SEISMIC ANALYSIS OF RC BUILDING WITH AND WITHOUT SHEAR WALL ON SLOPING GROUND

Ankit Choudhary[1], Rahul Bhukar[2], Kartikey Chaturvedi[3], Sahil Kumar[4], Adesh Dara[5], Alok Sharma[6]

[1,2,3,4,5] U.G. students, School of Civil Engineering, Lovely Professional University, Punjab, India,

[6]Assistant Professor, School of Civil Engineering, Lovely Professional University, Punjab, India.

Abstract

In the current scenario, appealing architecture along with high rise buildings is not limited to plain terrain but also extended to the hilly terrain keeping in mind the problems arised and their effects. In this study, the five different sloping ground frames building i.e., 0-degree slopes, 8 Degree slopes, 10 Degree slopes, 14 Degree slopes & 18 Degree slopes frames of G+6 storey has been analyze by using structural software which is STAAD.Pro. V8i for seismic Zone –V, Mandi, Himachal. The objective of this study is to carried out equivalent static analysis (ESA) for five different sloping RCC frame building and various parameters are compared against various constraints and results obtained from various building cases. To analyze the variation of stability parameters such as axial force and node displacement at different slopes. The dynamic response of the structure on hillslope has been discussed. A review of studies on the seismic behaviour of buildings resting on the sloping ground has been presented. It is observed that the seismic behaviour of buildings on the sloping ground differs from other buildings.

Introduction

India has a record of earthquakes in various regions mostly in the hilly areas which result in loss of human lives and economy as well as the shaking of the surface of the earth which results in a sudden release of energy in the earth's lithosphere causes seismic waves. These seismic waves are caused by the sudden breaking of rock within the earth, the moment or trembling of tectonic plates or any explosion which has occurred naturally or by human activities. Human life gets heavily affected due to these waves resulting in the loss of property and life. Apart from the loss of life the most vulnerable to damage due to these are the high-rise buildings in seismic zones. To understand the behaviour of seismic waves and prevent damage to property and life seismic zones are set up. Seismic zones are the areas that are prone to Earthquakes due to their particular topography. Bureau of Indian standards has grouped India into four seismic zones which are Zone-Zone-IV, Zone-III, Zone-II. Where Zone-II the least intense zone and Zone-V is the most severely intense zone.
Mapping seismic zones help in detecting the lowest, moderate as well as highest hazardous or earthquake-prone areas in India. The most important application is that this map guides architects and engineers to design safe and durable buildings in such areas that are prone to earthquakes which led to the prevention of losses of lives and property.

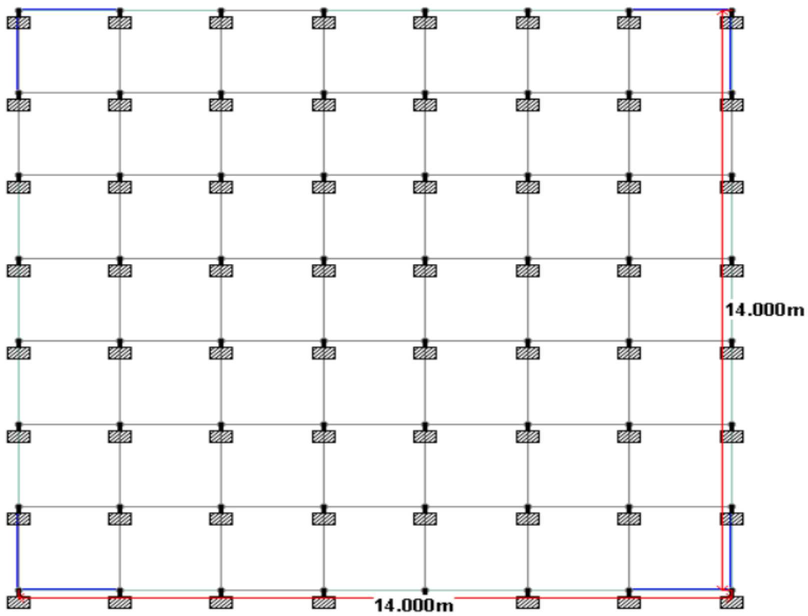
Buildings that are made on high elevation areas are vulnerable to damages when earthquakes hit the place and the underlying causes can be either damage due to soil conditions or damage resulting from poor design and errors while construction.

- Structural Modeling- A RCC medium-rise building of six stories with a floor height of three-meter subjected to earthquake loading in IV has been thought of. In this regard, STAAD professional V8i software system has been thought of as a tool to perform. impact of the sloping impact of the bottom on the behaviour of structural frames is analyzed.
- Step set back building (Step back)–Setback-Resting on sloping ground-

The Buildings on the hill dissent from alternative buildings. the varied floors of such building step back towards the Capitol Hill slope and at identical time buildings could have setbacks additionally. Buildings located in cragged areas are rather more susceptible to seismic surroundings. during this study, 3D analytical model of ten storied buildings are generated for bilateral and uneven building Models and analyzed victimization structural analysis tool 'STADD-PRO" to check the impact of variable height of columns in-ground keep thanks to sloping ground and also the impact of a shear wall at completely different positions throughout an earthquake

- Modeling of the building-

The building is modelled with help of the software STAAD pro. The analytical models of the building embody all parts that influence the mass, strength, stiffness and deformability of the structure. The building structural system consists of columns, beams, walls, slab, and foundation. The non-structural parts that don't considerably influence the building behaviour aren't modelled. The slopes of a building are varied from zero to eighteen degrees

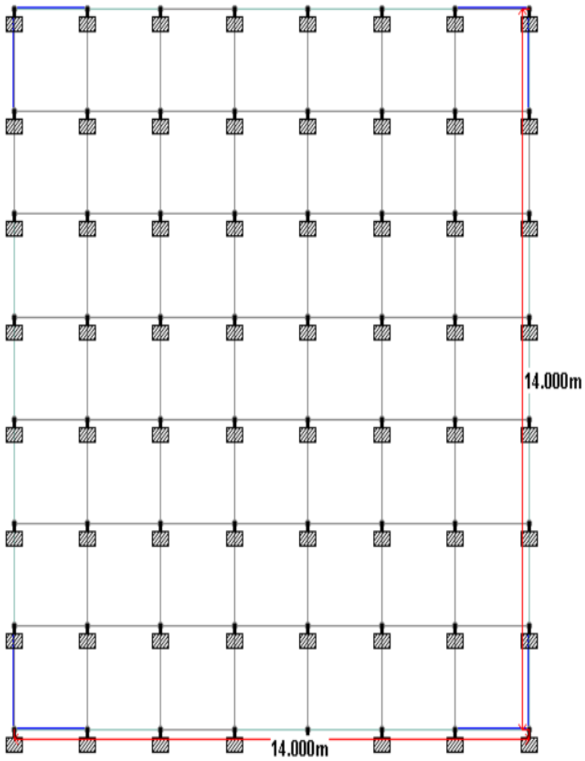


A. Methodology and Modeling

The study is all about analyzing the (G+6) multistorey building with the shear wall using step set back configuration on different sloping condition for example 0degree,8-degree,10-degree, 14 degree and 18-degree using STAAD Pro. A G+6 multistorey building is configured comprising of 7 no's of bays along length and width each of 2m in length and 7 no of bays along with the height each of 3m in length. All the different 5 cases (as mentioned in the table) and studied and analyzed according to Indian standard code IS 1893 (Part 1): 2016 for the seismic parameters in the zone – V using static analysis method and using STAAD Pro software to check the possibilities to resist the deformation and to check whether the structure can withstand the earthquake loads.

