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Effect of Setbacks on Lateral Displacement in G+6 Multistorey Structure Using STAAD Pro

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Abstract: The multistorey structures/ buildings solve the population's living problems increasing daily. Many clients require more area for commercial purposes such as parties or other celebrations. Therefore, structures are designed with floating columns and setbacks. These elements generate the geometrical irregularity in the structures. Therefore, the present research work has determined the impact of setbacks on the lateral displacement of the structure. The A/L ratios of setbacks are 0.1, 0.125, 0.133, 0.167, 0.2 and 0.233 considered in the design and analysis of structure. The lateral displacement results of irregular structures (with setbacks) have been compared with regular structures (without setbacks) and provisions given in the code.

I. INTRODUCTION

A. General

A three-dimensional structure with multiple stories and vertical movement utilizing stairs and lifts are known as a multistorey building. The multistorey building is generally designed to serve as a commercial mall, residential apartment, commercial apartment, hospital, etc. The construction speed of multistorey buildings is faster than other conventional buildings due to the high level of pre-fabrication material, accuracy in design, riskless construction, and best quality checks with the help of consulting agencies. Figure 1.1 shown below is a typical 3D multistoried building designed on software.

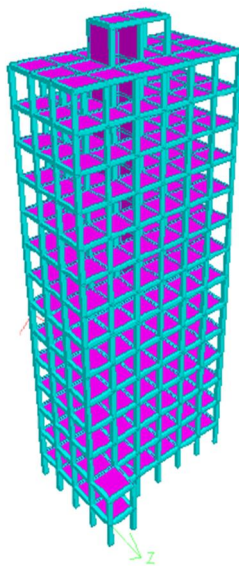


Fig. 1.1: 3D Model of Multistoried Building

B. Setbacks in Multistory Structures

When there is a need to change the terrace space at any level of the building, the structural geometry of the structure may be reduced within its original construction area. The setbacks are a geometrical part of the multistoried building used as the pathway on any floor to the super structure. The typical building having offset is provided when there is a requirement for a terrace garden, entertainment space, space for making temporary sheds, etc. Figure 1.2, shown below, illustrates a multistoried building having uniform setbacks at floor level 2.

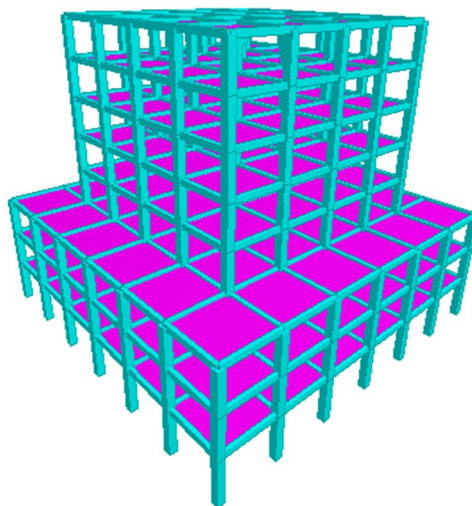


Fig. 1.2: Multistoried building having setbacks at floor level

C. Type of Setbacks/ Offsets

As per Indian standards, there is a criterion of providing setbacks in regular building configuration in clause 7.1. In this clause, the regular buildings suffer minor damage as compared to setbacks buildings since the following types define the main concept of effective setbacks:

- 1) Plan Setbacks
- 2) Vertical Setbacks

II. MODELLING AND ANALYSIS OF STRUCTURES

In the present research work, for determining the effect of setbacks, two types of G+6 storey structures having the length of 30m and 40m have been designed and analyzed using STAAD Pro. The structures are designed for aspect ratio (A/L) of 0.1, 0.125, 0.133, 0.167, 0.200, and 0.233. Six structures with setbacks at 1st, 2nd, 3rd, 4th, 5th, and 6th storey have been designed and analyzed for each A/L ratio, and displacement results have been obtained.

In addition, two bare frame G+6 storey structures have been developed and analyzed to map the comparison with structures having setbacks. However, the displacement of G+6 bare frame structures has been calculated using IS code 1893:2016 formula of $0.004 \times \text{height of storey} \times \text{number of the storey}$ (i.e., $0.004 \times 3500 \times 7 = 98\text{mm}$). Furthermore, the displacement obtained from IScodal formula, bare frame structure, and structures having setbacks has been compared. The comparison is mapped as –

- 1) Comparison of results of lateral displacement for Constant A/L ratio.
- 2) Comparison of results of lateral displacement for varying A/L ratio.

A. Structural Parameters

The following structural parameters have been used to design the G+6 storey structures with and without setbacks, as given in Table 2.1.

TABLE 2.1: STRUCTURAL PARAMETERS USED FOR DESIGN

| | |
|------------------------|----------------------|
| Building configuration | G + 6 |
| Building type | Residential building |
| Total plinth area | 900 m ² |
| Height of each floor | 3.5 m |
| Beam dimensions | 500 mm x 300 mm |

| | |
|-------------------|-----------------|
| Column dimensions | 600 mm x 600 mm |
| Slab thickness | 130 mm |
| Support | Fixed |
| Concrete Grade | M40 |
| Steel Grade | Fe 500 |

1) *Properties of Buildings*

TABLE 2.2: SITE PROPERTIES

| Parameters | Values |
|-------------------------|--------|
| External wall thickness | 225mm |
| Internal wall thickness | 125mm |
| Floor height | 3.5m |

2) *Size of Members*

TABLE 2.3: SIZE OF MEMBERS

| Structural members | Values |
|------------------------|-----------------|
| Beams for all models | 500 mm x 300 mm |
| Columns for all models | 600 mm x 600 mm |
| Slab thickness | 130 mm |

3) *Loading on Structure*

TABLE 2.4: LOADING ON STRUCTURES

| Loading Type | Values |
|------------------------|--|
| Seismic loads | +X direction -X-direction +Z direction -Z direction |
| Dead loads | Program calculated as per model information |
| Self-weight | 2.5 KN/m ² |
| Floor finish load | 0.408 KN/m ² |
| Waterproofing load | 14.98 KN/m |
| External wall load | 8.33 KN/m |
| Internal wall load | 2.38 KN/m |
| Parapet wall load | |
| Live loads | |
| For floors | 3.25 KN/m ² |
| For roof | 1.2 KN/m ² |
| Response spectrum load | |
| Combination method | CQC |
| Subsoil class | Medium soil |
| Damping | 0.05 |

4) *Structures Developed in the Present Study*

The following structures are developed in the present study to study the effect of setbacks.

- a) G+6 storey structure having the length of 30m and 40m without setbacks (model A1 and A2).

- b) G+6 storey structure having length of 30m with setbacks of different A/L ratio such as 0.1, 0.125, 0.133, 0.167, 0.200, and 0.233. The setbacks are provided at each storey for each ratio.
- c) G+6 storey structure having length of 40m with setbacks of different A/L ratio such as 0.1, 0.125, 0.133, 0.167, 0.200, and 0.233.
- d) For an A/L ratio of 0.1, the setbacks are provided at the first storey. Similarly, for an A/L ratio of 0.125, 0.133, 0.167, 0.200, and 0.233, the setbacks are provided at the 2nd, 3rd, 4th, 5th, and 6th storey. The model designations are given in Table 3.5 for 30m and 40m G+6 storey structures.

TABLE 2.5: MODEL DESIGNATION

| L=30m | | | L=40m | | | A/L Ratio | Configuration |
|-------|-------|----|-------|-------|----|-----------|---------------|
| Case | A | L | Case | A | L | | |
| A1 | 0m | 30 | A2 | 0m | 40 | 0 | Bare Frame |
| B11 | 3m | 30 | B21 | 4m | 40 | 0.10 | 1 + 6 |
| B12 | 3m | 30 | B22 | 4m | 40 | 0.10 | 2 + 5 |
| B13 | 3m | 30 | B23 | 4m | 40 | 0.10 | 3 + 4 |
| B14 | 3m | 30 | B24 | 4m | 40 | 0.10 | 4 + 3 |
| B15 | 3m | 30 | B25 | 4m | 40 | 0.10 | 5 + 2 |
| B16 | 3m | 30 | B26 | 4m | 40 | 0.10 | 6 + 1 |
| C11 | 3.75m | 30 | C21 | 5m | 40 | 0.125 | 1 + 6 |
| C12 | 3.75m | 30 | C22 | 5m | 40 | 0.125 | 2 + 5 |
| C13 | 3.75m | 30 | C23 | 5m | 40 | 0.125 | 3 + 4 |
| C14 | 3.75m | 30 | C24 | 5m | 40 | 0.125 | 4 + 3 |
| C15 | 3.75m | 30 | C25 | 5m | 40 | 0.125 | 5 + 2 |
| C16 | 3.75m | 30 | C26 | 5m | 40 | 0.125 | 6 + 1 |
| D11 | 4m | 30 | D21 | 5.32m | 40 | 0.133 | 1 + 6 |
| D12 | 4m | 30 | D22 | 5.32m | 40 | 0.133 | 2 + 5 |
| D13 | 4m | 30 | D23 | 5.32m | 40 | 0.133 | 3 + 4 |
| D14 | 4m | 30 | D24 | 5.32m | 40 | 0.133 | 4 + 3 |
| D15 | 4m | 30 | D25 | 5.32m | 40 | 0.133 | 5 + 2 |
| D16 | 4m | 30 | D26 | 5.32m | 40 | 0.133 | 6 + 1 |
| E11 | 5m | 30 | E21 | 6.64m | 40 | 0.166 | 1 + 6 |
| E12 | 5m | 30 | E22 | 6.64m | 40 | 0.166 | 2 + 5 |
| E13 | 5m | 30 | E23 | 6.64m | 40 | 0.166 | 3 + 4 |
| E14 | 5m | 30 | E24 | 6.64m | 40 | 0.166 | 4 + 3 |
| E15 | 5m | 30 | E25 | 6.64m | 40 | 0.166 | 5 + 2 |
| E16 | 5m | 30 | E26 | 6.64m | 40 | 0.166 | 6 + 1 |
| F11 | 6m | 30 | F21 | 8m | 40 | 0.200 | 1 + 6 |
| F12 | 6m | 30 | F22 | 8m | 40 | 0.200 | 2 + 5 |
| F13 | 6m | 30 | F23 | 8m | 40 | 0.200 | 3 + 4 |
| F14 | 6m | 30 | F24 | 8m | 40 | 0.200 | 4 + 3 |
| F15 | 6m | 30 | F25 | 8m | 40 | 0.200 | 5 + 2 |
| F16 | 6m | 30 | F26 | 8m | 40 | 0.200 | 6 + 1 |
| G11 | 7m | 30 | G21 | 9.32m | 40 | 0.233 | 1 + 6 |
| G12 | 7m | 30 | G22 | 9.32m | 40 | 0.233 | 2 + 5 |
| G13 | 7m | 30 | G23 | 9.32m | 40 | 0.233 | 3 + 4 |
| G14 | 7m | 30 | G24 | 9.32m | 40 | 0.233 | 4 + 3 |
| G15 | 7m | 30 | G25 | 9.32m | 40 | 0.233 | 5 + 2 |
| G16 | 7m | 30 | G26 | 9.32m | 40 | 0.233 | 6 + 1 |

