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EFFECT OF USING HIGH STRENGTH CONCRETE COLUMNS ON THE STRUCTURE OF BUILDING FRAME

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Abstract:
In high-rise buildings and heavy loaded structures where RC columns are subjected to heavy loads, the use of High Strength Concrete (HSC) in columns construction is essential for the purpose of reducing column size and increasing column capacity. However, from the economic standpoint, combination of high and normal strength concrete (NSC) in building construction is becoming common practice, where HSC is used for columns and NSC is used for the surrounding beams/slabs floor system. Hence in the present work, an attempt is made to study the seismic behavior of the multi-storey G+10 buildings constructed on plain and various sloping ground with and without shear walls using high strength concrete columns on the structure of building frames. The buildings situated on hill slopes in earthquake prone areas are generally irregular, torsionally coupled. Hence, subjected to severe damage when affected by earthquake ground motion Such buildings have mass & stiffness varying along the vertical & horizontal planes, resulting the center of mass & center of rigidity do not coincide on various floors, they demand torsional analysis, in addition to lateral forces under the action of earthquakes. This study compels with a studies on the seismic behavior of buildings resting on sloping ground with a shear walls. This project to highlight the applications of high strength concrete in earthquake resistant frame structures and study the behaviour of important high strength concrete elements in those building frames A case study is presented to show the comparative difference in seismic performance typical frame structure

1.0 INTRODUCTION

A large portion of India is susceptible to damaging levels of seismic hazards. Hence, it is necessary to take in to account the seismic load for the design of high-rise structure. The different lateral load resisting systems used in high-rise building are: 1.Bare frame 2.Brace frame 3.Shear wall frame. In tall building the lateral loads due to earthquake are a matter of concern. These lateral forces can produce critical stresses in the structure, induce undesirable stresses in the structure, induce undesirable vibrations or cause excessive lateral sway of the structure. Sway or drift is the magnitude of the lateral displacement at the top of the building relative to its base traditionally, seismic design approaches are stated, as the structure should be able to ensure the minor and frequent shaking intensity without sustaining any damage, thus leaving the structure serviceable after the event. The structure should withstand moderate level of earthquake ground motion without structural damage, but possibly with some structural as well as non-structural damage. This limit state may correspond to earthquake intensity equal to the strongest either experienced or forecast at the site In present study the effect of bare frame, brace frame and shear wall frame is studied under the earthquake loading. The results are studied for response spectrum method. The main parameters considered in this study to compare the seismic performance of different models are storey drift, base shear, story deflection and time period.

Column supported shear walls

Shear walls resist two types of forces: shear forces and uplift forces. Shear forces are generated in stationary buildings by accelerations resulting from ground movement and by external forces like wind and waves. This action creates shear forces throughout the height of the wall between the top and bottom shear wall connections Uplift forces exist on shear walls because the horizontal forces are applied to the top of the wall. These uplift forces try to lift up one end of the wall and push the other end down. In some cases, the uplift force is large enough to tip the wall over. Uplift forces are greater on tall short walls and less on low long walls. Bearing walls have less uplift than non-bearing walls because gravity loads on shear walls help them resist uplift. Shear walls need hold down devices at each end when the gravity loads cannot resist all of the uplift. The hold down device then provides the necessary uplift resistance

Objectives:

- To study the high strength concrete columns on the structure of building frame
- To study seismic behavior of building without shear wall constructed on plain and sloping ground
- To study seismic behavior of building with Straight shear wall resting on plain and sloping ground

2.0 LITARATURE REVIEW

Y.M. Fahjan & J. Kubin & M.T. Tan (2010) found that in the countries with active seismicity, reinforced concrete structural walls are widely used in multi-storey structure systems. Therefore, a proper modeling of the shear walls is very important for both linear and nonlinear analyses of building structures. The shell element can be used efficiently for the analysis of building structures with shear walls. The shell element considered in most of the design software has 6 degrees of freedom at each node and an in-plane rotational degree of freedom, which makes it compatible with three dimensional beam-type finite element models. Shear wall modelling requires mesh discretization in order to get realistic behaviour. The advantage of using shell elements is the ability to model very long, interacting and complex shear walls within the three dimensional model.

