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# Influence of Plan Dimensions, Seismic Zone, Infill on the Behavior of I-Shaped Reinforced Concrete Buildings

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***Abstract**: Recently it has become mandatory to design all the civil engineering structures including building frames for the earthquake effects in addition to dead load, live load and wind load effects. The present work deals with the determination of storey drifts and force response of 20-storeyed reinforced concrete I-shaped buildings located in different seismic zones using ETABS 2013 Ultimate 13.2.2. The effects of plan dimensions, severity of seismic zone, infill walls on the storey drifts and force response have been evaluated. It is observed that the absolute maximum storey drift occurs in Zone V and that the effect of presence of infill walls in the analysis is to reduce the storey drifts. The influence of infill wall on the moments in transfer girders and main beams is not insignificant. Both the design ultimate positive and negative moments in transfer girders and main beams decrease in magnitude when the effect of infill wall is considered in the analysis.The response spectrum method predicts lower maximum storey drift in x-direction compared to the equivalent static lateral force method in all the cases when infill is not accounted in the analysis. The response spectrum method predicts slightly higher maximum storey drift in x-direction compared to the equivalent static lateral force method in all cases when infill is accounted in the analysis. The response spectrum method predicts lower maximum storey drift in y-direction compared to the equivalent static lateral force method in all the cases.*
***Keywords:** reinforced concrete buildings; storey drift; force response; infill wall; seismic zone.*

## I. Introduction

Building Codes specify that the effects due to earthquake load be considered in addition to those due to dead, live load and wind loads. A vast literature on dynamic analysis exists and a few of them are briefly mentioned here. Wakchaure M R and Ped S P [1] studied the effects of infill in high rise buildings. The infill walls were modeled as equivalent single strut by using the FEMA-356 approach. Mohammed Yousuf and P M Shimpale [2] carried out dynamic analysis for G+5 storied buildings located in seismic zone IV. They considered a rectangular symmetrical, C-shape, L-shape and irregular L unsymmetrical buildings for the analysis. The analysis was carried out by using the ETABS 9.5 software. Amin Alavi and P Srinivasa Rao [3] studied the behavior of the 5-storied buildings located in seismic zone V. The buildings consisted of eight different configurations with re-entrant corners. Himanshu Gaur et al. [4] analyzed the horizontally irregular buildings for their stability using STAAD.Pro software. They considered the 20-storeyed buildings of different shapes like L, U and H-shape for the analysis, each shape having different lateral length ratios. M G Shaikh and Hashmi S Shakeeb [5] investigated the seismic performance of L-shaped building with varying bay length and storey height. The buildings were modeled using STAAD.Pro V8i software. The results obtained for infill and without infill building models were compared. Ravikumar C M et al. [6] studied the seismic performance of the buildings which are having irregularities in plan with geometric and diaphragm continuity, re-entrant corners, vertical irregularity with setback and also buildings resting on sloping ground. S Mahesh and Dr P B Panduranga Rao [7] studied the behavior of the G+11 storied building of regular and irregular configurations subjected to earthquake and wind load using ETABS and STAAD.Pro V8i software. B Srikanth and V Ramesh [8] studied the earthquake response of a 20-storeyed building by seismic coefficient and Response spectrum methods. Pravin Ashok Shirule and Bharti V Mahajan [9] conducted the parametric studies on G+13 storeyed RC frame building with asymmetric column distribution with and without shear wall by using response spectrum method of analysis. A E Hassaballa et al. [10] carried out the seismic analysis of a multi-storied RC frame building situated in Khartoum city using STAAD.Pro software. Critical damping of 5% was considered in response spectrum method of analysis. Ramesh Konakalla et al. [11] studied the response of the 20-storeyed building by linear static analysis using STAAD.Pro software. One regular symmetric model and three vertical irregular models were considered in the analysis. S.S. Patil et al. [12] carried out the response spectrum analysis for G+14 storeyed building situated in the seismic zone IV using STAAD.Pro software. The buildings were modeled as RC bare frame, bare frame with bracing and bare frame with shear wall in the analysis. Bracing and shear walls were located at different locations and directions in the building. Haroon Rasheed Tamboli and Umesh.N.karadi [13] performed the seismic analysis on ten storey buildings considering three cases i) bare frame ii) infill frame iii) infill with ground soft storey and using ETABS software. Seismic zone III and 5% damping was considered in the analysis. Infill was modeled as an equivalent diagonal strut in the analysis. Mohit Sharma and Savitha Maru [14] carried out static and dynamic analyses on G+30 storeyed regular building using STAAD.Pro software. Seismic zones II and III and medium soil type were considered in the analysis. P.B Prajapathi and Prof.Mayur G. Vanza [15] analysed 10 storeyed RCC residential buildings with different plan configurations and studied the influence of plan irregularity on the building. Static and dynamic analyses were carried out using SAP software. For dynamic analysis, response spectrum method and time history methods were used. Md Irfanullah and Vishwanath. B. Patil [16] studied the behavior of the building when subjected to seismic loading with various arrangements of infill. The building was having five bays in both X and Y directions and situated in seismic zone IV. Models considered for the analysis were i) Bare frame ii) full infill frame iii) infill in all floor except below plinth iv) infill with first floor as soft storey v) Infill with soft storey at first floor and basement vi) Infill with soft storey at first and basement and infill provided in swastika pattern in ground floor. Equivalent static analysis was carried out by using ETABS 9.6 software.

# II. Present Work

### 2.1 Details of Buildings, Loads and Load Combinations Considered

I-shaped Reinforced Concrete Buildings of 20 storeys having soft storey, floating columns and transfer girders with and without infill are analyzed for all loading combinations specified by IS Codes using ETABS software. The effects of the following parameters: 1) $L_1/L_2$ ratio ($L_1$ and $L_2$ are defined later), 2) Location of building and the corresponding seismic zone, 3) Infill walls or No infill walls on (a) storey drifts and (b) maximum ultimate forces and moments in the main beams and transfer girders are evaluated by performing the stiffness analysis using ETABS Version 2013 Ultimate 13.2.2 software. In the present work, I-shaped reinforced concrete buildings having a foundation depth of 2.0 m below existing ground level, plinth height = 0.5 m and 20 storeys each of 3 m height located in seismic zones II, III, IV and V (Infill and No infill) are considered. In all the cases the first storey (ground floor) is a soft storey. The floating columns start from the top of the 15th floor and extend up to the roof. These are marked as FC in Fig. 1. The other columns shown in Fig. 1 extend up to the roof starting from footing top (regular columns). The floating columns are supported by transfer girders (marked as TB1 and TB2) spanning between regular columns. The dimensions $L_1$ and $L_2$ are as defined in Fig. 1. The sizes of the beams and columns are given in Table 1. All the slabs including the roof are of 150 mm thickness. M50 grade concrete is used for all slabs, beams and columns.

**Table 1: Sizes of beams and columns in I-shaped buildings**

| Member | Size |
|---|---|
| Regular Columns | a) footing top to 15th floor slab<br>800 x 800 mm, 1000 x 1000 mm<br>b) 15th floor slab to roof slab<br>300 x 750 mm |
| Floating Columns | 300 x 750 mm |
| Stub Columns up to plinth level | 300 x 300 mm |
| Plinth Beams connecting stub and other columns | 300 x 450 mm |
| Main Beam<br>(a) 12 m span (up to 15th floor)<br>(b) 9m span (up to 15th floor )<br>(c) 6m span (up to 15th floor )<br>(d) 4 m span (16th floor to roof) | <br>300 x 1200 mm<br>300 x 900 mm<br>300 x 900 mm<br>300 x 450 mm |
| Secondary Beam<br>(a) 12 m span<br>(b) 4 m span | <br>300 x 750 mm<br>300 x 450 mm |
| Transfer Girder<br>TB1<br>TB2 | 800 x 800 mm<br>1000 x 1000 mm |

