Analysis of An Irregular Tall Structure Considering Seismic Load Using Etabs: A Review

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Abstract- *The response of skyscraper multi story structures in the event of parallel loads straightforwardly depends of the underlying mass, primary firmness and its solidarity in both the bearings of the plain opposing the heap of the design. In multi-storeyed illustrated structures, hurt from quake ground development overall beginnings at areas of essential weaknesses present in the equal weight contradicting housings. Further, these deficiencies will overall feature and concentrate the essential mischief through plasticization that finally prompts complete breakdown. In some cases, these deficiencies may be made by discontinuities in robustness, strength or mass between bordering stories. Such discontinuities between stories are consistently associated with sudden assortments in the edge estimation close by the height. There are various examples of the failure of designs in past tremors due to such vertical discontinuities. Irregular plans either in course of action or level were routinely seen as one of the essential drivers of dissatisfaction during past seismic quakes.*

In this paper presenting a literature review related to structural analysis publications

***Keywords*-** Setback building; sucker investigation; abnormality; target removal; sidelong burden profile; time history examination, Etabs

I. INTRODUCTION

In multi-storeyed outlined structures, damages from quake ground movement by and large starts at areas of underlying shortcomings present in the parallel burden opposing casings. This conduct of multi-story outlined structures during solid seismic tremor movements relies upon the circulation of mass, firmness, and strength in both the even and vertical planes of structures. At times, these shortcomings might be made by discontinuities in firmness, strength or mass between neighboring stories. Such discontinuities between stories are frequently connected with unexpected varieties in the edge math alongside the tallness. There are numerous instances of the disappointment of structures in past tremors because of such vertical discontinuities. Primary specialists have created trust in the plan of structures in which the disseminations of mass, solidness and strength are pretty much uniform. Yet, there is less certainty about the plan of designs having sporadic mathematical setups.

A typical sort of vertical mathematical anomaly in building structures that emerge is the presence of difficulties, for example the presence of an unexpected decrease of the sidelong element of the structure at explicit levels of the rise. This structure classification is known as 'misfortune building'. This structure is turning out to be progressively well known in current multi-story building development primarily due to its useful and tasteful design. Specifically, such a mishap structure accommodates satisfactory light and ventilation for the lower stories in a metropolitan region with firmly divided tall structures.

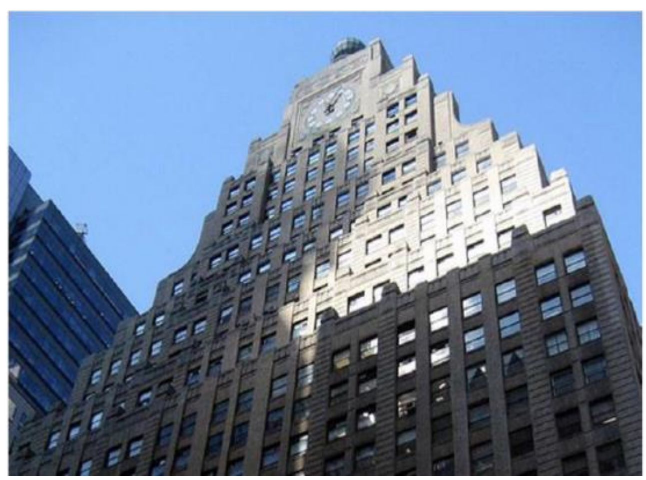

Fig 1: Irregular structure

Mohammad Kasim and Dr. Asif Husain (2019) in the research paper, one regular and six setback models of G+9 storey RC frames, namely Model R, S1- type and S2-type. S1- types and S2- types setback frame structure have select for comparing the base shear, base moment, storey displacement and storey drift by using THA-Linear Time History Analysis and RSA- Response Spectrum Analysis for 0.3368 PGA- (Peak Ground Acceleration) concerning Regular frame. Furthermore, response spectrum analysis (0.2354g, 0.3368g, 0.487g, 0.757g, 1.022g, 1.475g PGA) for S1-4-8 and S2-4-8 type setback frame have done and obtained results are compared with regular Model-R in terms of the base shear, base moment, top-storey displacement (i.e. 35m height). However, another one study also done for these same models by using linear time history analysis for Bhuj earthquakes in terms of base shear, base moment, storey displacement, storey drift. These all studies have done by using finite element based software, SAP 2000 v20.0.0. As per all observations, we found that the Setback frame structures are not seen to be highly susceptible to damage or highly susceptible to higher mode effect as compared to the regular frame structure.

