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Simulation of Nonlinear Behaviour of RC Joints with 180°-hook under Varying Axial Load

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Abstract

In this study, an analytical model for predicting the nonlinear behaviour of exterior reinforced concrete (RC) beam-column joints under varying axial load has been developed. The main focus was on the assessment of effect of axial load variations on response of RC joints. According to experimental evidences, it can significantly affect nonlinear behaviours, i.e. bond mechanism and shear failure of RC beam – column joints. To simulate these nonlinearities, a joint model including a rotational spring in the joint core and some rotational springs in other parts has been developed. The joint spring characteristics could be computed using proposed principal tensile stress - rotation relation in the joint core. A new methodology was also developed to consider the effects of the axial load variations in determining characteristics of rotational springs. The verification results showed that the proposed model would accurately predict the experimental response of joints under varying or constant axial loads.

Keywords: RC beam-column joints, Analytical model, Joint shear failure, Axial load variations.

1. INTRODUCTION

Joints and columns are critical and essential elements in frame structures. Columns tend to transfer vertical forces from roof and stories to foundations, while joints transmit moments and shears of beams end into the columns. Due to seismic loads, such as earthquake loading or wind, columns and joints are subjected not only to the effects of gravity loads but also to combined variable moment, shear and axial loads. Significant effects of axial load on inelastic behaviour of RC joints were confirmed by experimental studies conducted by Beres et al. [1], Hakuto et al. [2], Clyde et al. [3] and Pantelides et al. [4]. On the other hand, to assess the seismic performance of RC joints under varying axial load, some experimental studies were performed [5-13]. The experimental results showed that lateral load-displacement of beam-column joints were significantly influenced by applied axial load variations on column. Moreover, a combination of biaxial loading with high concurrent varying axial load might lead to a severe reduction in strength capacity and deformation of tested specimens. On the other hand, it is well known that to perform a realistic nonlinear analysis, nonlinearities in the joint core should be simulated. For this, several analytical and numerical joint models have been provided in the literature [14-20]. In general, these models are not practical and suitable enough to be used by engineers for predicting the nonlinear behavior of beam-column joints, even though practical models are known to be scarce.

In this study, a practical procedure was developed to consider the nonlinear behaviour of the joint core under varying axial load which was traditionally assumed as being rigid in nonlinear analyses. Nonlinear characteristics of the joint panel were calculated based on principle tensile stress- joint rotation relation. Therefore, for the joints with various beam longitudinal bar anchorage detailing, the principal tensile stress-rotation relations in the joint core were proposed. In addition, a new approach was proposed to consider the significant effects of fluctuation in applied axial load on columns in the nonlinear response of RC joints and columns during lateral loads. The evaluation procedure could be carried out by hand calculations without needing to follow any special software. It could make the model sufficiently suitable for practical applications.