Analysis Of Seismic Response Of A Steel Braced Frame Structure Considering Soil Structure Interaction

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Abstract - **This Project summarizes estimated seismic response results from soil strucuresintereaction , by supporting on pile foundation for different soil condition , mostly the structure analysis should be able to provide optimum balance between the function and economy , moreover , pile foundations are not designed to resist major or moderate earthquake , for such a designing we are usually done by considering gravity loading only without considering the earthquake loads, which makes these pile foundations vulnerable during an earthquake. It is therefore essential to consider the effect of earthquake loadings, while designing the pile foundations to mitigate the effects of major earthquake. Since earthquake is a natural phenomenon, which generate in the earth's crust .The magnitude of the seismic loads on the structure during an earthquake depend upon the factors like the mass of the pile foundation, dynamic properties of the pile foundation, the intensity of ground motion and its damping characteristics. The severity of ground shaking at a given location during an earthquake can be minor, moderate and strong .Minor shakings occur frequently; moderate shakings occurs occasionally and strong shakings occurs rarely. This is a major objective of seismic design codes throughout the world. In the present study, finite element analysis of pile foundation supported on different soil types and carried out ,Then the effect of the soil structure interaction are studied. An effort is made to study the effect of seismic loading on these structures. so in this we are considering five storeystructure,for different seismic zones and analysis was carried out by using the software of SAP2000 software, The main aim of the present study is to analyse the five storey building that is supported on pile foundation for different soil conditions and compare the results of maximum displacement, maximum acceleration for all the conditions of the soil and the structure. IndexTerms—Incremental Dynamic Analysis , Flexural Rigidity, natural frequency , drift frequency,seismiczones ,SAP2000**

keywords - **Incremental Dynamic Analysis , Flexural Rigidity, natural frequency , drift frequency, seismiczones , SAP2000**

I. INTRODUCTION

The purpose of all types of structural systems used in the building is to transfer gravity loads effectively. The resultant loads from effect of gravity and vertical are dead load , live load , ans snow load, structures are additionally subjected to parallel burdens caused by wind, impacting or earthquake. RCC building should designed to have a capacity to carry combined loads at certain degree of reliability. In addition to faulty design and improper construction, there are other situations that could impair the future performance of structural building such as alteration of building functions, changes of seismic load characteristics in the area, ingress of aggressive agent from the environment, etc. A multi-stored, multi-panelled frame is a complicated statically indeterminate structure. It consists of a number of beams and columns built monolithically, forming a network. This building frame is subjected to both vertical as well as horizontal loads. The high rise structures are subjected to dominantly horizontal forces i.e., earthquake forces in addition to gravity forces. therefore, it is warranted, to make the building earthquake resistant, to resist the effects of ground shaking without collapsing. a structure is highly influenced, not only by the super structural response but also on the response of the foundation and ground. Hence, the seismic analysis of a structure strongly recommends the usage of a whole structural system considering the super structure, foundation and ground giving rise to an area called SOIL STRUCTURE INTERACTION.

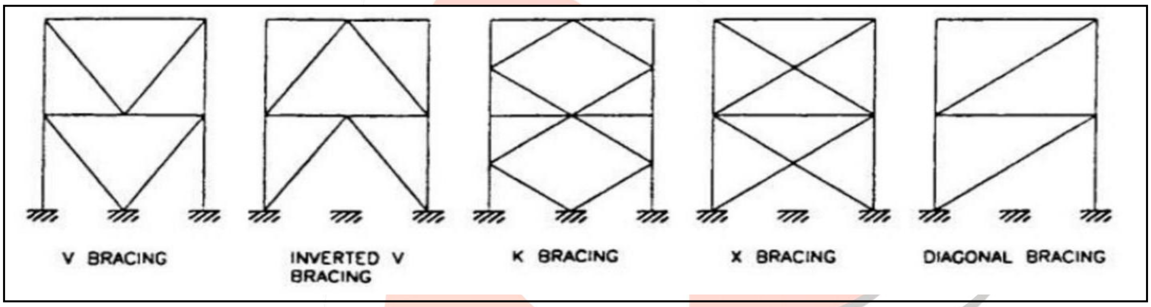
The Soil-Structure Interaction problem has become a significant trait of Structural Engineering with the advent of enormous constructions on soft soils such as concrete and earth dams, nuclear power plants, etc,. Underground structures, bridges, buildings and tunnels may need a special attention to be given to the problems of Soil-Structure Interaction. If the structure is extremely huge and rigid, and the foundation is quite soft, the motion at the base of thestructure may beconsiderably unusual than the free-field surface motion. The result of Soil-Structure Interaction is to be studied for the code designed buildings. For understanding the Soil-Structure Interaction problem properly, it is essential to have the knowledge of the earthquake wave propagation through the soil medium for two primary reasons. Firstly, when the seismic waves propagates through the soil as an input ground motion, their dynamic features relies on the soil as an input ground motion. Secondly, the understanding of the vibration characteristics of the soil medium is extremely beneficial in establishing the soil impedance functions and fixing the boundaries for a semi-infinite soil medium, when the wave propagation analysis is executed by applying numerical methods.

