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STRUCTURAL ANALYSIS AND DESIGN OF MULTISTOREY BUILDING FOR SESIMIC AND WIND RESISTANCE

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ABSTRACT:The effective design & construction of earthquake and wind safe structures have a lot of significance in present day engineering. This project entitled "Structural Analysis & Design of Multi-storey Building for Seismic and Wind Resistance" describes analyzing and designing a G+9 residential building to withstand the earthquakes and wind pressures. The area of the proposed building is 11040 square meters, will be constructed as RCC frame structure. The project engages with planning, layouts, Analysis & Design. The building will be planned within this limited area, satisfying each and every need of people. The building layouts are developed for different structural elements like column, beam, slab to determine the location and dimensions. AutoCAD is used to develop plans and layouts. A base file from AutoCAD is used for Modelling in STAAD pro. The Material properties, loads and combinations are applied based on the site condition by following the Indian Standard Codes of practice. The analysis results are used to study the building response against seismic and wind loads. Advance Reinforced concrete extension is used to group the members and design them according to the dimensional and level similarities. The design results are used to produce the structural drawings of structural elements of the building. The three dimensional model of the respective building is developed with the help of Sketchup pro for visual and conceptual understanding.

Keywords: Multi-story building, Building planning, Structural analysis, Design of RCC, STAAD Pro, AutoCAD,

1. INTRODUCTION

The basic need of human existence for happy living is clothing, shelter & food.Everyone desires for peaceful condition for a happy living, it is fulfilled by having asafe place for living and convenient location. These are the importance of having anice home. It is necessary to build fast, quality and eco-friendly buildings, whichwould be attractive and convenient for use. The possession of shelter is that to feel safeat the time of natural calamities and a form of respect in a social life. A peaceful living compromises the following.

• A blissful environment.

• Basis resources required by a human to be present in his livelihood area.

• Safety from all-natural source and climatic conditions.

The planner has to consider basic amenities like municipal conditions, budget,water supply, discharge management, aeration, future provisions, oxygenating and byfollowing building bye laws. while suggesting a building plan to any client orconsultant.

Residential building is the building which provides accommodation, includes cooking area, toilets, sleeping and living space. Some examples that include residential building category are Single family or Multifamily dwelling units, Apartments, Villas,Lodgings or rooming houses, Hostels, Hotels. The residential need varies from person to person depending on the taste, background, community, locality.

This project deals with the proposed G+9 residential building of site area 11040square meters. The requirements for this building is to have the basic amenities likeindividual dwelling units along with recreational places like swimming pool,playground, garden, party halls, play room, generator room and car parking. The Sitewas facing North and East. The site dimensions facing East and West directions are 120 m and on North and South directions, it is 92 m.

The road connecting the plot is30 m wide road. The SBC provided is 200 kN/m2. The climatic conditions are normalwith less records of weather outbreaks in terms of cyclones, earthquakes, floods etc.for three decades. By following the client's requirements and site conditions a properbuilding plan is produced. A framework is a that can resist loads applied without showing largerdeformations. A framework isassembly of individual elements like pinned elements,beams, columns, shear wall, slabs and many other elements. Structural engineering isa science in which a structure is designed and planned in a way that meets all therequire requirements. Structural analysis is a way of identifying the amount of forcethe structure is getting and the displacement under different load cases. Design processis involved in getting the required sectional properties and their detailing which isnecessary at site. The main motto is to design a structure that meets safety conditions in a most economical way possible. The structural elements used in the paper arederived by using the Limit State method.To analyze and design the G+9 residential building there are various software application and programming tools used to make the work efficient, faster and moredetailed. The detailing is done based on SP16 1980.

2.LITERATURE REVIEW

S.P and Chakraborty (2010) endeavored to research the corresponding conveyanceof sidelong powers advanced through seismic activity in every storeylevelbecause ofchanges in mass and firmness of building. According to the BIS arrangements, amulti-storey even structure is considered as improved irregularity mass model for theinvestigation with different mass and firmness proportions. The influence example ofmultistoried structure under seismic excitation is mulled over with explanatory shapecapacities. The outcome closes as a structure with high mass and firmness proportiongives precariousness and pulls in colossal story shear.

Hasan et al. (2011) ISSN 1992 -1950, D discussed the effect of sway and non-swaymethods for analyzing and design for multi storey buildings.

Suresh and Nanduri (2012) Focussed on the earthquake resistant analysis and nonearthhquake resistant analysis.The conclusion they arrived is that the reinforcementdetailing is same in both the designs and the is no much cost required in buildfing theearthquake resistant buildings.

Kayvani (2014), 'Design of high-rise buildings: past, present and future', In thispaper she discussed the design considerations of the modern high rise buildings.

