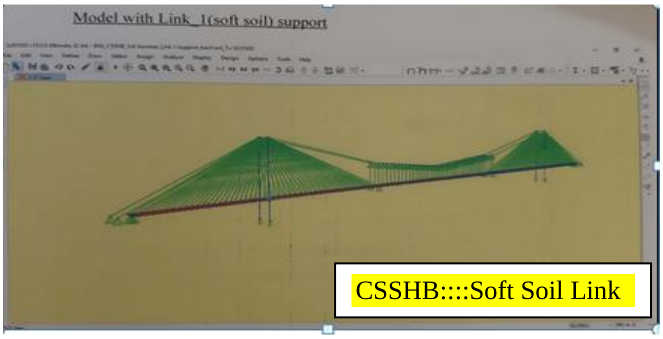
Soil as a link element : Spring stiffness for different types of soil are calculated at the base according to the FEMA 356 "pre standard and commentary for the seismic rehabilitation of buildings

Data Details of acceleration time history

Name : Bhuj
Magnitude : 7.7
Duration of earthquake: 133.53 second
Peak ground acceleration : 1.0382 m/sec²
Time for PGA : 46.940 second
Duration: long.
Total no of acceleration records : 26706
Time step :0.005 second





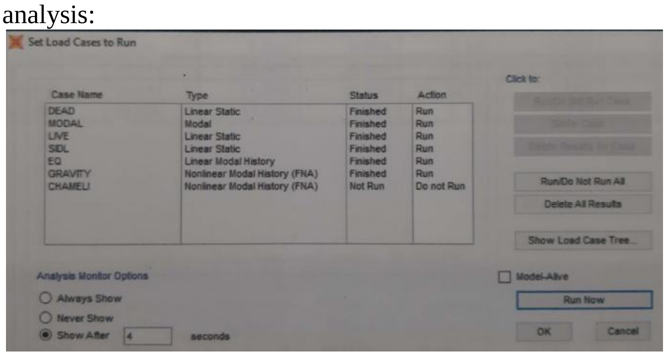


Load Assignments

Sr	Load	Value of load assigned	Element Assigned
1	Dead Load	97.98 kN/m	Deck
2	SIDL	50.00 klN/m	Deck
3	Live Load	34.65 kN/m	Deck

Analysis

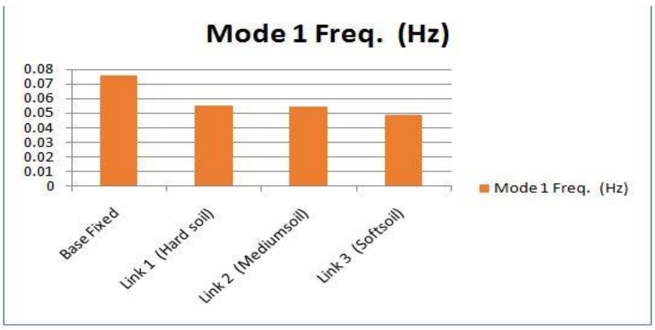
The model prepared was run for the following cases for analysis:

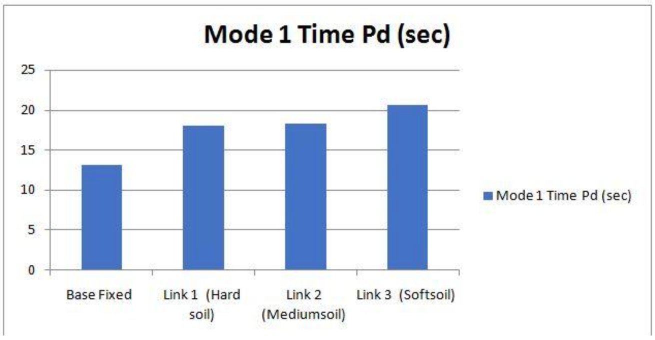


II. RESULTS

Modal periods

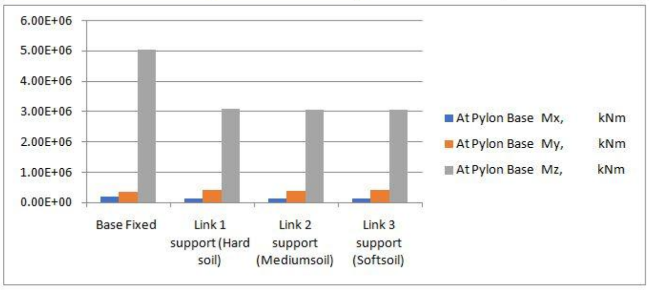
Support Particulars	Mode 1	
	Time Pd (sec)	Freq. (Hz)
Base Fixed	13.129	0.076
Link 1 (Hard soil)	18.07	0.0553
Link 2 (Mediumsoil)	18.242	0.0548
Link 3 (Softsoil)	20.632	0.0485