BRACING SYSTEM

In order to make multi-storey structures stronger and stiffer, which are more susceptible to earthquake and wind forces, the cross sections of the member increases from top to bottom this makes the structure uneconomical owing to safety of structure. therefore, it is necessary to provide special mechanism or mechanisms that improve lateral stability of the structure. many existing strengthened solid structures require retrofitting to defeat lacks to oppose seismic loads. numbers of analysts have inspected different systems, for example, encasing sections, adding dividers to existing segments, infilling dividers and including solid bracings or steel bracings to enhance the quality or potentially flexibility of existing structures. supporting has been utilized to balance out along the side most of the world's tallest building structures and in addition one of the real retrofit measures. supported casings are an exceptionally basic type of development, being financial to build and easy to break down.

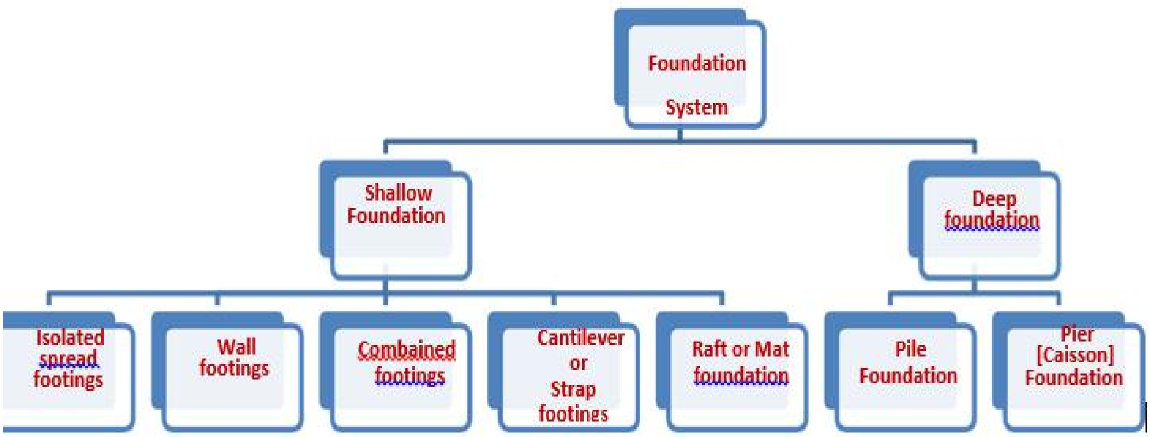
Concrete braced or steel braced reinforced concrete frame is one of the structural systems used to resist earthquake loads in multi-storeyed buildings. The use of these bracing systems for strengthening or retrofitting seismically inadequate RC frames is a persistent solution for improving the earthquake resistance. The use of these bracings is greatly an effective and economic method of opposing horizontal forces in a frame structure.Steel bracings can be used to minimize the drift demands of steel structures. These bracings are not difficult to erect, possesses less space, practical and has adaptability to outline for meeting the required quality and solidness. Bracings, which gives solidness and opposes sidelong loads, might be from corner to corner steel individuals or, from a solid centre. In supported development, shafts and segments are planned under vertical load just, accepting the propped framework conveys every single parallel load. Braced frames develop their conflict to lateral forces by the bracing action of diagonal members .