G. Nandini Devi, K.Subramanian & A.R.Santhakumar (June 2009) studied a three bay R.C frame without and with shear wall in middle bay which was subjected to static cyclic lateral load. Shear wall of one bay was subjected to static reversed cyclic lateral load to assess its individual behaviour. Cyclic effects on the shear wall frame were considered for comparison. Shear wall frame and dual frame was compared to assess the individual behaviour of shear wall and when it is designed with beam column Frame. It was found that in spite of carrying large load, the dual frame exhibited less top storey deflection. At the initial stage of loading the dual frame was 7.84 times stiffer than the bare frame and 4.84 times higher than the shear wall frame. At service load (50% of the ultimate load, the dual frame is 10.56 times stiffer than the bare frame and 6.76 times stiffer than the shear wall frame. When the frames are compared at service load, it was found that the dual frame can be used for a larger service load and can withstand higher seismic loads with small deflection.

Kevadkar M.D., Kodag P.B. The authors have stressed the need of "Lateral Load Analysis" as these loads can develop high stresses, produce sway movement or cause vibrations. It is therefore important for such structures as well as for new structures to possess strength for vertical and lateral forces. Further, they discuss the methods of strengthening like, provision of shear wall, steel bracing. They compared steel bracing to shear wall method and conclude as steel bracing is preferable to shear wall. Seismic analysis of Steel Braced Reinforced Concrete Frams Authors has observed damages like fatigue and wear-tear, which they contribute as a result of increase in volume and weight of traffics on the bridges. The RCC framed structures had deficiencies like ground floor left open for parking, culminating into a soft story behavior, under reinforced for seismic resistivity. The main variable studied were the number of CFRP layers in the test zone, the presence of column damage, and the level of applied axial load. In the conclusion they state CFRP jacketing has ease of installation, can increase ductility and energy dissipation capacity, improve seismic resistance, shear and moment capacities. For higher axial load larger amount of CFRP required.

Mukharjee Abhijit, Mangesh Joshi (2012) Recent Advances in Repair and Rehab of RCC Structures with Nonmetallic Fibers. Authors have explained the advantages of use of FRC's, and express the need to include the design criteria and procedure in BIS Codes, and wide publicity is essential to promote its use. as it efficiently reduces the use of steel and cement, the limited resources. Use of FRC's in retrofitting after Gujarat earthquake, and in seismic prone areas have proved that these methods results in better strength without affecting the stiffness factor of the structure as these are very thin, corrosion resistant and last important but not the Earthquake Damaged Reinforced Concrete Strengthening. The authors are reviewing development of general technique of strengthening and Rehabilitation of the damaged concrete structures. For minor repairs they studied The emphasize on Rehabilitation of RCC Structures by focusing on visible symptoms of the problem and using apt repair material and techniques. The author has further discussed how electrochemical repairs of RC structures are proving to be highly effective in terms of durability life cycle costing. The author concluded the paper with case study of in which FRP wrapping method was applied and the test report shows the strength and load carrying capacity were doubled.

3.0 METHODOLOGY

Multi storeyed building comprising of three different composite framing systems was considered for the investigation. All building frames were modeled and analyzed using the software stadd pro. Based on the results obtained, the performance of the three systems described Building frame system consists of steel column, composite concrete encased square column and composite steel encased circular column considered for the investigation. Frames were analyzed for dead, live and wind loads. Loads and combinations were considered as per relevant standards. Structural elements were designed as per IS 11384, IS 800 and Euro code. Suitable optimum column section has been adopted to resist the actual axial load on column. Seismic waves are arbitrary in nature and are not predictable in nature, different engineering tool or structure to be the structure under the action on seismic forces. Seismic forces delicately modeled so that to determine the actual behavior of the building with getting the idea of failure and it should be managed. Due to Improper Availability of flat land in hilly areas ,most of the buildings have to be constructed on sloping grounds with the regular or irregular configuration of building. Due to increase in population as well residential demand is also increasing day by day. Because of this reason scarcity of plain grounds is also there, and also some of the cities are also situated in sloping grounds because lack of plain grounds. In India, the northern part is covered with most of the hilly areas and most of the tourist places are available. So that many hotels and many other buildings are constructed on sloping grounds

Performance based design:

A performance based design is an choice of the design based on extent of damage of the structure caused due to seismic forces before it is subjected to or if the structure is seismically deficit proper response parameter has to be estimated. The objective study is to evaluate state of art of the Seismic performance of a Moment Resisting Reinforced concrete structure. The evaluation is majorly between the structure supported on plane and sloping terrain. Where the further study involves, deciding the possible methods adopted for improving the lateral resistance of the building by shear walls with various and best suitable positions within the respective structural frames. This analysis is carried out using non-linear static pushover analysis method using SAP 2000, the results of pushover is checked for its yielding behavior of the structural elements against the same lateral displacement and force which was computed from the elastic design and checking its seismic performance for both the cases mentioned above. The comparison of various results obtained from pushover analysis such as base shear storey displacement storey drift and storey shear is done on G+10 building and the design in shear walls buildings done by using STADD PRO In order to ensure that we have a validated results, the structure is checked for various methods of seismic analysis like static, Dynamic and nonlinear dynamic analysis, which is necessary for concluding remarks for the comparison study.

TABLE: DETAILED DISCRIPTION OF BUILDING FOR ANALYSIS

Structure type	SMRF
response reduction factor	5
seismic zone factor	0.24
Soil condition	medium
thick ness of slab	150mm
beam size	38.5M
column size	300x450
live load	3KN/m^2
wall load	13.92Kn/m^2
floor finish	1Kn/m^2

Material properties:

M30 grade:

Concrete Grade: M30

Compressive strength of Concrete: 30000 KN/m3

Steel: Fe500

Characteristics strength of reinforcing steel *fy*= 50000 KN/m3

Density of concrete = 25000KN/m3

sloping ground angle	27degree
No of bays in x direction	5 No's
No of bays in y direction	5 No's
young's modulus	2.74x10^{10} N/mm^2
passion ratio	0.2

4.0 RESULTS

Adequate stiffness is to be ensured in high rise buildings for resistance to lateral loads induced by wind or seismic events. Reinforced concrete shear walls are designed for buildings located in seismic areas, because of their high bearing capacity, high ductility and rigidity. In high rise buildings, beam and column dimensions work out large and reinforcement at the beam-column joins are quite heavy, so that, there is a lot of clogging at these joints and it is difficult to place and vibrate concrete at these places which does not contribute to the safety of buildings. These practical difficulties call for introduction of shear walls in High rise buildings. Buildings engineered with structural walls are almost always stiffer than framed structures, reducing the possibility of excessive deformation and hence damage. RC multi storied buildings are adequate for resisting both the vertical and horizontal load. When such buildings are designed without shear walls, beams and column sizes are quite heavy. Shear walls may became imperative from the point of view of economical and control large deflection. Lateral forces, that is, the forces applied horizontally to a structure derived from winds or earthquakes cause shear and overturning moments in walls. The shear forces tend to tear the wall just as if you had a piece of paper attached to a frame and changed the frame's shape from a rectangle to a Parallelogram. The changing of shape from a rectangle to parallelogram is referred to as racking. At the end of shear walls, there is a tendency for the wall to be pushed down at the end away from the force. This action provides resistance to overturning moments. Lateral loads can develop high stresses, produce sway movement or cause vibration. Therefore, it is very important to have sufficient strength for the structure against vertical loads. Earthquake and wind forces are the only major lateral forces that affect the buildings. The function of lateral load resisting systems or structure form is to absorb the energy induced by these lateral forces by moving or deforming without collapse. The determination of structural form of a tall building or high rise building would perfectly involve only the arrangement of the major structural elements to resist most efficiently the various combinations of lateral loads and gravity loads.The taller and more the slender a structure, the more important the structural factors become and the more

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necessary it is to choose an appropriate structural form or the lateral loading system for the building. In high rise buildings which are designed for a similar purpose and of the same height and material, the efficiency of the structures can be compared by their weight per unit floor area.