B. Design And Analysis Of Models

1) Modeling of Structure with L=30 m Configurations

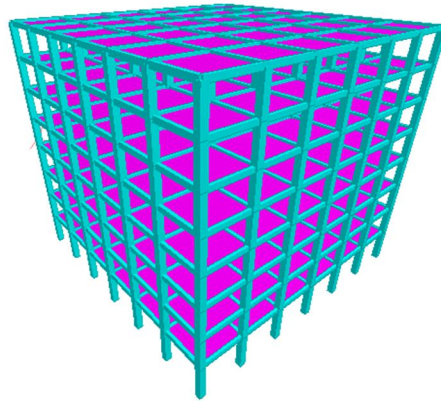


Fig.2.1: 3D view of possibility case A1 (A/L ratio = 0)

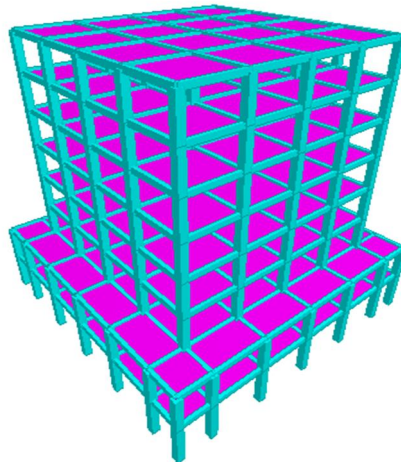


Fig. 2.2: 3D view of possibility case B11 (A/L ratio = 0.1)

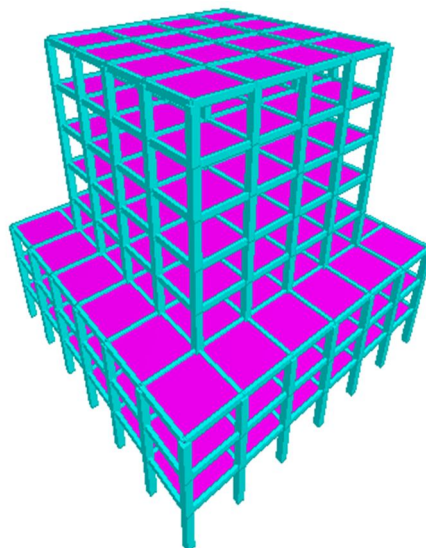


Fig. 2.3: 3D view of possibility case B12 (A/L ratio = 0.1)

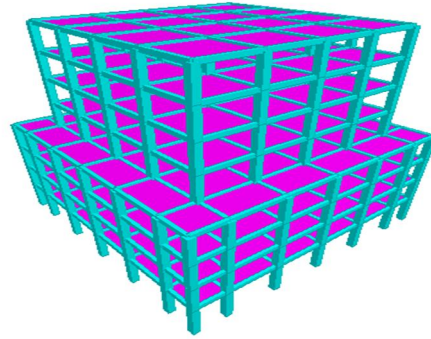


Fig. 2.4: 3D view of possibility case B13 (A/L ratio = 0.1)

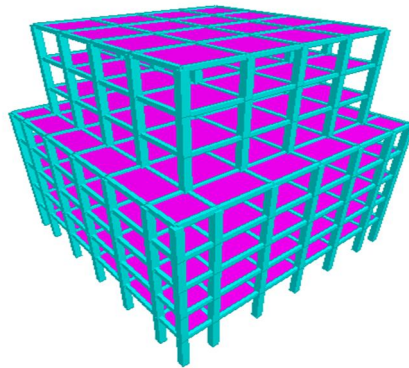


Fig. 2.5: 3D view of possibility case B14 (A/L ratio = 0.1)

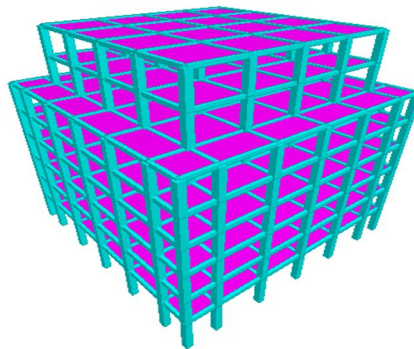


Fig. 2.6 3D view of possibility case B15 (A/L ratio = 0.1)

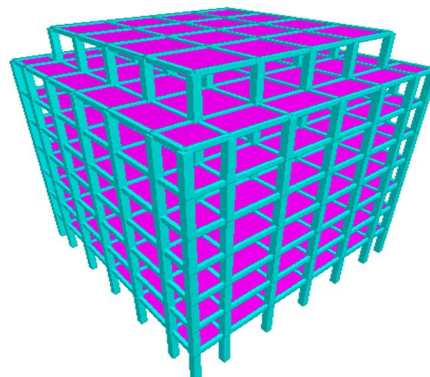


Fig 2.7: 3D view of possibility case B16 (A/L ratio = 0.1)

The same modelling is done for G+6 storey structure having A/L ratio of 0.125 (C11-C16), 0.133 (D11-D16), 0.167 (E11-E16), 0.2 (F11-F16), and 0.233 (G11-G16).

2) Modeling of Structure with $L=40m$ Configurations

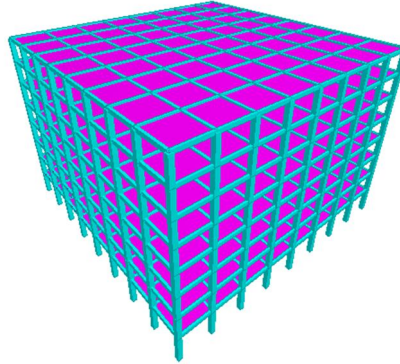


Fig. 2.8: 3D view of possibility case A2 (A/L ratio = 0)

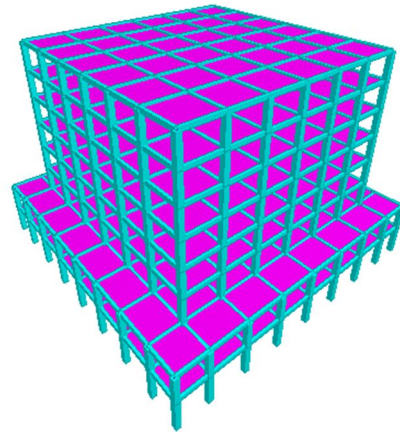


Fig 2.9: 3D view of possibility case B21 (A/L ratio = 0.1)

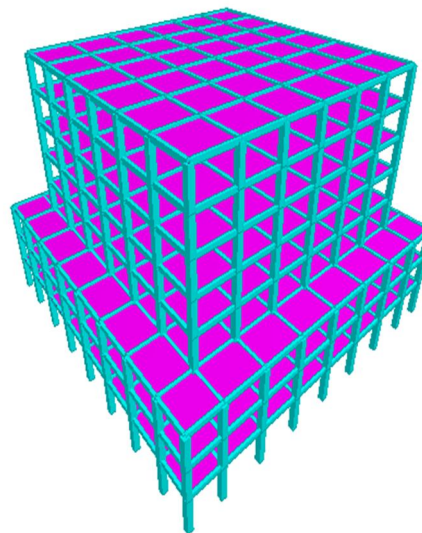


Fig. 2.10: 3D view of possibility case B22 (A/L ratio = 0.1)

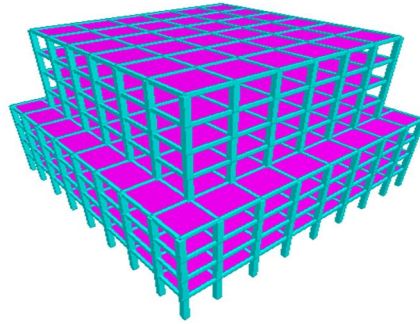


Fig. 2.11: 3D Front elevation view of possibility case B24 (A/L ratio = 0.1)

