Abstract

The thesis deals with tests and rigid-plastic modelling of the load carrying capacity of two different types of loop connections between precast concrete elements. The thesis is divided into two self-contained parts, corresponding to the two types of connections investigated.

Part 1 deals with U-bar loop connections loaded in combined tension and bending. Such connections are often used to establish structural continuity in the deck of steel-concrete composite bridges. Here, the main design challenge in practice is to ensure a load carrying capacity that corresponds to the strength of the connected precast deck elements, i.e. a load carrying capacity that is governed by yielding of the U-bars and not by fracture of the joint concrete. As a contribution to solve this problem, the thesis presents plasticity models for the calculation of the pure tensile strength and the combined tension and bending strength of U-bar loop connections. The models enable the designers to determine the load margin between the capacity related to failure of the joint concrete and the yield capacity of the U-bars. As an important part of the work in Part 1, a large experimental programme has been carried out. The tests were dedicated to study the load carrying capacity related to fracture of the joint concrete. The test results are compared with the theoretical findings and it is shown that the models are able to capture important experimental tendencies. This includes the influence of important design parameters - such as the overlapping length of the U-bars, the spacing between adjacent U-bars and the amount of transverse reinforcement - on the load carrying capacity.

Part 2 deals with the in-plane shear strength of wire loop connections between precast concrete walls. In such connections, the traditional overlapping U-bars are replaced by ropes made of high strength steel wires. The solution is mainly used in vertical joints between walls in building structures. Compared to the traditional U-bar loops, the wire loops are more flexible and thus more construction-friendly. Unfortunately, commercially available wire ropes are mostly made of high strength wires without any yield plateau on the stress-strain relationship. This brittle behaviour makes the use of wire loops in load transferring connections problematic - especially in Denmark where structural design in the ultimate limit state is mainly based on plastic methods. In addition to this challenge, there is currently no accepted method to calculate the shear capacity of wire loop connections. As a contribution to solve this problem, the thesis presents solutions for shear strength calculation of wire loop connections. Collapse modes involving a multi-body mechanism are considered. The special issue of using mortar instead of concrete as grout material (when dealing with joints in building structures) is addressed. As a basic assumption, the wire loops are considered the "strongest link" in the connection. This means that at the ultimate load, the wires remain intact while the mortar fails under the concentrated contact pressure exerted by the wire loops. A strength criterion for the transition between wire rupture and mortar crushing is established. This provides a guideline for when and how to use wire loops. The theoretical results are compared with test results published in the literature. Satisfactory agreements are found. For use in practice, an approximate solution is proposed.