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EFFECTS OF STAIRCASE ON THE SEISMIC PERFORMANCE OF RCC FRAME BUILDINGS

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Abstract — *In the present paper, the effects of staircase on the seismic performance of the RCC frame buildings of different heights and different plans have been studied. Generally, the stair model is not included in the analysis of RC frame buildings. Due to the rigidity of inclined slab and of short columns around staircase, beams and columns are often characterized by a high seismic demand. The identification of the weakest elements of the structure, the failure type considering the presence of the stairs, and their contribution in the non linear performance of RC frame buildings are some of the areas on which the present paper has presented. For analysis and design, Etab v.9 has been used. Performances of both categories of the buildings have been evaluated through Response Spectrum Method.*

Keywords- *Response Spectrum Method, Staircase, Story Drift, Story Displacement.*

I. INTRODUCTION

In RC frame buildings, there are mainly two structural systems, Primary structural system and secondary structural system. The primary structural system to resist lateral load are beams and columns. Besides, primary structural system, some elements also contribute to lateral load resistance. These elements fall in the category of secondary systems. Secondary system can be structural secondary like staircase, structural partition etc and non-structural secondary like storage tanks, machinery etc A special case of structural secondary members which are normally designed for non seismic force are concrete staircase

In the present study, the effects of staircase on the seismic performance of the RC frame buildings of different heights and different plans have been studied. In general the presence of a stair creates a discontinuity in a reinforced concrete frame made of beams and columns. From geometrical point of view, a stair is composed by inclined elements (beams and slabs) and by short (squat) columns. These elements contribute to increase the Stiffness of the building for these reasons the elements that constitute the stair are often characterized by a high seismic demand. The short columns are subjected to high shear force that can lead to a premature brittle failure. The inclined beams are subjected by high variation in axial force than major variations are come in the resistance and deformability of all these elements. The identification of the vulnerable elements of the structure, the failure type with the presence of the stairs, and the contribution of stair in the nonlinear performance of RC frame buildings are some of the points have been considered in this study.

II. BUILDING MODELING

In the present project, the buildings with doglegged stair with 4 and10 story are referred without model as A-1, A-2 and the building with stair model as B-1, B-2 respectively with a 3.2 meter height for each story, regular in plan is modeled. These building where design in compliance to the Indian Code of Practice for Seismic Resistant Design of Building. The building are assume to be fixed at the base and floor s acts as rigid diaphragms. The section of structural elements are square and rectangular and there dimensions are same for different building. Story height for different building is assumed to be constant including the ground story. The buildings are model using software EAB v 9.5.0. Location of staircase is at centre in all buildings. Models are studied in zone III comparing lateral displacement, story drift, story shear, bending moment, axial force in column and beam in all zones for all models.

Building details are as follows:

1. Grade of concrete used is M20 and grade of steel is Fe 415
2. Floor to floor height is 3.2m
3. Plinth height above foundation is 1.5m
4. Slab thickness (S1) is 120mm.
5. Inclined slab thickness is 150mm.
6. External wall thickness is 300 mm and internal wall thickness is 110mm
7. Live load on floor is 3kN/m^2 and live load on roof is 3 KN/m^2
8. Site located in Seismic zone III
9. Building is resting on medium soil (II).

10. Take importance factor as 1.
11. Building frame type is special Moment Resisting Frame.
12. Density of concrete is 25 KN/m^3.
13. Density of masonry wall is 20 KN/m^3

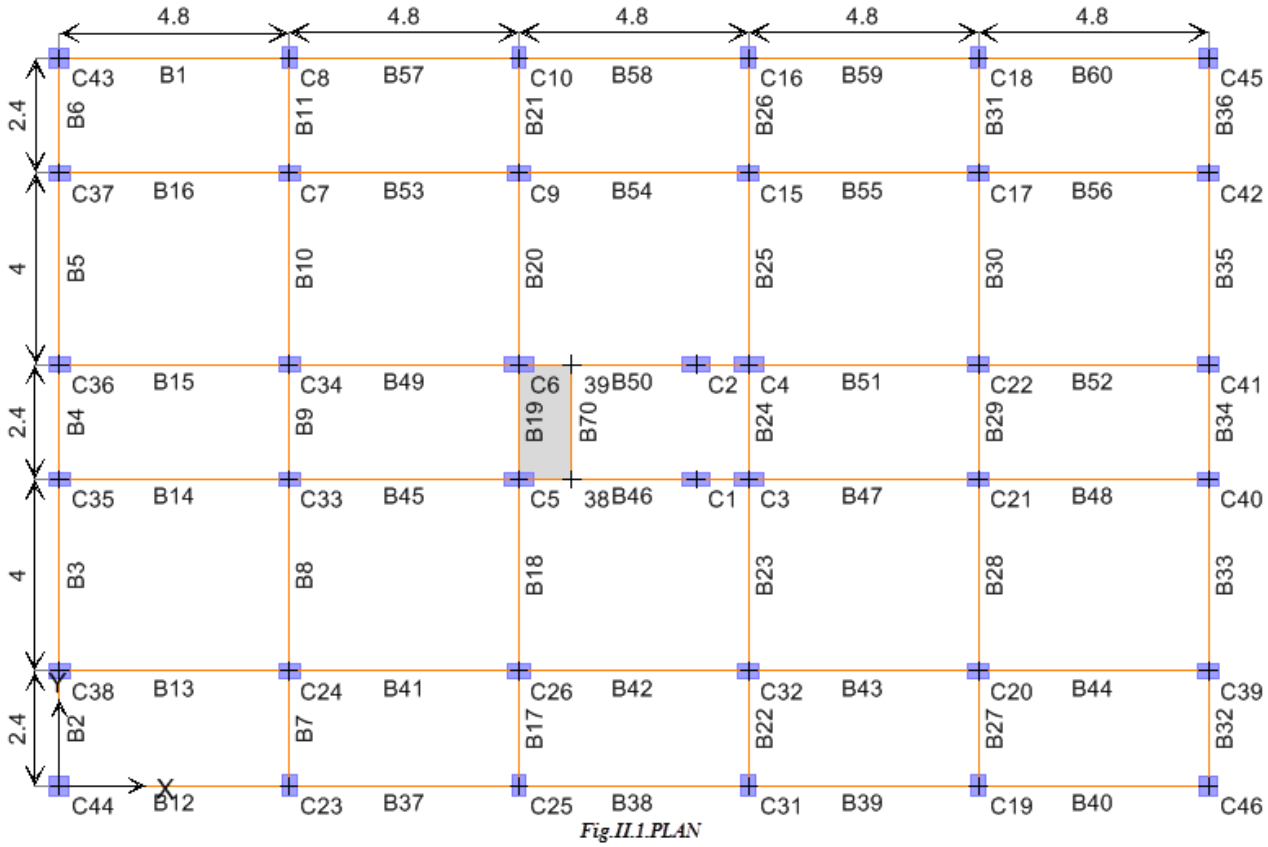


Fig.II.1.PLAN

Element sizes uses for modelling are as follows:

tnemelE	Size(M)
C1	0.6X0.3
C2	0.45X0.3
C3	0.4X0.4
FB1	0.45X0.3
FB2	0.3X0.3
PB1	0.45X0.3
PB2	0.3X0.3

III.RESULTS AND DISCUSSION

III.1: RESULT FOR MODELS A-1 AND B-1 TYPE OF BUILDING

III.1.1: COMPARISON OF STOREY DISPLACEMENT :-

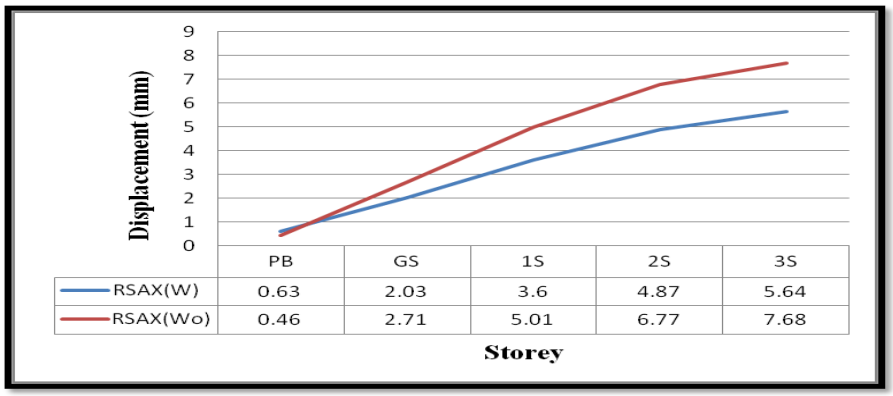


FIG. 1.1.X GRAPHICAL REPRESENTATION OF STOREY DISPLACEMENT WITH AND WITHOUT STAIR MODEL.(X- DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 26% to 28% .Only at the plinth the displacement in the with stair model building increase by 27% only.