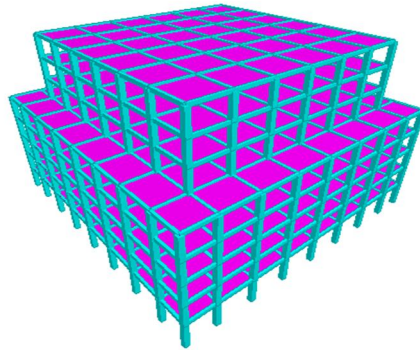


Fig. 2.12: 3D view of possibility case B24 (A/L ratio = 0.1)

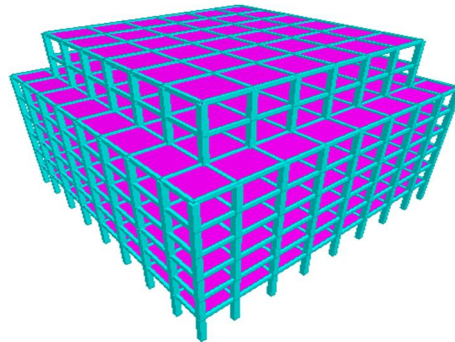


Fig. 2.13: 3D view of possibility case B25 (A/L ratio = 0.1)

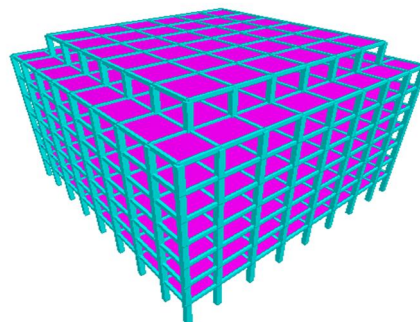


Fig. 2.14: 3D view of possibility case B26 (A/L ratio = 0.1)

The same modelling is done for G+6 storey structure having A/L ratio of 0.125 (C21-C26), 0.133 (D21-D26), 0.167 (E21-E26), 0.2 (F21-F26), and 0.233 (G21-G26).

III. RESULTS AND DISCUSSION

A. General

In the present research work, the effect of setbacks has been determined for G+6 storey structures having the length of 30m and 40m. This chapter is divided into two parts

Case A – Regular G+6 storey structure with no offset.

Cases B to G – Irregular G+6 storey structure having A/L ratio of 0.1 (Case B), 0.125 (Case C), 0.133 (Case D), 0.167 (Case E), 0.2 (Case F), and 0.233 (Case G) for each L=30m and L=40m.

TABLE 3.1 – CONFIGURATION AND POSSIBLE CASES FOR EACH A/L RATIO

| Case | A/L | For L=30m | For L=40m | Configurations |
|------|-----|-----------|-----------|----------------|
| B | 0.1 | B11 | B21 | 1+6 |
| | | B12 | B22 | 2+5 |
| | | B13 | B23 | 3+4 |
| | | B14 | B24 | 4+3 |
| | | B15 | B25 | 5+2 |
| | | B16 | B26 | 6+1 |

Table 3.1 illustrates that the setbacks have been generated from bottom to top storey. In B11 and B21, the setbacks have been generated at the first storey. In addition, B12/B22, B13/B23, B14/B24, B15/B25, and B16/B26 show that setbacks have been generated at the second, third, fourth, fifth, and sixth storey in the G+6 storey structure. The same cases have been developed for A/L ratios of 0.125, 0.133, 0.167, 0.2, and 0.233 for each L=30m and L=40m. The effect of setbacks has been determined in lateral displacement for each case and discussed below.

B. Results of Lateral Displacement

The results of lateral displacement of G+6 storey structure having L=30m and L=40m and their cases have been discussed (Refer to Annexure – I).

1) Results of Lateral Displacement for G+6 Storey Structure of L=30m

Six conditions have been developed in this research work by creating setbacks for each A/L ratio. Thus, thirty-six models have been developed and analyzed for the G+6 storey structure of L=30m. The results of lateral displacement of analyzed models have been discussed below.

a) Results of Lateral Displacement for Case B (L=30m)

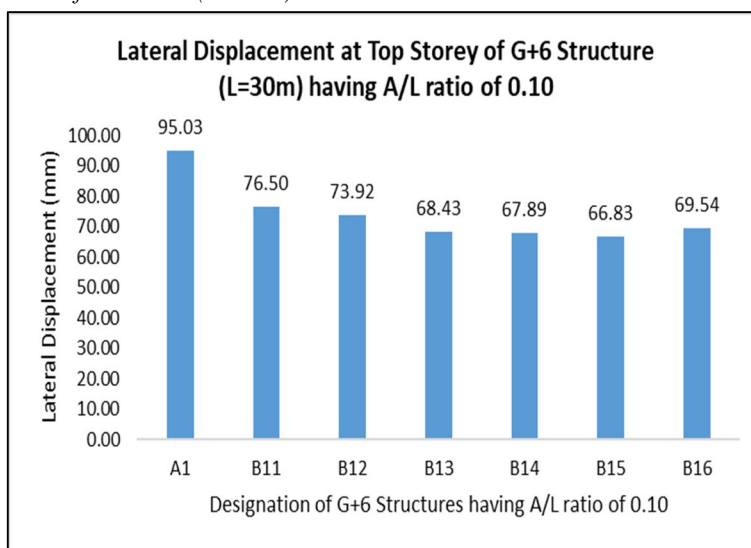


Fig. 3.1. Lateral displacement at the top storey of G+6 storey structure (L=30m) case B

Fig. 3.1 shows the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.10.

b) Results of Lateral Displacement for Case C (L=30m)

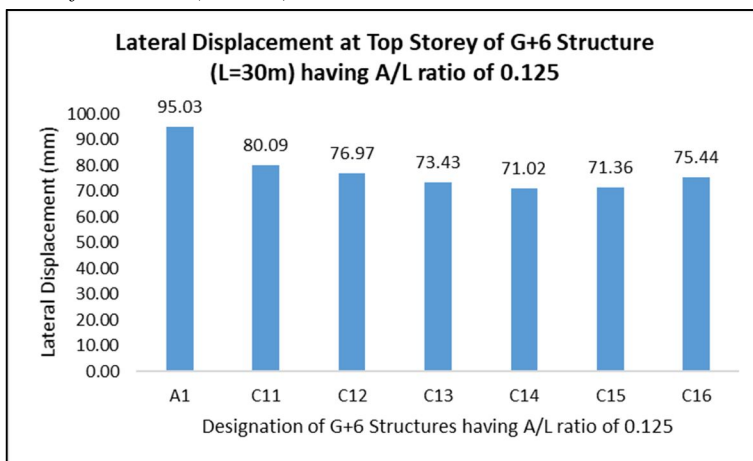


Fig. 3.2. Lateral displacement at the top storey of G+6 storey structure (L=30m) case C

Fig. 3.2 illustrates the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.125.

c) Results of Lateral Displacement for Case D (L=30m)

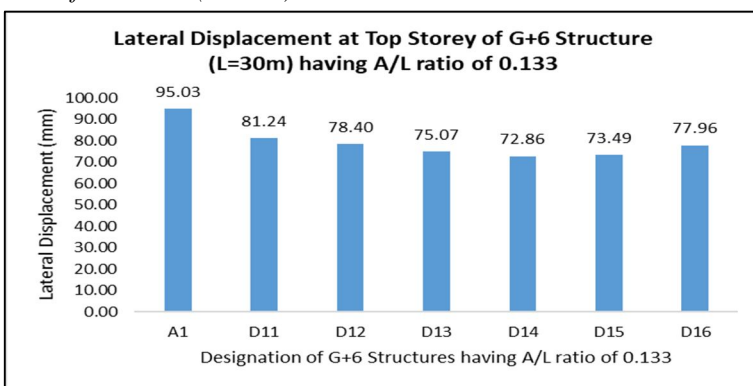


Fig. 3.3. Lateral displacement at the top storey of G+6 storey structure (L=30m) case D

Fig. 3.3 depicts the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.133

d) Results of Lateral Displacement for Case E (L=30m)

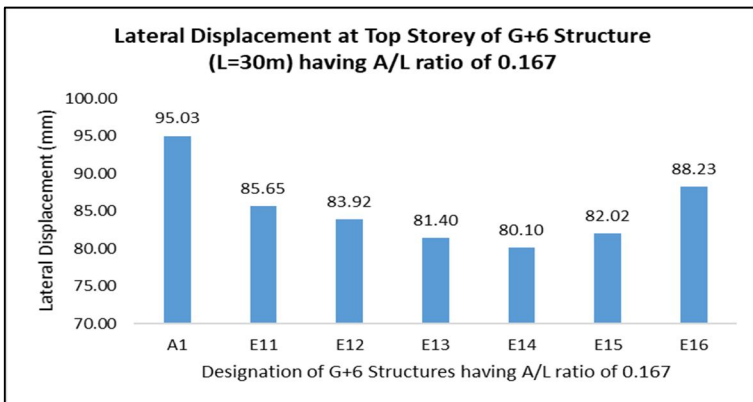


Fig. 3.4. Lateral displacement at the top storey of G+6 storey structure (L=30m) case E

Fig. 3.4 illustrates the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.167.

e) Results of Lateral Displacement for Case F (L=30m)

