A Study on RCC Frames under Sloping Ground with Different Shear Wall Conditions using STAAD Pro

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Abstract - The study of the thesis is about analysis of different inclined/sloping ground RCC Frames along with different cases of shear wall and finding the problem of frames in respect to maximum displacement factor along with the quantity of materials used and also the retrofitting possibilities with minimum economic conditions. In this thesis, three sloping shaped (10-D, 15-D & 20-D) addition to the different shear wall condition of multi-storey RCC frame building of equal physical properties such as built-up, beam & column size is analyzed using STAAD.Pro.V8i (Series 6) for seismic Zone –IV. Then, frames have been improved by changing the ideal location of shear wall retrofitting, Seismic isolation methods and supplemental dampers or bracings are also some remedies for retrofitting

Key Words: RCC Frames, sloping shaped (10-D, 15-D & 20-D), shear wall, G+9, Seismic Zone-IV, STAAD Pro, Storey displacement, Compressive Stress, Story Shear.

1. INTRODUCTION

Earthquake is the vibration of earth's surface caused by waves coming from a source of disturbance inside the earth. As the waves radiate from the fault, they undergo geometric scattering and reduction due to loss of energy in the rocks. Since the interior of the earth consists of heterogeneous formations, the waves undergo multiple reflections, retraction, dispersion and reduction as they travel. The seismic waves arriving at a site on the surface of the earth are a result of complex superposition giving rise to irregular motion and shaking of ground. When a structure is subjected to seismic forces it does not cause loss to human lives directly but due to the damage cause to the structures that leads to the collapse of the building. Mass destruction of the low and high rise buildings in the recent earthquakes leads to the need of investigation especially in a developing country like India. Structure subjected to seismic/earthquake forces are always vulnerable to damage and if it occurs on a sloped building as on hills which is at some inclination to the ground the chances of damage increases much more. Structures on slopes vary from those on plains because they are asymmetrical horizontally as well as vertically.

In this paper, the seismic behavior of RC buildings on sloping ground is analyzed; considering the G+9 storey frame geometries with shear wall and without shear wall at different slopes. The modeling and analysis is done with the help of STAAD Pro v8i. The objectives of the study are as follows:

Comparative study is to be done for seismic parameters such as story shear, displacement, compressive stress, story drift in order to check stability check using STAAD Pro

To compare the cost and material quantity of steel & concrete for each case.

1.1 METHODS OF ANALYSIS

This study includes comparative study of behavior with and without shear wall and also study the behavior of different types of three sloping shaped in multi-storey RCC frame. Following steps of methods of analysis are adopted in this study:

Step-1: Selection of models having without shear wall , 2 storey shear wall, 4 storey shear wall and with full shear wall by using multi-storey RCC frame building of equal physical properties such as built-up, beam & column size is analyzed using STAAD.Pro.V8i.

Step-2: Selection of seismic zone. (IV)

Step-3: Formation of load combination.

Step-4: Modeling of building frames Using STAAD Pro software.

Step-5: Analyses each models considering each load combinations for 12 Model Cases.

Step-6: Comparative study is to be done for seismic parameters such as story shear, displacement, compressive stress, story drift in order to check stability check using STAAD Pro.

1.2 BUILDING SPECIFICATION

The building with different slope multi-storey RCC frame building are to be analyzed in STAAD Pro. It lies in zone IV.

1.3 FORMULATION OF MODELS

The built-up area considered here are taken equal for all different cases i.e. no shear wall, Shear Wall up to 2 Storey, Shear Wall up to 4 Storey & Full Storey Shear Wall in full respectively analyzed for each 10D frame,15D frame and

20D Slope frame. The Sloping ground building are of size i.e. 21m x 21m equal to 441 m^2 with a height of (G+9) Storey. The floor to floor height is taken as 3 meter for all the structures and also the section properties is also common for all case frame structures.

