Influences of Masonry Infill Wall, Tie Beam and RCC Bracing on Soft Storey Mechanism

Prof. Prakarsh. Sangave1, Mr. Rajkumar Waghmare2, Mr. Nitin Hanamgaonswami2, Mr. Zaid Ahmed Kalyani2, Ms. Aishwarya Pawar2, Ms. Harsha Shinde2

ABSTRACT: The presence of infill wall in the building gives better behavior under lateral loads. Engineers believe that ignoring infill effect gives conservative design. For multistoried structures, the consideration of effect of bottom storey under seismic forces would be an important parameter. As per IS 1893 (Part-I) :2002 the columns and beams of the soft storey are to be designed for 2.5 times the storey shear and moments calculated under the seismic load of a bare frame (i.e. without considering infill effect). In this paper model is studied to investigate the magnification factor for various load combinations considering peripheral masonry infill wall only, peripheral masonry infill wall along with tie beams and RCC X bracings under seismic effect. The Equivalent diagonal strut method is used to calculate the width of infill strut by FEMA approach. The R.C.C. building model (P+7) has been prepared using ETAB software. The Seismic Coefficient Method has been performed for the analysis of various models. The results of investigations and their conclusions are discussed below.

Index Terms: Base shear, Displacement, Equivalent diagonal strut, Infill wall, Tie beam, R.C.C. X-Bracing, Load combinations, Magnification factor, Soft Story.

1 INTRODUCTION

Currently India is a rapidly urbanizing country which leads to acquisition of land under different mega structures. The Reinforced Concrete (RC) Frame building is one of the under category field which is the current scope of construction in India. Now days due to the limitations of the horizontal development of the building, it has become necessary to grow vertically (Multi-storey, Sky scrapers etc.). Hence, due to higher height of the building, the effect of earthquake plays a dominant role for mechanism of structural parameters. One of the major considerations in high rise building is the ‘Soft storey’. According to Indian standard code 1893 (Part-I) : 2002 clause 4.20 page no.10 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. The soft storey may be in the form of vehicle parking (Refer Fig.1), for Commercial shop purpose, Intermediate soft storey for firefighting purpose etc.

The significant use of this storey is functionally, but from a seismic performance point such a building is considered to have increased vulnerability. From the past earthquakes it is found that major failure occurred in the soft storey floor. Therefore it is necessary to withstand the soft storey under lateral loads with sufficient strength and stiffness and adequate ductility. The soft storey can be strengthened by using the structural and/or non-structural element like provision of RCC bracings, steel bracings, shear wall, peripheral tie beam, provision of brick masonry infill panels or combinations. According to Indian standard code 1893 (Part-I) : 2002 clause 7.10.3 (a) page no.27 states that, the columns and beams of the soft storey are to be designed for 2.5 times the storey shear and moments calculated under the seismic loads of a bare frame (i.e. without considering infill effect). The factor 2.5 is called as magnification factor. The magnification factor is supposed to be compensating for stiffness discontinuity. The F. Demir’s and M. Sivri (2002) approach is used to calculate the masonry infill strut width. Indian standard code is silent about considering the provision of peripheral infill effect, peripheral infill effect along with tie beams or RCC bracings in soft storey for magnification factor.

2 OBJECTIVE OF THE WORK

The objective behind the work descrip below:

i) To check the applicability of magnification factor 2.5 with considering the provisions like peripheral infill effect, peripheral infill effect with peripheral tie beams and peripheral infill effect with peripheral RCC bracings in OGS.

ii) To check the applicability of magnification factor 2.5 with various load combinations given in IS code.
3 VARIOUS LOAD COMBINATIONS
As per IS code 1893 (Part-I): 2002 clause 6.3.1.2 page no.13
1) 1.5 (DL + LL)                    2) 1.2 (DL + LL ± EQx)
3) 1.2 (DL + LL ± EQy)         4) 1.5 (DL ± EQx)
5) 1.5 (DL ± EQy)                  6) 0.9 DL ± 1.5 EQx
7) 0.9 DL ± 1.5 EQy
By considering the above load combinations the Magnification factor has been investigated.

4 STRUCTURAL FRAMING
The presence of only masonry infill walls, masonry infill wall along with Tie beam or RCC X-bracing in a framed building not only enhance the lateral stiffness but also alters the transmission of forces in beams and columns as compared to the bare frame. In a bare frame, the resistance to lateral forces is due to the development of bending moments and shear force in the beam and column through the rigid jointed action.

