A NONLINEAR BOND-SLIP ANALSYSI OF DEBONDING OF FRP REINFORCED CONCRETE BEAMS

Jialai Wang

Department of Civil Engineering
North Dakota State University
Fargo, ND 58105-528
Jialai.Wang@ndsu.edu

External bonding of FRP plates or sheets has emerged as a popular method for strengthening reinforced concrete. Debonding along the FPR-concrete interface can lead to premature failure of the structure. In this study, a bond-slip analysis is established to study the interface debonding induced by a flexural crack in FPR-plated concrete beam. The reinforced concrete beam and FRP plate are modeled as two linearly elastic Euler-Bernoulli beams bonded together through a thin layer of FRP-concrete interface. The interface layer is essential modeled as a large fracture processing zone of which the stress-deformation relationship is described by a nonlinear bond-slip model. Three different bond-slip models (bi-linear, triangular and linear-damaging) are used. By dividing the debonding process into several stages, governing equations of interfacial shear and normal stresses are obtained. Closed-form solutions are then obtained for the interfacial shear and normal stresses and the deflection of the beam in each stage of debonding. In such a way, the proposed model unifies the whole debonding process, including elastic deformation, debonding initiation and growth, into one model. With such a superior feature, the proposed model provides an efficient and effective analytical tool to study FRP-concrete interface debonding.

To better understand the debonding behavior of FPR-concrete interface, numerical results and parametric studies of the bond-slip model are also presented. Numerical verification is first carried out through comparing the present analytical solutions with that of finite element analysis. Excellent agreement has been achieved by these two methods. A cracked concrete beam reinforced by FRP plate under three point bending load is then examined in details for each stage of the whole debonding process. It is found that debonding only initiates from one side to the crack and propagates to the nearer support. Numerical results reveal that triangular and linear-damaging bond-slip models provide good upper and lower bound estimations of the ultimate load for the plated beam, respectively. Parametric studies are carried out to illustrate the effects of the bond-slip shape, thickness of FRP plate and the crack size on the debonding. Some interesting phenomena have been identified which shed new lights on the debonding process of the FRP-concrete interface.

Keywords: composites; concrete; debonding