3.METHODOLOGY

Data collection: To start any construction project site data and building requirements are collected by studying the standards for building service. The requirements like height, stability and strength, dimensional stability, etc. are established from the regional data collection. The data mentioned above can be used for preparation of the building plan. While the data like dimensions of structuralelements from the building plan is collected for analysis. More details from the standardcodes are followed such that the planned building satisfy rules and regulations.

Preparation of building plan: An architectural plan is prepared such that itfulfils the requirements of client. The building is planned in such a way that it blendswith the surroundings. All the levels of the building are made accessible with ease andcomfort. The life style of the community that shall use the building is kept in mindwhile planning. The basic amenities are provided in and around building to keep thehealth and comfort for people using it. The drawings for the concept of the building aredeveloped level wise using AutoCAD.

Preparation of Structural layouts: The building plan is used to prepare theStructural layouts (column layout, Beam layout and Slab layout) with proper and cleardimensions. As the levels of building are not similar, the level grouping is carried out.Layouts of each level is developed for each structural member and further used asconstruction drawings. The layouts are produced using AutoCAD.Analysis and Design using STAAD Pro: The structural layouts fromAutoCAD are exported to STAAD Pro as .DXF file. The transferred layout is used asbase. The graphical user interface of STAAD Pro helps in modelling the structure. Theframe of the structure developed by using some useful tools (translation repeat,Copying with reference points, etc.). From the building data collect we define andassign the member properties and also the support conditions. By following IS 875-1987 parts, the loads and combinations are created and assigned to the structure. Thedesign is carried out by defining all the parameter and commands as per Indianstandards. Additionally, STAAD Foundation and STAAD RCDC is used forfoundation design from reactions and reinforced concrete design along with scheduling of bars with proper drawings. The results are evaluated and used to produce thestructural drawings

as the output.Structural drawings as output: The design results are used to produce thedetailed structural drawings of beams, slabs, columns, foundation. These drawingsalong with the layouts are used for construction of the Proposed Residential G+9building.

4. MODELLING AND ANALYSIS:

This paper deals with the proposed G+9 residential building of site area 11040square meter. The requirements for this building is to have the basic amenities likeindividual dwelling units along with recreational places like swimming pool,playground, garden, party halls, play room, generator room and car parking. The Sitewas facing North and East. The site dimensions facing East and West directions are 120 m and on North and South directions, it is 92 m. The road connecting the plot is30 m wide road. The SBC provided is 200 kN/m2. The climatic conditions are normalwith less records of weather outbreaks in terms of cyclones, earthquakes, floods etc.for three decades. By following the client's requirements and site conditions a properbuilding plan is produced. Table 1 shows the site information.

Table:1 Site Information

| Building type	: Residential Building
Site Area	: 11040 m2 (2.73 acers)
Built-up area	: 1420 m2
Building Height	: 34 m (each floor height is 3.3m)
Number of storey	: Ground floor+9
Type of Construction	: RCC framed structure
Number of staircase	: Two (dog legged staircase)
Number of elevators	: Two
Type of wall	: Brick Wall
Front facing	: North, East
Requirement	: basic amenities that can fit the space
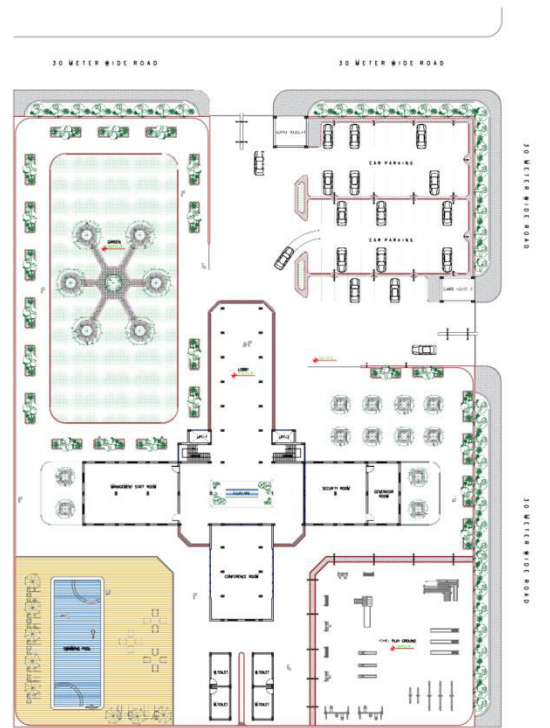
Figure:1 Plan of the building

The proposed building plan is drawn by using AutoCAD as shown in Figure 1. The vision for the building is clearly digitalized with feet and inches as units and with unit precision. The layers for each stage of the building are maintained. The layers for Construction lines or grids, base lines, doors and window, text and dimensions, etc. are properly organized.

