Shear Test on RC Elements with Circular Cross Section

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Summary

Reinforced concrete members with circular cross section are widely used in bridge engineering, either as piers or as piles to support pile caps. In codes, guidelines for shear design of circular concrete members are almost none-existing. Some codes specify rules based on shear models for rectangular members. The shear behaviour of members with circular cross section is, however, quite different from that of rectangular members. The published experimental research on the shear behaviour of circular members contains only test results with very low shear reinforcement percentages. In this paper shear tests on a series of heavily confined concrete members are reported. The specimens have shear reinforcement percentages (hoops) up to more than three times the maximum percentage found in existing tests. The test results are compared with a recently developed shear design model for circular members Good agreement has been found.

Keywords: Shear tests, Circular cross section, Reinforced concrete, Crack Sliding Model

1. Introduction

Despite the very large number of circular RC members used to support bridges and the importance of verifying the shear strength of these members, relatively few studies on the shear strength of such members are available in the literature. Furthermore the published test data on shear capacity of circular members have only made it possible to verify shear design models for members with shear reinforcement degrees up to $\psi \sim 0.10$. Test results for heavily hoop reinforced members cannot be found in the literature. This is a problem in bridge engineering when piers or piles have to be designed for large shear actions. Moreover, most design codes only specify shear design rules for rectangular elements. These rules cannot be used for circular elements due to two main reasons: 1) the assumption of plane stress condition in the rectangular case does not apply to a circular section. 2) rectangular stirrups contribute differently to the shear capacity than circular hoops.

This paper describes an experimental investigation of simply supported, circular concrete members loaded monotonically in shear. The test series consisted of sixteen specimens – four without shear reinforcement and twelve with mechanical degree of shear reinforcement ψ varying between 0.075 and 0.333. The main objective of the test program was to provide data for the shear capacity of heavily hoop reinforced members and use the results to verify a recently developed shear design model for circular members, the so-called Crack Sliding Model.

2. Experimental Program

The specimens had a cross sectional diameter D of 250mm and a total length of 1800mm. The shear span a varied from 325mm to 700mm. The shear reinforcement consisted of closed hoops with yield stress varying between 573 - 587 MPa. The cylinder compressive strength at the time of testing was f_c = 31.7 MPa. Fig. 1 shows the general layout of the test specimens.

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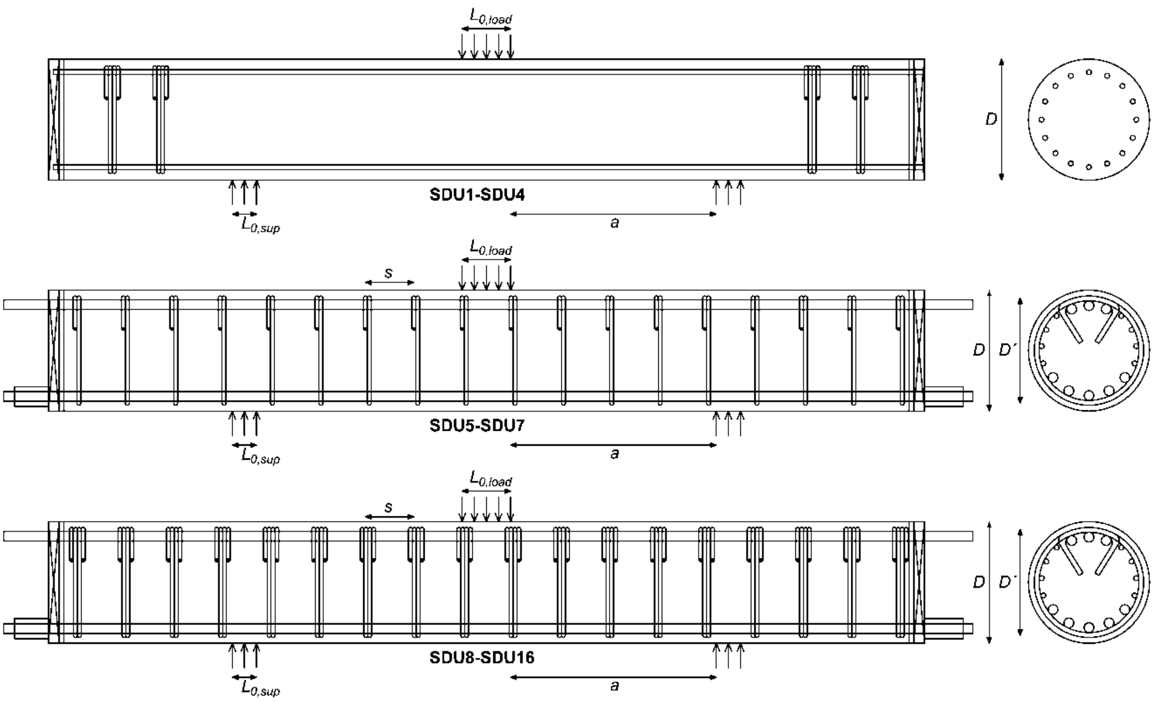

