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DEFORMATION CAPACITY AND CRACKS OF REINFORCED CONCRETE BEAMS

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ABSTRACT

A large test programme has been carried out at The Structural Research Laboratory at Aalborg University in the period of February 1994 to October 1995. The test programme consisted of 117 reinforced concrete beams subjected to three-point bending. The project is a Round Robin on Scale Effects and Transitional Failure Phenomena of Reinforced Concrete Beams in Flexure under the European Structural Society Technical Committee 9.

For the reinforced concrete beams four different parameters were varied. Three beam cross-sections, three slenderness numbers, five reinforcement ratios and two concrete strengths were chosen.

The experimental results show a major size effect on the load- carrying capacity, and that the rotational capacity of the beams is dependent on the reinforcement ratio especially for the low reinforcement ratios. It is also observed that the rotational capacity is dependent on the failure mode.

Key words: Rotational Capacity, Concrete Beams, Experiments, Size Effect, Cracks, Ultimate Failure.

1 INTRODUCTION

In December 1993 the Department of Building Technology and Structural Engineering at Aalborg University joined a Round Robin research project on Scale Effects and Transitional Failure Phenomena of Reinforced Concrete Beams in Flexure in cooperation with nine European and one Australian University. The purpose of the experimental research was to verify the scale dependency of plastic rotational capacity and minimum reinforcement, and the existence of transitional phenomena of failure. The research at Aalborg University consists of an investigation of rotational capacity of reinforced normal strength an high strength concrete beams at low and intermediate reinforcement ratios.

The test programme at Aalborg University comprised 117 reinforced concrete beams with beam depths of 100 mm, 200 mm and 400 mm, and slenderness numbers of 6, 12 and 18 giving nine differents geometries. The reinforcement ratios ranged from 0.06 % to 1.57 % and concrete strengths of 50 MPa and 90 MPa were used. To obtain the low reinforcement ratios for the small cross-section, cold deformed Ø4 and Ø5 mm reinforcement bars with no significant yield capacity were used. Ø6 to Ø20 bars have a very large yield capacity. All experiments were repeated three times.

2 RESULTS

From three-point bending tests in a servo controlled material testing system especially designed for the wide range of geometries load displacement curves and beam curvature along the beam axis were obtained for the test beams. The beams were tested to ultimate failure. In figure 1 typical load-displacement curves are shown for a reinforced normal strength concrete beam as a function of the reinforcement ratio. The effect on the load-carrying capacity when changing the reinforcement ratio is clearly seen. In figure 1 also the plastic rotational capacity according to rotations of the beam supports are shown for the three normal strength concrete cross-sections with slenderness number 12. It is seen that the rotational capacity increases for the low reinforcement ratios due to tensile failure of the reinforcement, while it is almost constant for the highest reinforcement ratios due to compression failure of the concrete.

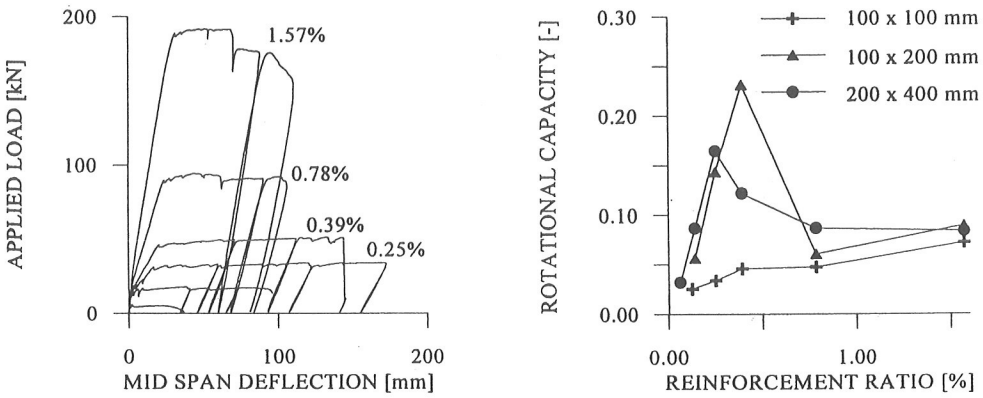

Figure 1. Load displacement curves and rotational capacity as a function of the reinforcement ratio for a reinforced normal strength concrete beam with dimension of 200 x 400 x 4800 mm.

3 CONCLUSION

In this research project a wide range of reinforced concrete beams have been tested. The main results of the experimental work are that the rotational capacity of the beams is increasing for the very low reinforcement ratios and decreasing for the intermediate reinforcement ratios, while it seems to be constant for the highest reinforcement ratios due to failure modes. Further experimental and analytical research will be carried out regarding rotational capacity of reinforced concrete beams at very low and at very high reinforcement ratios.