Analytical Model for Prediction of Flexural Behaviors of PC Girder

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Abstract

Structural behaviors of concrete structures after cracking cannot be predicted by elastic theory. Material and/or geometrical nonlinearity must be taken into account. Many researchers proposed analytical tools using a nonlinear finite element model but the process is time consuming. This paper proposes a simplified analytical model to predict flexural behaviors of full-scale prestressed concrete (PC) girder under static loading. Moment-curvature relationship (M-ϕ diagram) of a concrete beam section has been developed then the load deflection relationship can be determined by using effective flexural rigidity (EI_e) calculated from M-ϕ diagram. Full scale test of Type III AASHTO highway girder with 20cm thick topping slab was performed. Analytical results were validated and found to be in good agreement with experimental results. This simplified model developed by the authors can also be applied to reinforced concrete (RC) or PC beam.

Keywords: Moment-curvature, effective flexural rigidity, Pretension.

1. Introduction

Flexural behavior of reinforced or prestressed concrete beams before cracking of the concrete section can be predicted precisely by elastic theory based on uncracked or gross section. RC beams generally crack at an applied load less than working load when tensile stress in concrete reaches its tensile strength expressed in terms of modulus of rupture. Cracking is delayed by precompressed compression force applied to concrete in PC beam so a crack may not occur at service loading condition. In some cases tension might be allowed in the PC member but crack cannot be permitted since it reduces sectional properties from gross section to cracked section leading to undesirable deflection and crack width. Flexural behaviors in terms of load deformation diagram of RC or PC members after cracking cannot be predicted accurately by elastic theory using gross section, since crack sectional properties change every step of applied load. Material nonlinearity of concrete and steel must be taken into account. Due to this reason, method to predict flexural behaviors under applied load after cracking of RC or PC members is quite difficult. An approximate method by means of nonlinear finite element model is used or developed by previous researchers but the process is complex and time consuming[1]. In this work, a simplified method is proposed and a full-scale test of a 12m span of standard AASHTO Type III I girder is done to verify the analytical results. Moment-curvature diagram of concrete section, RC or PC, is developed first and then the load-deflection diagram can be constructed and verified with experimental results of full-scale PC girder.

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