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Analysis and Design of Building with ESA Method on STAAD-PRO

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ABSTRACT: Structural design is the primary aspect of civil engineering. The foremost basic in structural engineering is the design of simple basic components and members of building viz., slabs, beams, columns and footings. The first step in any design is to decide the plan of the particular building. The location of beams and columns are decided. Then the vertical loads like dead and live loads are calculated. Once the loads are obtained, the component which takes the load first i.e. the slabs can be designed. From the slabs, the loads are transferred to the beams. The loads coming from the slabs onto the beam may be trapezoidal or triangular. Depending on this, the beam may be designed. The loads (mainly shear) from the beams are then transferred to the columns. For designing columns, it is necessary to know the moments they are subjected to. For this purpose, frame analysis is done by Moment Distribution Method. Most of the columns designed in this project were considered to be axially loaded with uniaxial bending. Finally, the footings are designed based on the loading from the column and also the soil bearing capacity value for that particular area. All component parts are checked for strength and stability.

The building was initially designed as per IS 456: 2000 without considering earthquake loads using STAAD.pro software. Then the building was analyzed for earthquake loads as per Equivalent static analysis method and after obtaining the base shear as per IS1893: 2002, again detailing has been obtained using ETABS.

KEYWORDS: Staad Pro, RCC Structure, ESA, Beam, Column and Slab.

I. INTRODUCTION

Earthquake is the result of a sudden release of energy in the earth's crust that creates seismic waves. The seismic activity of an area refers to the frequency, type and size of earthquakes experienced over a period of time. Buildings are subjected to ground motion. PGA (Peak Ground Acceleration), PGV (Peak Ground Velocity), PGD (Peak Ground Displacement), Frequency Content, and Duration play predominant rule in studying the behaviour of buildings under seismic loads.

The new hospital block is located at the Lucknow, UttarPardesh. The total built up area of the hospital building is 611.2 square meters and has five floors (Ground floor +5). The Hospital building consists of various divisions like Ortho ward, Orthopedic ward, Opthamology ward, ENT ward, major and minor operation theaters, outpatient ward, seminar halls for medical students, scanning and X-ray Centre and medicine store room, etc. The building is located in seismic prone zone (zone factor III). Since hospitals are very important buildings and need to remain standing after the earthquake, the design of such buildings needs to be done as per earthquake design considerations. The present study deals with seismic analysis using Equivalent static analysis of (G+5) story RC buildings using Structural Analysis and Design (STAAD Pro.) software.

A list of natural and man-made earthquake sources

Seismic Sources	
Natural Source	Man-made Source
<ul style="list-style-type: none"> • Tectonic Earthquakes • Volcanic Earthquakes • Rock Falls/Collapse of Cavity • Microseism 	<ul style="list-style-type: none"> • Controlled Sources (Explosives) • Reservoir Induced Earthquakes • Mining Induced Earthquakes • Cultural noise (Industry, Traffic, etc)

1.1 General

Structural analysis is the backbone of civil engineering. During recent years, there has been a growing emphasis on using computer aided software and tools to analyze the structures. There has also been advancement in finite element analysis of structures using Finite Element Analysis methods or matrix analysis. These developments are most welcome, as they relieve the engineer of the often lengthy calculations and procedures required to be followed while large or complicated structures are analyzed using classical methods. But not all the time such detailed analysis are necessary to be performed i.e. sometimes, just approximate analysis could suffice our requirements as in case of preparing the rough estimates and participating in the bidding process for a tender. Now- a-days, high rise buildings and multi-bay-multi-story buildings are very common in metropolitan cities. The analysis of frames of multistoried buildings proves to be rather cumbersome as the frames have a large number of joints which are free to move. Even if the commonly used Moment distribution method is applied to all the joints, the work involved shall be tremendous. However, with certain assumptions, applying the substitute analysis methods like substitute frame method, portal method, cantilever method or factor method, the structures can be analyzed approximately.

1.2 Geometry of the Hospital

The plan of the Hospital building is regular. It has a story height of $H = 4.0\text{m}$ where all stories are of the same height. The Hospital building consist of five stories, it is six stories including ground floor. The Hospital building length is 31.75m and width is 19.25m so the area is 611.1875m^2 . The building consist of square columns with cross- section $(0.5 \times 0.5)\text{m}$, rectangular beams with cross- section $(0.6 \times 0.3)\text{m}$ and slab thickness of 150mm. The size of column is constant for all stories. In each storey, the size of the beam is constant. The elastic rigidity of outer beams and columns are half that of interior ones and elastic rigidity of corner columns is one fourth that of interior ones.

1.3 Objective and Scope

Since hospital is the most important place during a disaster to give humanitarian aid and medical treatment, it is important to make sure that the hospital building can withstand the earthquake. The objective of this study is to make comparisons of analysis and design of a (G+5) story hospital building. Several cases of seismic loads will be applied to the building. The building will be designed according to the Earthquake resistant considerations as per IS1893:2000. The present study deals with an Equivalent Static Analysis of 6 story RCC hospital building using Structural Analysis and Design (STAAD Pro.) software.

1.4 Methodology

- Review the existing literature and Indian design code provision for analysis and design of the earthquake resistant building.
- The different types of structures are selected.
- The selected structures are modelled.
- Performing linear analysis for selected building for both gravity load, and earthquake loads and then a comparative study of both is obtained from the analysis.
- Also design the building manually for design and analysis results obtained and compare with the area of steel of the models obtained.

