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3D Non-Linear Analyses by Using Finite Element Method about the Prediction of the Cracking in Post-Tensioned Dapped-End Beams

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Abstract : In recent years, for the elevated viaducts in Mexico City, a construction system based on precast/pre-stressed concrete elements has been used, in which the bridge girders are divided in two parts by imposing a hinged support in sections where the bending moments that are originated by the gravity loads in a continuous beam are minimal. Precast concrete girders with dapped ends are a representative sample of a behavior that has complex configurations of stresses that make them more vulnerable to cracking due to flexure–shear interaction. The design procedures for ends of the dapped girders are well established and are based primarily on experimental tests performed for different configurations of reinforcement. The critical failure modes that can govern the design have been identified, and for each of them, the methods for computing the reinforcing steel that is needed to achieve adequate safety against failure have been proposed. Nevertheless, the design recommendations do not include procedures for controlling diagonal cracking at the entrant corner under service loading. These cracks could cause water penetration and degradation because of the corrosion of the steel reinforcement. The lack of visual access to the area makes it difficult to detect this damage and take timely corrective actions. Three-dimensional non-linear numerical models based on Finite Element Method to study the cracking at the entrant corner of dapped-end beams were performed using the software package ANSYS v. 11.0. The cracking was numerically simulated by using the smeared crack approach. 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 longitudinal post-tension was modeled using LINK8 elements with multilinear isotropic hardening behavior using von Misses plasticity. The reinforcement was introduced with smeared approach. The numerical models were calibrated using experimental tests carried out in “Instituto de Ingeniería, Universidad Nacional Autónoma de México”. In these numerical models the characteristics of the specimens were considered: typical solution based on vertical stirrups (hangers) and on vertical and horizontal hoops with a post-tensioned steel which contributed to a 74% of the flexural resistance. The post-tension is given by four steel wires with a 5/8’’ (16 mm) diameter. Each wire was tensioned to 147 kN and induced an average compressive stress of 4.90 MPa on the concrete section of the dapped end. The loading protocol consisted on applying symmetrical loading to reach the service load (180 kN). Due to the good correlation between experimental and numerical models some additional numerical models were proposed by considering different percentages of post-tension in order to find out how much it influences in the appearance of the cracking in the reentrant corner of the dapped-end beams. It was concluded that the increasing of percentage of post-tension decreases the displacements and the cracking in the reentrant corner takes longer to appear. The authors acknowledge at “Universidad de Guanajuato, Campus Celaya-Salvatierra” and the financial support of PRODEP-SEP (UGTO-PTC-460) of the Mexican government. The first author acknowledges at “Instituto de Ingeniería, Universidad Nacional Autónoma de México”.

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