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Study Behaviour of PEB Structure with Isolated Foundation Considering Soil Structure Interaction

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Abstract: In this study behaviour and concept of Pre- Engineered structure & SSI is included. Behavioural study of pre-engineered building is observed in this paper. Soil structure interaction (SSI) taken into consideration to study the interface between Soil and the structure rested on that soil. Many resources can be used to gather information on the present theories and practices, including IEEE explorer, technical papers, journal, conferences, patent information research thesis, international and national workshop proceedings. The following case studies the influence of soil structure interaction on pre-engineered building (PEB). By considering the fixed support conditions at the base of structure, the structural behaviour is analysed. The structural response of building seems to be affected because in conventional method the foundation flexibility of soil mass has been ignored. Winkler's spring model approach is used for the analysis of soil flexibility by integrating. The effect of SSI on various parameters like base shear, lateral displacement, etc. are studied and discussed. The subgrade must be modelled adequately well to get real behaviour of superstructure. The analysis is administered in STAAD Pro. connect edition software using response spectra of IS 1893-2016
Keywords: Soil Structure Interaction (SSI), Pre-Engineered building (P.E.B), Kinematic Interaction, Inertial Interaction etc.

I. INTRODUCTION

The term earthquake refers to the shaking of the ground caused by sudden ruptures of large tectonic plates that cause the ground to shake. In the past, there has been a history of devastating earthquakes on the Indian subcontinent. The fact that no part of the country is safe from seismic hazards is evident after the quakes that occurred in Killari (1993), Jabalpur (1997), and Bhuj (2001). As a result of the movement of the Indian plate towards the Eurasian plate at approximately the rate of 49mm per year, there is a high intensity of earthquake in India due to the movement of the Indian plate towards the Eurasian plate. According to geographic statistics, almost 54 percent of India's land is vulnerable to earthquakes. During earthquakes excitation forces & lateral forces induced on structure at that time soil strata plays important role. The developed nations like UK, USA, Chin, Japan already started building structures which is earthquake proof and can resist earthquake up to magnitude of 7. Soil Structure interaction is important analysis in many civil engineering structure, as India is not aware about seismic resistant structures, in that we have to assume support given by the soil. For any residential or industrial structure with isolated footing we have to assume boundary condition for analysis. There are six boundary conditions like three Displacement, Three Rotation. Fixity of structure is depending on soil below and near the support. Isolated footing may behave like fixed support if the soil below the footing is hard rock, and it will behave like hinged support if soil below is clay soil. Interaction between structural element like beam plates of finite or infinite element resting on isolated linear or nonlinear deformable elastic media.

The elastic media is represented by-

1) Mechanical Model
2) Mathematical Model
3) Numerical model.

II. MECHANICAL CLASSIFICATION OF SOIL STRUCTURE INTERACTION

The way structure interrelates with the soil called soil structure interaction. SSI can be defined as a co-dependent response relationship between a structure and its supporting soil. Soil structure interaction is one of the main factors affecting the behaviour of structure under dynamic loading. The importance of nature of subsoil, its natural period of vibration is demonstrated in many past earthquakes. In simpler terms, when a seismic wave hits a structure, two effects occur simultaneously:

1) Kinematic Interaction
2) Inertial Interaction

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Seismic waves incident on the structure are diffracted and reflected into the foundation. This is called Kinematic interaction and is independent of the inertial properties of the structure. Next, the motion is transmitted to the structure. It is dynamic response of the coupled system. This is called Inertial interaction. The above two interactions are together called soil structure interaction. So, currently, widely used engineering practices do not consider SSI in the design of structures. The superstructure in the conventional design procedures is analysed by isolating it from the soil, assuming that the superstructure is fixed at the foundation level and no interaction occurs. Although neglecting SSI is reasonable for small structures, its effect is prominent for large and heavy structures.

A. Need for the SSI

1) The same structure, when built on soils with different properties, will have different load distributions.
2) With a decrease in soil hardness, the natural period of structures increases affecting the design.
3) Design after considering SSI will be less conservative and hence more economical.