5 FRAMING SYSTEM CONSIDERED FOR ANALYSIS
For the analysis purpose four models are prepared (see Table 1) namely,

<table>
<thead>
<tr>
<th>Model No.</th>
<th>Abbreviation</th>
<th>Descriptions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model I</td>
<td>M₁</td>
<td>Bare frame</td>
</tr>
<tr>
<td>Model II</td>
<td>M₁I</td>
<td>Peripheral masonry infill in Bottom Storey</td>
</tr>
<tr>
<td>Model III</td>
<td>M₁II</td>
<td>Peripheral masonry infill wall along with tie beams in Bottom Storey</td>
</tr>
<tr>
<td>Model IV</td>
<td>M₁IV</td>
<td>Peripheral masonry infill wall along with RCC bracings in Bottom Storey</td>
</tr>
</tbody>
</table>

The bottom storey Columns & beams being grouped according to their position as follows (See Table 2 and 3, refer Fig.3),

<table>
<thead>
<tr>
<th>Group</th>
<th>Location</th>
<th>Beam No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>G - I</td>
<td>Corner Beams</td>
<td>B₁, B₃, B₁₆, B₁₈-₁₉, B₂₃, B₃₄, B₅₈</td>
</tr>
<tr>
<td>G - II</td>
<td>Peripheral Beams 1</td>
<td>B₂, B₄, B₆-₇, B₉-₁₀, B₁₂-₁₃, B₁₅, B₁₇</td>
</tr>
<tr>
<td>G - III</td>
<td>Peripheral Beams 2</td>
<td>B₂₈-₂₉, B₃₁, B₂₈-₂₉, B₃₃, B₃₅-₃₇</td>
</tr>
<tr>
<td>G - IV</td>
<td>Central Beams</td>
<td>B₅, B₆, B₁₁, B₁₄, B₂₅-₂₇, B₃₅-₃₂</td>
</tr>
</tbody>
</table>

For the analysis purpose the following structural and seismic data has been considered (See Table 4)

<table>
<thead>
<tr>
<th>SR.NO.</th>
<th>Building Parameters</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>Type of Frame</td>
<td>SMRF</td>
</tr>
<tr>
<td>2</td>
<td>Seismic Zone</td>
<td>V</td>
</tr>
<tr>
<td>3</td>
<td>Importance Factor (I)</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>Response Reduction Factor</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Type of Soil</td>
<td>Hard (Type I)</td>
</tr>
<tr>
<td>6</td>
<td>Damping of Structure</td>
<td>5%</td>
</tr>
<tr>
<td>7</td>
<td>Spacing of Frame,</td>
<td></td>
</tr>
<tr>
<td>i) In X - Direction</td>
<td>4.50 m</td>
<td></td>
</tr>
<tr>
<td>ii) In Y - Direction</td>
<td>4.00 m</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Loadings,</td>
<td></td>
</tr>
<tr>
<td>i) Dead Load</td>
<td>Self-weight of structural elements</td>
<td></td>
</tr>
<tr>
<td>ii) Floor Finishes</td>
<td>1 KN/m²</td>
<td></td>
</tr>
<tr>
<td>iii) Live Load</td>
<td>4 KN/m²</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Storey</td>
<td>G + 7 (5 x 3 Bay)</td>
</tr>
<tr>
<td>i) Open Ground Storey Height</td>
<td>4.00 m</td>
<td></td>
</tr>
</tbody>
</table>
(Continuous……..)

<table>
<thead>
<tr>
<th>Table 5 Axial Force Ratios</th>
</tr>
</thead>
<tbody>
<tr>
<td>SR.NO.</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
<tr>
<td>6</td>
</tr>
<tr>
<td>7</td>
</tr>
<tr>
<td>8</td>
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<tr>
<td>9</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>11</td>
</tr>
<tr>
<td>12</td>
</tr>
<tr>
<td>13</td>
</tr>
</tbody>
</table>

7 Results

For various forces acting on bottom storey column cross section as shown in Fig.4 under various load combinations for R1, R2 and R3 are tabulated and graphically represented as below,
### Table 6 Moment Ratio about YY-axis