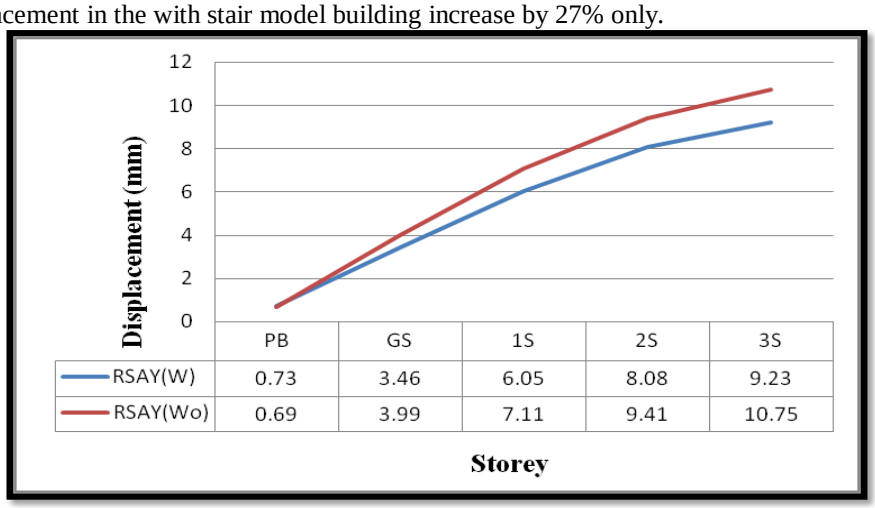
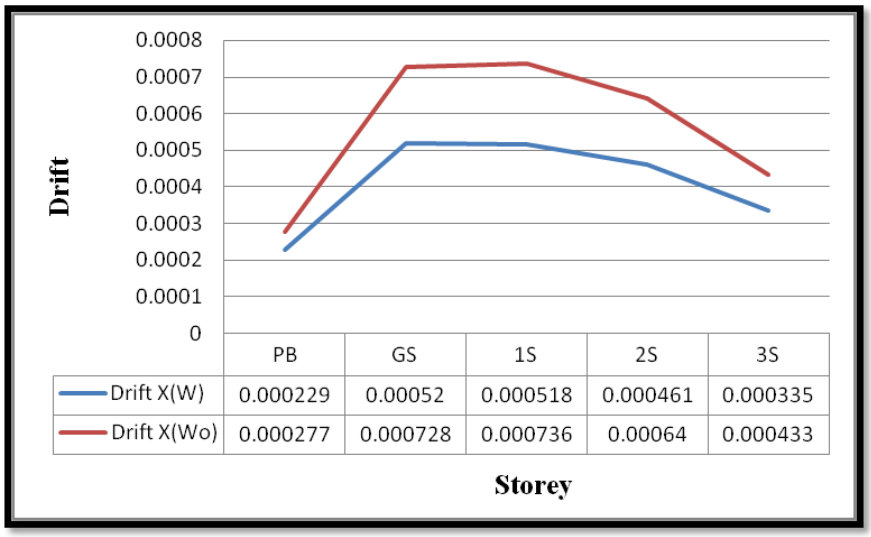


FIG. 1.1.Y GRAPHICAL REPRESENTATION OF STOREY DISPLACEMENT WITH AND WITHOUT STAIR MODEL. (Y- DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 24% to 25% .Only at the plinth the displacement in the with stair model building increase by 5.5% only.

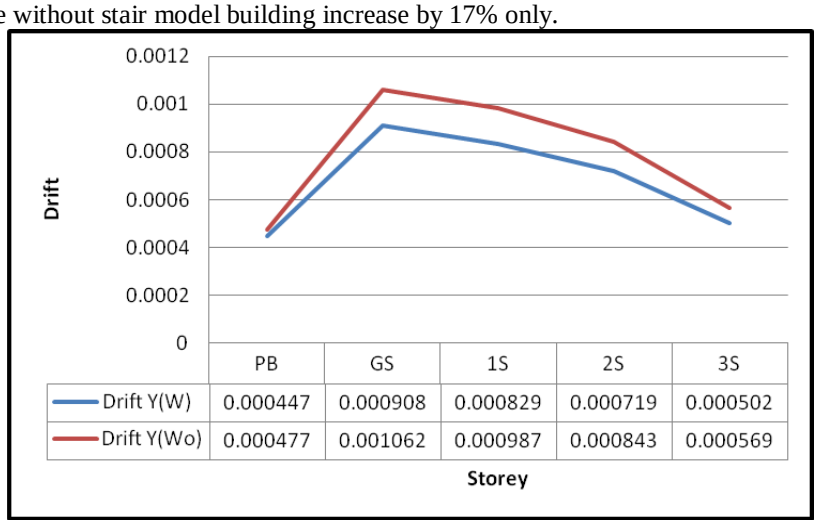
III.1.2: COMPARISON OF STOREY DRIFT :-



	PB	GS	1S	2S	3S
Drift X(W)	0.000229	0.00052	0.000518	0.000461	0.000335
Drift X(Wo)	0.000277	0.000728	0.000736	0.00064	0.000433

FIG. 1.2.X GRAPHICAL REPRESENTATION OF STOREY DRIFT WITH AND WITHOUT STAIR MODEL.(X-DIRECTION)

In the above graph a drift values decrease due to modelling of stair. The values varies by 22% to 29% .Only at the plinth the displacement in the without stair model building increase by 17% only.



	PB	GS	1S	2S	3S
Drift Y(W)	0.000447	0.000908	0.000829	0.000719	0.000502
Drift Y(Wo)	0.000477	0.001062	0.000987	0.000843	0.000569

FIG. 1.2.Y GRAPHICAL REPRESENTATION OF STOREY DRIFT WITH AND WITHOUT STAIR MODEL.(Y-DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 12% to 16% .Only at the plinth the displacement in the without stair model building increase by 6% only.

III.1.3: COMPARISON OF STOREY SHEAR :-

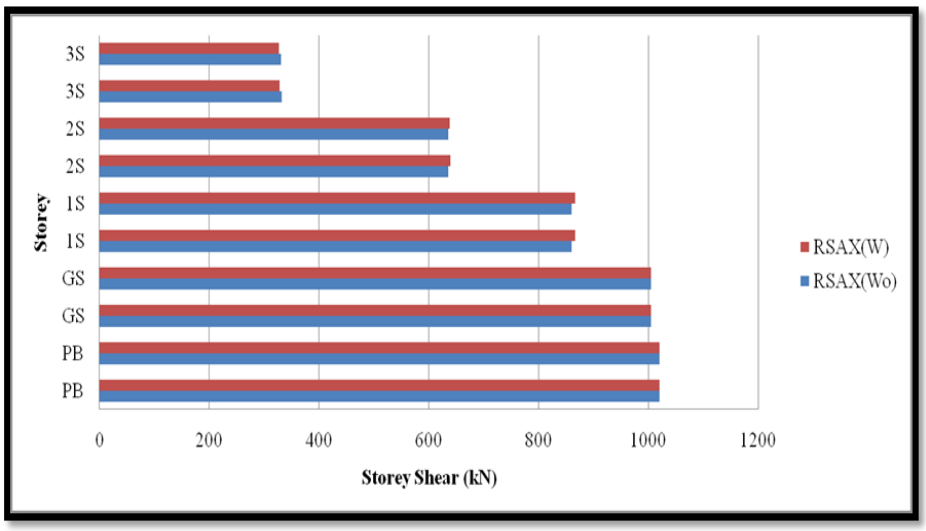


FIG. 1.3.X GRAPHICAL REPRESENTATION OF STOREY SHEAR WITH AND WITHOUT STAIR MODEL.(X-DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 0.8% to 1.2% .Only at the plinth the displacement in the without stair model building increase by 0.03% only.

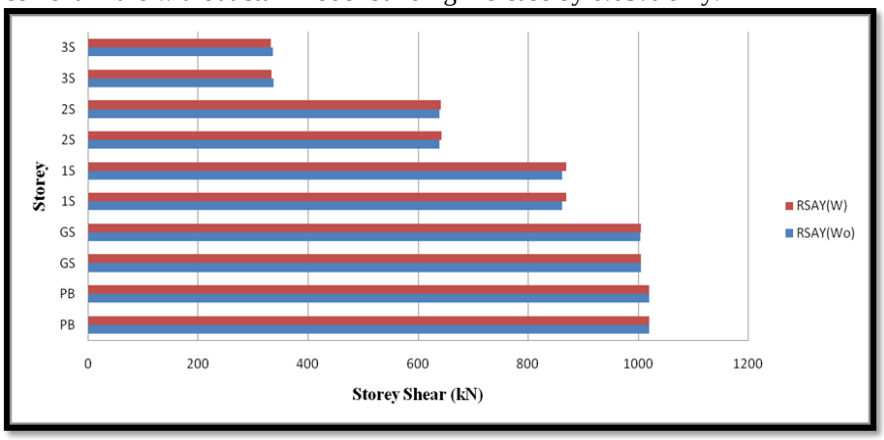


FIG. 1.3.Y GRAPHICAL REPRESENTATION OF STOREY SHEAR WITH AND WITHOUT STAIR MODEL.(Y-DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 0.8% to 1.2% .Only at the base the displacement in the without stair model building increase by 0.03% only.

III.1.4: COMPARISON OF BENDING MOMENT FOR COLUMN C1 AND C5 :-

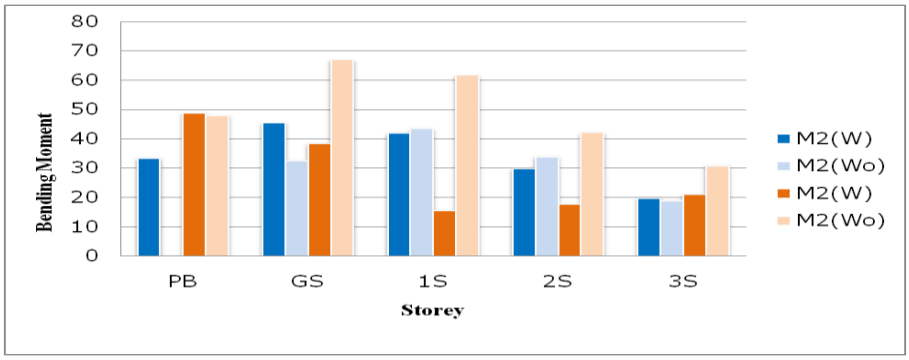


FIG. 1.4 GRAPHICAL REPRESENTATION OF BENDING MOMENT WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a displacement values decrease due to modelling of stair. The displacement varies by 68% to 99%. In M2 (W) value decreases up to 1st storey, after 1st storey value increases.

III.1.5: COMPARISON OF SHEAR FORCE FOR COLUMN C1 AND C5 :-

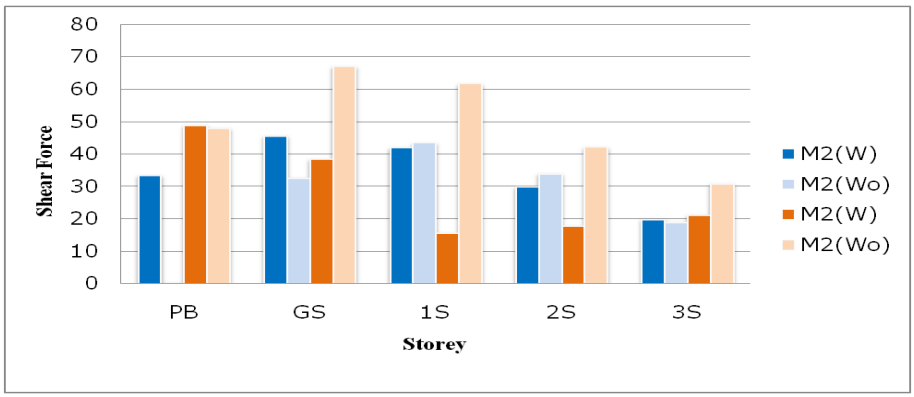


FIG.1.5 GRAPHICAL REPRESENTATION OF SHEAR FORCE WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a displacement values decrease due to modelling of stair. The value varies by 17% to 99%. The values in without modelling of staircase are much higher than with modelling.