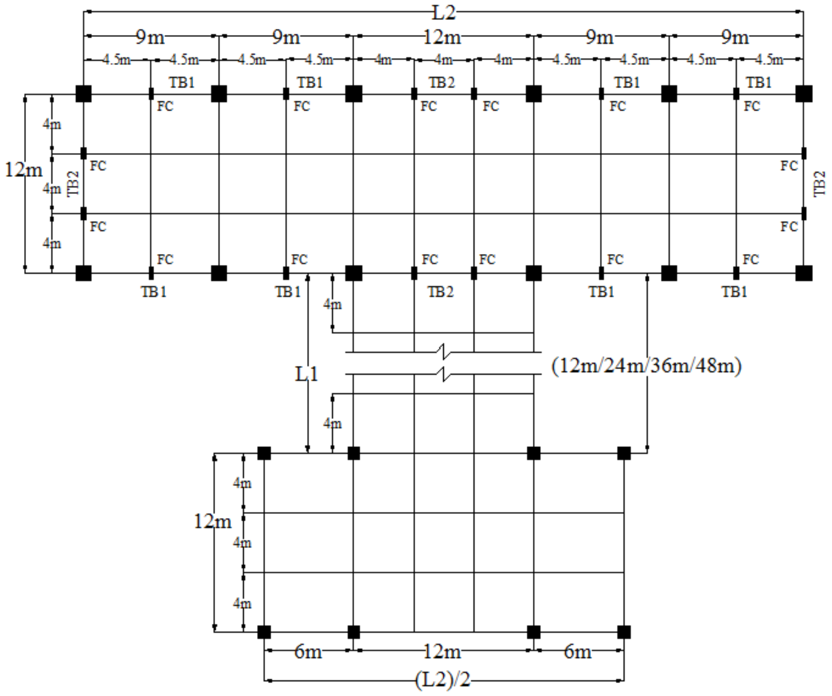


**Fig.1:** Plan of I-shaped building at 15th floor level

The live loads considered are 3.5 kN/m$^2$ for floors and 1.5 kN/m$^2$ for roof. The floor finish is assumed as 1.0 kN/m$^2$. The roof finish is taken as 2.0kN/m$^2$. 300 mm thick masonry walls are provided on the beams at all floor levels along the periphery of the building. 150 mm thick parapet walls are provided along the periphery of the building at the roof level. In addition to the dead and live loads, wind and seismic loads corresponding to the chosen four locations Vishakhapatnam, Vijayawada, Delhi and Darbhanga are considered. Load combinations are made in accordance with IS: 456, IS: 875 and IS: 1893. Stiffness analysis of frames is performed using ETABS Version 2013 Ultimate 13.2.2. The load combinations used for the limit state of collapse are shown in Table 2.

**Table 2: Load combinations for the limit state of collapse**

| Sl. No. | Load combination | Sl. No. | Load combination |
|---|---|---|---|
| 1 | 1.5 ( DL + LL ) | 20 | 1.5 ( DL + $WL_Y$ ) |
| 2 | 1.2 ( DL + LL + $EQ_X$ ) | 21 | 1.5 ( DL - $WL_Y$ ) |
| 3 | 1.2 ( DL + LL - $EQ_X$ ) | 22 | 0.9 DL + 1.5 $WL_X$ |
| 4 | 1.2 ( DL + LL + $EQ_Y$ ) | 23 | 0.9 DL - 1.5 $WL_X$ |
| 5 | 1.2 ( DL + LL - $EQ_Y$ ) | 24 | 0.9 DL + 1.5 $WL_Y$ |
| 6 | 1.5 ( DL + $EQ_X$ ) | 25 | 0.9 DL - 1.5 $WL_Y$ |
| 7 | 1.5 ( DL - $EQ_X$ ) | 26 | 1.2 ( DL + LL + $SPEC_X$ ) |
| 8 | 1.5( DL + $EQ_Y$ ) | 27 | 1.2 ( DL + LL - $SPEC_X$ ) |
| 9 | 1.5 ( DL - $EQ_Y$ ) | 28 | 1.2 ( DL + LL + $SPEC_Y$ ) |
| 10 | 0.9 DL + 1.5 $EQ_X$ | 29 | 1.2 ( DL + LL - $SPEC_Y$ ) |
| 11 | 0.9 DL - 1.5 $EQ_X$ | 30 | 1.5 ( DL + $SPEC_X$ ) |
| 12 | 0.9 DL + 1.5 $EQ_Y$ | 31 | 1.5 ( DL - $SPEC_X$ ) |
| 13 | 0.9 DL - 1.5 $EQ_Y$ | 32 | 1.5 ( DL + $SPEC_Y$ ) |
| 14 | 1.2 ( DL + LL + $WL_X$ ) | 33 | 1.5 ( DL - $SPEC_Y$ ) |
| 15 | 1.2 ( DL + LL - $WL_X$ ) | 34 | 0.9 DL + 1.5 $SPEC_X$ |
| 16 | 1.2 ( DL + LL + $WL_Y$ ) | 35 | 0.9 DL - 1.5 $SPEC_X$ |
| 17 | 1.2 ( DL + LL - $WL_Y$ ) | 36 | 0.9 DL + 1.5 $SPEC_Y$ |
| 18 | 1.5 ( DL + $WL_X$ ) | 37 | 0.9 DL - 1.5 $SPEC_Y$ |
| 19 | 1.5 ( DL - $WL_X$ ) | | |

The load combinations used for the serviceability limit state are shown in Table 3.

**Table 3: Load combinations for the limit state of serviceability**

| Sl.No. | Load combination | Sl.No. | Load combination |
|---|---|---|---|
| 1 | DL + LL | 14 | DL + 0.8 LL + 0.8 $WL_X$ |
| 2 | DL + $EQ_X$ | 15 | DL + 0.8 LL - 0.8 $WL_X$ |
| 3 | DL - $EQ_X$ | 16 | DL + 0.8 LL + 0.8 $WL_Y$ |
| 4 | DL + $EQ_Y$ | 17 | DL + 0.8 LL - 0.8 $WL_Y$ |
| 5 | DL - $EQ_Y$ | 18 | DL + $SPEC_X$ |
| 6 | DL + 0.8 LL + 0.8 $EQ_X$ | 19 | DL - $SPEC_X$ |
| 7 | DL + 0.8 LL - 0.8 $EQ_X$ | 20 | DL + $SPEC_Y$ |
| 8 | DL + 0.8 LL + 0.8 $EQ_Y$ | 21 | DL - $SPEC_Y$ |
| 9 | DL + 0.8 LL - 0.8 $EQ_Y$ | 22 | DL + 0.8 LL + 0.8 $SPEC_X$ |
| 10 | DL + $WL_X$ | 23 | DL + 0.8 LL - 0.8 $SPEC_X$ |
| 11 | DL - $WL_X$ | 24 | DL + 0.8 LL + 0.8 $SPEC_Y$ |
| 12 | DL + $WL_Y$ | 25 | DL + 0.8 LL - 0.8 $SPEC_Y$ |
| 13 | DL - $WL_Y$ | | |

The effect due to seismic loading is evaluated using (i) Equivalent Static Lateral Force Method and (ii) Response Spectrum Method separately. The more critical value obtained from these two methods is considered in the design. The effect of the infill wall is accounted in the analysis by treating it as a diagonal strut in accordance with the recommendations of FEMA 356.

### 2.2 Storey Drifts

#### (a) Design Storey Drifts in X-Direction (No Infill)

The design storey drifts in x-direction for I-shaped buildings with no infill are given in Table 4 for various values of $L_1/L_2$ratio and zones II and III and in Table 5 for various values of $L_1/L_2$ratio and zones IV and V. Each storey drift entry in the table represents the maximum value obtained by considering all load combinations specified by the relevant IS Codes (called design storey drift).

**Table 4: Values of design storey drift in m**

| WL/EL in X-direction; No Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE II | | | | ZONE III | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00017 | 0.00017 | 0.00017 | 0.00017 | 0.00028 | 0.00028 | 0.00028 | 0.00028 |
| 19 | 0.00031 | 0.00032 | 0.00032 | 0.00032 | 0.0005 | 0.0005 | 0.00051 | 0.00051 |
| 18 | 0.00042 | 0.00043 | 0.00044 | 0.00045 | 0.00068 | 0.00069 | 0.0007 | 0.00072 |
| 17 | 0.00053 | 0.00054 | 0.00055 | 0.00056 | 0.00084 | 0.00086 | 0.00087 | 0.00089 |
| 16 | 0.00045 | 0.00046 | 0.00047 | 0.00048 | 0.00073 | 0.00074 | 0.00076 | 0.00077 |
| 15 | 0.00017 | 0.00018 | 0.00021 | 0.00024 | 0.00027 | 0.00028 | 0.00029 | 0.0003 |
| 14 | 0.00022 | 0.00024 | 0.00028 | 0.00031 | 0.00035 | 0.00037 | 0.00038 | 0.00039 |
| 13 | 0.00027 | 0.00031 | 0.00036 | 0.0004 | 0.0004 | 0.00043 | 0.00044 | 0.00046 |
| 12 | 0.00032 | 0.00038 | 0.00044 | 0.00049 | 0.00044 | 0.00047 | 0.00049 | 0.0005 |
| 11 | 0.00037 | 0.00044 | 0.00052 | 0.00058 | 0.00047 | 0.0005 | 0.00052 | 0.00058 |
| 10 | 0.00042 | 0.00051 | 0.00059 | 0.00066 | 0.00049 | 0.00053 | 0.00059 | 0.00066 |
| 9 | 0.00047 | 0.00057 | 0.00066 | 0.00074 | 0.00051 | 0.00057 | 0.00066 | 0.00074 |
| 8 | 0.00052 | 0.00063 | 0.00073 | 0.00082 | 0.00053 | 0.00063 | 0.00073 | 0.00082 |
| 7 | 0.00056 | 0.00069 | 0.00080 | 0.0009 | 0.00056 | 0.00069 | 0.0008 | 0.0009 |
| 6 | 0.0006 | 0.00074 | 0.00086 | 0.00097 | 0.0006 | 0.00074 | 0.00086 | 0.00097 |
| 5 | 0.00064 | 0.00079 | 0.00092 | 0.00104 | 0.00064 | 0.00079 | 0.00092 | 0.00104 |
| 4 | 0.00068 | 0.00084 | 0.00098 | 0.0011 | 0.00068 | 0.00084 | 0.00098 | 0.0011 |
| 3 | 0.00071 | 0.00089 | 0.00104 | 0.00116 | 0.00071 | 0.00089 | 0.00104 | 0.00116 |
| 2 | 0.00074 | 0.00093 | 0.00110 | 0.00124 | 0.00074 | 0.00093 | 0.0011 | 0.00124 |
| 1 | 0.00075 | 0.00098 | 0.00119 | 0.00136 | 0.00075 | 0.00098 | 0.00119 | 0.00136 |
| PLINTH | 0.00043 | 0.00056 | 0.00068 | 0.00078 | 0.00043 | 0.00056 | 0.00068 | 0.00078 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 4 for I-Shaped Buildings in Zone II (No Infill):

- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.2.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ ratio =1.0, the value is 1.36 mm.
- The following observations are made from Table 4 for I-Shaped Buildings in Zone III (No Infill):
- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.2.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ ratio =1.0, the value is 1.36 mm.

**Table 5: Values of design storey drift in m**

| WL/EL in X-direction; No Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE IV | | | | ZONE V | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00041 | 0.00041 | 0.00041 | 0.00042 | 0.00062 | 0.00062 | 0.00062 | 0.00062 |
| 19 | 0.00075 | 0.00076 | 0.00076 | 0.00077 | 0.00113 | 0.00113 | 0.00114 | 0.00115 |
| 18 | 0.00102 | 0.00103 | 0.00105 | 0.00107 | 0.00153 | 0.00155 | 0.00158 | 0.00161 |
| 17 | 0.00126 | 0.00129 | 0.00131 | 0.00133 | 0.00189 | 0.00193 | 0.00197 | 0.00200 |
| 16 | 0.00109 | 0.00111 | 0.00114 | 0.00116 | 0.00163 | 0.00167 | 0.0017 | 0.00174 |
| 15 | 0.0004 | 0.00042 | 0.00044 | 0.00045 | 0.0006 | 0.00063 | 0.00066 | 0.00067 |
| 14 | 0.00052 | 0.00055 | 0.00058 | 0.00059 | 0.00078 | 0.00083 | 0.00086 | 0.00088 |
| 13 | 0.0006 | 0.00064 | 0.00067 | 0.00068 | 0.0009 | 0.00096 | 0.001 | 0.00103 |
| 12 | 0.00066 | 0.0007 | 0.00073 | 0.00075 | 0.00099 | 0.00105 | 0.0011 | 0.00113 |
| 11 | 0.00071 | 0.00075 | 0.00078 | 0.00081 | 0.00106 | 0.00113 | 0.00118 | 0.00121 |
| 10 | 0.00074 | 0.00079 | 0.00082 | 0.00085 | 0.00111 | 0.00119 | 0.00124 | 0.00127 |
| 9 | 0.00077 | 0.00082 | 0.00086 | 0.00088 | 0.00115 | 0.00123 | 0.00128 | 0.00132 |
| 8 | 0.00079 | 0.00084 | 0.00088 | 0.00091 | 0.00119 | 0.00127 | 0.00132 | 0.00136 |
| 7 | 0.00081 | 0.00086 | 0.0009 | 0.00093 | 0.00121 | 0.00129 | 0.00135 | 0.00139 |
| 6 | 0.00082 | 0.00087 | 0.00091 | 0.00094 | 0.00123 | 0.00131 | 0.00137 | 0.00141 |
| 5 | 0.00082 | 0.00088 | 0.00092 | 0.00095 | 0.00123 | 0.00132 | 0.00138 | 0.00142 |
| 4 | 0.00082 | 0.00088 | 0.00092 | 0.00097 | 0.00123 | 0.00131 | 0.00137 | 0.00141 |
| 3 | 0.00081 | 0.00086 | 0.00092 | 0.00103 | 0.00121 | 0.00129 | 0.00135 | 0.00141 |
| 2 | 0.00079 | 0.00084 | 0.00097 | 0.00109 | 0.00118 | 0.00125 | 0.00133 | 0.0015 |
| 1 | 0.00072 | 0.00087 | 0.00105 | 0.0012 | 0.00107 | 0.00119 | 0.00143 | 0.00164 |
| PLINTH | 0.00038 | 0.0005 | 0.0006 | 0.00069 | 0.00055 | 0.00068 | 0.00082 | 0.00094 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 5 for I-Shaped Buildings in Zone IV (No Infill):

- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.18.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ ratio =1.0, the value is 1.33 mm.
- The following observations are made from Table 5 for I-Shaped Buildings in Zone V (No Infill):
- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.18.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ ratio =1.0, the value is 2.0 mm.

**(b) Storey Drifts in Y-Direction (No Infill)**

The design storey drifts in y-direction for I-shaped buildings with no infill are given in Table 6 for various values of $L_1/L_2$ ratio and zones II and III and in Table 7 for various values of $L_1/L_2$ ratio and zones IV and V. Each storey drift entry in the table represents the maximum value obtained by considering all load combinations specified by the relevant IS Codes.

**Table 6: Values of design storey drift in m**

| WL/EL in Y-direction; No Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE II | | | | ZONE III | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.0005 | 0.00048 | 0.00047 | 0.00046 | 0.0005 | 0.00048 | 0.00047 | 0.00046 |
| 19 | 0.00067 | 0.00066 | 0.00064 | 0.00064 | 0.00067 | 0.00066 | 0.00064 | 0.00064 |
| 18 | 0.00086 | 0.00084 | 0.00082 | 0.00081 | 0.00086 | 0.00084 | 0.00082 | 0.00081 |
| 17 | 0.00098 | 0.00096 | 0.00094 | 0.00092 | 0.00098 | 0.00096 | 0.00094 | 0.00092 |
| 16 | 0.00091 | 0.00085 | 0.00081 | 0.00078 | 0.00091 | 0.00085 | 0.00081 | 0.00078 |
| 15 | 0.00078 | 0.00064 | 0.00054 | 0.00046 | 0.00078 | 0.00064 | 0.00054 | 0.00046 |
| 14 | 0.00089 | 0.00071 | 0.0006 | 0.00051 | 0.00089 | 0.00071 | 0.0006 | 0.00051 |
| 13 | 0.00099 | 0.00079 | 0.00066 | 0.00056 | 0.00099 | 0.00079 | 0.00066 | 0.00056 |
| 12 | 0.00108 | 0.00086 | 0.00072 | 0.00062 | 0.00108 | 0.00086 | 0.00072 | 0.00062 |
| 11 | 0.00116 | 0.00093 | 0.00078 | 0.00067 | 0.00116 | 0.00093 | 0.00078 | 0.00067 |
| 10 | 0.00125 | 0.001 | 0.00084 | 0.00072 | 0.00125 | 0.001 | 0.00084 | 0.00072 |
| 9 | 0.00133 | 0.00107 | 0.00089 | 0.00077 | 0.00133 | 0.00107 | 0.00089 | 0.00077 |
| 8 | 0.0014 | 0.00113 | 0.00095 | 0.00082 | 0.0014 | 0.00113 | 0.00095 | 0.00082 |
| 7 | 0.00147 | 0.00119 | 0.001 | 0.00086 | 0.00147 | 0.00119 | 0.001 | 0.00086 |
| 6 | 0.00154 | 0.00125 | 0.00105 | 0.00091 | 0.00154 | 0.00125 | 0.00105 | 0.00091 |
| 5 | 0.00159 | 0.0013 | 0.00109 | 0.00095 | 0.00159 | 0.0013 | 0.00109 | 0.00095 |
| 4 | 0.00163 | 0.00134 | 0.00113 | 0.00098 | 0.00163 | 0.00134 | 0.00113 | 0.00098 |
| 3 | 0.00163 | 0.00135 | 0.00115 | 0.00100 | 0.00163 | 0.00135 | 0.00115 | 0.00100 |
| 2 | 0.00156 | 0.00132 | 0.00114 | 0.001 | 0.00156 | 0.00132 | 0.00114 | 0.001 |
| 1 | 0.00138 | 0.00121 | 0.00108 | 0.00097 | 0.00138 | 0.00121 | 0.00108 | 0.00097 |
| PLINTH | 0.00066 | 0.00059 | 0.00053 | 0.00048 | 0.00066 | 0.00059 | 0.00053 | 0.00048 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 6 for I-Shaped Buildings in Zone II (No Infill):

- For $L_1/L_2$ ratio = 0.25, maximum design storey drift occurs at floor no. 4 and 5.
- For $L_1/L_2$ ratio =0.5, 0.75 and 1.0, maximum design storey drift occurs at floor no.4.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.63 mm.

