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ORIGINAL ARTICLE

Performance of cast-in anchors in early age concrete with supplementary cementitious materials

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Abstract This paper investigates the behavior of cast-in headed anchors in early age concrete with different mixes and supplementary cementitious materials. A series of anchor pull-out tests of cast-in headed anchors were conducted using slag and fly ash as Supplementary Cementitious Materials (SCMs) and their amounts were varied from 0 to 50% for slag and 0 to 25% for fly ash of total cement content in concrete. The tests were conducted from 18 h to 28 days after concrete being casted. The results from the experiment were compared with the current theoretical model used in literatures and design standards to predict concrete cone failure for mature concrete to check their applicability for early age concrete with SCMs. Further, a comprehensive 3D finite element model was developed and verified against experimental results. The verified finite element model was used to conduct detailed parametric studies varying concrete and anchor properties. A detailed discussion on the anchorage behavior with different types and amount of SCMs based on findings of this study is presented in this paper. The concrete cone capacity method was found to be applicable for early age concrete with headed anchor with 40 mm effective depth and concrete strength as low as 3 MPa for anchors tested in this study.

Keywords Early age concrete · Normal strength concrete (NSC) · High Strength concrete (HSC) · Fracture energy of concrete · Supplementary cementitious materials (SCMs) · Finite element analysis

1 Introduction

The behavior of headed anchors under tensile load has been extensively studied in the past by various researchers. The investigations focused mainly on the prediction of anchor capacities and their failure mechanisms [1–5]. The most common failure mode for the cast-in headed anchors is concrete cone failure. This failure mode in mature concrete has been extensively addressed in Eligehausen et al. [6]. Fuchs et al. [7] has developed the Concrete Capacity Design Method (CCD-Method) to predict the tensile capacity of such anchors. This method has been extensively used in anchorage design standards internationally

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