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Analysis and Design of Highrise Building G+12 With Swimming Pool at Top and Shaer Wall by Using Staad-Pro with Seismic Loading in All Zones

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Abstract: In these modern days the Buildings are made to fulfill our basic aspects and better Serviceability. The aim of the Structural engineers are to design the structures safe, durable and economical. It is not an issue to construct a Building any how its, important to construct an efficient building which will serve for many years without showing any failure. Unique structures need more time for its time consuming calculations, if we use manual methods. STAAD Pro provides us a quick results. It is easy to use for analyze and design any structure for more accuracy. In the STAAD Pro limit state method is use as per Indian Standard Code and Practices. We can conclude that this software can save much time and very accurate in designs. The Project aims in finding better technique for creating Geometry, defining the cross sections for column and beam etc., Creating supports (to define a support weather it is fixed or pinned),then the Loads are defined (mainly under seismic and wind loads). After that the model is analyzed by 'run analysis'. Then reviewing (whether beam column passed in loads or failed) results. Then the design performed. After all analysis, We can say that there is a much variation in results as the positon of swimming pool plays an important role in the designing of the building and here it's been concluded that the single side positon pool comprises the best position for the regular buildings and the kind I shear wall suggested within this analysis turns out to be more effective and can achieve maximum safety towards earthquake.
Keywords: Structural designing, Analysis, Seismic, Shear Wall, STAAD. Pro, Programming tools Flexural strength. Deduction Area, Earthquake Effects,, Shear Wall

I. INTRODUCTION

A. Building Design Software (STAAD-PRO)

1) In 21st century due to huge population the no. of areas in units are decreasing day by day. Few years back the populations were not so vast so they used to stay in Horizontal system (due to large area available per person).But now a day's people preferring Vertical System(high rise building due to shortage of area).In high rise buildings we should concern about all the forces that act on a building ,its own weight as well as the soil bearing capacity .For external forces that act on the beam, column and reinforcement should be good enough to counteract these forces successfully. And the soil should be good enough to pass the load successfully to the foundation. If we will do so much calculation for a high rise building manually then it will take more time as well as human errors can be occurred. So the use of STAAD-PRO will make it easy.
2) STAAD-PRO can solve typical problem like Static analysis, Seismic analysis and Natural frequency. These type of problem can be solved by STAAD-PRO along with IS-CODE.
3) STAAD-PRO has a greater advantage than the manual technique as it gives more accurate and precise result than the manual technique.
4) STAAD-PRO was born giant. It is the most popular software used now a days. Basically it is performing design works.

There are four steps using STAAD-PRO to reach the goal.

a) Prepare the input file:- First of all we described the structure. In description part we include geometry, the materials, cross sections, the support conditions.
b) Analyze the input file.
c) Watch the results and verify them.
d) Send the analysis result to steel design or concrete design engines for designing purpose.

- *Prepare the Input File*
- First of all we described the structure. In description part we include geometry, the materials, cross sections, the support conditions.

- *Analyze the Input File*
- We should sure that we are using STAAD-PRO syntax. Else it will error.
- We should sure that all that we are inputting that will generate a stable structure .Else it will show error.
- At last we should verify our output data to make sure that the input data was given correctly.

- *Watch the Results and Verify Them.*
- Reading the result take place in POST PROCESSING Mode.
- First we choose the output file that we want to analyze (like various loads or load combination) .Then it will show the results.

- Send the analysis result to steel design or concrete design engines for designing purpose.
- If someone wants to do design after analysis then he can ask STAAD-PRO to take the analysis results to be designed as design
- The data like Fy main,Fc will assign to the view
- Then adding design beam and design column.
- Running the analysis it will show the full design structure.

B. Swimming Pool

The trend of RCC high rise structures has increased nowadays in India. Many different amenities like swimming pool, garden etc. have been provided in high story building which is very attractive from an aesthetical point of view but it is dangerous from a structural point of view. The swimming pool is a heavy weight and the detailing is complicated, but it is not much different than other structural loads. If the pool were to break for some reason and all the water rushed out, it would destroy some interior and possibly some windows. But otherwise, it wouldn't level the building. In fact, in most cases, the extra water mass will help the building resist earthquakes by acting as a liquid mass dampener.

1) General Shapes of the Swimming Pool

Understanding the different pool shapes that are available can help you in making the decision to buy a pool. Many people don’t understand what the possibilities are for different kinds of pools in their backyard. The shape you pick can be helpful or detrimental to the type of experience you are looking for. This post will outline the basics of what each shape does for your home. To make a decision on a pool shape you need to keep in mind the location where the pool will be built. The shape should be well accommodated to the place. It should also accommodate the activities you expect to take place. Which are- Oval Pools, Kidney Pools, Figure 8 Pools, Rectangular Pools, Lazy L Pool, Circular Pools, Free Form Pools, and Geometric Pools.