- General

A G+6 multistorey building is configured comprising of 7 no's of bays along with length and width each of 2m in length and 7 no of bays along the height each of 3m in length. All the different 10 cases are studied and analyzed according to Indian standard code IS 1893 (Part 1): 2016 for the seismic parameters in the zone – V using static analysis method and using STAAD Pro software to check the possibilities to resist the deformation and to check whether the structure can withstand the earthquake loads.



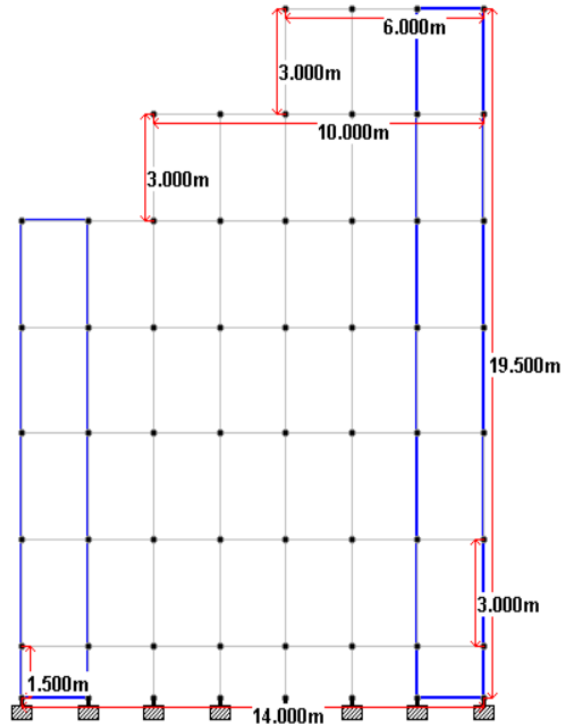


Figure-1: plan of the building (top view)

Figure-1.1: Dimensions(isometric view)

- Input Data

PARAMETERS	ASSUMED DATA
Length of building	14m
Width of building	14m
Height of building	19.5m
Exterior beam size	350mm x 350mm
Interior beam size	300mm x 300mm
Base column size	400mm x 400mm
Floor column size	350mm x 350mm
Floor slab size	125mm
Roof slab size	150mm
Shear wall	150mm
Depth of foundation	1.5m
Material properties	Concrete (M25)
Support	fixed
Floor height	3m
Wall thickness	230mm
Inner plastering	12mm
Outer plastering	15mm
Unit weight of plain cement concrete	20KN/m^3
Unit weight of RCC	25KN/m^3
Beam depth deduction	450mm

Table-1: Assumed data

PARAMETERS	ASSUMED DATA
Soil type	Medium soil
Seismic zone	V (Z = 0.36)
Response reduction factor	5
Importance factor	1 (for commercial building)
Damping ratio	5%
Fundamental natural period of vibration (T_a)	Ta_x = 0.48416 seconds Ta_y = 0.48416 seconds

Table-2: Earthquake parameters

- LOADING DETAILS

The load applied in the structure are all primary loads and their load combination is taken according to IS 1893:2002/2016. Primary loads are generally DEAD LOAD(DL), LIVE LOAD(LL), static seismic load (EQX AND EQZ).

The calculation of all primary loads are as follows: -

1. DEAD LOAD(DL)- Dead load is the self-weight of the elements of the structure which include dead load exterior beam, interior beam, dead loads of columns and dead loads of floor slab and roof slab.

Dead loads of exterior walls(w1) = (wall thickness + inner plastering + outer plastering) x (unit weight of pcc) x (floor height – beam depth) = (0.230+0.012+0.015) x 20 x (3-0.45) = 13.1 KN/m

Dead loads of interior walls(w2) = 15% reduction = 0.85 x w1 = 0.85 x 13.1 = 11.1KN/m

Parapet wall (w3) = 5.1 KN/m

Floor slab dead load = (slab thickness x unit weight of rcc) + (inner plastering + floor finish) x unit weight of pcc = (0.125 x 25) + (0.012 + 0.075) x 20 = 4.85KN/m^2

Roof slab dead load = (0.150 x 25) + (0.012 + 0.150) x 20 = 6.99KN/m^2

2. LIVE LOAD(LL) - All the values are considered according to the IS code 875-part 2 live load on the floor is same 0f intensity 3KN/m^2 and live load on the roof slab is of intensity 1KN/m^2.
3. SEISMIC LOAD (EQX AND EQZ) – Seismic load calculation includes submission of all dead loads plus some 25% percentage of live loads on the roof. The seismic parameters used in the projects are as follows: -

Seismic zone factor = (z - 0.36) – zone v, importance factor = 1 (commercial building)

soil type = medium soil condition, damping ratio = 5% and moment resisting frame

Time period=T = 0.09h/√d

T_Z = 0.09 X 12/√14 + 0.09 X 3/√6 + 0.09 X 3/√10 = 0.48416 - T_Z

T_X = 0.09 X 18/√14 = 0.43296-T_X

AH = (Z/2) X (SA/G) / (R/I) = 0.36/2 X 2.5 % 5 = 0.09 - A_H

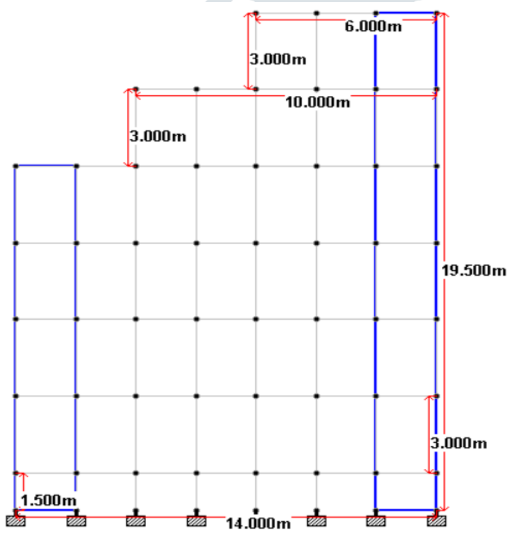
V_B (design base shear) = AH X W = V_B = 0.09 X 6859.16 = 617.32KN

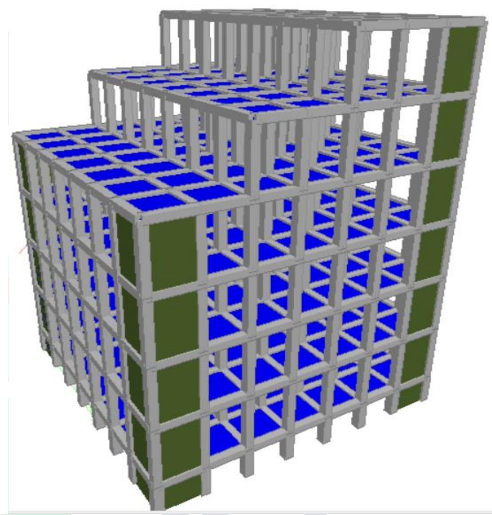
4. Load Combination

Load cases	Details of load cases
i.	1.5(DL+LL)
ii.	1.2(DL+LL+EQX)
iii.	1.2(DL+LL-EQX
iv.	1.2(DL+LL-EQZ)
v.	1.2(DL+LL+EQZ)
vi.	1.5(DL+LL-EQZ)

