Behaviour of concrete elements subjected to cyclic bending

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Description

This thesis is dedicated to the investigation of the behaviour of concrete beams subjected to cyclic loading. In addition to standard data acquisition tools such as DIC and CATMAN, a new measuring system is used in this project. Optical fibers from LUNA FIBER OPTICS are glued onto the longitudinal reinforcement bars to measure a complete strain profile along the entire length of the sample. The focus of the analysis was twofold. First, the feasiblity of the fiber optics is investigated and secondly, the difference between shear and flexion cracks is examined as well.

Experimental campaign

To gather enough data, three beam samples are produced. The main characteristics are listed below. For each sample, the front side is filmed with DIC cameras allowing the direct analysis of crack openings. At the same time, CATMAN is used to gather information on the vertical displacement using five different LVDT's which are placed alongside the sample length. Finally, optical fibers are glued directly onto the surface of the rebars to measure the longitudinal strain. By measuring the top as well as the bottom side of the bars, it is possible to create localised strain profiles at every point of the sample.

Geometry		**Reinforcement**		**Materials**	
Length:	3.00 m	Diameter:	22 mm	Steel:	S670B
Width:	0.30 m	Number:	2	Concrete:	C25/30
Height:	0.32 m	Ratio:	0.925 %		

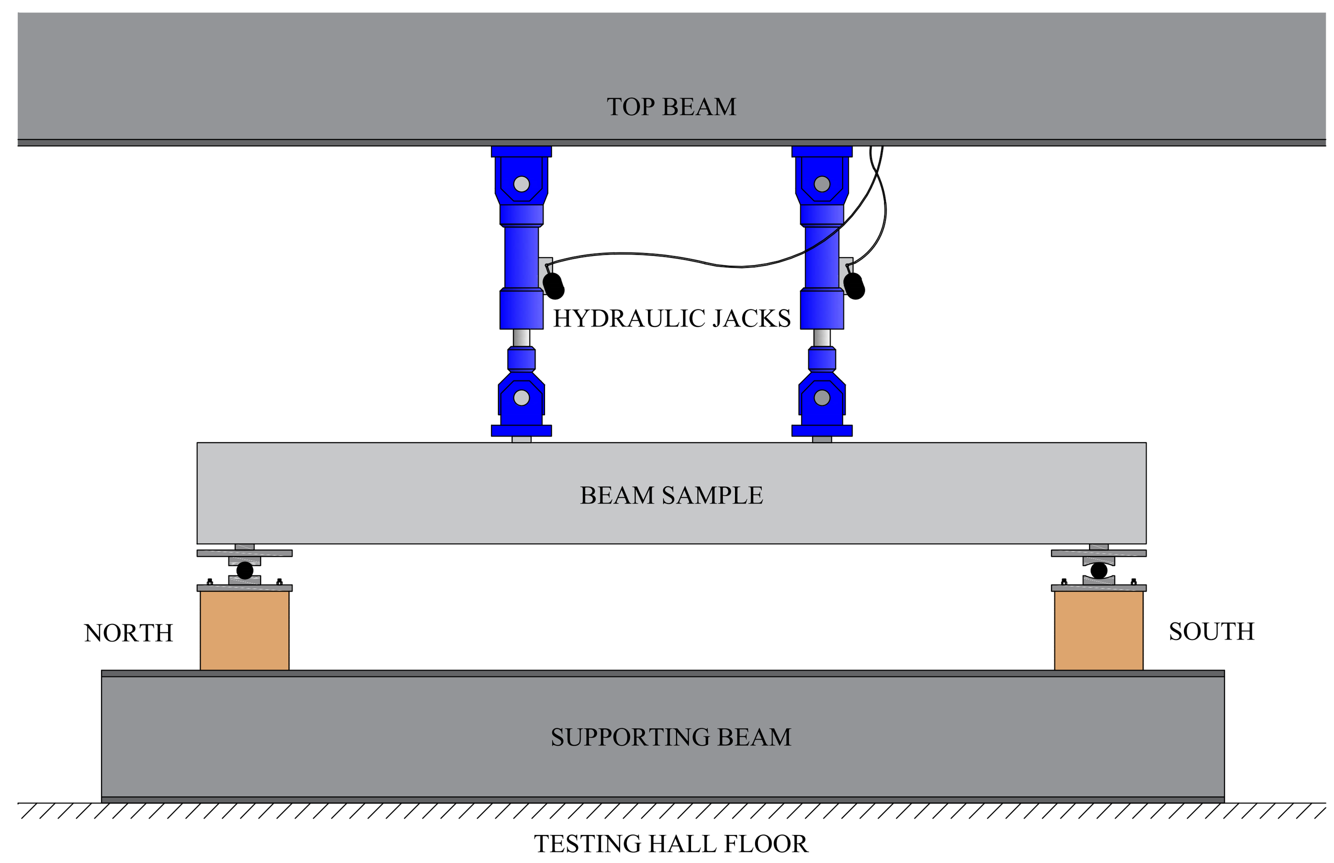

***Figure 1*:** Testing set up showing the 4-point bending configuration selected for the tests to observer both pure bending as well as shear cracks on the same sample. The two hydraulic jacks were synchronised to exert the same force at any point during the test.

