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Calculation of seismic vulnerability index for steel structures

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Abstract

Seismic vulnerability analysis of steel structures requires some basic information on their mechanical and structural properties. The present study aims to quantify the seismic vulnerability of steel structures, through the use of the needed information. The first step to do so is the identification of the main parameters that play an important role in the seismic vulnerability of such structures. Then using seismic feedback experience, weighting coefficients of each parameter are determined. An expression of a vulnerability index is given and based on the obtained value a building under study is classified as safe or unsafe according a proposed classification.
A vulnerability index program (VIP) is developed in order to classify steel structures. This program is used to study several examples. The results are satisfactory comparing with in situ observations

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Keywords: Seismic vulnerability; Steel structures; Vulnerability index; Seismic parameters

1. Introduction

Steel structures offer an advantage against the seismic stress due their lightness and ductility. Despite these characteristics steel structures can suffer significant damage after an earthquake [1,2].

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The assessment of the seismic vulnerability of steel structures has been the subject of several studies HAZUS, RISK-UE, and RADIUS. Where vulnerability curves have been established using vulnerability index [3,4,5].This index is calculated based of some parameters having an influence on the seismic behaviour of steel constructions and allowing description of seismic quality of such constructions [6].

These studies do not consider all influencing parameters, so in order to improve the existing index and to quantify more accurately the seismic behavior of such structure a vulnerability index method is developed [7,8,9,10].

Nomenclature

R	behaviour factor
Ki	weighting factor Ki
VI	vulnerability index

2. Vulnerability index method

The parameters that have a significant influence on the seismic vulnerability of steel frame structures are given here after.

2.1. Selected parameters:

These parameters are determined based on post-seismic observations and seismic experience feedback. The parameters taken into account are:

1- Ductility 5- Type of soils 9- Modifications 13- Roof
2- Bearing capacity 6- Floor 10- Elevation regularity 14- Details
3- Assemblage 7- Buckling 11- Pounding effect
4- General maintenance conditions 8- Plan regularity 12- Ground conditions

Among these parameters, Ductility, Bearing capacity and Buckling need calculation, the others parameters are related to the in situ observation. In this paper, only Ductility is presented because it is an important and complex parameter.

- Ductility : under a strong earthquake, steel frame structures undergo plastic deformations, due to their faculty of dissipation of energy. Indeed, they have the ability to resist greater strain than the design one.

  To take into account these plastic deformations, the seismic codes consider a reducing factor called “Behavior Factor” defined by the coefficient ‘R’ according to the Algerian seismic code (RPA 99 version 2003). The R values are given in table 1.

Table 1.Ductility according the behavior factor ‘R’ for steel frame structures.

Ductility level	Value of "R"
High Ductility: Class A	[6 – 4 [
Average Ductility: Class B	[4 - 2 [
Low Ductility: Class C	≤ 2

2.2. Parameters quantification:

Weighting factors for each parameter are proposed on table 2. These factors are determined on a basis of a statistical data containing more than 300 constructions damaged by different earthquakes (Ain Temouchent (1999) and Boumerdes (2003)). The considered parameter can take only one factor. For each parameter and each considered class, a coefficient (ki) is identified expressing its seismic quality.