5. Analysis

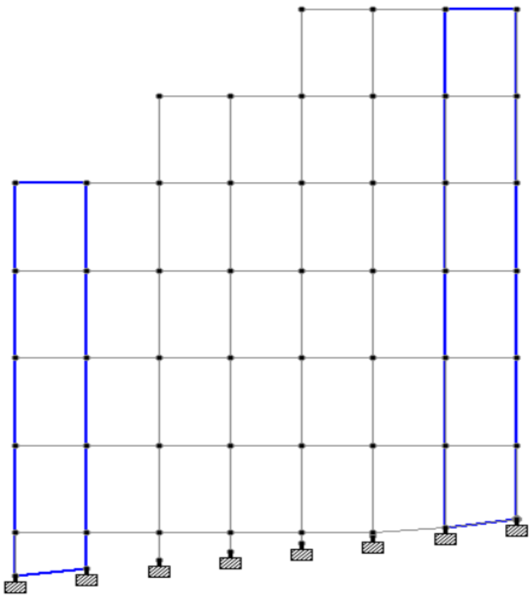
The sample model was created in the software using STAAD Pro software to check the possibilities to resist the deformation and to check whether the structure can withstand the earthquake loads

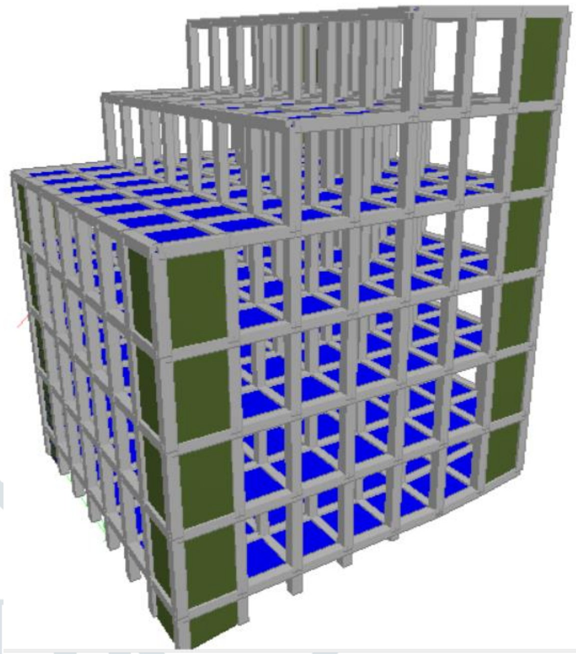


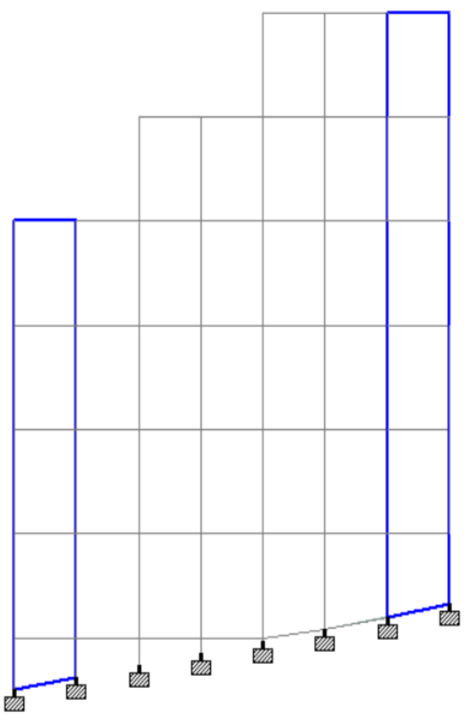


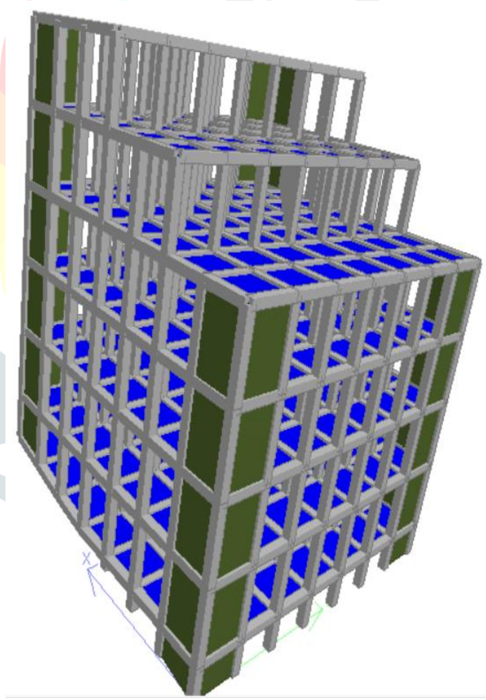
0 DEGREE(A0) **Figure -2**

8 DEGREE(A1) **Figure - 3**

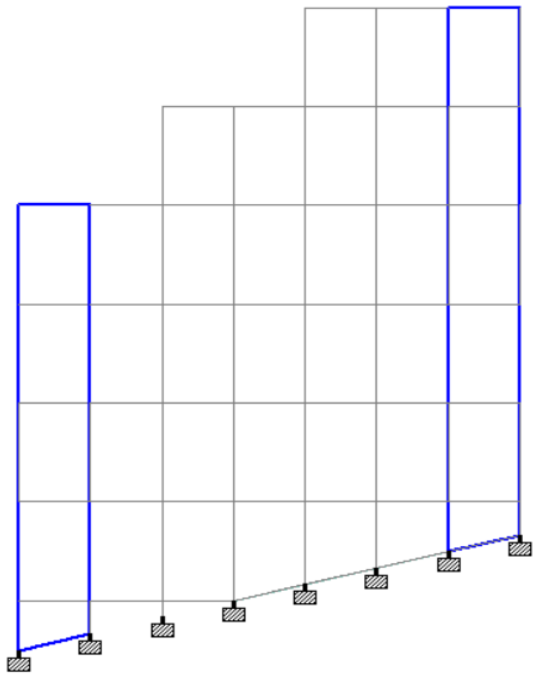








10 DEGREE (A2) **Figure -4**



14 DEGREE(A3)

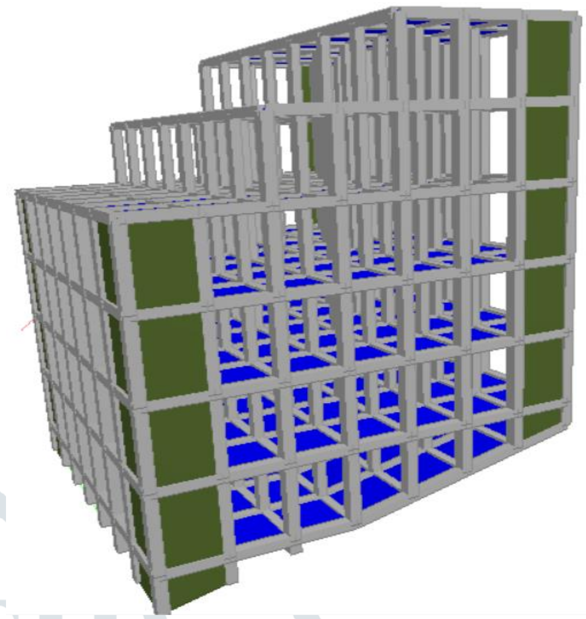
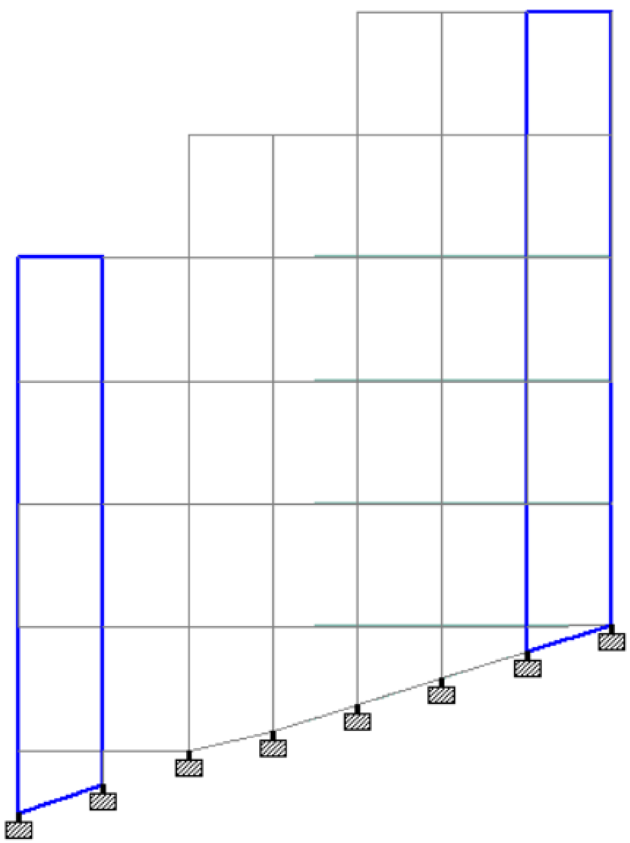


Figure – 5



15 DEGREE (A4)

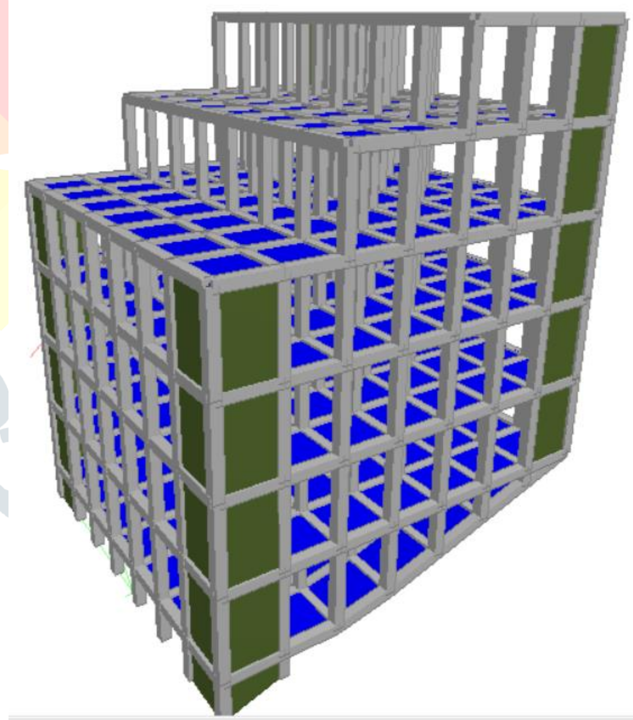


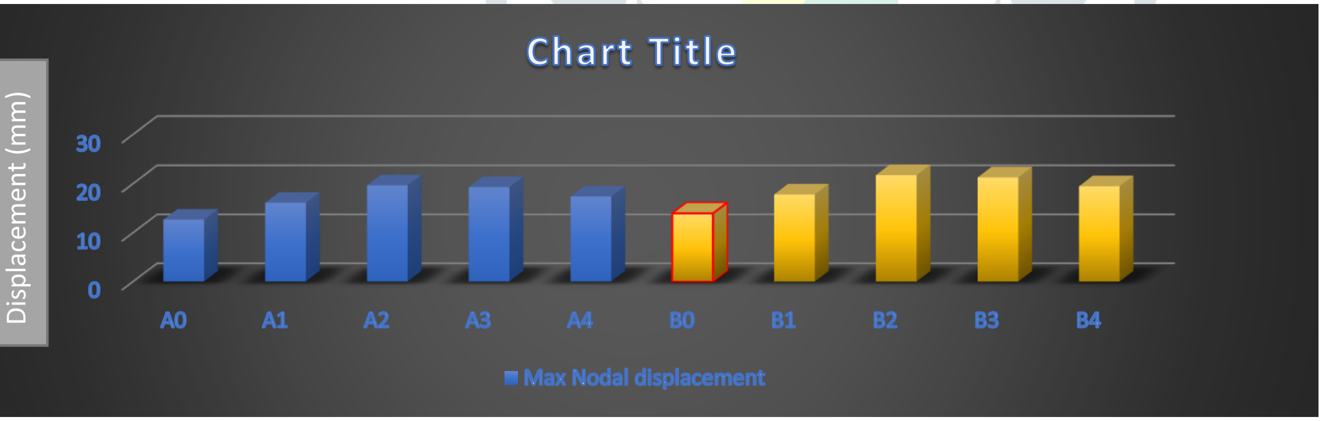
Figure – 6

B. Result

