Effect of Soil Structure Interaction on Buildings with Stiffness Irregularity under Seismic Load

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Abstract - *The main objective of the study is to investigate the significance of effect of soil structure interaction on building with stiffness irregularity. In the present study the behavior of building with stiffness irregularity is considered. To address this problem, a Finite Element Method is used to model soil structure interaction analysis of foundation and supported framed structures by SAP 2000 V18 software. An attempt has been made to evaluate the effect of soil structure interaction on building with stiffness irregularity by considering the systematic parameters like time period, base shear, lateral displacement, storey drift. Response spectrum analysis has been carried out and the parameters like time period, base shear, roof top displacement and storey drift of the building frames resting over foundation and soil media has been studied*.

Key Words: soil structure interaction, vertical irregularity, stiffness irregularity, response spectrum.

1. INTRODUCTION

An earthquake cause, failure of structure which starts at points of weakness. Discontinuity in mass, stiffness and geometry of structure cause weaknesses in structure. The structures which having such type of discontinuity are termed as Irregular structures. Building with vertical irregularities are one of the major reasons of failures of structures during earthquakes. Structures with soft storey were the most notable structures which collapsed. Such effect of vertical irregularities in the seismic performance of structures becomes very important. Changes in height-wise stiffness and mass cause the dynamic characteristics of these buildings different from the regular' building. IS 1893 definition of Vertically Irregular structures: The irregularity in the building structures may be due to irregular distributions in their mass, strength and stiffness along the height of building. When such buildings are constructed in high seismic zones, the analysis and design becomes more complicated. So the effect of soil structure interaction effect cosideration is most important parameter.

1.1 Soil-Structure Interaction (SSI)

Soil-Structure Interaction (SSI) is phenomena in the response of structures caused by the flexibility of the foundation soils, as well as in the response of soils caused by the presence of structures. Analytic and numerical models for dynamic analysis typically ignore SSI effects of the coupled in nature structure foundation-soil system. It has been recognized that SSI effects may have a significant impact especially in cases involving heavier structures rest on soft soil conditions.

1.2 Stiffness Irregular Building

According to IS 1893-2002, A soft storey is one in which the lateral stiffness is less than 70 percent of that in the storey above or less than 80 percent of the average lateral stiffness of the three storeys above

2. OBJECTIVE OF STUDY

Study of soil structure interaction due to seismic load having vertical irregularity with different types of soils viz. soft, medium and hard, using software consists of

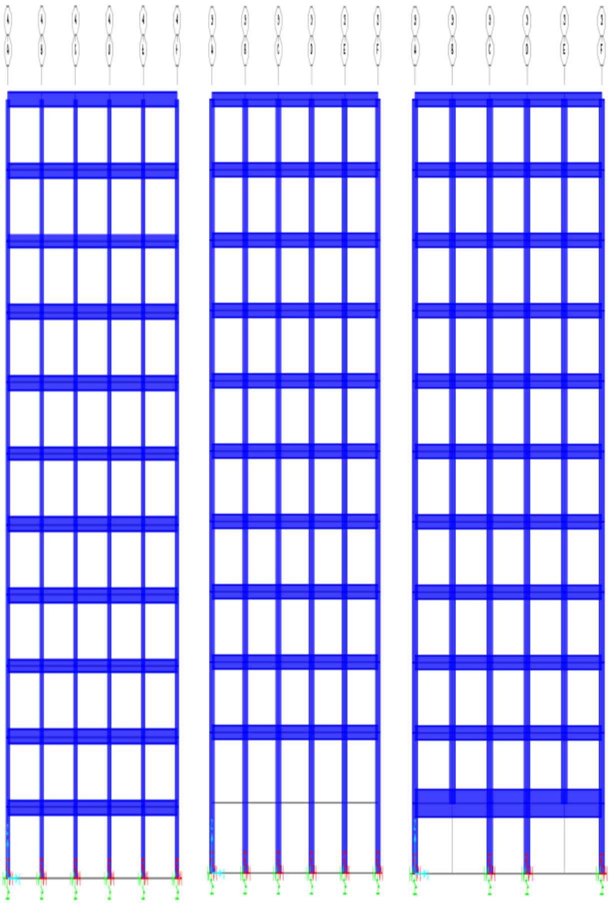
1. Modeling and analysis of regular building and building with stiffness irregularity without and with considering soil structure interaction with different types of soils.
2. Comparison of above responses of regular buildings and irregular buildings on different types of soils like base shear, time period, top storey displacement and storey drift.