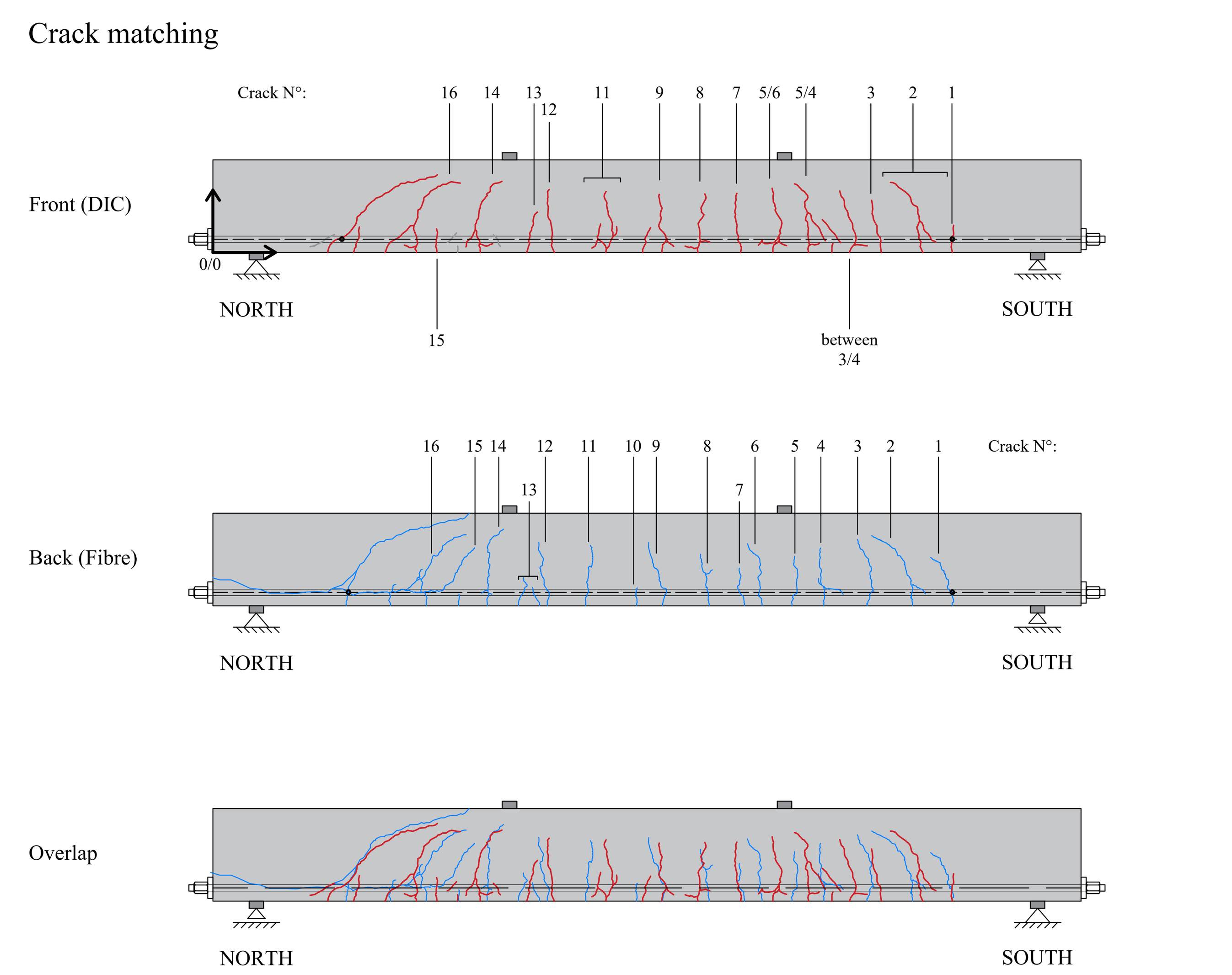

***Figure 2*:** Crack patter on the front (top) and back (centre) of sample SC76 as well as the superposition of both (bottom) to allow quick visual comparison.

Results

The three samples are tested at three different load levels (Level 1: 24 kN, Level 2: 50 kN, Level 3: 80 kN) to investigate the behaviour during each of the critical phases - crack development phase, crack opening phase as well as creation of the Critical Shear Crack (CSC) . All of the samples failed in shear. However