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Finite Element Analysis of Beam Bending Moments in a Reinforced Concrete Frame

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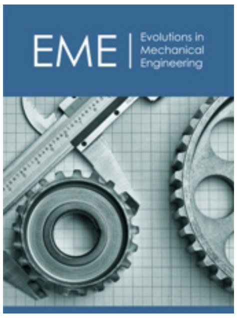

Huu Dien Nguyen*

Department of Technology, Long An University of Economics and Industry, Vietnam

Abstract

This paper presents the finite element analysis of bending moments in reinforced concrete beams of a multi-story building using ETABS software. The methodology includes global structural modeling, load assignment and internal force extraction based on finite element analysis. The bending moment envelopes were obtained for critical beams in the structural frame, serving as the basis for reinforcement design. Results demonstrate that the computed bending moments are within the acceptable range for structural safety and serviceability according to TCVN 5574:2018..

Keywords: Finite element method; Bending moment; Reinforced concrete beam; Structural analysis; TCVN 5574:2018

***Corresponding author:** Huu Dien Nguyen, Department of Technology, Long An University of Economics and Industry, Vietnam

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Introduction

Accurate determination of internal forces is essential for the design of reinforced concrete members. Finite Element Method (FEM) software such as ETABS enables engineers to model complex structures and obtain reliable bending moment distributions under various loading conditions. This study focuses on the FEM-based moment analysis of a reinforced concrete frame, which forms the basis for reinforcement detailing in beams [1-5].

Methodology

The building model was developed in ETABS 19, including beams, columns, slabs and load-bearing walls. Dead loads, live loads, finishing loads, wind loads and seismic loads were applied according to Vietnamese standards. FEM analysis was conducted to compute internal forces [6-10].

A. Beam frame under study: Axis 2 frame of the Gia Định 2 building.

B. Analysis output: Bending moment envelopes at mid-span and supports of beams B116-B122 across different stories.

C. Design standard: TCVN 5574:2018 for reinforced concrete structures.

Results and Discussion

Moment distribution

The bending moment envelopes extracted from ETABS are illustrated in Figures 1 & 2. Negative support moments and positive span moments were clearly identified, reflecting the flexural behavior of continuous beams under gravity and lateral loads [11-15].

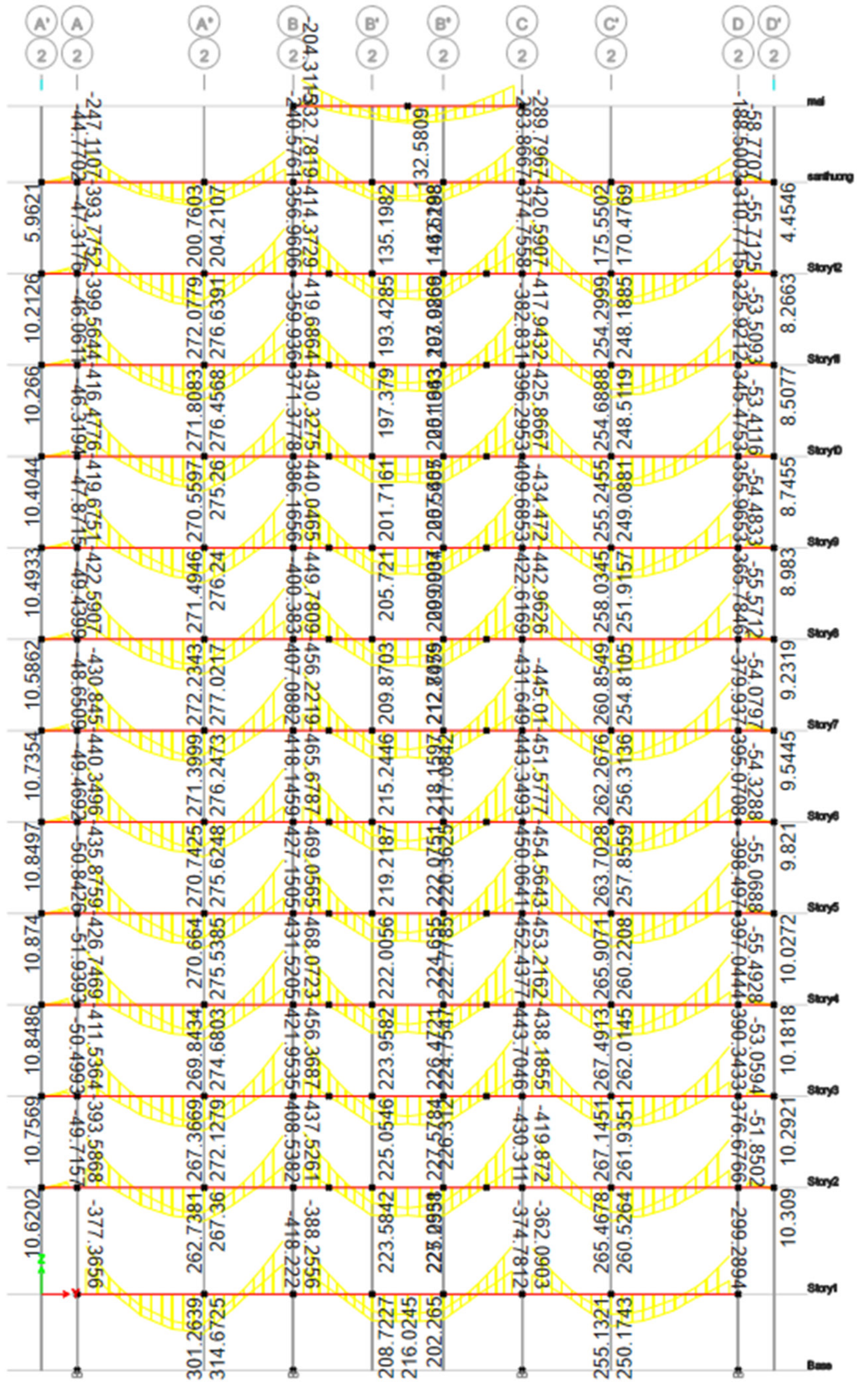

Figure 1: Moment envelope diagram of the frame beam at axis 2 (kNm).