III.1.6: COMPARISON OF AXIAL FORCE FOR COLUMN C1 AND C5 :-

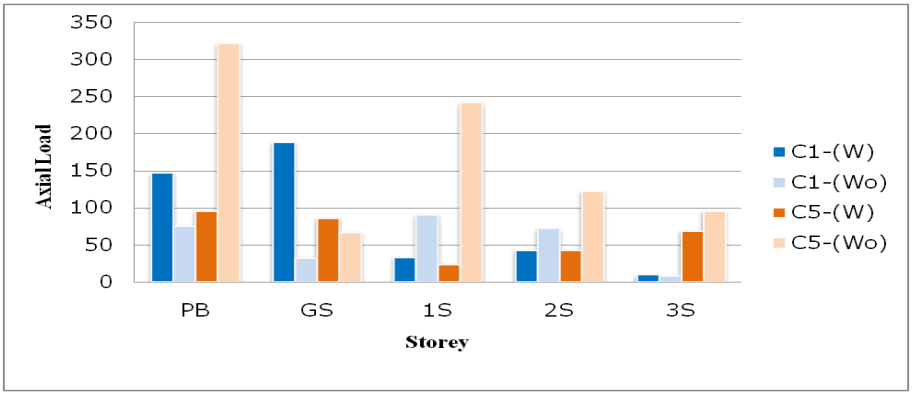


FIG. 1.6 GRAPHICAL REPRESENTATION OF AXIAL FORCE WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a axial values decrease due to modelling of stair. The values varies by 25% to 27%.

III.1.7: COMPARISON OF PERCENTAGE OF STEEL FOR COLUMN C1 AND C5 :-

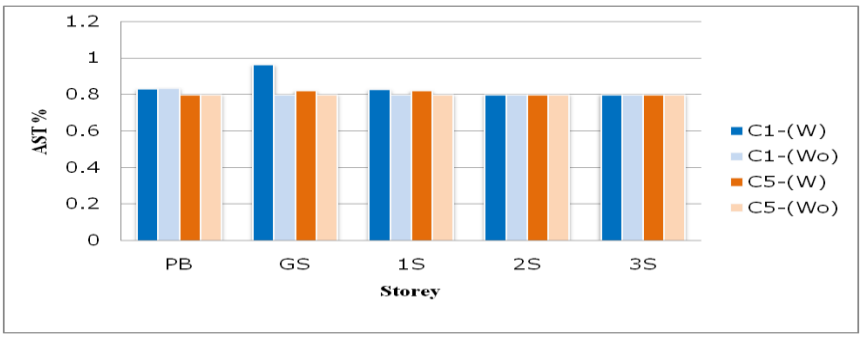


FIG. 1.7 GRAPHICAL REPRESENTATION OF PERCENTAGE OF STEEL WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a Ast% values decrease due to modelling of stair. The value varies by 0% to 17%.

III.1.8: COMPARISON OF BENDING MOMENT FOR BEAM B46 AND B70 :-

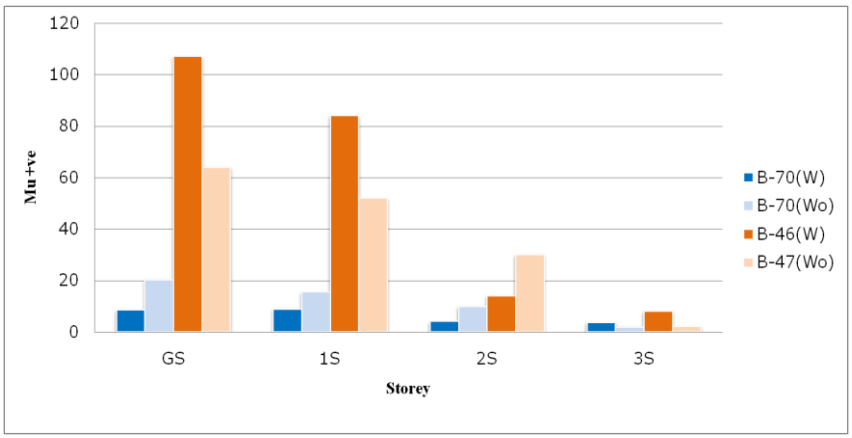


FIG.1.8.A GRAPHICAL REPRESENTATION OF BENDING MOMENT(+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a Mu +ve values increases due to modelling of stair. The value varies by 5% to 41%.

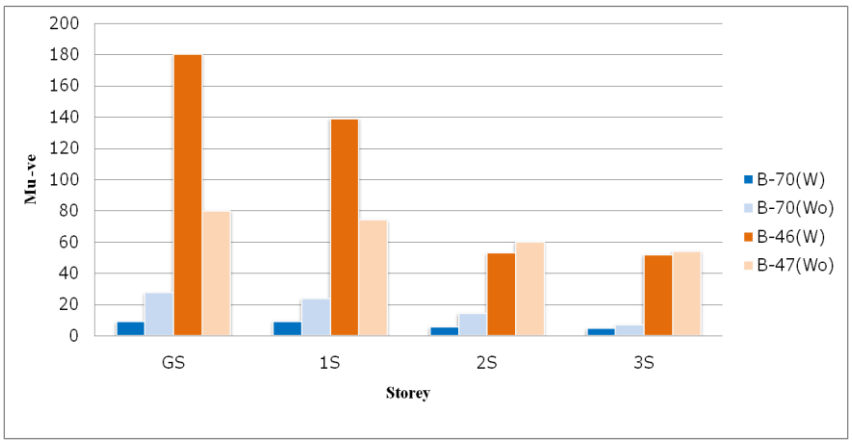


FIG.1.8.B GRAPHICAL REPRESENTATION OF BENDING MOMENT(-VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values increases due to modelling of stair. The values varies by 0.5% to 55%.

III.1.9: COMPARISON OF SHEAR FORCE FOR BEAM B46 AND B70:-

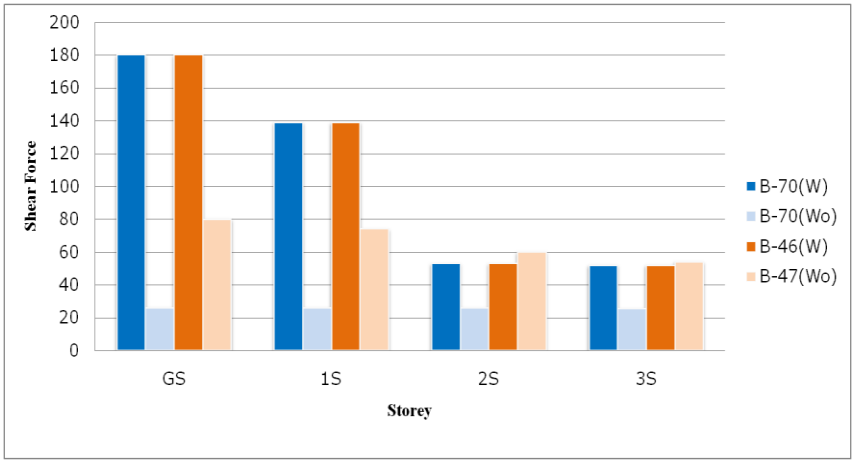


FIG.1.9 GRAPHICAL REPRESENTATION OF SHEAR FORCE WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values increases due to modelling of stair. The values varies by 40% to 88%.

III.1.10: COMPARISON OF AREA OF STEEL FOR BEAM B46 AND B70:-

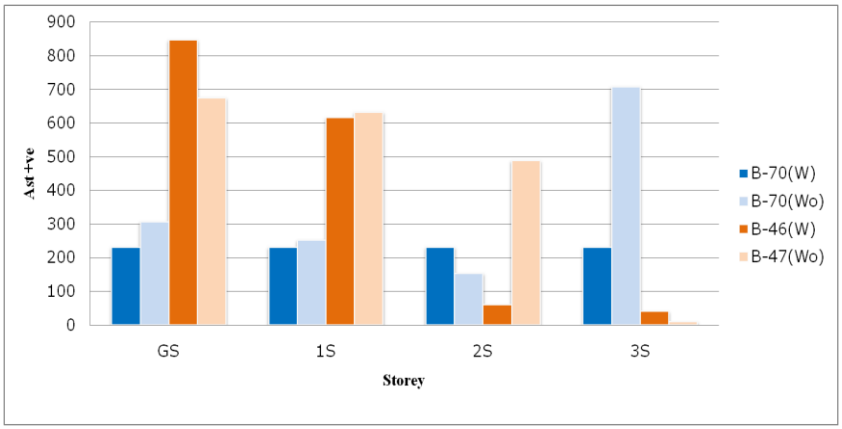


FIG.1.10.A GRAPHICAL REPRESENTATION OF AREA OF STEEL (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values increases due to modeling of stair. The values varies by 68% to 99%.

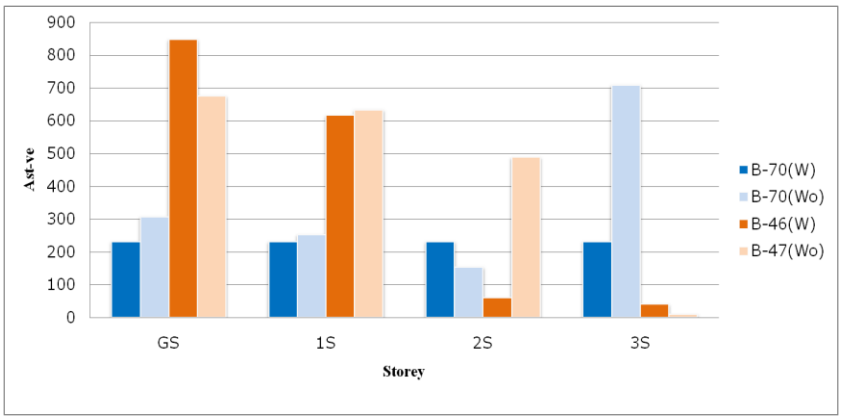
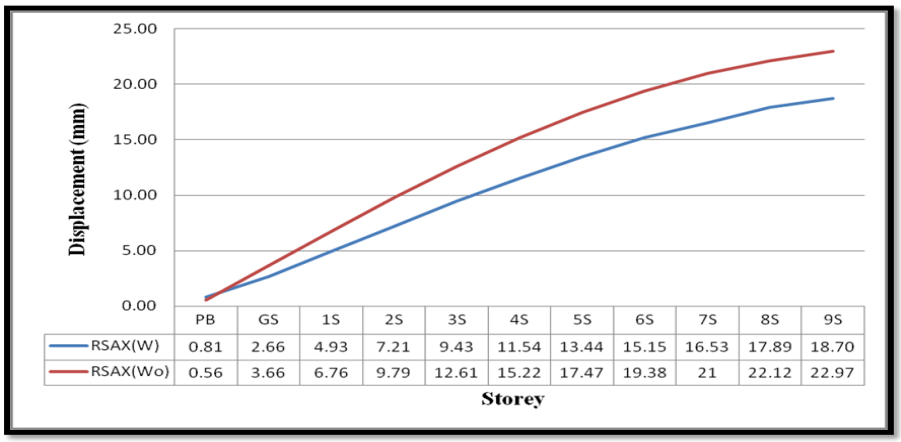


FIG. 1.10.B GRAPHICAL REPRESENTATION OF AREA OF STEEL (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values increases due to modelling of stair. The values varies by 66% to 99%.