For soil idealization, Winkler's model is used which is a mechanical type of model. This model is commonly used to analyze foundation problems. The Winkler's model was studied in 1867. Winkler describes soil as a system of identical, discrete, closely spaced, linearly elastic springs. This theory states that foundations are only deformed in loaded regions. Many studies of soil structure interactions have used the Winkler hypothesis. The basic problem with this model is determining the stiffness of elastic springs used to replace soil beneath foundations. By specifying spring stiffness's, soil flexibility can be considered. To analyze the complete structural system containing the soil foundation and structure under loading, the impedance functions associated with a rigid mass less foundation are used. The analysis took into account translations of the foundation in two mutually perpendicular principal horizontal directions and vertical directions as well as rotations about these three directions. The effect of soli flexibility has been simulated by attaching three translational springs below the foundation and two horizontal and one vertical axes respectively, as well as three rotational springs about those mutually perpendicular axes.

III.STRUCTURAL MODELLING

For the analysis of work, the earthquake forces considered to study the soil structure interaction behaviour of this structure. The building 10.5 m of height and 60m in length and 30m in width, elevation of crane girder is 8m. Building is symmetrical along both the X and Z-axis having 10 number of bays along Z-axis and 5 number of bays along X-axis, each bay of 6m. Isolated footings are considered to be resting on three sorts of soil strata's namely, hard soil, medium soil, and soft soil.

Table 1
Structural Configuration

Structure	P.E.B
Spans	30m.
Column Height(m)	10m
Roof slope	1:5
Crane height(m)	8m
Bay spacing	6m
Purlin spacing	1.53m
L/W	2

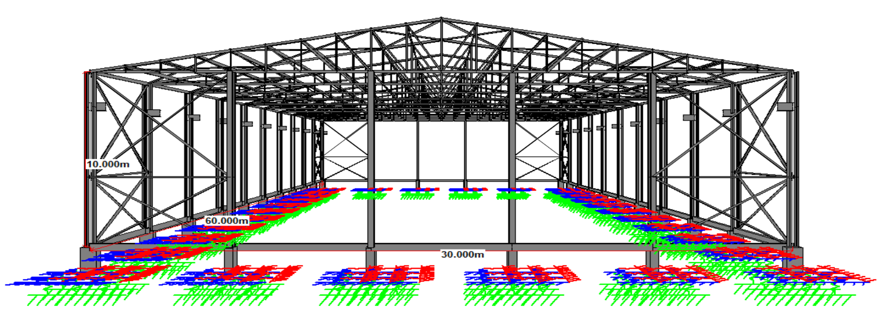

Fig.1: Front View of the structure

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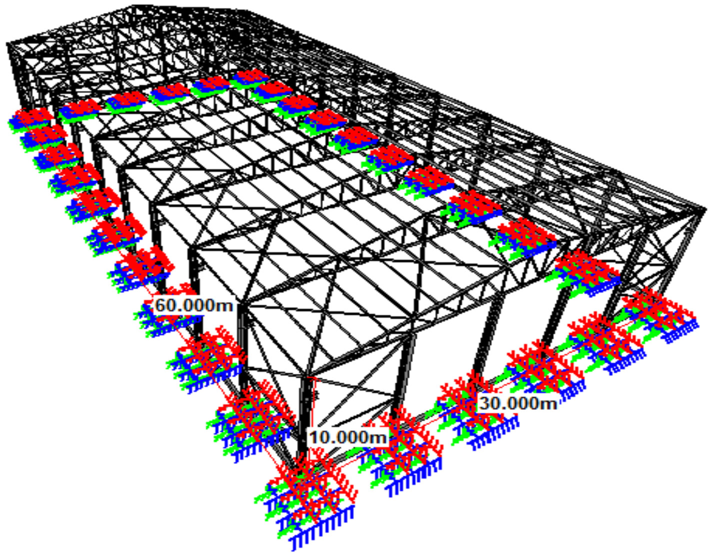

Fig.2: 3-D View of the structure

IV. WINKLER'S MODEL LINEAR SPRING

For analysing of soil structure interaction Winkler model is used. Equivalent springs are used in this model which has six degree of freedom for signifying the soil medium. Stiffness of the spring is depending on the properties of respective soil conditions. By using George Gazetas formula stiffness for different soils calculated.

$$q\ (x, y) = k\ W\ (x, y)$$

In this q (x, y) is proportional to the displacement W of the spring and where so that means this k is modulus of subgrade reaction in stress per unit area.
Where, Kx, Ky, Kz = Stiffness of equivalent soil springs along the translational DOF along X, Y and Z axis.
Krx, Kry, Krz= Stiffness of equivalent soil springs along the rotational DOF along X, Y and Z axis.

