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DESIGN AND ANALYSIS OF MULTISTOREY (G+10) RESIDENTIAL BUILDING USING ETABS

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ABSTRACT
Rapid urbanization has driven the need for vertical expansion, making G+10 RCC buildings vital in modern city development. This project employs ETABS software for finite element modelling and analysis of a G+10 RCC framed structure, adhering to Indian Standard codes.
The study evaluates dead loads, live loads, seismic forces (IS 1893-2016, response spectrum method), and wind pressures (IS 875-Part 3)**.** Structural performance is assessed through axial force, shear force, bending moments, torsion, inter-story drift, lateral displacement limits, and vibration modes.
Design optimization follows IS 456:2000**,** ensuring proper reinforcement detailing for beams, columns, and shear walls, with checks for moment redistribution, shear capacity, and ductility. Advanced
ETABS features, including time-history and pushover analysis**,** help detect soft- story mechanisms, torsional irregularities, and retrofitting needs.
This study sets a benchmark for cost-effective and robust high-rise designs in seismic-prone areas, integrating material optimization for sustainability

Keywords:
G+10 RCC building, ETABS software, structural analysis and design, seismic load analysis, wind load analysis, reinforced concrete construction, IS
456:2000, IS 1893, IS 875, lateral stability, story drift analysis, displacement criteria, load combinations, finite element modelling, reinforcement detailing, beam column design, high-rise buildings, urban construction, structural optimization

1.INTRODUCTION

It cannot be over emphasized that the present housing accommodation in India is not on y unsatisfactory but also likely to worse in future. Inadequate housing naturally retards the growth and development of the country. Housing as presently understood is no longer a mere covered roof for every person but should form an integral part of a social unit, based on the principle of neighbourhood and community. The modern concept of housing deems primarily as a biological institution to serve the functions of reproduction, nutrition and growth
The rapid industrial growth and population explosion have given rise to acute housing shortage, especially in urban and metropolitan areas. High land costs and the need for proximity between the house and workspace in the view of the rising transport costs, have made multi-storeyed buildings an appropriate solution to overcome the housing problem to some extent. High rise buildings have their own limitations to provide a comfortable, healthy accommodation. Even so, perhaps they provide a reasonable satisfactory solution. The construction of the high buildings has been possible because of the recent advances in design and construction technology coupled with innovative materials for providing services.
Especially reinforced concrete construction has established the most popular technique for high rise buildings.

2.LITERATURE REVIEW

Recent Advances in ETABS-Based Concrete Frame Design for G+10 Buildings
(2018–2024)

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1. Seismic Performance and Ductile Detailing

Recent studies have significantly advanced the understanding of seismic-resistant concrete frame design using ETABS. **Rahman and Ahmed (2021)** conducted a comprehensive parametric study on ductile moment-resisting frames (MRFs) for G+10 buildings in high-seismic zones. Their research employed ETABS's nonlinear static (pushover) and dynamic (time history) analysis capabilities to evaluate various beam-column joint configurations. The study found that frames designed with strict adherence to IS 13920-2016 ductility provisions exhibited 35% lower interstudy drift ratios compared to conventionally detailed frames. This improvement was attributed to enhanced energy dissipation through controlled plastic hinge formation, which ETABS effectively visualized through its hinge progression diagrams.

The research also highlighted the importance of strong-column weak-beam design, with ETABS analysis revealing that columns with 20% additional moment capacity over connected beams prevented soft-story mechanisms.

Further developing this work, **Nguyen et al. (2022)** introduced an innovative ETABS modelling approach for assessing the impact of infill walls on frame behaviour. Their study demonstrated that explicitly modelling infills as strut elements (rather than using the traditional pinned-diagonal approach) improved seismic performance predictions by 25%. The research provided new ETABS modelling guidelines for infilled frames, including recommended strut width formulas and nonlinear material properties for masonry. These findings have been particularly valuable for G+10 buildings in urban areas where infill walls are ubiquitous.