The following observations are made from Table 6 for I-Shaped Buildings in Zone III (No Infill):

- For $L_1/L_2$ ratio = 0.25, maximum design storey drift occurs at floor no. 4 and 5.
- For $L_1/L_2$ ratio =0.5, 0.75 and 1.0, maximum design storey drift occurs at floor no.4.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.63 mm.

**Table 7: Values of design storey drift in m**

| WL/EL in Y-direction; No Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE IV | | | | ZONE V | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00045 | 0.00044 | 0.00043 | 0.00044 | 0.00058 | 0.00057 | 0.00059 | 0.00062 |
| 19 | 0.0006 | 0.00059 | 0.00058 | 0.0006 | 0.00079 | 0.00079 | 0.00083 | 0.00086 |
| 18 | 0.00077 | 0.00075 | 0.00074 | 0.00075 | 0.00102 | 0.001 | 0.00104 | 0.00108 |
| 17 | 0.00088 | 0.00085 | 0.00084 | 0.00083 | 0.00118 | 0.00114 | 0.00117 | 0.00121 |
| 16 | 0.00081 | 0.00076 | 0.00072 | 0.0007 | 0.0011 | 0.00103 | 0.00102 | 0.00104 |
| 15 | 0.0007 | 0.00057 | 0.00049 | 0.00045 | 0.00094 | 0.00077 | 0.00071 | 0.00067 |
| 14 | 0.00079 | 0.00064 | 0.00056 | 0.00052 | 0.00107 | 0.00088 | 0.00082 | 0.00077 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 13 | 0.00088 | 0.0007 | 0.00062 | 0.00059 | 0.00119 | 0.00098 | 0.00092 | 0.00087 |
| 12 | 0.00096 | 0.00077 | 0.00068 | 0.00065 | 0.0013 | 0.00107 | 0.001 | 0.00095 |
| 11 | 0.00103 | 0.00083 | 0.00073 | 0.0007 | 0.0014 | 0.00114 | 0.00108 | 0.00103 |
| 10 | 0.00111 | 0.00089 | 0.00077 | 0.00074 | 0.0015 | 0.00121 | 0.00114 | 0.00109 |
| 9 | 0.00118 | 0.00095 | 0.0008 | 0.00077 | 0.0016 | 0.00129 | 0.00119 | 0.00115 |
| 8 | 0.00124 | 0.001 | 0.00084 | 0.0008 | 0.00169 | 0.00137 | 0.00123 | 0.00119 |
| 7 | 0.0013 | 0.00106 | 0.00089 | 0.00081 | 0.00178 | 0.00144 | 0.00125 | 0.00122 |
| 6 | 0.00136 | 0.0011 | 0.00093 | 0.00083 | 0.00186 | 0.00151 | 0.00127 | 0.00123 |
| 5 | 0.00141 | 0.00115 | 0.00097 | 0.00084 | 0.00192 | 0.00157 | 0.00132 | 0.00125 |
| 4 | 0.00144 | 0.00118 | 0.001 | 0.00087 | 0.00197 | 0.00161 | 0.00137 | 0.00125 |
| 3 | 0.00144 | 0.00119 | 0.00102 | 0.00089 | 0.00197 | 0.00163 | 0.00139 | 0.00123 |
| 2 | 0.00138 | 0.00116 | 0.00101 | 0.00089 | 0.00189 | 0.00159 | 0.00138 | 0.00121 |
| 1 | 0.00123 | 0.00107 | 0.00095 | 0.00086 | 0.00167 | 0.00145 | 0.0013 | 0.00117 |
| PLINTH | 0.00059 | 0.00052 | 0.00047 | 0.00043 | 0.00079 | 0.0007 | 0.00064 | 0.00058 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 7 for I-Shaped Buildings in Zone IV (No Infill):

- For $L_1/L_2$ ratio = 0.25, maximum design storey drift occurs at floor no. 4 and 5.
- For $L_1/L_2$ ratio =0.5, 0.75 and 1.0, maximum design storey drift occurs at floor no.4.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.44 mm.

The following observations are made from Table 7 for I-Shaped Buildings in Zone V (No Infill):

- For $L_1/L_2$ ratio = 0.25, 0.5 and 0.75 maximum design storey drift occurs at floor no. 4.
- For $L_1/L_2$ ratio =1.0, maximum design storey drift occurs at floor no.5 and 6.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.97 mm.

**Table 8: Values of maximum design storey drift in m (No Infill)**

| Zone | EL / WL in X- Direction | | | | EL / WL in Y- Direction | | | |
|---|---|---|---|---|---|---|---|---|
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| II | 0.00075 | 0.00098 | 0.00119 | 0.00136 | 0.00163 | 0.00135 | 0.00115 | 0.00100 |
| III | 0.00075 | 0.00098 | 0.00119 | 0.00136 | 0.00163 | 0.00135 | 0.00115 | 0.00100 |
| IV | 0.00126 | 0.00129 | 0.00131 | 0.00133 | 0.00144 | 0.00119 | 0.00102 | 0.00089 |
| V | 0.00189 | 0.00193 | 0.00197 | 0.00200 | 0.00197 | 0.00163 | 0.00139 | 0.00125 |

From Table 8, it can be observed that:

- The maximum design storey drift in x-direction, for any given zone, increases with $L_1/L_2$ ratio.
- The maximum design storey drift in y-direction, for any given zone, decreases with $L_1/L_2$ ratio.
- The absolute maximum (maximum of maximums) design storey drift in x- or y-direction occurs in zone V.
- The maximum design storey drifts are almost same for zones II and III.

(c) Storey Drifts in X-Direction (Infill)

The design storey drifts in x-direction for I-shaped buildings with infill are given in Table 9 for various values of $L_1/L_2$ ratio and zones II and III and in Table 10 for various values of $L_1/L_2$ ratio and zones considering all load combinations specified by the relevant IV and V. Each storey drift entry in the table represents the maximum value obtained by IS Codes.

**Table 9: Values of design storey drift in m**

| WL/EL in X-direction; Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE II | | | | ZONE III | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00011 | 0.00012 | 0.00012 | 0.00012 | 0.00017 | 0.00018 | 0.00018 | 0.00018 |
| 19 | 0.0002 | 0.0002 | 0.00021 | 0.0002 | 0.00031 | 0.00031 | 0.00032 | 0.00031 |
| 18 | 0.00027 | 0.00028 | 0.00028 | 0.00028 | 0.00042 | 0.00043 | 0.00043 | 0.00043 |
| 17 | 0.00033 | 0.00034 | 0.00034 | 0.00035 | 0.00051 | 0.00052 | 0.00053 | 0.00053 |
| 16 | 0.00032 | 0.00033 | 0.00033 | 0.00034 | 0.0005 | 0.00051 | 0.00051 | 0.00052 |
| 15 | 0.00015 | 0.00017 | 0.0002 | 0.00023 | 0.00024 | 0.00025 | 0.00026 | 0.00027 |
| 14 | 0.0002 | 0.00023 | 0.00027 | 0.0003 | 0.00032 | 0.00034 | 0.00035 | 0.00036 |
| 13 | 0.00024 | 0.00029 | 0.00034 | 0.00038 | 0.00037 | 0.00039 | 0.00041 | 0.00042 |
| 12 | 0.00029 | 0.00035 | 0.00041 | 0.00047 | 0.00041 | 0.00043 | 0.00045 | 0.00047 |
| 11 | 0.00034 | 0.00041 | 0.00048 | 0.00055 | 0.00044 | 0.00046 | 0.00048 | 0.00055 |
| 10 | 0.00038 | 0.00047 | 0.00055 | 0.00063 | 0.00046 | 0.00049 | 0.00055 | 0.00063 |
| 9 | 0.00043 | 0.00053 | 0.00062 | 0.0007 | 0.00048 | 0.00053 | 0.00062 | 0.0007 |
| 8 | 0.00047 | 0.00058 | 0.00068 | 0.00077 | 0.00049 | 0.00058 | 0.00068 | 0.00077 |
| 7 | 0.00051 | 0.00064 | 0.00075 | 0.00084 | 0.00051 | 0.00064 | 0.00075 | 0.00084 |
| 6 | 0.00055 | 0.00068 | 0.0008 | 0.00091 | 0.00055 | 0.00068 | 0.0008 | 0.00091 |
| 5 | 0.00059 | 0.00073 | 0.00086 | 0.00097 | 0.00059 | 0.00073 | 0.00086 | 0.00097 |
| 4 | 0.00062 | 0.00077 | 0.00091 | 0.00103 | 0.00062 | 0.00077 | 0.00091 | 0.00103 |
| 3 | 0.00065 | 0.00082 | 0.00096 | 0.00109 | 0.00065 | 0.00082 | 0.00096 | 0.00109 |
| 2 | 0.0007 | 0.00088 | 0.00104 | 0.00117 | 0.0007 | 0.00088 | 0.00104 | 0.00117 |
| 1 | 0.00073 | 0.00096 | 0.00116 | 0.00133 | 0.00073 | 0.00096 | 0.00116 | 0.00133 |
| PLINTH | 0.00042 | 0.00055 | 0.00067 | 0.00077 | 0.00042 | 0.00055 | 0.00067 | 0.00077 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 9 for I-Shaped Buildings in Zone II (Infill):

- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.2.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ratio =1.0, the value is 1.33 mm.