III.2: RESULT FOR MODELS A-2 AND B-2:-

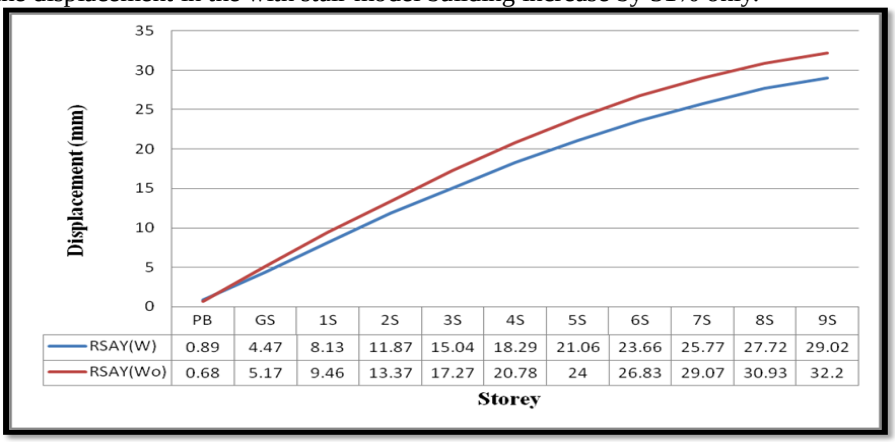
III.2.1: COMPARISON OF STOREY DISPLACEMENT:-



	PB	GS	1S	2S	3S	4S	5S	6S	7S	8S	9S
RSAX(W)	0.81	2.66	4.93	7.21	9.43	11.54	13.44	15.15	16.53	17.89	18.70
RSAX(Wo)	0.56	3.66	6.76	9.79	12.61	15.22	17.47	19.38	21	22.12	22.97

FIG. 2.1.A GRAPHICAL REPRESENTATION OF STOREY DISPLACEMENT WITH AND WITHOUT STAIR MODEL.(X- DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The displacement varies by 18% to 31% . Only at the plinth the displacement in the with stair model building increase by 31% only.



	PB	GS	1S	2S	3S	4S	5S	6S	7S	8S	9S
RSAY(W)	0.89	4.47	8.13	11.87	15.04	18.29	21.06	23.66	25.77	27.72	29.02
RSAY(Wo)	0.68	5.17	9.46	13.37	17.27	20.78	24	26.83	29.07	30.93	32.2

FIG. 2.1.B GRAPHICAL REPRESENTATION OF STOREY DISPLACEMENT WITH AND WITHOUT STAIR MODEL.(Y- DIRECTION)

In the above graph a displacement values decrease due to modeling of stair. The values varies by 9% to 23% .Only at the plinth the displacement in the with stair model building increase by 23% only.

III.2.2: COMPARISON OF STOREY DRIFT:-

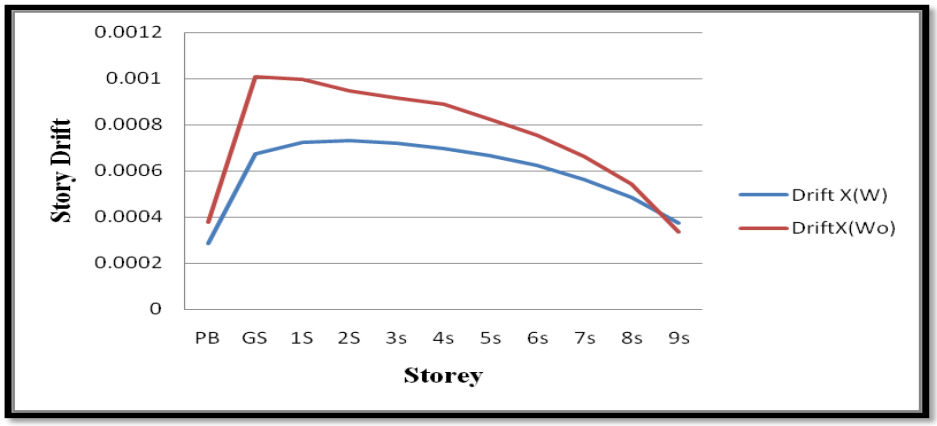


FIG. 2.2.X GRAPHICAL REPRESENTATION OF STOREY DRIFT WITH AND WITHOUT STAIR MODEL.(X-DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 10% to 85% .Only at the 9 storey the displacement in the with stair model building increase by 10% only.

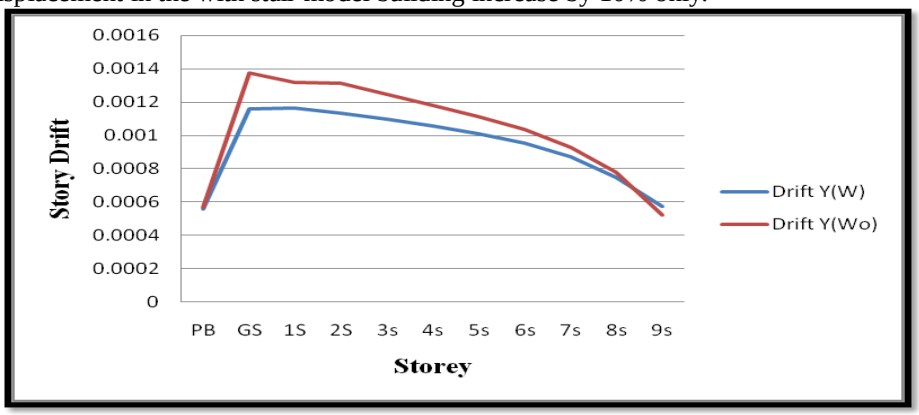


FIG. 2.2.Y GRAPHICAL REPRESENTATION OF STOREY DRIFT WITH AND WITHOUT STAIR MODEL.(Y-DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 10% to 84% .Only at the 9 storey the displacement in the with stair model building increase by 10% only.

III.2.3: COMPARISON OF STOREY SHEAR:-

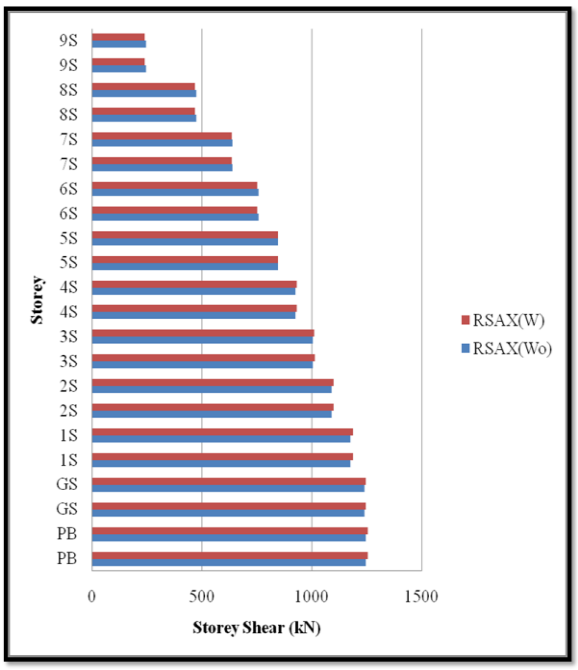


FIG. 2.3.A GRAPHICAL REPRESENTATION OF STOREY SHEAR WITH AND WITHOUT STAIR MODEL.(X-DIRECTION)

In the above graph a displacement values decrease due to modelling of stair. The values varies by 1% to 3% .

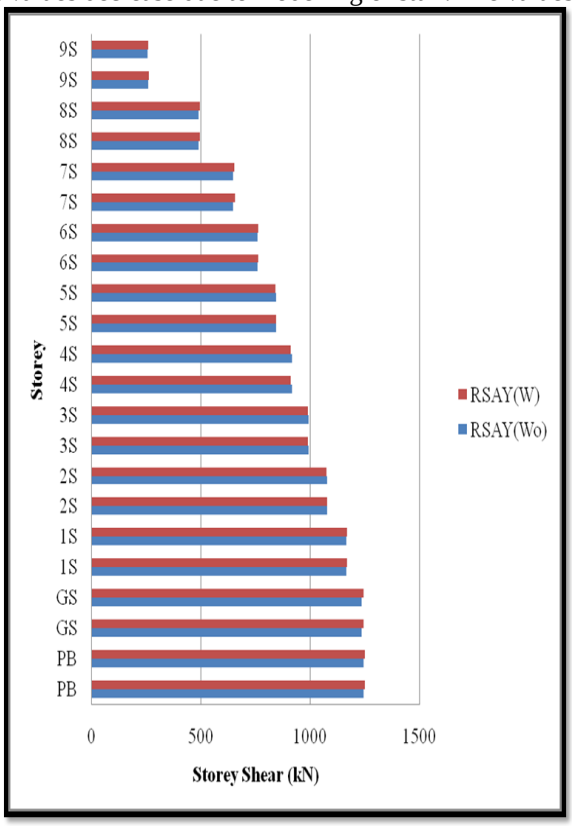


FIG. 2.3.B GRAPHICAL REPRESENTATION OF STOREY SHEAR WITH AND WITHOUT STAIR MODEL.(Y-DIRECTION)

In the above graph a displacement values increases due to modelling of stair. The values varies by 1% to 3%.