C. Shear Wall

Reinforced concrete (RC) buildings often have vertical plate-like RC walls called Shear Walls in addition to slabs, beams and columns. These walls generally start at foundation level and are continuous throughout the building height. Their thickness can be as low as 150mm, or as high as 400mm in high rise buildings. Shear walls are usually provided along both length and width of buildings. Shear walls are like vertically-oriented wide beams that carry earthquake loads downwards to the foundation. The main purpose of all types of structural systems utilized in your building kind of structures would be to support gravity loads. The most typical loads caused by the result of gravity are dead load, live load and snow load. Besides these vertical loads, structures will also be exposed to lateral loads brought on by wind, raging or earthquake. Lateral loads can be cultivated high stresses, produce sway movement or cause vibration. Therefore, it is crucial for that structure to possess sufficient strength against vertical loads along with sufficient stiffness to face up to lateral forces. The usefulness of walls in the structural planning of multi-story buildings has long been recognized. When walls are situated in advantageous positions in a building. They can be very efficient in resisting lateral loads originating from wind or earthquakes. Because a large portion of the lateral load on a building, if not the whole amount, and the horizontal shear force resulting from the load, are often assigned to such structural elements, they have been called shear walls. Shear walls in buildings must be symmetrically located in plan to reduceill-effects of twist in buildings.

They could be placed symmetrically along one or both directions in plan. Shear walls are more effective when located along exterior perimeter of the building – such a layout increases resistance of the building to twisting. Within this present study, primary focus is to look for the solution for shear wall location in multi-floor building. The item from the study would be to model and evaluate shear wall presented structures and also to suggest appropriate locations of shear walls for those structures considered for analysis. The use of shear walls or their equivalent becomes imperative in certain high-rise buildings if inter story deflections caused b lateral loading, are to be controlled. Well-designed shear walls in seismic areas have a very good record. Not only, can they provide adequate structural safety, but they also give a great measure of protection against costly non-structural damage during moderate seismic disturbances.

II. LITERATURE REVIEW

Viviane Warnotte summarized basic concepts on which the seismic pounding effect Occurs between adjacent buildings. He identified the conditions under which the seismic Pounding will occur between buildings and adequate information and, perhaps more Importantly, pounding situation analyzed. From his research it was found that an elastic model cannot predict correctly the behaviors of the structure due to seismic pounding. Therefore non-elastic analysis is to be done to predict the required seismic gap between buildings.

Shehata E. Abdel Raheem developed and implemented a tool for the inelastic analysis of seismic pounding effect between buildings. They carried out a parametric study on buildings pounding response as well as proper seismic hazard mitigation practice for adjacent buildings. Three categories of recorded earthquake excitation were used for input. He studied the effect of impact using linear and nonlinear contact force model for different separation distances and compared with nominal model without pounding consideration.

Robert Jankowski addressed the fundamental questions concerning the application of the nonlinear analysis and its feasibility and limitations in predicting Seismic pounding gap between buildings. In his analysis, elastoplastic multi-degree of freedom. Lumped mass models are used to simulate the structural behavior and non-linear viscoelastic impact elements are applied to model collisions. The results of the study Prove that pounding may have considerable influence on behavior of the structures.

Aksogan et al. [1] carried out the forced vibration analysis of a multi-bay coupled shear wall on an elastic foundation. Shear walls with a finite number of stiffening beams were considered, the properties of which varied from span to span and/or from section to section in the vertical direction. Continuous connection method (CCM) was employed to find the structure stiffness matrix. A time-history analysis using the Newmark numerical integration method was used to obtain the response. The outcomes of the present method was then compared with SAP2000 structural analysis program and found a good match among themselves. Tuken [2] proposed an analytical method to determine the sway of a mixed structure (frame + shear wall) subject to seismic forces. The validity of the analytical method was tested on 3-D buildings of different heights. He also obtained the sway response using SAP2000 and found that the sway results obtained by the analytical method matches well with the results of SAP2000. Anshuman.S et al. [3] studied the effect of shear wall location in multi-storey building based on their elastic and elasto-plastic behaviour. Seismic effects were induced on a fifteen storey building situated at seismic-zone four of India. Elastic and elasto-plastic analyses using both STAAD Pro 2004 and SAP (2000) showed agreement in results. Shear walls were placed to reduce the drift index in the columns based upon the results.