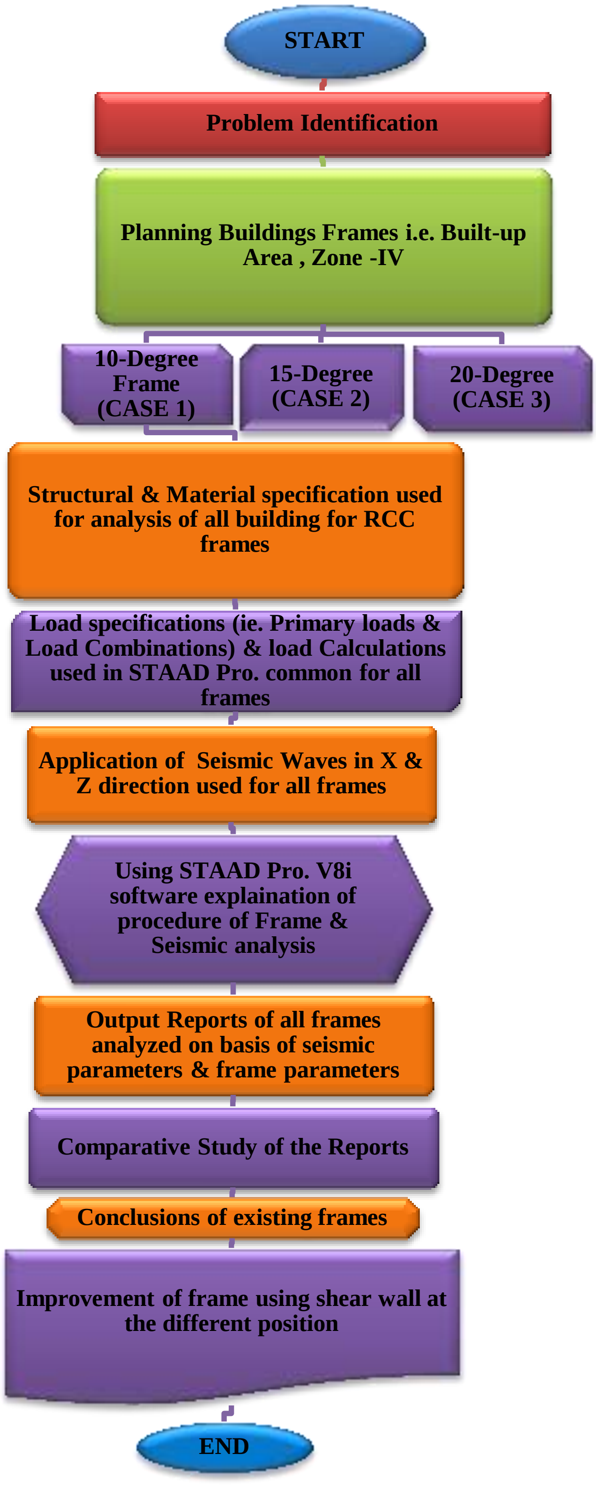
Table-1: Distribution of all Models for the Study Analysis

MAIN CASES	CASE DETAILS	SUB-CASES
10-Degree Slope (Case 1)	Frame with No Shear Wall	Case 1A
	Frame with Shear Wall Up to 2 Storey	Case 1B
	Frame with Shear Wall Up to 4 Storey	Case 1C
	Frame With Full Storey Shear Wall	Case 1D
15-Degree Slope (Case 2)	Frame with No Shear Wall	Case 2A
	Frame with Shear Wall Up to 2 Storey	Case 2B
	Frame with Shear Wall Up to 4 Storey	Case 2C
	Frame With Full Storey Shear Wall	Case 2D
20-Degree Slope (Case 3)	Frame with No Shear Wall	Case 3A
	Frame with Shear Wall Up to 2 Storey	Case 3B
	Frame with Shear Wall Up to 4 Storey	Case 3C
	Frame With Full Storey Shear Wall	Case 3D

Table- 2: Structural Properties used for all buildings

PARTICULARS	STRUCTURAL PROPERTIES
Total Built-Up Area	441 square meter
Number of Stories	G+9
Floor to floor Height	3.0 meter
Size of Columns (First, Second &Third Floor)	700 X 700 mm
Size of Columns (Fourth to Tenth Floor)	500 X 500 mm
Beam Size	400 X 400 mm
Slab/Plate thickness	150 mm
Surface Thickness	500 mm
Main Wall thickness	230 mm
Partition Wall thickness	120 mm
Dead load	IS 875 Part-1 (Reference 4.5.2.1)
Live load	IS 875 Part-2 (Reference 4.5.2.2)
Roof live load	IS 875 Part-2 (Reference 4.5.2.2)
Earthquake load	IS 1893:2002 (Reference 4.5.2.3)

