Proceedings of the International Conference on Civil, Structural and Transportation Engineering
Ottawa, Ontario, Canada, May 4 – 5, 2015
Paper No. 303

Numerical Modelling of Transfer Length for Precast Prestressed Concrete Beams

Chadon Lee, Songhee Lee
Chung-Ang University, School of Architecture and Building Science
84 Heukseok-Ro, Dongjak-Gu, Seoul, Korea
cdlee@cau.ac.kr; sh86136@naver.com

Extended Abstract

Prestressing force is transferred to surrounding concrete by the bond stress. Near the ends of the member, a distance from the beam end to a section with effective prestress level is known as transfer length. Transfer length needs to be accurately predicted in precast prestressed concrete members. Underestimated transfer length may cause the risk of cracking at the ends due to higher stresses than expected one. Overestimation may reduce shear and moment capacity of the member at the ultimate state. However most existing equations (ACI Committee 318-11, 2011, Mitchell et al. 1993) are based on crude estimations, excluding some of the influencing parameters on transfer length such as bond strength-related ones, the surface condition of prestressing steels, the diameter of the prestressing steel (d_p), concrete compressive strength (f_c') and bond stiffness (k), and initial prestress (f_{pi}) (Kose, 2007).

In this research, a numerical model of transfer length has been developed. The model considers a pretensioned straight steel tendon embedded and centered in prismatic rectangular section with a finite length of concrete beam. The model is developed based on the following assumptions: 1) no displacement occurs at the mid-span of the beam by the symmetric beam geometry; 2) the bond strength between prestressing steels and surrounding concrete can be modelled with discrete springs; and 3) all materials are in elastic condition.

The model employs discrete springs simulating a lump sum of bond stresses between prestressing steel and surrounding concrete to represent bond strength along the span. The springs are activated by relative displacement (i.e., slip) of prestressing steels with respect to a surrounding concrete at each node. Formulations are given for the equilibrium of discrete linear steel element and the equilibrium and compatibility conditions at element nodes. For the given member geometry, initial prestress and material properties, the nodal displacements are first found. The transfer length was then estimated as the distance from the end of the beam to the node with negligible displacement. The model was able to simulate the transfer length for different prestressing conditions and the effects of different parameters on transfer length. Parametric studies were then performed using the developed model. Considered parameters were concrete strength, diameter of the tendon, initial prestress, bond stiffness, and beam length. It was found that the bond stiffness is the most influencing factor affecting transfer lengths.

ACI Committee 318-11 (2011), Building code requirements for structural concrete (ACI 318-11) and commentary (318R-11). American Concrete Institute, Farminton Hills, March.

Kose M.M. (2007) Prediction of transfer length of prestressing strands using neural networks. ACI Structural Journal. 104(2), 162-169

Mitchell D., Cook W.D., Khan, A., and Thanm T. (1993). Influence of high strength concrete on transfer and development length of pre-tensioning strand. PCI J. 38(3), 52-55