The following observations are made from Table 9 for I-Shaped Buildings in Zone III (Infill):

- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.2.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ratio =1.0, the value is 1.33 mm.

**Table 10: Values of design storey drift in m**

| WL/EL in X-direction; Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE IV | | | | ZONE V | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00026 | 0.00026 | 0.00026 | 0.00026 | 0.00038 | 0.00039 | 0.00039 | 0.00039 |
| 19 | 0.00045 | 0.00046 | 0.00046 | 0.00046 | 0.00066 | 0.00068 | 0.00068 | 0.00068 |
| 18 | 0.00061 | 0.00063 | 0.00063 | 0.00063 | 0.0009 | 0.00092 | 0.00093 | 0.00093 |
| 17 | 0.00075 | 0.00076 | 0.00077 | 0.00078 | 0.0011 | 0.00106 | 0.00114 | 0.00115 |
| 16 | 0.00073 | 0.00074 | 0.00075 | 0.00076 | 0.00107 | 0.00096 | 0.00111 | 0.00112 |
| 15 | 0.00036 | 0.00038 | 0.00039 | 0.0004 | 0.00054 | 0.00057 | 0.00059 | 0.0006 |
| 14 | 0.00048 | 0.0005 | 0.00052 | 0.00053 | 0.00071 | 0.00075 | 0.00078 | 0.0008 |
| 13 | 0.00055 | 0.00059 | 0.00061 | 0.00062 | 0.00083 | 0.00088 | 0.00091 | 0.00093 |
| 12 | 0.00061 | 0.00065 | 0.00067 | 0.00069 | 0.00091 | 0.00096 | 0.001 | 0.00103 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 11 | 0.00065 | 0.00069 | 0.00072 | 0.00074 | 0.00097 | 0.00103 | 0.00108 | 0.00111 |
| 10 | 0.00069 | 0.00073 | 0.00076 | 0.00078 | 0.00103 | 0.00109 | 0.00114 | 0.00117 |
| 9 | 0.00071 | 0.00076 | 0.00079 | 0.00081 | 0.00107 | 0.00114 | 0.00118 | 0.00122 |
| 8 | 0.00074 | 0.00078 | 0.00082 | 0.00084 | 0.0011 | 0.00117 | 0.00122 | 0.00126 |
| 7 | 0.00075 | 0.0008 | 0.00084 | 0.00086 | 0.00112 | 0.0012 | 0.00125 | 0.00129 |
| 6 | 0.00076 | 0.00081 | 0.00085 | 0.00087 | 0.00114 | 0.00122 | 0.00127 | 0.00131 |
| 5 | 0.00077 | 0.00082 | 0.00086 | 0.00088 | 0.00115 | 0.00123 | 0.00128 | 0.00132 |
| 4 | 0.00077 | 0.00082 | 0.00086 | 0.00091 | 0.00115 | 0.00123 | 0.00128 | 0.00132 |
| 3 | 0.00078 | 0.00084 | 0.00087 | 0.00096 | 0.00116 | 0.00125 | 0.0013 | 0.00133 |
| 2 | 0.00078 | 0.00084 | 0.00092 | 0.00104 | 0.00116 | 0.00125 | 0.0013 | 0.00142 |
| 1 | 0.00074 | 0.00085 | 0.00103 | 0.00118 | 0.0011 | 0.00117 | 0.0014 | 0.0016 |
| PLINTH | 0.00038 | 0.00049 | 0.00059 | 0.00068 | 0.00055 | 0.00066 | 0.00081 | 0.00093 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 10 for I-Shaped Buildings in Zone IV (Infill):

- For $L_1/L_2$ ratio = 0.25 and 0.5, maximum design storey drift occurs at floor no. 3 and 4.
- For $L_1/L_2$ ratio =0.75 and 1.0, maximum design storey drift occurs at floor no.2.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ ratio =1.0, the value is 1.18 mm.

The following observations are made from Table 10 for I-Shaped Buildings in Zone V (Infill):

- For $L_1/L_2$ ratio = 0.25, 0.5 and 0.75, maximum design storey drift occurs at floor no. 3 and 4.
- For $L_1/L_2$ ratio = 1.0, maximum design storey drift occurs at floor no.3.
- As $L_1/L_2$ ratio increases the maximum design storey drift increases. When $L_1/L_2$ ratio =1.0, the value is 1.42 mm.

(d) Storey Drifts in Y-Direction (With Infill)

The design storey drifts in y-direction for I-shaped buildings with infill are given in Table 11 for various values of $L_1/L_2$ ratio and zones II and III and in Table 12 for various values of $L_1/L_2$ ratio and zones IV and V. Each storey drift entry in the table represents the maximum value obtained by considering all load combinations specified by the relevant IS Codes.

**Table 11: Values of design storey drift in m**

| WL/EL in Y-direction; Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE II | | | | ZONE III | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00047 | 0.00045 | 0.00044 | 0.00043 | 0.00047 | 0.00045 | 0.00044 | 0.00043 |
| 19 | 0.00062 | 0.00061 | 0.0006 | 0.00059 | 0.00062 | 0.00061 | 0.0006 | 0.00059 |
| 18 | 0.00079 | 0.00078 | 0.00076 | 0.00075 | 0.00079 | 0.00078 | 0.00076 | 0.00075 |
| 17 | 0.00092 | 0.00089 | 0.00087 | 0.00085 | 0.00092 | 0.00089 | 0.00087 | 0.00085 |
| 16 | 0.00086 | 0.0008 | 0.00076 | 0.00073 | 0.00086 | 0.0008 | 0.00076 | 0.00073 |
| 15 | 0.00072 | 0.00058 | 0.00048 | 0.00042 | 0.00072 | 0.00058 | 0.00048 | 0.00042 |
| 14 | 0.00081 | 0.00064 | 0.00053 | 0.00045 | 0.00081 | 0.00064 | 0.00053 | 0.00045 |
| 13 | 0.0009 | 0.00071 | 0.00058 | 0.0005 | 0.0009 | 0.00071 | 0.00058 | 0.0005 |
| 12 | 0.00098 | 0.00077 | 0.00064 | 0.00054 | 0.00098 | 0.00077 | 0.00064 | 0.00054 |
| 11 | 0.00105 | 0.00083 | 0.00069 | 0.00059 | 0.00105 | 0.00083 | 0.00069 | 0.00059 |
| 10 | 0.00113 | 0.00089 | 0.00074 | 0.00063 | 0.00113 | 0.00089 | 0.00074 | 0.00063 |
| 9 | 0.0012 | 0.00095 | 0.00079 | 0.00067 | 0.0012 | 0.00095 | 0.00079 | 0.00067 |
| 8 | 0.00127 | 0.00101 | 0.00084 | 0.00072 | 0.00127 | 0.00101 | 0.00084 | 0.00072 |
| 7 | 0.00133 | 0.00106 | 0.00088 | 0.00076 | 0.00133 | 0.00106 | 0.00088 | 0.00076 |
| 6 | 0.00139 | 0.00111 | 0.00093 | 0.0008 | 0.00139 | 0.00111 | 0.00093 | 0.0008 |
| 5 | 0.00144 | 0.00116 | 0.00097 | 0.00084 | 0.00144 | 0.00116 | 0.00097 | 0.00084 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 4 | 0.00147 | 0.0012 | 0.00101 | 0.00087 | 0.00147 | 0.0012 | 0.00101 | 0.00087 |
| 3 | 0.00149 | 0.00123 | 0.00104 | 0.00091 | 0.00149 | 0.00123 | 0.00104 | 0.00091 |
| 2 | 0.00146 | 0.00122 | 0.00106 | 0.00093 | 0.00146 | 0.00122 | 0.00106 | 0.00093 |
| 1 | 0.00132 | 0.00115 | 0.00102 | 0.00092 | 0.00132 | 0.00115 | 0.00102 | 0.00092 |
| PLINTH | 0.00064 | 0.00057 | 0.00051 | 0.00047 | 0.00064 | 0.00057 | 0.00051 | 0.00047 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 11 for I-Shaped Buildings in Zone II (Infill):

- For $L_1/L_2$ ratio = 0.25 and 0.5, maximum design storey drift occurs at floor no. 4.
- For $L_1/L_2$ ratio = 0.75 and 1.0, maximum design storey drift occurs at floor no.3.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.49 mm.

