

The use of headed reinforcement in concrete has found an increasing interest in construction applications. From shear reinforcement in walls to longitudinal reinforcement in beams and columns, there is a growing need to understand the behavior of headed rebars. A headed rebar is a deformed bar with a head attached to its end and while similar anchorage devices such as headed studs and hooked rebars are well established in theory with design equations developed, headed reinforcement lack this level of knowledge and hence, their application in industry is limited.

Current code provisions such as fib Model Code 2010 allow the design of headed rebars as (1) a hooked bar, (2) a headed stud, and (3) using experimental results. Moreover, ACI 318-19 only contains a design equation for the development length of headed rebars but not its capacity. While the literature has justified the approximation of the capacity of headed rebars with hooked bars through a multitude of studies comparing both anchorage devices. Such a justification is not well-founded for headed studs due to a scarcity of studies comparing headed rebars to headed studs. Moreover, there is a lack of design equations accurately predicting the behavior of headed rebars in several parameters. All these issues emanate from the complexity of headed rebars due to their joint mechanism of anchorage coming from both resistance along the rebar deformations and bearing on the head.

This study aims to better understand the behavior of headed bars by numerically analyzing the influence of different parameters on their performance. Furthermore, direct comparisons are made between headed reinforcement, headed studs, and straight bars to segregate the effect of the bond along the shaft and the bearing at the head on the behavior of headed bars.

The parameters included in this study are embedment depth, edge distance, and concrete compressive strength. The numerical models are verified using a 3D non-linear finite element software MASA (Macroscopic Space Analysis) which employs the microplane model with relaxed kinematic constraint as the constitutive laws of concrete. Two numerical approaches, which differ only in the interface properties between the head and concrete, are validated against experimental results before carrying out the parametric study. Several properties including head, concrete, and bond stresses, along with ultimate capacities and crack patterns are extracted from the models and analyzed. Moreover, the load-displacement graphs of headed rebars, studs, and straight rebars are compared and contrasted. Assessments and theories about the discrepancies between the behavior of headed studs and rebars are stipulated. Finally, potential methods for formulating design equations are proposed for future studies.