In this research paper, various cases are analyzed according to IS CODE 1893:2016 for seismic zone V against all the cases given the above table 3. The seismic analysis had been performed for all the different cases against various load combinations with or without shear wall using step set back configuration. The parameter used for the comparative examinations is maximum nodal displacement, maximum base shear, maximum shear force, maximum bending moment by both tabular and graphical form for models using with shear wall and without a shear wall.

Table – 3 Maximum nodal displacement for various building cases

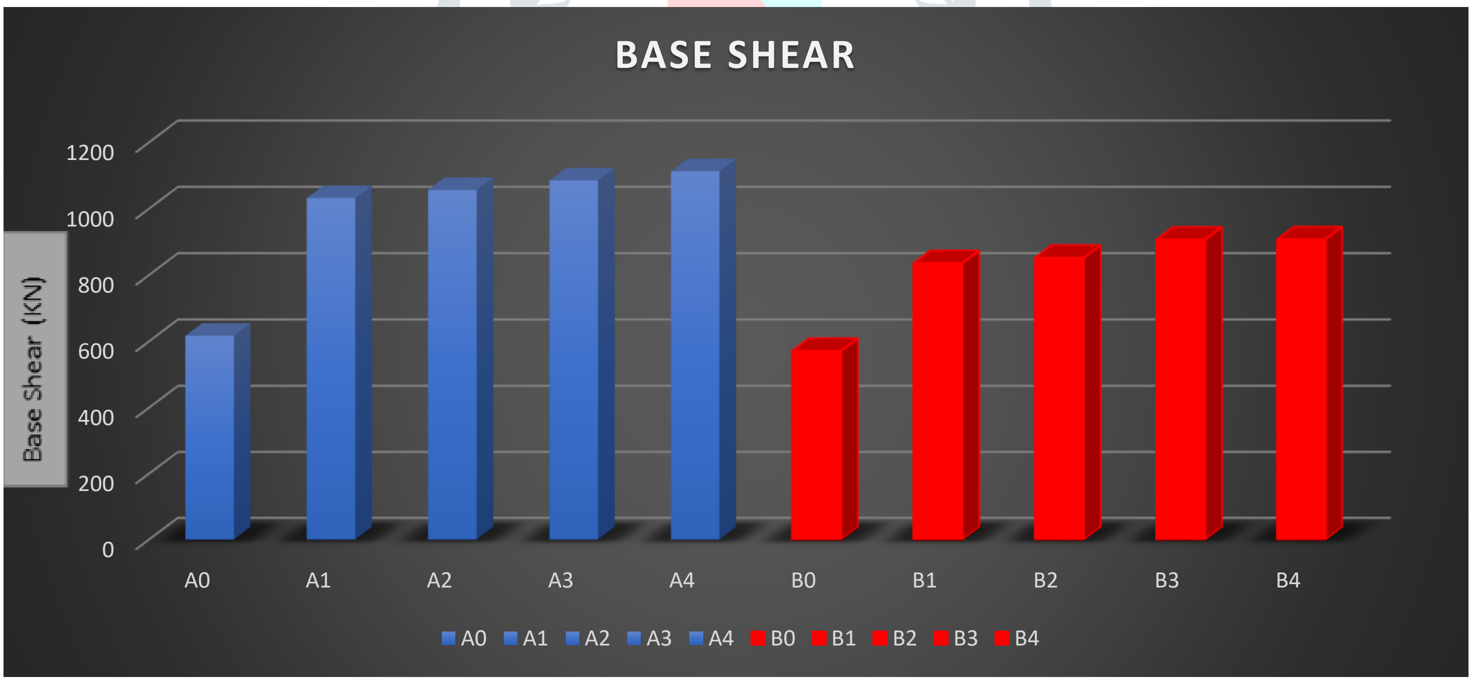
BUILDING	DISPLACEMENT(mm)	BUILDING	DISPLACEMENT (mm)
A0	12.701	B0	13.982
A1	16.160	B1	17.833
A2	19.708	B2	21.759
A3	19.739	B3	21.309
A4	17.435	B4	19.508