III.2.4: COMPARISON OF BENDING MOMENT FOR COLUMN C1 AND C5:-

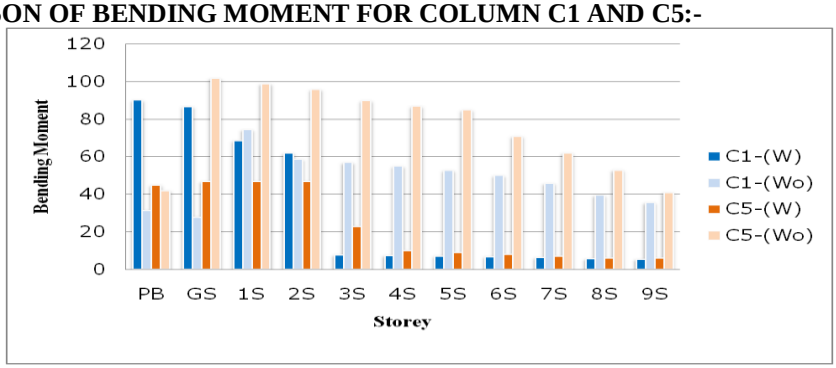


FIG. 2.4 GRAPHICAL REPRESENTATION OF BENDING MOMENT WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a displacement values decrease due to modeling of stair. The value varies by 10% to 99%.

III.2.5: COMPARISON OF SHEAR FORCE FOR COLUMN C1 AND C5:-

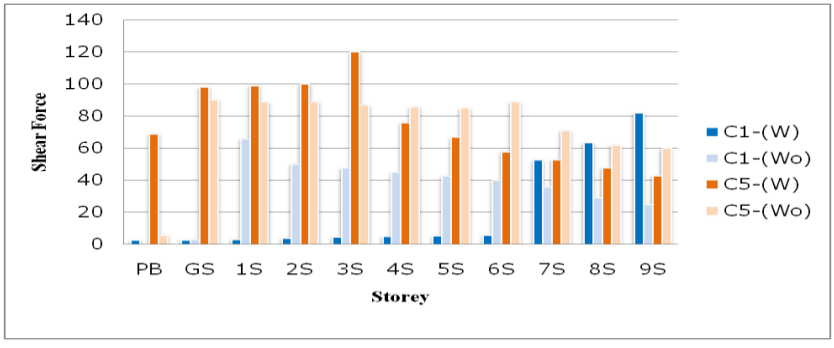


FIG. 2.5 GRAPHICAL REPRESENTATION OF SHEAR FORCE WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a displacement values decrease due to modelling of stair. The value varies by 10% to 99%. Maximum shear force on column C-5 in with staircase design is at 3rd storey and in C-1 is at 9th storey.

III.2.6: COMPARISON OF AXIAL FORCE FOR COLUMN C1 AND C5:-

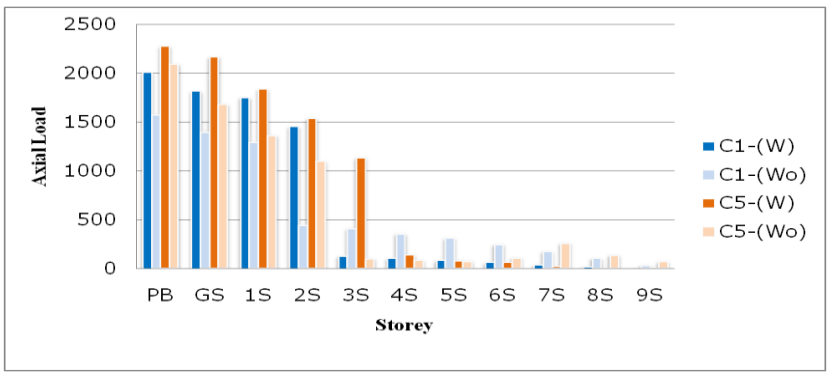


Fig. 2.6 Graphical representation of Axial Force with and without stair model for column C1 and C5

In the above graph a displacement values increases due to modelling of stair. The values varies by 10% to 99%. Axial force is suddenly increases after 3 and 4 storey.

III.2.7: COMPARISON OF PERCENTAGE OF STEEL FOR COLUMN C1 AND C5:-

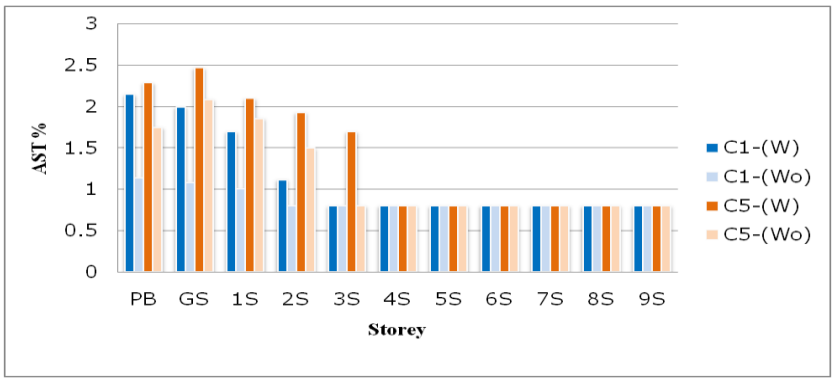


FIG. 2.7 GRAPHICAL REPRESENTATION OF PERCENTAGE OF STEEL WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a displacement values increases due to modelling of stair. The values varies by 0% to 50% and from 4 storey to 9 storey percentage of steel is constant.

III.2.8: COMPARISON OF POSITIVE BENDING MOMENT FOR BEAM B46 AND B70:-

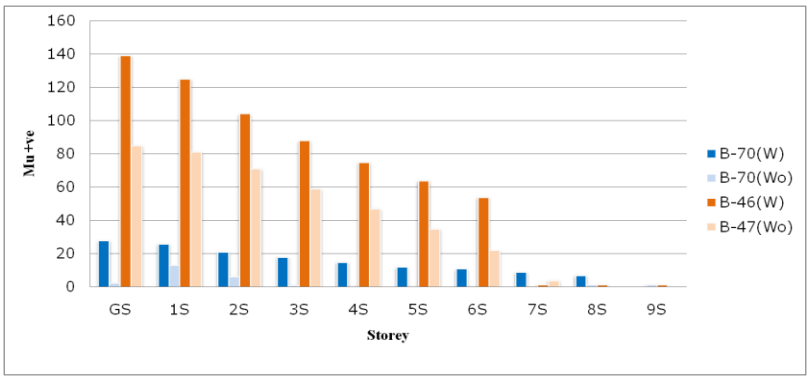


FIG. 2.8.A GRAPHICAL REPRESENTATION OF BENDING MOMENT (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values increases due to modelling of stair. The value varies by 25% to 27%.

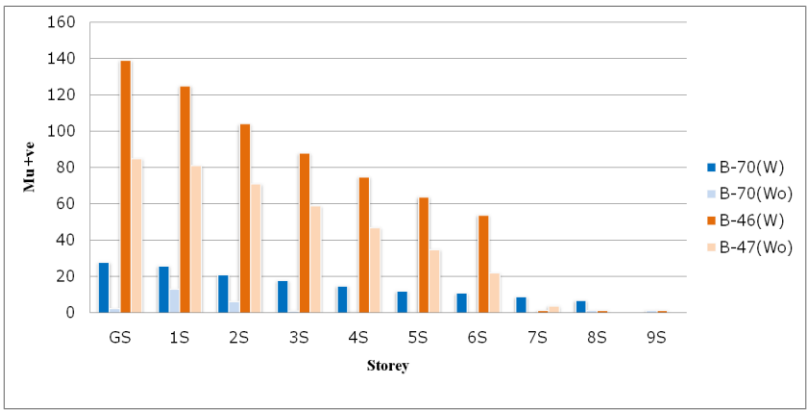


FIG. 2.8.B GRAPHICAL REPRESENTATION OF BENDING MOMENT(-VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a bending moment values increases due to modelling of stair. The bending moment varies by 5% to 99%.

III.2.9: COMPARISON OF SHEAR FORCE FOR BEAM B46 AND B70:-

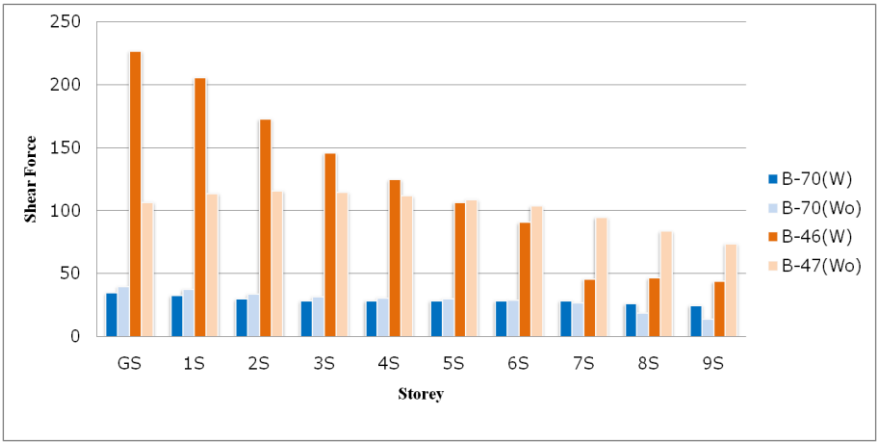


FIG. 2.9 GRAPHICAL REPRESENTATION OF SHEAR FORCE WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values increases due to modelling of stair. Shear force in B-70 beam without staircase modeling is greater from 9th storey to 5th storey after that they mey get decreases. In B-46 beam without staircase modelling is greater upto 6th storey, after 6th storey they mey get decreases.