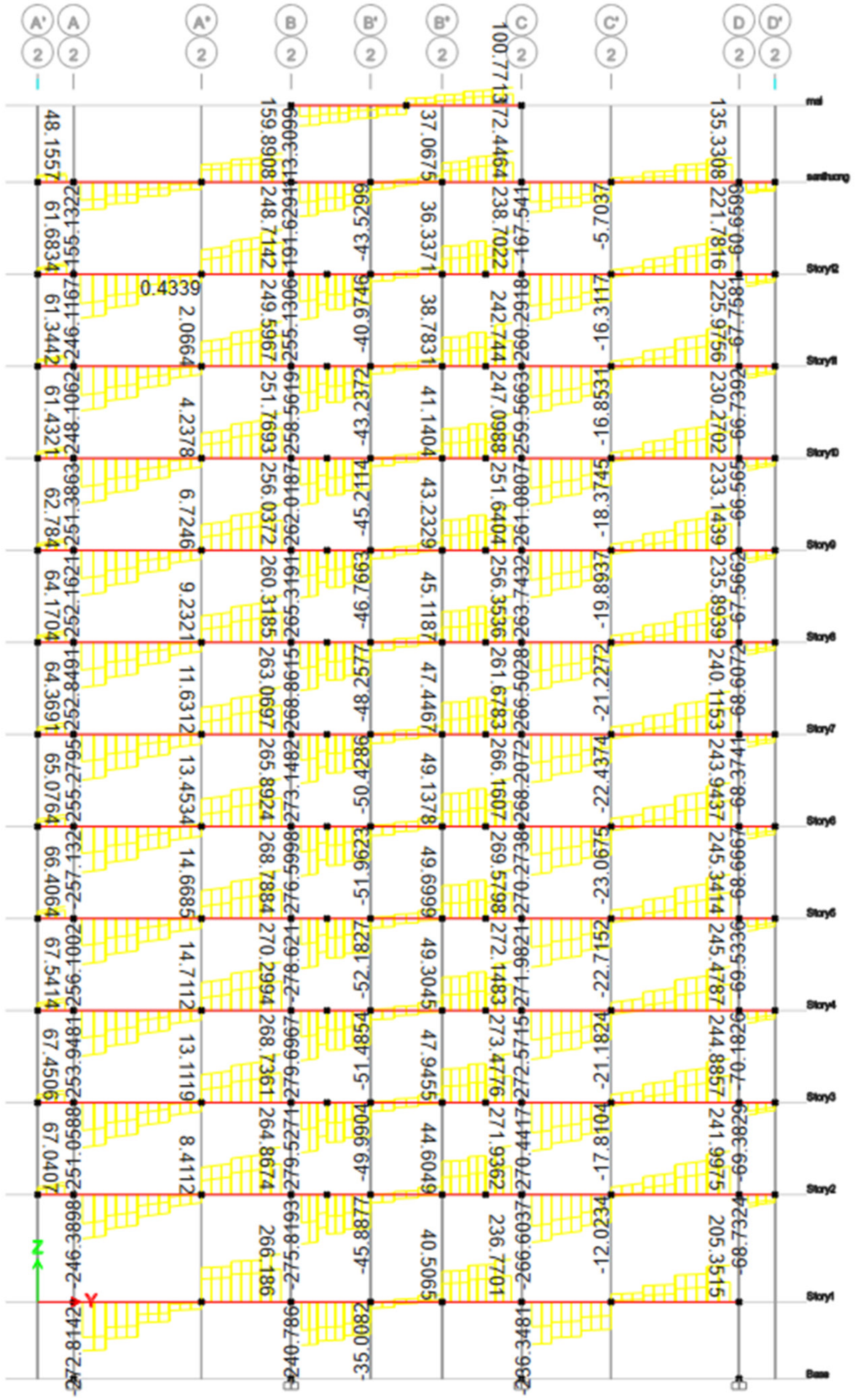

Figure 2: Bending moment envelope for the beam on axis 2 (kNm).

Example (Story 1, Beam B116-B117):

a) Support moment: –299.29kNm

b) Span moment: +255.13kNm

Example (Story 2, Beam B118-B120):

A. Support moment: –430.31kNm

B. Span moment: +227.09kNm

These values indicate that beams are primarily subjected to flexure, confirming their function as bending-dominated members [16-20].

Structural implications

The calculated bending moments were used to design longitudinal reinforcement. Comparison with code-based design resistance confirmed that all beams satisfy the strength requirements. The FEM moment distribution also ensures rational detailing, with higher reinforcement demands at supports where negative moments are critical [21-34].

Conclusion

Finite element analysis using ETABS provides reliable bending moment distributions for reinforced concrete beams in multi-story frames. The results confirmed that the beams satisfy both strength and serviceability criteria under the applied loading conditions. The FEM-based approach is essential for accurate reinforcement design and can be extended to nonlinear and dynamic analyses in future studies.

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