TYPES OF BRACINGS



PILEFOUNDATION

The foundation of a structure is that part of the structure which is in direct contact with the subsoil and transmits the load of the structure to it. There are two types of foundations tabulated below :



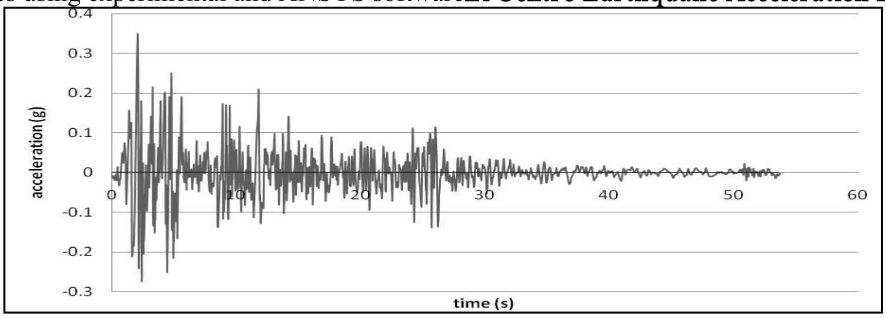
II.LITERATURE REVIEW:

The recent study performed by researchers on SEISMIC RESPONSE OF A STEEL BRACED FRAME CONSIDERING SOIL STRUCTURE INTERACTIONare:

Response of Buildings with Soil-Structure Interaction with varying soil types" [2015]

Shreya Thusoo, et.al., studied the effect of Soil Structure Interaction (SSI) on multi-storey buildings with varying under-lying soil types after proper validation of the effect of SSI

Study on seismic behaviour of knee braced steel frames" [2015]
Anitha M, Divya K.K considered a single storey frame of span 3 m and height 2 m. Before proceeding, they did the validation for the software by considering a 2 storey frame of span 3m and height 2m with knee bracings as shown in fig 2.4. The time period values using experimental and ANSYS software**El Centro Earthquake Acceleration Record**



Behaviour of Multi-storey Steel Structure with Different Types of Bracing Systems (A Software Approach)" [2015]
SachinDhiman, et.al., considered a 14 - storey building using STAAD Pro V8i software. The building is modeled using different types of bracings, which are provided at the peripheral of the columns and analyzed for seismic zones IV as per IS 1893:2002. It is found that performance of cross bracing system is better than the other specified bracing systems.

Effectiveness of inclusion of steel bracing in existing RC framed structure" [2014]
Vani Prasad considered a 10 storey building and modeled using SAP2000performed Time History analysis. The building considered is modeled and analyzed in three parts:

- Model without bracing and shearwall
- Model with different bracingsystem
- Model with shearwall

Out of these three combinations, the model with steel bracings significantly reducedthe lateral drift. Comparing concentric and eccentric bracing system, concentric braces increased the lateral stiffness of the frame thus increased the natural frequency and decreasing the lateral drift.

From the above literature reviews, the following findings were drawn:

The deflection of the building decreased considering SSI effect .
As there was a shift from hard to soft soil, there was an increase in the deflection of the structure.
It was found that the base shear and time period values of a RC structure decreased with decrease in base fixity.
Variation in storey drift was least for type-II (medium soil) soil for flexible structure considering SSI effect.
In Time history analysis, the displacement observed for knee bracings was 90% more than the frame without bracings and 50% more than eccentric braced frames.
There was a maximum reduction in the lateral displacement of a structure when Chevron type of bracings were incorporated.
Maximum increment in axial force has been observed in cross braced frame structure

III. AIM AND OBJECTIVE OF THE STUDY

The Main Aim Of The Present Study Is To Analyse The Five Storey Building That Is Supported On Pile Foundation For Different Soil Conditions And Compare The Results Of Maximum Displacement, Maximum Acceleration For All The Conditions Of The Soil And The Structure. By Using SAP 2000 V 22.1.0 Analysis.
Based On The Numerous Literature Reviews, Findings From Literature, The Following Objectives Of The Study Has Been Defined:

1. Seismic Analysis Of 5 Storied RC Concentric Braced System Considering SSI Effects.
2. Evaluation Of Maximum Displacement Of Bracing System Under
   a) Slopped Ground Condition Considering SSI With And Without Ground Water Table
   b) Horizontal Ground Condition Considering SSI With And Without Ground Water Table
3. Fixed Base Analysis Of A Five Storied RC Building With Concentric Braced Frame.

