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(Review Article)

Structural design and analysis of G+5 framed structure using ETABS

Apurba Rakha *, Vikram Choudhry and Md. Zeyaul Haque

Department of Civil Engineering, Cambridge Institute of Technology, Ranchi, India.

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Abstract

This paper is an overview of the work done for the design and analysis of the multi-storey building (G+5) under the effect of various forces acting on the building such as dead load, imposed load, wind load, and seismic load. The work was done for the purpose of designing and analyzing the building to withstand the effects of these various forces. The fact that these pressures are working on the building demonstrates that if the buildings are not carefully planned and built with enough strength, then this may lead to the partial or entire collapse of the multi-storey structures. It is necessary to do an analysis and design the structures of multi-story buildings in such a way that they are able to resist the numerous pressures that operate on these buildings in order to guarantee the inhabitants' safety. The primary purpose of this endeavor is to investigate and analyze the effects of wind and seismic activity on the structures. The residential building is a G+5 storey construction, and it is situated in Raipur city, which is the capital of Chhattisgarh state. According to the criteria for the study of seismic load, zone II applies to the location of the building. Throughout the course of its lifetime, every structure will be susceptible to the impacts of a variety of forces, including those caused by dead load, live load, wind forces, and seismic forces. Both wind load and earthquake load contribute to the dynamic load, whereas dead load and imposed load only contribute to the static load. The whole of the structure was analyzed with the assistance of the STAAD PRO programme.

Keywords: Framed Structure; Seismic Analysis; ETABS; Collapse Mechanism

1. Introduction

The upkeep, repair, and alteration of various structural components is considered to be one of the most pressing concerns in the field of civil engineering. The strengthening of a structure is a common practise that may enhance its load-carrying capacity and lengthen its service life (Kaushik et al., 2006; Ahmed, M.; Khan, M.K.D and Wamiq, 2008). The search for several methods for repairing or strengthening infrastructure decay caused by premature deterioration of buildings and structures has been prompted by the investigation of various applications for repairing or strengthening infrastructure decay caused by premature deterioration of buildings and structures. One of the most difficult aspects of strengthening concrete structures is coming to an agreement on a strengthening method that will improve the structure's strength and serviceability while also taking into consideration constraints such as constructability, building operations, and budgetary considerations (Dixit, 2004; Xiong, C.; Lu, X; Lin, 2019).

Deficiencies may be caused by a number of factors, including deterioration (for example, corrosion of steel reinforcement and loss of concrete section), structural damage, or mistakes in the initial design or construction. The bulk of structural strengthening consists of enhancing the structural element's capacity to safely resist one or more of the internal forces that are generated by loading. These internal forces include flexure, shear, axial, and torsion (Patil et al., 2012; Deokar, AD and Mathada, 2015). Either decreasing the total quantity of these pressures or raising the member's resistance to them is required to accomplish the task of strengthening the structure. Traditional strengthening methods such as section enlargement, externally bonded reinforcing, post-tensioning, and additional

* Corresponding author: Apurba Rakha

supports may in fact be utilised in order to increase both the structure's strength and its serviceability (Barron, J.M and Hueste, 2004). In order to avoid problems caused by corrosion, recent research has shown that fiber-reinforced polymer, also known as FRP, reinforcement may successfully take the place of steel reinforcement in concrete projects (Shubham et al., 2022). Both the concrete and the steel in reinforced concrete (RC) constructions experience a reduction in their strength as the steel reinforcement corrodes. The strength of a steel reinforcing bar is decreased as a result of corrosion, which also affects the cross-sectional area of the bar. While the steel reinforcing bars are corroding, the integrity of the concrete is being compromised as a consequence of the expansion of the corrosion products, which is causing the concrete cover to split. This is causing the concrete to fail (Shariq et al., 2017; Rautela et al., 2020)).

The primary objective of this study is to describe the procedures and findings conducted by researchers from all over the world on advanced retrofitting techniques, such as reinforced concrete jacketing, steel jacketing, fiber-reinforced polymer composite jacketing, steel bracing system, addition of shear walls, seismic isolation system, and shotcrete method. Another secondary objective of this study is to determine the effectiveness of these advanced retrofitting techniques. This article does not approach the topic of repairing and retrofitting RC buildings in a methodical way in order to provide the reader with a comprehensive grasp of each strategy.

