IJESRT: 9(9), September, 2020 ISSN: 2277-9655

International Journal of Engineering Sciences & Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

Website: www.ijesrt.com Mail: editor@ijesrt.com

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[Gosavi *et al.*, 9(9): September, 2020]
ICTM Value: 3.00

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT

INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

SEISMIC ANALYSIS OF FLAT SLAB BUILDING ON SLOPING GROUND

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DOI: https://doi.org/10.29121/ijesrt.v9.i9.2020.4

ABSTRACT

In a developing country like India urbanization and industrialization has accelerated real estate development which leds to scarcity of land. This started the construction of multistorey buildings on sloping ground. Buildings constructed on sloping ground are very irregular and unsymmetrical in vertical and horizontal plane as compared to the buildings on level ground. Also, these buildings on sloping ground require great attention for seismic analysis. The present work studies the behavior of flat slab buildings on sloping ground. For this, G+8 storey 36 different building models with square plan area on sloping ground are considered. The total plan area and mass of the building is kept constant for all models. The sloping angles 0°, 16°, 21° are considered for square plan. The corner and core columns of some models are replaced with shear wall by keeping the mass constant. The response spectrum analysis of all models is carried out using software Etabs17. The study concludes that flat slab building with shear wall at outer periphery of building is preferable than the discontinuous shear wall at core of the building.

KEYWORDS: Flat slab, Sloping ground, Shear wall, Response spectrum analysis, ETABS 2017.

1. INTRODUCTION

In a developing country like India economic growth, urbanization and industrialization has accelerated the real estate development. Due to this, population density has increased very rapidly. This situation leds to the scarcity of land on level ground and started construction of multistorey building on sloping ground. The buildings constructed on sloping ground are very irregular and unsymmetrical in vertical and horizontal plane as compared to the buildings on level ground. Such buildings may be torsionally coupled because their centre of mass and centre of rigidity do not coincide on various floors. When buildings are resting on sloping ground they have varying column heights. The multistorey buildings on sloping ground are susceptible to severe damage when earthquake occurs in that region. Lack of lateral strength and stability causes the demolition of structure during earthquake. These unsymmetrical buildings require great attention in the analysis and design.

The development in construction activity started flat slab building construction over regular frame building construction. Flat slab buildings have benefits of architectural flexibility, increased floor height, easier formwork and speedy construction. From functional aspect a flat-slab R.C. frame building is more efficient than a regular frame building. So, construction of flat-slab building is increasing also on sloping ground. Due to absence of deep beams, flat slab structural system is significantly more flexible for lateral loads than regular frame system. This makes the flat slab system more vulnerable under seismic events. For this purpose, the study of flat slab building on sloping ground under seismic load is very important. The variety of structural forms are used to resist earthquake in multistory building. Shear wall is most commonly used form of lateral load resisting system. Shear wall generally start at foundation level and and is continuous throughout the building height. In multistorey buildings, it can be provided at stairways, lifts and utility cores.

2. MATERIALS AND METHODS

2.1 Modelling Data

In the present study, seismic behavior of flat slab building without shear wall and flat slab building with shear wall on sloping ground is studied for various G+8 storied building models. The slope of the ground considered are 0°, 16° and 21°.The mass of the all models is kept constant. For models with shear wall, columns are

ISSN: 2277-9655
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replaced with shear wall having same mass. The response spectrum analysis as per IS 1893:2016 is done with the help of Etabs17.

Table1: Data Problem

Sr.No	Description	Problem 1 (Square Plan)
A	**Geometrical Properties**	
1	Floor height	3.5m
2	Size of bay	6m X 6m
3	No of stories	G+8
4	Plan Area	36 m X 36m
B	**Material Properties**	
1	Grade of concrete	M30
2	Grade of steel	Fe500
C	**Section Properties**	
1	Beam size (including slab)	300 mm X 600mm
2	Column size	650mm X 650mm
3	Slab thickness	150 mm
4	Flat slab thickness	200 mm
5	Drop thickness	300 mm
6	Shear wall	1500 mm X 150 mm
D	**Loads on structures**	
1	Live load	5 kN/m^2
2	Floor finish	1 kN/m^2
E	**Earthquake Parameters**	
1	Type of Frame	OMRF
2	Seismic zone	III
3	Importance factor	1
4	Response reduction factor	3
5	Type of soil	Medium
6	Damping of structure	5%

