STUDY ON THE BEHAVIOUR OF RC FRAMED STRUCTURE WITH SHEAR WALL AND BRACING SYSTEM FOR REGULAR AND IRREGULAR IN PLAN WITH CONSIDERING SSI

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Abstract: Earthquake has a high potential to cause a wide spread damages in densely populated areas which causes heavy loss of life and high economic losses. Conventional analysis of structures is generally carried out by assuming the base of structure to be fixed. The soil below foundation alters the earthquake loading and varies the lateral forces action on the structure. Therefore, it is unrealistic to analysis the structure by considering it to be fixed at base. In present study, the effect of SSI with shear wall and bracing system is carried out for regular and irregular in plan reinforced concrete framed structure. Analysis will be carried out for G+9 storey structures with C and T shapes in plan with shear wall and X-bracing in seismic zone IV. Analysis will be compare with bare frame model by using ETABS to study SSI. Seismic parameters i.e. Maximum Storey Displacement, Maximum Storey Drift, Time period and Base shear will be considered for the comparison.

Index Terms –Irregular building, Shear wall, X-bracing, Soil Structure Interaction, Winkler’s approach, Response Spectrum Analysis.

I. INTRODUCTION

Over the last few years, considerable progress has been made in understanding the nature of the earthquake and seismic behavior of the structure. During past and recent earthquakes it is seen that the seismic response of the super-structure and sub-structure affected by Soil Structure Interaction (SSI) effect and also soil greatly influence the overall structural response. Due to seismic waves, damages of the structure it not only depending on the behavior of super-structure but also on the soil below and surrounding the foundation. The earthquake caused socio-economic damaged is depends on a great extent on the characteristics of the strong ground motion.

Traditional seismic analysis and design of superstructure is carried out by assuming fixed base condition. In other words, seismic response of the structure is only influence by structure itself and neglecting flexibility of the soil. Conventionally design of the superstructure and substructure are carried our as independent systems. But, the actual behavior of the structure during an earthquake significantly depends on the structure, the foundation and the soil underlying also surrounding foundation. Overall response of structure is linkage between soil and structure. Secondly, the frequently and amplitude of the ground motion is change by the stiffness of the soil deposit. Building with an asymmetric distribution of stiffness and strength in plan undergo coupled lateral and torsional motions during earthquake

The free field motion is defined as it is a ground motion that are generated by the absence of the structure. If the light weight structure is resting on the rock, input motion of the structure is almost same as free field motion. If the structure is heavy weight and resting on the medium or soft soil than input motion of the structure is varies from the free field motion. The SSI problem has become most significant for heavy weight structure like bridges, underground structures, nuclear plants, tall building etc. its foundation is resting on the flexible soil condition.

II. OBJECTIVES

To evaluate the SSI effect on regular and irregular in plan R.C.C. frame structure having shear wall.
To evaluate the SSI effect on regular and irregular in plan R.C.C. frame structure having X-bracing system.
To comparative study the structural response of structure having regular and irregular in plan with and without considering soil structure interaction effect for various types of soil condition.

III. LITERATURE REVIEW

6Nirav M. Katarmal, Hemal J. Shah, investigated that displacement is increases up to 69% for irregular plan with SSI and also conclude that % of displacement is more for FEM compared to spring model and fixed base condition.
7Pallavi Badry, Dr. Neelima Satyam, investigated that C-shaped building is more critical as it experience the 38% and 29% more displacement than T-shaped and L-shaped building respectively.
8Purva M. Kulkarni, investigated that story displacement increases up to 28% while considering soil structure interaction effect and for clayey soil condition SSI effect is more.

IV. METHODOLOGY

In present work the analysis of following structures having 10 storey structure with and without Soil Structure Interaction (SSI) effect are to be carried out for various types of structure:

i) Bare Frame
ii) R.C.C. frame with Shear Wall  
iii) R.C.C. frame with X-bracing system  
The plan areas of the all structures are same for the analysis; also, the beam and column dimensions are same. The material properties such as Poisson ratio, Density of RCC, Density of Masonry, Young’s modulus, compressive strength of steel and concrete etc. are kept constant in all buildings. George Gazetas equations are used for soil spring.  
• The Response Spectrum Analysis for Zone IV is considered.  
• The result parameter includes the Base Shear and Displacement.