The Seismic Analysis Of A 5 Storey RC Building Has Been Performed By Time History Analysis Using SAP 2000 Software

IV. METHODOLOGY

- Geotechnical information and dynamic properties of the soil is collected and Earthquake ground motion data is collected.
- Analysis of five storied building model with different soil types using SAP 2000 software.
- Interpretation of performance parameters such as displacement and acceleration is done from the analysis

γ	Unsaturated	Saturated
Loose sand	90 - 14.139 =14.14	118 - 18.54
Dense sand	109 - 7.12 = 17.12	130 - 20.42
Very soft clay	76 - 11.94 = 11.94	110 - 17.28

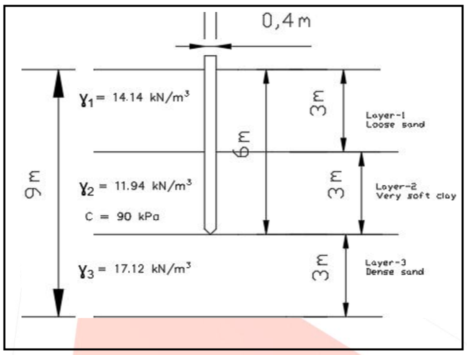
V.SAP2000 SOFTWARE

SAP is a structural analysis desigininingprogramme which is used analysis and design of any type of structural system and also design tools for engineers working on industrial, sports, transportation, public works, and other facilities.

The SAP name has been synonymous with state-of-the-art analytical methods since its introduction over 30 years ago , From its 3D object based graphic modelling environment to the wide variety of analysis and design options completely integrated across one powerful user interface, it has proven to be the most integrated, productive and practical general purpose structural program on the market today. Complex Models can be, SAP2000 is the easiest, most productive generated and meshed with powerful built in templates. From a simple small 2D static frame analysis to a large complex 3d nonlinear dynamic analysis solution for your structural analysis and design needed.

VI. PROPOSED STUDY

A Ground + 5 storey building will be considered for different seismic zones and the analysis was carried out using SAP-2000 software. Different bracing system will be incorporated during the modelling for exterior panels as well as for interior panels of the structure. Further the soil and the structure interaction will be studied considering the available earthquake data and the structural responses like storey drift, natural frequency, etc., will be obtained and the comparison for different seismic zones will be drawn



- ❖ By calculating the capacity of the pileQu = Ap [0.5 x D γ Nγ + PD Nq] + Asi [kitanδiPDi] + [As C α] + As [k tanδ PD],given by Eq : 4.2 as per IS 2911-1-3(2010)-Part 1-Section3 Qui = Ap [Nc x Cp] + As [α x Cavg]is given by Eq:4.3 as per IS 2911-1-3(2010)-Part 1-Section 3

$A_p = a^2 = 0.4 \times 0.4 = 0.16\ m^2$ D = a = 0.4 m Nγ =10.88 [fromIS 6403, Table - 1]

P_D = 15D = 15*0.4= 6m [For θ=25º <= 30º]

$P_D = \sum (z\,\gamma)$

= (3*14.14) + (3*11.94) + (3*17.12)

= 129.6 kPa

N_q = 17 [For θ=25º] [IS 2911 (part-1),fig-1] A_{s3} = 4a*z3 = 4*0.4*3 =4.8m²

k= 1

S= Φ/2, 3/2Φ,2/3Φ

= 12.5, 18.75, 16.67 = average of 15.97

Therefore, S = 16kN/m²

$P_D = \gamma_1 z_1 + \gamma_2 z_2 + (\gamma_3 z_3/2)$

= (14.14 * 3) + (11.9 * 3) + [(17.12 * 3 / 2)]

= 103.92 kPa

$A_{s2} = 4a{*}z_2$ = 4*0.4*3 = 4.8 m² C =

90 kPa

α_2 = 0.5 [for C=90kPa, from IS2911 (part-1), pg - 15] $A_{s1} = 4a{*}z_1$ = 4*0.4*3 = 4.8m²

$P_D = \gamma_1 z_1 / 2$ = (14.14*3) / 2 = 21.21 kPa

Qu= {0.16 [(0.5*0.4*17.12*10.88) + (129.6*17)]} + (4.8*1*tan16*103.92)+(4.8*1*tan16*21.21)

= 746.698 kN **Qa = Qu / FS**

= 746.698 / 2.5 [Assume, FS =2.5]

