# Numerical Simulation of Flexural Behaviour of Concrete Columns Reinforced by Plain Bars

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## ABSTRACT

There are many concrete structures that have been constructed before 1970, and have been reinforced by plain bars. For retrofitting these structures, it is necessary to investigate seismic performance of them, and to evaluate their ductility, strength and stiffness. The objective of this paper is to propose a numerical model to simulate the response of concrete columns with old design details. The model is based on bond-slip properties of plain bars derived from pullout tests. The global behaviour, then, is calibrated by results of monotonic tests performed on three concrete columns reinforced by plain bars. The numerical modelling carried out by MATLAB programming. For modelling, three displacement components of column, under lateral loading have been considered; bending, slip, and shear. By means of the model, important seismic characteristics of the columns (ductility, strength and stiffness) can be estimated and compared with allowable limits in current design codes.

**Key Words:** Reinforced concrete, Plain (smooth) bar, Seismic assessment

## 1 INTRODUCTION

Concrete structures built before 1970s, almost have reinforced by plain bars. These structures have different behaviour in comparison with those reinforced by deformed bars. As a consequence of poor reinforcement detailing and of the absence of capacity design principles, a significant lack of ductility is expected for these structures [1]. Before retrofitting of them, it's significant to extract the main components of their behaviour. Recent researches have demonstrated that predominant behaviour in these structures is related to fixed end rotation, which originates from slip at the joints; whether in beam- column joints or in column- foundation interfaces [1-3]. So bond- slip effects should be included in the numerical models of the structural analysis for achieving a better simulation of the real behaviour of existing RC structures, especially those reinforced by plain bars. This governing phenomenon happens because of a complex mechanism that is illustrated in bond-slip curves. On the other hands, the slippage behaviour of plain bars in concrete can be obtained by bond- slip rules for both bar and surrounding concrete.

Abrams, 1913 [4], after experimenting pullout tests on the concrete specimens, contained plain bars, asserted that there are two dominant phases for bond of plain bars; respectively, adhesion and wedging performances. Other tests were done by Mylear, 1948 [5], confirmed Abrams' results. Both of them also emphasized that after maximum bond resistance, there is a descending branch in bond- slip curve. CEB-FIP, 1990 [6], proposed two relationships between slip and bond for plain bars. Both of two bond- slip curves consist of an ascending branch and an upper bound for ultimate bond (Figure 1). CEB- FIP doesn't consider bond resistance decreasing after bond peak caused by slip increasing.