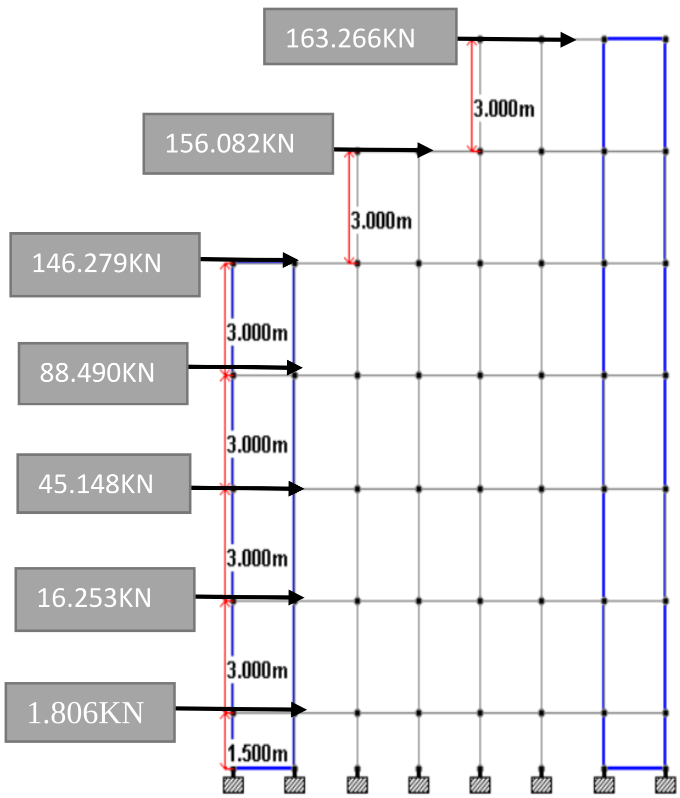
Graph – 1 Graphical representation of maximum nodal displacement for all building cases

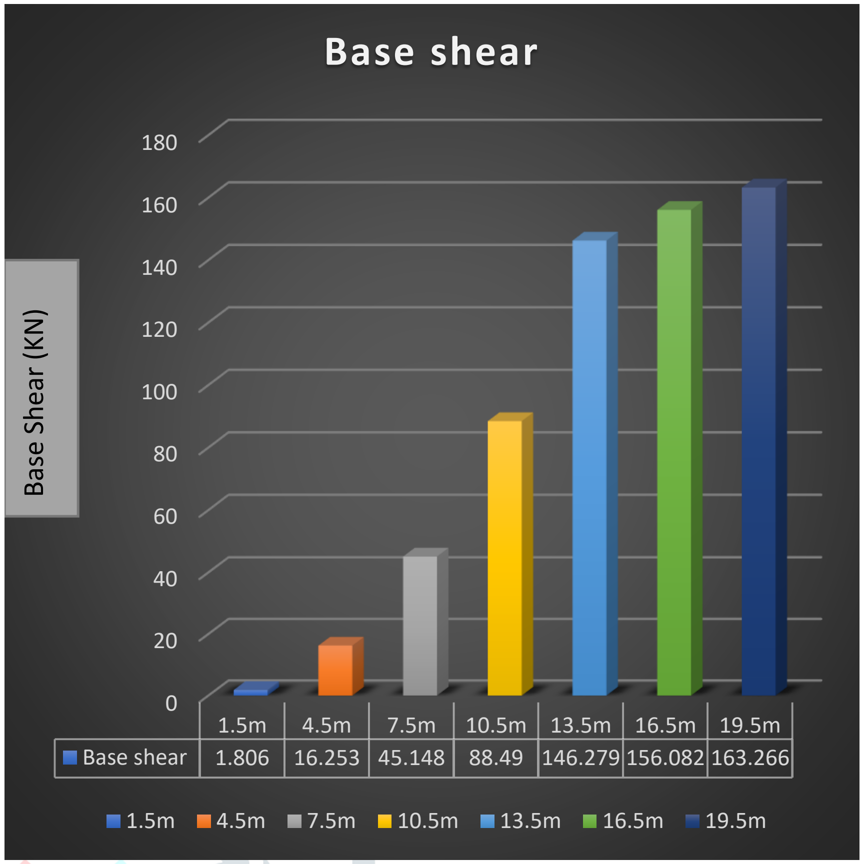
Table – 4 Maximum base shear value in X direction for all building cases

BUILDING	BASE SHEAR (X DIRECTION) - KN
A0	617.324 KN
A1	1032.291 KN
A2	1056.881 KN
A3	1085.904 KN
A4	1113.063 KN
B0	571.222 KN
B1	835.674 KN
B2	851.971 KN
B3	906.711 KN
B4	907.514 KN



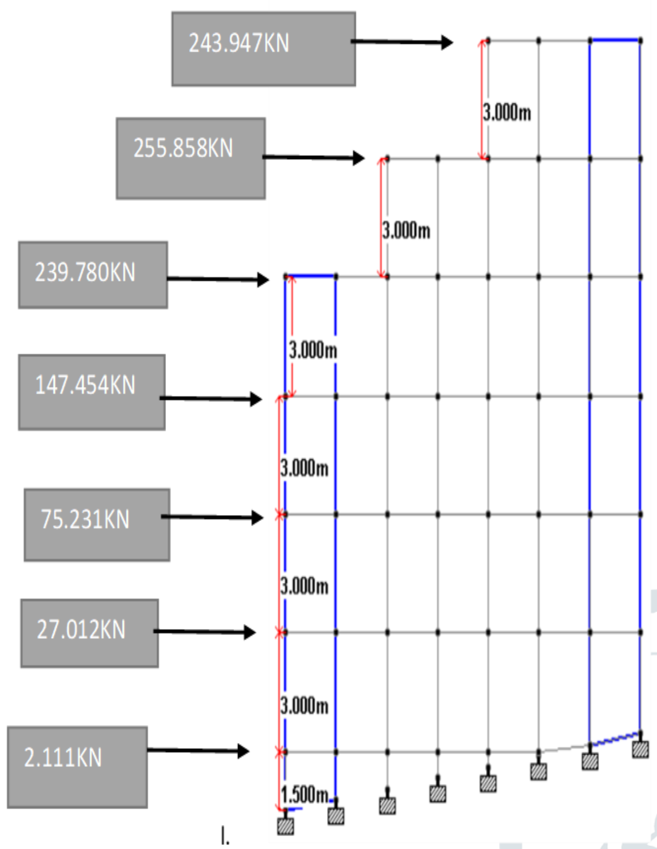
Graph -2 Graphical representation of base shear in x direction for all different cases of building