Fig. 1: Illustration of specimen layout

For the shear reinforced specimens, eight high strength DYWIDAG dia. 20mm threadbars together with eight dia. 10 mm deformed bars were used as longitudinal reinforcement in order to prevent flexural failure. The specimens without shear reinforcement had sixteen dia. 10 bars as longitudinal reinforcement.

The specimens without shear reinforcement were observed to suffer brittle shear failure with only one or few visible diagonal cracks. The specimens with hoops exhibited a more ductile shear failure mode with formation of several diagonal cracks. Comparison of test results with calculations based on The Crack Sliding Model can be seen in Fig. 2. The average value of τ_u/τ_{exp} was found to be 0.98 with a standard deviation of 0.08.

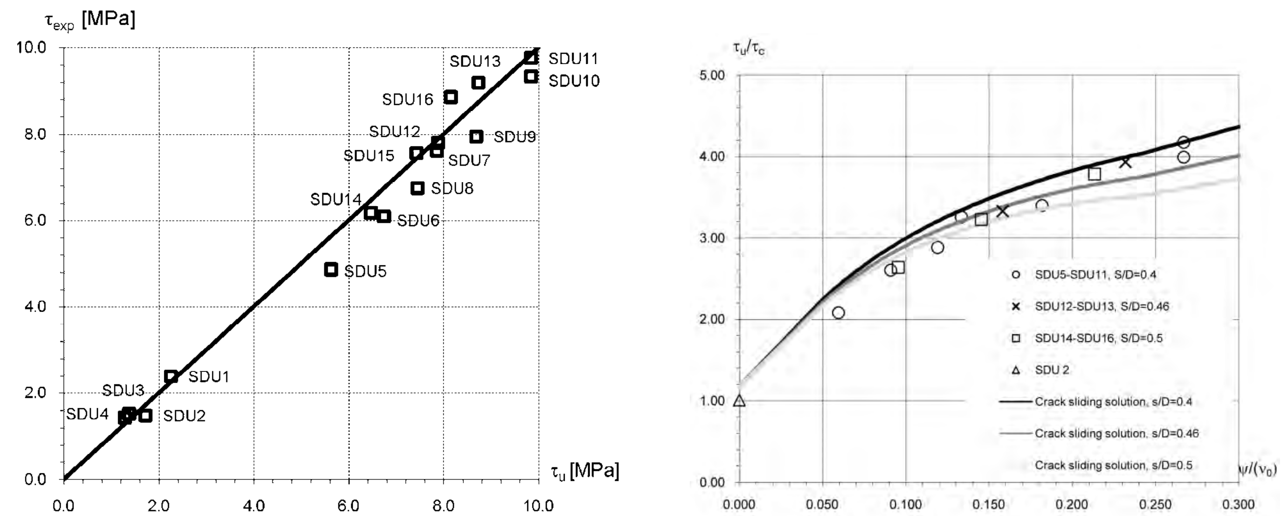

Fig. 2: Comparison of test results with calculations

3. Conclusion

The objective of this paper has been to report a new shear test series on RC members with circular cross section. The 16 specimens consisted of four specimens without shear reinforcement and twelve specimens with shear reinforcement designed with a mechanical degree of shear reinforcement ψ between 0.075 and 0.333. The most heavily shear reinforced specimens had shear capacity approximately 6 times the capacity of specimens without shear reinforcement. The tests have been compared with the Crack Sliding Model and very good agreement has been found.