III.2.10: COMPARISON OF AREA OF STEEL FOR BEAM B46 AND B70:-

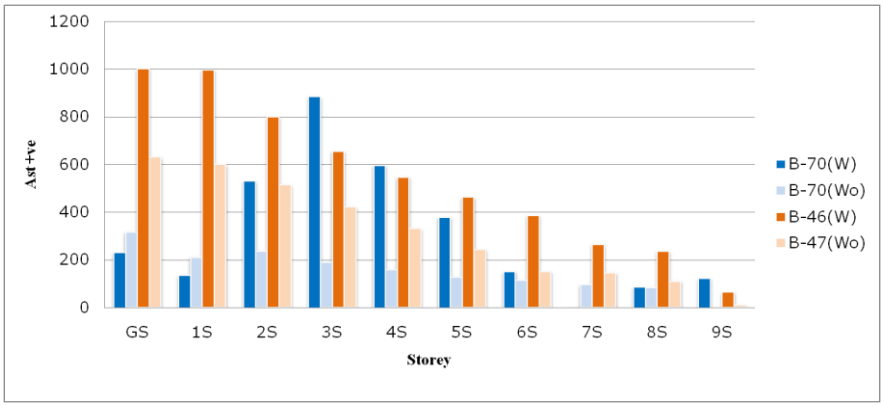


FIG. 6.4 GRAPHICAL REPRESENTATION OF AREA OF STEEL (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

It has been observed that with incorporation of stair model values of story drift varies by 10% to 100%.

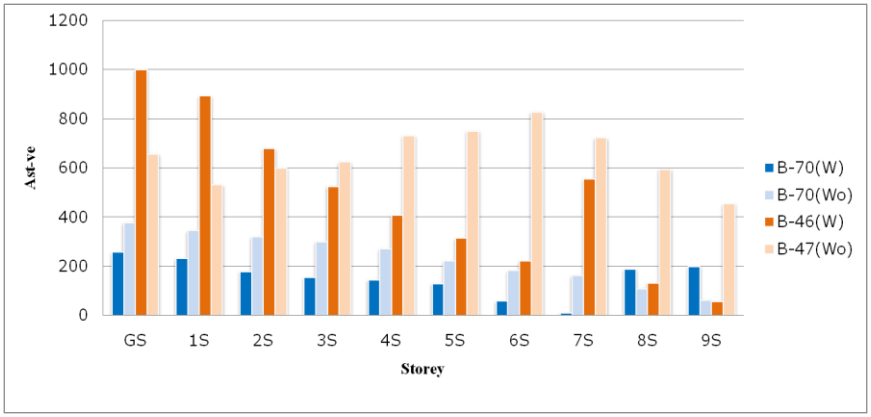


FIG. 6.4 GRAPHICAL REPRESENTATION OF AREA OF STEEL (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

It has been observed that with incorporation of stair model values of story drift varies by 10% to 100%.

III.3: RESULT FOR MODELS A-3 AND B-III.3 TYPE OF BUILDING

III.3.1: COMPARISON OF STOREY DISPLACEMENT:-

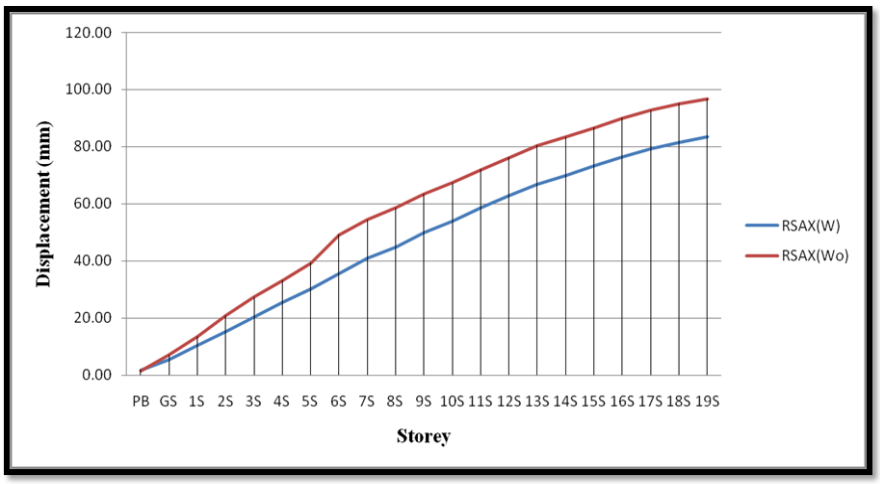


FIG. 6.1 GRAPHICAL REPRESENTATION OF STOREY DISPLACEMENT WITH AND WITHOUT STAIR MODEL.(X- DIRECTION)

It has been observed that with incorporation of stair model values of story drift varies by 25% to 27%.

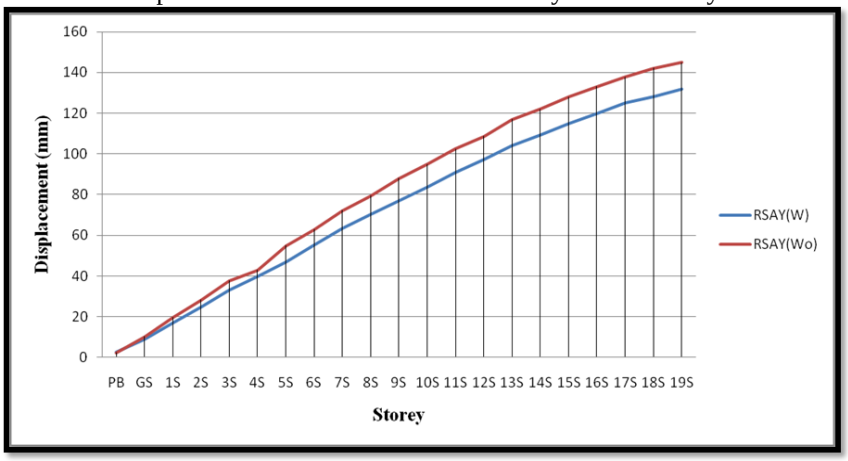


FIG. 2.10 GRAPHICAL REPRESENTATION OF STOREY DISPLACEMENT WITH AND WITHOUT STAIR MODEL.(Y- DIRECTION)

It has been observed that with incorporation of stair model values of story drift varies by 25% to 27%.

III.3.2: COMPARISON OF STOREY DRIFT:-

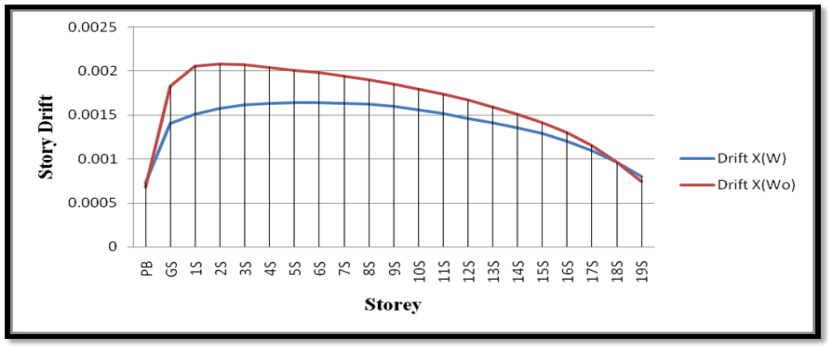


FIG. 3.2.A GRAPHICAL REPRESENTATION OF STOREY DRIFT WITH AND WITHOUT STAIR MODEL.(X-DIRECTION)

It has been observed that with incorporation of stair model values of story drift varies by 25% to 27%.

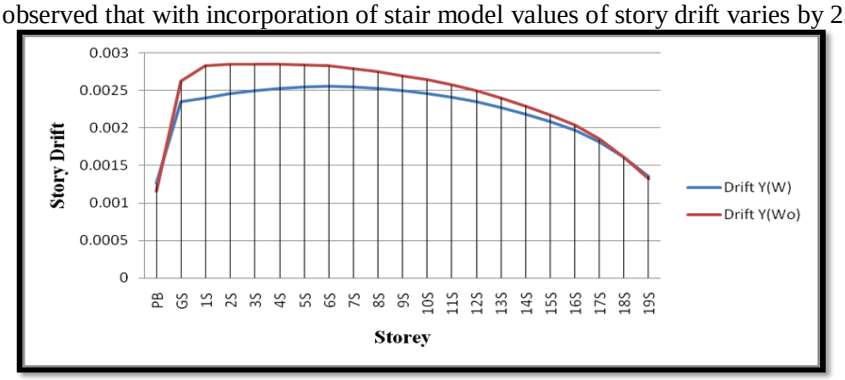


FIG. 3.2.B GRAPHICAL REPRESENTATION OF STOREY DRIFT WITH AND WITHOUT STAIR MODEL.(Y-DIRECTION)

It has been observed that with incorporation of stair model values of story drift varies by 25% to 27%.

III.3.3: Comparison of Storey Shear:-

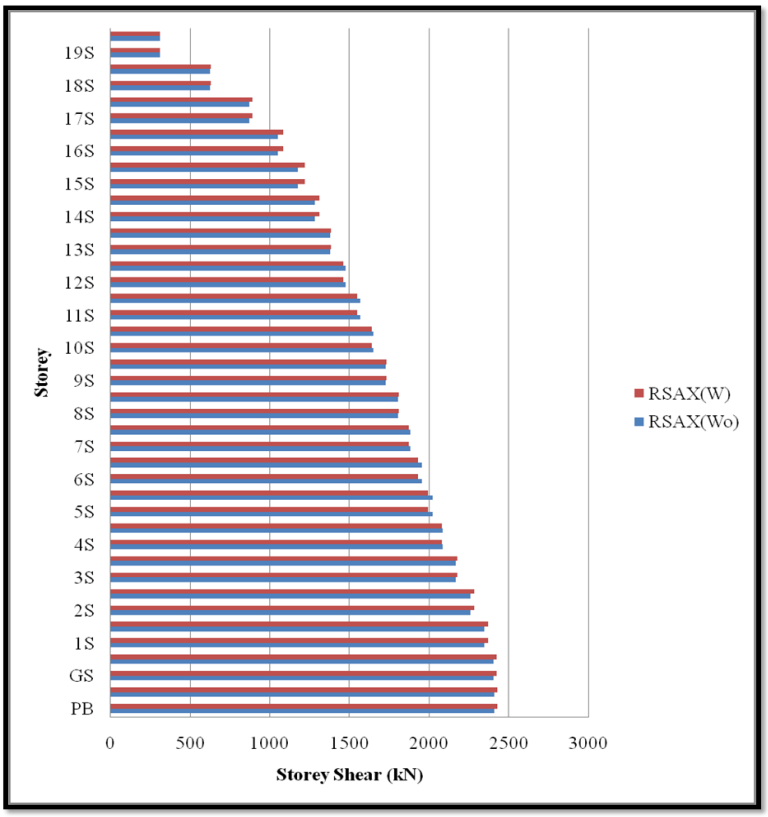


FIG. 3.3.A GRAPHICAL REPRESENTATION OF STOREY SHEAR WITH AND WITHOUT STAIR MODEL.(X-DIRECTION)

It has been observed that with incorporation of stair model values of story shear varies by 1% to 3%.