2. METHODOLOGY



Flow Chart-1: Methodology

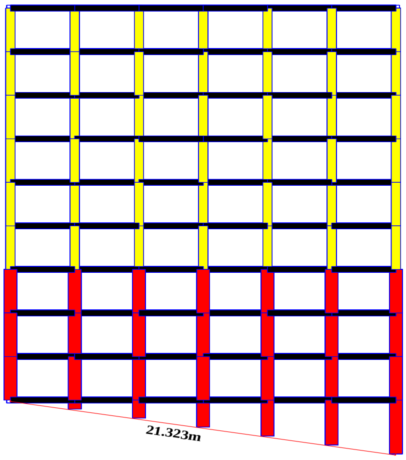


Fig-1: Elevation of 10-Degree Slope Building

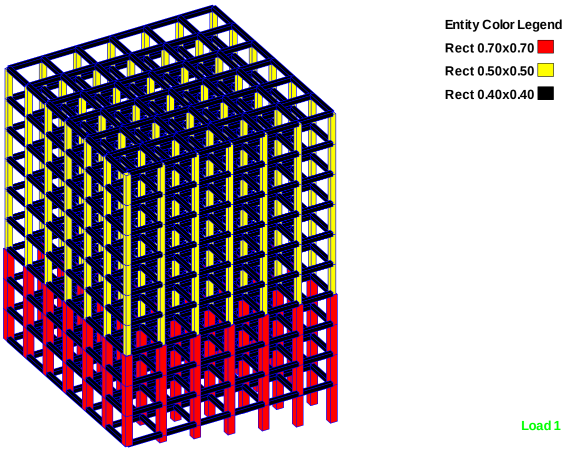


Fig-2: Three-Dimensional View of 10-Degree Building

three dimensional view of 10-Degree Slope building in which there is difference in the sectional properties of beams in all floors and as well as their is difference in sectional properties of columns as we go further in the higher storeys. The columns present in the First, Second and Third floors of 10-Degree slope building are of size 0.70 X 0.70 meter in red colour . The columns present in the Fourth to tenth floors of 10-Degree building are of size 0.50 X 0.50 meter in yellow colour.The beams present in all the floors are of size 0.40 X 0.40 meter in black colour .The Slab /Plate thickness of above building is same for all the floors i.e. 150 mm.

These RCC slope building frames are made up of two basic materials i.e. concrete and reinforced steel. The table given below shows the properties of materials considered for design and analysis of all RCC frame buildings.

Table- 3: Material Specification

Particular	Details
Grade of Concrete	M30
Grade of Main Steel	Fe415
Grade of Secondary Steel	Fe415
Beam & column cover	25 mm & 40 mm
Density of Reinforced Concrete	25 KN/m^3
Density of Brick walls, Plaster	18 KN/m^3
Young's modulus of steel	2 X 10 ^{5} N/mm^2

Model Frames -

As after feeding dimension, the actual structural frames appear on the main screen after defining the section properties in all the cases and sub-cases models. The figure given below shows the three dimensional rendering view after making the frame of sub-cases i.e. no shear wall, up tp 2 storey, up to 4 storey & full storey shear wall.

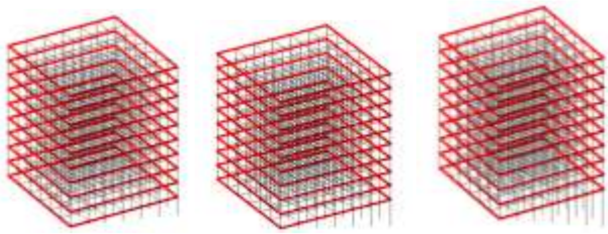


Fig. 3 Model Frames with No Shear Wall (Case 1A, Case 2A, Case 3A)

