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Numerical Prediction of Width Crack of Concrete Dapped-End Beams

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Abstract : Several methods have been utilized to study the prediction of cracking of concrete structural under loading. The finite element analysis is an alternative that shows good results. The aim of this work was the numerical study of the width crack in reinforced concrete beams with dapped ends, these are frequently found in bridge girders and precast concrete construction. Properly restricting cracking is an important aspect of the design in dapped ends, it has been observed that the cracks that exceed the allowable widths are unacceptable in an aggressive environment for reinforcing steel. For simulating the crack width, the discrete crack approach was considered by means of a Cohesive Zone (CZM) Model using a function to represent the crack opening. Two cases of dapped-end were constructed and tested in the laboratory of Structures and Materials of Engineering Institute of UNAM. The first case considers a reinforcement based on hangers as well as on vertical and horizontal ring, the second case considers 50% of the vertical stirrups in the dapped end to the main part of the beam were replaced by an equivalent area (vertically projected) of diagonal bars under. The loading protocol consisted on applying symmetrical loading to reach the service load. The models were performed using the software package ANSYS v. 16.2. The concrete structure was modeled using three-dimensional solid elements SOLID65 capable of cracking in tension and crushing in compression. Drucker-Prager yield surface was used to include the plastic deformations. The reinforcement was introduced with smeared approach. Interface delamination was modeled by traditional fracture mechanics methods such as the nodal release technique adopting softening relationships between tractions and the separations, which in turn introduce a critical fracture energy that is also the energy required to break apart the interface surfaces. This technique is called CZM. The interface surfaces of the materials are represented by a contact elements Surface-to-Surface (CONTA173) with bonded (initial contact). The Mode I dominated bilinear CZM model assumes that the separation of the material interface is dominated by the displacement jump normal to the interface. Furthermore, the opening crack was taken into consideration according to the maximum normal contact stress, the contact gap at the completion of debonding, and the maximum equivalent tangential contact stress. The contact elements were placed in the crack re-entrant corner. To validate the proposed approach, the results obtained with the previous procedure are compared with experimental test. A good correlation between the experimental and numerical Load-Displacement curves was presented, the numerical models also allowed to obtain the load-crack width curves. In these two cases, the proposed model confirms the capability of predicting the maximum crack width, with an error of ± 30 %. Finally, the orientation of the crack is a fundamental for the prediction of crack width. The results regarding the crack width can be considered as good from the practical point view. Load-Displacement curve of the test and the location of the crack were able to obtain favorable results.

Keywords : cohesive zone model, dapped-end beams, discrete crack approach, finite element analysis
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