Table 2
George Gazetas formulas for stiffness calculation

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

Table-3: Calculated Spring Stiffness of Soil Springs 30m span P.E.B

Degrees of freedom	Calculated Stiffness of soil springs (kN/m)		
Soil Type	Hard	Medium	Soft
Horizontal (lateral direction)	108984.3	77343.7	39711.17
Horizontal (longitudinal)	108984.3	77343.7	39711.17
Vertical	178357.1	104041.6	48649
Rocking (about longitudinal)		10695.5	8149.3
Rocking (about lateral)	21391	10695.5	8149.3
Torsion	261825	138091.25	105216.5

V. PARAMETRIC STUDY

In parametric study different base condition are consider for comparison purpose. In this analysis three different soil condition are considered i.e. Hard soil strata, Medium soil strata, Soft soil strata and also a fixed supported condition. Comparative analysis of Base shear, Lateral deflection and column moment with the help of different soil condition.

A. Base Shear

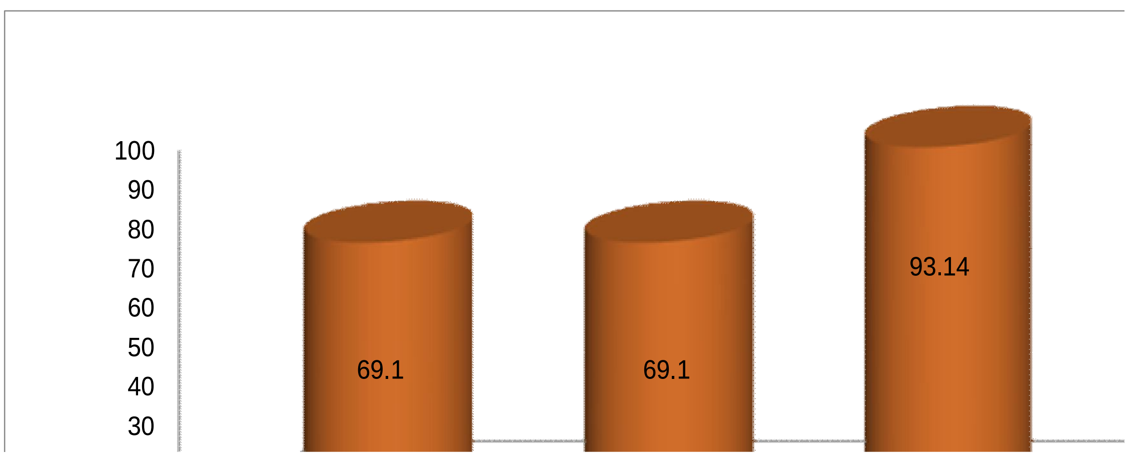

Fig 3: Base shear for different Soils.