Qa = 298.679 kN Ap= a x b = 0.4 x 0.4 = 0.16m²

N_c=9

$C_p = U_{cc} / 2$ = 80/2 = 40kPa

A_s= 4al = 4 x 0.4 x 6 = 9.6m

α= 1 Cavg= 40 kPa

Qui= [0.16 x 9 x 40] + [9.6 x 1 x 40]= 441.6 kN

- ❖ **Qag= Qug/ F**600 = Qugx 2.5 Qug= 1500kN

- Eq : 4.4 is used to calculate number of pilesthe

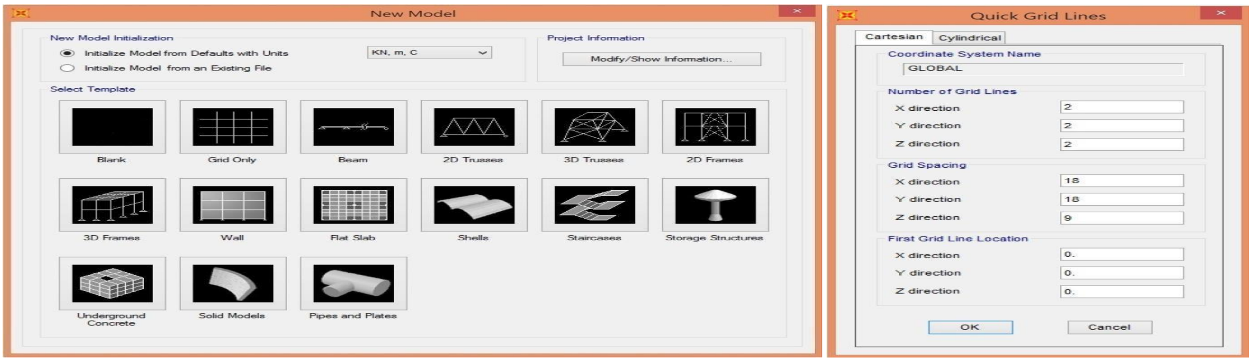
  Qui= N x Qui

  1500 = N x 441.6

  N = 3.39 = 4 piles

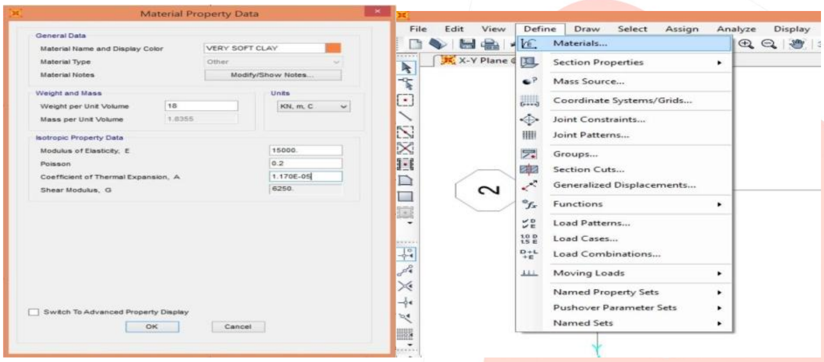
calculating the length of pile and calculate number of piles by using the equtions given , as per IS 2911-1-3(2010)-Part 1-Section 3

VII. MODELLING

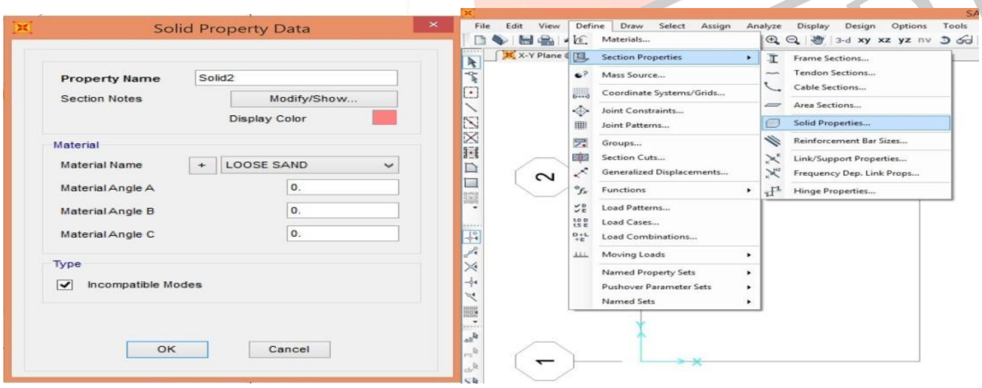


The Step by step procedure of modelling the RC frame and soil profile is as follows by using SAP2000

