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**APPLICATION OF FRACTURE MECHANICS TO  
CONCRETE BRIDGES**

**Finite Element Analyses and Experiments**

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## ABSTRACT

Material models based on fracture mechanics together with non-linear finite element analyses have been used in combination with experiments to study the behaviour of reinforced concrete bridges. The work covers two aspects of interest in the design of concrete bridges.

- The shear behaviour was studied in full-scale tests on two highway bridges. The capacities of the bridges were compared with the shear capacities according to the design model in the Swedish concrete code. Non-linear finite element analyses were performed on one of the bridges tested.
- The reinforcement detailing in frame corners was studied and the alternative of splicing the reinforcement within the corners of a frame bridge was examined in three test series. Non-linear finite element analyses were performed for some of the specimens tested.

The objective of the study was to obtain greater knowledge of the behaviour of concrete bridges for these two aspects, as well as to find out how analyses based on fracture mechanics can be used to improve understanding of this behaviour. A background to the fracture mechanics for concrete and to the models used in the analyses is given.

The results of the full-scale shear tests indicate that the design model for shear can predict the capacity for typical shear failures. However, when a combination of shear and moment actions leads to failure, the test results revealed shortcomings in the design models in the Swedish concrete code. A finite element analysis based on the discrete crack approach was performed successfully up to initiation of the final failure; the analysis showed that the inclined crack leading to failure was initiated at mid-height of the bridge slab.

The tests on frames and frame corners included both monotonic and cyclic loading. Reinforcement detailing suitable for portal frame bridges, and also detailing suitable for civil defence shelters, was studied. The test results did not uncover any drawbacks related to splicing of the reinforcement in the frame corners. Some of the test specimens were analysed using a material model for concrete based on fracture mechanics and the smeared crack approach. The finite element analyses were found to reflect the mechanical behaviour of the specimens tested throughout the failure process; the analysis results were in good agreement with the test results. The results from both the analyses and the tests support the idea that it should be feasible to splice the reinforcement within the corner area of a frame bridge.

The use of fracture mechanics and non-linear finite element analyses has been shown to be a most powerful tool which, together with a limited number of tests, can increase understanding of the failure process in reinforced concrete structures.