Seismic Analysis of Asymmetric Multi-Storied Frame-Shear Wall Building Including Soil Structure-Interaction

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Abstract: *In the conventional method of analysis flexibility of soil mass is ignored which is likely to affect the performance of structure. The buildings that are irregular in plan have a tendency to attract more earthquake forces as compared to the regular buildings. Also, irregular buildings have certain weaknesses in the lateral load resisting system. In the proposed study an attempt is made to understand the effect of soil flexibility on the performance of asymmetric structures resting on shallow foundation.*

As the conventional analysis method does not address the soil-structure interaction explicitly, the effect of soil structure interaction on reinforced concrete structure is studied using response spectrum method. The main objective of this present investigation is to understand the seismic performance of superstructure considering the interaction between superstructures, the isolated footing resting on the soil and comparing the responses in soil flexibility with those of fixed base assumption, soil being idealized as modified Winkler mode in ETABS2016. An attempt has been made to evaluate the effect of soil structure interaction of super structure by considering the systematic parameters like base shear, lateral displacement, story drift and story shear. In this project shear wall are added improvement is finished ETABS and also the shear walls area unit organized in such a way to resist the lateral forces in zone V region throughout the structure in with Indian codes.

***Key Words*: SSI, Response Spectrum Method, Winkler model, ETABS 2016**

1. INTRODUCTION

In this modern industrial era, one can see huge construction activities taking place everywhere and Construction of structures has been triggered up. The main aim is to do response spectrum analysis on asymmetric RCC building of G+30 stories. Seismic response of a building usually depends on the behavior of the soil, on which the building is laid. Since the design of earthquake resistant buildings started assumption made that supports are fixed and traditionally, soil-structure interaction effects were ignored in seismic design of structures, since they were believed to only have favorable effects. The effects of soil structure interaction have been subjective to research for about half a century, but are still under discussion. Code provisions relating to soil-structure interaction nowadays are still very limited and straight forward procedures to account for soil structure interaction in design are not included in most codes. The process in which the response of the soil influences the motion of the structure and the motion of the structure influences the response of the soil is termed as soil-structure interaction (SSI).

1.1 Objectives

1) To study soil-structure interaction effects on seismic behavior of asymmetric reinforced concrete frame structure loaded and designed according to the Indian Standard Codes.
2) To assess the effect of soil structure interaction on various parameters like Base shear, Story drift, Story displacements and story shear of structures.
3) To study the change in different seismic response parameters of a building with the change in the location of shear wall.
4) To compare and give appropriate solution in all types of models.

1.2 Structural modeling

In this study, the analysis of G+ 30 stories asymmetric RCC framed buildings with and without SSI are designed in order to determine the behavior of the structure during high seismic activity. The material properties are selected on the basis of displacement limitations and strength as per IS 800-2007. For the analysis, to compute the responses such as base shear, lateral displacement, story drift, Story shear. To counter act for soil structure interaction the shear walls are provided in different ways. The shear wall of dimension 0.15m thickness is used and analyzed for different load cases as per code specification in ETABS software.

The model is generated in ETABS-2016 software package. The building is analyzed as bare frame with computer software package ETABS-2016. To study the soil structure interaction of the 30 storied building over a foundation is resting on the soil medium. The each building models are rested on the soft, medium and hard soil profiles. The story height for all the models was considered as 3m and the bay length of frames as 3m c/c.