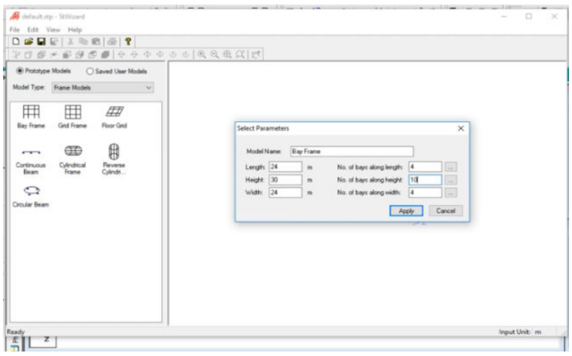


Figure: Building frame parameters

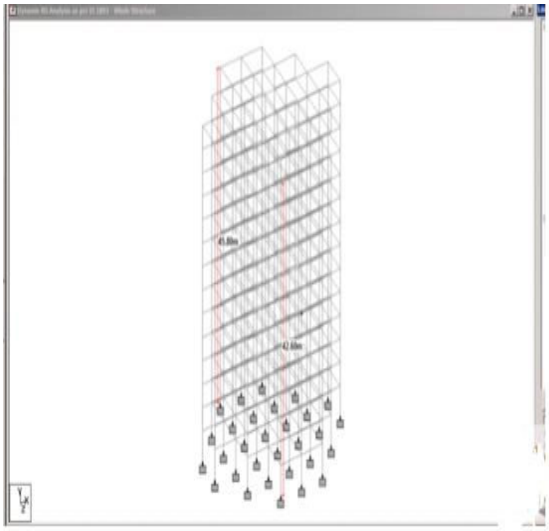


Figure: Whole structure

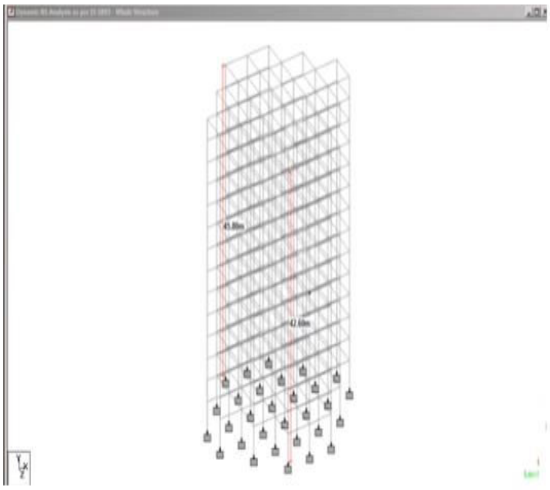
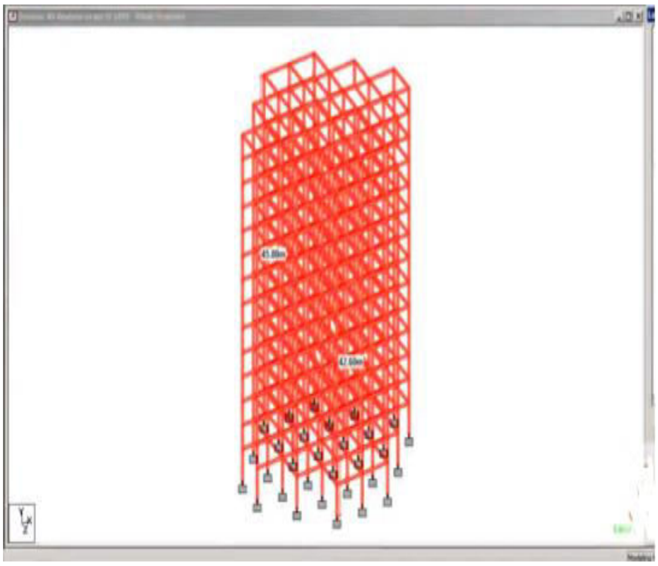
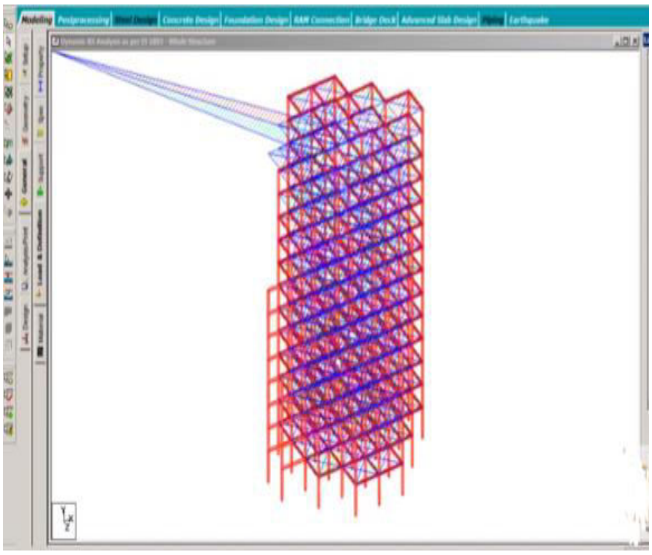


