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# Effect of Variation of span of P.E.B. Structure considering Soil Structure Interaction

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**Abstract -** *In India the growth of the industrial structure is tremendous. Economy, speed of construction, safety also quality in construction plays vital role in design of any industrial structures. The pre-engineered structures are suits for all of these requirements. Many of India's industrial zones are located in earthquake prone area and sub soil condition of these areas varies significantly so the soil structure interaction phenomena play an important role. In this dissertation the Pre-engineered building with the effect of the soil Structure interaction is carried out with different soil stratum, different span of PEB structure.*

***Key Words***: **Pre-engineered Building, Soil Structure interaction, Sub Soil Conditions, Span of PEB, Stadd-Pro.**

## 1. INTRODUCTION

In India now a days there is rapid adoptability of Pre-Engineered building structures due to its cost effectiveness and quality of the structural members. In PEB structures normally the tapered sections are normally used, the dimensions of these structures are based upon the moment consideration. Due this there is reduction in the material ultimately helps in the reduction of the cost with optimum structural members also these members are pre-fabricated by using hot rolled plate sections give us the very good quality. Design of the PEB structures depends on the various factors such as the height of the structures, bay spacing, support conditions, wind intensity and many other factors. In India effect of the earthquake plays a major role in design of the any structures as India is affected by several earthquakes in past decades so the seismic evaluation of the PEB structures should also be assessed.

### 1.1 Soil Structure Interaction

The soil structure interaction simply means the "The process in which the response of the soil influences the motion of respect to structure influence the response of the soil is termed as soil structure interaction"(Deshpande, Kulkarni and Nitin, 2017) The effect of soil structure interaction consists many parameters which depend on the types of soils such as hard, medium, soft soil. The effect of soil structure interaction is very vital on structures. The Winkler's spring model is mostly used for assessing the effect of soil structure interaction with consists 6 degrees of freedom and George Gazetas chart gives us the algebraic formulas for calculating the dynamic stiffness and damping coeffient (Darmia *et al.*, 2011).

### 1.2 RESPONSE SPECTRUM ANAYSIS

It is a type of dynamic analysis which falls apart in a type of linear as well as in the non linear also, where as response spectrum analysis is linear dynamic analysis and the time history analysis is non linear dynamic analysis. In this contribution of the maximum response of the elastic structure in each natural mode is determined. By this insight view of the dynamic behavior of the structure by measuring pseudo- spectral acceleration , velocity, displacement for a given level of damping.

## 2. METHODOLOGY

The present study includes analysis of Pre-engineered building structure with soil structure interaction having different span of structure such as 16m, 18m, 20m, and 22m with constant height of 6m using software Stadd-Pro. Soil Structure phenomena plays important role in structure located in higher seismic zones so for this analysis we consider zone IV structure located in Delhi for this we used response spectrum method for carrying out analysis. The Winkler's spring model is used to calculate spring stiffness for different types of soil. Mainly 4 support conditions are considered in the analysis i.e. fixed support, Hard soil Stratum, Medium Soil stratum, Soft soil stratum. The main objective of this study is to Study the effect of soil structure interaction on various span of PEB Structures.

## 3. Structure Modeling and Spring Stiffness Calculations

For this analysis work a PEB Structure with different span 16m, 18m, 20m, 22m is considered with constant height of 6m. A 2D frame is modeled in the Stadd-Pro by using tapered sections is used. Following are the basic seismic parameters used in the analysis process.

**Table 1:** Basic Seismic Parameters (IS1893-2016)

| | |
|---|---|
| Zone in which Structure located | IV, Z= 0.24 |
| Response reduction factor | Steel SMRF = 5 |
| Damping | 0.05 |
| Importance Factor | 1.5 |

For considering effect of Soil Structure interaction we consider mainly 3 types of soil i.e. hard soil, Medium Soil, Soft soil and compare their result with fixed support condition of the PEB structure. Winkler's Spring Model is used for this analysis. For the calculating spring stiffness by Winkler's approach following basic soil parameters are taken into account Such as modulus of elasticity of soil, Shear modulus of the soil, Poisson ratio of the soil these parameters are varying as per the soil Stratum. Following is the table shows the different values of above parameter as per the soil condition.

**Table – 2:** Soil Parameters for Different types of Soil.

| Soil type | Modulus of elasticity (E) KN/m$^2$ | Shear Modulus (G) KN/m$^2$ | Passions Ratio |
|---|---|---|---|
| Hard Soil | 65000 | 25000 | 0.3 |
| Medium Soil | 35000 | 13461.53 | 0.3 |
| Soft Soil | 15000 | 6357.14 | 0.4 |

George Gazetas presented a list of formulas to calculate spring stiffness of Winkler's spring model which has 6 degrees of freedom. After calculating these stiffness it is assigned to the software model and analysis is carried out by response spectrum method.