Objectives

The main objectives of this study are:

- To successfully complete structural analysis and design in order to grasp the fundamentals of buildings by following Indian Standard Codes (IS 875:1987)
- To learn the design parameters for beams, columns, slabs, and other structural components.
- Implementing E-TABS software for in-depth analysis and design by constructing a 3D model of the building.

1.1. Data used for the design

1.1.1. Structural Audit

Existing G+3 residential building in Shastri Nagar, Patna is the subject of this study. Buildings were constructed in 1984, and on 22 September 2021 a structural audit was conducted to determine the current strength of the building's weakest components. Based on the architectural drawings (Fig.1), a 3D model based on FEA using ETABS is developed (Fig.2).

1.1.2. Structural Size and Components

Building is located in Patna, it's a residential building G+3 structure, and building is 45 years old. Other essential data given below in Table 1.

1.1.3. Combinations of Load

Table 1 Structural Element Details

Type of structure= RCC Building	**Density of RCC concrete = 25.0 kN/m3**
Zone = III	Unit weight of brick masonry is =20.0 kN/m3
Number of stories = G + 3	Weight of floor finish (FF) = 1.0 kN/m2
Parapet wall =150.00 mm thick including plaster	Live load on floor = 2.0 kN/m2
Wall thickness =230.00 mm thick including plaster	Type of soil = hard soil
Total depth of the slab =150.00 mm	Size of all beams = 230 × 400 mm
Size of all columns = 230 × 450 mm	Layout = as shown in fig 1.

The loading information as applied to the model has been discussed in Table 2.