Figure: Dead load live loads



Self-weight X1



Self-weight Y1

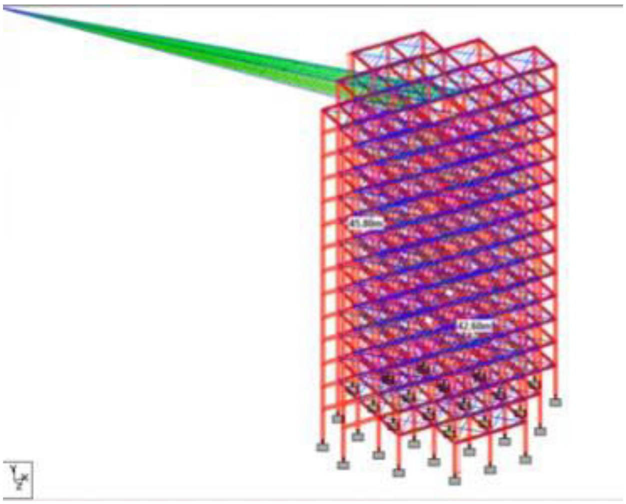


Figure: Self-weight Z1

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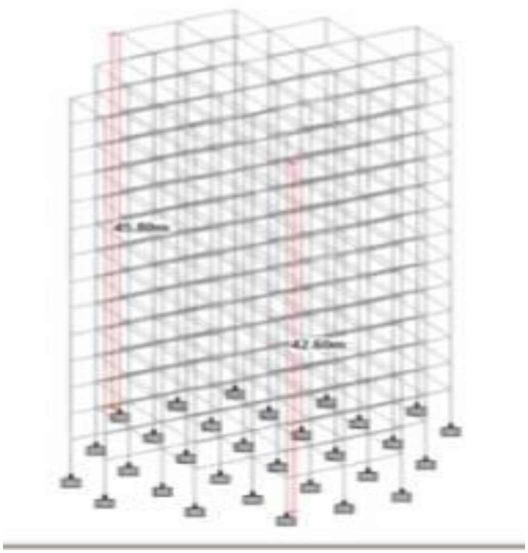


Figure: seismic loads

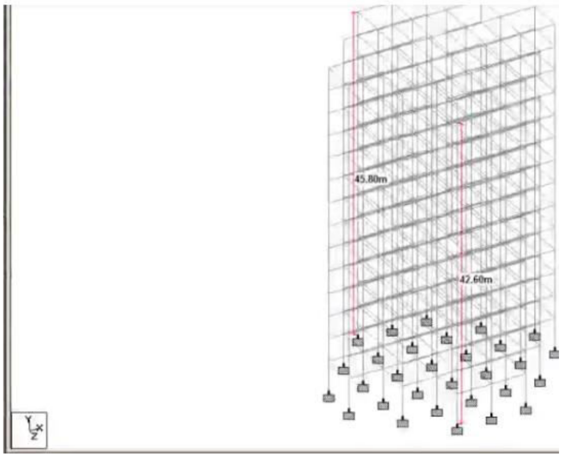
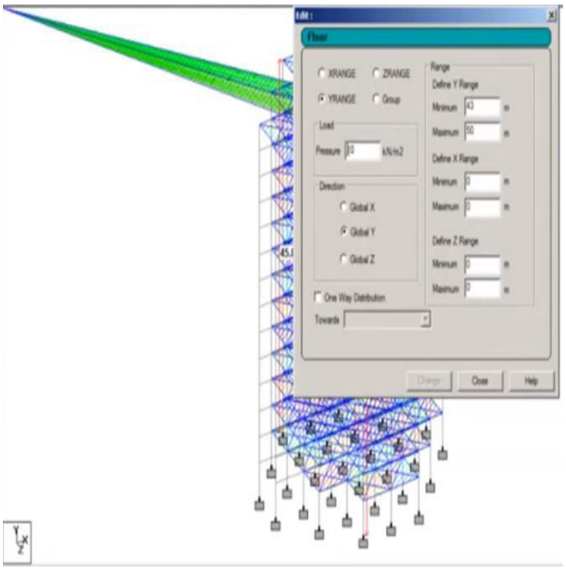