Table 2: Model Description with notation

Sr.No	Model Description for problem 1	Notation	Sr.no	Model Description for problem 2	Notation
1	Regular Frame building on level ground	R1	10	Flat slab building on level ground	F1
2	Regular Frame building on 16° slope	R2	11	Flat slab building on 16° slope	F2
3	Regular Frame building on 21° slope	R3	12	Flat slab building on 21° slope	F3
4	Regular Frame building with shear wall at outer periphery on level ground	R1S1	13	Flat slab building with shear wall at outer periphery on level ground	F1S1
5	Regular Frame building with shear wall at outer periphery on 16° slope	R2S1	14	Flat slab building with shear wall at outer periphery on 16° slope	F2S1
6	Regular Frame building with shear wall at outer periphery on 21° slope	R3S1	15	Flat slab building with shear wall at outer periphery on 21° slope	F3S1
7	Regular Frame building with shear wall at core on level ground	R1S2	16	Flat slab building with shear wall at core on level ground	F1S2
8	Regular Frame building with shear wall at core on 16° slope	R2S2	17	Flat slab building with shear wall at core on 16° slope	F2S2
9	Regular Frame building with shear wall at core on 21° slope	R3S2	18	Flat slab building with shear wall at core on 21° slope	F3S2

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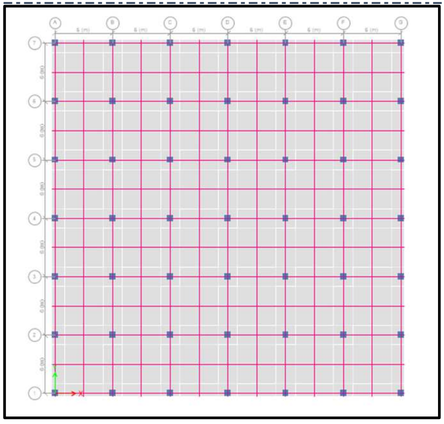

