Connections in Precast Buildings using Ultra High-Strength Fibre Reinforced Concrete

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CONNECTIONS IN PRECAST BUILDINGS USING ULTRA HIGH - STRENGTH FIBRE REINFORCED CONCRETE

Keywords. High - strength fibre reinforced concrete, precast buildings, connections, slabs, beams

Abstract. Ultra high - strength concrete adds new dimensions to the design of concrete structures. It is a brittle material but introducing fibres into the matrix changes the material into a highly ductile material. Furthermore, the fibre reinforcement increases the anchorage of traditional reinforcement bars and the fire resistance.Such a fibre reinforced ultra high - strength material has been used to develop a simple joint solution between slab elements in a column - slab building system.

1. Introduction

A new building system has been developed by the Danish architect firm Dall and Lindhartsen and the Danish consulting firm Carl Bro. Futhermore, the Cement and Concrete Laboratory at Aalborg Portland and The Structural Laboratory at Aalborg University have tested the new building system. This new system will be applied for new buildings at Aalborg University and will be ready for use in the summer of 1996.

2. The new building system

The load bearing system for the new building system is a solution with prefabricated concrete slabs and concrete columns in a square net of 6 times 6 meters. The slabs are cast as 3 times 6 meters slabs and are made of normal strength concrete. At the building site the slabs are connected with a very special connection using ultra high - strength fibre reinforced concrete thus forming a continuous slab with the columns as supports. In other words:

The prefabricated slab elements and this new connection act as cast in situ homogeneous concrete slab.
A sketch of the new building system is shown in figure 2.1

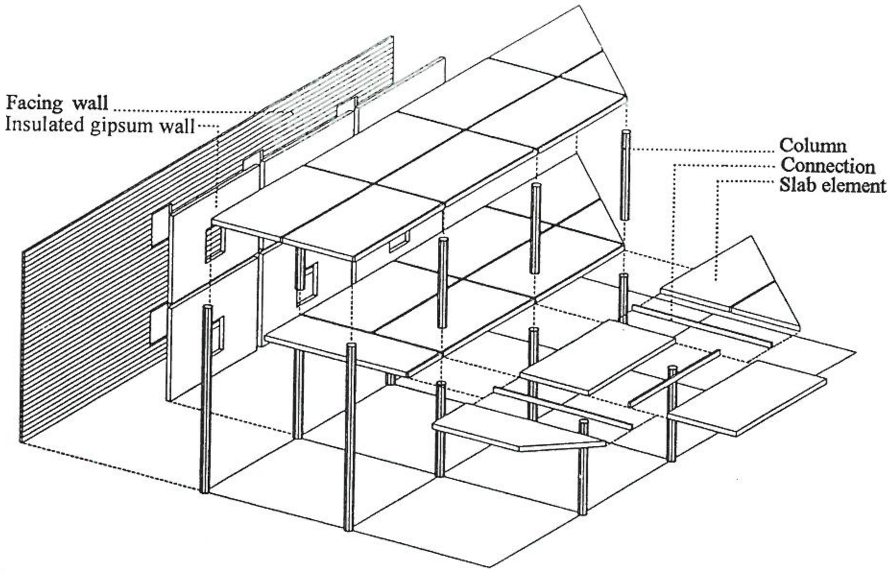

Figure 2.1 Sketch of the new building system at Aalborg University

The new system gives the architects more freedom to create the plan solution for the building and it is possible to allow different solutions at boundaries as shown on the sketch. Another great advantage is that there is no beams in the system and this means good possibilities to place all the technical installations between the slab elements and the non-bearing ceilings.

The slab elements are as mentioned cast in ordinary reinforced concrete and the reinforcement bars are continued 80 mm outside the elements. Placed 100 mm from each other and using high - strength fibre reinforced concrete in the joint, fully anchorage of the bars and fire resistance are obtained.

3. Load tests

In this chapter a few results from the load tests are mentioned. Only a few results can be given here but more information can be found in [1]. The fire testing is not described in this paper. Three types of load tests were applied, namely tests on small tension specimens, beams and slabs as described in the following.