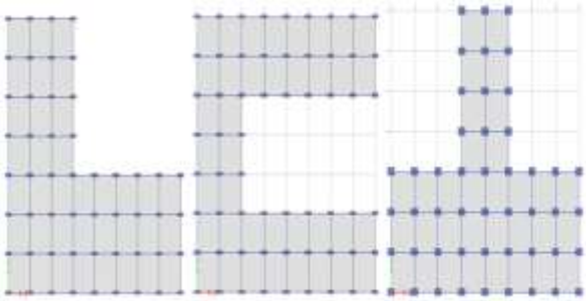

Fig.1 Different plan configurations with fixed base

Fig. 2 Different plan configurations with SSI

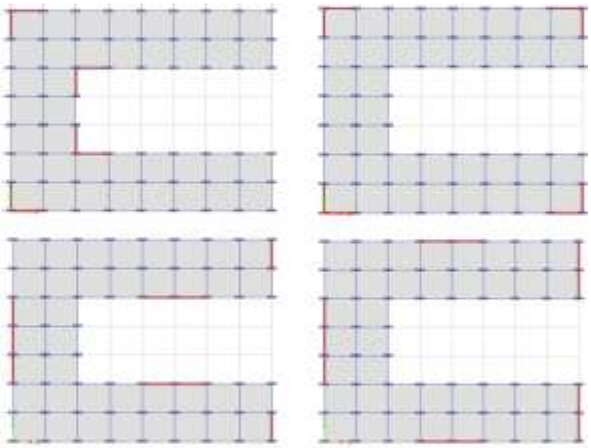

Fig. 3 Plan of C type building with different positions Of shear wall

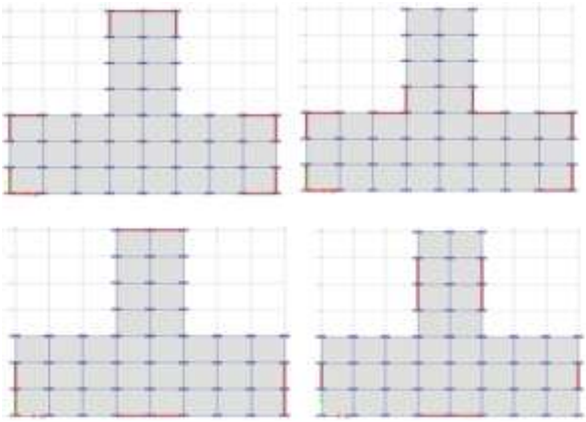

Fig. 4 Plan of T type building with different positions Of shear wall

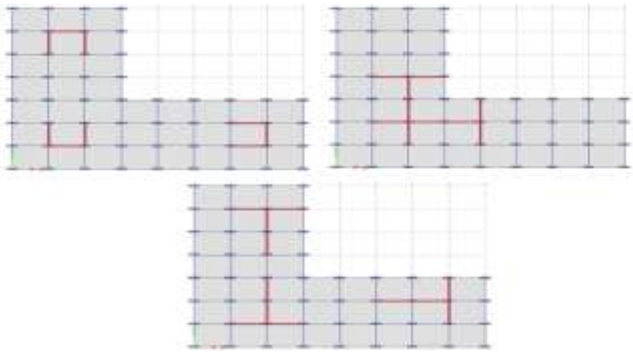

Fig. 5 Plan of L type building with different positions Of shear wall

2. STRUCTURES CONSIDERED FOR ANALYSIS

Model 1:30 story asymmetric structure with C type plan with fixed base
Model 2: 30 story asymmetric structure with T type plan with fixed base
Model 3: 30 story asymmetric structure with L type plan with fixed base
Model 4: 30 story asymmetric structure with C type plan with SSI on soft, medium and hard soil
Model 5: 30 story asymmetric structure with T type plan with SSI on soft, medium and hard soil
Model 6: 30 story asymmetric structure with L type plan with SSI on soft, medium and hard soil
Model 7: 30 story asymmetric structure with C type plan with SSI on soft, medium and hard soil with shear wall at different positions
Model 8: 30 story asymmetric structure with T type plan with SSI on soft, medium and hard soil with shear wall at different positions
Model 9: 30 story asymmetric structure with L type plan with SSI on soft, medium and hard soil with shear wall at different positions

3. METHODOLOGY

This research paper deals with comparative study of behavior of structure frames with three geometrical plan configurations and different positions of shear walls for each configuration. This study is attempted in following steps:

1. Selection of building plan C, L, and T of 30story 2D frame with fixed base.
2. Selection of building plan C, L, and T of 30story 2D frame with SSI.
3. Modeling of building frames by adding shear walls at different positions using ETABs-2016 software.
4. Response spectrum analysis is carried out in software and gives appropriate solution for each plan configuration.

3.1 Soil Modeling

To analyze the foundation and structure under seismic loading, soil is modeled as a set of elastic continuum.

Translations of foundation in two horizontal and vertical axes are considered in the present study, these springs are attached to the footing to estimate the effect of soil flexibility.

3.1.1 SSI Mode Consider For Study

Effect of this soil for SSI is considered by considering equivalent springs with 3 DOF. The stiffness along these 3 degrees of freedom is determined as per George Gazetas, Formulae for impedances of surface and embedded foundations is shown in Table I.

$$K z = \frac{2\,GL}{1-\vartheta}\left[0.73 + 1.54\left(\frac{B}{L}\right)^{0.75}\right] \qquad \text{......... (1)}$$

$$K y = \frac{2\,GL}{2-\vartheta}\left[2 + 2.5\left(\frac{B}{L}\right)^{0.85}\right] \qquad \text{......... (2)}$$

$$K x = K y = \frac{0.2}{0.75-\vartheta} GL\left[1 - \left(\frac{B}{L}\right)\right] \qquad \text{......... (3)}$$

such that L≥ B and size of the foundation is 2L x 2B.

Where $G = \frac{E}{2\,(1+\vartheta)}$ is Shear Modulus and ϑ is poison's ratio of the soil.

Soil type	Shear Modulus (G) in kN/m^2	Poisson's Ratio (μ)
Hard Soil	2700	0.25
Medium Soil	451.1	0.33
Soft Soil	84.5	0.48

SPRING CONSTANTS	TYPE OF SOIL		
	SOFT SOIL	MEDIUM SOIL	HARD SOIL
Kx	2763.5	5527.019	11054.138
Ky	2763.5	5527.019	11054.138
Kz	3474.68	6949.37	13898.84

Serial no.	Material properties	
1	Column size	300x750mm
2	Beam size	300x900mm
3	Height of ground floor	3 m
4	Thickness of slab	150mm
5	Grade of steel	HYSD415
6	Grade of concrete	M25,M35
7	Live load	2 KN/m2
8	Floor finish	1 KN/m2
9	No. of stories	G+30
10	Floor to floor height	3 m
11	Type of soil	Soft, Medium, Hard Soil
12	Seismic zone	V
13	Importance factor	1.5