❖ Structure and Section details:

<table>
<thead>
<tr>
<th>Storey</th>
<th>10 storey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan Dimension</td>
<td>42m X 30m</td>
</tr>
<tr>
<td>Bay Width in X-Direction</td>
<td>6m</td>
</tr>
<tr>
<td>Bay Width in Y-Direction</td>
<td>5m</td>
</tr>
<tr>
<td>Floor Height</td>
<td>3m</td>
</tr>
<tr>
<td>Shear wall Thickness</td>
<td>230mm</td>
</tr>
<tr>
<td>Bracing</td>
<td>300mm x 300mm</td>
</tr>
<tr>
<td>Slab Thickness</td>
<td>150mm</td>
</tr>
<tr>
<td>Beam Dimension</td>
<td>300mm X 500mm</td>
</tr>
<tr>
<td>Column Dimension</td>
<td>600mm X 600mm</td>
</tr>
<tr>
<td>Live Load</td>
<td>4 KN/m²</td>
</tr>
<tr>
<td>Floor Finish</td>
<td>1.5 KN/m²</td>
</tr>
<tr>
<td>External Wall Load</td>
<td>13.8 KN/m²</td>
</tr>
<tr>
<td>Internal Wall Load</td>
<td>6.9 KN/m²</td>
</tr>
<tr>
<td>Concrete Grade</td>
<td>M30</td>
</tr>
<tr>
<td>Steel Grade</td>
<td>Fe500</td>
</tr>
</tbody>
</table>

❖ Soil properties of soil used in the study (Mehta and Gandhi, 2008):

<table>
<thead>
<tr>
<th>Sr. no.</th>
<th>Soil type</th>
<th>Modulus’s modulus (KN/m²)</th>
<th>Poisson’s ratio</th>
<th>Shear modules (KN/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Rock</td>
<td>30.42 x 10⁷</td>
<td>0.30</td>
<td>3758900</td>
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<tr>
<td>2.</td>
<td>Dense Soil</td>
<td>50.53 x 10⁷</td>
<td>0.35</td>
<td>822000</td>
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<tr>
<td>3.</td>
<td>Medium Soil</td>
<td>25.84 x 10⁴</td>
<td>0.45</td>
<td>183500</td>
</tr>
<tr>
<td>4.</td>
<td>Soft Soil</td>
<td>14.95 x 10⁴</td>
<td>0.49</td>
<td>36700</td>
</tr>
</tbody>
</table>

Fig 1. Elevation view of 10 storey having shear wall (a) Rectangle (b) T-shaped (c) C-shaped
Fig 2. Elevation view of 10 storey having X-bracing (a) Rectangle (b) T-shaped (c) C-shaped

V. RESULTS

Maximum Storey Displacement:

- **Figures 3-5:** Graphs showing Maximum Storey Displacement (mm) for 10 Storey structures for different types of soils.

0 5 10 15 20 25 30 35

Max. Displacement (mm)

### Maximum Storey Displacement (mm) of 10 Storey: (a) Rock (b) Dense Soil

<table>
<thead>
<tr>
<th>Bar Frame</th>
<th>SW</th>
<th>XB</th>
<th>Rectangle</th>
<th>29.1</th>
<th>13.0</th>
<th>18.2</th>
<th>30.0</th>
<th>10.5</th>
<th>14.7</th>
<th>29.3</th>
<th>12.9</th>
<th>19.2</th>
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</thead>
<tbody>
<tr>
<td>Fixed</td>
<td></td>
<td></td>
<td>C-shape</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flexible</td>
<td>29.1</td>
<td>13.2</td>
<td>18.3</td>
<td>30.0</td>
<td>10.7</td>
<td>14.9</td>
<td>29.3</td>
<td>13.1</td>
<td>19.3</td>
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</table>

<table>
<thead>
<tr>
<th>Bar Frame</th>
<th>SW</th>
<th>XB</th>
<th>T-shape</th>
<th>29.1</th>
<th>13.0</th>
<th>18.2</th>
<th>30.0</th>
<th>10.5</th>
<th>14.7</th>
<th>29.3</th>
<th>12.9</th>
<th>19.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Flexible</td>
<td>29.1</td>
<td>13.2</td>
<td>18.3</td>
<td>30.0</td>
<td>10.7</td>
<td>14.9</td>
<td>29.3</td>
<td>13.1</td>
<td>19.4</td>
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</tbody>
</table>