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>Load Combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>0.9</td>
<td>0.16</td>
<td>1.02</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>0.14</td>
<td>0.14</td>
<td>1.05</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>0.17</td>
<td>0.14</td>
<td>1.05</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>0.34</td>
<td>0.062</td>
<td>0.26</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.06</td>
<td>0.68</td>
<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.22</td>
<td>0.09</td>
<td>0.57</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.63</td>
<td>0.1</td>
<td>0.56</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL-EQy)</td>
<td>1.06</td>
<td>0.58</td>
<td>0.25</td>
</tr>
<tr>
<td>9</td>
<td>0.9DL+1.5EQx</td>
<td>1.83</td>
<td>0.14</td>
<td>0.55</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL-1.5EQx</td>
<td>0.54</td>
<td>0.12</td>
<td>0.05</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL+1.5EQy</td>
<td>0.83</td>
<td>0.5</td>
<td>0.45</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL-1.5EQy</td>
<td>0.83</td>
<td>0.14</td>
<td>0.45</td>
</tr>
</tbody>
</table>

### Table 7 Moment Ratio about XX-axis

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>Load Combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>3.78</td>
<td>0.89</td>
<td>1.48</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>0.23</td>
<td>0.62</td>
<td>0.2</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>1.34</td>
<td>0.67</td>
<td>0.2</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.18</td>
<td>1.03</td>
<td>1.17</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.26</td>
<td>1.06</td>
<td>1.17</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.28</td>
<td>0.64</td>
<td>0.18</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.33</td>
<td>0.67</td>
<td>0.18</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>1.04</td>
<td>0.88</td>
<td>1.01</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>0.46</td>
<td>0.38</td>
<td>0.44</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>1.35</td>
<td>0.54</td>
<td>0.14</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>1.32</td>
<td>0.65</td>
<td>0.16</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>1.23</td>
<td>0.98</td>
<td>1.17</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>1.32</td>
<td>1.01</td>
<td>1.2</td>
</tr>
</tbody>
</table>

Fig.10. Moment ratio about yy-axis

Fig.11. Moment ratio about xx-axis
### Table 8: Axial Force Ratios

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>Load combinations</th>
<th>R1</th>
<th>R1</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>0.9</td>
<td>1.11</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>1.03</td>
<td>1.21</td>
<td>1.18</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>1.19</td>
<td>1.05</td>
<td>1.04</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.45</td>
<td>1.32</td>
<td>1.21</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.45</td>
<td>1.63</td>
<td>1.28</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.48</td>
<td>1.27</td>
<td>1.23</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>0.98</td>
<td>1.06</td>
<td>0.65</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>1.56</td>
<td>1.36</td>
<td>1.37</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>1.17</td>
<td>1.05</td>
<td>1.03</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>1.76</td>
<td>1.4</td>
<td>1.53</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>1.31</td>
<td>1.04</td>
<td>1.2</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>1.8</td>
<td>1.55</td>
<td>1.53</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>1.18</td>
<td>1.01</td>
<td>1.05</td>
</tr>
</tbody>
</table>

### Table 9: Moment Ratio about YY-axis

<table>
<thead>
<tr>
<th>SR. NO.</th>
<th>Load combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>0.85</td>
<td>0.15</td>
<td>1.07</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>0.51</td>
<td>0.06</td>
<td>0.62</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>0.51</td>
<td>0.06</td>
<td>0.71</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.02</td>
<td>0.54</td>
<td>1.27</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.05</td>
<td>0.58</td>
<td>1.61</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.13</td>
<td>1.11</td>
<td>0.63</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.14</td>
<td>1.13</td>
<td>0.71</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>0.99</td>
<td>0.63</td>
<td>0.47</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>1.02</td>
<td>0.55</td>
<td>0.49</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>1.78</td>
<td>0.7</td>
<td>0.64</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>0.65</td>
<td>0.072</td>
<td>0.71</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>0.9</td>
<td>0.54</td>
<td>1.48</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>0.8</td>
<td>0.53</td>
<td>0.97</td>
</tr>
</tbody>
</table>

