

Seismic Performance Assessment and Ductile Design of a G+2 Hospital Building Using CSI ETABS Software

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Abstract - This study presents the seismic performance assessment and ductile design of a G+2 reinforced concrete hospital building using CSI ETABS software. The structure was modeled as a Special Moment Resisting Frame (SMRF) with shear walls and analyzed under gravity and earthquake loading conditions in accordance with IS 456:2000, IS 875, IS 1893 (Part 1):2016, and IS 13920:2016 provisions. Response Spectrum Analysis was performed to evaluate structural parameters such as storey displacement, storey drift, base shear, and modal behavior. Ductile detailing provisions were incorporated to enhance earthquake resistance and energy dissipation capacity. The results indicate that the building satisfies code requirements and exhibits adequate stability and seismic performance under the considered loading conditions.

Key Words- Etabs , Seismic Analysis , Ductile Detailing , Response Spectrum Method.

1. INTRODUCTION

Earthquakes are among the most destructive natural hazards affecting buildings and infrastructure. Public buildings such as hospitals are classified as essential facilities because they must remain functional during and after seismic events. Therefore, evaluating their structural performance under earthquake loading is of significant importance. Modern structural engineering software such as CSI ETABS enables accurate modeling and analysis of reinforced concrete buildings subjected to seismic forces. Dynamic analysis techniques, particularly Response Spectrum Analysis, help engineers estimate the response of structures under earthquake excitation. Parameters such as storey displacement, storey drift, base shear, and natural period provide valuable information regarding structural safety and performance. The present study focuses on the seismic analysis and ductile design of a G+2 hospital building located in Maharashtra. The building is analyzed according to Indian Standard codes to ensure adequate strength, stability, and earthquake resistance.

2.0 LITERATURE REVIEW

Paulay and Priestley (2003) explained that ductile design plays an important role in improving the earthquake resistance of reinforced concrete structures. According to their study, properly detailed structural members can undergo large deformations during seismic events without

losing their strength, which helps prevent sudden structural failure.

Chopra, A.K. (2015) discussed the dynamic behavior of buildings subjected to earthquake forces. His work provided a detailed explanation of analysis techniques such as Response Spectrum Analysis and Time History Analysis, which are commonly used in structural design software like ETABS for evaluating seismic performance.

Murty, C.V.R. (2016) emphasized that inadequate reinforcement detailing is one of the major reasons for structural damage during earthquakes. He highlighted the importance of following the ductile detailing provisions specified in IS 13920 to improve the seismic performance and safety of reinforced concrete buildings.

G. Guruprasad. (2017) carried out a seismic analysis of G+15 reinforced concrete buildings having different plan configurations such as rectangular, L-shaped, and C-shaped layouts using ETABS software. The study compared parameters including storey drift, storey shear, support reactions, and building modes. The results indicated that the L-shaped building developed higher storey shear compared to the other configurations, while the C-shaped building showed comparatively lower performance under earthquake loading.

Ankitha and Kumar (2018) investigated the seismic behavior of a G+10 storey building using ETABS. Their study focused on parameters such as storey displacement and storey drift. The results demonstrated that ETABS is an effective tool for predicting lateral movement and assisting in the economical design of structural members.

Reddy, K. and Rao, D. (2019) studied the application of ETABS software for the design of reinforced concrete framed structures subjected to seismic loading. Their findings showed that ETABS can efficiently analyze different load combinations and provide reliable design results for beams, columns, and slabs according to Indian Standard codes.

Ramaswami Mallarapu and Tarangini (2022) explored the use of Artificial Neural Networks (ANN) in seismic analysis. Their research showed that ANN techniques can improve the prediction of structural responses, particularly displacements in high-rise buildings. The study suggested that machine learning approaches can be useful for

evaluating seismic performance and supporting safer structural design.

3.0 OBJECTIVE

- 1.To model and analyze a G+2 public hospital building using CSI ETABS software.
- 2.To apply relevant loads such as dead load, live load, and earthquake load as per IS 875 (Part 1 & 2) and IS 1893 (Part 1):2016.
- 3.To perform seismic analysis of the building using Response Spectrum Method as recommended by IS 1893:2016.
- 4.To study the dynamic behavior of the building including storey displacement, storey drift, and base shear.

BRIEF DESCRIPTION OF PROJECT:

- Type of The Project : Seismic Analysis Of Public Building
 Building Type : Public Building
 Location : Boisar , Maharashtra
 Structural Type : Special Moment Resisting Rc Frame Structure
 No. of Storey : G+2
 Floor To Floor Height : 4.2 M
 Types of Slab : One Way / Two Way Slab
 Foundation System : Isolated Footing
 Design Method : Limit State Design
 Concrete Grade : M30
 Steel Grade : Fe550
 Soil Type : Medium Soil
 Bearing Capacity : 200 KN/M2

4.0 METHODOLOGY

1. Data Collection - Architectural and structural data were collected before modeling. The following parameters were considered:

- i) Building type: Hospital building
- ii) Structure type: RC Moment Resisting Frame
- iii) Number of storeys: G+ 2
- iv) Concrete grade: M30
- v) Steel grade: Fe550
- vi) Importance factor: 1.5
- vii) Soil type: Medium soil
- viii) Seismic zone: Zone III

