CRC JointCast – examples of applications

CRC or Compact Reinforced Composite is a fibre reinforced high performance concrete developed by Aalborg Portland in 1986, now marketed and sold by CRC Technology. CRC has been the subject of a number of research projects, and one of the properties which has been investigated is bond. Due to the large content of micro silica and steel fibres CRC has exceptional bond properties, which means that CRC can be used for small, strong and simple joints /1,2,3/.

As these joints are typically cast in-situ whereas many typical CRC applications are pre-cast a special product has been made. CRC is typically sold as a binder, where local sand and aggregates are chosen for each application. As CRC JointCast is used in small quantities and typically in critical parts of the structure where quality control is very important, CRC JointCast is provided as a dry mortar – with binder, sand and steel fibres. Water is the only ingredient, which is not provided. CRC JointCast is marketed and sold by CRC Technology.

In the following will be given examples of different types of applications of CRC JointCast and a few applications or research projects will be described briefly. The description is given first and pictures are shown in the last part of the note.

Aalborg University

CRC JointCast has been used for two buildings at the university in Aalborg – each building about 7000 m^2. Before each application extensive documentation has been carried out as part of a development project sponsored by the Danish Ministry of Education. The tests included a fire resistance test establishing that the joint could sustain a standard fire for more than 90 minutes. The joint used had a width of 100 mm, and it was applied in the section with the maximum moment. Only straight 8 mm bars with a characteristic yield strength of 550 MPa were used. A number of test reports are available (in Danish) and an overview of the results are given in various papers /4,5,6/. A video has also been produced describing this application. A few pictures from the project are shown on the next pages.

Repair work

CRC JointCast has also been used for repair on the Øresund bridge, where a number of reinforcing bars were accidentally cut. By using CRC JointCast it was only necessary to cut out a relatively small area of the structure and introduce lap bars, whereas it would have been necessary to make a much larger repair patch if conventional concrete had been used.

Frame joints

Another type of application was used for a factory in Sdr. Felding, where CRC JointCast was used for connecting parts of frames. The building had a floor area of 20,000 m^2 but as the joints were quite small, only 2 m^3 of CRC JointCast was used for the entire project.

Bridge joints

Together with Strängbetong, Sweden an investigation is carried out to verify whether CRC JointCast can be used with advantage to replace a rather cumbersome type of joint traditionally used in pre-cast bridges. 16 mm rebars with 550 MPa characteristic yield strength was used as tensile reinforcement. The documentation tests were carried out at Chalmers University, Sweden and included static as well as fatigue tests. The static tests were concluded in December 1998, and the fatigue tests were carried out in September-October 1999. The joint was typically stronger than the equivalent monolithic beam, except for the case simulating that the transverse bars had been left out by mistake. In that case the failure mode was an anchorage failure, but failure occurred after yielding of the rebars at approximately 96% of the ultimate load.

Beam tests, Japan

Shimizu, Japan has carried out several tests on CRC JointCast. The first of these tests concerned a joint between two beam parts. Casting of the joint – which had a width of 250 mm and a lap length of 190 mm using 19 mm bars – is shown in a few pictures. When tested, the beam with a CRC joint had strength and ductility corresponding to that of the monolithic beam /7/.

Pull-out tests, Japan

Most of the pull-out tests carried out have been performed on reinforcing bars or prestressing strands with a maximum size of 20 mm. The reinforcement used in Japan is typically quite large diameter bars due to seismic design provisions. Shimizu has carried out a number of pull-out tests on bars of up to 51 mm diameter, where the measured values of bond strength varied from 26.3 MPa to 86.8 MPa. The embedment lengths used were typically on the order of 3 times the bar diameter, and it has been observed that the calculated bond strength will decrease with increasing embedment length. In one case a 51 mm diameter bar was loaded to failure before pull-out occurred with only 3 bar diameters of embedment /8/.

Pull-out tests, fatigue

Fatigue tests have previously been carried out using small test specimens with a low rebar cover. These tests have recently been complimented by a large study carried out at Aalborg University on larger specimens where type and dimension of rebars was varied.