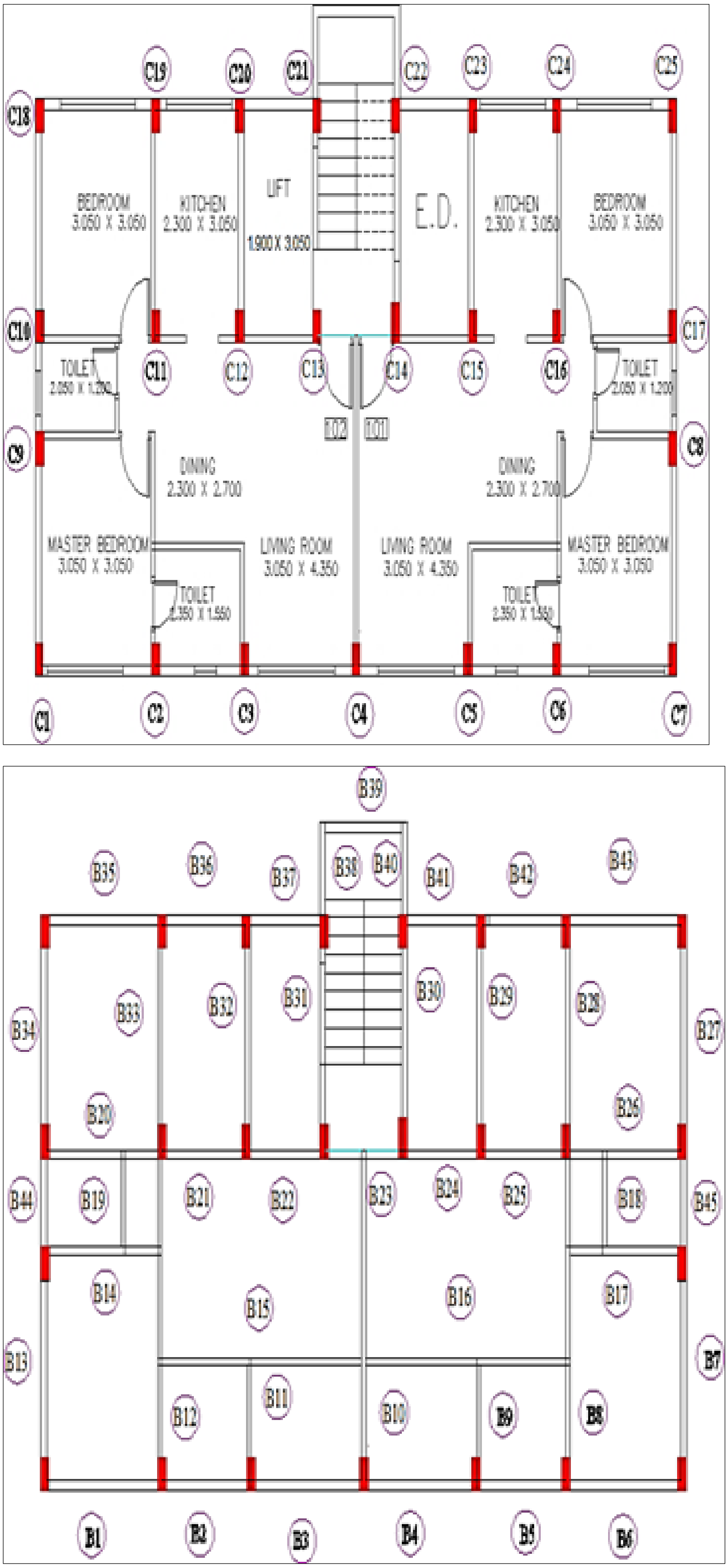


Figure 1 Typical Column Placement & Beam Placement

Table 2 Load Parameters

Name	Type	Self-Weight Multiplier
DEAD	Dead	1.0
SDL	SuperimposediDead	0.0
LL0.5	ReducibleiLive	0.0
LLNR	Live load	0.0
EQX	Seismic load	0.0
EQY	Seismic load	0.0
WINDiX	Wind load	0.0
WINDiY	Wind load	0.0
TEMPERATURE	Others	0.0
PARTITIONiWALL	SuperimposediDead	0.0
FLOORiFINISH	SuperimposediDead	0.0
MEP	SuperimposediDead	0.0
FILL	SuperimposediDead	0.0
ROOFiLL	ReducibleiLive	0.0
LL0.25	ReducibleiLive	0.0

2. Methodology

- **Step I:** We'll be establishing our base of standard codes and country codes.
- **Step II:** Points for the grid are created, and the framework is generated. After ETABS is launched, a new model window opens, into which the grid and story measurements of the structure are input.
- **Step III:** In this case, the material attribute was first established through the "define menu material properties" route. By outlining the exact requirements for our structural components (beams, columns, and slabs), we are able to use new materials. Then, we add the necessary section for beams, columns, etc., and set section size by choosing frame sections.
- **Step IV:** After the property is defined, the structural elements are drawn using the program's menu system. For beams, draw a line for the beam and for columns, make columns in the area for columns to finish the property assignment.
- **Step V:** By maintaining our selection at the foundation and picking each column individually, we were able to assign supports by selecting joint frame Restraints (supports) fixed from the menu.
- **Step VI:** Once the weights have been determined. External walls are given dead loads, but interior walls may simply be assumed to be without any dead weight at all, as seen in the table above.
- **Step VII:** Assigning live loads to the whole building, including the flooring, is a standard practise in construction.
- **Step VIII:** According to IS 875 1987 PART 3, wind loads are classified based on wind speed and wind direction. There is no need to assign wind loads since the building is a G+3 residential building with a height of less than 17 metres.
- **Step IX:** IS 1893: 2002 provides a definition and assignment of seismic loads that includes information on the zone, soil type, and response reduction factor in the X and Y directions.
- **Step X:** By using the Define > Load Combinations command Both the dead load and the live load will be multiplied by 1.5.
- **Step XI:** Once we reached this point, we analysed the data and looked for mistakes.
- **Step XII:** After finishing the study, we developed a concrete design for the building in accordance with IS 456:2000. Every part of the building is designed by ETABS. For the benefit of the user, X and Y coordinates are used to define the grid system, and the grid spacing technique is based on the centerline diagram.

3. Results and discussion

The purpose of this research was to analyze an already-built RC structure and provide a retrofitting strategy in case any of the components break. The G+3 RCC construction of the building is 60 years old. There will be a structural inspection of the building. The audit found that although the footings and slabs were secure, the beams and columns were not. Details of the building's layout and reinforcement plan were laid forth. The current construction strength of the building is calculated in ETABS, and it is found to be unsafe; thus, many approaches are employed to design additional moment jacketing.