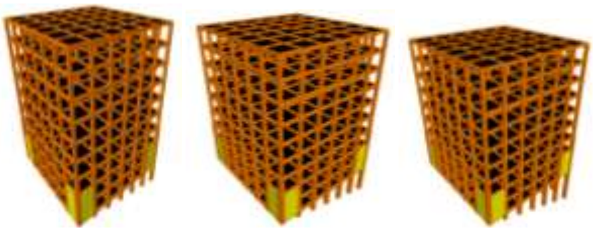


Fig. 4 Model Frames with Shear Wall up to 2 Storey (Case 1B, Case 2B, Case 3B)

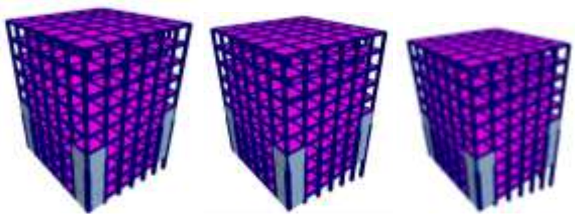


Fig. 5 Model Frames with Shear Wall up to 4 Storey (Case 1C, Case 2C, Case 3C)

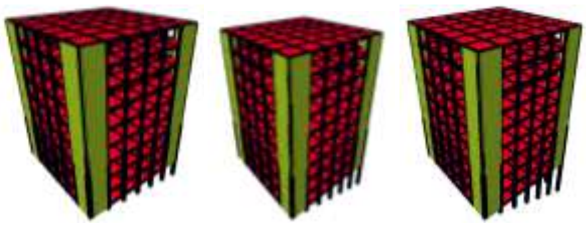
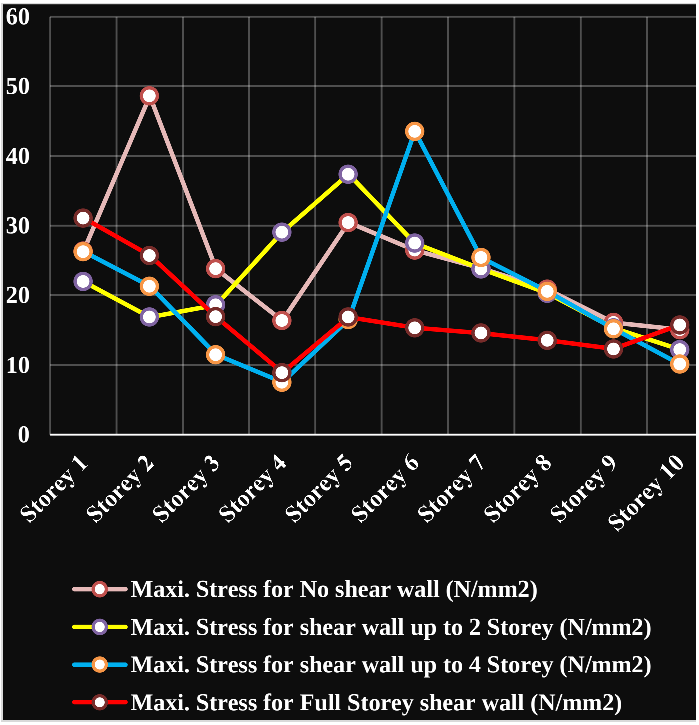


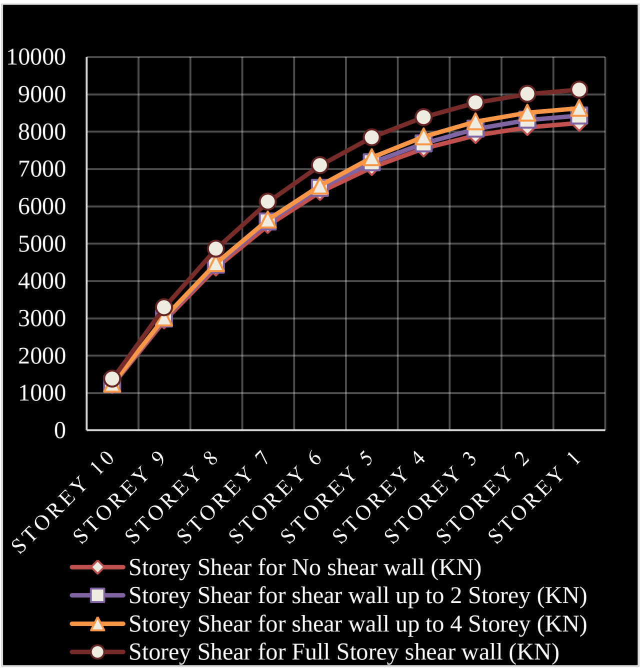
Fig. 6 Model Frames with Full Storey Shear Wall (Case 1D, Case 2D, Case 3D)