III. METHODOLOG (MODAL GENERATION AND ANALYSIS)

A. General

An RC framed irregular building has been used for the purpose of study. The height of the building is 36m above ground level (G+11). The loads acting on the frame are Dead Load (DL), Live Load (LL) and Earthquake Load (EL). The sectional properties of the building is shown in the tables below.:

Table-1. Various sectional properties of the building

Height of the ground storey	3 m
Height of upper storey's	3 m
Size of Column	600mm x 450mm
Size of Beam	450mm x 300mm
Size of Slab	150mm
Size of exterior walls	Full brick masonry (9 inches or 230mm)
Size of interior walls	Half brick masonry(4.5 inches or 115mm)

Table-2. Seismic zone factors for different zones in India

Seismic Zone of India	Seismic coefficient	Seismic zone factor (z)
V	0.08	0.36
IV	0.05	0.24
III	0.04	0.16
II	0.02	0.1

B. Loads Considered

1) Dead Load

The dead load at different floor and roof levels will be considered for current analysis are mention below:

load of Slab	0.150 x 25	3.75 KN/m2
load of exterior walls	0.150 x 25 x3	17.25 KN/ m2
load of interior walls	0.115 x 25 x3	8.625 KN/ m2
load of partition wall	0.150 x 25	2.875 KN/ m2

2) Live Load

The live load at different floor and roof levels will be considered under code IS 1893:2002. for current analysis are mention below:

load of Slab (expect top floor)	2.5 KN/m2
load of Slab (only top floor)	1.5 KN/ m2

3) Earthquake or Seismic Load (EX & EZ)]

Seismic or Earthquake Load is designated as EX & EZ where “E” stands for Dynamic load and X & Z represents their respective direction of action. As per IS 1893:2016, Article 7.3.1 the total seismic load is calculated by adding total dead load of the structure and appropriate percentage of floor live load. The percentage of live load to be added depends upon its magnitude as given in table 8 in IS 1893:2016. The seismic load values were calculated as per IS 1893-2002. STAAD Pro has a seismic load generator in accordance with the IS code mentioned.

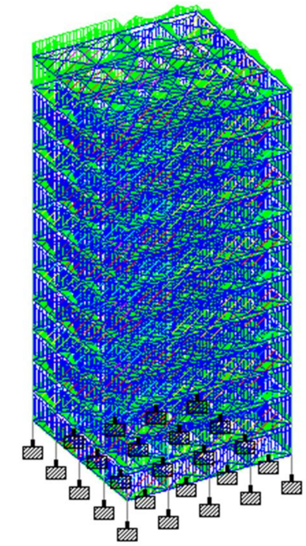
4) Load Combinations Used For Analysis of All Case Frames

In the post-processing mode, the analysis for beams, columns and floors were performed followed by the calculation of the drift and base shear for the columns. The worst load condition is identified for the maximum deflection, bending moment and shear force of the structural components.

The results indicate that the storey drift and base shear of the structural components crossed the allowable limits as prescribed in IS: 456-2000 for bare framed structure. In this context shear walls were introduced to the structure to reduce the effect of lateral forces and design the building for serviceability and collapse.

a) DL +LL
b) DL+WL
c) DL+0.8LL+0.8WL
d) 1.5 (DL+-LL)
e) 1.2 (DL+LL+-EL)
f) 1.5 (DL+-EL)
g) 0.9 DL+- 1.5EL

Assignment Of Loads



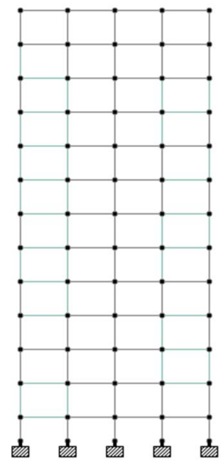
5) Design Parameter Provided to All RCC Frame Cases

The detail concrete design of all frame models is done in Staad. Pro. Software. The design parameter provide in software are kept same for all frames. Details of the provided design parameter are given the table.

Table Design Parameter Provided to All Frame Models

Design Code	IS 13920: 2000
Grade of Concrete	M30
Grade of main reinforcement	Fe500
Grade of secondary reinforcement	Fe500
Max. steel of main reinforcement	16 mm
Min. steel of main reinforcement	12 mm
Max. steel of secondary reinforcement	12 mm
Min. steel of secondary reinforcement	12 mm

IV. DETAILS OF THE STRUCTURE



Elevation Of Structure

V. RESULT

For that study suggested in multi-storey building of G+11 storey with 4 bays in longitudinal direction and 4 bays in lateral direction was considered for analysis.