Fig.1 Plan of model F1

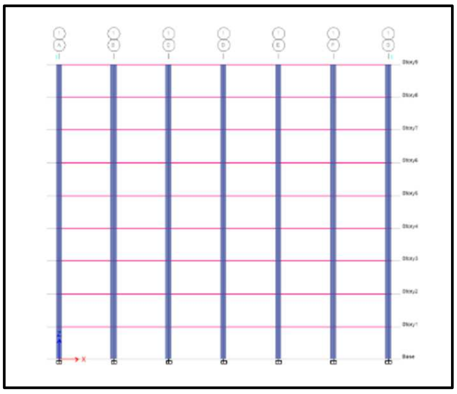

Fig.2 Sectional Elevation of model F1

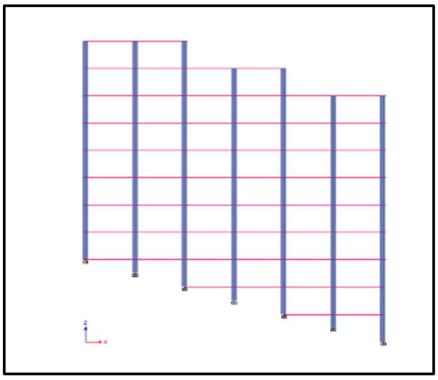

Fig.3 Sectional Elevation of model F2

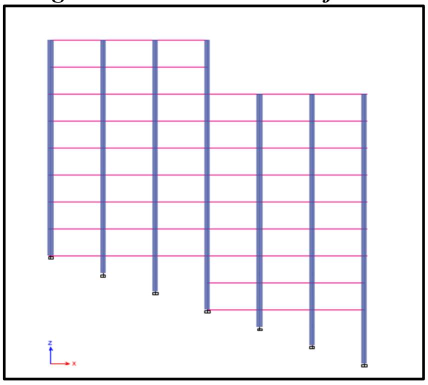

Fig.4 Sectional Elevation of model F3

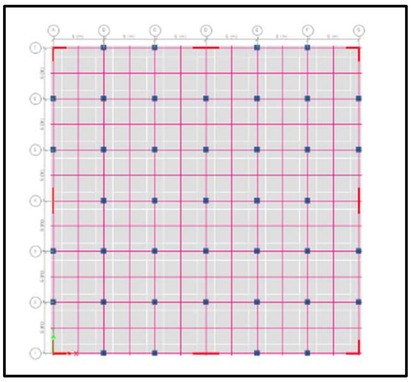

Fig.5 Plan of model F1S1

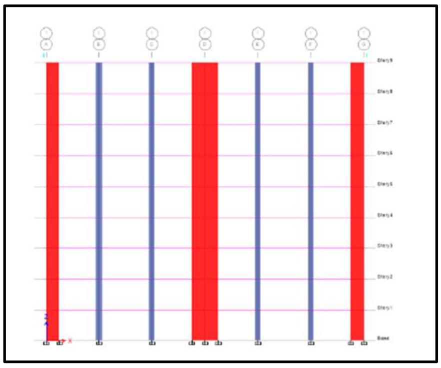

Fig.6 Sectional Elevation of model F1S1

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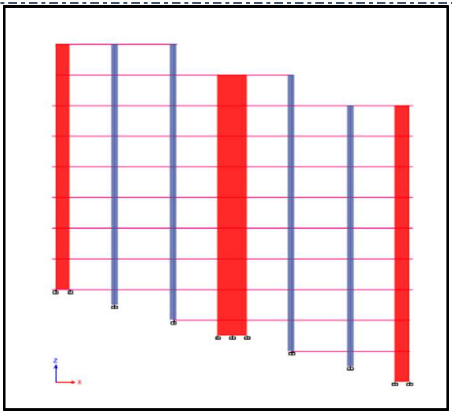

