Towards a New Seismic Risk Screening Methodology for Non-Structural Components of Existing Buildings in Canada

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ABSTRACT

A methodology for seismic risk screening of non-structural components of existing buildings has been developed as part of a new Semi-Quantitative Seismic Risk Screening Tool (SQST). The methodology incorporates a simple but comprehensive seismic risk scoring system that qualitatively assesses seismic adequacy of non-structural components. Global seismic risk scores for the most critical non-structural components in existing buildings are compared with threshold scores for different consequences of failure. The seismic risk scores correspond to the sum of basic scores and a series of score modifiers accounting for key parameters amplifying or reducing the seismic response of non-structural components. The scoring system reflects the expected seismic risk for different seismic zones, i.e. acceptable seismic risk in Very Low and Low seismic zones and unacceptable seismic risk in High and Very High seismic zones. Seismic screening of existing buildings located in different seismic zones in Canada demonstrated the applicability of the non-structural seismic risk scoring system.

Keywords: Non-Structural Components, Seismic Risk Screening, Existing Buildings, Screening Methodology, Seismic Risk Scoring.

INTRODUCTION

Purpose

The objective of the proposed methodology is to ensure acceptable and consistent seismic risk of non-structural components with the focus on minimizing threats to life safety of occupants of existing buildings. The proposed seismic risk screening methodology can also be utilized for prioritizing existing buildings within a large portfolio for further detailed seismic evaluation of their non-structural components. The methodology aims to supersede the non-structural screening methodology in the 1993 NRC Manual for Screening of Buildings for Seismic Investigation [1].

Target Non-Structural Components

The scoring system for non-structural components aims to determine global scores based on the most critical non-structural components within existing buildings. In addition, it can be used to determine the seismic risk of specific non-structural components or group of non-structural component categories (i.e., architectural, mechanical and electrical, and others systems).

Basis of Seismic Risk Scoring

Seismic risk scoring of non-structural components is based on the seismic design force prescribed in the 2015 edition of the National Building Code of Canada (NBC) [2]. Based on the sequence of changes in seismic design requirements in the editions of the NBC since 1941, four design periods are identified for seismic risk screening of non-structural components: 1) Pre-1953 (NBC 1941 and before), 2) 1953-1975 (NBC 1953 to NBC 1970), 3) 1975-2005 (NBC 1975 to NBC 1995), and 4) Post-2005 (NBC 2005 to NBC 2015).

METHODOLOGY

The methodology for seismic risk screening of non-structural components incorporates a comprehensive seismic risk scoring system that qualitatively assesses the seismic risk of non-structural components that are permanently attached to structures, including their supports and attachments. It is based on prescribed and qualitative parameters that reflect the effect of amplified seismic demands on the seismic response of non-structural components, rather than their probability of collapse or damage. Global non-structural scores are determined for the most critical non-structural components in existing buildings, which are compared with corresponding threshold scores determined for maximum vulnerability and consequence of failure of the

components for a threshold seismic intensity (i.e., intensity VI in the Modified Mercalli Intensity scale – MMI VI). Additional details of the methodology and its application for seismic screening of non-structural components can be found elsewhere [3].

Non-Structural Seismic Risk Scoring

Scoring of non-structural components is performed with Non-Structural Scores, *NS*, which are dimensionless scores that combine Non-Structural Basic Scores, NS_B, with a series of Non-Structural Score modifiers, NM_i, accounting for the different parameters that can potentially affect the seismic risk of non-structural components. NS_B are calculated from the seismic coefficient of a reference non-structural component, while NM_i are determined by varying different structural and non-structural behavioural parameters. The Non-Structural Scores are compared with acceptable Non-Structural Score Thresholds, NS_{TH}, to determine the need of detailed non-structural seismic evaluation.

The Non-Structural Basic Scores, NS_B, were developed based on the seismic coefficients from the design seismic force equation in the NBC 2015. They range from 40 to 80 for proposed six Canadian seismic zones (i.e. Very Low, Low, Medium, Moderately High, High, and Very High) [3].

The Non-Structural Score modifiers were calculated as a logarithmic function of factors affecting the seismic demand for the following parameters: site class, structural response (building type, building irregularities, pounding, and deterioration and age), nonstructural component response, non-structural design code year, and remaining occupancy.

The acceptable Non-structural Score Thresholds, NS_{TH}, were determined for consequences of failure associated with consequence classes and subclasses proposed by Fathi-Fazl and Lounis [4] (i.e., Very Low, Low, Medium, High, and Very High). Basic Thresholds correspond to the least possible non-structural score for Low seismic zone. The thresholds are in line with the seismic risk acceptance criteria defined by Fathi-Fazl et al. [5] for preliminary seismic risk screening.

Example of seismic risk screening

Seventeen (17) existing buildings consisting of 33 sections, towers, or wings were screened as a pilot study using the proposed non-structural seismic risk screening methodology. The calculated *NS* values ranged from 31 to 68. Lower values of *NS* correspond to higher seismic risk, while higher values of *NS* correspond to lower seismic risk.

SUMMARY AND CONCLUSIONS

A new methodology has been proposed for seismic risk screening of non-structural components of existing buildings in Canada. The methodology utilizes a scoring system to qualitatively determine global non-structural seismic risk based on seismic demand and consequence of failure. It consists of basic scores and a number of score modifiers accounting for different structural and non-structural parameters that can potentially affect seismic response of non-structural components. The resulting non-structural scores are compared with corresponding score thresholds to determine the need of further detailed non-structural seismic evaluation. The scoring system is consistent with passing criteria based on seismic intensity as demonstrated by the seismic screening of non-structural components in 17 buildings located in different areas across Canada.

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