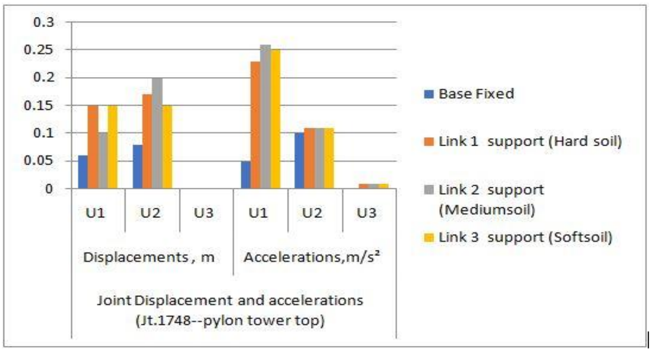
At Base: Moments

Due to EQ	At Pylon Base		
	Mx, kNm	My, kNm	Mz, kNm
Base Fixed	**2.00E+05**	3.40E+05	5.04E+06
Link 1 support (Hard soil)	**1.40E+05**	4.10E+05	3.10E+06
Link 2 support (Mediumsoil)	**1.40E+05**	3.90E+05	3.06E+06
Link 3 support (Softsoil)	**1.32E+05**	4.00E+05	3.07E+06



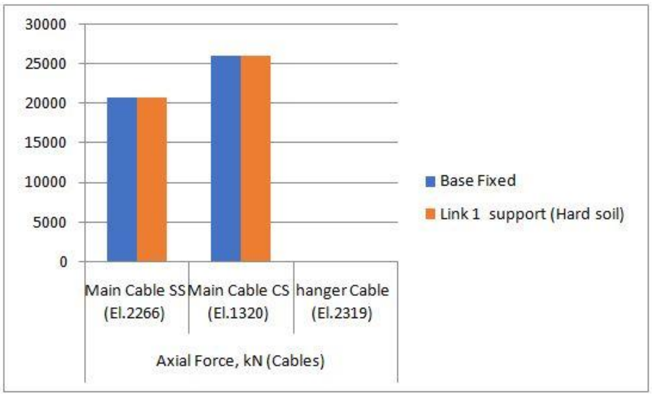
Joint Displacement and acceleration (Pylon Tower Top)

Due to EQ	Joint Displacement and accelerations (Jt.1748--pylon tower top)					
	Displacements , m			Accelerations,m/s²		
	U1	U2	U3	U1	U2	U3
Base Fixed	0.06	0.08	0.00	**0.05**	**0.10**	0.00
Link 1 support (Hard soil)	0.15	0.17	0.00	**0.23**	**0.11**	0.01
Link 2 support (Mediumsoil)	0.1	0.20	0.00	**0.26**	**0.11**	0.01
Link 3 support (Softsoil)	0.15	0.15	0.00	**0.25**	**0.11**	0.01



Axial Forces in Cables

Due to EQ	Axial Force, kN (Cables)		
	Main Cable SS (El.2266)	Main Cable CS (El.1320)	hanger Cable (El.2319)
Base Fixed	**20854**	**26088**	0.02
Link 1 support (Hard soil)	**20840**	**26063**	0



III. CONCLUSION

- SSI can be quite significant for stiff structures founded on soft soils
- Fundamental period of soil-structure system is longer than that of fixed-base structure
- Effective damping of soil-structure system is higher than damping of structure alone
- SSI is not significant for cases of flexible structures on stiff soil deposits
- There is a great influence of SSI effects on seismic response of bridge and it increases fundamental time period of the bridge
- Neglecting SSI is equivalent to assuming the structure is supported on rigid materials
- The type of foundation is a major contributor to the seismic response of buildings with SSI and should therefore be given careful consideration in order to ensure a safe and cost effective design.

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