Figure: Live Loads



Y range 40-50 F load 10 GY

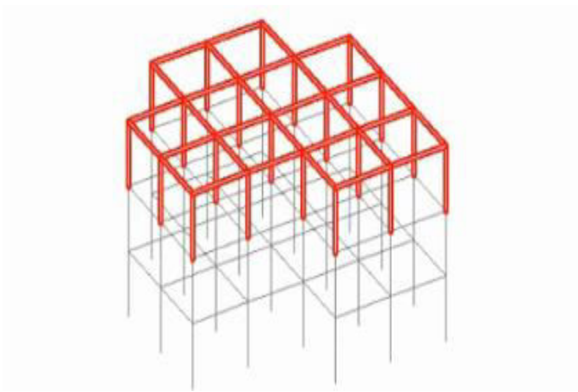
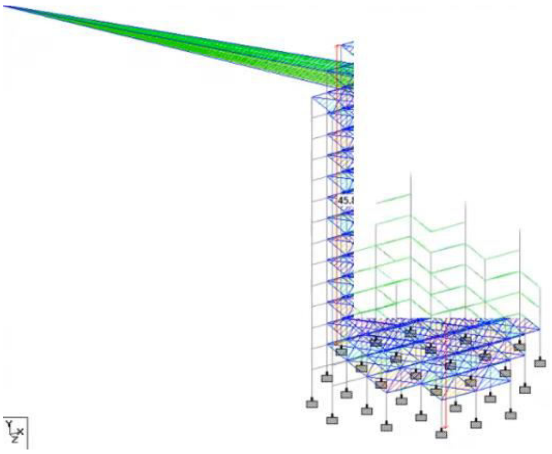


Figure base structural view of building footings



X range 40-50 F load 10 GY

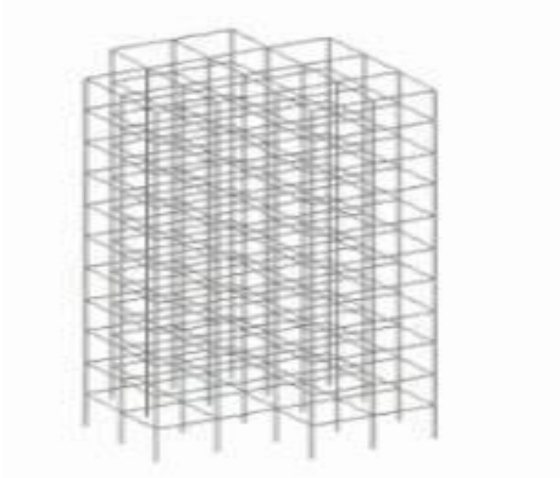


Figure Basic view of the G+10 building Frequencies load case of G+10 building

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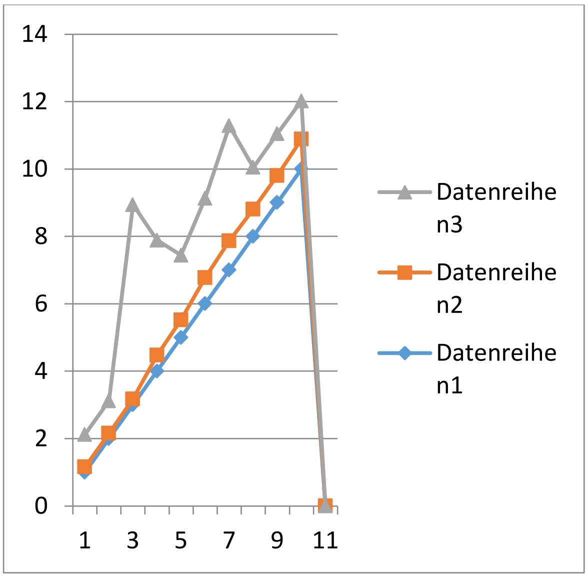
1	0.156	0.965546
2	0.156	0.963646
3	0.176	5.763682
4	0.473	3.414123
5	0.523	1.917784
6	0.769	2.354689
7	0.869	3.414123
8	0.806	1.240884
9	0.806	1.240884
10	0.884	1.13176