Analysis and Design Using Staad Pro

STAAD Pro is a powerful design software. It stands for structural analysis anddesign program. The Structural layouts from AutoCAD are imported in the form .DXFfile. The imported geometry will be a base for the whole building. Here certain actions are performed to model the building. The properties of the structural elements likecolumn dimensions, beam dimensions and others are defined by following thestructural layout. The Indian standard code are used to assign the loads acting on thestructure. The IS codes we follow while modelling in STAAD Pro are IS-456, IS-875(parts), IS-1893. The loading changes

with the change for the intended use of building.After the application of the loads the model is saved and analyzed for bendingmoments and shear forces along various axes. The model is then design as per IS 456-2000. In the above process the model in STAAD pro is checked for errors. Thismodel as shown in Figure 2 can be developed any time for better performance.
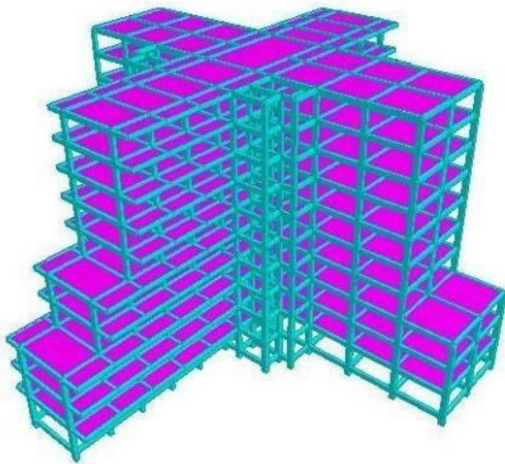

Figure:2 Rendered image of G+9 building from STAAD Pro

Model Geometry

The Modelling of the G+9 residential building starts with the importing of baseexternal reference from AutoCAD. The direction should be Y-up and the units are inmeters and Kilo Newton. The imported geometry is checked for any errors. The totalgeometry is selected and by using the translational repeat as shown in Figure 3, thegeometry is copied as many times it is required. The floor height is 3.3m, the plinthheight from ground is 1m and the steps should be linked, which will create theconnecting column for the given number of steps. The members are added andremoved further to form the required structure, as the levels of the structure are different. Members properties are assigned to the structure.

The following are the data required and assumed for the design process.

Table:2 Building Data for Analysis

Dimensions of beams	: R1 (0.60 m X 0.30 m) : R2 (0.45 m X 0.30 m)
Dimensions of column	: R1 (0.60 m X 0.45 m) : R2 (0.60 m X 0.30 m)
Thickness of Slab	: 0.15 m
Thickness of outer wall	: 0.23 m
Thickness of inner/partition wall	: 0.12 m
Live Load intensity	: 2.0 kN/m2
SDL intensity	: 1.5 kN/m2
Support condition	: Fixed support
Define the data in properties and assign it to the model.	

5. RESULTS AND DISCUSSIONS

Structural Analysis deals with the prediction of performance of the structureunder stipulated loads and other external effects. The performance characteristics ofthe structural members are stresses and stress resultants such as axial forces, shearforces, bending moments, deflections, base shear, nodal displacements and supportreactions. The ductile detailing of the structural elements like slab, beam, column andfooting are produced by using the above mentioned resultants. The drawing helps usto understand the structure while execution.

Running analysis in STAAD pro. Gave multiple set of results. Post processingis a step of workflow, where the structural elements' behavior on the application ofdifferent load cases as of Figure3.
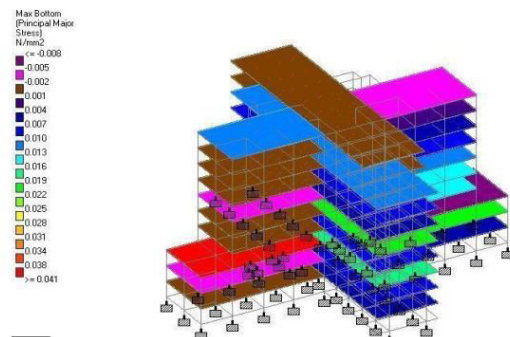

