The effect of confining concrete on strut capacity inside massive pile caps

Uffe G. Ravn, Kenneth C. Kleissl

Major Bridges International, COWI A/S, Denmark

Contact: ugj@cowi.com

Abstract

Reinforced concrete pile caps in bridge engineering are often massive structures. Typically, the pile cap span to depth ratio is so small that it acts as a deep member, which in practice is usually designed by strut-and-tie models (STMs). The strength of a concrete strut in a STM depends on the state of stress and the orientation of the cracks. Design codes like Eurocode provide simplified and conservative values for the allowable compressive strength. Only limited research regarding the allowable strength of a strut is available in the literature, most of which is based on deep beams. In this paper it is investigated whether the codified efficiency factors for STM struts are also valid for a three-dimensional bulging strut in a pile cap. This has been done by comparison of the design approach usually used in practice with a range of experimental test results of pile caps found in the literature.

Keywords: bridges, reinforced concrete, pile caps, strut-and-tie

1 Introduction

Pile foundations are a common foundation type seen in bridge engineering. Here a massive foundation block normally referred to as a pile cap is used to transfer the loads from the pier to the pile group.

Pile caps are characterised by a low span to depth ratio (typically less than 2) where the loads are transmitted directly to the piles. Pile caps used to be verified and detailed based on a sectional approach where the sectional forces were calculated based on beam theory [1]. That is however not strictly valid for such members and for that reason design codes, e.g. Eurocode [2], ACI [3] and AASHTO [4], recommend that the structural verification is carried out based on strut-and-tie models (STMs), see Figure 1.

The STM approach is not a recently development in the history of reinforced concrete and first found its way into codes in a simple form at the beginning of the 1990s.

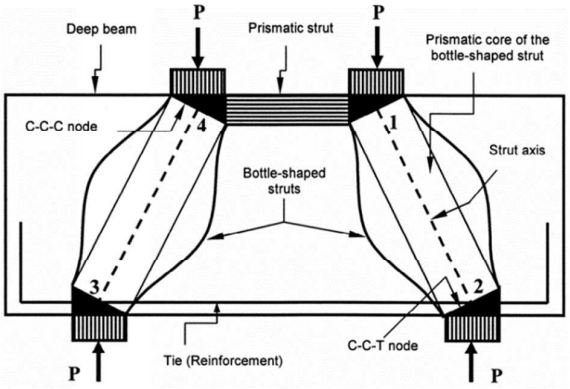

Figure 1. Illustration of a typical strut-and-tie model of a deep beam (the figure is reproduced from [14]).

STM uses a truss analogy where the actual stress flow is idealised by compression struts and ten-

https://doi.org/10.2749/stockholm.2016.2037