Overview of a New Structural Seismic Risk Scoring Methodology for Existing Buildings in Canada

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ABSTRACT

This paper summarizes the structural seismic risk scoring methodology that is part of a newly developed Semi-Quantitative Seismic Risk Screening Tool for identifying and prioritizing existing buildings with potential unacceptable seismic risk for further detailed seismic evaluation. The methodology determines the structural seismic risk by quantitatively evaluating the probability of building collapse and identifying the consequences of building failure to life safety. A structural score is calculated based on the probability of building collapse and then compared with a structural threshold that is a function of consequence of building failure. The aim is to determine if the building is tagged for further detailed structural seismic evaluation. The methodology was used to screen the seismic risk of existing buildings located in different regions of Canada. The results demonstrated the applicability of the structural seismic risk scoring methodology.

Keywords: seismic risk screening, scoring methodology, probability of collapse, consequence of failure, existing buildings.

INTRODUCTION

In 1993, The National Research Council Canada (NRC) published the Manual for Screening of Buildings for Seismic Investigation [1]. This manual presented a scoring methodology that is qualitative and based on seismic demand. The main purpose of the methodology is to identify and prioritize existing buildings for further detailed seismic evaluation. The methodology, however cannot be used for exemption purpose, given its qualitative nature. In the last two decades, new seismic screening methodologies have emerged in North America. FEMA 154 handbook entitled "Rapid Visual Screening of Buildings for Potential Seismic Hazards" [2-3] updated its structural scoring system by adopting the HAZUS earthquake loss estimation methodology [4]. FEMA 154, however, cannot be directly used to evaluate the seismic risk of existing buildings in Canada due to the differences in seismicity and building seismic design practices in the U.S. and Canada. Some researchers have adapted existing methodologies to quantitatively assess the seismic risk of existing buildings in Canada [5-7]. However, these methodologies were developed for specific regions or provinces and thus cannot be used nationwide. In addition, some of these methodologies were applied only to school buildings, which further limits their applications. Saatcioglu *et al.* [8] updated the NRC screening manual in 2013, however, the methodology is still qualitative.

Given the need to have a new methodology for quantitatively assess the seismic risk of existing buildings across the country, Public Service and Procurement of Canada (PSPC) founded the NRC to develop a Semi-Quantitative Seismic Risk Screening Tool (SQST) [9]. The new screening tool consists of a quantitative structural seismic risk scoring system and a qualitative seismic risk scoring system for non-structural components in existing buildings. Structural scores and non-structural components scores are calculated separately and compared with corresponding structural and non-structural component thresholds to determine whether the seismic risk of buildings is unacceptable, thus triggering detailed seismic evaluation. A general review of the structural seismic risk scoring methodology of the SQST is presented herein. The methodology for seismic risk screening of non-structural components is presented in a companion paper [10].

STRUCTURAL SEISMIC RISK SCORING METHODOLOGY

The structural seismic risk scoring methodology is largely based on the HAZUS earthquake loss estimation methodology. However, it has been customized to suit Canadian building seismic design practices, specifically for three key parameters: (1) building code edition, (2) seismic design factors and coefficients, and (3) level of seismicity. In addition, the methodology incorporates a number of new features:

1. Additional building attributes, including (1) building importance, (2) building deterioration and age, and (3) remaining occupancy time;

2. Consequence classes that were defined to describe the consequences of failure of existing buildings [11]; and
3. A set of structural thresholds corresponding to different consequence classes.

The methodology quantitatively evaluates the probability of failure of existing buildings based on generic building capacity and fragility curves for different building types. Furthermore, a consequence classification system, proposed by Fathi-Fazl and Lounis [11], was adopted to identify the consequence classes of existing buildings. A structural score that is defined as the negative common logarithmic of the probability of collapse of the building being screened is compared with a specified structural threshold that corresponds to the consequence class of the building associated with an acceptable probability of collapse. By comparing the structural score with the corresponding threshold, the need of detailed structural seismic evaluation is determined. More details of the methodology can be found elsewhere [9].

EXAMPLE OF SEISMIC RISK SCREENING

The methodology was implemented to screen the seismic risk of seventeen (17) existing buildings. Different sections of the buildings were screened separately with the consideration of potential pounding hazards. The structural scores varied from 0.4 to 4.6, which correspond to probability of collapse of 39.81% and 0.0025%, respectively. More details of the example are provided elsewhere [9].

SUMMARY AND CONCLUSIONS

This papers presents a summary of the structural seismic risk scoring methodology developed by the National Research Council Canada. The methodology is based on loss estimate methodology developed by HAZUS. It has been customized to suit the Canadian seismicity and seismic design practices. A number of new features were added to the methodology. These features include: (1) additional building attributes, (2) consequence classes, and (3) structural thresholds for different consequence classes. A structural score is determined by quantitatively calculating the probability of collapse of the building being screened. The structural score is compared with a structural threshold that corresponds to the consequence of failure of the building to determine if the building requires further detailed structural seismic evaluation. Implementation of the methodology to seismic risk screening of seventeen existing buildings demonstrated the applicability of the methodology.

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