Results stated that the storey drifts by RSA is low as compared to the storey drift by THA for the same PGA 0.3368g of Modal- R, S1-type and S2-type structures. The percentage of storey displacement for S1-type, S2-type frame due to Bhuj earthquake loading in Xdirection have decreased over the full height as compared to Modal-R.

MallaKarthik Kumar et.al. (2016) the research paper presented three groups of building (i.e. configurations) are considered, out of which two are resting on sloping ground and third one was on plain ground. The first one was set back buildings and next two are step back and step back-set back buildings. The slope of ground was 10 degree with horizontal, which was neither too steep nor too flat. The height and length of building in a particular pattern was in multiple of blocks (in vertical and horizontal direction), the size of block is being maintained at 5m x 5 m x 4m. The depth of footing below ground level is taken as 2 m where, the hard stratum is available. Earthquake analysis was carried out by Equivalent lateral force method (static method) or Dynamic analysis.' The static method was the simplest method with less computational effort. Dynamic analysis should be performed for regular buildings greater than 40 m in height in zones IV and V, and those greater than 90 m in height in zones II and III. For irregular buildings higher than 12 m in zones IV and V, and those greater than 40m in height in zones II and III, dynamic analysis is to be performed. In present case its height doesn't exceed 40m in any case. The modelling and analysis was done using ETABS. Using the analysis results various graphs were drawn between the Storey displacements, base shear, bending moment and torsion, being developed for the building on plane ground and sloping ground and the results were compared.

Conclusion derived from the results stated that since the mass was not varying with the increased ground slope, it can be concluded that the stiffness of the building is getting reduced where length of the columns is higher, relative to the other extreme end. There was a considerable variation in the distribution of storey shears. The maximum variation in storey shear is about 55%. Hence it is advisable to adopt response spectrum method for building with sloping ground. The variation in bending moment between long column and short column is about 22%.This is due to presence of ground-slope is making one side of the building stiffer than the other side, which leads to variation in bending moment due to short column effect. The variation of torsion moments in Step back buildings is 2% higher compared to Step back set back buildings. Hence, Step back Set back buildings are found to be less vulnerable than Step back building against seismic ground motion. In Step back buildings and Step back-Set back buildings, it is observed that extreme left column at ground level, which are short, are the worst affected. Special attention should be given to these columns in design and detailing.

Krishna Kumar et.al (2018) the research paper analyzed the behavior of step back building. The structural model was analyzed on flat surface. Parameters such as lateral displacement, story drift, base shear, time period, bending moment, shear force were considered in the investigation and compared using ETABS software with reference of IS 456 and IS 1893:2002.

Conclusion stated that the building Share due to the response spectrum method in y direction is much more than in the x direction and the drift in the y direction is higher than the x direction but the stiffness in both are almost same. The graph for the maximum Story Drift kept on increasing till the story 3 which has maximum story drift and then it reduces to zero on the base but the difference between the Response Spectrum in X direction n y direction much high the drift due RS in Y is much higher than RS in X.

Sripriya Arjun and Arathi S (2016) the research paper investigatedthe dynamic characteristics of a G+3 storied RC framed step back set back building on a hill slope by varying the slope angles. Modelling and analysis of the structure was performed using STAAD.Pro. The objectives of the research included to study the variation of base shear, displacement with respect to variation in various hill slopes and determine the angle that is subjected to less displacement and which is safe in increasing the height of building.

Results stated that the 16.7 degree sloped frame experiences maximum storey displacement due to low value of stiffness of column. The top storey displacement decreases with the increase in slope angles. The base shear value increases with the increase in slope angles. The base shear of all the buildings are nearly the same with little variations but their distribution on columns of ground storey is such that the short column attracts the majority (75% approx.) of the shear force which leads to plastic hinge formation on the short column and are vulnerable to damage. The base shear acts more in longitudinal direction than in transverse direction. Conclusion stated that 21.8 and 26.57 degrees were safe to increase the height of the building due to the less displacement values.