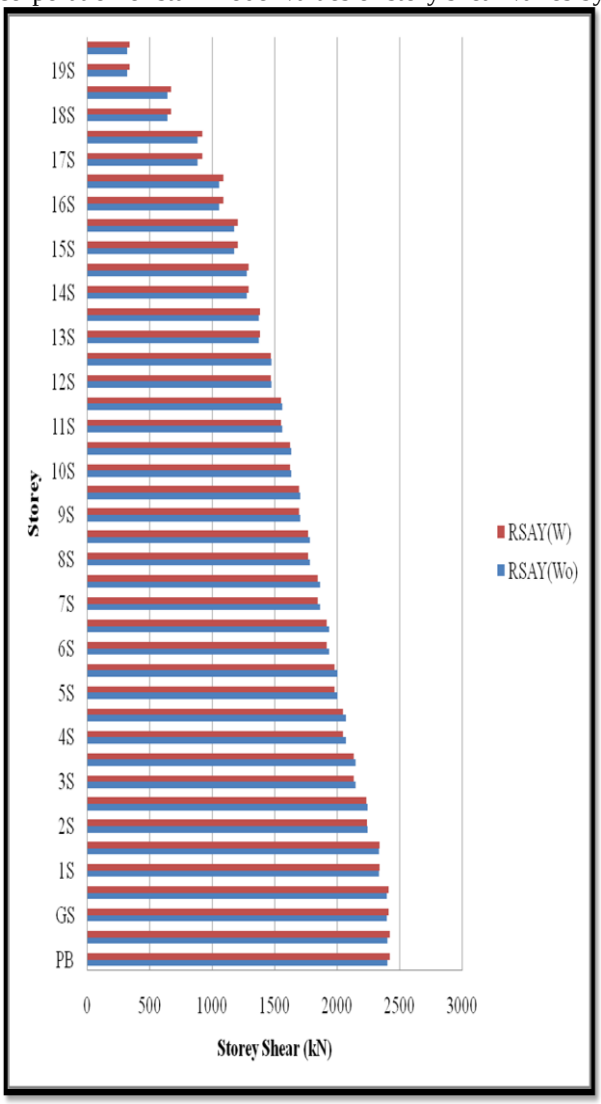


FIG. 3.3.B GRAPHICAL REPRESENTATION OF STOREY SHEAR WITH AND WITHOUT STAIR MODEL.(Y-DIRECTION)

It has been observed that with incorporation of stair model values of story shear varies by 1% to 3%.

III.3.4: COMPARISON OF BENDING MOMENT FOR COLUMN C1 AND C5:-

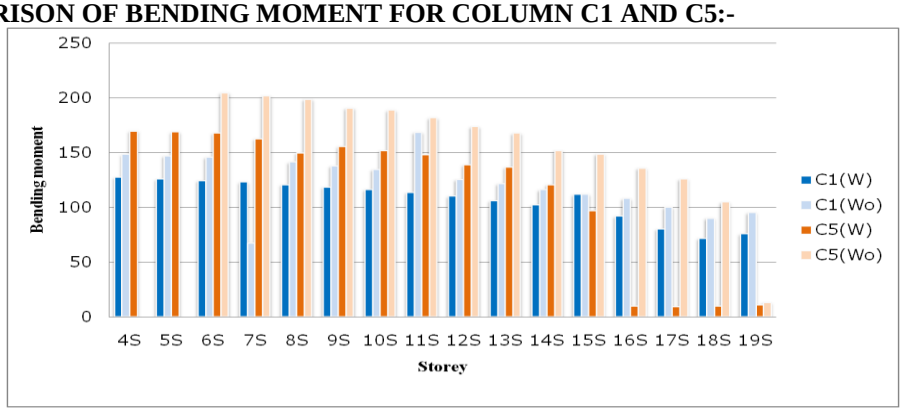


FIG. 3.4 GRAPHICAL REPRESENTATION OF BENDING MOMENT WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

It has been observed that with incorporation of stair model, Axial Force in columns touching landing beam have been varies by 10% to 99%.Column below 4 story had been failed hence there is no result below 4th story.

III.3.5: COMPARISON OF SHEAR FORCE FOR COLUMN C1 AND C5:-

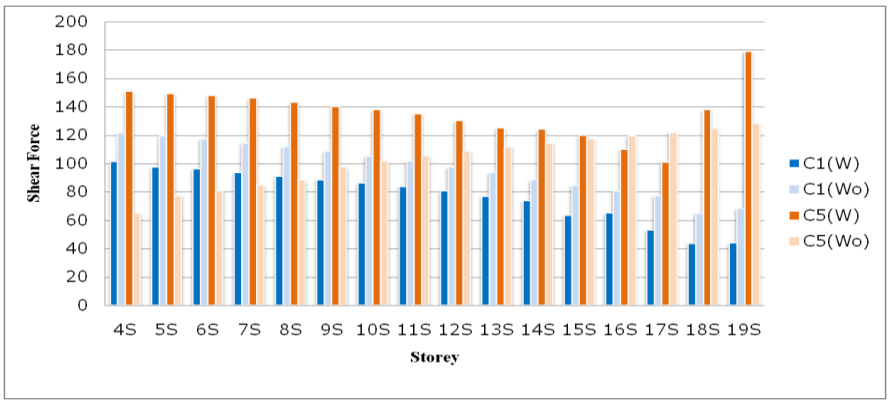


FIG. 3.5 GRAPHICAL REPRESENTATION OF SHEAR FORCE WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

It has been observed that with incorporation of stair model, Axial Force in columns touching landing beam have been varies by 10% to 99%.Column below 4 story had been failed hence there is no result below 4th story.

III.3.6: COMPARISON OF AXIAL FORCE FOR COLUMN C1 AND C5:-

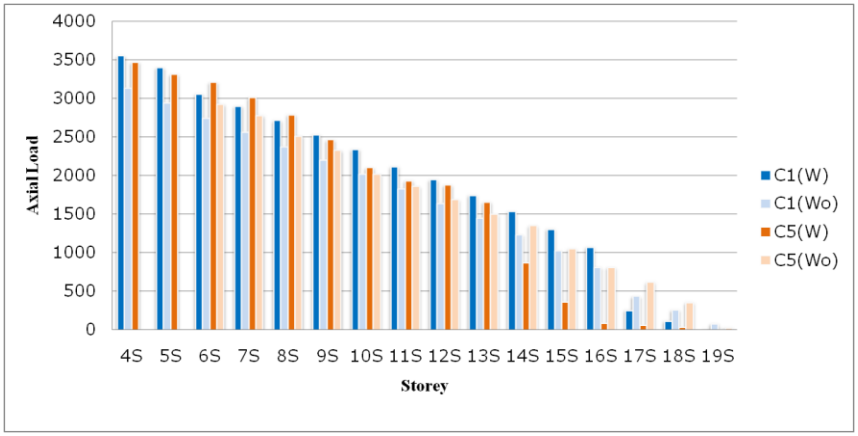


FIG. 3.6 GRAPHICAL REPRESENTATION OF AXIAL FORCE WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

It has been observed that with incorporation of stair model, Axial Force in columns touching landing beam have been varies by 25% to 27%. Column below 4 story had been failed hence there is no result below 4th story.

III.3.7: COMPARISON OF PERCENTAGE OF STEEL FOR COLUMN C1 AND C5:-

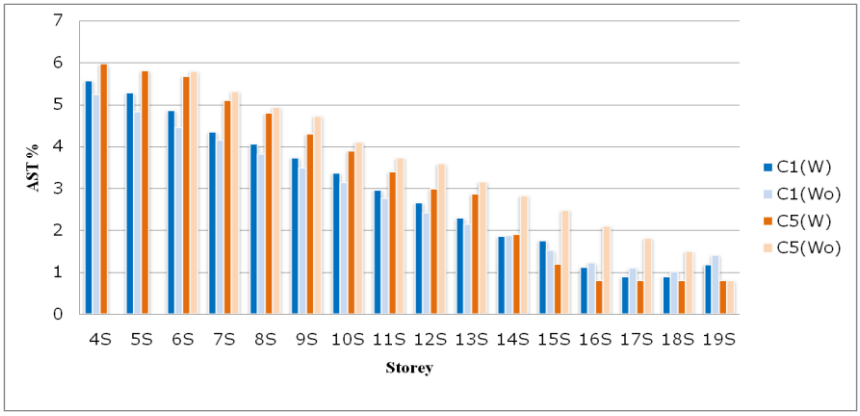


FIG. 3.7 GRAPHICAL REPRESENTATION OF PERCENTAGE OF STEEL WITH AND WITHOUT STAIR MODEL FOR COLUMN C1 AND C5

In the above graph a Ast% values decrease due to modeling of stair. The displacement varies by 5% to 20%.

III.3.8: COMPARISON OF BENDING MOMENT FOR BEAM B46 AND B70:-

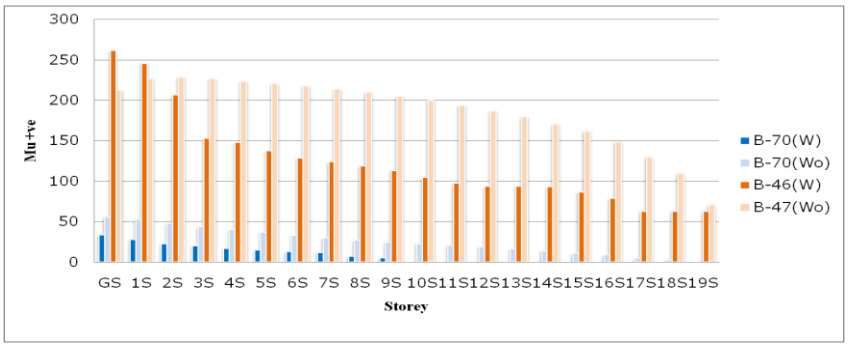


FIG. 3.8.A GRAPHICAL REPRESENTATION OF BENDING MOMENT (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a displacement values decrease due to modelling of stair in few stories. The displacement varies by 25% to 100%. In B-70(W) up to 10th story there is no value. In B-46(Wo) bending moment may get increases upto 2nd story after this story value slightly decreases.