The following observations are made from Table 11 for I-Shaped Buildings in Zone III (Infill):

- For $L_1/L_2$ ratio = 0.25 and 0.5, maximum design storey drift occurs at floor no. 4.
- For $L_1/L_2$ ratio = 0.75 and 1.0, maximum design storey drift occurs at floor no.3.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.49 mm.

**Table 12: Values of design storey drift in m**

| WL/EL in Y-direction; Infill | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| STOREY NO. | ZONE IV | | | | ZONE V | | | |
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| 20 | 0.00042 | 0.00041 | 0.00042 | 0.00043 | 0.00054 | 0.00056 | 0.00058 | 0.00059 |
| 19 | 0.00056 | 0.00055 | 0.00055 | 0.00056 | 0.00074 | 0.00074 | 0.00077 | 0.0008 |
| 18 | 0.00071 | 0.0007 | 0.00068 | 0.00069 | 0.00094 | 0.00092 | 0.00096 | 0.001 |
| 17 | 0.00082 | 0.00079 | 0.00078 | 0.00076 | 0.00109 | 0.00112 | 0.00107 | 0.00111 |
| 16 | 0.00076 | 0.00071 | 0.00068 | 0.00065 | 0.00104 | 0.00109 | 0.00094 | 0.00095 |
| 15 | 0.00064 | 0.00051 | 0.00044 | 0.00041 | 0.00086 | 0.0007 | 0.00065 | 0.0006 |
| 14 | 0.00072 | 0.00057 | 0.0005 | 0.00047 | 0.00097 | 0.0008 | 0.00074 | 0.00069 |
| 13 | 0.0008 | 0.00063 | 0.00056 | 0.00053 | 0.00108 | 0.0009 | 0.00083 | 0.00079 |
| 12 | 0.00087 | 0.00068 | 0.00062 | 0.00059 | 0.00118 | 0.00098 | 0.00092 | 0.00087 |
| 11 | 0.00093 | 0.00074 | 0.00067 | 0.00064 | 0.00127 | 0.00105 | 0.00099 | 0.00095 |
| 10 | 0.001 | 0.00079 | 0.00071 | 0.00068 | 0.00136 | 0.00111 | 0.00105 | 0.00101 |
| 9 | 0.00106 | 0.00084 | 0.00074 | 0.00071 | 0.00145 | 0.00116 | 0.0011 | 0.00106 |
| 8 | 0.00112 | 0.00089 | 0.00076 | 0.00073 | 0.00153 | 0.00122 | 0.00114 | 0.00109 |
| 7 | 0.00118 | 0.00094 | 0.00078 | 0.00075 | 0.00161 | 0.00128 | 0.00116 | 0.00112 |
| 6 | 0.00123 | 0.00098 | 0.00082 | 0.00077 | 0.00168 | 0.00134 | 0.00118 | 0.00115 |
| 5 | 0.00127 | 0.00102 | 0.00086 | 0.00078 | 0.00174 | 0.0014 | 0.0012 | 0.00116 |
| 4 | 0.0013 | 0.00106 | 0.00089 | 0.00078 | 0.00178 | 0.00145 | 0.00122 | 0.00117 |
| 3 | 0.00132 | 0.00108 | 0.00092 | 0.00080 | 0.00180 | 0.00148 | 0.00126 | 0.00117 |
| 2 | 0.00129 | 0.00108 | 0.00093 | 0.00082 | 0.00177 | 0.00148 | 0.00128 | 0.00116 |
| 1 | 0.00117 | 0.00102 | 0.00091 | 0.00082 | 0.0016 | 0.00139 | 0.00123 | 0.00112 |
| PLINTH | 0.00057 | 0.0005 | 0.00045 | 0.00042 | 0.00077 | 0.00068 | 0.00062 | 0.00057 |
| BASE | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The following observations are made from Table 12 for I-Shaped Buildings in Zone IV (Infill):

- For all the $L_1/L_2$ ratios, maximum design storey drift occurs at floor no.4.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.32 mm.

The following observations are made from Table 12 for I-Shaped Buildings in Zone V (Infill):

- For $L_1/L_2$ ratio = 0.25 maximum design storey drift occurs at floor no.4.
- For $L_1/L_2$ ratio = 0.5 maximum design storey drift occurs at floor no.3 and 4.
- For $L_1/L_2$ ratio = 0.75 maximum design storey drift occurs at floor no.3.
- For $L_1/L_2$ ratio = 1.0 maximum design storey drift occurs at floor no.4 and 5.
- As $L_1/L_2$ ratio increases the maximum design storey drift decreases. When $L_1/L_2$ ratio =0.25, the value is 1.80 mm.

**Table 13: Values of design storey drift in m (Infill)**

| Zone | EL / WL in X- Direction | | | | EL / WL in Y- Direction | | | |
|---|---|---|---|---|---|---|---|---|
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| II | 0.00073 | 0.00096 | 0.00116 | 0.00133 | 0.00149 | 0.00123 | 0.00106 | 0.00093 |
| III | 0.00073 | 0.00096 | 0.00116 | 0.00133 | 0.00149 | 0.00123 | 0.00106 | 0.00093 |
| IV | 0.00078 | 0.00084 | 0.00103 | 0.00118 | 0.00132 | 0.00108 | 0.00092 | 0.00080 |
| V | 0.00116 | 0.00125 | 0.00130 | 0.00142 | 0.00180 | 0.00148 | 0.00128 | 0.00117 |

From Table 13, it can be observed that:

- The maximum design storey drift in x-direction, for any given zone, increases with $L_1/L_2$ ratio.
- The maximum design storey drift in y-direction, for any given zone, decreases with $L_1/L_2$ ratio.
- The absolute maximum design storey drift in x- or y-direction occurs in zone V.
- The maximum design storey drifts are almost the same for zones II and III.

2.3 Variation of Design Ultimate Positive Moment and Design Ultimate Negative Moment in Transfer Girders TB1 and TB2

The design ultimate positive and negative moments in transfer girders are given in Tables 14 and 15.

**Table 14: Maximum moments in Transfer Girders (No Infill)**

| Transfer Girder | Design Ultimate Positive Moment | | | | Design Ultimate Negative Moment | | | |
|---|---|---|---|---|---|---|---|---|
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| TB1 | 2813.28 | 2813.341 | 2813.3316 | 2813.3264 | 2257.9823 | 2257.5716 | 2257.116 | 2256.7763 |
| TB2 | 4033.15 | 4033.301 | 4033.4583 | 4033.5764 | 5160.0265 | 5159.6872 | 5160.006 | 5160.2729 |

**Table 15: Maximum moments in Transfer Girders (Infill)**

| Transfer Girder | Design Ultimate Positive Moment | | | | Design Ultimate Negative Moment | | | |
|---|---|---|---|---|---|---|---|---|
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| TB1 | 2270.82 | 2271.051 | 2271.0244 | 2270.996 | 1850.3811 | 1850.562 | 1850.1 | 1849.7355 |
| TB2 | 3364.56 | 3364.431 | 3364.5626 | 3364.6706 | 4272.5021 | 4270.2769 | 4270.45 | 4270.6757 |

From the results obtained, the following are observed in regard to transfer girders:

- The variation of moments with $L_1/L_2$ ratio is insignificant.
- The variation of moments with zone is also insignificant.
- The influence of infill wall on the moments is significant. Both the design ultimate positive and negative moments decrease in magnitude when the effect of infill wall is considered in the analysis as indicated by Tables 14 and 15.

**2.4 Variation of Design Ultimate Positive Moment and Design Ultimate Negative Moment in Main Beams**

The design ultimate positive and negative moments in main beams are given in Tables 16 and 17.