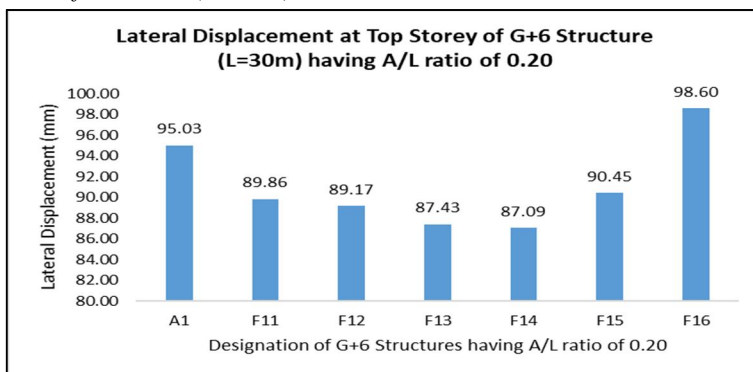


Fig. 3.5. Lateral displacement at the top storey of G+6 storey structure (L=30m) case F

Fig. 3.5 depicts the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.20

f) Results of Lateral Displacement for Case G (L=30m)

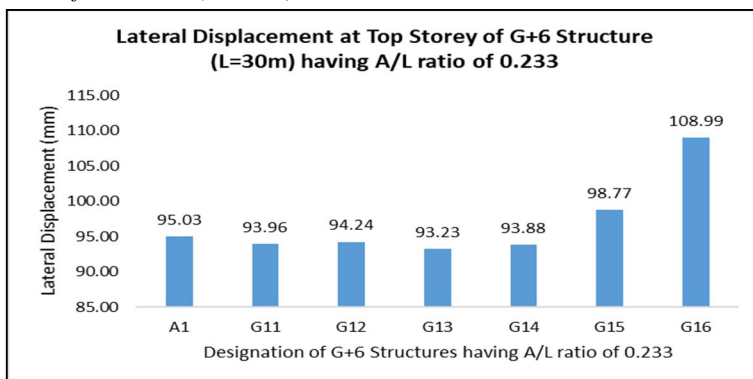


Fig. 3.6. Lateral displacement at the top storey of G+6 storey structure (L=30m) case G

Fig. 3.6 depicts the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.233.

2) Results of Lateral Displacement for G+6 Storey Structure of L=40m

Six conditions have been developed in this research work by generating setbacks for each A/L ratio. Thus, thirty-six models have been developed and analyzed for the G+6 storey structure of L=40m. The results of lateral displacement of analyzed models have been discussed below.

a) Results of Lateral Displacement for Case B (L=40m)

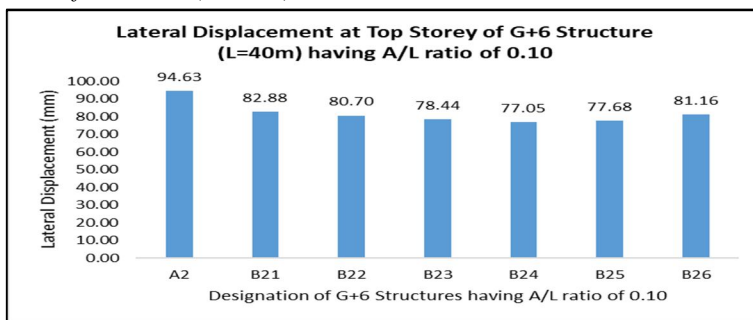


Fig. 3.7. Lateral displacement at the top storey of G+6 storey structure (L=40m) case B

Fig. 3.7 illustrates the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.10.

b) Results of Lateral Displacement for Case C (L=40m)

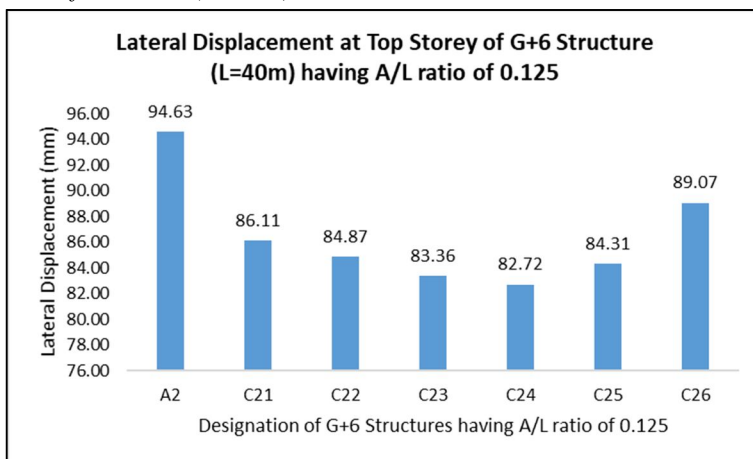


Fig. 3.8. Lateral displacement at the top storey of G+6 storey structure (L=40m) case C

Fig. 3.8 depicts the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.125.

c) Results of Lateral Displacement for Case D (L=40m)

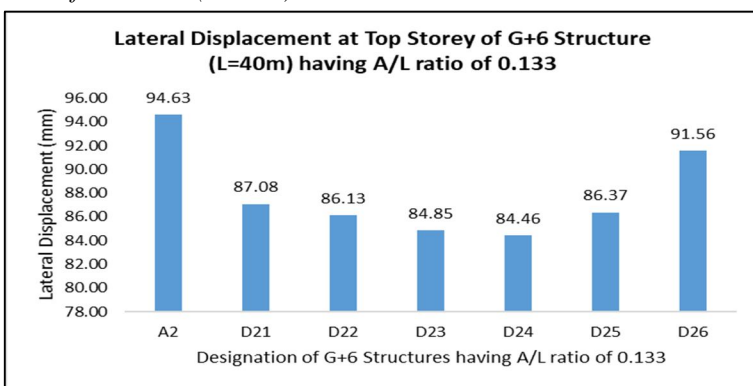


Fig. 3.9. Lateral displacement at the top storey of G+6 storey structure (L=40m) case D

Fig. 3.9 demonstrates the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.133.

d) Results of Lateral Displacement for Case E (L=40m)

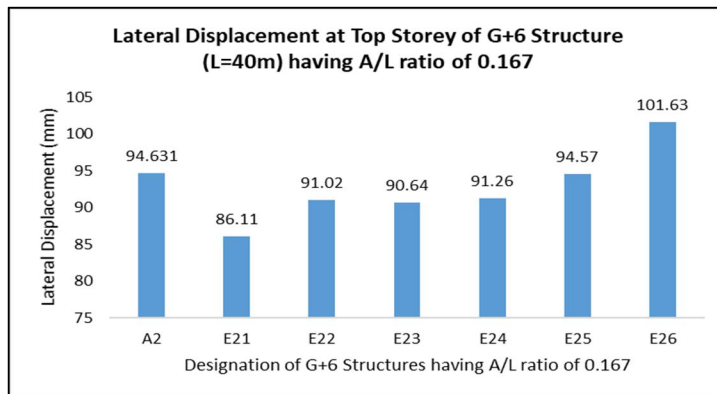


Fig. 3.10. Lateral displacement at the top storey of G+6 storey structure (L=40m) case E

Fig. 3.10 depicts the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.167.

e) Results of Lateral Displacement for Case F (L=40m)

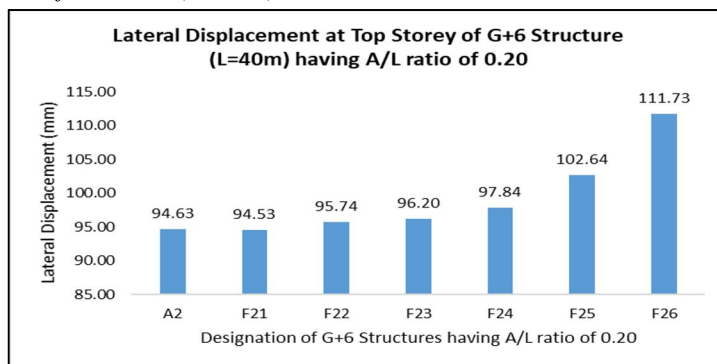


Fig. 3.11. Lateral displacement at the top storey of G+6 storey structure (L=40m) case F

Fig. 3.11 shows the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.20.

f) Results of Lateral Displacement for Case G (L=40m)

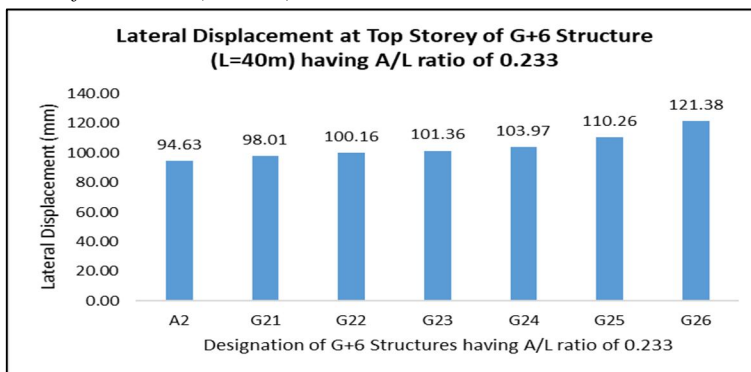


Fig. 3.12. Lateral displacement at the top storey of G+6 storey structure (L=40m) case G

Fig. 3.12 depicts the lateral displacement at the top storey of a G+6 structure with an A/L ratio of 0.233.

C. Comparison of Results of Lateral Displacement

The comparison of results of lateral displacement has been mapped for the G+6 storey structure of L=30m and L=40m.