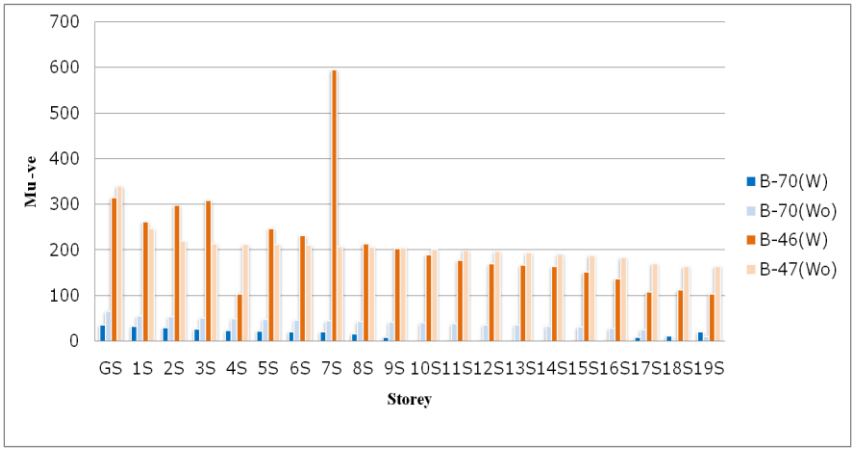


FIG. 3.8.B GRAPHICAL REPRESENTATION OF BENDING MOMENT (-VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a +ve bending moment values increases due to modelling of stair. The value varies by 25% to 100%. In B-70(W). value suddenly increases at 7th storey.

III.3.9: COMPARISON OF SHEAR FORCE FOR BEAM B46 AND B70:-

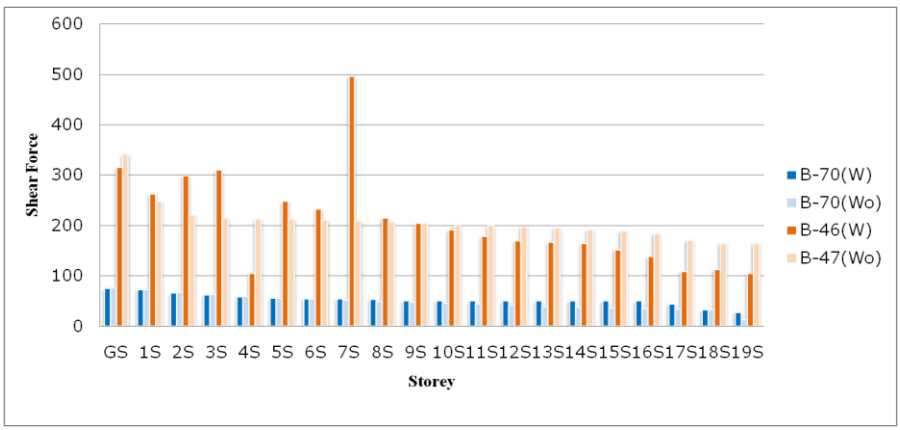


FIG.3.9 GRAPHICAL REPRESENTATION OF SHEAR FORCE WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

In the above graph a shear force values decrease from 9th storey due to modelling of stair. The values varies by 25% to 100%. In B-70(W) value suddenly increases at 7th storey.

III.3.10: COMPARISON OF AREA OF STEEL FOR BEAM B46 AND B70:-

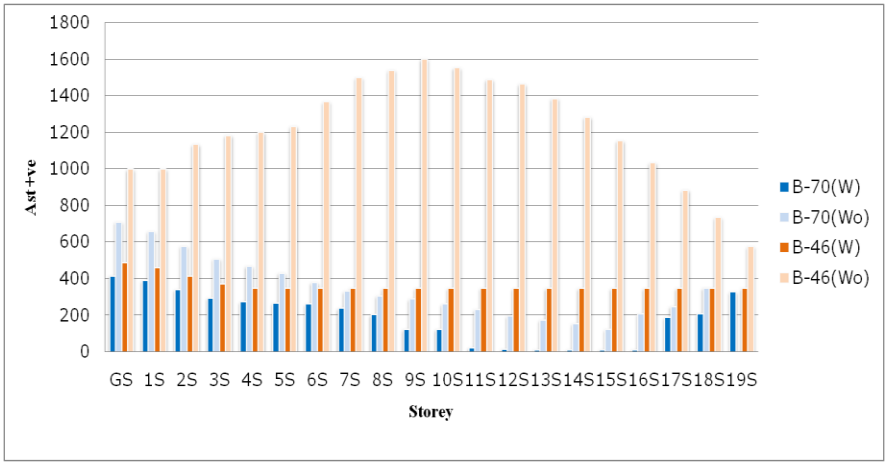


FIG.3.10.A GRAPHICAL REPRESENTATION OF AREA OF STEEL (+VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

It has been observed that incorporation of stair model in the building reduces the dynamically analysed area of steel of in B70 has been decreases and in B46 it has been increases in structure.

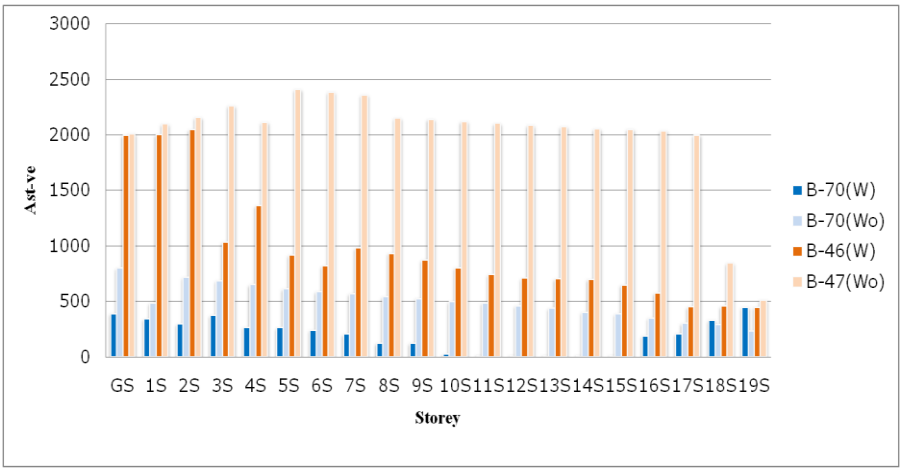


FIG.3.10.B GRAPHICAL REPRESENTATION OF AREA OF STEEL (-VE) WITH AND WITHOUT STAIR MODEL FOR BEAM B46 AND B70

It has been observed that incorporation of stair model in the building reduces the dynamically analysed area of steel of in B70 has been decreases and in B46 it has been increases in structure

IV. CONCLUSION

From the study made and from the results presented in the previous sections, the following important conclusions have been drawn within the purview of the buildings considered.

(1) It has been observed that the presence of staircase tremendously influence the peak value of response quantities of beams and columns around staircase. The landing columns below 4th story adjacent to staircase have been found to fail due to excessive demand imposed owing to the presence of staircase.

(2) Incorporating only weight of staircase and not stair element in computer model shall lead to under design. As the codal design is inadequate to cater the additional demand imposed due to presence of staircase on landing beams and columns adjacent to staircase.

(3) With incorporation of stair model, columns touching landing beam have been found to be subjected to an increase in axial force by an average of 19%. The lateral moment in such columns increased on average by 32%. Shear force in landing beam increased by 36% on average. The torsional moment in landing beam increased enormously.

(4) The interstorey drift ratio has been found to reduce by 33% in short direction and 23% in long direction on average on incorporation of stair model.

(6) If staircase and there elements not design properly by considering diagonal effect of staircases, staircase may get fail under major earthquakes.

V. REFERENCES

1. Aray, A.S. and Anand P, "*Analysis of Helicoidal Staircase with Intermediate Landing*", ACI Journals, Vol.3, 2004, pp 157-184.
2. Bellidoa, A. Quiroza, A. Panizoa and J.L. Torerob, "*Performance Assessment of Pressurized Stairs in High Rise Building*", Fire Technology 45 (2), pp. 189-200, 2009.
3. Christoph Ho lschera, Tobias Meilingera, B. Georg Vrachliotisa,c, Martin Bro samlea, Markus Knauffa , "*Up the down staircase: Way finding strategies in multi-level buildings*", Journal of Environmental Psychology,vol.26,2006,pp 284-299.
4. Dr Shah.V.L. Dr. Karve.S.R., "*Illustrated Design of R.C. Buildings*",Structures Publications, Pune, Sixth Edition,(2010).
5. Dayaratnam N. P., "*Computer Aided Design of slab*", M-Tech Thesis, IIT Kanpur, Dec 1986.
6. Franz S, "*Free Standing Stairs*", ACI Journals, vol.4, 1961, pp 847-870.
7. Frederick S.M, &Jonathan T. Rictetts, "*Building Design and Construction Handbook*", McGraw Hill,New Delhi, sixth edition,(2000).
8. Galagali A , "*Computer Aided Structural Design of Building System*", M-Tech Thesis, IIT Kanpur, June 1988
9. Kumar S, "*Treasure of R.C.C Design*", Standard Book House, Naisarak Delhi, seventeen editions,(2009)
10. Khose V. N., "*Analysis and Design of Four Storied RC Buildings Using SAP 2000v14*", IIT Roorkee, March 2008.
11. Michael S.R, "*Serious Stair Injuries Can Be Prevented by Improved Stair Design*" Applied Ergonomics, vol. 32 (2001), pp135-139.
12. Silvia F, Rita Stagni, Angelo Cappello, Alberto Leardini, "*Effect Of Different Inertial Parameter Sets On Joint Moment Calculation During Stair Ascending And Descending*", Medical Engineering & Physics ,vol.27 2005,pp 537–541.
13. Xuan Xu and Weiguo Song, "*Staircase Evacuation Modeling and Its Comparison with an Egress Drill*", ACI Journals, vol.6, 1999, pp 266-278.
14. Yahya M Y, "*An Analysis of the Effect of Staircase Intermediate Landing Floor on the Evacuation Time*", ACI Journals, vol.6, 2006, pp 269-281.
15. N SHYAMANANDA SINGH, *"Effects of Staircase on the Seismic Performance of RCC frame building*", International Journal of Engineering Science and Technology (IJEST), Vol. 4 No.04 April 2012, ISSN : 0975-5462.