Apart from these tests and applications CRC JointCast has been used in a demonstration project at BRE, England and a number of tests on beam connections and pull-out specimens have been carried out at CBL, Aalborg Portland /9/. These tests have included verification tests that joints can achieve adequate strength in only 3 maturity days as well as tests on effect of lap length and effect of different types of rebars (English, Swedish or Danish).

Innovative joints

CRC JointCast has been investigated in a large research project carried out by Building Research Establishment, UK. The project aim was the development of a number of innovative joints for the precast industry – joints that would be simpler and more cost effective and would assist in speeding up construction with precast components. In late 2001 5 dif-

ferent types of full scale joints with CRC JointCast were tested, all of them successfully. An additional 5 tests will be carried out in early 2002 to conclude the project.

Other types of applications

CRC JointCast has been used for number of smaller projects and pictures from a few of these projects are shown in this note. This includes the lengthening of a number of beams used in a renovation project and a joint between supporting columns and a wall in renovation of a hospital building.

References

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2. **Aarup**, Bendt & **Jensen**, Bjarne Chr., “Bond Properties of High Strength Fiber Reinforced Concrete”. Bond and Development of Reinforcement, SP-180, ACI, Michigan, USA, 1998.

3. **Aarup,** Bendt et al., “Fiber Reinforced High Performance Concrete for in-situ Cast Joints.” Proceedings of International Symposium on High Performance Concrete, September 25-27, 2000, Orlando, Florida, USA.

4. **Jensen**, B.C. et al, “Connections in Precast Buildings Using Ultra High-Strength Fibre Reinforced Concrete”. Nordic Symposium on Modern Design of Concrete Structures, Aalborg University, Denmark, May 3-5, 1995.

5. **Hansen**, L.P. & **Jensen**, B.C.,”A new building system using joints of ultra high-strength fibre reinforced concrete”. Innovation in Concrete Structures: Design and Construction, 1999, pp. 543-552.

6. **Jensen**, B.C., “Applications of Steel-Fibre-Reinforced Ultra-High-Strength Concrete”, Structural Engineering International V.9, no. 2, May 1999, pp. 143-146.

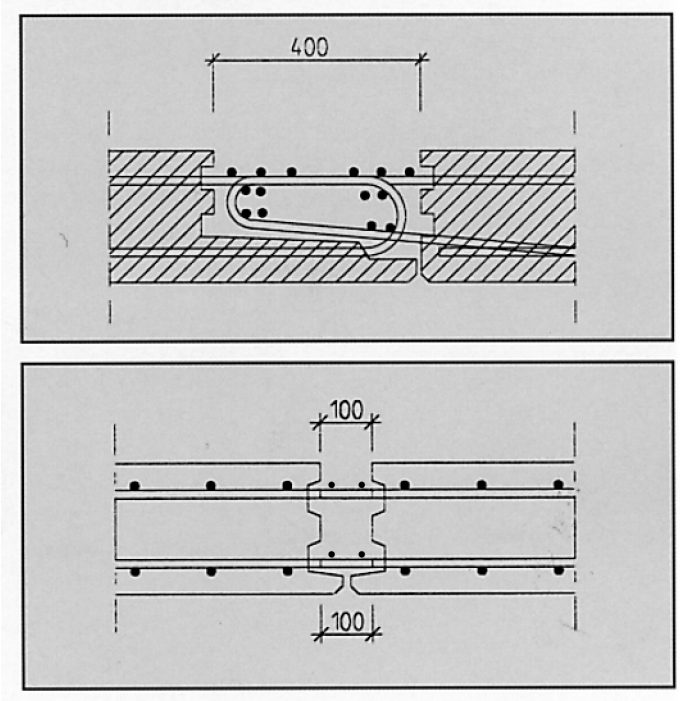
7. **Shioya**, T. et al, “Pre-cast Concrete Joint using Steel Fiber Reinforced High Strength Mortar and/or H-beam”, Proceedings of the Japanese Concrete Institute, Vol. 19, No. 2, 1997, pp. 1305-1310 (in Japanese).

8. **Kurita**, Morio et al, “Properties of High Strength Steel Fiber-Reinforced Mortar”, Proceedings of Japan Concrete Institute, vol. 22, No. 2, 2000 (in Japanese).