**Table -3**: George Gazetas soil Stiffness Formulas

| Degrees of freedom | Spring Stiffness |
|---|---|
| Horizontal (Lateral) | $(2GL/(2-\gamma))(2+2.50X^{0.85})$ with $x= Ab/4L^2$ |
| Horizontal (Longitudinal) | $(2GL/(2-\gamma))(2+2.50X^{0.85})$-$(0.2/(0.75-\gamma))GL(1-(B/L))$ with $x= Ab/4L^2$ |
| Vertical | $(2GL/(1-\gamma))(0.73+1.54X^{0.75})$ with $x= Ab/4L^2$ |
| Rocking (About Longitudinal) | $(G/(1-\gamma))I_{bx}^{0.75}(L/B)^{0.25}(2.4+0.5(B/L))$ |
| Rocking (About Lateral) | $(G/(1-\gamma))I_{bx}^{0.75}(L/B)^{0.15}$ |
| Torsion | $3.5\ G\ I_{bz}^{0.75}(B/L)^{0.4}(I_{bz}/B^4)^{0.2}$ |

**Table-4:** Calculated Soil Stiffness.

| SR.NO | Degree of Freedom | Hard soil | Medium Soil | Soft Soil |
|---|---|---|---|---|
| 1 | Horizontal (Lateral) | 165441.17 | 89083.65 | 37667.10 |
| 2 | Horizontal ( Longitudinal) | 165441.17 | 89083.65 | 37667.10 |
| 3 | Vertical | 202678.57 | 109134.56 | 50669.61 |
| 4 | Rocking (About Longitudinal) | 13091.74 | 8636.13 | 7162.8 |
| 5 | Rocking (About Lateral) | 13091.74 | 8636.13 | 7162.8 |
| 6 | Torsion | 16047.400 | 10580.00 | 9635.34 |

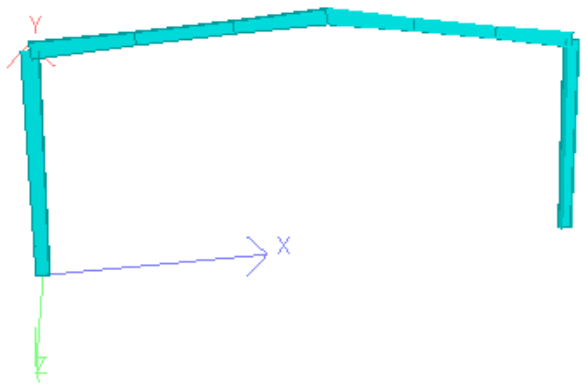


**Figure -1**: 2D Model of 16m Span PEB Structure.

After carrying out the analysis with all the models considering soil structure interaction we come across various parametric results such as base shear, time period, displacement, Column moment, Support reactions out of which we mainly considered base shear, time period, column moment for evaluating the performance of Pre engineered building under the effect of soil structure interaction. Following charts shows the variation in these parameters as a soil changes and span increases.

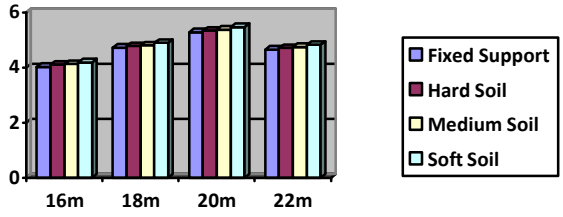


**Chart -1**: Variation of base Shear across (span on X – axis & Y- axis base shear)

From above results and graph we can say that the base shear variation in the pre engineered structure is 5.44% when height of the structure is increased keeping span of the structure constant where as when height of the structure kept constant the base shear variation is an average of 3.76%.

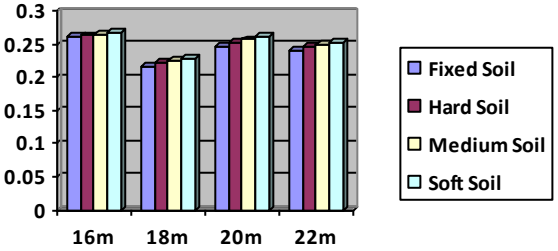


**Chart -2** : Variation of Time Period across (span on X – axis Y- axis Time Period)

From the above graph and results of time period for variation in height of the structure it varies as on average of 5.5% and where as the span of structure varies it varies on an average of 5% across all the span.

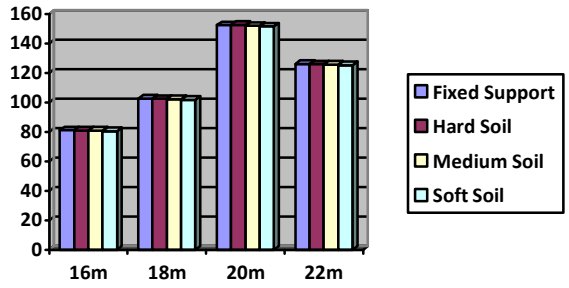


**Chart -3:** Variation of Column moment across (span on X – axis Y- axis Column moment)

## 3. CONCLUSION

In Seismic analysis the base shear, time period varies 5 % and 5.5% respectively. This indicates large seismic forces are attracted towards soft soil as compare to the fixed support and hard soil. There was not much displacement of PEB structure in seismic analysis as compare to wind analysis but it varies in the range of 10%. The column moment was decreased in seismic analysis also by 5%.

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