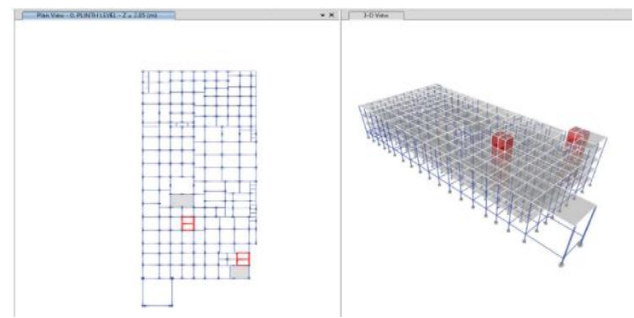


Fig. Model of Building in Etabs

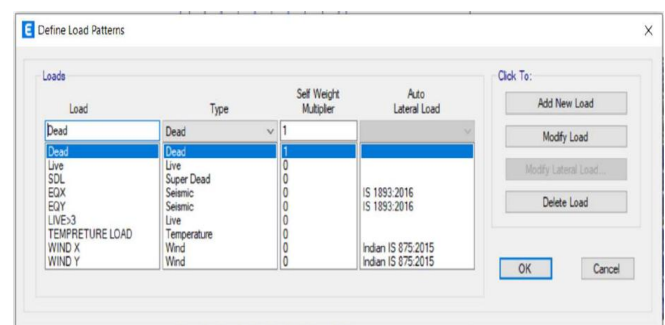


Fig. Load Patterns

2. Software Used - The entire structural analysis and design were carried out using: CSI ETABS Codes Used The design and analysis were performed according to:
 i. IS 456:2000 – Plain and Reinforced Concrete
 ii. IS 875 (Part 1 & 2) – Dead and Live Loads
 iii. IS 1893 (Part 1):2016 – Earthquake Resistant Design

3. IS 13920:2016 – Ductile Detailing Structural Modeling - The building was modeled as a three-dimensional RC frame in ETABS. Beams, columns, slabs, and shear walls were defined with appropriate dimensions and material properties.

4. Structural Components

- i) Beam sizes: 230×530 mm, 300×600 mm, 300×900 mm
- ii) Column sizes: 230×450 mm, 300×600mm,750×750mm
- iii) Slab thickness: 150 mm
- iv) Foundation type: Isolated footing

5. Load Calculation - The following loads were applied:

1) Dead Load, Live Load, Seismic Load

Important seismic parameters:

- i) Zone factor (Z) = 0.16

- ii) Importance factor (I) = 1.5
- iii) Response reduction factor (R) = 5
- iv) Damping ratio = 5%

Base Shear - The calculated base shear in both X and Y directions was:

- I) $V_{bx} = 7869.96 \text{ KN}$
- II) $V_{by} = 7869.96 \text{ KN}$

Base Shear : $V_b = A_h \times W$

$$= 0.06 \times 131166.0307 = 7869.96 \text{ KN.}$$

Design Horizontal Seismic Coefficient :

$$A_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$

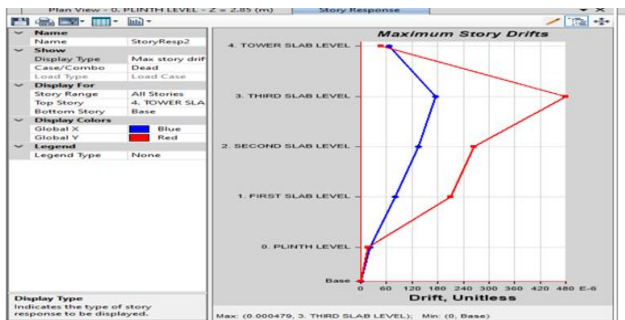
Dynamic Analysis - Response Spectrum Analysis was performed to evaluate

- i) Storey displacement
- ii) Storey drift
- iii) Base shear
- iv) Modal mass participation

CQC modal combination method was adopted for accurate dynamic response estimation.

5.0 ANALYSIS RESULTS

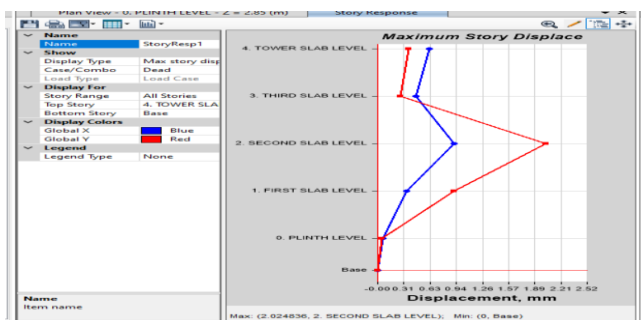
1] Maximum Storey Drift



The Value of Maximum Storey Drift is 0.000479 , Which is within permissible Limit.

2] Maximum Storey Displacement

The Value Of Maximum Storey Displacement Is 2.024836



It Value Also In Within Limit.

The base shear values confirm that the structure can safely resist seismic forces.

Modal Analysis - Modal analysis showed significant mass participation in the first few modes. Some torsional effects were observed, indicating slight eccentricity between the center of mass and center of stiffness.

However, the structure remained within acceptable safety limits.

Ductile Detailing -Ductile detailing provisions according to IS 13920 were incorporated in beam-column joints, ties, anchorage, and reinforcement detailing. These provisions improve energy absorption capacity and reduce the risk of brittle failure during earthquakes.

6.0 CONCLUSION

The seismic analysis and ductile design of the G+2 public hospital building were successfully completed using CSI ETABS software. The structure was analyzed under gravity and earthquake loads according to Indian Standard codes. The analysis results showed that the storey drift and displacement values were within permissible limits. The building has sufficient lateral stiffness and can safely resist seismic forces. The base shear values obtained from the analysis were satisfactory for the selected seismic zone. Ductile detailing improved the overall seismic performance of the structure by increasing energy dissipation capacity and reducing the possibility of brittle failure. Therefore, the designed structure can be considered safe, stable, and earthquake resistant.

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