Fig.7 Sectional Elevation of model F2S1

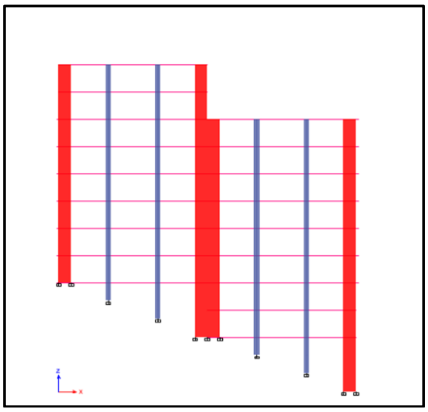

Fig.8 Sectional Elevation of model F3S1

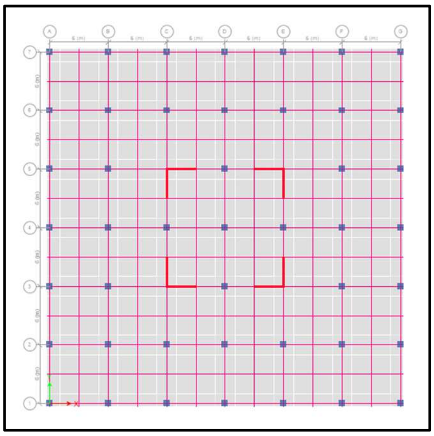

Fig.9 Plan of model F1S2

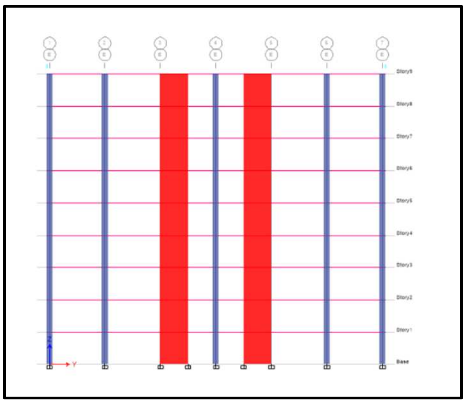

Fig.10 Sectional Elevation of model F1S2

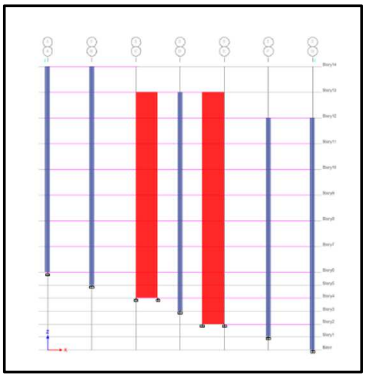

Fig.11 Sectional Elevation of model F2S2

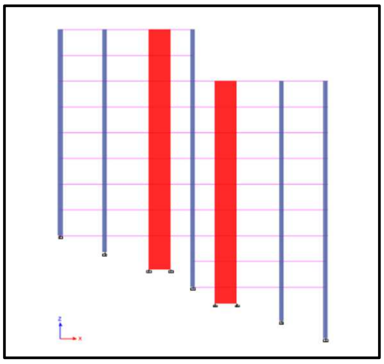

Fig.12 Sectional Elevation of model F3S2

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3. RESULTS AND DISCUSSION

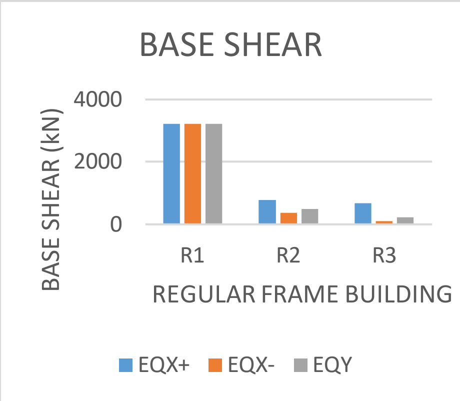

Fig.13 Base shear of regular frame building models on sloping ground

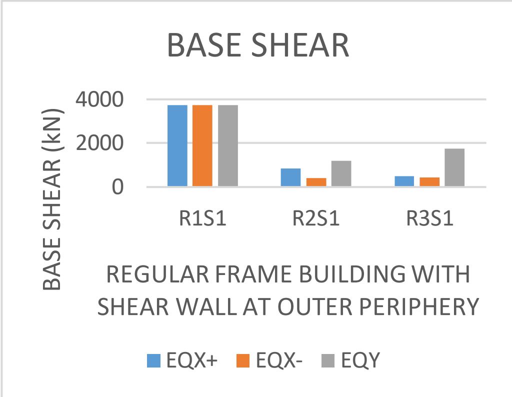

Fig.14 Base shear of regular frame building with shear wall at outer periphery on sloping ground

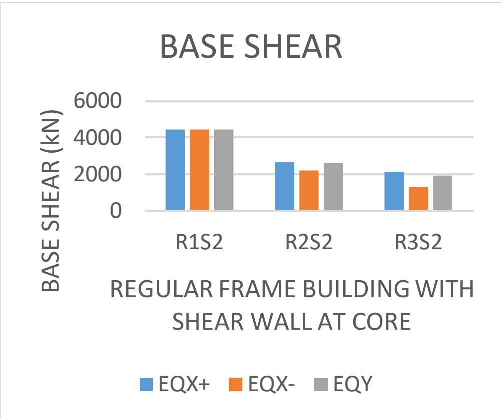

Fig.15 Base shear of regular frame building With discontinuous shear wall at core

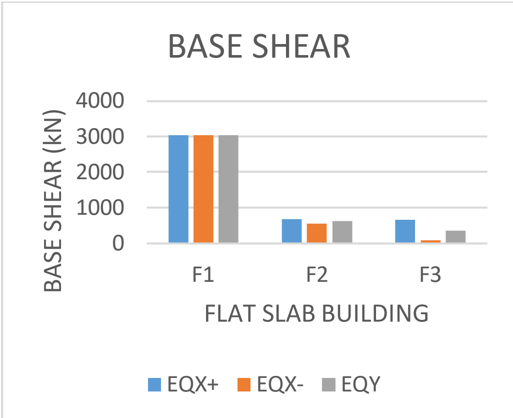

Fig.16 Base shear of Flat slab building models on sloping ground on sloping ground

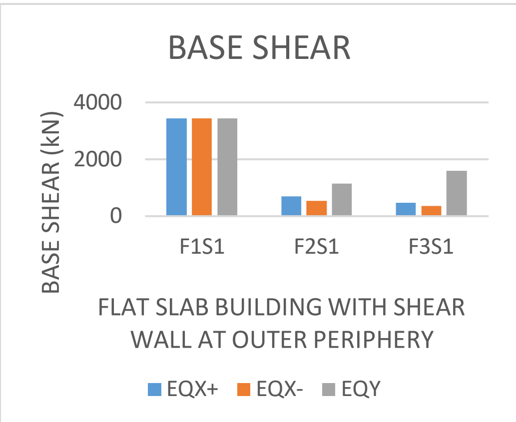

Fig.17 Base shear of flat slab building with shear wall at outer periphery on sloping ground

