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Seismic behavior of 1960's RC buildings exposed to marine environment

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ABSTRACT

Steel rebars corrosion is one of the most important problems of reinforced concrete (RC) structures. The mechanical performance loss of RC elements because of steel corrosion can be aggravated under horizontal loads (e.g. wind pressure or seismic actions). This paper presents a methodology for the study of the seismic behavior of a residential typology of the Mediterranean coast, which was widely spread during the 1960's. These RC frame structures are usually 10 to 15 stories high, located very close to the coast and are exempt buildings, which made them specially exposed to chloride corrosion. Besides, there are some design conditions that should be taken into account: (i) these structures were designed only under gravity loads, especially seismic actions were not considered. (ii) The raw materials had lower quality than those considered in current design codes, e.g. structural concrete strength was around 15 MPa, and made with natural beach sand as fine aggregates (hence including chlorides into the concrete mass). Therefore, two important aspects converge in these buildings, fifty years of marine exposure (i.e. degradation by corrosion) and the omission of the seismic loads in the original design, making them especially vulnerable to earthquakes (in an area with a moderate-high seismicity). Hence, a methodology for the seismic analysis of the corroded structure is proposed, in order to determine the structural safety factor of this type of structures, and evaluate the effectiveness of a retrofitting if necessary.

1. Introduction

The great explosion of tourism in the Valencian coast at the end of the 1950's, caused the urbanization of a great area of the littoral. This urban development prioritized the views and proximity to the sea. Therefore, the architectural design tried to optimize the orientation and views limiting the closed areas, hence large perimeter cantilevered balconies were a basic feature as solariums. The rationalist architect Juan Guardiola-Gaya was one of the main protagonists of this architecture in the early 1960's. He is responsible for the current architectural image of the Costa Blanca from Alicante to Benidorm. Fig. 1a includes some examples of this building typology, like the development of Albufereta Beach or the Vistamar tower (inspired by the Pirelli Tower in Milan by Pier Luigi Nervi). All these buildings have a common set of characteristics: compact and regular plans, façades facing the sea with large balconies supported by cantilever beams, reinforced concrete (RC) frame structures with flat beams, and direct marine spray exposure. Besides, this area of Spain presents a medium to high seismic activity according to current design codes [1]. The recent earthquake that heavily affected the city of Lorca in 2011 is an example, in which peak ground accelerations up to 0.36 g were recorded [2]. As a summary, these constructions present some common aspects that highly increase their seismic vulnerability: (i) All buildings are inhabited and the economic value of these apartments is higher than other neighborhoods. (ii) The original structure

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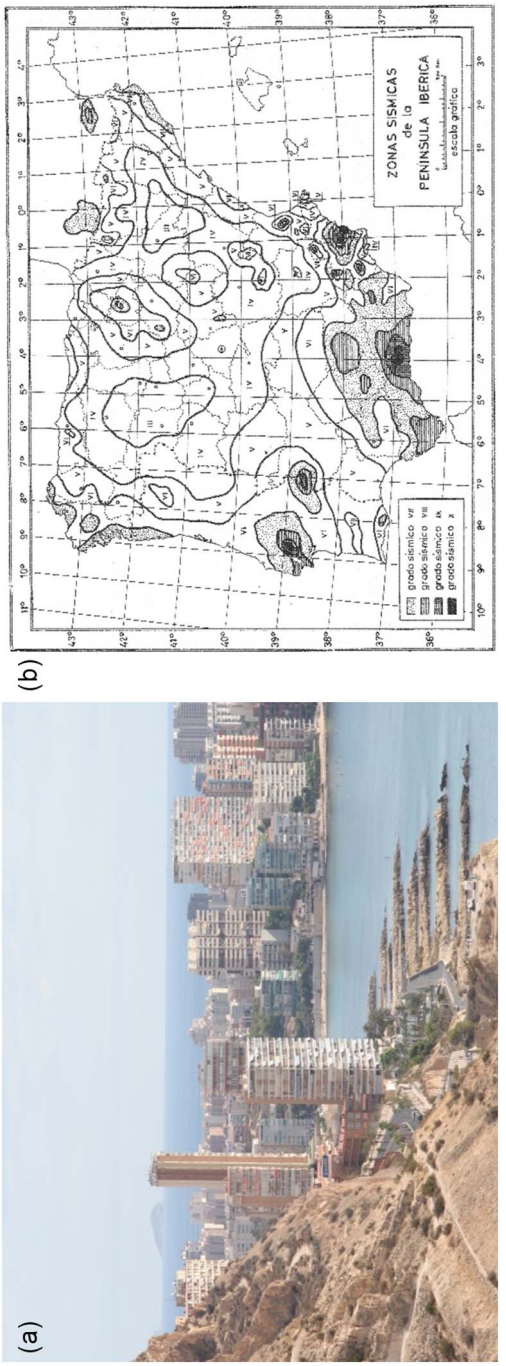

Fig. 1. (a) Mediterranean Spanish Coast, landscape of Albufera area (Alicante). (b) Seismic hazard map of 1962 Spanish standard.