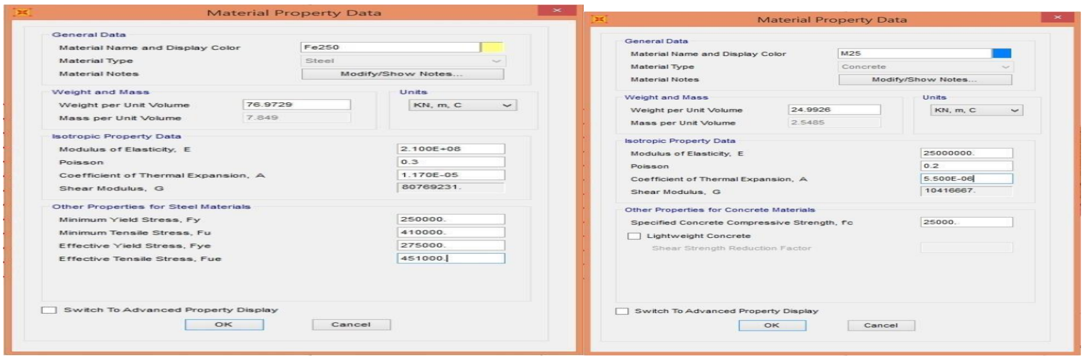
STEP 1 : The geometrical model of soil profile is created as per the parameters mentioned and model to be choosed .



STEP 2: Defining material property of different soil layers like very soft clay, loose sand, dense sand, saturated clay and saturated sands, as per the parameters waqs considered **Defining theMaterialProperties Propertyofdifferentsoil**



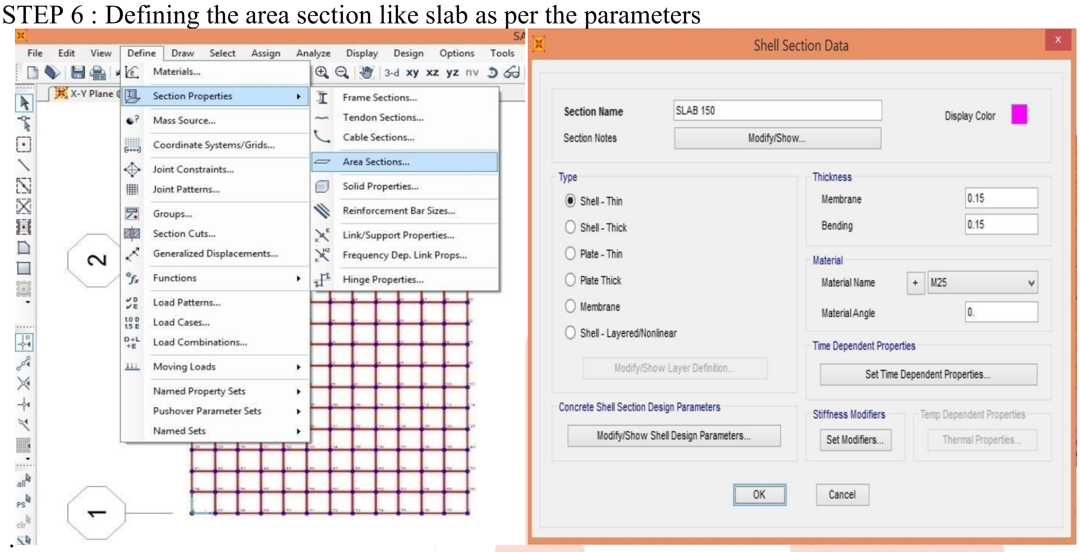
STEP 3 : Defining the solid properties for different types of soils .