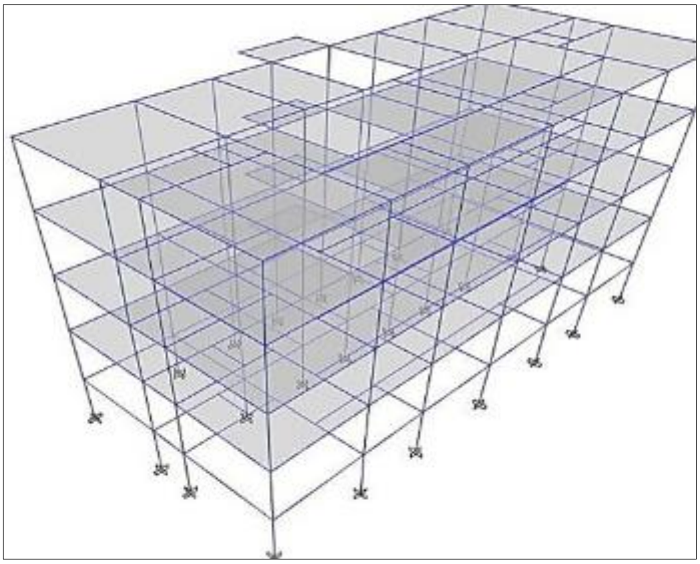


Figure 2 3D view of Building in E-Tabs

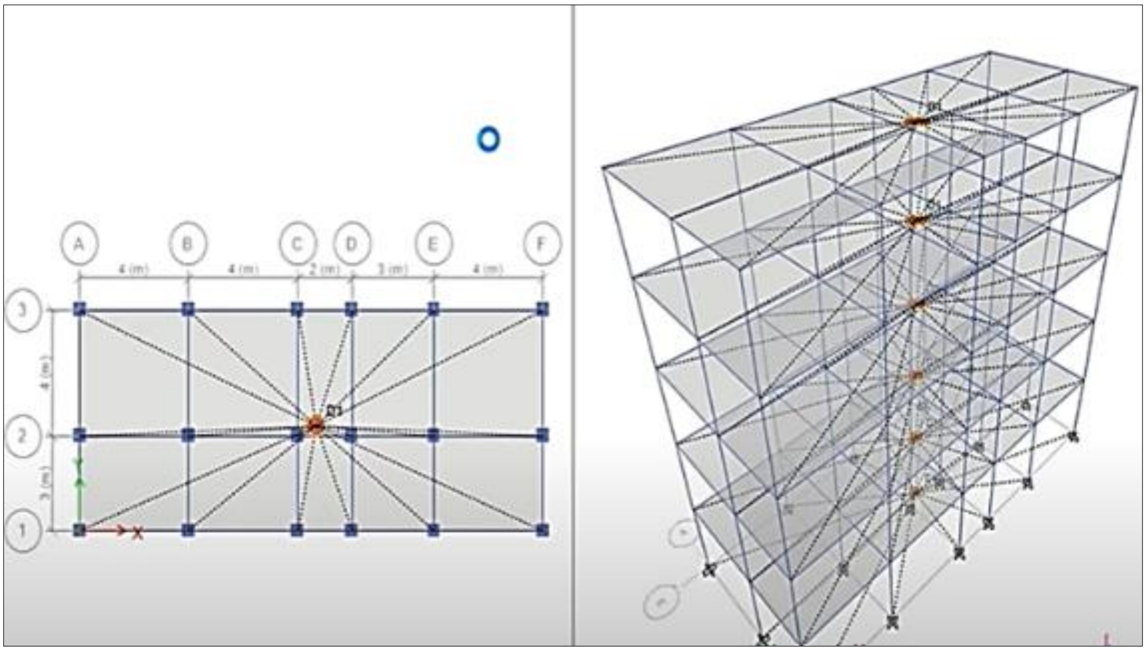


Figure 3 Application of Load

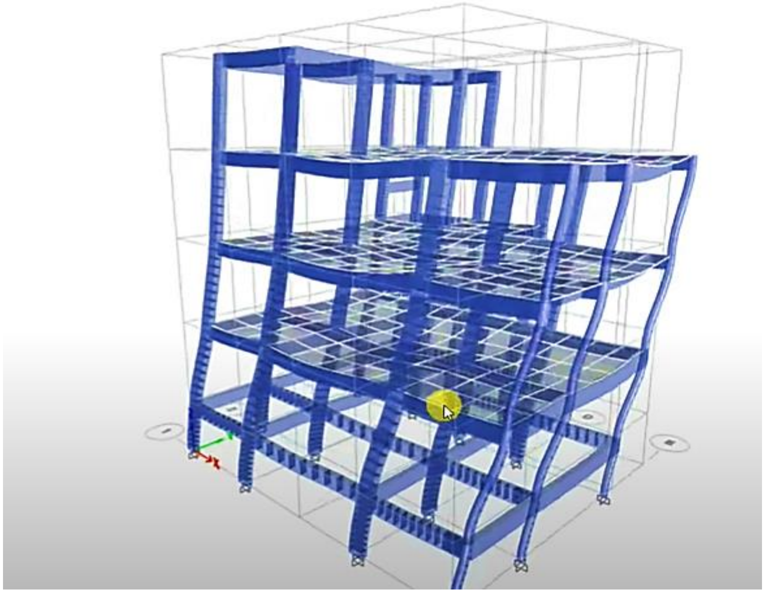
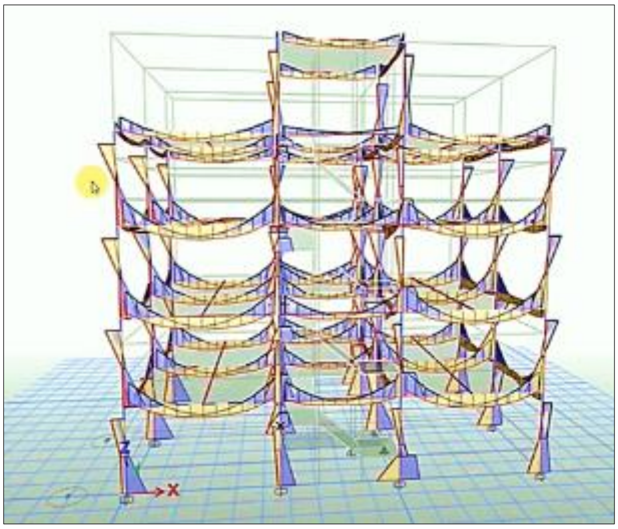


Figure 4 Deflection in the Structure



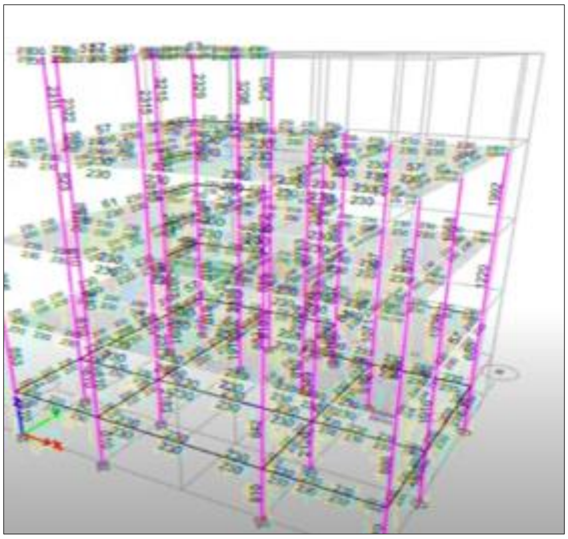


Figure 5 Bending Moment and Shear Force observed in the Structure

Besides its cost-effectiveness, the structure's design—based on E-TABS and the LIMIT STATE METHOD—features sufficient robustness, usability, and longevity. Variation in distance moved, shear force, and bending moment shown. If a beam fails, new beam and column dimensions may be determined, and reinforcing details can be made.

4. Conclusion

After the analysis and design of G+5 multi storey framed structure using STAAD Pro software the following conclusions obtained.

- Proposed size of the beam and column can be safely used in the structure.
- The structure is safe in shear bending and deflection.
- There is no hazardous effect on the structure due to wind and seismic load on the structure.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that there is no conflict of interest.

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