B. Lateral Deflection

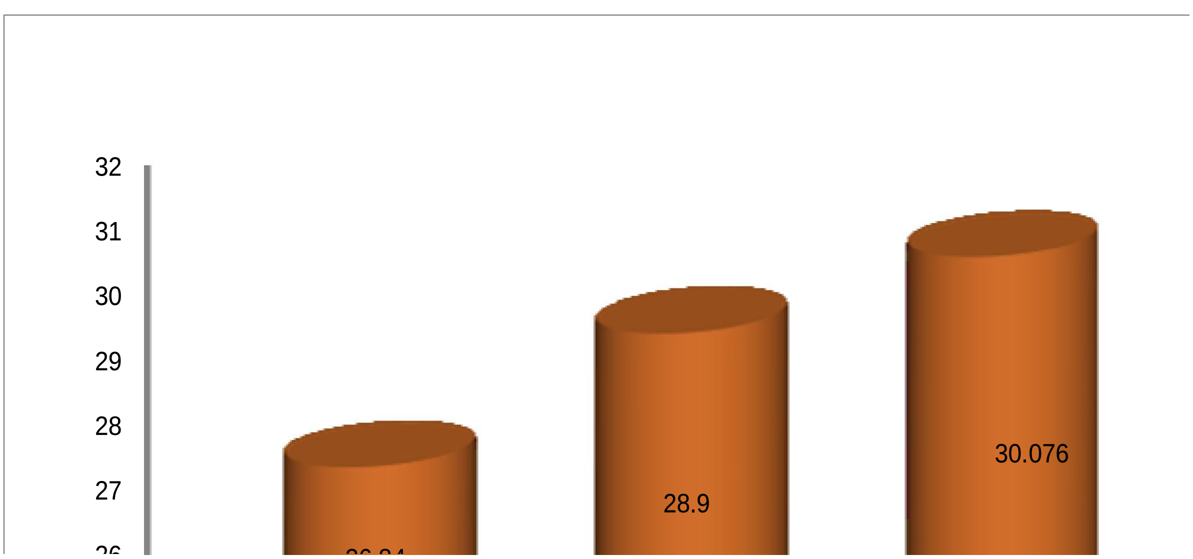

Fig 4: Displacement for various soils.

C. Column Moment

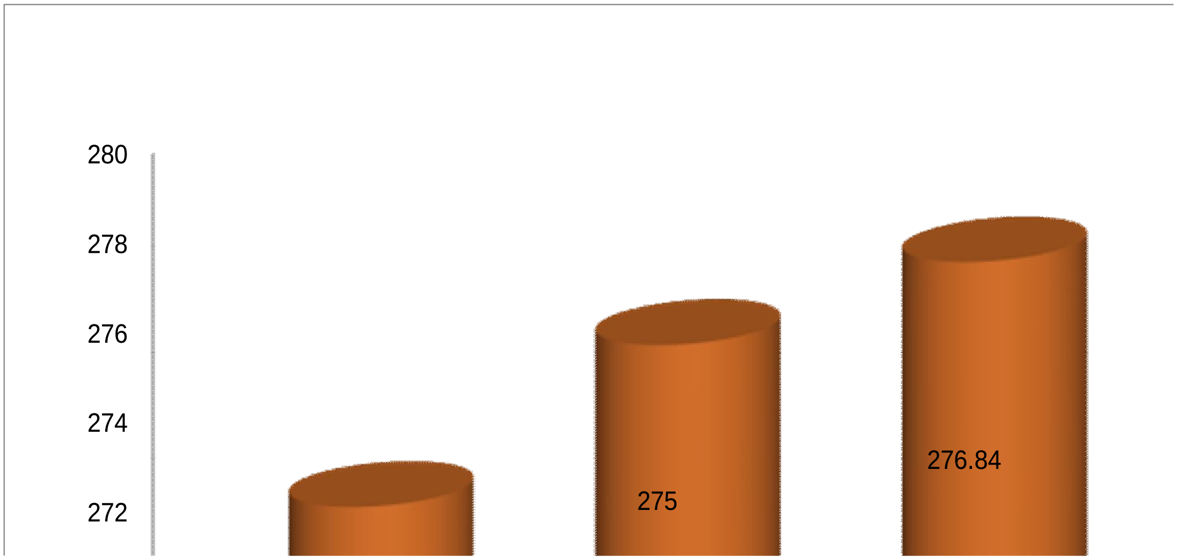

Fig 5: Column moment for different soil.

VI. CONCLUSIONS

1) Base shear and lateral deflection for soft soil is 64.77% and 18% more as compared to fixed base condition.
2) It is observed that column moment 30m span increases by 0.97% for soft soil condition compared to fixed support condition
3) The column moment of a structure increases due to soil structure interaction. As the elasticity of increases, the column moment is also increases. When designing any structure, the column moment is an important consideration. Design errors may result if SSI effect is ignored.
4) At the time of actual practise site condition are not perfectly inelastic, it has some elasticity due to different soil strata. Hence considering SSI effect is important for steel structure building.