**Table 16: Maximum moments in Main Beams (No Infill)**

| Zone | Design Ultimate Positive Moment | | | | Design Ultimate Negative Moment | | | |
|---|---|---|---|---|---|---|---|---|
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| II | 380.9724 | 380.4921 | 380.1221 | 379.8129 | 727.7456 | 784.4022 | 828.8546 | 866.1198 |
| III | 380.9724 | 380.4921 | 380.1221 | 379.8129 | 727.7456 | 784.4022 | 828.8546 | 866.1198 |
| IV | 381.0051 | 380.8025 | 380.559 | 380.8025 | 720.6526 | 744.0504 | 776.7591 | 809.6839 |
| V | 382.4666 | 386.4732 | 393.0214 | 399.0952 | 890.3024 | 925.41 | 956.5497 | 982.1407 |

**Table 17: Maximum moments in Main Beams (Infill)**

| Zone | Design Ultimate Positive Moment | | | | Design Ultimate Negative Moment | | | |
|---|---|---|---|---|---|---|---|---|
| | $L_1/L_2$ Ratio | | | | $L_1/L_2$ Ratio | | | |
| | 0.25 | 0.5 | 0.75 | 1.0 | 0.25 | 0.5 | 0.75 | 1.0 |
| II | 316.0198 | 315.5544 | 315.1986 | 314.8999 | 609.9405 | 663.9523 | 706.5305 | 742.4589 |
| III | 316.0198 | 315.5544 | 315.1986 | 314.8999 | 609.9405 | 663.9523 | 706.5305 | 742.4589 |
| IV | 315.8433 | 315.6328 | 324.5871 | 324.793 | 628.0838 | 651.6811 | 671.3035 | 689.8132 |
| V | 320.1364 | 329.7287 | 349.8426 | 362.1748 | 798.1204 | 833.3924 | 862.6645 | 890.3607 |

From the results obtained, the following are observed in regard to main beams:

- The variation of moments with $L_1/L_2$ ratio is not significant.
- The variation of moments with zone is not significant except in the case of negative moment in zone V.
- The influence of infill wall on the moments is moderate. Both the design ultimate positive and negative moments decrease in magnitude when the effect of infill wall is considered in the analysis as indicated by Tables 16 through 17.

### 2.5 Comparative Study of Equivalent Static Lateral Force Method and Response Spectrum Method

#### 2.5.1 Loading Combinations Considered

For the purpose of comparing the two methods, the load combinations shown in Table 18 are considered.

**Table 18: Load combinations for the limit state of serviceability**

| Load combination | | | |
|---|---|---|---|
| Sl.No. | Equivalent Static Lateral Force Method | Sl.No. | Response Spectrum Method |
| 1 | $DL + EQ_X$ | 1 | $DL + SPEC_X$ |
| 2 | $DL - EQ_X$ | 2 | $DL - SPEC_X$ |
| 3 | $DL + EQ_Y$ | 3 | $DL + SPEC_Y$ |
| 4 | $DL - EQ_Y$ | 4 | $DL - SPEC_Y$ |
| 5 | $DL + 0.8\ LL + 0.8\ EQ_X$ | 5 | $DL + 0.8\ LL + 0.8\ SPEC_X$ |
| 6 | $DL + 0.8\ LL - 0.8\ EQ_X$ | 6 | $DL + 0.8\ LL - 0.8\ SPEC_X$ |
| 7 | $DL + 0.8\ LL + 0.8\ EQ_Y$ | 7 | $DL + 0.8\ LL + 0.8\ SPEC_Y$ |
| 8 | $DL + 0.8\ LL - 0.8\ EQ_Y$ | 8 | $DL + 0.8\ LL - 0.8\ SPEC_Y$ |

#### 2.5.2 Maximum Storey Drifts in X-Direction

The maximum values of storey drift in x-direction for various values of $L_1/L_2$ ratio and seismic zone are given in Tables 19 through 22 for both infill and no infill.

**Table 19: Maximum values of storey drift in x-direction for Zone II**

| $L_1/L_2$ RATIO | ZONE II , X -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.000525 | 0.000488 | 0.000334 | 0.000333 |
| 0.5 | 0.000536 | 0.000493 | 0.000351 | 0.000357 |
| 0.75 | 0.000546 | 0.000498 | 0.000366 | 0.000371 |
| 1.0 | 0.000556 | 0.000503 | 0.000376 | 0.000380 |

**Table 20: Maximum values of storey drift in x-direction for Zone III**

| $L_1/L_2$ RATIO | ZONE III , X -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.000840 | 0.000780 | 0.000520 | 0.000525 |
| 0.5 | 0.000857 | 0.000789 | 0.000554 | 0.000562 |
| 0.75 | 0.000874 | 0.000797 | 0.000577 | 0.000585 |
| 1.0 | 0.000890 | 0.000805 | 0.000594 | 0.000600 |

**Table 21: Maximum values of storey drift in x-direction for Zone IV**

| $L_1/L_2$ RATIO | ZONE IV , X -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.001260 | 0.001170 | 0.000772 | 0.000779 |
| 0.5 | 0.001286 | 0.001184 | 0.000824 | 0.000837 |
| 0.75 | 0.001311 | 0.001195 | 0.000860 | 0.000871 |
| 1.0 | 0.001334 | 0.001207 | 0.000885 | 0.000894 |

**Table 22: Maximum values of storey drift in x-direction for Zone V**

| $L_1/L_2$ RATIO | ZONE V , X -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.001890 | 0.001755 | 0.001152 | 0.001162 |
| 0.5 | 0.001929 | 0.001776 | 0.001230 | 0.001248 |
| 0.75 | 0.001966 | 0.001793 | 0.001283 | 0.001300 |
| 1.0 | 0.002001 | 0.001811 | 0.001321 | 0.001334 |

From Tables 19 through 22, the following observations are made:

- The maximum storey drift in x-direction increases monotonically with the severity of the zone.
- Absolute maximum value of storey drift in x-direction in any zone occurs when $L_1/L_2$ ratio is unity.
- The maximum storey drift in x-direction in any case is smaller when infill is considered in the analysis.
- The response spectrum method predicts lower maximum storey drift in x-direction compared to the equivalent static lateral force method in all the cases when infill is not accounted in the analysis.
- The response spectrum method predicts slightly higher maximum storey drift in x-direction compared to the equivalent static lateral force method in all cases when infill is accounted in the analysis.

**2.5.3 Maximum Storey Drifts in Y-Direction**

The maximum values of storey drift in y-direction for various values of $L_1/L_2$ ratio and seismic zone are given in Tables 23 through 26 for both infill and no infill.

**Table 23: Maximum values of storey drift in y-direction for Zone II**

| $L_1/L_2$ RATIO | ZONE II , Y -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.000400 | 0.000350 | 0.000367 | 0.000328 |
| 0.5 | 0.000377 | 0.000345 | 0.000347 | 0.000322 |
| 0.75 | 0.000378 | 0.000358 | 0.000352 | 0.000331 |
| 1.0 | 0.000390 | 0.000370 | 0.000363 | 0.000342 |

**Table 24: Maximum values of storey drift in y-direction for Zone III**

| $L_1/L_2$ RATIO | ZONE III , Y -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.000629 | 0.000553 | 0.000583 | 0.000522 |
| 0.5 | 0.000596 | 0.000534 | 0.000553 | 0.000511 |
| 0.75 | 0.000574 | 0.000528 | 0.000537 | 0.000506 |
| 1.0 | 0.000580 | 0.000546 | 0.000534 | 0.000504 |

**Table 25: Maximum values of storey drift in y-direction for Zone IV**

| $L_1/L_2$ RATIO | ZONE IV , Y -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.000934 | 0.000824 | 0.000871 | 0.000782 |
| 0.5 | 0.000888 | 0.000798 | 0.000827 | 0.000763 |
| 0.75 | 0.000856 | 0.000782 | 0.000802 | 0.000754 |
| 1.0 | 0.000833 | 0.000782 | 0.000783 | 0.000750 |

**Table 26: Maximum values of storey drift in y-direction for Zone V**

| $L_1/L_2$ RATIO | ZONE V , Y -DIRECTION | | | |
|---|---|---|---|---|
| | NO INFILL | | INFILL | |
| | ESLFM | RSM | ESLFM | RSM |
| 0.25 | 0.001393 | 0.001231 | 0.001302 | 0.001170 |
| 0.5 | 0.001326 | 0.001195 | 0.001238 | 0.001141 |
| 0.75 | 0.001280 | 0.001170 | 0.001200 | 0.001125 |
| 1.0 | 0.001246 | 0.001150 | 0.001170 | 0.001118 |

From Tables 23 through 26, the following observations are made:

- The maximum storey drift in y-direction increases monotonically with the severity of the zone for all the cases.
- Absolute maximum value of storey drift in y-direction occurs when $L_1/L_2$ ratio is 0.25 for all zones and both cases of infill and no fill according to ESLFM.
- The maximum storey drift in y-direction in any case is smaller when infill is considered in the analysis.
- The response spectrum method predicts lower maximum storey drift in y-direction compared to the equivalent static lateral force method in all cases.

# III. Conclusions

### 3.1 Design Storey Drifts

- The absolute maximum design storey drift in x- or y-direction occurs in Zone V.
- The maximum design storey drift in x- or y-direction for any zone and any value of $L_1/L_2$ ratio is smaller when infill wall is considered in the analysis. Thus the effect of infill walls is to reduce the storey drifts.