Fig. 12. Axial force ratio

Fig. 13. Moment ratio about yy-axis
### TABLE 10: MOMENT RATIO ABOUT XX-AXIS

<table>
<thead>
<tr>
<th>SR.NO.</th>
<th>Load combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>2.39</td>
<td>0.1</td>
<td>0.99</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>1.28</td>
<td>0.87</td>
<td>0.22</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>1.36</td>
<td>0.96</td>
<td>0.23</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.145</td>
<td>0.25</td>
<td>1.21</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.45</td>
<td>0.27</td>
<td>1.28</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.36</td>
<td>0.89</td>
<td>0.19</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.37</td>
<td>1</td>
<td>0.21</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>0.56</td>
<td>0.26</td>
<td>0.5</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>0.46</td>
<td>0.26</td>
<td>0.5</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>1.2</td>
<td>0.85</td>
<td>0.2</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>1.42</td>
<td>1.4</td>
<td>0.2</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>1.79</td>
<td>0.43</td>
<td>1.54</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>1.18</td>
<td>0.44</td>
<td>1.08</td>
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</tbody>
</table>

### TABLE 11: AXIAL FORCE RATIOS

<table>
<thead>
<tr>
<th>SR.NO.</th>
<th>Load combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>1.03</td>
<td>1.02</td>
<td>1.03</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>1.03</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>1.03</td>
<td>1.03</td>
<td>1.02</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.04</td>
<td>1.04</td>
<td>1.04</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.01</td>
<td>0.83</td>
<td>1.03</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.06</td>
<td>1.06</td>
<td>1.05</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.06</td>
<td>1.06</td>
<td>0.54</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>1.07</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>1.03</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>1.06</td>
<td>1.06</td>
<td>1.04</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>1.05</td>
<td>1.06</td>
<td>1.05</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>1.08</td>
<td>1.07</td>
<td>1.06</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>1.01</td>
<td>1.06</td>
<td>1.07</td>
</tr>
</tbody>
</table>

**Fig. 14.** Moment ratio about xx-axis

**Fig. 15.** Axial force ratio
TABLE 12 MOMENT RATIO ABOUT YY-AXIS

<table>
<thead>
<tr>
<th>SR.NO.</th>
<th>Load combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>1.04</td>
<td>0.62</td>
<td>0.62</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>0.47</td>
<td>0.03</td>
<td>0.002</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>0.47</td>
<td>0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.03</td>
<td>0.54</td>
<td>0.25</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.08</td>
<td>0.57</td>
<td>0.25</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.08</td>
<td>0.07</td>
<td>0.004</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.08</td>
<td>0.07</td>
<td>0.16</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>1.04</td>
<td>0.54</td>
<td>0.25</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>1.08</td>
<td>0.57</td>
<td>0.25</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>0.53</td>
<td>0.04</td>
<td>0.01</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>0.53</td>
<td>0.034</td>
<td>1.03</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>0.84</td>
<td>0.44</td>
<td>0.27</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>0.86</td>
<td>0.46</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Fig.16. Moment ratio about yy-axis

TABLE 13 MOMENT RATIO ABOUT XX-AXIS

<table>
<thead>
<tr>
<th>SR.NO.</th>
<th>Load combinations</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.5(DL+LL)</td>
<td>1.48</td>
<td>1.32</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>1.2(DL+LL+EQx)</td>
<td>1.3</td>
<td>0.54</td>
<td>0.31</td>
</tr>
<tr>
<td>3</td>
<td>1.2(DL+LL-EQx)</td>
<td>1.38</td>
<td>0.6</td>
<td>0.31</td>
</tr>
<tr>
<td>4</td>
<td>1.2(DL+LL+EQy)</td>
<td>1.05</td>
<td>1.04</td>
<td>1.05</td>
</tr>
<tr>
<td>5</td>
<td>1.2(DL+LL-EQy)</td>
<td>1.01</td>
<td>0.8</td>
<td>1.03</td>
</tr>
<tr>
<td>6</td>
<td>1.5(DL+EQx)</td>
<td>1.31</td>
<td>0.55</td>
<td>0.23</td>
</tr>
<tr>
<td>7</td>
<td>1.5(DL-EQx)</td>
<td>1.37</td>
<td>0.59</td>
<td>0.2</td>
</tr>
<tr>
<td>8</td>
<td>1.5(DL+EQy)</td>
<td>1.07</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>9</td>
<td>1.5(DL-EQy)</td>
<td>1.07</td>
<td>1.06</td>
<td>1.06</td>
</tr>
<tr>
<td>10</td>
<td>0.9DL+1.5EQx</td>
<td>1.57</td>
<td>0.56</td>
<td>0.22</td>
</tr>
<tr>
<td>11</td>
<td>0.9DL-1.5EQx</td>
<td>1.36</td>
<td>0.58</td>
<td>0.17</td>
</tr>
<tr>
<td>12</td>
<td>0.9DL+1.5EQy</td>
<td>1.08</td>
<td>1.07</td>
<td>0.13</td>
</tr>
<tr>
<td>13</td>
<td>0.9DL-1.5EQy</td>
<td>1.01</td>
<td>1.06</td>
<td>1.08</td>
</tr>
</tbody>
</table>