Bilal Ahmad Lone et.al (2020) the research paper considered three G+30 storeyed buildings of same plan dimensions 52mx44m namely regular building, plan irregular building and vertical irregular buildings. These buildings were modelled and analysed in different terrains using ETABS software. All the MRF elements are designed as per IS 456-2000. Wind and earthquake loads are defined as per IS 875 part-3, and IS 1893-2016 respectively. The research presented comparison of seismic capacity moment resisting frame structure with regular plan (rectangular), and irregular plan for the earthquake zone-V and wind resistance of a regular building, plan irregular building and vertical irregular building. The building models with regular and irregular structures will be compared by changing type of terrain category, and topography factor to provide better information about the response of the system.

Results stated that the displacement of plan irregular building increases with increase of slope angle. Storey drift with slope of ground 15 degrees are increased 37%, 14% and 42%. Over-turning moment also increases with increase of ground slope. From both the analysis (seismic and wind) it was concluded that vertical irregular building with ground slope less than 3 degrees provides greater resistance against both seismic and wind loading among all buildings.

Naveen Kumar S M et.al (2017) the research paper considered a G+10 RCC structure for the analysis snd was further compared with bulidng resting on level ground. The modelling and analysis of the structure was performed using ETABS 2015. Seismic analysis was performed using response spectrum analysis as per IS: 1893 (Part I): 2002. The objectives of the research includedstudy on difference between building on sloping ground and plane ground and analyze the effect of total base shear, storey displacement, storey shears and overturning moment for the model on sloping ground and flat ground.

Conclusion stated that the displacement value was more on plain ground as compare to sloping ground, the storey drift was less for flat ground than sloping ground. Base shear is more for sloping strata than plain strata. The overturning moment gradually decreases on sloping ground than compare to flat ground.

HemaVenkataSekhar and T. Venkata Das (2017) the primary objective of the research was to present building behavior during earthquakes always depends on its strength, durability, stiffness and adequacy of the regular configuration of the structure. The analysis always depends on the forces and importance on the cost of analyzing the structure. Creating the 3D building model for both linear and non-linear dynamic method of analyses. Understanding the seismic behavior of Setback buildings and Co-relating the seismic behavior of the Setback building with that of a building without Setback finally comparing the seismic behavior of building with a setback at every two levels to that of the building with a setback at each floor level. Study the influence of vertical irregularity in the building when subjected to earthquakes. The research was limited to reinforced concrete framed structure designed for seismic loads (DL, LL & EL). The seismic behavior of three 8-Storied buildings with and without setbacks was compared. The buildings were analyzed using Time History Analysis and Response Spectrum Method and. The effect of Setback was analyzed considering the parameters such as Time Period, storey drifts, Displacements, Storey Shears, Bending Moments and Shear Forces and correlated with the building without a setback.

Conclusion derived from results stated that Generation of all forces due to unequal distribution of mass was identified by critical setback ratio along the section of the plan and also in the vertical height of the building. The ideal appraisals of basic difficulty proportions are RA and RH. The evaluation conforms to the criteria given in gauges for sporadic structures were considered. The outcomes unpredictable structures was treated with appropriate plan and ought to be trailed by all IS code procurements given the guidelines. The alteration of quake codes geometric horizontal anomalies appear to be important to determine more preventive ordinates or apply more precise explanatory strategy to distinguish the seismic execution of difficulty building. Especially for structures with basic difficulty proportions assumes a critical part.

Milind V. Mohod and Nikita A. Karwa (2014) the methodology adopted to perform the seismic evaluation of the building requires an understanding of equivalent lateral force procedure also recognized as equivalent static procedure. The seismic stability of the structure under the various load combinations in accordance with IS 1893-2002 (part 1). The modelling of the structure was done on frames which were plane and orthogonal with storey heights and bay widths considering different building geometries. These building geometries represent varying degree of irregularity or amount of setback. Nine different categories of setback buildings, ranging from 4 to 4 bays (in X and Z direction) with a bay width of 4mX3m and 11 bays in Y direction.