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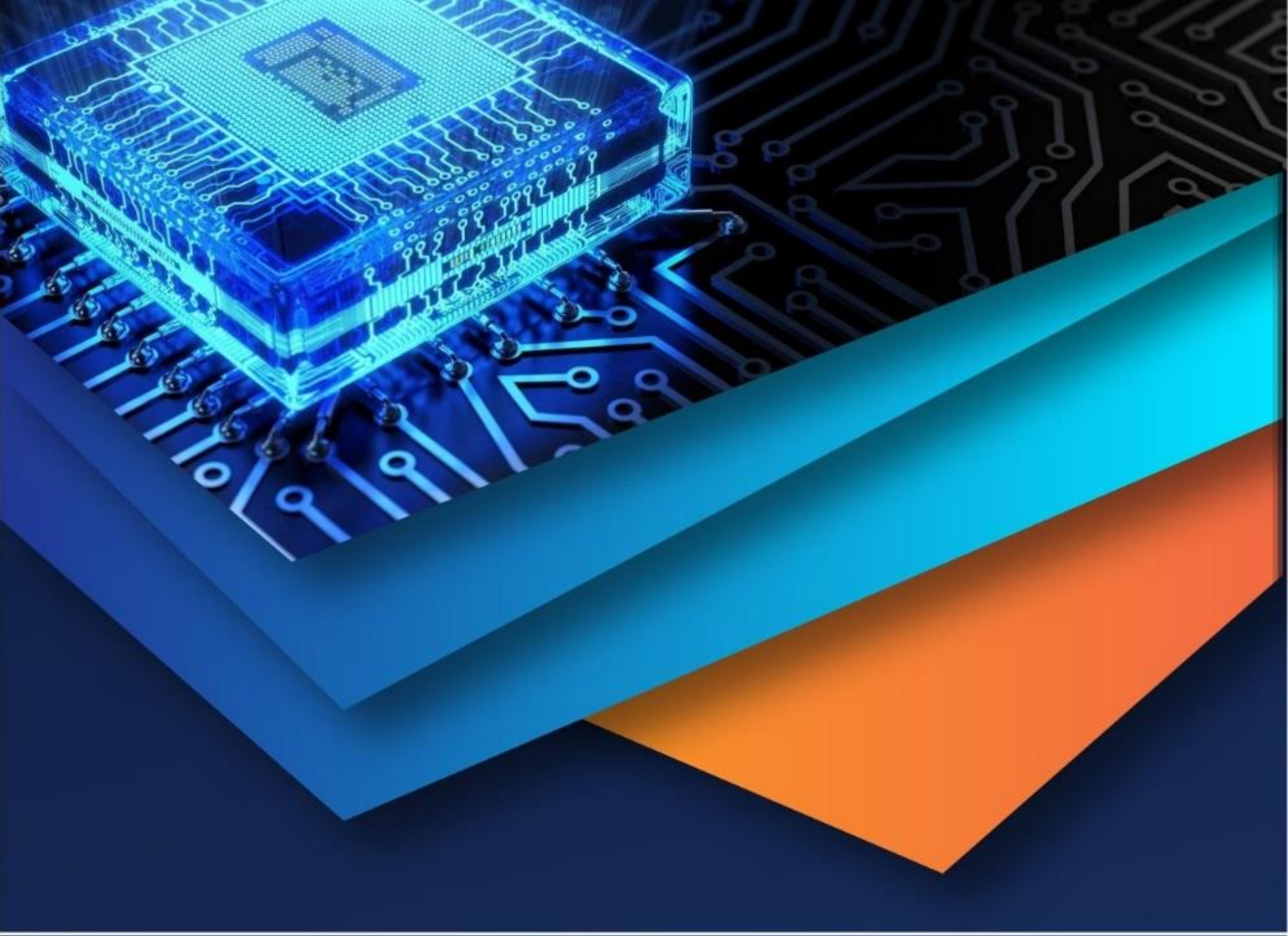

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