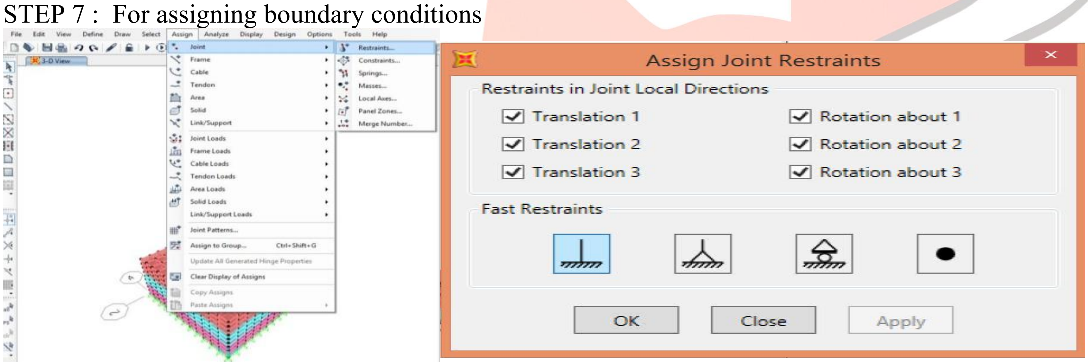
STEP 4 : Defining material properties of concrete and steel as per the parameters .

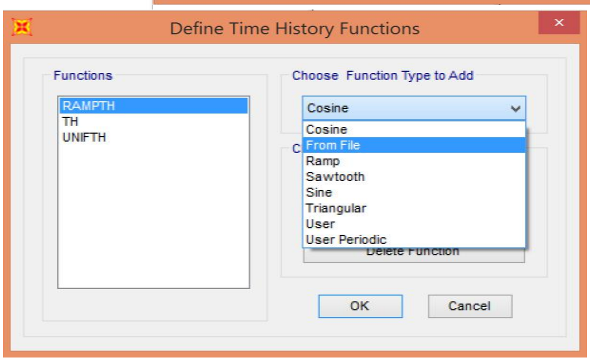
STEP 5 : Defining the frame sections like beams, columns, bracings and piles as per the parameters

