



# Seismic behaviour of infilled and pilotis RC frame structures with beam–column joint degradation effect

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## ABSTRACT

The influence of the exterior joints capacity deterioration on the local and global failure mechanisms of reinforced concrete structures with infills is investigated. Exterior beam–column joints with reduced capacity is the common case for the majority of RC structures designed according to older design standards. Nevertheless in common practise the response of these regions is typically assumed as rigid. A key parameter of this investigation is the inclusion of the joints strength and stiffness degradation in the study of the seismic performance of the structures. In this direction, a special-purpose rotational spring element that incorporates a special behaviour model is employed for the simulation of the exterior joints' local response. The spring element has been incorporated in a well-established general program for nonlinear static and dynamic analysis. The effectiveness of the used joint element model has been demonstrated in a previous paper through comparisons with experimental data reported in literature. In this paper an attempt is presented for the investigation of the influence of the exterior joint damage on the seismic behaviour of bare and infilled RC frame structures. Two types of masonry infilled structures are considered: (a) infilled frame and (b) infilled frame without infills at the base storey (pilotis frame). A parametrical study of the overall seismic response using push over analyses and step-by-step analyses is performed. Results in terms of interstorey drifts, base shear, failure mode, ductility requirements and joints rotational requirements demonstrate that neglecting the possible local damage of the exterior joints may lead to erroneous conclusions and unsafe design or seismic behaviour evaluation that subsequently may become critical in some cases. Furthermore the influence of exterior joints degradation has been proven of vital importance for the overall behaviour of pilotis frames.

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## 1. Introduction

Based on the substantial knowledge that has been acquired so far through numerous field observations after damaging earthquakes, it is now generally accepted that the seismic behaviour of reinforced concrete (RC) frame structures is significantly influenced by the behaviour of beam–column connections. Literature provides many examples where the reduced capacity of the exterior joints has been proven crucial for the behaviour of whole buildings. Local damage or failure of the beam–column connections [1,2] has been repeatedly identified as a leading cause of building failure and collapse. Nevertheless in common practise the analysis and design procedures for reinforced concrete multi-storey structures consider the response of the exterior beam–column connections as rigid regions without strength or stiffness degradation. Several approaches have been proposed for the simulation of the actual seismic response of RC beam–column joints.

First attempts considered that the relative rotational deformation between beam and column is controlled by one or more rotational springs [3,4]. A more refined but rather complex analytical model for the simulation of RC beam–column joints was presented by Youssef and Ghobarah in 2001 [5]. For the simulation of the seismic behaviour of an interior joint, this analytical model required the use of twelve concrete springs, twelve steel springs and two diagonal axial springs.

Recently, Lowes and Altoontash [6] proposed an element for the inelastic response of interior RC beam–column joints that was composed of one shear panel, eight bar-slip springs and four interface–shear springs elements. The envelope of the shear behaviour of the joint core was defined based on the Modified Compression Field Theory, and experimental data was used for defining the response under cyclic loading. A modified version of the previously proposed model of Lowes–Altoontash has been recently (in 2007) presented by Mitra and Lowes [7], which is capable of accurately predicting the response of a wide range of joints through the use of more than 30 parameters.

Shin and Lafave [8] proposed for RC joints the use of four rigid link elements and three rotational spring elements in parallel, embedded in one of the four hinges that connect the rigid links.

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