RESULT

For 20 degree frame



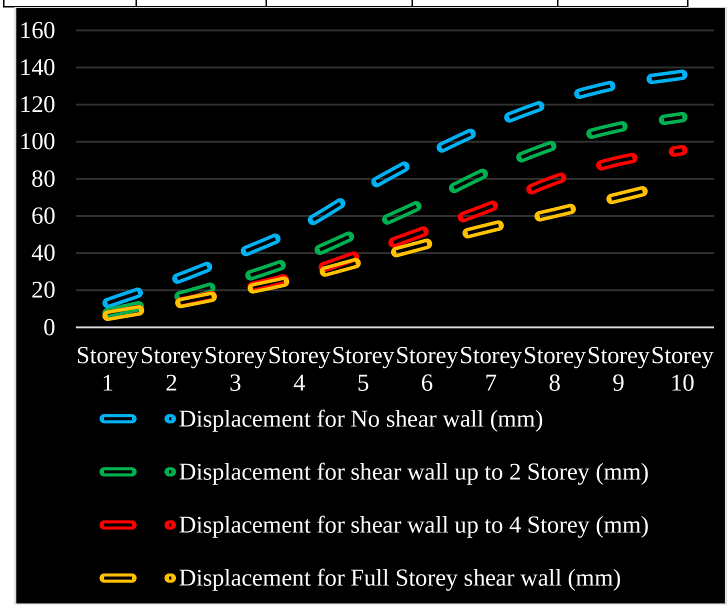
Graph-1: *Comparison Report for Compressive Stress* for all cases



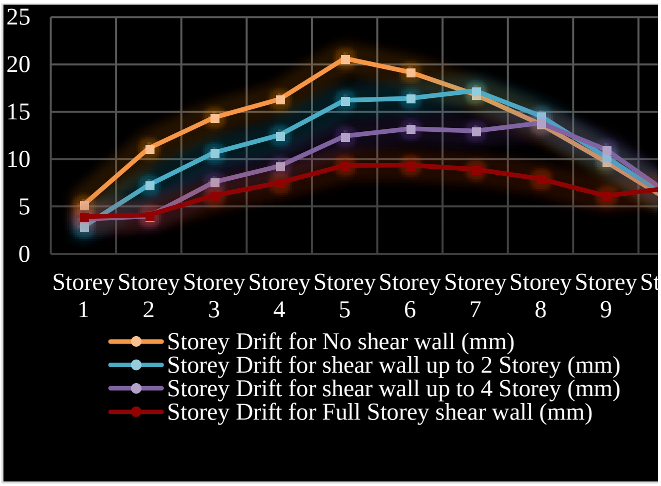
Graph-2: *Comparison Report for Peak Storey Shear for* all cases

Table- 4: Comparison Report for Lateral Load

Storey	Lateral Load for No shear wall (KN)	Lateral Load for shear wall up to 2 Storey (KN)	Lateral Load for shear wall up to 4 Storey (KN)	Lateral Load for Full Storey shear wall (KN)
Storey 1	35.751	36.907	37.758	36.318
Storey 2	120.618	132.485	132.052	127.019
Storey 3	252.818	277.28	287.946	276.973
Storey 4	413.332	421.928	459.287	441.785
Storey 5	601.028	613.528	683.1	675.189
Storey 6	852.665	870.399	880.568	941.917
Storey 7	1148.19	1172.073	1185.766	1269.8
Storey 8	1487.61	1518.55	1536.292	1646.57
Storey 9	1870.92	1909.829	1932.142	2072.24
Storey 10	1340.07	1367.941	1383.923	1525.81



Graph-3: Comparison Report for Storey Displacement



Graph-4: Comparison Report for Storey Drift

3. CONCLUSIONS

The following conclusions were made after the analysis of the different sub-case frames-