3. PROBLEM FORMULATION

For this study, an 11-storey with 5 bays frame (Each bay span 6 m) and floor height 3.0m, regular in plan is considered. This building is considered to be situated in seismic zone 'iv' and designed in compliance to the Indian Code of Practice for Earthquake Resistant Design of Structures. The building is modeled using software SAP 2000 and analyzed by response spectrum method.. Model is studied for comparing, base shear, time period, top storey displacement and storey drift as follow:

Following models are considered for this study.
1) Regular building and
2) Two models with stiffness irregularity having same total seismic weight, are considered.

3.1 Models



Model 1 **Model 2** **Model 3**

Figure 1 regular building and stiffness irregular buildings

3.2 Common Data for All Models

Foundation size:-

Length of footing L=4.5 m

Width of footing B=4.5 m

Depth of footing d =0.9 m

depth of foundation from ground level D=4m

Table 1 Gravity Loads Assigned to RC Building

No. of stories	11
Floor to Floor Height	3000 mm
Beam size	300 mm X 600 mm, 600mmX1000mm
Column size	900 mm X 900mm,
Thickness of slab	150 mm
Density of the concrete	25 kN/m^3
Soil Type	Medium
Zone factor (Z)	0.24
Importance factor (I)	1
Response reduction factor (R)	3
Grade of Concrete	M30
Grade of Steel	Fe 415

Table 2 Gravity Loads Assigned to RC Building

Gravity Load	**Value**
Slab Load (dead load)	3.75 kN/m^2
Floor Finish	1.0 kN/m^2
Roof Finish	1.0 kN/m^2
Live Load	3.0 kN/m^2
Roof Live	1.5 kN/m^2
Wall Load	9.6 kN/m

Table 3 Foundation Parameters

Soil type	Designation	Modulus of elasticity (KN/m^2)	Poisson's ratio(μ)
Hard soil	E-65000	65000	0.3
Medium soil	E-35000	35000	0.4
Soft soil	E-15000	15000	0.4

Table 4 Stiffness of Equivalent Soil Spring(KN/m)(ref. FEMA 356)

Soil type	E-65000	E-35000	E-15000
Translation along x-axis(Kx)	536972.88	285266.84	122257.22
Translation along y-axis(Ky)	536972.88	285266.84	122257.22
Translation along z-axis(Kz)	334731.70	195260.16	83682.93
Rocking about x-axis(Kox)	626095.10	365222.14	156523.77
Rocking about y-axis(Koy)	716522.96	417971.73	179130.74
Torsion about z-axis(Koz)	971272	485636	208129.71

4. RESULT AND DISCUSSION

Response Spectrum Analysis is carried out for Bare frame. The models are checked for time period, base shear, and maximum top displacement.