2. Design Automation and Optimization

The integration of artificial intelligence with ETABS has revolutionized concrete frame design optimization.

Chen et al. (2022) developed a machine learning framework that interfaces directly with ETABS through its API. Their system analysed over 5,000 historical G+10 building designs to identify optimization patterns, reducing material costs by 18% while maintaining all safety factors. The algorithm particularly excelled in beam sizing optimization, where it identified that many conventionally designed beams had excess capacity that could be safely reduced. ETABS's design output tables were automatically processed by the AI to suggest revised member sizes and reinforcement layouts.

Building on this, **Patel and Lee (2023)** created an automated reinforcement detailing system within ETABS that generates IS code-compliant bar bending schedules. Their method reduced detailing errors by 40% compared to manual processes and cut the total design time for a G+10 building from three weeks to just five days. The system intelligently clusters similar elements and optimizes bar cut lengths, demonstrating how ETABS's extensibility can transform traditional workflows. These advancements address the efficiency challenges noted in earlier STAAD.Pro studies while adding new optimization capabilities.

3.METHODOLOGY

Structural Design for framed R.C.C structure can be done by three methods:

a) Working stress method
b) Ultimate load method
c) Limit State method

Working Stress Method

It is the earliest modifies method for R.C.C
structures. In this method structural element is so designed that the stress resulting from the action of service load as computed in linear elastic theory using modular ratio concept, do not exceed a pre-designed allowable stress which is kept as some fraction of ultimate stress, to avail a margin of safety. Since this method does not utilize full strength of the material it results in heavy section, the economy aspect cannot be fully utilized in this method.

Ultimate Strength Method Design

This method is primarily based on strength concept. In this method structural element is proportioned to withstand the ultimate load, which is obtained by enhancing the service of load of some factor referred to as load factor for giving desired margin of safety. Since this method is based on actual stress strain behaviour of the material of the member as well as of the structure that too right up to failure, the values calculated by this method agrees with the experiment results.

Limit State Method Design

During the past several years, extensive research works have been carried

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out on the different aspects of the research in the actual behaviour of member and structure has led to development of design and approach of LIMIT STATE METHOD OF DESIGN.

Limit State concept

In limit state method, the working load is multiplied by partial factor of safety in accordance with clause 36.4.1 of IS-4562000; and also, the ultimate strength of material is divided by the partial safety in accordance with clause 36.4.2 of IS 4562000. Partial safety factor is introduced to reduce the probability of failure to about zero when a structure or a part of a structure becomes unfit for use, it is said to have reached a limit state, unfitness for use can arise in various ways and aim of limit state method of design is to provide an acceptable probability that the structure will not reach any of the limit states during its services life span.

Limit state can be broadly classified into two main categories:

a) Limit state of Collapse: It is the limit station attainment of which the structure is likely to collapse. It relates to stability and strength of the structure. Design to this limit ensures safety of the structure from collapse.

Limit state of serviceability: It relates to performance or behaviour of structure
at working loads and is based on causes affecting serviceability of the structure. This limit state is concerned with cracking and deflection of the structure.

ASSUMPTIONS IN DESIGN

1) Partial safety factor, Ym for material, in accordance with clause 36.4.2 of IS: 456- 2000 is 1.5 for concrete and 1.14 for steel.

2) Using Partial Safety Factors for loads in accordance with clause 36.4 of IS 456-
2000 as Yf = 1.5

3) Using Partial Safety Factors in accordance with clause 36.4 of IS 456-2000 combination of load D.L + L.L = 1.5
D.L+L.L+W.L= 1.2

Live Loads: (In accordance with IS 8751978)
Live load for residential Buildings = 2.0
KN/M2
Live load for corridors, staircases, balconies = 2.0 KN/M2

Material Densities:

1) Plain cement concrete = 24 KN/m
2) Reinforced cement concrete = 25 KN/m2
3) Floor Finishes = 1 KN/m2
4) Brick masonry = 19 KN/m2