- Using structural analysis and design Software ETABS and STAAD Pro and comparing both results.
- Observation of results and discussions.

II. LITERATURE REVIEW

Valmundsson and Nau(1997) studied the earthquake response of 5-, 10-, and 20-story framed structures with non-uniform mass, stiffness, and strength distributions. The object of the study was to investigate the conditions for which a structure can be considered regular.

Das (2000) found that the structures designed by ELF method performed reasonably well. He concluded that capacity based criteria must be suitably applied in the vicinity of the irregularity.

Sadjadi et al. (2007) presented an analytical approach for seismic assessment of RC frames using nonlinear time history analysis and push-over analysis. The results from analytical models were validated against available experimental results. He observed that ductile and less ductile frames behaved very well under the earthquake considered.

Adiyanto (2008) analyzed a 3-storey hospital building using STAAD Pro. Seismic loads were applied to the building. The dead loads and live loads were taken from BS6399:1997 and seismic loads intensity is based on equivalent static force procedure in UBC1994. Result showed that the building can withstand any intensity of earthquake. It means that the buildings were suitable to be built in any area located near the epicenter of the earthquake.

Kim and Elnashai (2009) observed that buildings for which seismic design was done using contemporary codes survived the earthquake loads. However the vertical motion significantly reduced the shear capacity in vertical members.

Griffith and Pinto (2009) investigated a 4-storey, 3-bay reinforced concrete frame test structure with unreinforced brick masonry (URM) infill walls for its weaknesses with regard to seismic loading. The concrete frame was shown to be essentially a “weak-column strong-beam frame” which was likely to exhibit poor post yield hysteretic behavior.

Di Sarno and Elnashai (2011) assessed the seismic performance of a 9-storey steel perimeter MRF (moment resisting frame) using the three types of bracings: special concentrically braces (SCBFs), buckling-restrained braces (BRBFs) and mega-braces (MBFs). Local (member rotations) and global (inter-storey and roof drifts) deformations were employed to compare the inelastic response of the retrofitted frames. MBFs were found to be the most cost-effective bracing system with the least storey drifts.

Kumar et al (2011) experimentally investigated the behavior of retrofitted FRP (fiber reinforced polymer) wrapped exterior beam-column joint of a G+4 building in Salem. The test specimen was taken to be one fifth model of beam column joint from the prototype specimen and was evaluated in terms of load displacement relation, ductility, stiffness, load ratio and cracking pattern. On comparing the test results with the analytical modeling of the joint on ANSYS and STAAD Pro, it was found that such external confinement of concrete increased the load carrying capacity of the control specimen by 60% and energy absorption capacity by 30-60%.

Agrawal (2012) did seismic evaluation of an old institute building. Agrawal evaluated the member for seismic loads by determining the Demand Capacity Ratio (DCR) for beams and columns. Being an old building, the reinforcement details of the building were not available. Hence Design-1 was done applying only DEAD and LIVE loads according to IS 456:2000 to estimate the reinforcement present in the building and assuming that this much reinforcement was present. In Design-2, seismic loads were applied and for this demand obtained from design-2 and capacity from design - 1, the DCR was calculated.

Poonam et al. (2012) concluded that any storey must not be softer than the storeys above or below. Irregularity in mass distribution contributed to the increased response of the buildings.

Rajeeva and Tesfamariam (2012) studied the Fragility based seismic vulnerability of structures considering soft - storey and quality of construction. Their study was demonstrated on three, five, and nine storey RC building frames

designed prior to 1970s. Probabilistic seismic demand model was developed using non-linear finite element analysis considering the interactions between soft-storey and quality of construction. Their study showed the sensitivity of the model parameter to the interaction of soft -storey and quality of construction.

Aslam (2014) analysed a (G+5) storey Hospital building in Agartala as one the projects undertaken by L&T. The seismic analysis of the proposed building was done in the software ETABS, version- 9.7, which is one of the most advanced software in the structural design field. The loads applied on the structure were based on IS:875(part I) 1987[dead load],IS:875(part II)- 1987[live load], IS:875(part III)-1987[wind load], IS:1893-2002 [Earthquake load]. Scale factor was calculated from the design base shear. Once the analysis was completed, all the structural components were designed according to Indian standard code IS:456-2000. This included footings, columns, beams, slabs, staircases and shear walls.

Moehle (2014) found that standard limit analysis and static inelastic analysis provide good measures of strength and deformation characteristics under strong earthquake motions.

Yen-Po Wang (2014) introduced the fundamentals of seismic base isolation as an effective technique for seismic design of structures. Spring-like isolation bearings reduced earthquake forces by changing the fundamental time period of the structure so as to avoid resonance. Sliding-type isolation bearings filter out the earthquake forces via discontinuous sliding interfaces and forces were prevented from getting transmitted to the superstructure because of the friction. The design of the base isolation system included finding out the base shear, bearing displacement etc. in accordance with site-specific conditions.

III. CONCLUSION AND FUTURE SCOPE

In the present study, G+5 Hospital building has been drawn in Auto CAD software and designed (Beams, Columns, Footings and Seismic load analysis by using Equivalent Static method) using STAAD Pro software. The dead load, live load and earthquake loads are calculated using IS: 456-2000 and IS 1893: 2002. Concrete grade M25 and HYSD bars Fe415 as per IS: 786-1985 are used.

The Scope of Study is that further we can analysis the High Rise Buildings with seismic irregularities and compare the study with response spectrum analysis method and we can also study the mass irregular structure with same methodology.

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