Fig.17. Moment ratio about xx-axis
7.2 The Magnification factors for Soft Storey Beams

7.2.1 Shear Force

**TABLE 12 SHEAR FORCE RATIOS OF OPEN GROUND STOREY BEAMS**

<table>
<thead>
<tr>
<th>Group I</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>G - I</td>
<td>1.058</td>
<td>0.721</td>
<td>4.4</td>
</tr>
<tr>
<td>G - II</td>
<td>0.92</td>
<td>0.7</td>
<td>4.07</td>
</tr>
<tr>
<td>G - III</td>
<td>1.065</td>
<td>0.78</td>
<td>3.41</td>
</tr>
<tr>
<td>G - IV</td>
<td>1.054</td>
<td>0.78</td>
<td>4.07</td>
</tr>
</tbody>
</table>

7.2.2 Moments

**TABLE 11 MOMENT RATIOS OF OPEN GROUND STOREY BEAMS**

<table>
<thead>
<tr>
<th>Group I</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
</tr>
</thead>
<tbody>
<tr>
<td>G - I</td>
<td>1.09</td>
<td>0.58</td>
<td>1.09</td>
</tr>
<tr>
<td>G - II</td>
<td>0.88</td>
<td>0.57</td>
<td>0.88</td>
</tr>
<tr>
<td>G - III</td>
<td>1.094</td>
<td>0.64</td>
<td>1.42</td>
</tr>
<tr>
<td>G - IV</td>
<td>1.09</td>
<td>0.65</td>
<td>0.69</td>
</tr>
</tbody>
</table>

7.3 Storey Base Shear and Displacement

7.3.1 Base Shear

**TABLE 13 BASE SHEARS OF DIFFERENT MODELS**

<table>
<thead>
<tr>
<th>Direction</th>
<th>Bare</th>
<th>Infill</th>
<th>Infill + Tie</th>
<th>Infill + Bracing</th>
</tr>
</thead>
<tbody>
<tr>
<td>EQX</td>
<td>1295.6</td>
<td>2477.18</td>
<td>2512.85</td>
<td>2502.98</td>
</tr>
<tr>
<td>EQY</td>
<td>1295.6</td>
<td>1804.19</td>
<td>1845.09</td>
<td>1809.85</td>
</tr>
</tbody>
</table>

7.3.2 Displacement

7.3.2.1 X-Direction

**TABLE 14 DISPLACEMENTS IN X-DIRECTION OF DIFFERENT MODELS**

<table>
<thead>
<tr>
<th>Storey</th>
<th>Bare</th>
<th>Infill</th>
<th>Infill + Tie</th>
<th>Infill + Bracing</th>
</tr>
</thead>
<tbody>
<tr>
<td>S - 1</td>
<td>4.4</td>
<td>5.4</td>
<td>2.36</td>
<td>1.49</td>
</tr>
<tr>
<td>S - 2</td>
<td>9.64</td>
<td>10.5</td>
<td>4.7</td>
<td>5.32</td>
</tr>
</tbody>
</table>
### 8 Results and Discussion

The results of the present study show that peripheral masonry infill wall along with tie beam and RCC X-bracing has very important effect on structural behavior under seismic forces.

8.1 For bottom storey columns the following Magnification Factor has been investigated for various load combinations and is discussed below.