STEP 6 : Defining the area section like slab as per the parameters

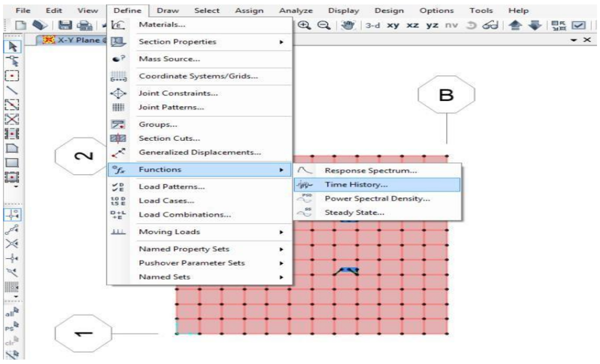


STEP 7 : For assigning boundary conditions

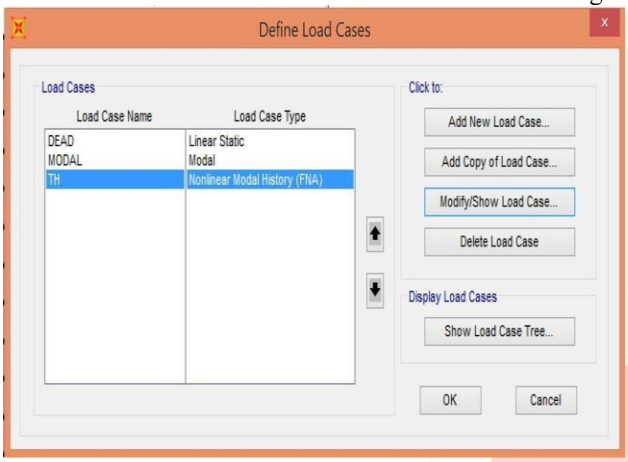


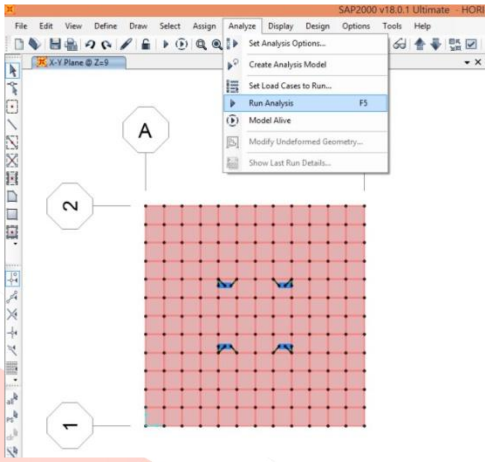


STEP 8 : Time History Analysis



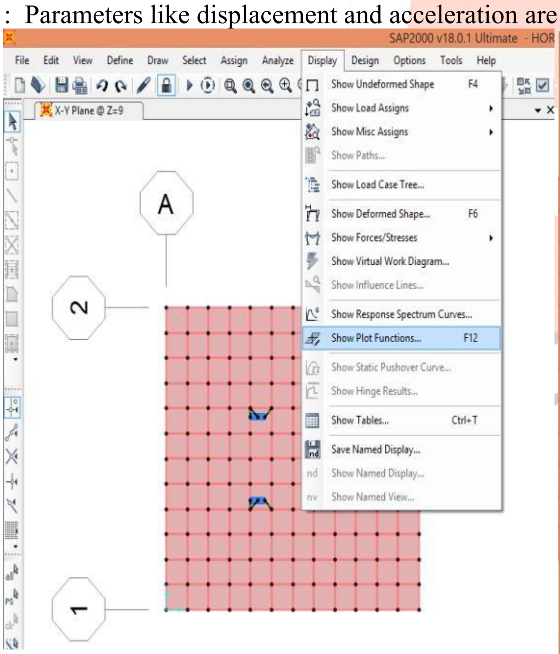
STEP 9 : Defining load cases

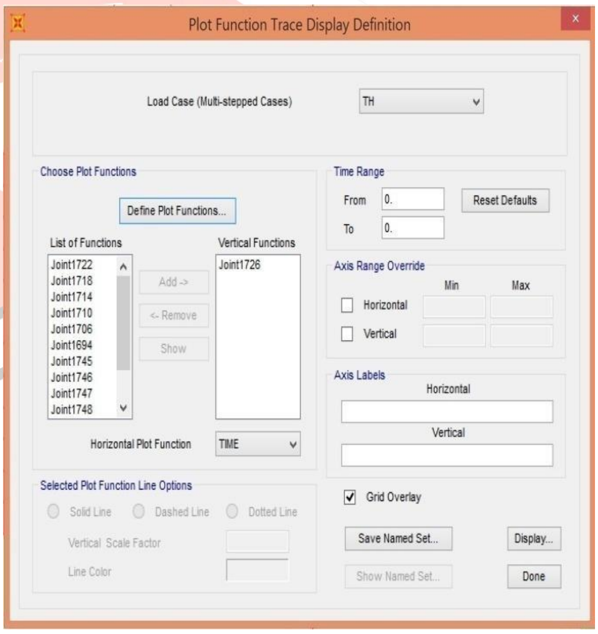




STEP 10 : dynamic analysis was run

STEP 11 : Parameters like displacement and acceleration are obtained





VIII. RESULTS AND DISCUSSION

The analysis using SAP 2000 has been performed for various combinations of soil profiles under different configurations of buildings that is with both springs and bracings; without springs and with bracings; and without springs and bracings. The horizontal displacement and acceleration at different storey levels, at pile head level and at every one meter interval below the pile head including the tip of the pile were obtained and the results are tabulated for different combinations

- COMBINATION I - 3m loose sand + 3m clay (saturated / unsaturated) + 3m densesand
- COMBINATION II - 3m clay + 3m loose sand (saturated / unsaturated) + 3m densesand
- COMBINATION III -3m clay + 3m loose sand + 3m dense sand (saturated /unsaturated)

IX. CONCLUSIONS

Based on the time history analysis and observations made during the present investigation the followings conclusions were drawn:

- Increase in stiffness of soil resulted in decrease in displacement of the structure for all the three combinations of the soilprofile.
- Compared to fixed base analysis, the displacement values are high for a structure with concentric bracingsystem.
- The acceleration values of the structure using Continuum Model with bracing were similar to the displacement values of the structure using Winkler Model with bracings.
- Displacement values of the structure on inclined soil profile were found to be more compared to the structure resting on horizontalsoil.
- Structures with bracings are found to have more acceleration when the piles are resting in the interface between loose sand and densesand
- Displacement values of the structure without bracing were found to be more when the piles are between loose sand and densesand.
- SSI effect considering water table showed more displacement when compared to the structures on unsaturatedsoils .

X. SCOPE OF FUTURE STUDIES

- A study on the inclusion of the braces in the interior frame of the building can be researchedupon.
- Interaction between the structure and the soil considering any other time of bracing system can be carriedout.
- Limited studies are available on RC frames structure with combination of shear wall and bracingsystem.
- Confined studies are available on Time History method or Push overanalysis.

XI. ACKNOWLEDGEMENT

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