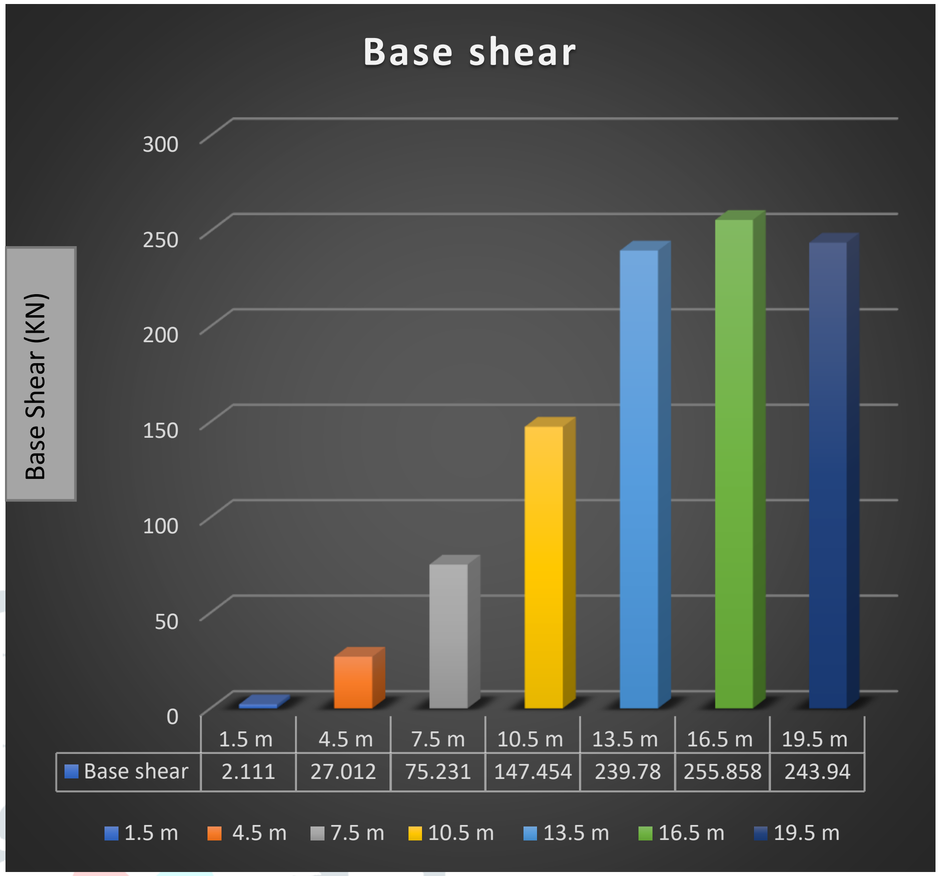


Base shear at (A0) (0 Degree slope with shear wall)

Graph – 3 (Base shear at (A0)
(0 Degree slope with shear wall))

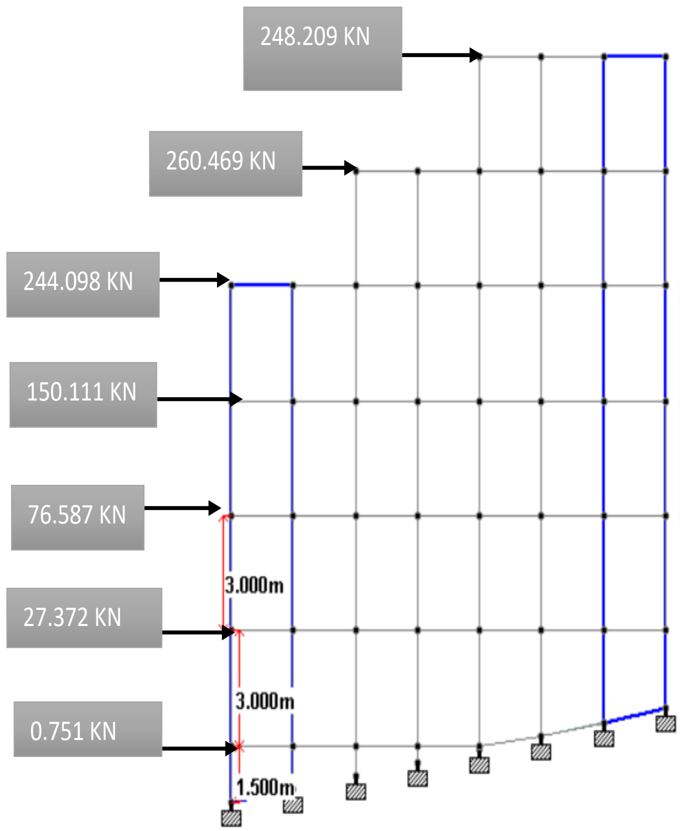


Base shear at A1 (8-degree slope with shear wall)

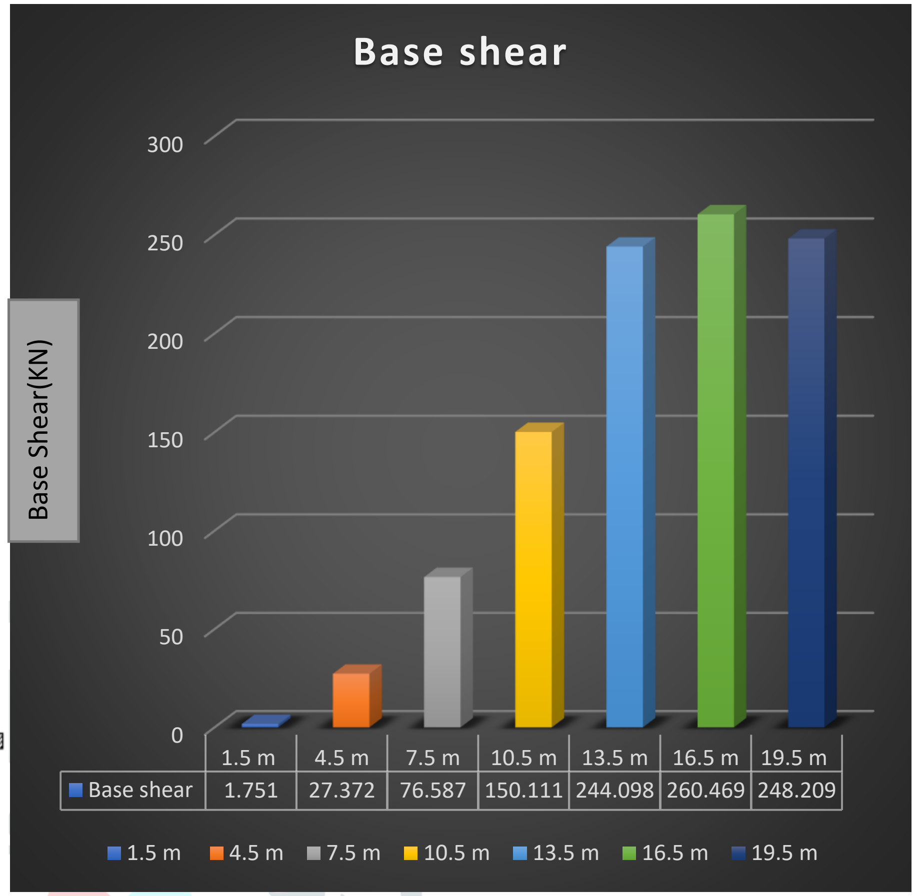


	1.5 m	4.5 m	7.5 m	10.5 m	13.5 m	16.5 m	19.5 m
Base shear	2.111	27.012	75.231	147.454	239.78	255.858	243.94