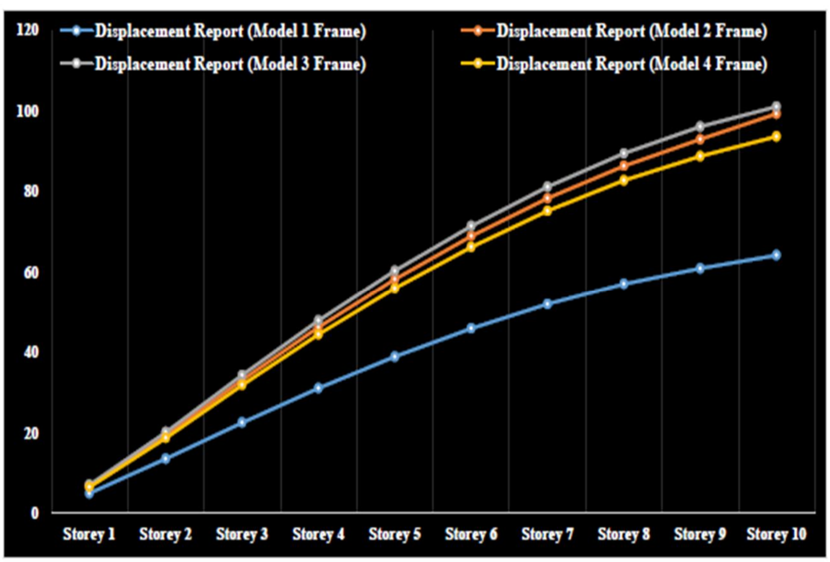
A. MAX. Deflection in X Direction

Load Combination	Calculated Deflection(mm)			
	CASE 1	CASE 2	CASE 3	CASE 4
1.2 (DL+LL+EQ)	1.451	1.121	0.97	0.54
1.5 (DL+EQ)	1.626	1.041	0.86	0.62
0.9DL+1.5EQ	1.139	0.97	1.011	0.59

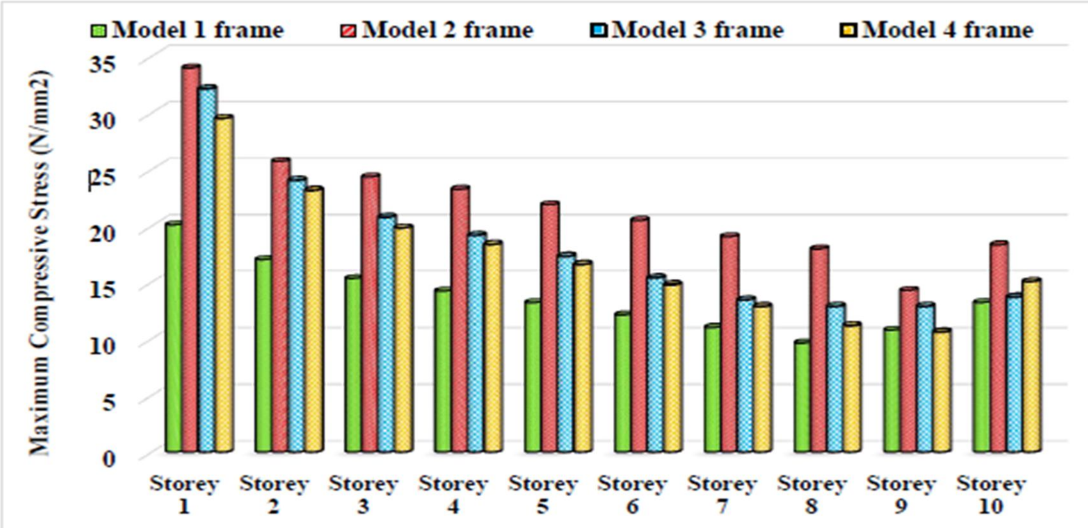
B. MAX. Deflection in Z Direction

Load Combination	Calculated Deflection(mm)			
	CASE 1	CASE 2	CASE 3	CASE 4
1.2 (DL+LL+EQ)	12.89	10.57	8.76	4.52
1.5 (DL+EQ)	16.07	11.75	7.58	9.44
0.9DL+1.5EQ	16.15	11.95	9.42	6.52