3.1. Tests of anchorage of reinforcement in the ultra high-strength fibre reinforced concrete

Previous to the testing of the beam and slab elements described in sections 3.2 and 3.3 some tests were carried out at the Cement and Concrete Laboratory at Aalborg Portland with small specimens (reinforcement and the ultra high-strength fibre reinforced concrete) subjected to pure tension. These tests are reported in [2] and [3] and the results from these tests form the basis for the design of the tested connections for the beams and slabs.

3.2 Tests of beams

18 beams were tested at the Structural Laboratory, Department of Building Technology and Structural Engineering, Aalborg University. The purpose of the beam tests was

- to develop a connection where the reinforcement is not pulled out of the concrete matrix. Beams with such a connection will then act as normal continuous beams with respect to strength and stiffness, and
- to estimate the sensitivity to the anchoring length and the placing of the reinforcement in horizontal direction, and
- to estimate the influence of horizontal reinforcement perpendicular to the principal reinforcement in the length direction.

The beams consisted of 2 prefabricated concrete parts connected with a 100 mm long connection of ultra high-strength fibre reinforced concrete. A sketch of the beam with loading is shown in figure 3.1. The concrete for the beam had a compressive strength of approx. 50 MPa and the principal reinforcement was weldable Danish "Kamstål" KS 550Y, diameter 8 mm, and a yielding strength of approx. 550 MPa.

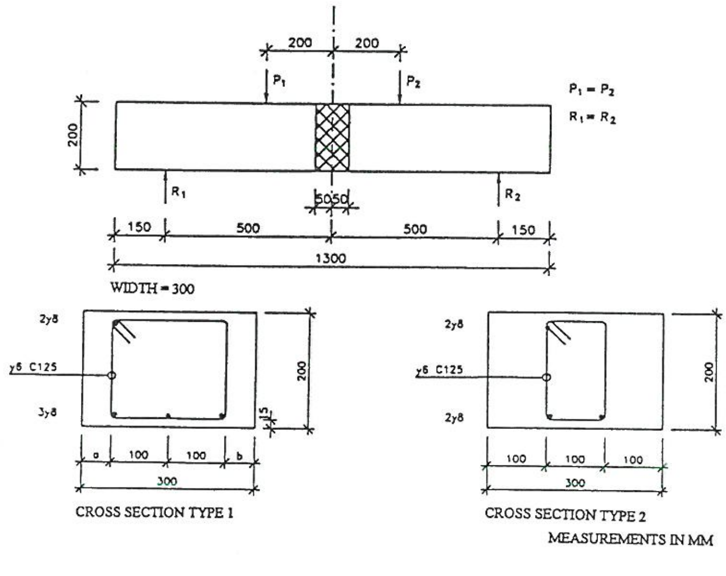

Figure 3.1 Sketch of beam, loading and cross section

6 different types of beams were tested and for each type 3 beams were tested.

3 types of the principal reinforcement, type A, B and C and 2 geometries of reinforcement perpendicular to the principal reinforcement were applied. The anchorage length was 40, 60 or 80 mm.
During the load tests different displacements, forces and strains were measured together with the crack development. A typical load - deflection curve is shown in figure 3.2 for the beam type A2, and it is seen that the beam acts in a plastic and ductile way.

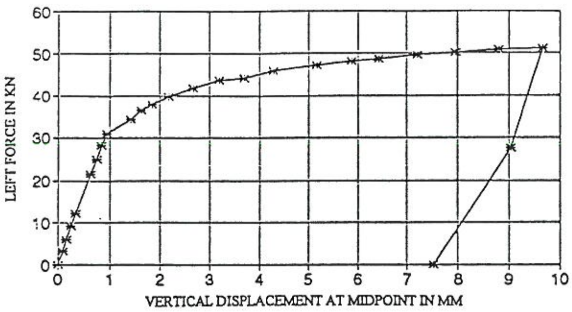

Figure 3.2 Load - deflection curve for beam type A2

The load bearing capacity (maximum value for one of the forces in figure 3.1) varied between 50.1 kN and 76.1 kN for the 6 different types of beams.