1) Comparison of Results of Lateral Displacement for constant A/L ratio (L=30m)

Based on the constant A/L ratio, the lateral displacement of the G+6 storey structure of L=30m has been discussed separately.

a) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.1 (L=30m)

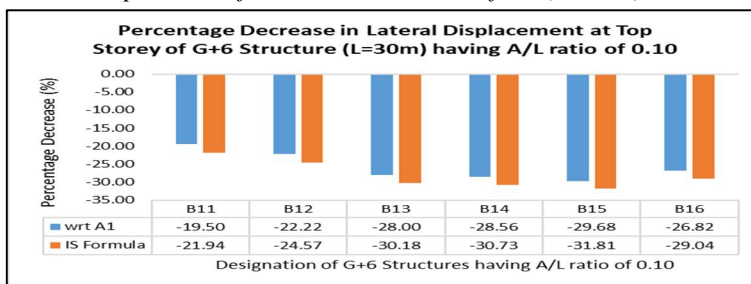


Fig. 3.13 Comparison of results of lateral displacement for A/L ratio of 0.1

Fig. 3.13 depicts the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.1.

b) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.125 (L=30m)

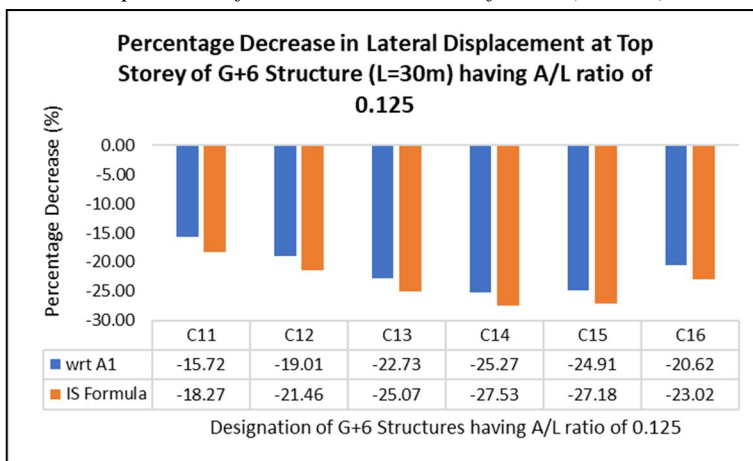


Fig. 3.14 Comparison of results of lateral displacement for A/L ratio of 0.125

Fig. 3.14 shows the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.125.

c) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.133 (L=30m)

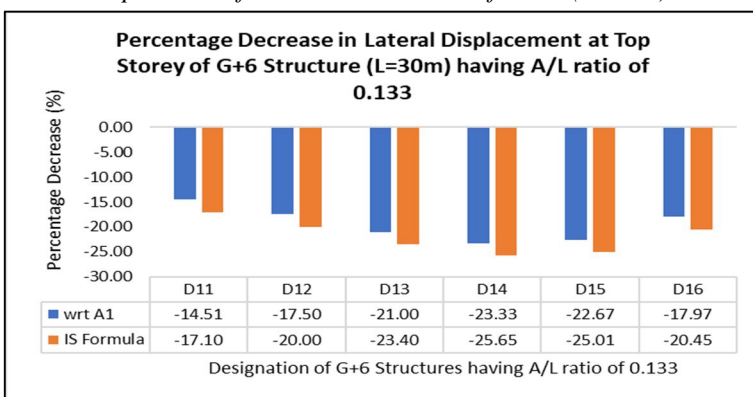


Fig. 3.15 Comparison of results of lateral displacement for A/L ratio of 0.133

Fig. 3.15 depicts the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.133.

d) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.167 (L=30m)

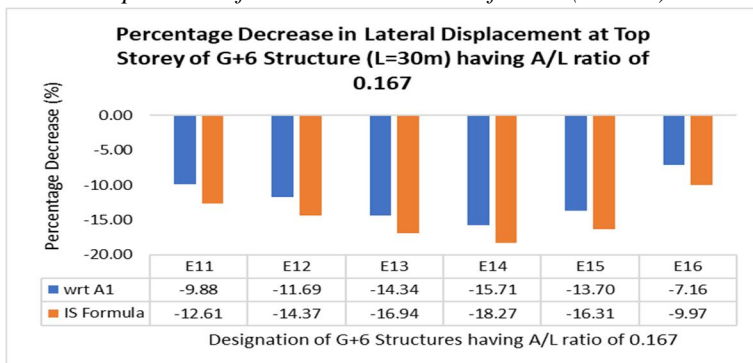


Fig. 3.16 Comparison of results of lateral displacement for A/L ratio of 0.167

Fig. 3.16 illustrates the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.167.

e) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.200 (L=30m)

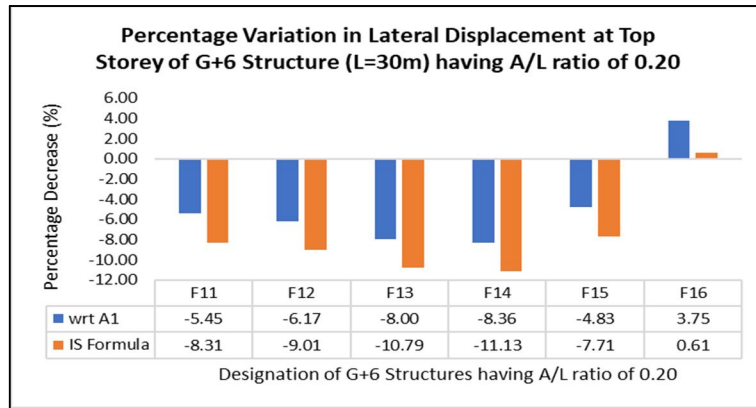


Fig. 3.17 Comparison of results of lateral displacement for A/L ratio of 0.200

Fig. 3.17 demonstrates the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.200.

f) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.233 (L=30m)

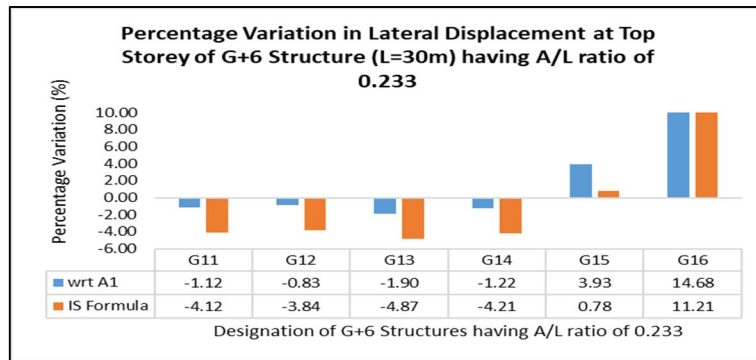


Fig. 3.18 Comparison of results of lateral displacement for A/L ratio of 0.233

Fig. 3.18 shows the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.233.

2) Comparison of Results of Lateral Displacement for constant A/L ratio (L=40m)

Based on the constant A/L ratio, the lateral displacement of the G+6 storey structure of L=40m has been discussed separately.

a) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.1 (L=40m)

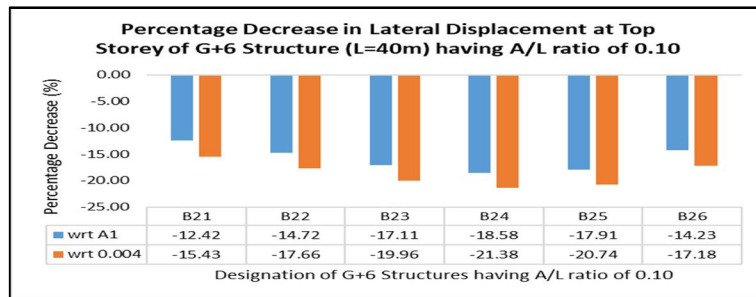


Fig. 3.19 Comparison of results of lateral displacement for A/L ratio of 0.1

Fig. 3.19 demonstrates the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.1.

b) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.125 (L=40m)

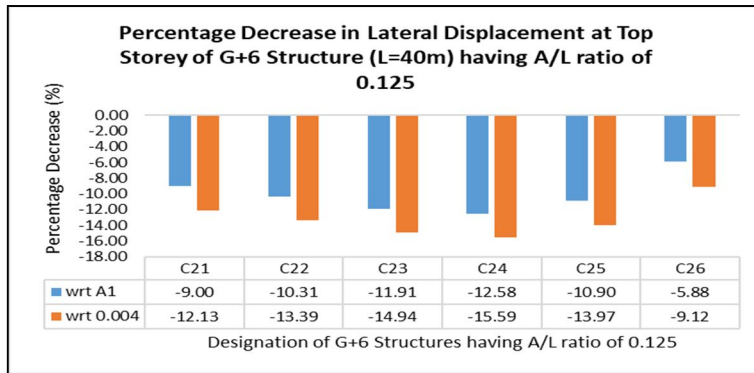


Fig. 3.20 Comparison of results of lateral displacement for A/L ratio of 0.125

Fig. 3.20 illustrates the percentage decrease in lateral displacement at the top storey structure (L=40m), having an A/L ratio of 0.125.

c) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.133 (L=40m)

