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A Study on FNA Method Calibration for Wind-Resistant High-Rise Building

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ABSTRACT

This paper proposes a novel approach to enhance the efficiency and accuracy of nonlinear analysis for wind-resistant design of high-rise buildings by calibrating the Fast Nonlinear Analysis (FNA) with the Direct Integration Method (DIM). Elastic design methods dominate wind-resistant design but have limitations, such as overdesigning horizontal members, which delays yielding compared to vertical members and reduces energy dissipation and ductility. To address these issues, recent performance-based wind designs are allowing nonlinear behavior in specific members, with several studies (Jeong et al., 2021, Ahn et al., 2022) focusing on nonlinear analysis for practical wind design. DIM provides high accuracy in time history wind analysis by considering P-Delta effects but requires a significant amount of analysis time. Conversely, FNA is faster but less accurate due to not considering P-Delta effects. This study aims to improve nonlinear analysis efficiency by aligning FNA results with DIM, achieving accurate results with shorter analysis times. Research using a 50-story modeled building, as shown in Fig. 1, was conducted in key steps: first, damping effects and P-Delta setting methods were investigated through linear analysis, showing that combined damping and setting P-Delta effect for preliminary load made DIM and FNA results nearly identical. Nonlinear analysis then revealed displacement differences related to hinge behavior, attributed to energy dissipation from hysteresis loops. To resolve these differences, a calibration process was carried out using SDOF model transformation, genetic algorithms, and P-Delta effects. The Newmark method algorithm with the Bouc-Wen model applied hinge behavior, and genetic algorithms extracted parameters. Displacements from FNA were converted into SDOF model displacements, and considering P-Delta effects, the results were calibrated to match DIM closely. The study confirmed that considering hinge behavior and P-Delta effects allows FNA displacements to align closely with DIM (Fig. 2). Thus, this paper presents a comprehensive methodology to enhance nonlinear wind-resistant design analysis efficiency by calibrating FNA to DIM, offering a practical solution for balancing analysis speed and accuracy.

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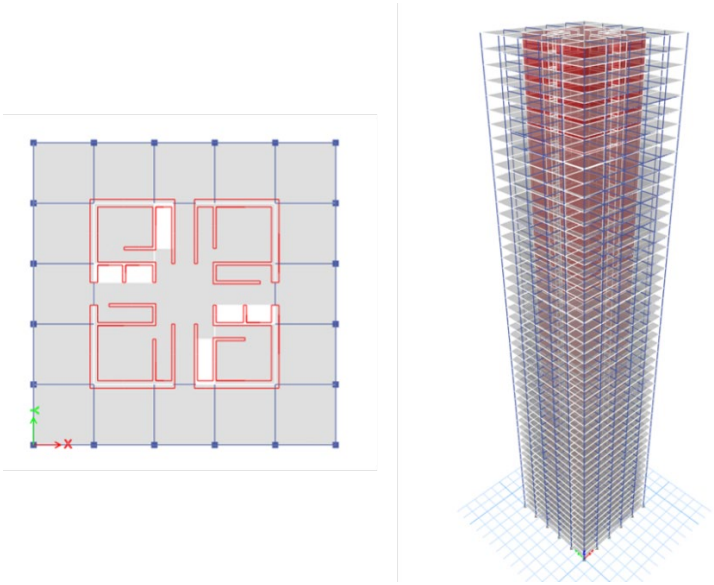

Fig. 1 Fifty-story nonlinear analysis model and its plan

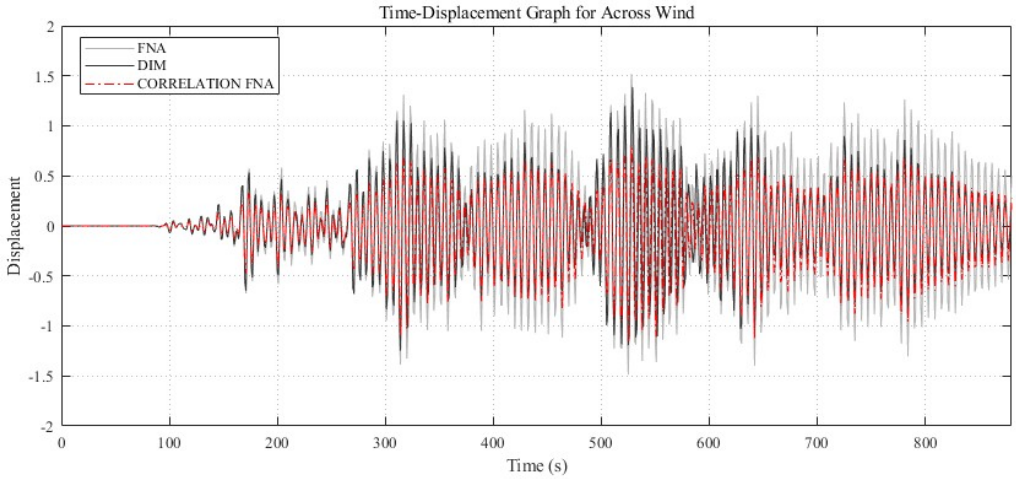

Fig. 2 Calibrated results

REFERENCES

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