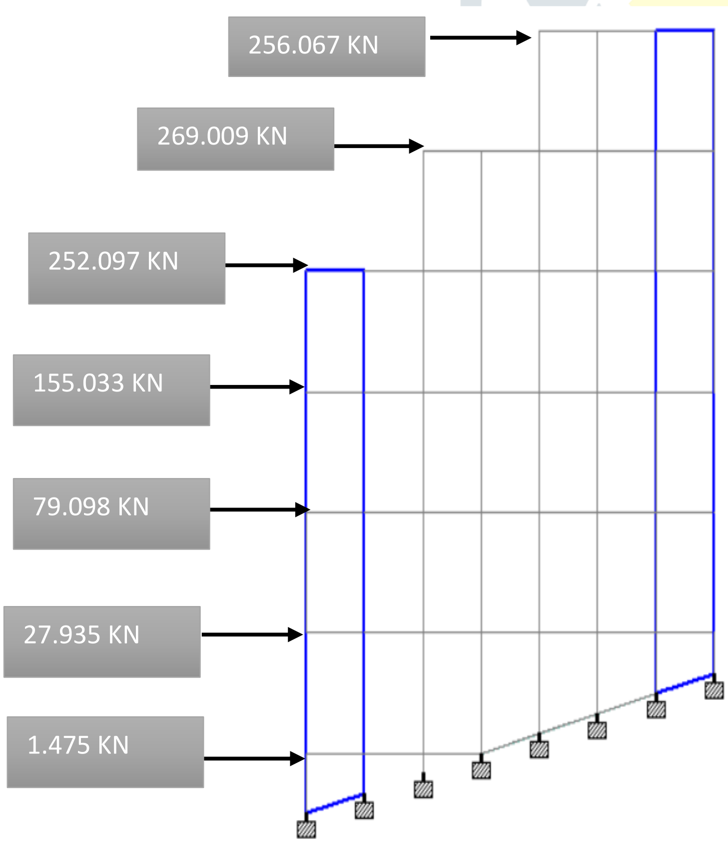
Graph-4(Base shear at A1 (8-degree slope with shear wall))



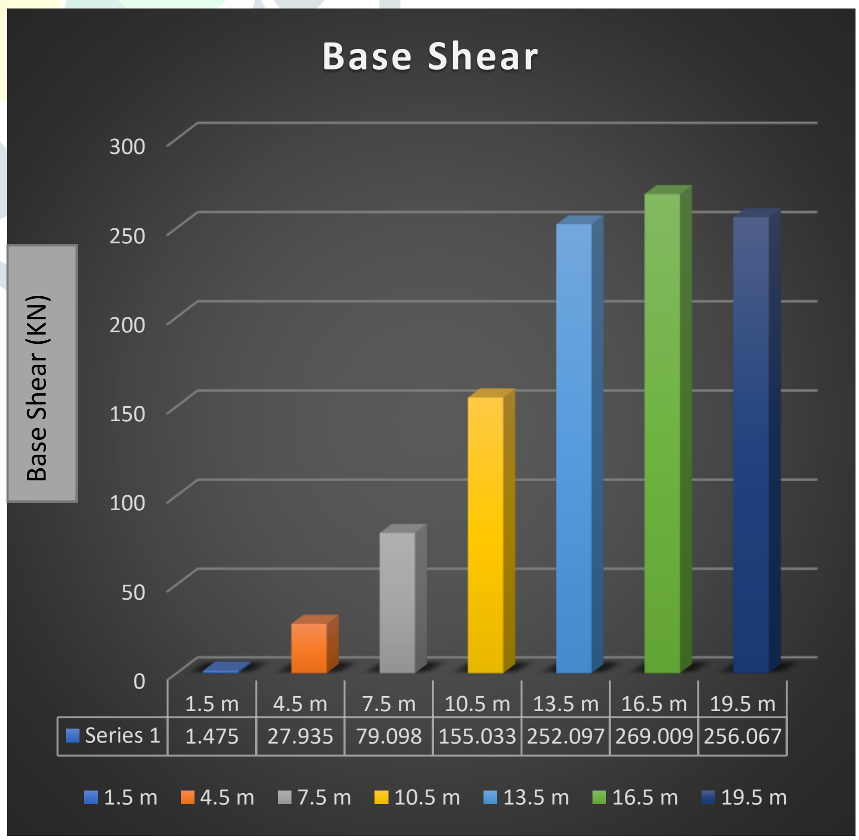
Base Shear at A2 (10-degree slope with shear wall)



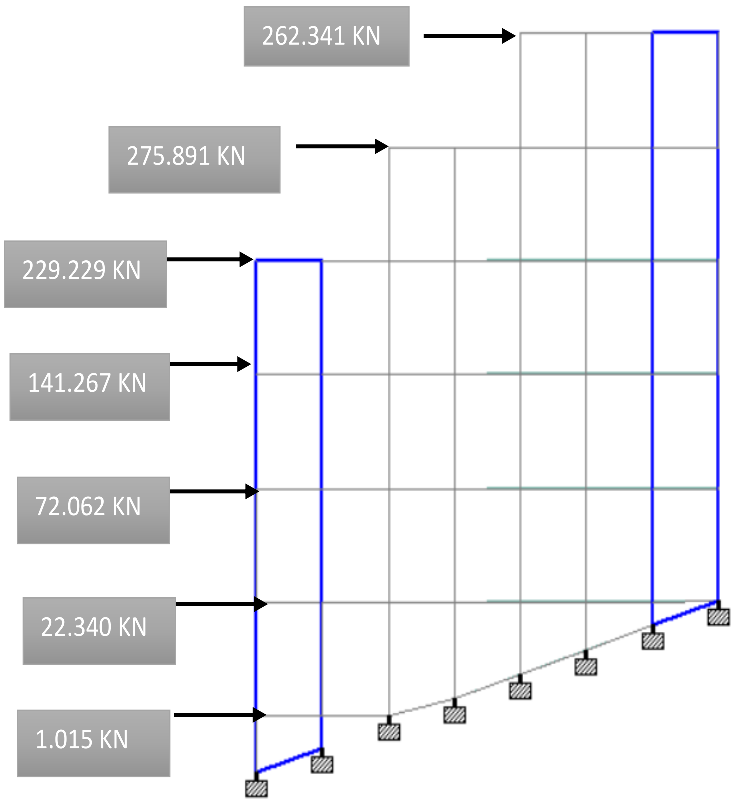
Graph – 5(Base shear at A3(14-degree slope with shear wall))