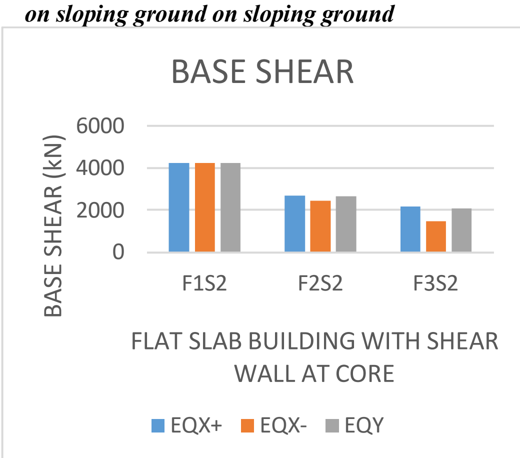

Fig.18 Base shear of flat slab building with shear wall at core on sloping ground

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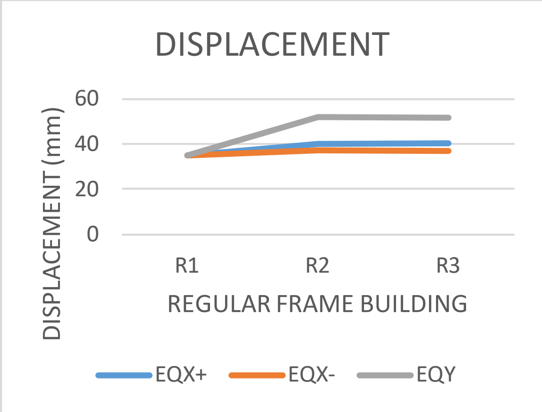

Fig.19 Displacement of regular frame building Models on sloping ground

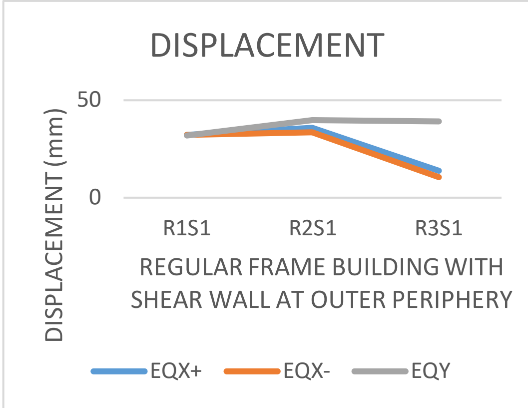

Fig.20 Displacement of regular frame building with shear wall at outer periphery

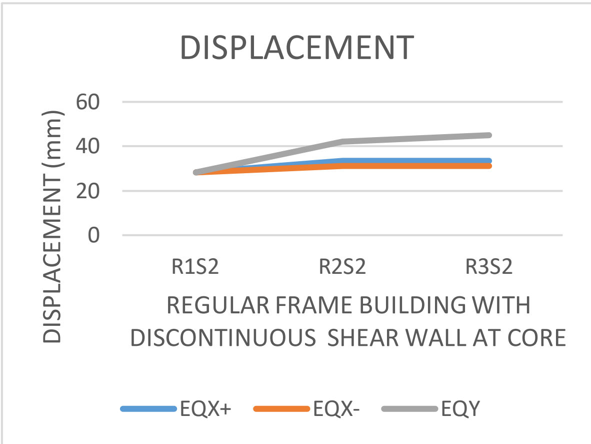

Fig.21 Displacement of regular frame building

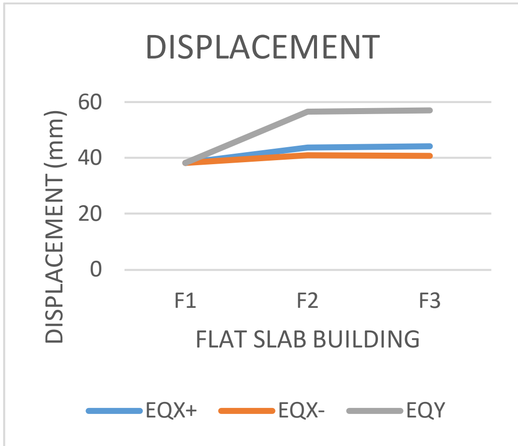

Fig.22 Displacement of Flat slab on sloping ground With discontinuous shear wall at core on sloping ground