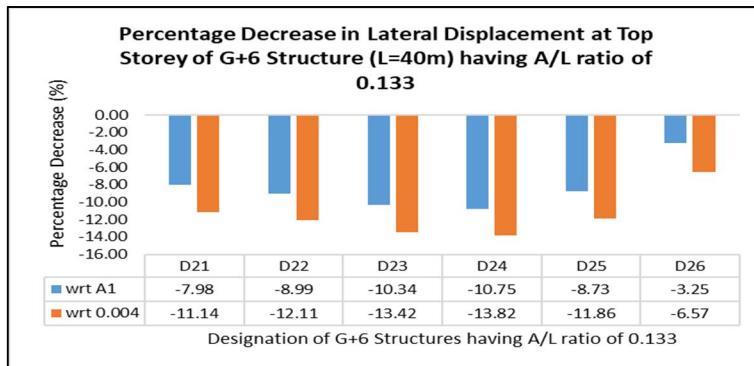


Fig. 3.21 Comparison of results of lateral displacement for A/L ratio of 0.133

Fig. 3.21 represents the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.133.

d) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.167 (L=40m)

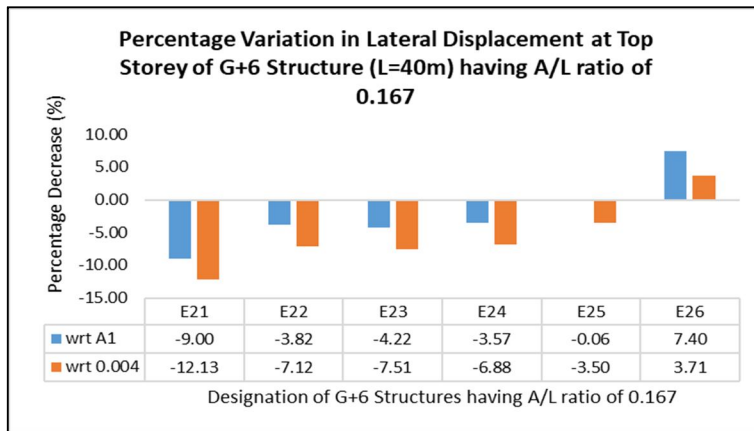


Fig. 3.22 Comparison of results of lateral displacement for A/L ratio of 0.167

Fig. 3.22 presents the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.167.

e) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.200 (L=40m)

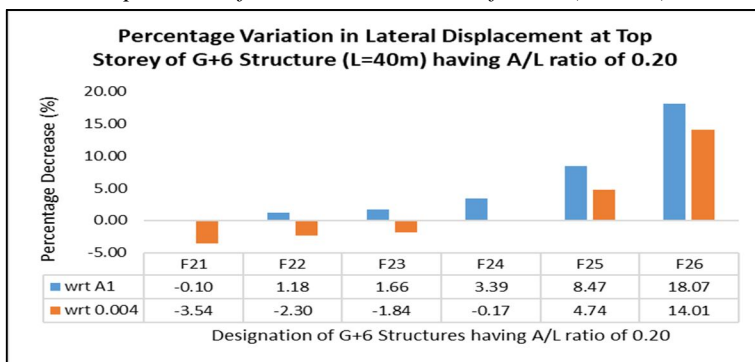


Fig. 3.23 Comparison of results of lateral displacement for A/L ratio of 0.200

Fig. 3.23 depicts the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.200.

f) Comparison of Results of Lateral Displacement for constant A/L ratio of 0.233 (L=40m)

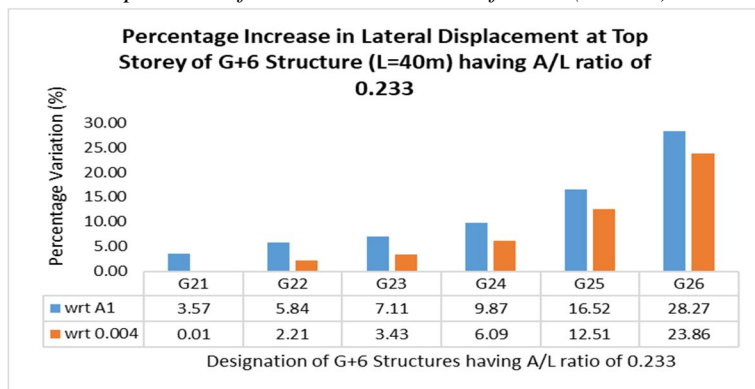


Fig. 3.24 Comparison of results of lateral displacement for A/L ratio of 0.233

Fig. 3.24 illustrates the percentage decrease in lateral displacement at the top storey structure (L=30m), having an A/L ratio of 0.233.

1) Comparison of Results of Lateral Displacement for Varying A/L ratio (L=30m)

Based on the varying A/L ratio, the lateral displacement of the G+6 storey structure of L=30m has been discussed separately.

a) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.1 (L=30m)

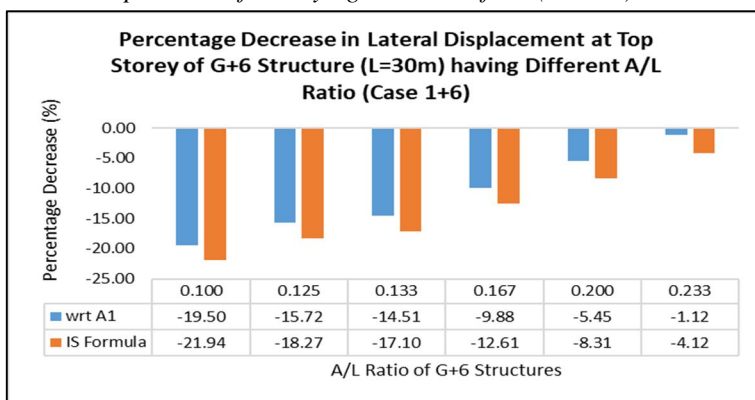


Fig. 3.25 Comparison of results of lateral displacement for varying A/L ratio (case 1+6, L=30m)

Fig. 3.25 shows the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=30m), having varying A/L ratios (case 1+6).

b) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.125 (L=30m)

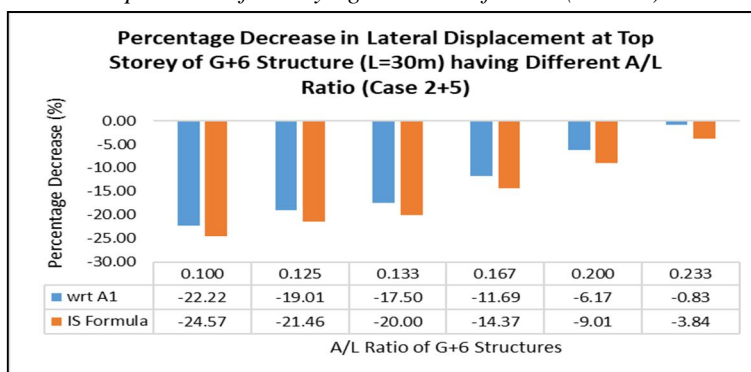


Fig. 3.26 Comparison of results of lateral displacement for varying A/L ratio (case 2+5, L=30m)

Fig. 3.26 illustrates the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=30m), having varying A/L ratios.

c) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.133 (L=30m)

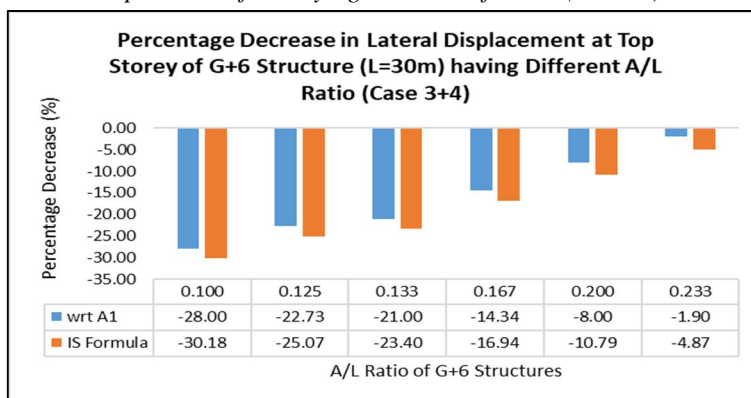


Fig. 3.27 Comparison of results of lateral displacement for varying A/L ratio (case 3+4, L=30m)

Fig. 3.27 shows the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=30m), having varying A/L ratios.

d) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.167 (L=30m)

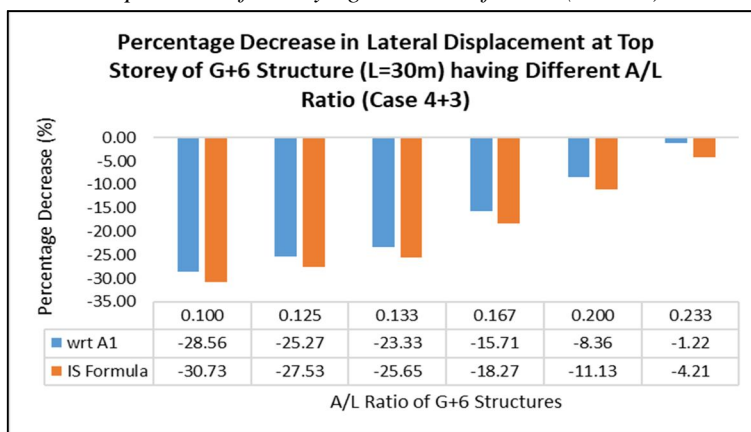


Fig. 3.28 Comparison of results of lateral displacement for varying A/L ratio (case 4+3, L=30m)

Fig. 3.28 presents the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=30m), having varying A/L ratios.

e) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.200 (L=30m)

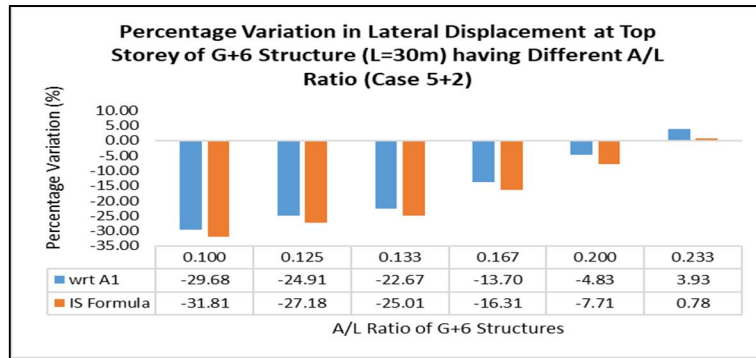


Fig. 3.29 Comparison of results of lateral displacement for varying A/L ratio (case 5+2, L=30m)

Fig. 3.29 presents the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=30m), having varying A/L ratios.

f) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.233 (L=30m)

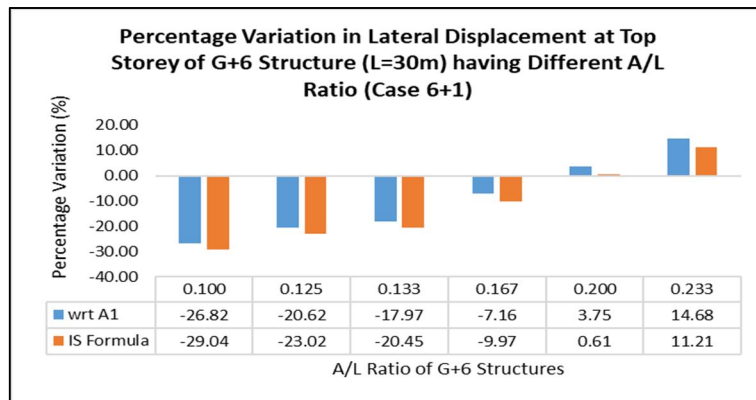


Fig. 3.30 Comparison of results of lateral displacement for varying A/L ratio (case 6+1, L=30m)

Fig. 3.30 shows the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=30m), having varying A/L ratios.

2) Comparison of Results of Lateral Displacement for Varying A/L ratio (L=40m)

Based on the varying A/L ratio, the lateral displacement of the G+6 storey structure of L=40m has been discussed separately.

a) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.1 (L=40m)

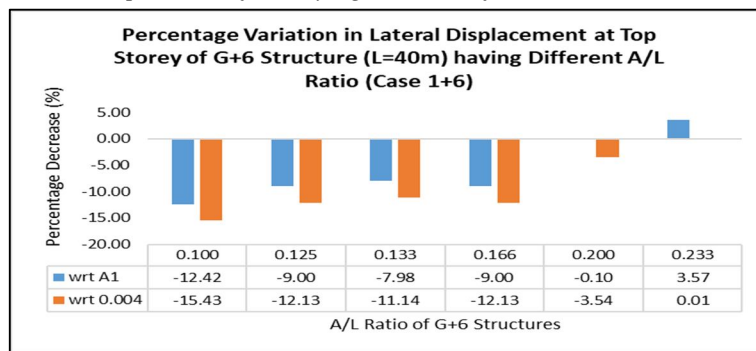


Fig. 3.31 Comparison of results of lateral displacement for varying A/L ratio (case 1+6, L=40m)

Fig. 3.31 shows the percentage variation in lateral displacement at the top storey of the G+6 structure (L=40m), having varying A/L ratios (case 1+6).

b) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.125 (L=40m)

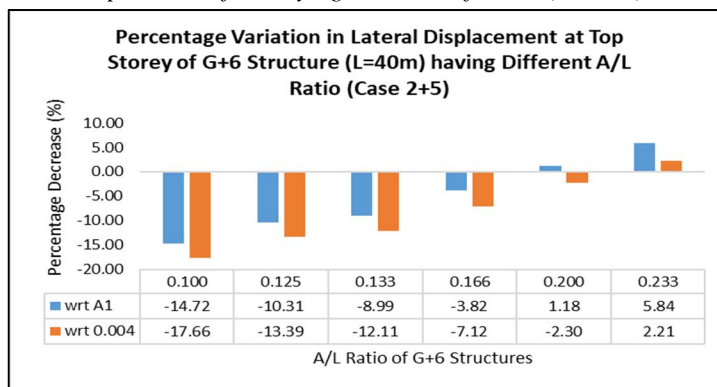


Fig. 3.32 Comparison of results of lateral displacement for varying A/L ratio (case 2+5, L=40m)

Fig. 3.32 illustrates the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=40m), having varying A/L ratios.

c) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.133 (L=40m)

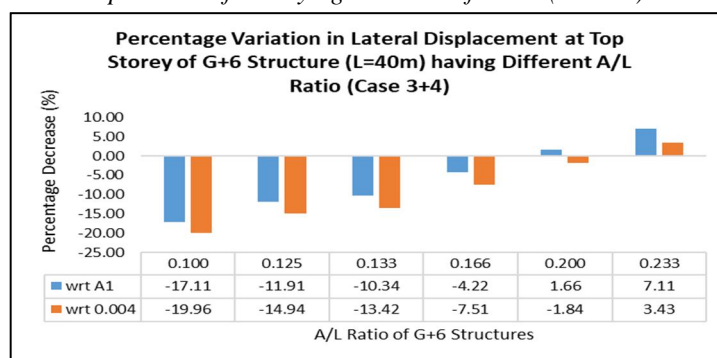


Fig. 3.33 Comparison of results of lateral displacement for varying A/L ratio(case 3+4, L=40m)

Fig. 3.33 depicts the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=40m), having varying A/L ratios.

d) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.167 (L=40m)

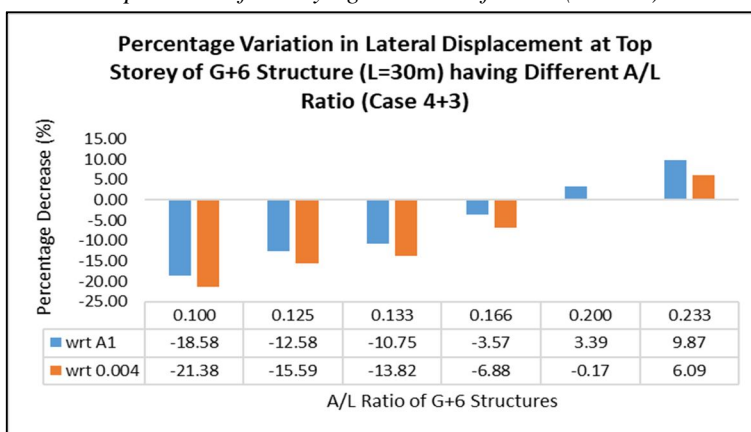


Fig. 3.34 Comparison of results of lateral displacement for varying A/L ratio (case 4+3, L=40m)

Fig. 3.34 presents the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=40m), having varying A/L ratios

e) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.200 (L=40m)

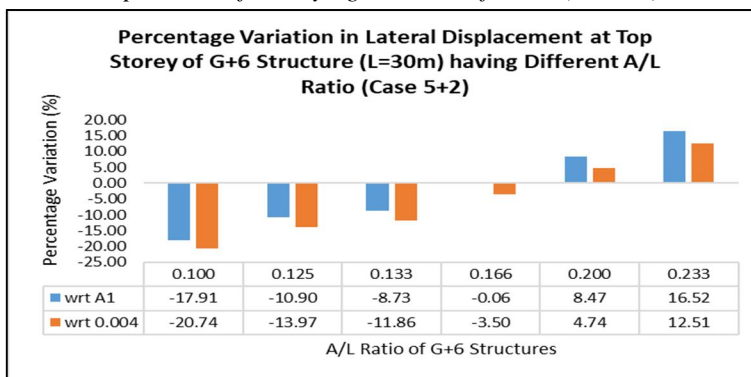


Fig. 3.35 Comparison of results of lateral displacement for varying A/L ratio (case 5+2, L=40m)

Fig. 3.35 depicts the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=40m), having varying A/L ratios.

f) Comparison of Results of Lateral Displacement for varying A/L ratio of 0.233 (L=40m)

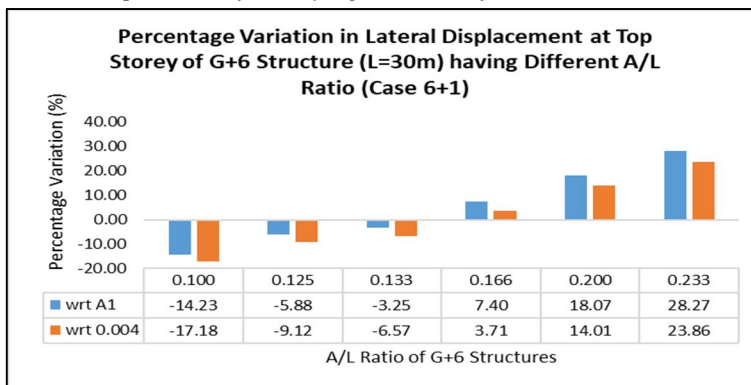


Fig. 3.36 Comparison of results of lateral displacement for varying A/L ratio (case 6+1, L=40m)

Fig. 3.36 shows the percentage decrease in lateral displacement at the top storey of the G+6 structure (L=40m), having varying A/L ratios.