3.3 Tests of slabs

4 different types of slabs were tested at the Structural Laboratory, Aalborg University. The slabs were conctructed as a part of greater slabs and the load on the slabs will simulate some typical load and support conditions. A sketch of the 4 types are given in figure 3.3.

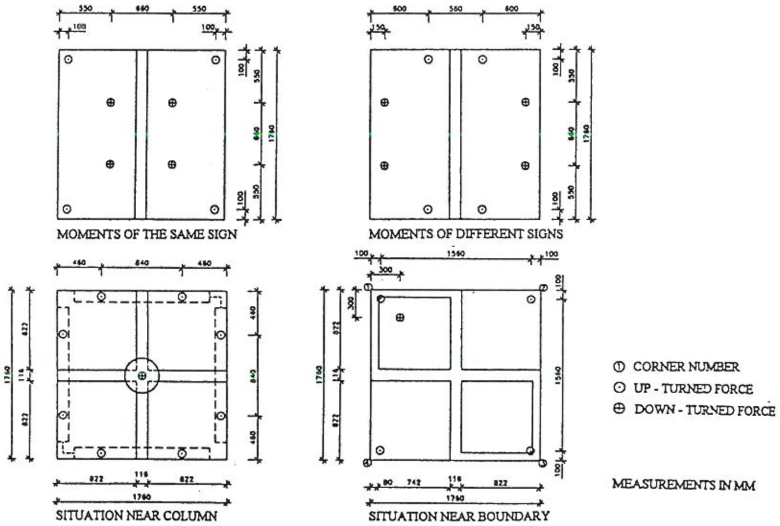

Figure 3.3 Different types of slabs

The connection for the type 1 slab is shown in figure 3.4 to the left and for type 2, 3 and 4 in figure 3.4 to the right.

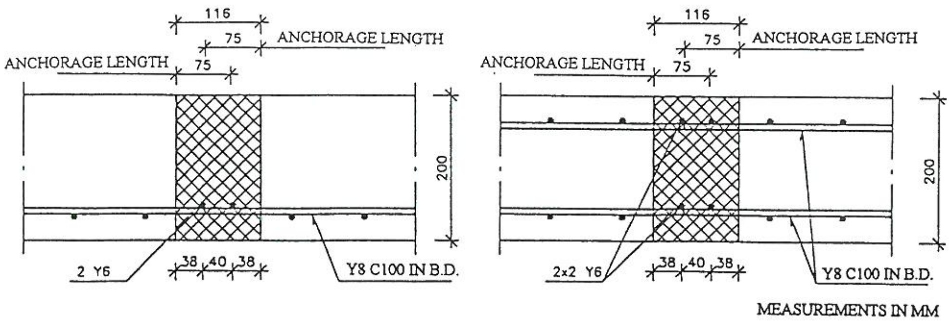

Figure 3.4 Connections for slabs type 1 and type 2,3 and 4

As for the beams different displacements, forces and strains were measured during the tests together with the crack development.
A typical load - deflection curve for slab type 1 is given in figure 3.5.

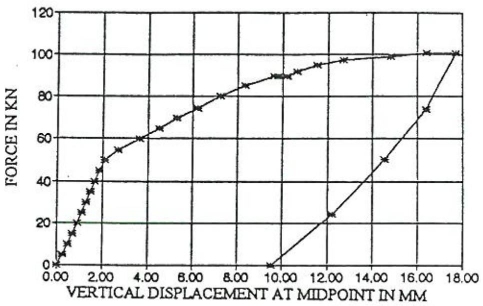

Figure 3.5 Load - deflection curve for slab type 1

Again it is seen that the structure acts as a plastic and ductile element.
The maximum force for the different slab types are given in table 3.1.

Slab type no.	Mean of maximum force in kN
1	98
2	107
3	896
4	450

Table 3.1 Ultimate loads for the different types of slabs

4. Conclusion

As a conclusion for the load tests it can be stated that the connection with the ultra high - strength fibre reinforced concrete has satisfactory properties. The connections are so strong and ductile that slabs constructed with these connections will act as normal concrete slabs and the usual calculating methods used for reinforced concrete can be applied.

Acknowledgements

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