ABSTRACT

A reinforced concrete (RC) column often needs to be repaired or strengthened. Among the different available techniques, the use of steel caging (steel angles and steel strips) is one of the most common solutions, widely spread both in Spain and around the world. Steel caging is mainly applied to square or rectangular columns, and involves the use of longitudinal angle sections fixed to the corners of the column, to which transverse steel strips are welded.

Although this technique has shown to be effective, economical and easy to apply, steel caging has to date received not a great attention from the scientific community, and most of the studies carried out have been focusing on the behaviour of a strengthened column under an axial load. Yet the case of a bending moment applied with the axial load has been scarcely investigated.

This PhD Thesis aims to delve into the behaviour of a steel-caged strengthened RC column under combined bending and axial loads. This study is a part of the research "Experimental and numerical study of beam-column and slab-column joints in strengthened RC columns", founded by Spanish Ministry of Science and Innovation under Research Project BIA 2008-06268, and carried out at the Institute of Concrete Science and Technology (ICITECH) of the Technical University of Valencia (Universitat Politècnica de València, UPV).

The Thesis has an experimental part and a numerical one. In both parts the existence and influence of the beam-column joint is taken into account. A total of 20 full-scale specimens simulating a strengthened column are tested, studying 4 different types of solving the strengthening in the beam–column joint area: welding tubes to the strengthening angles, adding capitals welded to the steel cage so that they are in contact with the beam, adding capitals connected to the beam by means of chemical anchors, and adding capitals linked by steel bars.

The numerical part involves the development of a finite element model, which is calibrated and validated based on the experimental results. The numerical model is used to define the axial load – bending moment diagram of a steel-caged strengthened RC column, as well as to carry out a parametrical study which enables to identify the influence of a series of factors in the strengthened column behaviour. In total, the numerical part requires more than 700 different finite element models.

Results obtained both experimentally and numerically are compared with three existing design proposals, analysing the degree of fit between them. As any of these proposals is not able to represent completely the behaviour of a steel-caged strengthened RC column, a new proposal is performed. This new one is based on the development of an Artificial Neural Network, a mathematical tool inspired by the way the human brain functions, which has revealed to be useful dealing with complex engineering problems. The new expressions obtained are compared with the experimental and numerical results, as well as the other design proposals. That comparison shows the new expressions developed in this Thesis can suitably and accurately represent the behaviour of a steel-caged strengthened RC column under axial loads and bending moments, and thus, they can be used by practitioners.

Keywords: RC columns; Strengthening; Experimental study; Numerical study; Finite element method; Steel caging; Artificial Neural Networks.