9. “Spanning roles”, Concrete Engineering, November 1998.

Pictures from Aalborg University. The 100 mm wide joints attain sufficient strength after 3 days that the joints are actually stronger than the slabs, which means that the failure will never occur in the joint and the column/slab system can be calculated as a monolithic slab.

Joints for frames at Sdr. Felding. The joints were used to make the elements easier to transport.

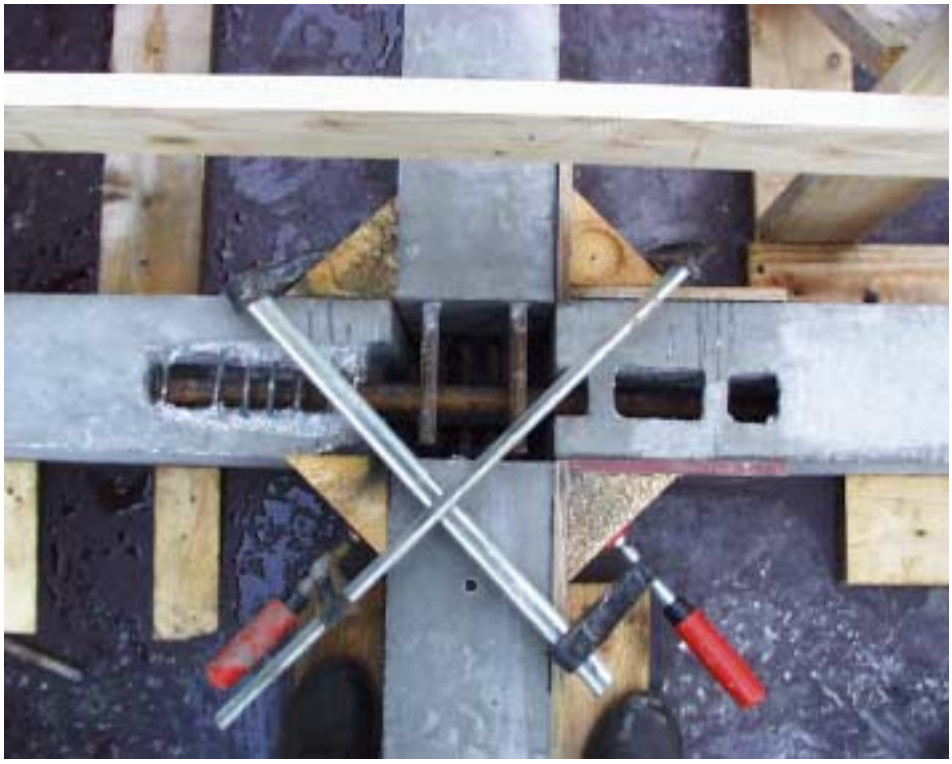


Joint between bridge slabs. On top is shown a traditional joint with looped bars and a number of transverse bars and the CRC joint with straight bars is shown below. Both joints are with 16 mm bars.

End of bridge slab for the CRC joint. The rebars at the bottom have a 20 mm cover.

Casting of joints at Shimizu. The beam was placed on its side for casting. During testing the bottom of the beam was the side which is shown against the Plexiglas shutter.

Simple joint with 12 mm bars and a width of 100 mm. The beam fails away from the joint.



The use of CRC JointCast for a staircase produced in CRC with 2% of fibres. An otherwise quite complicated joint is made simple by just casting with CRC JointCast and afterwards no sign of the joint is visible.

The staircase at the library of Roskilde University. The joint shown on the previous page is not visible and the beams crossing underneath the platform could have been cast on site.

CRC JointCast was used for joining slabs on the top floor of the European Concrete Building Project at Cardington, UK. The staircases were also joined with CRC Jointcast.

In a current project on “Innovative Joints” the BRE produce and test a number of different types of joints based on the use of CRC JointCast. The tests are carried out at as close to full-scale as possible. Above is shown a slab/slab and column/slab joint.

Joint for connection of column and supporting wall at Rigshospitalet, Copenhagen .- and simultaneous beam joint.