An experimental and numerical approach to investigate the load-deformation behaviour of anchorages with headed fasteners in reinforced-concrete columns

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Abstract

This paper presents the results of experimental and numerical investigations performed to determine load-bearing resistance and load-deformation behaviour of an structural joint comprised of an anchor plate with headed fasteners (studs) embedded in a reinforced-concrete (RC) column which was detailed with supplementary steel reinforcements next to the anchor plate. The load-deformation behaviour of joint, crack patterns on the RC-column, load distribution on the supplementary reinforcements and the failure modes of the anchorage are presented in detail. In addition, the overall test geometry is modelled in a finite element analysis software, Abaqus, to better understand the main failure mechanism of the anchorage and the loads carried by the supplementary reinforcements. The finite element analysis outputs are validated with the data collected during the test. Detailed investigations of the test results and the analysis outputs showed that the concrete breakout body was formed progressively due to the concrete-cone and concrete pry-out failures but the overall joint failure was triggered by the pull-out failure mode. The ultimate test capacity is compared with the maximum vertical load to be applied to the joint derived from EN1992 – 4:2018 based on the mean resistances of the joint components, and derived from the recent studies in the literature. It is shown that EN1992-4:2018 underestimates the test capacity while the recent approaches are promising for the development of more reliable design equations.

Keywords: Joints in Steel-concrete Interface, Anchorages in Concrete, Headed Fasteners, Concrete Cone Failure, Pry-out Failure, Pull-out Failure.

1 Introduction

In the last few decades, the demand for multi-storey and high-rise buildings motivated the general constructors to invest in steel-concrete mixed construction methodologies [1]. Therefore, a need for robust and reliable structural joints became inevitable to connect reinforced-concrete (RC) columns and walls with steel girders. Cast-in place anchor plates with headed fasteners gained popularity for the design of structural joints of steel-concrete composite building frames due to their superior load-bearing performance with respect to the post-installed fastening technologies [2]. In Europe, the design of the anchorages with headed fasteners must be consisted with European Technical Approvals (ETAs). In addition, recently European Committee for Standardization (CEN)