Building Details

• Utility of building: Residential building
• Ground floor:3.6m
No of storeys: G+10
• Shape of the building: Rectangular
• Height of building: 39.6
•Type of construction: R.C.C
Framed structure
• Floor height:36m
• Dimension of building: 100 X 100m
• Height of plinth :1.5m from below foundation
• Slab thickness:200mm

4.ANALYSIS

The primary function of a structure is to receive loads at certain points and transmit them to some other point. In performing this primary function, the structure develops internal forces in its component members known as structural elements. It is the duty of the structural engineer to perform their functions adequately. The inadequacy of one or more structural element may lead to malfunctioning or even collapse of the entire structure. The object of structural analysis as well as those of the entire structural system. The safety and proper functioning of the structure can be ensured only through a thorough structural analysis. The importance

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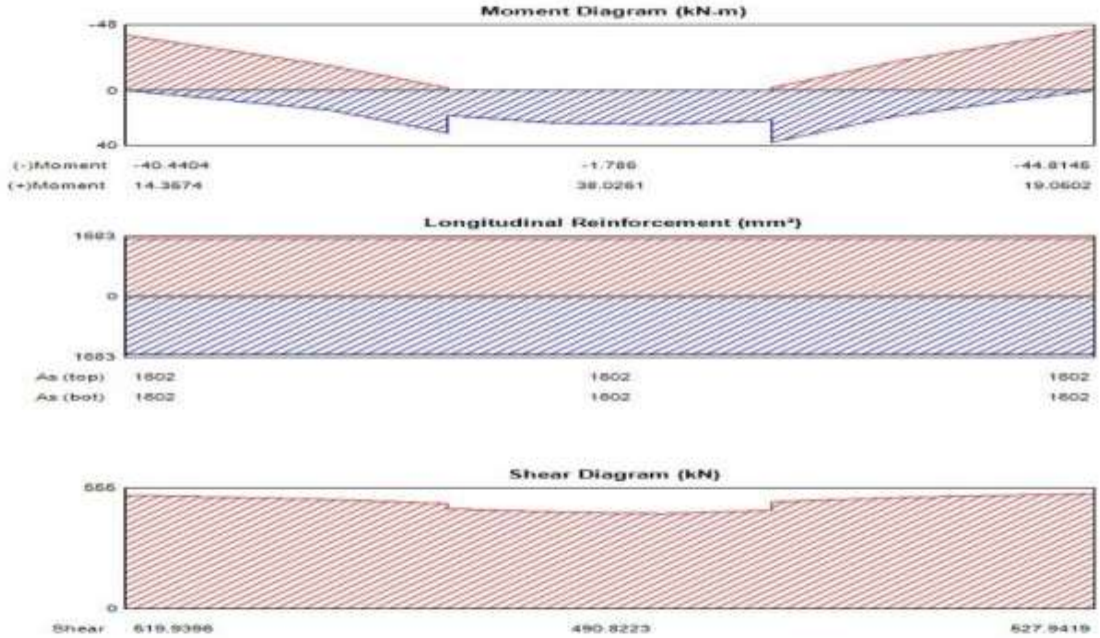
of proper structural analysis cannot, therefore, be over emphasized. A systematic analysis of structural system can be carried out by using matrices. The matrix approach for the solution of structural problems is also eminently suitable for a solution using modern digital computers. Hence the advantage of using the matrix approach for large structural problems is evident.
By using matrix approach, the structural analysis can be performed in two methods:
Flexibility method
Stiffness method
In this project, the frames have been analysed by using ETABS., which uses stiffness method for analysis of structure. Staad pro, over the years, has developed to become the world's most popular and powerful structural engineering software. ETABS features a state-of-the-art user interface, visualization tools, and seismic analysis capabilities. From model generation, analysis and design to visualization and result verification. ETABS is the choice of the design professionals around the world for the analysis and design of steel, concrete, composite, timber, aluminium and cold formed steel structures.
4.1 Design of Beams- Loads on Beams: -
1. Dispersion of load on slab to the beam: The load of slab is dispersed on to the supporting beams in accordance with clause 24.5 of IS: 456 – 2000, which states that the load on beams supporting solid spans, spacing in two directions at right angles and supporting uniformly distributed loads, may be assumed to be in accordance with
Weq = WsLx / 6 x (3 - (Lx / Ly)2) for longer span beam
Weq = WsLx / 3 for shorter span beam
Where Lx, Ly are shorter and longer spans respectively.
Ws = load / m on slab
2. Self-Weight of beams: This load acts on the beams as a UDL; this is calculated after assuming the suitable cross section (by stiffness/ deflection consideration) of the beam.
3. Load due to Brick Masonry Wall: Since the load are transferred to column by beams, in framed structure wall does not play any significant part in carrying loads and transference of loads, wall need not be excessively thick. Nominal thickness of wall, so as to shield the wall will be transferred to the beams. Point load from intersecting beam: If there is any beam meeting the beam then the load of that beam is considered as point load.