Graph Different variations of load cases of G+10 building

Table Results of the spectrum Analyses Performed on the G+10 Buildings

Direction	Transverse	Longitudinal
First Effective Yielding Seismic Coefficient, *Cb, y*	0.079 0.124	0.079 0.124
Collapse Seismic Coefficient, *Cb,c*	.088 0.160	0.088 0.160
First Effective Yielding Displacement, *uy* (cm)	1.43 2.15	1.43 2.15
Collapse Displacement, *uc* (cm)	3.16 4.78	3.16 4.78
Mass, *M* (kN·s2/m)	578 578	578 578
Effective Stiffness, *Keff* (MN/m)	32.0 1	33.1
Effective Period, *Teff* (s)	0.85	0.84
Ductility Ratio, μ	1.98	1.92

Table Relative Seismic Resistance *R* (%) of the G+10 building

Seismic Zone	Original Building	Transverse Direction	Longitudinal Direction
	Building + Walls	43	66
High Seismicity	SR+W	75	60
	Original Building	135	135
Medium Seismicity	Building + Walls	62	90
	SR+W	104	84
Low Seismicity	Original Building	189	189
	Building + Walls	100	183
	SR+W	174	140
		315	315

Discussions:

Base shear vs displacement results shows that the roof displacement is more in for the buildings on sloping ground which shows that buildings on sloping ground is more vulnerable for seismic forces compared to the building on plain grounds. By introducing the shear wall in the building, which has drastically influenced the structure's nature resisting against lateral forces which can be witnessed in the reduced strorey Drifts, Hence shear wall significantly increases the lateral stability.

Under three different cases of shear wall at center, center apart and corner, the study has suggested the shear wall at the corners can resist lateral forces well and is better compared to the shear walls at center apart and shear wall at center apart is better than the shear wall at centre.

Looking into the storey shear vs displacement the shear wall at the corner has least storey displacement at top compared with center apart and center apart is least compared to shear wall at center. Twisting moment is more towards the shorter column than the longer columns at the sloping side.

Torsional moment is more at the other direction compared to sloping side. There is a substantial decrease in bending moment and shear forces in the columns at the base, when shear wall is introduced compared to building without shear wall.

Building on the sloping ground tends to be more vulnerable for seismic forces which can be seen in the performance check. The hinge formation at the base towards the column at the shorter direction is more, this is because the geometry of the building where we can see increased torsional moment nearer to the shorter columns

5.0 CONCLUSIONS

The use of high strength concrete (with f ' c>50MPa) is very common in buildings and other structures designed recently. Economy, superior strength, stiffness and durability are the major reasons for its popularity. Structural Engineers are presently exploring the benefits of using this efficient material in various applications Fundamental time period is reduces considerably due to increase in lateral stiffness of building by providing shear walls Base shear of building decreases as slope of ground increases from 0° to 27° but due to provision of shear wall base shear get increased in both X and Y direction. There is significant improvement observed in seismic behavior of building on plain as well as sloping ground by incorporation of shear wall, since floor displacements are reduced considerably due to increase in lateral stiffness of building The sloping ground buildings possess relatively more maximum displacement and shear forces which may give to critical situations than the flat ground Natural period vs frequency of the building is least for the model no 6 whereas the shear wall is positioned at the corner, hence suggesting us to this location could be preferable for resisting lateral loads more efficiently than any other location.

- Displacement is maximum at the top story when compared with bottom storeys in all other models along x and y-direction..
- From the analysis, Storey Acceleration is decrease with increase in slope angle.

Scope for future work:

- A high rise building of higher storeys has to be studied to check the effect of sloping ground for different seismic zones.
- concrete frame structures are strong and economical. Hence almost any walling materials can be used with them. The heavier options include masonry walls of brick, concrete block, or stone. The lighter options include drywall partitions made of light steel or wood studs covered

with sheeting boards. The former are used when strong, secure, and sound-proof enclosures are required, and the latter when quick, flexible lightweight partitions are needed.

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