samples 1 and 2 failed during the static loading which was performed after at least 50 cycles had been completed successfully. The failure load was 92 and 94 kN respectively. The last sample failed during the 22nd cycle at a load of 78 kN.

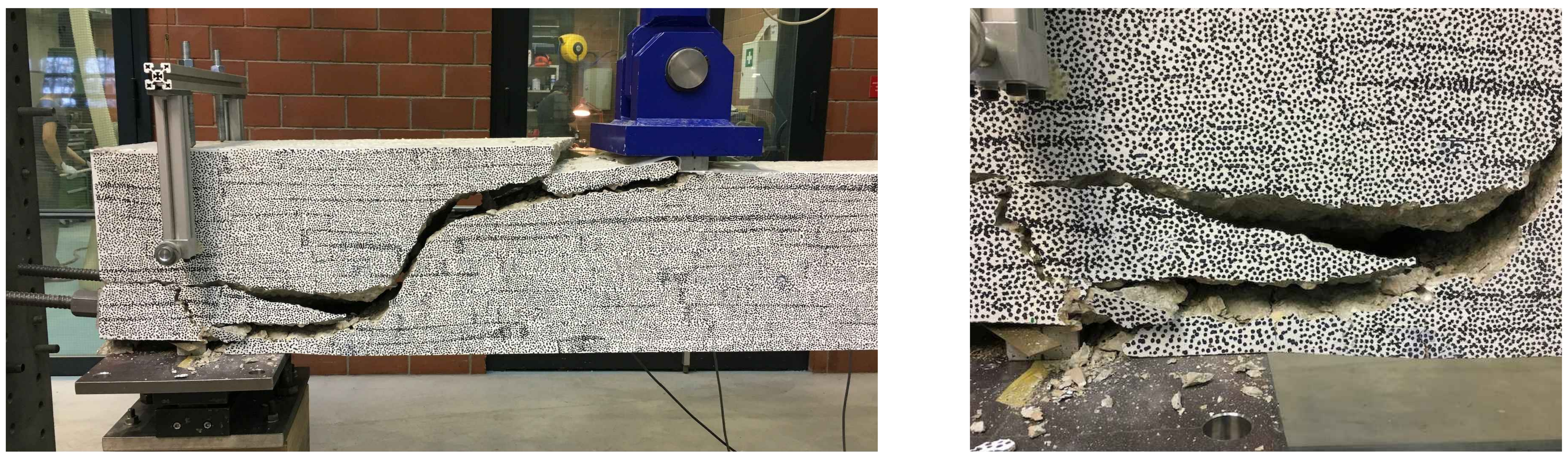

***Figure 3*:** *Post failure of sample SC75 showing very clearly the shear crack that led to the failure of the sample. On the right side a close up of the lower part of the fracture showing the influence of the dowel action on the failur mechanism.*