C. Comparison Report For Storey Displacement



D. Comparison Report For Compressive Stress



VI. CONCLUSIONS

1) For the above reason shear wall was provided at different locations in a building i.e. at corners, along the periphery of building, in the middle as CASE I, II and III respectively.
2) All the load combinations, the combination of 1.5 (DL+EQ) is discovered to be more critical combination for the models.
3) The lateral deflection for building with CASE I, shear wall is reduced as in comparison to all models. Hence, it may be stated that building with CASE-I shear wall is much more efficient than all other models with shear wall.
4) Shear wall is placed at outer edge parallel to X and Z direction of the building significantly reduces displacement
5) It is been concluded that the displacement in One-Side Swimming Pool Building is approximately 30% less than Center-Position Swimming Pool Building whereas 36% less than Two-Side Swimming Pool Building & 40% less than Three-Side Swimming Pool Building. It concludes that as the position of swimming pool changes, there is change in displacement. One-side Swimming pool Building shows better results whereas the other Case Model shows less variation when compared with each other.
6) After all analysis, We can say that there is a much variation in results as the positon of swimming pool in elevation plays an important role in the designing of the building and here it's been concluded that the single side positon pool comprises the best position for the regular buildings.

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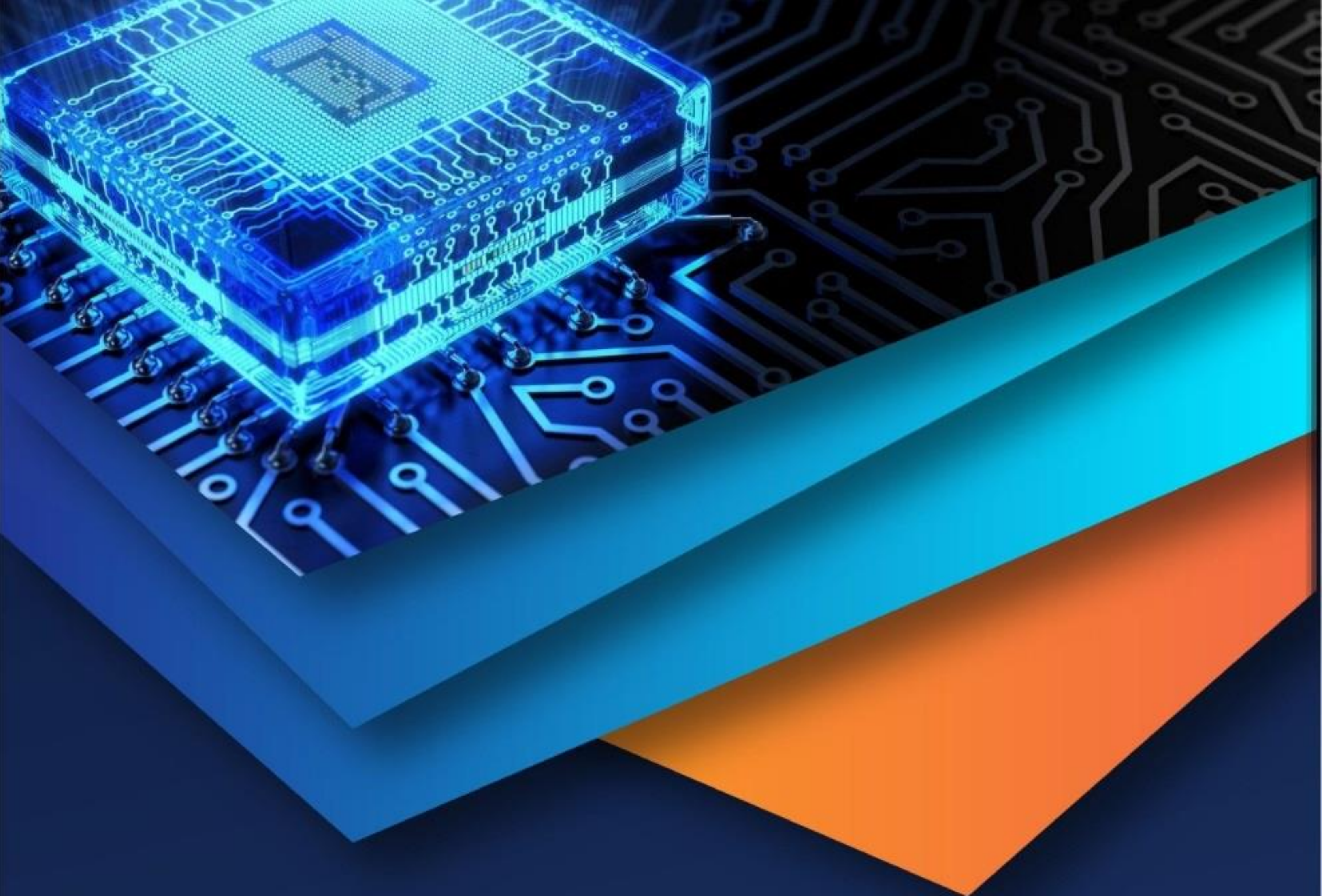

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