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Seismic Response of Reinforced Concrete Buildings: Field Challenges and Simplified Code Formulas

Authors : Michel Soto Chalhoub

Abstract : Building code-related literature provides recommendations on normalizing approaches to the calculation of the dynamic properties of structures. Most building codes make a distinction among types of structural systems, construction material, and configuration through a numerical coefficient in the expression for the fundamental period. The period is then used in normalized response spectra to compute base shear. The typical parameter used in simplified code formulas for the fundamental period is overall building height raised to a power determined from analytical and experimental results. However, reinforced concrete buildings which constitute the majority of built space in less developed countries pose additional challenges to the ones built with homogeneous material such as steel, or with concrete under stricter quality control. In the present paper, the particularities of reinforced concrete buildings are explored and related to current methods of equivalent static analysis. A comparative study is presented between the Uniform Building Code, commonly used for buildings within and outside the USA, and data from the Middle East used to model 151 reinforced concrete buildings of varying number of bays, number of floors, overall building height, and individual story height. The fundamental period was calculated using eigenvalue matrix computation. The results were also used in a separate regression analysis where the computed period serves as dependent variable, while five building properties serve as independent variables. The statistical analysis shed light on important parameters that simplified code formulas need to account for including individual story height, overall building height, floor plan, number of bays, and concrete properties. Such inclusions are important for reinforced concrete buildings of special conditions due to the level of concrete damage, aging, or materials quality control during construction. Overall results of the present analysis show that simplified code formulas for fundamental period and base shear may be applied but they require revisions to account for multiple parameters. The conclusion above is confirmed by the analytical model where fundamental periods were computed using numerical techniques and eigenvalue solutions. This recommendation is particularly relevant to code upgrades in less developed countries where it is customary to adopt, and mildly adapt international codes. We also note the necessity of further research using empirical data from buildings in Lebanon that were subjected to severe damage due to impulse loading or accelerated aging. However, we excluded this study from the present paper and left it for future research as it has its own peculiarities and requires a different type of analysis.

Keywords : seismic behaviour, reinforced concrete, simplified code formulas, equivalent static analysis, base shear, response spectra
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