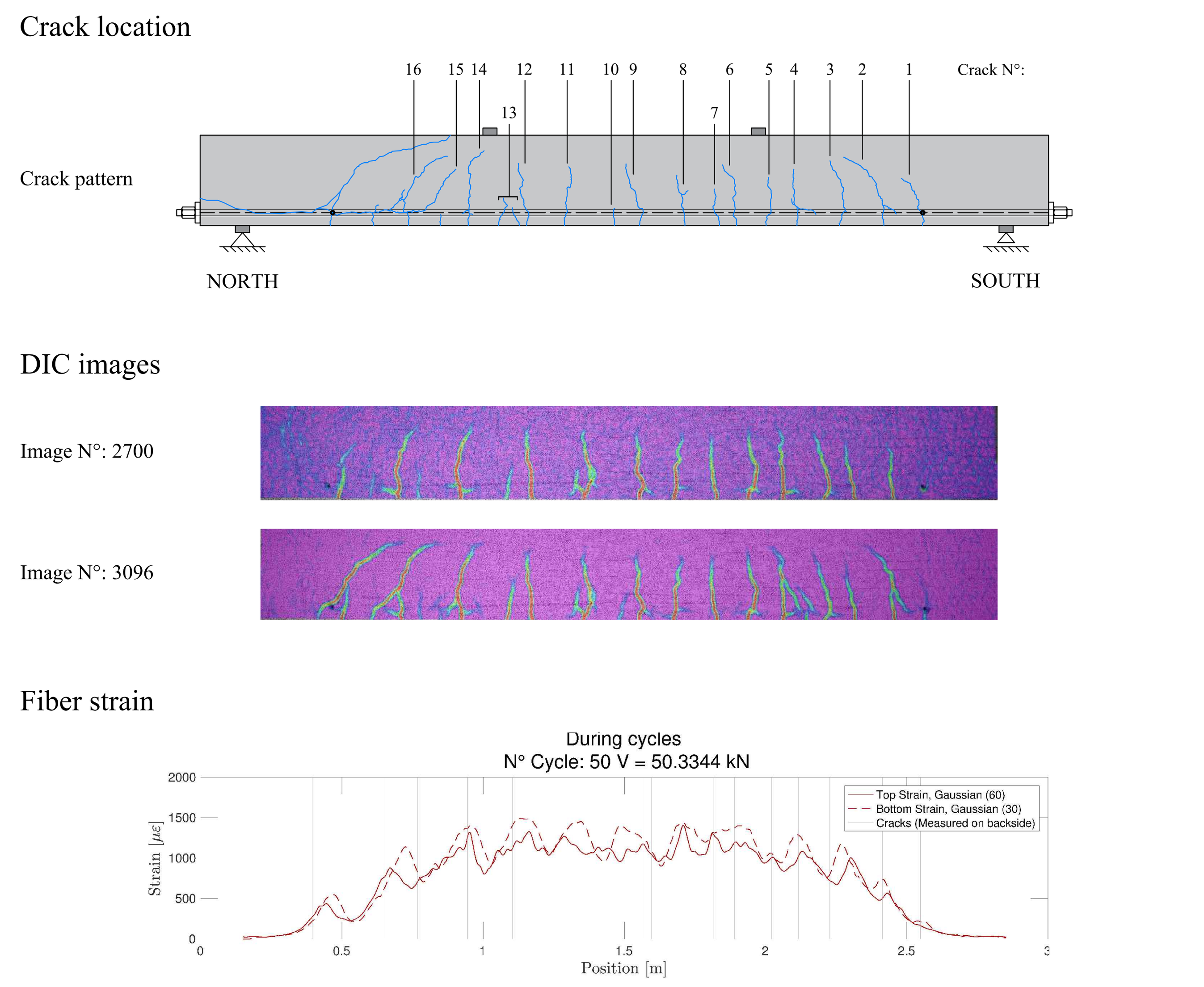

***Figure 4*:** Determination of the exact crack location both from DIC images (centre) and fiber measurements (bottom).

Analysis

For further analysis of the data, it is critical to know the exact location of the cracks. As the cracks were traced both on the front as well as the back surface of the sample (see figure 2), their intersection with the rebar is known for both sides. However, the cracks can cross the sample at an oblique angle and the crack position on the surface does not correspond with the crack position at the rebar. Figure 3 shows the process used to determine the exact crack location - Comparing the crack pattern (Figure 3, top) with the DIC images (Figure 3, centre) as well as the fiber strain of the top and bottom of the rebar (Figure 3, bottom).

