Ageing and fatigue on the concrete glued reinforcement

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Fiber reinforced polymers in concrete

Reliability of the bond

Concrete retrofitting gains importance particularly for structures subjected to ageing or increasing traffic load, e.g. bridges. Strengthening concrete structure with externally bonded FRP strips is a well known technique that leads to an increase of service life. To analyze the bond between concrete and CFRP strips diverse cohesive laws are available in literature without a consideration of the aggregate interlock, which strongly influences the bond failure mechanism. The composition of the aggregate components within the concrete could strongly affect the resistance of the bond but it hasn't found an appropriate description. Especially in cases of fatigue or long term loading the effect on the reliability of the bond has to specified.

Goal of the project

Define the concrete parame-ters, that influence the bond failure by studying the decoupling phenomena in mesoscale. The study has to involve concrete that could be compared with structure undergone to ageing, assumed with low performance cement. The study of the fracture evolution involve an experimental campaign and a following analytical model.

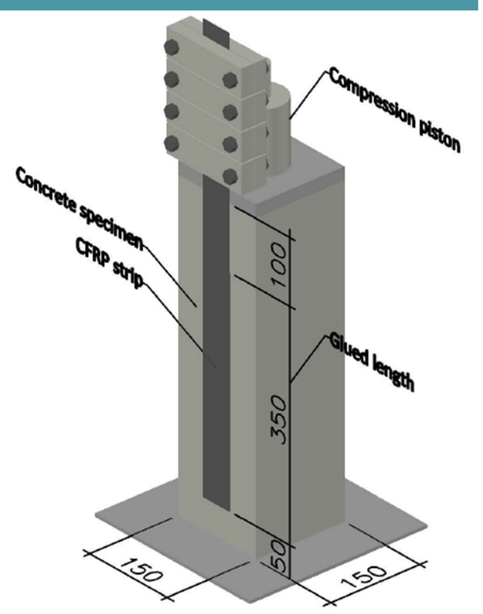

Figure 1: (Macro scale) single lap shear test

Methodology

The experimental test program includes:

- double lap shear test in meso scale
- study of the debonding with the help of X-rays projections and X-rays Computer Tomography (CT)
- tests deal to define the characteristics of the concrete components.
- Upscaling test, to compare the result in meso- with macro scale tests.

To prove and describe the results obtained in the investigation part, a finite element model is prepared. The properties of the concrete component, (aggregate, cement, interface transition zone and pores) are modelled with characteristics defined in other tests. In order to obtain a real concrete elements representation, the mesh is obtained from Computer Tomography scans.

Fatigue and upscaling

After static test on micro scale, the behavior at microscale is tested in microscale also under cyclic tests. The concrete mixture used in the tests is compared as function of the load condition and the scale. To define the scale effect different tests are conduced on conventional (macroscale) with scaling mixture. The mixture characteristics are defined with load tests but also on consideration of image scans of the specimens or drill cores.

Computer Tomography

Segmentation of concrete phases

For concrete based material, the segmentation of computer tomography scans, namely the separation between components (e.g. concrete-aggregate), is complicated due to similar radiological properties of the material. In order to simplify the image processing procedure and at the same time analyze concrete with different properties, contrast enhancers and homogeneous aggregate particles are used in the concrete mixture. Hence, to segment concrete casted with different aggregate shape, from one side the contrast enhancers are used to affect the attenuation coefficient (capacity of a material to be penetrated from x-rays) of cement and on the other side for broken aggregate concrete are used ones with higher density.

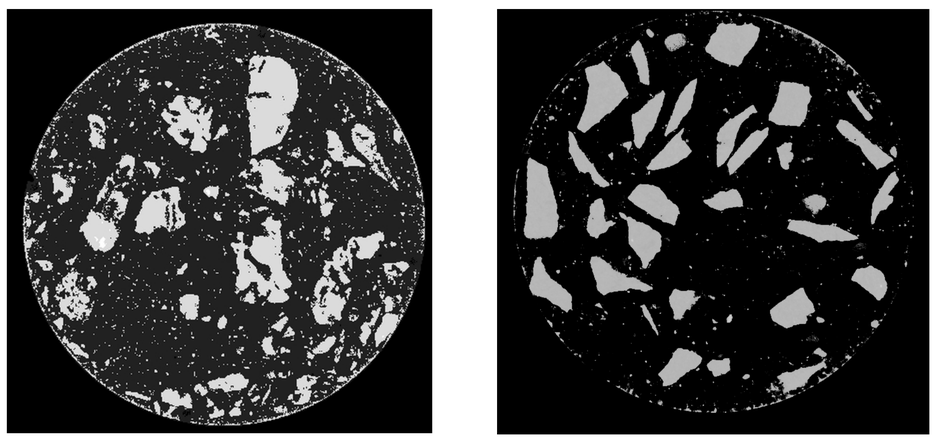

Figure 2: Computer tomography scan section of diabase (left) and basalt (right) aggregate concrete.

Double shear tests

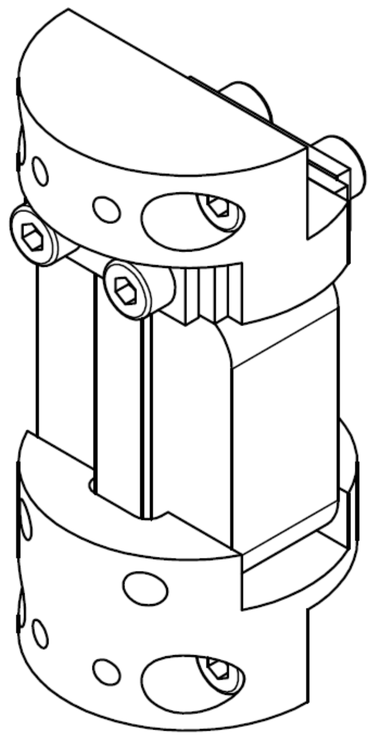

Figure 3: Double lap shear test in micro scale

To study the deformations on the strips and in the concrete, the tests are carried out in CT. To avoid interferences with the restraining framework material, e.g. steel that present great density differences to concrete, a carbon FRP sheet jacket applied on the concrete specimen. In this way is possible to restrain the specimen with screws from the bottom. In the double shear tests the debonding on broken and round aggregate is tested. The specimens present different water cement ratio as well as different scales.

The stress flux between concrete and CFRP strip is calculated on the real cracked surface and not as usual in the fictive regular line of the epoxy.

Reference

Lunardelli M., Leusmann T., Budelmann H.: Improvement of debonding behavior among low strength concrete and externally bonded CFRP In: 8th International Conference on FRP Composites in Civil Engineering (CICE 2016): 14-16 December 2016.