(i) No Infill

- As seismic severity of the zone increases, the maximum design storey drift in x-direction varies and is maximum for zone V.
- In zone II and III, the maximum design storey drift in x-direction occurs at floor no.2. In zone IV and V, the maximum design storey drift in x-direction occurs at floor no.18.
- As seismic severity of the zone increases, the maximum design storey drift in y-direction varies and is maximum for zone V.
- In zone II ,III and IV the maximum design storey drift in y-direction occurs at floor no.4 or 5. In zone V, the maximum storey drift in y-direction occurs at floor no.4 or 5 or 6.
- The maximum design storey drift in x-direction, for any given zone, increases with $L_1/L_2$ ratio.
- The maximum design storey drift in y-direction, for any given zone, decreases with $L_1/L_2$ ratio.
- The absolute maximum (maximum of maximums) design storey drift in x- or y-direction occurs in zone V.
- The maximum design storey drifts are almost same for zones II and III.

(ii) With Infill

- As seismic severity of the zone increases, the maximum design storey drift in x-direction varies and is maximum for zone V.
- In zone II and III, the maximum design storey drift in x-direction occurs at floor no.2. In zone IV, the maximum design storey drift in x-direction occurs at floor no.2 or 3 or 4. In zone V, the maximum storey drift in x-direction occurs at floor no. 3 or 4.
- As seismic severity of the zone increases, the maximum design storey drift in y-direction varies and is maximum for zone V.
- In zone II and III, the maximum design storey drift in y-direction occurs at floor no.3 or 4. In zone IV, the maximum design storey drift in y-direction occurs at floor no. 4. In zone V, the maximum storey drift in y-direction occurs at floor no. 3 or 4 or 5.
- The maximum design storey drift in x-direction, for any given zone, increases with $L_1/L_2$ ratio.
- The maximum design storey drift in y-direction, for any given zone, decreases with $L_1/L_2$ ratio.
- The absolute maximum design storey drift in x- or y-direction occurs in zone V.
- The maximum design storey drifts are almost the same for zones II and III.

### 3.2 Design Ultimate Moments in Transfer Girders and Main Beams

- The variation of moments with $L_1/L_2$ ratio is insignificant.
- Both the design ultimate positive and negative moments decrease in magnitude when the effect of infill wall is considered in the analysis

### 3.3 Equivalent Static Lateral Force Method versus Response Spectrum Method

- The maximum storey drift in x- and y-directions increases monotonically with the severity of the zone.
- Absolute maximum value of storey drift in x-direction in any zone occurs when $L_1/L_2$ ratio is unity.
- Absolute maximum value of storey drift in y-direction occurs when $L_1/L_2$ ratio is 0.25 for all zones and both cases of infill and no fill according to ESLFM.
- The maximum storey drift in x- and y-directions in any case is smaller when infill is considered in the analysis.
- The response spectrum method predicts lower maximum storey drift in x-direction compared to the equivalent static lateral force method in all the cases when infill is not accounted in the analysis.
- The response spectrum method predicts slightly higher maximum storey drift in x-direction compared to the equivalent static lateral force method in all cases when infill is accounted in the analysis.
- The response spectrum method predicts lower maximum storey drift in y-direction compared to the equivalent static lateral force method in all cases.


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## References


[1] Wakchaure M.R, Ped S. P, "Earthquake Analysis of High Rise Building with and Without In filled Walls", ISO 9001:2008 Certified International Journal of Engineering and Innovative Technology (IJEIT),Volume 2, Issue 2, August 2012.

[2] Mohammed Yousuf, P.M. Shimpale,"Dynamic Analysis of Reinforced Concrete Building with Plan Irregularities", International Journal of Emerging Technology and Advanced Engineering, Volume 3, Issue 9, September 2013.

[3] Amin Alavi, P. Srinivasa Rao, "Effect of Plan Irregular RC Buildings In High Seismic Zone", Australian Journal of Basic and Applied Sciences, November 2013, Pages: 1-6.

[4] Himanshu Gaur, R.K Goliya, Krishna Murari, Dr. A. K Mullick "A parametric study of multi- storey r/c buildings with horizontal irregularity", IJRET: International Journal of Research in Engineering and Technology, Volume: 03,Issue: 04, Apr-2014.

[5] M.G.Shaikh, Hashmi S.Shakeeb, "Effect of Seismic Joint in the Performance of Multi-Storeyed L-Shaped Building", IOSR Journal of Mechanical and Civil Engineering, Volume 10, Issue 1 (Nov. - Dec. 2013), pp-70-77.

[6] Ravikumar C M, Babu Narayan K S, Sujith B V, Venkat Reddy D, "Effect of Irregular Configurations on Seismic Vulnerability of RC Buildings", Architecture Research 2012, 2(3): 20-26.

[7] Mr. S.Mahesh, Mr. Dr.B.Panduranga Rao, "Comparison of analysis and design of regular and irregular configuration of multi Storey building in various seismic zones and various types of soils using ETABS and STAAD", IOSR Journal of Mechanical and Civil Engineering, Volume 11, Issue 6 Ver. I (Nov- Dec. 2014), pp-45-52.

[8] B. Srikanth, V. Ramesh, "Comparative Study of Seismic Response for Seismic Coefficient and Response Spectrum Methods", Int. Journal of Engineering Research and Applications, Vol. 3, Issue 5, Sep-Oct 2013, pp-1919-1924.

[9] Pravin Ashok Shirule, Bharti V. Mahajan, "Response Spectrum Analysis of Asymmetrical Building", International Journal of Science, spirituality, business and technology (IJSSBT), Vol. 1, No.2, February 2013.

[10] A. E. Hassaballa, Fathelrahman M. Adam., M. A. Ismaeil, "Seismic Analysis of a Reinforced Concrete Building by Response Spectrum Method", IOSR Journal of Engineering, Vol. 3, Issue 9 (September. 2013), pp-01-09.

[11] Ramesh Konakalla, Ramesh Dutt Chilakapati, Dr.Harinadha Babu RaparlaI, "Effect of Vertical Irregularity in Multi-Storied Buildings Under Dynamic Loads Using Linear Static Analysis", IJEAR Vol. 4, Issue spl-2, Jan - June 2014.

[12] Prof. S.S. Patil, Miss. S.A. Ghadge, Prof. C.G. Konapure ,Prof. Mrs. C.A. Ghadge"Seismic Analysis of High-Rise Building by Response Spectrum Method", International Journal Of Computational Engineering Research, Vol.3, Issue.3.

[13] Haroon Rasheed Tamboli and Umesh.N.Karadi, "Seismic Analysis of RC Frame Structure with and without Masonry Infill Walls", Indian Journal Of Natural Sciences International Bimonthly,Vol.3, Issue 14, October2012.

[14] Mohit Sharma, Dr. Savita Maru, "Dynamic Analysis of Multistoried Regular Building", IOSR Journal of Mechanical and Civil Engineering , Volume 11, Issue 1 Ver. II (Jan. 2014), pp-37-42.

[15] P.B.Prajapati, Prof.Mayur G. Vanza, "Influence of Plan Iregularity on Sesimic Response of Buildings", Int. Journal of Engineering Research and Applications, Vol. 4, Issue 6 (Version 6), June 2014, pp-85-89.

[16] Md Irfanullah ,Vishwanath. B. Patil, "Seismic Evaluation of RC Framed Buildings with Influence of Masonry Infill Panel", International Journal of Recent Technology and Engineering (IJRTE), Volume-2, Issue-4, September 2013.

[17] Pankaj Agarwal and Manish Shrikande, Earthquake resistant design of structure (Prentice-Hall India, 2005).

[18] Chopra A.K (2001), Dynamics of Structures: Theory and Application to Earthquake Engineering( Second Edition, Prentice Hall).

[19] Clough R.W and Penzien J (1993), Dynamics of Structures (Second Edition, McGraw Hill).

[20] K. S. Jagadish, B.V. Venkatarama Reddy, K. S. Nanjunda Rao, Alternative Building Materials and Technologies(New Age International Publishers).

[21] IS 456:2000, Plain and Reinforced Concrete –Code of Practice, ISI New Delhi,2000.

[22] IS 875 Part 1, Code of Practice for Design Loads (Other than Earthquake) for Building and Structures, Dead Loads, BIS, New Delhi,1987.

[23] IS 875 Part 2, Code of Practice for Design Loads (Other than Earthquake) for Building and Structures, Imposed Loads, BIS, New Delhi,1987.

[24] IS 875 Part 3,Code of Practice for Design Loads (Other than Earthquake) for Building and Structures, Wind Loads, BIS New Delhi,1987.

[25] IS 1893 Part 1, Criteria For Earthquake Resistant Design Of Structures, General Provisions and Buildings, BIS, New Delhi, 2002.

[26] SP 20, Handbook on Masonry Design and Construction,BIS, New Delhi, 1991.

[27] SP 16, Design aids for Reinforced Concrete, BIS, New Delhi, 1987.

[28] SP 34, Handbook on Concrete Reinforcement and Detailing, BIS, New Delhi, 1987.

[29] FEMA 356, Prestandard and commentary for the seismic rehabilitation of buildings, ASCE, Reston, Virginia, 2000.