Strain development

For selected cracks, detail analysis of the crack development as well as the strain development are performed. In the case of the sample tested at 80 kN, figure 5 shows clearly the difference between the critical shear crack (on the left) and one where the strain remains constant during the cycles (on the right).

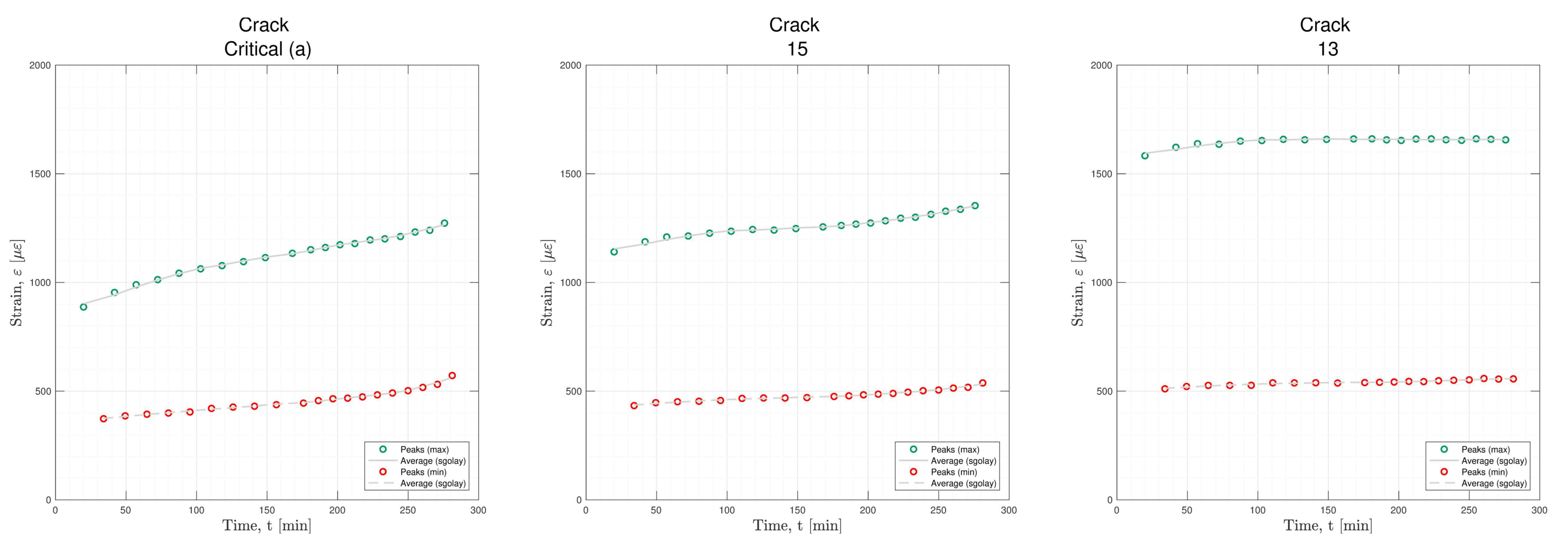

***Figure 5*:** Strain development of three selected cracks for sample SC77 showing the difference in the behaviour of the various cracks.