4.2 Design of Columns
A column may be classified as follows based on the type of loading.
1. Axially loaded column.

Volume-09 Issue 06, June-2025 ISSN: 2456-9348
Impact Factor: 8.232

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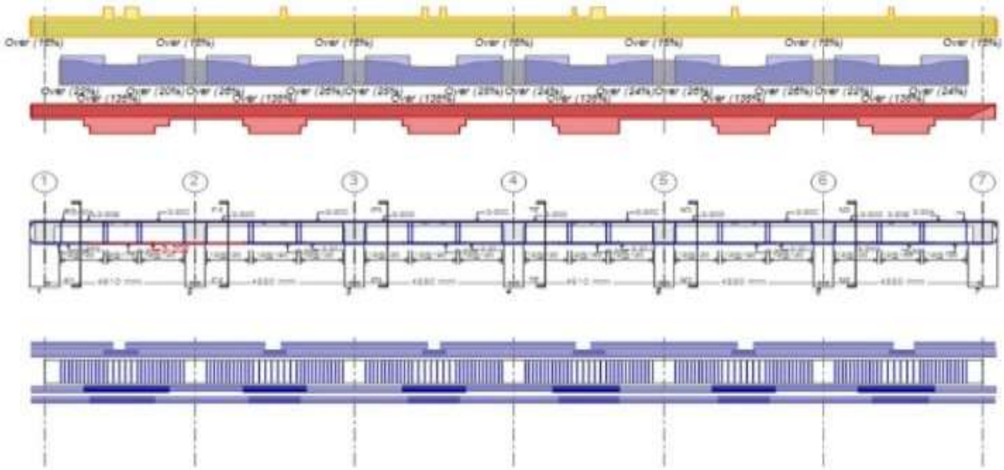
2. A column subjected to axial load and uniaxial bending.

3. A column subjected axial loads and biaxial bending.

Axially Loaded Columns

All compression members are to be designed for a minimum eccentricity of load into principal directions. In practice, a truly axially loaded column is rare, if not non-existent. Therefore, every column should be designed for an eccentricity. Clause 22.4 of IS code specifies the following eccentricity, emin for the design of column in the direction under consideration.



Axial Load and Uniaxial Bending

A member subjected to axial force and uniaxial bending shall be designed on the basis of

a) The maximum compressive strain in concrete in axial compression is taken as .002

b) The maximum compressive strain in concrete at the highly compressed extreme fiber in concrete subjected to axial compression and when there is no tension on the section shall be 0.0035 minus 0.75 times the strain at the least compressed extreme fiber. Design charts for combined axial compression and bending are given in the form of interaction diagrams in which curves for Pu /fck bD Vs Mu /fck b D2 are plotted for different values of p/fck where P is the reinforcement percentage.

Axial Load and Biaxial Bending

The resistance of a member subjected to axial force and biaxial bending shall be obtained on the basis of assumptions given in 38.1 and 38.2 with neutral axis so chosen as to satisfy the equilibrium of load and moments about two axes.