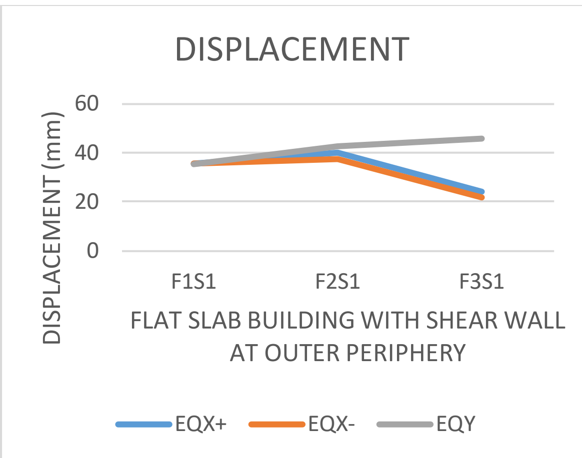

Fig.23 Displacement of flat slab building with shear wall at outer periphery on sloping ground

Fig.24 Displacement of flat slab building with discontinuous shearwall at core on sloping ground

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3.1 Observations

1. When R1 is compared with R2 & R3 base shear in R2 & R3 is less than the base shear in R1.
2. When F1 is compared with F2 & F3 base shear in F2 & F3 is less than the base shear in F1.
3. Comparison of R1 with R2 & R3 shows that displacement in R2 & R3 is more than the displacement in R1.
4. Comparison of F1 with F2 & F3 shows that displacement in F2 & F3 is more than the displacement in F1.
5. From the results of R1, R1S1, R1S2 it is seen that provision of shear wall increases base shear and decreases displacement.
6. From the results of R2, R2S1, R2S2 it is seen that provision of shear wall increases base shear and decreases displacement.
7. From the results of R3, R3S1, R3S2 it is seen that provision of shear wall increases base shear and decreases displacement.
8. For F2S1 top storey displacement is 40.05mm along slope and 42.605mm perpendicular to slope and for F2S2 top storey displacement is 36.626mm along slope and 43.139mm perpendicular to slope. This shows that building with shear wall at outer periphery has less displacement than the building with shear wall at core.
9. For F3S1 top storey displacement is 24.288 mm along slope and 45.718 mm perpendicular to slope and for F3S2 top storey displacement is 36.725mm along slope and 46.828 mm perpendicular to slope. This shows that building with shear wall at outer periphery has less displacement than the building with discontinuous shear wall at core.
10. For model R2S2 top storey displacement along the slope is 33.317mm and perpendicular to slope is 42.1mm. For model F2S2, 36.626mm is top storey displacement along the slope and 43.139mm is perpendicular to slope. It is seen that for regular and flat slab buildings displacement perpendicular to slope is more compared to displacement along slope.
11. For model R3S2 top storey displacement along the slope is 33.553 mm and perpendicular to slope is 45.04 mm. For model F3S2, 36.725 mm is top storey displacement along the slope and 46.828 mm is perpendicular to slope. It is seen that for regular and flat slab buildings displacement perpendicular to slope is more compared to displacement along slope.
12. From the results of F2, F2S1, F2S2 it is seen that when earthquake is acting down the slope displacement is more than the when the earthquake is acting up the slope.

4. CONCLUSION

When the buildings are analyzed for earthquake forces,

1. In flat slab buildings displacement is more and base shear is less as compared to regular frame building.
2. For regular frame buildings as well as flat slab buildings, displacement of buildings on sloping ground is more than the displacement of buildings on level ground.
3. For regular frame buildings as well as flat slab buildings on sloping ground, displacement perpendicular to slope is more compared to displacement along slope.
4. Provision of shear wall reduces displacement of building but increases base shear for both regular frame buildings and flat slab buildings.
5. For regular frame buildings as well as flat slab buildings, when shear wall is placed at outer periphery it reduces deflection of building as compared to discontinuous shear wall placed at core of the building.
6. For regular frame buildings as well as flat slab buildings, base shear of buildings on level ground is more than the base shear of buildings on sloping ground.

5. ACKNOWLEDGEMENTS

First & foremost, I would like to thank my guide Prof. J. P. Patankar. It is because of his encouragement that I decided to work for this subject. His strong support always shows path to get acquainted with new things. His encouragement and enthusiasm have made this project a true joy for me.

I would like to thank my parents without whom no achievement is mine. They always nurtured and encouraged me always to pursue my passion. I'm also thankful to my dear sister and fiancé who always helped me at every step of my dissertation. Support of my in laws during dissertation work helped me a lot for successful completion. I express my gratitude towards my friends for their help during my work.

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