Strengthening of Shear Walls - DTU Orbit (06/12/2018)

**Strengthening of Shear Walls: A Fracture Mechanical Approach**

The theory for concrete structures strengthened with fiber reinforced polymer materials has been developing for approximately two decades, and there are at the present time numerous guidelines covering strengthening of many commonly encountered structural building elements. Strengthening of in-plane loaded walls and disks is however not included in any guidelines, and only a small fraction of scientists have initiated research within this topic. Furthermore, studies of the principal behavior and response of a strengthened disk has not yet been investigated satisfactorily, and this is the principal problem treated in this thesis.

By using non-linear fracture mechanics for analysis of a strengthened disk, it is possible to extract detailed information of the fracture processes when an in-plane load is applied. To enable a simple but accurate analysis of a strengthened disk, a tool has been developed that describes a unit width strip of a strengthened disk. The unit width strip is named a strengthened concrete tension member and contains a single tensile crack and four debonding cracks. Analysis of the member results in closed form expressions for the load-crack opening relationship. Further analysis of the response, results in the ability to determine and characterize the two-way crack propagation, i.e. the relationship between tensile cracking in the concrete and interface debonding between strengthening and concrete.

Using the load-crack opening relationship from the strengthened concrete tension member and dividing it with the total disk thickness, an effective cohesive law is obtained. The effective cohesive law will include non-linear effects from both tensile cracking and interface debonding. This facilitates use of the response of the strengthened concrete tension member as a pseudo material law. If a strengthened disk is modeled with the effective cohesive law, it will allow for 3D effects to be modeled in 2D, since the effective cohesive law will contain all information about tensile cracking and interface cracking.

Analyzing and comparing a half-infinite strengthened concrete disk in a 3D finite element model with a 2D finite element model using an effective cohesive law, shows a good correlation. All different aspects of the non-linear behavior, including tensile crack propagation, load prediction, size of debond, crack opening and global behavior including snap-back were captured in the 2D model. The research suggests that the 2D model paired with the effective cohesive law can be used as a substitute for computationally heavy 3D models of strengthened disks.

For problems concerning strengthened structural members with finite geometry, the theory of the strengthened concrete tension member must be altered to fit the surrounding boundary conditions. The effective cohesive law will then become a function of the investigated structural geometry. A simplified approach for the latter topic was used to predict the load capacity of concrete beams in shear. Results obtained were acceptable, but the model needed further refinement to predict all tendencies seen in tests.

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