IV. CONCLUSIONS

The following conclusions are mapped from the comparative study of lateral displacement results.

- 1) The lateral displacement results of the G+6 storey structure having an A/L ratio of 0.1 to 0.167 (L=30m) show that the lateral displacement increases if the setbacks are provided up to the fifth and sixth storey. These kinds of structures are having lateral displacements within permissible limits as per IS code and hence, safe. Furthermore, the G+6 storey structure having an A/L ratio of 0.2 and 0.233 (L=30m) achieves more lateral displacement than the regular structure and the Indian standards, which makes the structure unsafe. G+6 storey structures having an A/L ratio of 0.2 and 0.233 are unsafe if the setbacks are provided at the sixth and fifth storey, respectively.
- 2) On the other hand, lateral displacement results of the G+6 storey structure having an A/L ratio of 0.1 to 0.133 (L=40m) show that the lateral displacement increases if the setbacks are provided up to the fifth and sixth storey. These kinds of structures are having lateral displacement within permissible limits as per IS code and hence, safe. Furthermore, the G+6 storey structure with an A/L ratio of 0.2 and 0.233 (L=40m) achieves more lateral displacement than the regular structure and the Indian standards, representing the structure as unsafe. The G+6 storey structure having an A/L ratio of 0.233 is identified as a critical structure because the lateral displacement is found more than regular structure and codal provisions, i.e., 98.01mm (case 1+6), 100.16mm (case 2+5), 101.36mm (case 3+4), 103.97mm (case 4+3), 110.26mm (case 5+2), 121.38mm (case 6+1).

- 3) The comparison of G+6 storey structure having L=30m and L=40m shows that if the length of the structure increases, the A/L ratio decreases for safe design and structure. In other words, the G+6 storey structure (L=30m) is safe for A/L ratios of 0.1, 0.125, 0.133, and 0.167, but the G+6 storey structure (L=40m) is only safe for A/L ratios of 0.1, 0.125, and 0.133.
- 4) The comparison of results of lateral displacement for G+6 storey structure with varying A/L ratios shows that lateral displacement increases with A/L ratio in both L=30 and L=40m structures.
- 5) Finally, the present study has concluded that the A/L ratio of setbacks affects the lateral displacement of the structure. The G+6 storey structure having an A/L ratio of less than 0.167 (for L=30m) and 0.133 (for L=40m) are safe as per the Indian provisions and may be constructed.

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ANNEXURE

Results of Lateral Displacement for G+6 Storey Structure (L=30m)

| Case | L=30m | | A/L Ratio | Configuration | Lateral Displacement (mm) |
|------|-------|----|-----------|---------------|---------------------------|
| | A | L | | | |
| A1 | 0m | 30 | 0 | Bare Frame | 95.03 |
| B11 | 3m | 30 | 0.10 | 1 + 6 | 76.50 |
| B12 | 3m | 30 | 0.10 | 2 + 5 | 73.92 |
| B13 | 3m | 30 | 0.10 | 3 + 4 | 68.43 |
| B14 | 3m | 30 | 0.10 | 4 + 3 | 67.89 |
| B15 | 3m | 30 | 0.10 | 5 + 2 | 66.83 |
| B16 | 3m | 30 | 0.10 | 6 + 1 | 69.54 |
| C11 | 3.75m | 30 | 0.125 | 1 + 6 | 80.09 |

| | | | | | |
|-----|-------|----|-------|-------|--------|
| C12 | 3.75m | 30 | 0.125 | 2 + 5 | 76.97 |
| C13 | 3.75m | 30 | 0.125 | 3 + 4 | 73.43 |
| C14 | 3.75m | 30 | 0.125 | 4 + 3 | 71.02 |
| C15 | 3.75m | 30 | 0.125 | 5 + 2 | 71.36 |
| C16 | 3.75m | 30 | 0.125 | 6 + 1 | 75.44 |
| D11 | 4m | 30 | 0.133 | 1 + 6 | 81.24 |
| D12 | 4m | 30 | 0.133 | 2 + 5 | 78.40 |
| D13 | 4m | 30 | 0.133 | 3 + 4 | 75.07 |
| D14 | 4m | 30 | 0.133 | 4 + 3 | 72.86 |
| D15 | 4m | 30 | 0.133 | 5 + 2 | 73.49 |
| D16 | 4m | 30 | 0.133 | 6 + 1 | 77.96 |
| E11 | 5m | 30 | 0.166 | 1 + 6 | 85.65 |
| E12 | 5m | 30 | 0.166 | 2 + 5 | 83.92 |
| E13 | 5m | 30 | 0.166 | 3 + 4 | 81.40 |
| E14 | 5m | 30 | 0.166 | 4 + 3 | 80.10 |
| E15 | 5m | 30 | 0.166 | 5 + 2 | 82.02 |
| E16 | 5m | 30 | 0.166 | 6 + 1 | 88.23 |
| F11 | 6m | 30 | 0.200 | 1 + 6 | 89.86 |
| F12 | 6m | 30 | 0.200 | 2 + 5 | 89.17 |
| F13 | 6m | 30 | 0.200 | 3 + 4 | 87.43 |
| F14 | 6m | 30 | 0.200 | 4 + 3 | 87.09 |
| F15 | 6m | 30 | 0.200 | 5 + 2 | 90.45 |
| F16 | 6m | 30 | 0.200 | 6 + 1 | 98.60 |
| G11 | 7m | 30 | 0.233 | 1 + 6 | 93.96 |
| G12 | 7m | 30 | 0.233 | 2 + 5 | 94.24 |
| G13 | 7m | 30 | 0.233 | 3 + 4 | 93.23 |
| G14 | 7m | 30 | 0.233 | 4 + 3 | 93.88 |
| G15 | 7m | 30 | 0.233 | 5 + 2 | 98.77 |
| G16 | 7m | 30 | 0.233 | 6 + 1 | 108.99 |

Results of Lateral Displacement for G+6 Storey Structure (L=40m)

| Case | L=40m | | A/L Ratio | Configuration | Lateral Displacement (mm) |
|------|-------|----|-----------|---------------|---------------------------|
| | A | L | | | |
| A2 | 0m | 40 | 0 | Bare Frame | 94.63 |
| B21 | 4m | 40 | 0.10 | 1 + 6 | 82.88 |
| B22 | 4m | 40 | 0.10 | 2 + 5 | 80.70 |
| B23 | 4m | 40 | 0.10 | 3 + 4 | 78.44 |
| B24 | 4m | 40 | 0.10 | 4 + 3 | 77.05 |
| B25 | 4m | 40 | 0.10 | 5 + 2 | 77.68 |
| B26 | 4m | 40 | 0.10 | 6 + 1 | 81.16 |
| C21 | 5m | 40 | 0.125 | 1 + 6 | 86.11 |
| C22 | 5m | 40 | 0.125 | 2 + 5 | 84.87 |
| C23 | 5m | 40 | 0.125 | 3 + 4 | 83.36 |
| C24 | 5m | 40 | 0.125 | 4 + 3 | 82.72 |
| C25 | 5m | 40 | 0.125 | 5 + 2 | 84.31 |
| C26 | 5m | 40 | 0.125 | 6 + 1 | 89.07 |
| D21 | 5.32m | 40 | 0.133 | 1 + 6 | 87.08 |
| D22 | 5.32m | 40 | 0.133 | 2 + 5 | 86.13 |



| | | | | | |
|-----|-------|----|-------|-------|--------|
| D23 | 5.32m | 40 | 0.133 | 3 + 4 | 84.85 |
| D24 | 5.32m | 40 | 0.133 | 4 + 3 | 84.46 |
| D25 | 5.32m | 40 | 0.133 | 5 + 2 | 86.37 |
| D26 | 5.32m | 40 | 0.133 | 6 + 1 | 91.56 |
| E21 | 6.64m | 40 | 0.166 | 1 + 6 | 86.11 |
| E22 | 6.64m | 40 | 0.166 | 2 + 5 | 91.02 |
| E23 | 6.64m | 40 | 0.166 | 3 + 4 | 90.64 |
| E24 | 6.64m | 40 | 0.166 | 4 + 3 | 91.26 |
| E25 | 6.64m | 40 | 0.166 | 5 + 2 | 94.57 |
| E26 | 6.64m | 40 | 0.166 | 6 + 1 | 101.63 |
| F21 | 8m | 40 | 0.200 | 1 + 6 | 94.53 |
| F22 | 8m | 40 | 0.200 | 2 + 5 | 95.74 |
| F23 | 8m | 40 | 0.200 | 3 + 4 | 96.20 |
| F24 | 8m | 40 | 0.200 | 4 + 3 | 97.84 |
| F25 | 8m | 40 | 0.200 | 5 + 2 | 102.64 |
| F26 | 8m | 40 | 0.200 | 6 + 1 | 111.73 |
| G21 | 9.32m | 40 | 0.233 | 1 + 6 | 98.01 |
| G22 | 9.32m | 40 | 0.233 | 2 + 5 | 100.16 |
| G23 | 9.32m | 40 | 0.233 | 3 + 4 | 101.36 |
| G24 | 9.32m | 40 | 0.233 | 4 + 3 | 103.97 |
| G25 | 9.32m | 40 | 0.233 | 5 + 2 | 110.26 |
| G26 | 9.32m | 40 | 0.233 | 6 + 1 | 121.38 |



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