8.1.1 From above analysis of group I column following points are observed.

- **R1** Max. Axial force Ratio is 1.65 for comb. 1.5(DL+LL), max. Moment Ratio about y-axis is 1.83 for comb. 0.9DL-1.5EQx and max. Moment Ratio about x-axis is 3.78 for comb. 1.5(DL+LL).
- **R2** Max. Axial force Ratio is 1.36 for comb. 1.5(DL+EQy), max. Moment Ratio about y-axis is 0.68 for comb. 1.5(DL+EQx) and max. Moment Ratio about x-axis 1.06 for comb. 1.5(DL+EQx).
- **R3** Max. Axial force Ratio is 1.47 for comb. 1.5(DL+LL), max. Moment Ratio about y-axis is 1.05 for comb. 1.2(DL+LL-EQx) and 1.2(DL+LL-EQy) and max. Moment Ratio about x-axis 1.48 for comb. 1.5(DL+LL).

8.1.2 From above analysis of group II columns following points are observed.

- **R1** Max. Axial force Ratio is 1.8 for comb. 0.9DL+1.5EQy, max. Moment Ratio about y-axis is 1.78 for comb. 0.9DL+1.5EQx and max. Moment Ratio about x-axis is 2.39 for comb. 1.5(DL+LL).
R2) Max. Axial force Ratio is 1.63 for comb. 1.2(DL+LL-EQy), max. Moment Ratio about y-axis is 1.13 for comb. 1.5(DL-EQx) and max. Moment Ratio about x-axis 1.4 for comb. 0.9DL-1.5EQx.

R3) Max. Axial force Ratio is 1.53 for comb. 0.9DL+1.5EQx and comb. 0.9DL+1.5EQy, max. Moment Ratio about y-axis is 1.61 for comb. 1.2(DL+LL-EQy) and max. Moment Ratio about x-axis 1.54 for comb. 0.9DL+1.5EQy.

8.1.3 From above analysis of group III columns following points are observed.

R1) Max. Axial force Ratio is 1.08 for comb. 0.9DL+1.5EQy, max. Moment Ratio about y-axis is 1.08 for comb.1.5 (DL-EQx), comb.1.5 (DL-EQy), comb. 1.5(DL+EQy) and comb.0.9DL+1.5EQx and max. Moment Ratio about x-axis for comb.1.5 (DL+LL).

R2) Max. Axial force Ratio is 1.07 for comb. 0.9DL+1.5EQy, max. Moment Ratio about y-axis is 0.62 for comb. 1.5(DL+LL) and max. Moment Ratio about x-axis 1.32 for comb. 1.5(DL+LL).

R3) Max. Axial force Ratio is 1.07 for comb. 0.9DL-1.5EQy, max. Moment Ratio about y-axis is 1.03 for comb.0.9DL-1.5EQx and max. Moment Ratio about x-axis 1.08 for comb. 0.9DL-1.5EQy.

8.2 The magnification factor of beams adjacent to RCC X-bracings gets increased for shear force.

9 Conclusions

As per IS 1893-2002 (Part I) clause 7.8.2, the Magnification factor 2.5 is a very conservative factor for design purpose of all columns and beams, especially for low rise building and even it is conservative for high rise building.

From above investigation done on this Magnification factor 2.5 considering different load combinations, some modified values other than 2.5 are as follows. For columns, grouping is done according to their location mentioned above and respective values are as follows.

1) When the Peripheral masonry infill wall is provided in soft storey, the Magnification factor for corner columns 3.7, for peripheral column 2.30 and for central column 1.85.

2) When the Peripheral masonry infill wall along with Tie beam is provided in soft storey, the Magnification factor for corner columns 1.36, for peripheral column 1.63 and for central column 1.32.

3) When the Peripheral masonry infill wall along with RCC X-bracing is to be provided in soft storey, the Magnification factor for corner columns 1.48, for peripheral column 1.60 and for central column 1.10.

4) When the Peripheral masonry infill wall along with Tie beam is provided in soft storey, the Magnification Factor for beams is less compared to frames without tie-beams.

5) When masonry infill wall along with tie-beam is provided in soft storey, the base shear value is more in both directions compared to frames without tie-beams.

6) Displacement in both directions is minimized when masonry infill along with tie-beam is provided compared to frames without tie-beams.

REFERENCES


1Assosiat Professor, Department of Civil Engineering
Nagesh Karajagi Orchid College of Engineering and Technology, Solapur-413002, Maharashtra, India.

2UG Student, Department of Civil Engineering
Nagesh Karajagi Orchid College of Engineering and Technology, Solapur-413002, Maharashtra, India.