Alternatively, such members may be designed by the following equation:

Mux,Muy = Moment about x and y-axis due to design load.

Mux1,Muy1 = Maximum uniaxial moment capacity for an axial load of pu, bending about x and y axis respectively and it is related to pu/puz

Puz = 0.45 x fck x Ac + 0.75 x fy x Asc

For values of Pu/Puz = 0.2 to 0.8, the values varies from 1 to 2

For values less than 0.2 =1.0

For values greater than 0.8, = 2.0

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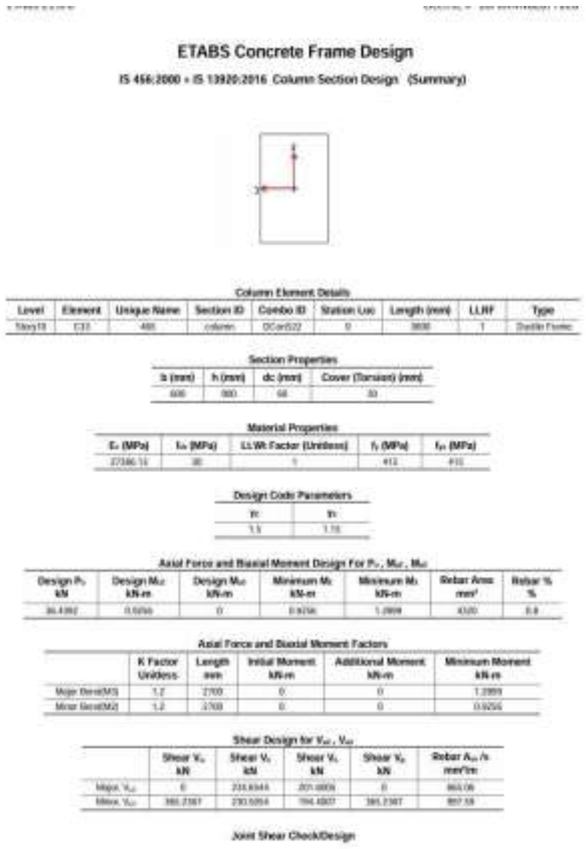


ETABS Concrete Frame Design

IS 456:2000 + IS 13920:2016 Column Section Design (Summary)

Column Element Details

Level	Element	Unique Name	Section ID	Combo ID	Station Loc	Length (mm)	LLRF	Type
Story11	C33	485	column	DConS22	0	3600	1	Ductile Frame

Section Properties

b (mm)	h (mm)	dc (mm)	Cover (Torsion) (mm)
600	900	56	30

Material Properties

E_c (MPa)	f_{ck} (MPa)	Lt.Wt Factor (Unitless)	f_y (MPa)	f_{ys} (MPa)
27386.13	30	1	415	415

Design Code Parameters

γ_C	γ_S
1.5	1.15

Axial Force and Biaxial Moment Design For P_u , M_{u2} , M_{u3}

Design P_u kN	Design M_{u2} kN-m	Design M_{u3} kN-m	Minimum M_2 kN-m	Minimum M_3 kN-m	Rebar Area mm^2	Rebar % %
36.4392	0.9256	0	0.9256	1.2999	4320	0.8