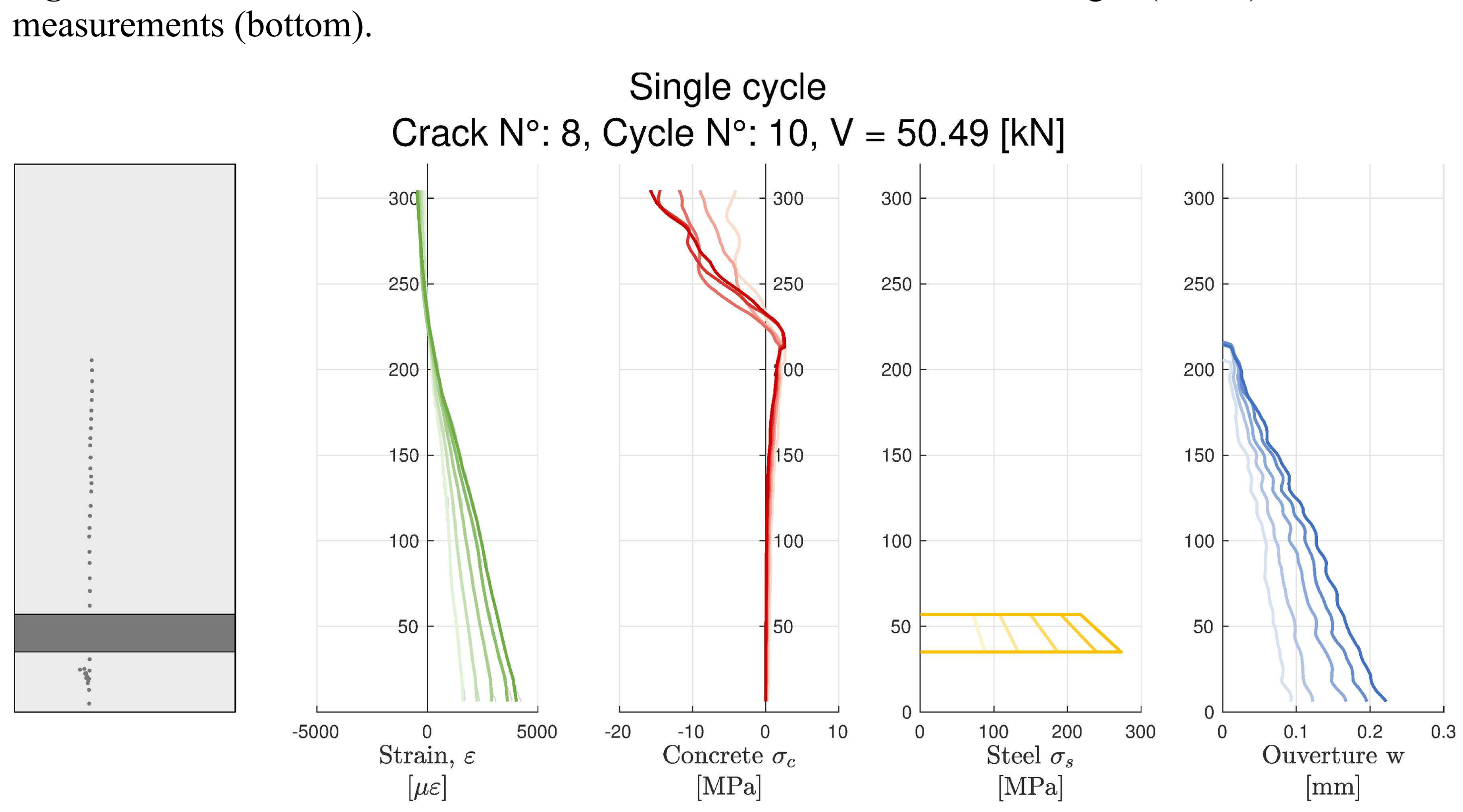

***Figure 6*:** Vertical profile describing the behaviour of the sample at the location of crack N° 8 by combining all of the different data acquisition methods. The shades indicate the difference in load (dark = max load, light = min load).

Vertical profiles

By combining the measurements from all three data acquisition tools, specific flexion cracks are selected for which the data is the most suitable and vertical profiles are created (see figure 6) showing the development of strain (green), stresses (red and yellow) as the well as crack opening (blue) during one chosen unloading cycle. The results obtained show good agreement with existing models.

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