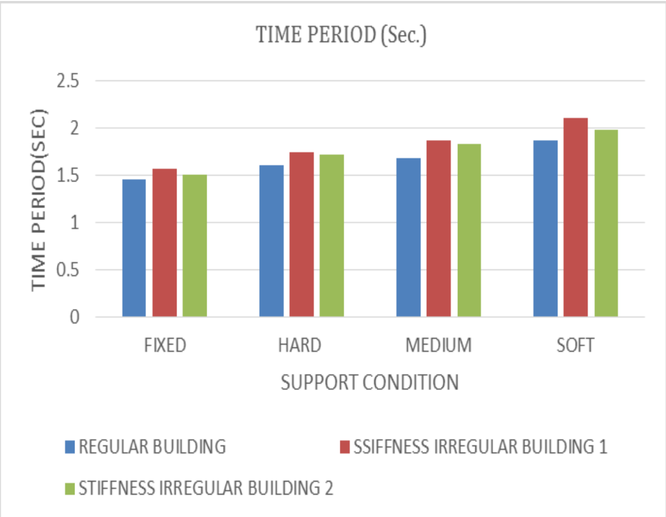


Chart 1 Comparison of Time Period for Regular and Stiffness Irregular Building

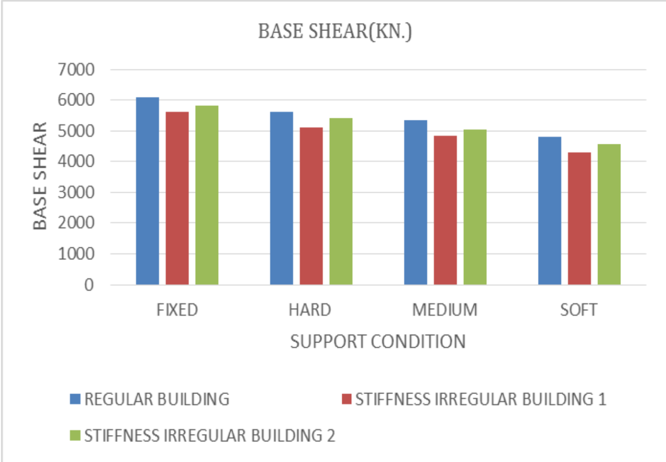


Chart 2 Comparison of Base Shear for Regular and Stiffness Irregular Building

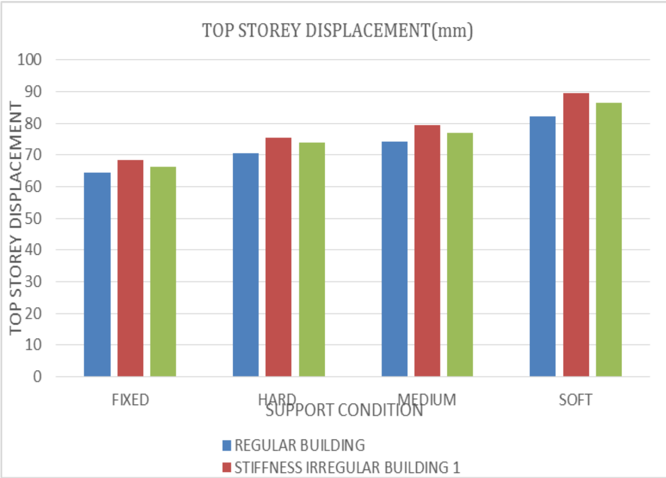


Chart 3 Comparison of Top Storey Displacement for Regular and Stiffness Irregular Building

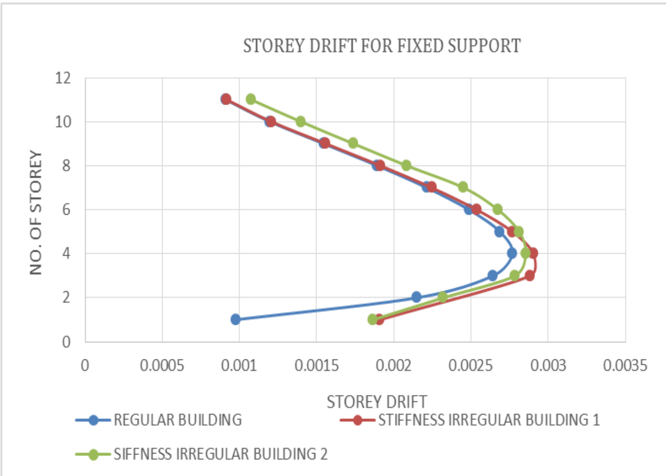


Chart 4 Comparison of Storey Drift for Regular and Stiffness Irregular Building for Fixed Condition