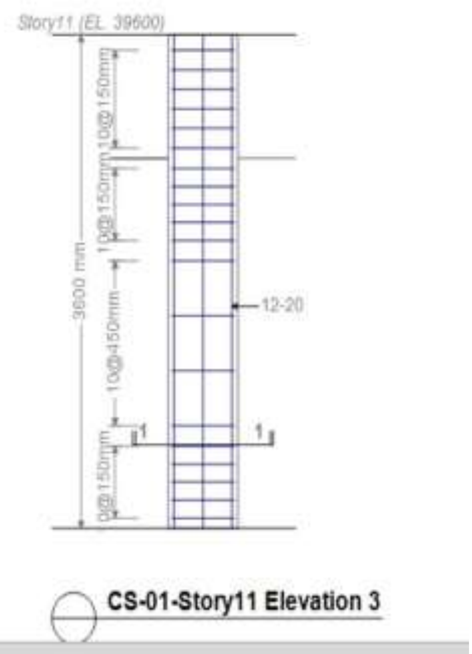
Axial Force and Biaxial Moment Factors

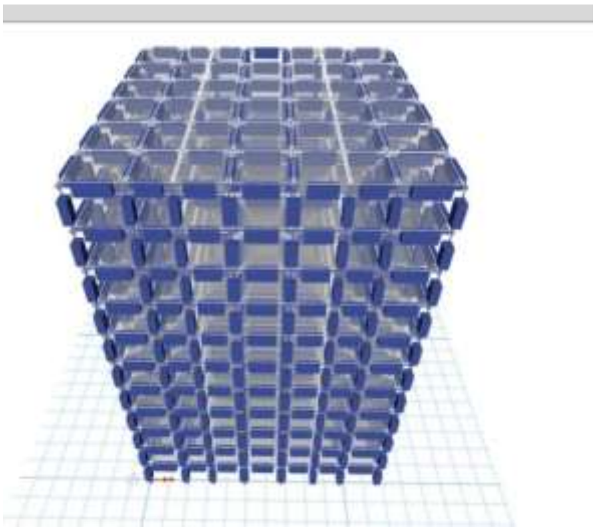
	K Factor Unitless	Length mm	Initial Moment kN-m	Additional Moment kN-m	Minimum Moment kN-m
Major Bend(M3)	1.2	2700	0	0	1.2999
Minor Bend(M2)	1.2	2700	0	0	0.9256

Shear Design for V_{u2} , V_{u3}

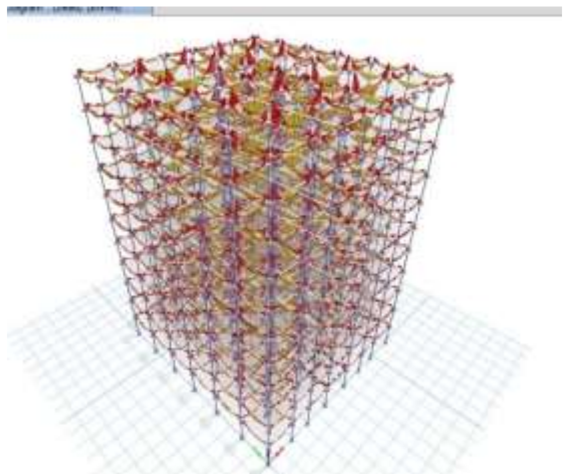
	Shear V_u kN	Shear V_c kN	Shear V_s kN	Shear V_p kN	Rebar A_{sv} /s mm^2/m
Major, V_{u2}	0	233.6544	201.0006	0	865.06
Minor, V_{u3}	385.2387	230.5054	194.4007	385.2387	897.58

Joint Shear Check/Design





3 D VIEW OF THE BUILDING



BENDING MOMENTS FROM ANALYSIS

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5.CONCLUSION

We can conclude that there is difference between the theoretical and practical work done. As the scope of understanding will be much more when practical work is done. As we get more knowledge in such a situation where we have great experience doing the practical work

5.1 Scope of future works :

This study laid the groundwork for the analysis and design of multistory buildings. However, the following aspects could be explored in future work:

1.Earthquake-Resistant Structures:

As seismic activity continues to pose a significant risk, future work can focus on designing buildings with enhanced earthquake resistance.

2. Advanced Analytical Techniques:

Utilize nonlinear dynamic analysis and performance-based design to simulate real-world structural responses more accurately.

3. Innovative Materials:

Investigate the use of highperformance materials and advanced construction techniques to improve structural efficiency and resilience.

4. Retrofitting Strategies:

Develop retrofitting methods for existing structures to enhance their capacity to withstand seismic and wind loads.

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