4. RESULT AND DISCUSSION

4.1 Displacement Comparison along with fixed base and SSI

Model Type	Soil Type	Maximum Displacement in mm
C type building	Fixed	148.851
T type building	Fixed	107.459
L type building	Fixed	114.104

C type with SSI	Soft	1358.962
	Medium	850.199
	Hard	571.85
T type with SSI	Soft	1478.7
	Medium	785.56
	Hard	438.479
L type with SSI	Soft	1610.896
	Medium	857.509
	Hard	479.886
C type with SSI and shear wall	soft	1233.333
	Medium	703.653
	Hard	431.247
T type with SSI and shear wall	soft	1342.35
	Medium	703.93
	Hard	384.128
L type with SSI and shear wall	soft	1502.799
	Medium	792.867
	Hard	436.876

Chart -1: Overall displacement chart

4.2 Drift Comparison along with fixed base and SSI

Model Type	Soil Type	Maximum Drift
C type building	Fixed	0.002108
T type building	Fixed	0.001431
L type building	Fixed	0.000838

C type with SSI	Soft	0.015774
	Medium	0.010064
	Hard	0.006993
T type with SSI	Soft	0.017727
	Medium	0.009943
	Hard	0.005967
L type with SSI	Soft	0.018974
	Medium	0.010532
	Hard	0.006244
C type with SSI and shear wall	soft	0.014463
	Medium	0.008617
	Hard	0.00597
T type with SSI and shear wall	soft	0.016718
	Medium	0.009457
	Hard	0.005642
L type with SSI and shear wall	soft	0.018593
	Medium	0.010484
	Hard	0.006232

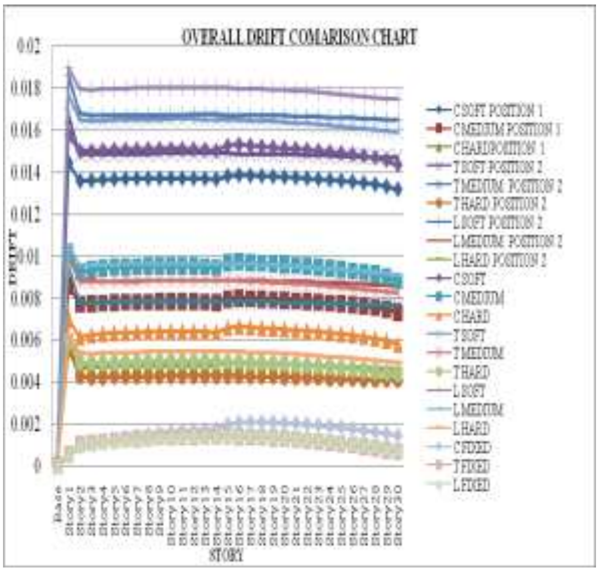

Chart 2: Overall drift chart

4.3 Base shear Comparison along with fixed base and SSI

Model Type	Soil Type	Base shear(KN)
C type building	Fixed	3148.65
T type building	Fixed	2879.0525
L type building	Fixed	2987.0164

C type with SSI	Soft	1258.3302
	Medium	1258.3302
	Hard	1258.3302
T type with SSI	Soft	1268.875
	Medium	1268.875
	Hard	1268.875
L type with SSI	Soft	1255.0402
	Medium	1255.0402
	Hard	1255.0402
C type with SSI and shear wall	soft	1355.3801
	Medium	1355.3801
	Hard	1355.3801
T type with SSI and shear wall	soft	1414.4497
	Medium	1414.4497
	Hard	1414.4497
L type with SSI and shear wall	soft	1376.3525
	Medium	1376.3525
	Hard	1376.3525

Chart -3: Base shear chart

5. CONCLUSIONS

In the present study asymmetrical building is analyzed for different plans and positioning of shear walls at different locations with and without including soil structure interaction. The results lead to following conclusions.

1) Lateral story displacement of the structure with SSI is more as compared to conventional fixed base structure (NSSI). It also increases with the soft soil and decreases with adding of shear walls for C, L and T shaped plan building.
2) Maximum story displacement is maximum in L shaped of asymmetric building than C and T shaped in soft, medium and hard soil with and without SSI.
3) The adding of shear walls which is required for stiffness in lateral direction not only increases the stiffness but also decreases lateral deflection.
4) Maximum story displacement is found lower in case of bare frames (fixed or NSSI) than that compared to shear wall buildings.
5) The shear wall at position 1 in C type building and at position 2 in T and L type building has minimum story displacement.
6) The base shear values are smaller in case of Flexible base (SSI) compared to fixed base buildings.
7) It was seen in old and conventional fixed base buildings; the base shear value was increasing with increase in flexibility of soil whereas it is decreasing in case of flexible base (SSI) and increasing in shear wall building.
8) Story displacement and story drifts are maximum in case of building with soil structure interaction than fixed base buildings (NSSI).

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