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Seismic vulnerability of existing R.C. buildings: A simplified numerical model to analyse the influence of the beam-column joints collapse

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ABSTRACT

In order to evaluate seismic vulnerability of existing reinforced concrete buildings, a simplified approach is proposed to take into account the beam-column joints shear collapse. This collapse is described by a link element which is introduced between column and beam. To develop and verify this element, several comparisons have been performed with experimental results of laboratory test and numerical results obtained by a two-dimensional finite element model specifically carried out for this check.

The link element uses a tri-linear moment–rotation law, compatible with standard Italian and European codes, whose features can be estimated by limited structural and geometrical information, which is a typical situation on older existing structures, and by standard code recommendations.

In order to give a preliminary evaluation of the seismic capacity for existing R.C. frames, taking into account the beam-column joints behaviour, this link element has been introduced in a one-dimensional model of bearing structure of the Unit N.1 of the Santa Maria Annunziata Hospital in Florence (Italy) and pushover analyses have been carried out.

1. Introduction

Nowadays, the relevance to take into account the effective Reinforced Concrete (R.C.) beam-column joint behaviour in seismic analysis has been fully understood. Regarding new structures, the classical approach proposed in several standard codes is to prevent the shear collapse of the joints by an adequate design. Following this approach in modelling of the response of R.C. structures to earthquake loading, it is assumed that beam-column joints are rigid. In the context of a performance-based seismic design, previous researches indicate the necessity to take into account the inelastic response of the beam-column joints in determining demands relative to the frame components [1–3]. Particular attention is required in case of seismic vulnerability analysis of older existing concrete buildings. For these structures the concrete beam-column connections were only designed for vertical loads, so that it is necessary to verify, in the seismic vulnerability analysis, the joints' conditions. After the classic approach proposed in [4], several laboratory testing of building subassemblages have been performed (for major references [5]). The check of joints can assume more relevance for exterior ones because of confinement lack as underlined in [6,7], this aspect has been taken into account in Italian standard code [8,9] which explicitly requires to check exterior joints in seismic vulnerability analysis of older existing structures.

In order to describe the behaviour of R.C. beam-column joints several models have been proposed in literature: from implicit models, where the stiffness and strength loss due to joint damage is modelled by modifying beam and column elements using nonlinear springs or plastic-hinges or both at the member ends [10–14], to explicit macroscopic models, that connect beam and column centerline elements to finite-volume joint macroelements which consider several aspects of the inelastic mechanisms governing joint behaviour [15–24].

Starting from an effective case study, in this paper, a non linear link element is proposed to model joint response within the context of a nonlinear frame analysis.

This zero length element is characterised by a tri-linear bending moment rotation law; it is placed at the beam-end section and rigid offsets are included in the beam and column elements to define the joint physical size. Moreover, an elastic–plastic strip model has been used to take into account the nonlinear behaviour of columns and beams.

Further features, of the proposed link element, are the compatibility with the standard codes, a limited number of parameters, assessable by the engineer from in situ investigations and design

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