Figure:3 Contours for Principle stresses in Plate elements

Analysis and Design of Beam

The beam results in Figure 4 for total model are available in the postprocessing mode. The beam stress, shear forces and bending moment diagram alongall the directions are available. The data on the right side can be exported to the MSexcel for further study of building. When double clicked on a beam the detailedinformation of the beam analysis and design are shown. The information like beam no.and Geometry, Shear force diagram and bending moment diagrams, deflection alongwith the values at all the points of the beam. The concrete design of the beam withsection details are presented.
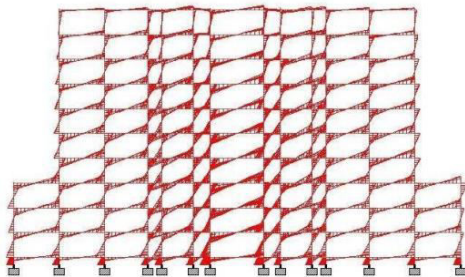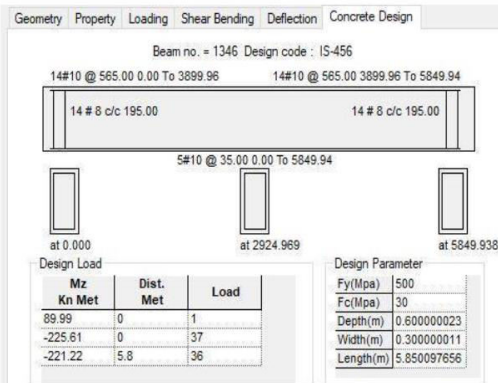

Figure:4 Bending moment of beams

Figure: 5 Beam reinforcement details

Analysis and Design of Column: The Column results for total model are available in the post processing mode.The beam stress, shear forces and bending moment diagram along all the directions are available. The data on the right side can be exported to the MS excel for furtherstudy of building. When double clicked on a column, the detailed information aboutthe column analysis and design are shown. The information like column no. andGeometry, Shear force diagram and bending moment diagrams, etc. The concretedesign of the column with section details are presented in Figure6.
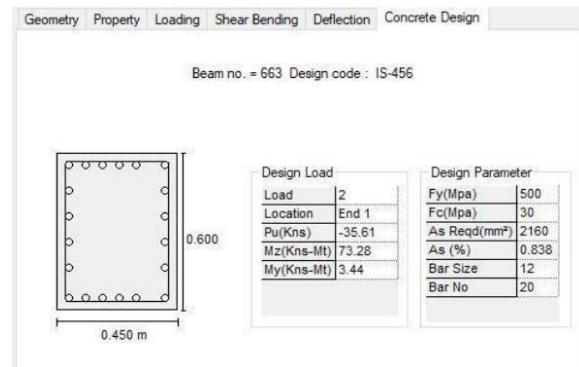

Figure:6 Design of Column

Analysis and Design of Foundation
The reactions from STAAD Pro are exported to the STAADFoundation. A new job is created for the foundation design. The load combination isselected and type of footing as Isolated footing. Then the soil properties in Figure 7are assigned and the foundation is designed.
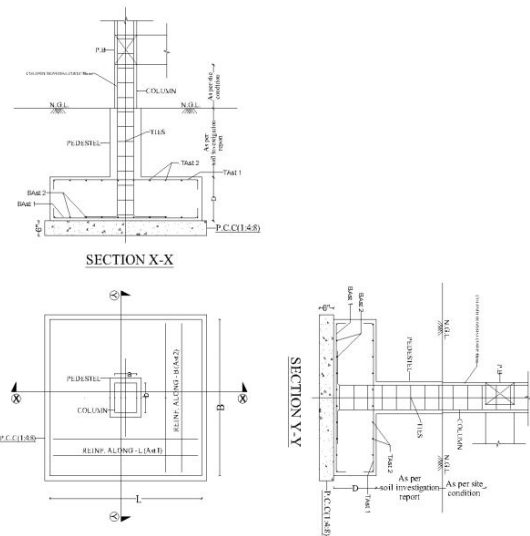

Figure:7 Foundation Details.

6. CONCLUSION
The proposed multistory building is analyzed and designed to resist wind and seismicloads as per IS codes of practice.
1. The architectural design provided with the desired amenities, fulfils the properfunction and utilization of building space.
2. Making or developing a 3D model of building will always reduce the time andefforts to visualize and

study the information about the building during constructiontime.

3. The placement of structural elements in the building is carried out withoutdisturbing and compromising the architectural concepts.

4. The analysis and design process in STAAD pro saved a lots of time and effort. Italso provides with a lot of information about structural behaviour under differentloading cases. The building is modelled in such a way that it replicates and createsthe forces acting on the structure in real life.

5. From the results obtained it is observed that the design will withstand forces comingon it successfully during it life time service.

6. The size of members in the building with respect to height decreased in terms ofload carrying capacity. As the height increased the members in the bottom storeyhad to take more loads and hence designed to withheld more stresses. This can beobserved especially for the columns

7. The effect of wind pressure increased proportionally with respect to the buildingheight.

8. Structural members are designed to with stand the stresses developed in themduring its service.

9. The steel provided in the slab and beams in more on tension sides. The supports inthe structure create positive moments and suspended parts of members create thenegative moment.

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