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Reliability Index of Tall Buildings in Earthquake Zones

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ABSTRACT

The paper develops a reliability index approach to assess the reliability of tall buildings subjected to earthquake loading. The reliability index β model measures the level of reliability of tall buildings in earthquake zones based on their response to earthquake loading and according to their design code. The reliability index model is flexible and can be used for: 1) all types of concrete and steel buildings and 2) all local and international codes of design. Each design code has its unique reliability index β as a magnitude and the interaction chart corresponding to it. The interaction chart is a very useful tool in determining the building drift for the desired level of reliability during the preliminary design of the building members. The assessments obtained using the reliability index approach of simulated, tested, and actual buildings in earthquake zones were acceptable as indicators of the buildings reliability.

Keywords: Reliability Index; Earthquake; Interaction Chart

1. Introduction

The lateral displacement or drift of structural systems during an earthquake has an important impact on their potential failure. The probability of failure of structures is therefore reduced by limiting their lateral displacements or drifts. The reliability index β, which is typically used to measure the probability of failure of structural systems, allows structures to reach the desired reliability level through the assessment of the likelihood that their earthquake responses exceed predefined building drift values (roof displacement). The reliability index approach made it possible for the reduction of the probability of failure of building structures [1-6].

Drift limitations are currently imposed by seismic design codes, such as Uniform building Code (UBC) and International Building Code (IBC), in order to design safe buildings [7,8]. The acceptable range for the drift index of conventional structures lies between the values of 0.002 and 0.005 (that is approximately $\frac{1}{500}$ to $\frac{1}{200}$). Excessive lateral displacements or drifts can cause failure in both structural and non-structural elements. Therefore, drifts at the final structural design stages must satisfy the desired reliability level and must not exceed the specified index limits [9-13]. While extensive research has been done in this important topic, no or limited studies addressed the use of reliability index to assess the building reliability in earthquake zones based on their lateral displacement and drift.

This paper develops a probabilistic model using the reliability index approach to assess the reliability of concrete and steel buildings subjected to earthquake loading in different zones and soil profiles based on their responses to earthquake loading, **Table 1**. The non-linear dynamic response of buildings was obtained using three simulated models of buildings, square, circular, and tube with different heights, **Figures 1-4**.

Other real buildings such as the full scale seven story reinforced concrete building that was tested statically and dynamically in Japan conducted under the US-Japan Cooperative Earthquake Engineering Research Program on the seismic performance of the building structure **Figure 5** [14].

Table 1. Soil profile and seismic factors.

Soil type (S)	Seismic factors (Z)
Hard Rock (S1)	0.075 gravitational acceleration (Z1)
Rock (S2)	0.150 gravitational acceleration (Z2)
Very dense soil and soft rock (S3)	0.20 gravitational acceleration (Z3)
Stiff soil (S4)	0.30 gravitational acceleration (Z4)
Soft soil (S5)	0.40 gravitational acceleration (Z5)