### Maximum Storey Displacement (mm) of 10 Storey: (a) Medium Soil (b) Soft Soil

<table>
<thead>
<tr>
<th>Bar Frame</th>
<th>SW</th>
<th>XB</th>
<th>Rectangle</th>
<th>48.6</th>
<th>21.5</th>
<th>30.4</th>
<th>50.0</th>
<th>15.2</th>
<th>24.6</th>
<th>48.8</th>
<th>19.5</th>
<th>32.1</th>
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</thead>
<tbody>
<tr>
<td>Fixed</td>
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<td>C-shape</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Flexible</td>
<td>49.3</td>
<td>27.2</td>
<td>34.4</td>
<td>51.3</td>
<td>19.6</td>
<td>28.4</td>
<td>49.6</td>
<td>24.9</td>
<td>36.6</td>
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<table>
<thead>
<tr>
<th>Bar Frame</th>
<th>SW</th>
<th>XB</th>
<th>T-shape</th>
<th>48.6</th>
<th>21.5</th>
<th>30.4</th>
<th>50.0</th>
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<tbody>
<tr>
<td>Fixed</td>
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<tr>
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<td>24.9</td>
<td>36.6</td>
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</tbody>
</table>
**Base Shear:**

**Base Shear (KN) 10 Storey Rock**

- **Bare Frame**: Rectangle
- **SW**: 1483.05 KN
- **XB**: 4043.63 KN
- **Bare Frame**: C-shape
- **SW**: 2660.64 KN
- **XB**: 1210.35 KN
- **Bare Frame**: T-shape
- **SW**: 2576.50 KN
- **XB**: 1180.43 KN

**Base Shear (KN) for 10 Storey at Rock**

- **Fixed**: 1483.05 KN, 4043.63 KN, 2660.64 KN, 1210.35 KN, 2576.50 KN, 1180.43 KN
- **Flexible**: 1482.95 KN, 4021.87 KN, 2650.01 KN, 1210.21 KN, 2576.50 KN, 1180.27 KN

**Base Shear (KN) 10 Storey Dense Soil**

- **Bare Frame**: Rectangle
- **SW**: 1985.47 KN
- **XB**: 5377.45 KN
- **Bare Frame**: C-shape
- **SW**: 3383.59 KN
- **XB**: 1613.77 KN
- **Bare Frame**: T-shape
- **SW**: 1600.51 KN
- **XB**: 3593.57 KN

**Base Shear (KN) for 10 Storey at Dense Soil**

- **Fixed**: 1985.47 KN, 5377.45 KN, 3383.59 KN, 1613.77 KN, 3593.57 KN, 1600.51 KN
- **Flexible**: 1982.60 KN, 4713.90 KN, 3157.85 KN, 1600.51 KN, 3593.57 KN, 1571.14 KN

**Base Shear (KN) 10 Storey Medium Soil**

- **Bare Frame**: Rectangle
- **SW**: 1985.47 KN
- **XB**: 5377.45 KN
- **Bare Frame**: C-shape
- **SW**: 3383.59 KN
- **XB**: 1613.77 KN
- **Bare Frame**: T-shape
- **SW**: 1600.51 KN
- **XB**: 3593.57 KN

**Base Shear (KN) for 10 Storey at Medium Soil**

- **Fixed**: 1985.47 KN, 5377.45 KN, 3383.59 KN, 1613.77 KN, 3593.57 KN, 1600.51 KN
- **Flexible**: 1982.60 KN, 4713.90 KN, 3157.85 KN, 1600.51 KN, 3593.57 KN, 1571.14 KN
VI. CONCLUSION

- Lateral displacement increases for flexible base with fixed base.
- Consideration of Soil Structure Interaction effect, base shear of the structure decreases as compared to fixed base.
- As the stiffness of the soil decreases, the effect of SSI becomes more predominant to the seismic behavior of the structure.
- Shear-walled structure having more SSI effect as compared to bare frame and X-bracing structure.
- Result variation is more in C-shaped plan compared to Rectangle plan and T-shaped plan.

VII. REFERENCES