

SEISMIC RESPONSE OF TALL REINFORCED-CONCRETE STRUCTURES

A THESIS

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by

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CANDIDATE'S DECLARATION

INDIAN INSTITUTE OF TECHNOLOGY ROORKEE

I hereby certify that the work which is being presented in the thesis entitled “Seismic Response of Tall Reinforced-Concrete Structures” in partial fulfilment of the requirements for the award of the Degree of Doctor of Philosophy and submitted in the Department of Earthquake Engineering of the Indian Institute of Technology Roorkee is an authentic record of my own work carried out during a period from July 2021 to June 2026 under the supervision of Prof. Rakesh Bhandari, Department of Earthquake Engineering, Indian Institute of Technology Roorkee, Roorkee.

The matter presented in the thesis has not been submitted by me for the award of any other degree of this or any other Institution.

(Ananya Rawat)

This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

(Prof. Rakesh Bhandari)

Supervisor

Date: _____

ABSTRACT

Tall reinforced-concrete buildings in seismically active regions of the Himalayan foothills must resist long-duration ground motions whose frequency content can excite higher vibration modes. Code-based design relies on equivalent static forces and response spectra calibrated mostly on shorter buildings. This thesis evaluates how well those procedures predict the demands on tall core-wall buildings. It develops nonlinear finite-element models of three buildings of 20, 30 and 40 storeys, subjects them to a suite of 22 recorded and simulated ground motions, and compares the resulting storey drifts and wall shear forces with code estimates. The response-spectrum method underestimates the shear force at the base of the core wall by 25% to 55%, with the error growing with height because of higher-mode contributions. A modified modal combination is proposed that brings the estimate within 12% of the nonlinear results.

Keywords: tall buildings, reinforced-concrete core walls, nonlinear dynamic analysis, higher modes, response spectrum

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Chapter 1

Introduction

Tall buildings are rising quickly in Indian cities that lie in high seismic zones. Their seismic design relies on procedures developed largely for low- and mid-rise structures (Bureau of Indian Standards, 2016). For tall, flexible buildings, higher vibration modes contribute substantially to internal forces, and simplified procedures can underestimate them (Chopra, 2012).

Chapter 2

Background

In the response-spectrum method, peak modal responses r_n are combined by the square root of the sum of squares,

$$r \approx \left(\sum_{n=1}^N r_n^2 \right)^{1/2}, \quad (2.1)$$

which assumes well-separated modal frequencies and elastic behaviour. When the base of a core wall yields in flexure, the first-mode response is capped while higher-mode shears continue to grow, a mechanism documented for cantilever walls by Priestley (2003).

Chapter 3

Nonlinear Models and Ground Motions

Each building was modelled with fibre elements for the core walls and lumped plasticity for the coupling beams. Ground motions were selected and scaled to match the design spectrum for the region over the period range of interest.

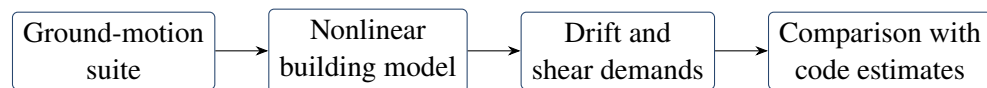


Figure 3.1: Analysis workflow.

Chapter 4

Results

Table 4.1 compares the base shear of the core wall from nonlinear analysis with the response-spectrum estimate.

Table 4.1: Core-wall base shear: nonlinear median versus response-spectrum estimate.

Building	Nonlinear (MN)	Code estimate (MN)	Underestimate (%)
20 storeys	18.6	14.0	25
30 storeys	27.9	17.3	38
40 storeys	39.4	17.7	55

Chapter 5

Conclusion

For tall core-wall buildings, code procedures underestimate base shear, increasingly so with height. Amplifying the higher-mode contributions in the modal combination corrects most of the gap; its adoption would need calibration across more building configurations.

Appendix A

Ground-Motion Records

Fourteen recorded and eight simulated records were used, with moment magnitudes between 6.5 and 7.8 and rupture distances between 10 and 80 km.

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