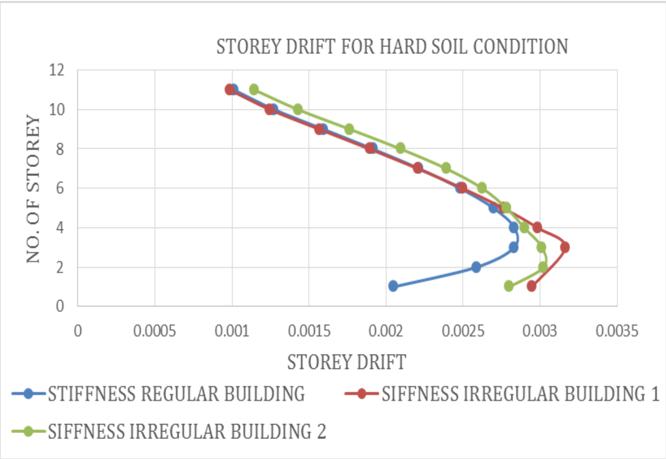


Chart 5 Comparison of Storey Drift for Regular and Stiffness Irregular Building for Hard Soil Condition

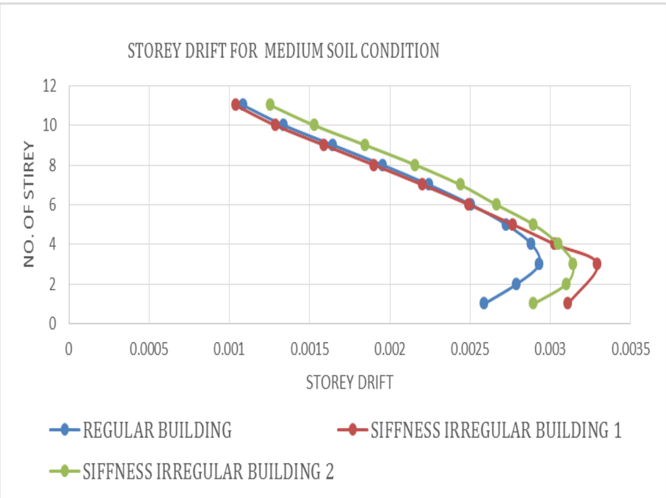


Chart 6 Comparison of Storey Drift for Regular and Stiffness Irregular Building for Medium Soil Condition

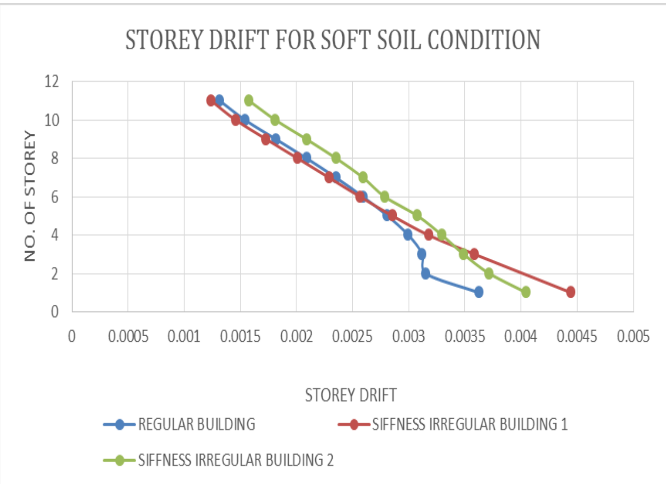


Chart 7 Comparison of Storey Drift for Regular and Stiffness Irregular Building for Medium Soil Condition

1. Fron chart 1, found that natural period of structure increases for building with stiffness irregularity. Rate is higher for model (2) with soft soil, it is increase 43.93% w.r.t regular building with fixed support condition.
2. From chart 2, found that increase in soil flexibility causes decrease in base shear. For soft soil base shear decreases with higher rate. From It is more for model (2); it decreases 29.05% w.r.t regular building with fixed support.
3. From chart 3, found that roof displacement is also observed to be increases for building with stiffness irregularity. For soft soil roof displacement is higher than fixed support condition. It is critical for model (2). It increases up to 38.90 % w. r. t. regular building with fixed support.
4. From chart 4 to 7 it is found that storey drift is maximum for model (2). It is increases from fixed support condition to soft soil condition. It is critical for model (2) with soft soil.

5. CONCLUSION

1. Base shear decreases for "stiffness irregularity" type building.
2. Time period, top storey displacement and storey drift increase for building of "stiffness irregularity" type. This effects are more prominent in soft soil condition.

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