Results stated that Critical setback ratio RA=0.25 and RH=6/5 shows the variation in story drift which signifies the jumping of the forces due to unequal distribution of mass along the plan as well as along the height. The optimum value of critical setback ratios mainly RA and RH comes out to be RA=0.75 and RH=6/5. The value complies with the criteria given in IS 1893 for considering the structure to be irregular. The results concluded that the irregular structures have to be treated with proper understanding and by following the codal provisions given in the code. The revision of seismic codes provisions for geometric vertical irregularities seems to be essential to stipulate more restrictive limits or apply more accurate analytical procedures to predict the seismic performance of setback structures under the seismic excitations, especially for structures with critical setback ratios.

Rahul ManojsinghPawar and S.B. Sohani (2017)the research paper presented 3D analytical model of 10,15 & 20 storied buildings generated for symmetric and asymmetric building Models and analyzed using structural analysis tool ‘STADD-PRO” to present the effect of varying height of columns in ground stored due to sloping ground and the effect of shear wall at different positions during earthquake. The project comprised of seismic analysis of RC structure with rectangular plain.The building was modeled as a 3D space frame with six degrees of freedom at each node using the software STAAD- PRO. Building (G+10, 15 and 20) was analyzed using Response Spectrum method on 0°, 10°, 15°, 20° slope ground where the Response Spectra as per IS 1893 (Part 1):2002 for medium soil was used and results were compared for same slope and same soil condition.

Results stated that buildings resting on sloping ground have less base shear compared to buildings on Plain ground Base shear increases as slope of ground increase. Buildings resting on sloping ground have more lateral displacement compared to buildings on Plain ground and Buildings with setback – step back is showing less displacement than step back model. Building presented high value of displacement in z- direction than in x direction. The critical axial force in columns is more on plain ground than on sloping ground. The shear force and moment in columns is more on sloping ground than on plain ground. The shear force and bending moment value in beams is high in plain ground model than on sloping ground model. The performance of set-step back building during seismic excitation could prove more vulnerable than other configurations of buildings. The development of moments in set - step back buildings is higher than that in the set back building. Hence, Set back buildings are found to be less vulnerable building against seismic ground motion. Step back Set back buildings, overall economic cost involved in leveling the sloping ground and other related issues needs to be studied in detail.

Rahul Ghosh and Rama Debbarma (2017) the research paper evaluated the seismic performance of setback structures resting on plain ground as well as in the slope of a hill, with soft storey configuration. The analysis has been performed in three individual methods, equivalent static force method, response spectrum method and time history method and extreme responses have been recorded for open ground storeyed setback building. All the models were analysed both in linear static method which is known as equivalent static force method (ESFM) and linear dynamic method which was response spectrum method (RSM) and time history method (THM). ESFM analysis and RSM analysis was done and results were compared to study the seismic behaviour of the structures. In modal analyses, mode shapes are generally obtained in normalized form, and thus, the results of response spectrum method need to be properly scaled. The scaling was done by equating the base shear obtained from ESFM to that obtained from RSM. In ESFM analysis, different load combinations suggested by different codes have been taken and the combination 1.5 (DL ± EL) has given the most of the effect. Time history analysis was done using real earthquake data of Kobe earthquake.

The ground storey stiffness of these models using these three techniques was more than that required to overcome soft storey effect of OGS model, and upper storey stiffness of these models also gets better. The storey displacement, drift, and torsion control are found to be excellent by these three techniques, and the controlling capacities of these techniques was also almost the same. Spreader construction of shear wall shows better torsional control, but the problem with shear wall is that shear walls are blocking accesses in OGS, thus reducing the functional efficiency of the structure and stiffness is concentrating at some particular locations of the structure. The possibility of generation of plastic hinges becomes prominent in the model where OGS columns are magnified with 2.5 times of storey forces. There was a sudden abrupt change of the RC column section at the junctions of OGS columns and immediate upper storey columns.

Prince Adani et.al (2018) the research paper summarized the behavior of structures on hill slopes as per dynamic response of the structure. The Seismic analysis of Step Back and Set Back Buildings was done using Response Spectrum Method in ETABS 2016.