1) It has been observed that Slope frame having no Shear Wall ***(Case 1A, Case 2A, Case 3A)*** frame having shear wall up to 2 Storey ***(Case 1B, Case 2B, Case 3B)***, frame having shear wall up to 4 Storey ***(Case 1C, Case 2C, Case 3C)*** are displaced more in lateral direction in comparison with the slope frame having full storey shear wall building ***(Case 1D, Case 2D, Case 3D)***. It is been concluded that the displacement of ***20-Degree slope frame with full storey shear wall (78.505 mm) is approximately 11% more than 10-Degree slope frame with full storey shear wall (70.278 mm)***. As the slope is lesser then, the frame are more rigid which result in minimum displacement.

2) The displacement result in the slope frame study shows not much difference hence, while increasing slope to a certain limit does not affect the building much practically. Finally above results indicate that, the damage in columns of frames at the top story need to be retrofitted with different location for the much different result. So, for minimizing displacement several remedial measure can be taken as ***C- shaped & rectangular shaped shear wall*** for 10-degree frame or 15-degree slope frame.

3) The storey drift being the important parameter to understand the drift demand of the irregular structure is considered while collecting the results from the software as per IS 1893-2002.The storey drift in any storey due to the minimum specified design lateral force, with partial load factor of 1.0 shall not exceed 0.004 times the storey height, which is not exceeded in any of the structure. ***It concludes that slope frames with no shear wall is showing vulnerable drift in the upper storey but as the continuous addition of shear wall gives the drift value decreases. The drift was maximum in 20-Degree frame with no shear wall (i.e. 20.62 mm) which is 55% more as compare to the 20-Degree frame with full storey wall (i.e. 9.35 mm) Hence, it concludes that adding shear wall makes real affect in the existing building.***

4) As from the regular frame concept the compressive is inverse of displacement. The maximum compressive stress develop in the bottom most storey. But, from the comparative analysis of different sub-case frames it has been observed that ***in case of no shear wall 20-Degree slope frame shows maximum stress (48.59 N/mm²) which is 0.64 times more when compared with case of 10-degree slope frames with full storey shear wall (31.06 N/mm²).Hence, the stress developed in the slope frames can also be reduced with the addition of full shear wall.***

5) Storey shear for slope model the maximum shear is shown by 20-degree frames. The shear analysis shown by 20-Degree frame with no shear wall ***is approximately 2 % more*** than the 20-Degree slope frame with shear wall up to 2 storey. ***Similarly,*** 20-Degree frame with shear wall up to 2 storey ***is approximately 2 % more*** than the 20-Degree slope frame with shear wall up to 4 storey and 20-Degree frame with shear wall 4 storey ***is approximately 5 % more*** than the 20-Degree slope frame with full shear wall. Overall changes when comparing 20-degree no shear wall frame with 20-degree full shear wall frame there is a ***percentage increase of 10 %***.

6) The analysis demonstrates that slope difference has a significant effect on the seismic response of buildings. The results shows that the maximum lateral load is shown by 10-Degree slope and the other two slope i.e. 15-Degree & 20-Degree frames shows lesser value. The lateral load analysis shown by 10-Degree frame with no shear wall ***is approximately 0.03 time more*** than the 20-Degree slope frame with shear wall up to 2 storey. ***Similarly,*** 20-Degree frame with shear wall up to 2 storey ***is approximately 0.03 times more*** than the 20-Degree slope frame with shear wall up to 4 storey and 20-Degree frame with shear wall 4 storey ***is approximately 0.08 times more*** than the 20-Degree slope frame with full shear wall. Overall changes when comparing 20-degree no shear wall frame with 20-degree full shear wall frame there is a ***percentage increase of 11 %***.

7) From results it has been found that the 15-Degree slope frame carry more weight than the other slope frames. Concluding that the quantity of steel for 15-degree frame with no shear wall model shows ***0.66 times*** less weight than the 15-degree frame with full storey shear wall model.

8) Similarly, in terms of quantity of concrete the results shows that the 15-Degree slope frame carry more quantity of concrete which is less cost effective. Concluding that the quantity of steel for 15-degree frame with no shear wall model shows ***0.07 times*** less weight than the 15-degree frame with full storey shear wall model.

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