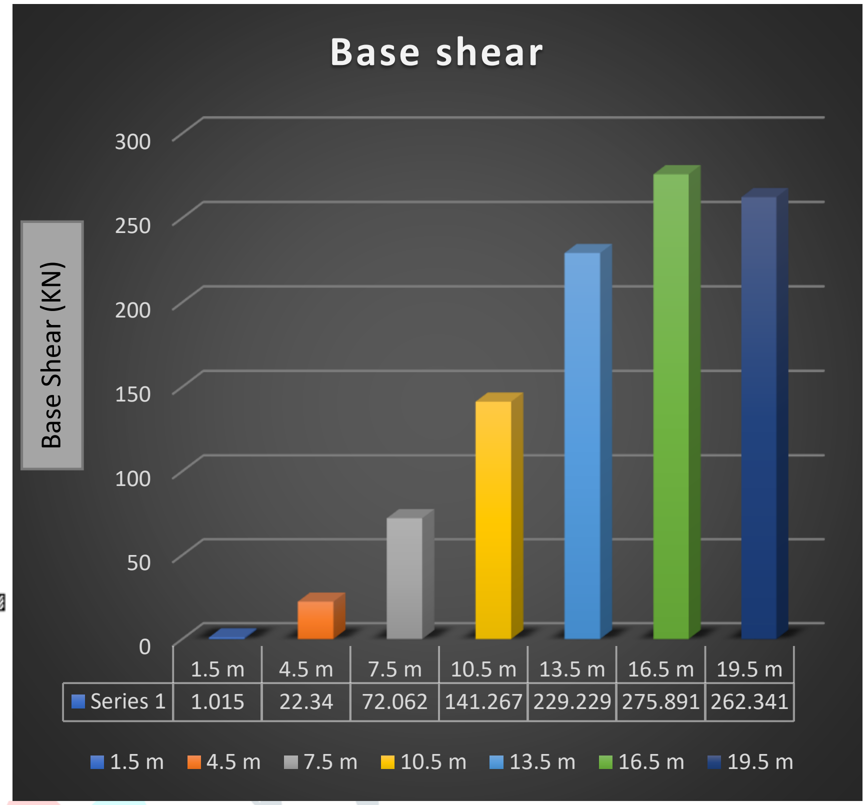


Base Shear at A3 (14-degree slope with shear wall)



Graph-6(Base shear at A4(14-degree slope with shear wall))





Base Shear at A4 (18-degree slope with shear wall)

Graph-7(Base shear at A5(18-degree slope with shear wall))

Conclusion

1. Maximum nodal displacement increases as increases in the slope of the building having step set back configuration rested on flat ground with shear wall and without shear wall both.
2. The values of maximum displacement will be more in building having step set back configuration without shear wall as compared building with shear wall.
3. Base shear increases as increases in the slope of the building having step set back configuration rested on flat ground with shear wall and without shear wall both.
4. The values of base shear will be less in building having step set back configuration without shear wall as compared building with shear wall.
5. The max values of base shear will be on the top floor and minimum value will be on the ground floor.

Reference

I. Mojahid Islam, Siddharth Pastariya Analysis of building on Sloping Ground subjected to Seismic Forces International Journal of Advanced Engineering Research and Science (IJAERS) [Vol-7, Issue-1, Jan-2020]18ISSN: 2349-6495(P) | 2456-1908(O).

II. Rajkumar Vishwakarma, Anubhav Rai Analysis of a RCC frame Tall Structure using Staad Pro on Different Seismic Zones Considering Ground Slopes International Research Journal of Engineering and Technology (IRJET)e-ISSN: 2395 -0056Volume: 04 Issue: 03 | Mar -2017p-ISSN: 2395-0072.

III. Prof. Dushyant A. Zamre, Raj S. Yetekar, Rahul G. Pawar, Shubham P. Sonawane, Arshad I. Shaikh Parametric Study of Responses of RCC Building on Sloping Ground Using Staad.Pro International Journal for Research in Applied Science & Engineering Technology (IJRASET)ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.429.

IV. Dr. R. B. Khadiranaikar and Arif Masali Seismic performance of buildings resting on sloping ground−A review IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE) e-ISSN: 2278-1684, p-ISSN: 2320-334X, Volume 11, Issue 3 Ver. III (May-Jun. 2014), PP 12-19.

V. K Divya, A Srikanth, T Sreedhar Babu Effect of Ground Slope on Dynamic Performance of G + 5 Building International Journal of Engineering Research and Management (IJERM) ISSN: 2349- 2058, Volume-05, Issue-08, August 2018.

VI. Mr. Anurag Wahane, Mr. Vedprakash Sahu Seismic Analysis on RCC Frame Building Resting on Sloping Ground Using STAADPro. Software © 2020IJRTI | Volume 5, Issue 2| ISSN: 2456-3315. Research Journal of Engineering and Technology (IRJET)e-ISSN: 2395 -0056Volume: 04 Issue: 03 | Mar -2017 p-ISSN: 2395-0072.

VII. Vedprakash Sahu, Prof. L. P. Shrivastava A Study on RCC Frames under Sloping Ground with Different Shear Wall Conditions using STAAD Pro International Research Journal of Engineering and Technology (IRJET)e-ISSN: 2395-0056Volume: 07Issue: 02| Feb2020 p-ISSN: 2395-0072.

VIII. Dr. S. A. Halkude, Mr. M. G. Kalyanshetti, Mr. V. D. Ingle "Seismic Analysis of Buildings resting on sloping grounds with varying Number of bays and hill Slopes", International Journal of Engineering Research and Technology, ISSN: 2278-0181, VOL 2, ISSUE 12, December 2013.

IX. Mohammed Umar Farooque Patel, A. V. Kulkarni, Nayeemulla Inamdar, (Mar 2012), "A Performance study and seismic evaluation of RC frame buildings on sloping ground", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE), ISSN: 2278-1684, P 51-58.

X. Prashant D, Dr. Jagadish Kori G "Seismic Response of one-way slope RC frame building with soft storey" International Journal of Emerging Trends in Engineering and Development Issue 3, Vol.5(September2013)

XI. Vinayak, B. V. Rajiv. Experimental and numerical studies on dynamic analysis of sloped buildings. international journal of innovative technologies vol.04, no. issue.14 (october-2016): 2461-2466.

XII. Gauri G. Kakpure, Ashok R. Mundhada, "Comparative Study of Static and Dynamic Seismic Analysis of Multistoried RCC Building by ETAB: A Review", International Journal of Emerging Research in Management &Technology ISSN: 2278-9359, Volume-5, Issue-12

XIII. Dr. B.G. Naresh Kumar and Avinash Gornale Seismic Performance Evaluation of Torsionally Asymmetric Buildings International Journal of Science and Engineering Research, bVolume 3, Issue 6, June 2012.

XIV. B.G. Birajdar and S.S. Nalawade5, Seismic analysis of buildings resting on sloping ground, 13th world conference on earthquake engineering, Vancuover, B.C., Canada, August 1-6, 2004, paper No. 1472

XV. G. S Kavya1, Ramesh B .M, P.S Ramesh, "Seismic Performance of Step-Back and Step Back-Set Back Building Resting on A Hill Slope", International Research Journal of Engineering and Technology, e-ISSN: 2395-0056, Volume: 05, Issue: 09, Sep 2018.

XVI. Sujit Kumar, Dr. Vivek Garg, "Effect of Sloping Ground on Structural Performance of Rcc Building Under Seismic Load", International Journal of Science, Engineering and Technology (IJSET), ISSN: 2348-4098, Volume 2 Issue 6 August 2014.