The fundamental Time Period from the IS 1893:2016 given equation presented higher value than from RS. Results concluded that the maximum displacement in both the direction in Step Back Building for given storey was more than that of in Step Back and Set Back Building. In Step Back-Set Back Building when Shear wall was introduced in X and XY both direction max. Displacement reduces by 60-80% in X-Dir. shear all cases. And for Y dir. when shear wall was introduced same results were seen. For Step Back Building Max. Displacement in X-Dir. reduces to 80-90% and in Y-Dir. it reduces to 50-80% for all cases. In all type of configuration without shear wall max. Base reaction was being taken by the top most support on Hill and when Shear wall was introduced in all type of configuration support connected to Shear Wall bears highest reaction. For same number storey Step Back buildings showed higher value of Storey drift and also of maximum displacement than Step-back Set-Back buildings hence they are more vulnerable to Earthquake

Amlan Kumar Bairagi and Sujit Kumar Dalui (2018) the research focused on comparison between two setback structures on the parameters of pressure, force and torsional moment coefficient. The results stated that the suction at the roof top of single-side setback was 95.84% higher than the both-side setback model. Torsional moment of both-side setback model was 259.02% higher than the single-side setback model. The conclusion stated that the both-side setback model was more susceptible than the single-side setback model.

ResmiVinod and Nimiya Rose Joshuva (2018) the research paper presented the effect of number of bays and bay width on the seismic behaviour of RC structures with setback irregularity using modal analysis, pushover analysis and response spectrum analysis in SAP2000. The objectives included in the research were to assess the effects of setbacks on the static and dynamic response of structures and further assess the influence of number of bays and bay width on the seismic behaviour of setback buildings. Non-linear static push over analysis was performed in order to investigate the performance of building frame on parameters of base shear and displacement.

Conclusion derived from the results stated that natural time period of a setback building depends not only on the height of the building but also on the bay width and number of bays. Increasing number of bays and bay width increases the time period of the structure. It was found that as number of bays and bay width increases, performance point base shear increases. Fundamental mode shape of a setback building was found to be translation with torsion. Greater damage was concentrated at the vicinity of the tower portion of a setback building due to change in stiffness, strength and mass.

Anil SagarS et.Al. (2018) the research paper conducted linear eleastic dynamic analysis to analyze the models as G+4 and G+15 at different sloping angles as 00,200,270 and 400**.** Response of the models for the given ground excitations was analyzed using response spectrum following code IS:1893-2002 part 2. Base shear and top storey displacement was computed using response spectrum analysis in both X & Y directions considering shell and membrane concepts. The seismic zone considered in the research was zone V in medium soil.

Results stated that as the slope of the ground increases top storey displacement increases, towards the increasing slope direction, maximum being at 400 sloping angle with horizontal. Compared to buildings with bare frame, the top storey displacement in the case of buildings with core wall is uniformly less. This reduction becomes much less in the case of G+15 storey compared to G+4 storey building. As the number of storeys increases the effect of core wall in reducing the top storey displacement becomes less. Here, uniform size of core wall has been adopted for both types of buildings. The effect will be better if the size of the core wall is increased. The top storey displacements obtained using shell elements gives less displacement compared to the displacements obtained using membrane elements. Compared to buildings with bare fame the base shear in the case of building with core wall uniformly increases. This increment becomes much less in the case of G+4 storey compared to G+15 storey building. As, the number of storeys increases the effect of core wall in increasing the base shear becomes more. The base shear obtained using shell elements gives lesser values compared to values obtained using membrane elements. In case of G+15 storey building the increase in base shear on the use of core wall is around 47% in the case of 00 slope. The increment reduced to around 33% in the case of 400 slope. In the case of G+4 building the increment in the base shear on the use of core wall is 20% in the case of 00 slope. This increment increases to 23% in the case of 400 slope.

II. CONCLUSION

Here authors observed that the lateral load resisting members are resisting lateral forces in high rise structures but specific effect of simultaneous structures (setback) which are ad-joint or at a distance from the structure is to be clarify.

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