Toward Rational Curvature of Reinforced Concrete Members

Ayman EMBABY
Structural Engineer
Professor Ain-Shams University
Senior Engineer, Dar-al-Handasah
Ayman.Embaby@dargroup.com

Ayman Embaby, born 1960,
B.Sc. 1983, Ain Shams University, Egypt
M.Sc. 1987,Ain Shams University, Egypt
Ph.D. 1994 McMaster University, Canada

SUMMARY

Rational estimate of curvature for reinforced concrete elements is one of the most challenging problems in predicting service, and ultimate responses. A proposed formula for the secant curvature of bending element; namely beams is presented for the calculation of the element deflection. Moreover, axial load-curvature relationship was proposed for axially loaded element to rationalize the determination of columns mid-height deflection. Assuming a sinusoidal deflected shape along with satisfying the compatibility and equilibrium conditions at mid-high section the secondary moment of the columns can be predicted. The predicted deflection by adopting the first formula was compared with ACI code as well other formulae and the strip method and proved to give consistent, and conservative results. The axial capacity using curvature-axial load relationship was compared with strip method, as well as Euro Code provisions, and proved to give conservative results.

Keywords: Curvature, deflection, secondary moment, columns

1. Introduction

Regarding the serviceability limit, the historical formula derived by Branson (1963) to predict what is called effective moment of inertia (I_{eff}) for reinforced concrete sections is currently considered as the core of predicting the deflection in ACI 318 and other code provisions. The effective inertia (I_{eff}) represents intermediate value between un-cracked sections, and cracked sections. The well-known formula in its general expression is expressed as follows:

$$I_{eff} = (\frac{M_{cr}}{M_a})^a \cdot I_{gr} + (1 - \frac{M_{cr}}{M_a})^a I_{cr} \quad (1)$$

Where M_{cr}, and M_a are the cracked, and the applied moment, I_{gr}, and I_{cr} are cracked, and gross moment of inertia of the section. The parameter (a) was taken equal to 3. In the ACI Code, it is permitted to take the value obtained from Eq. (1) at mid-span section for simple, and continuous spans, and at support for cantilever.

Several attempts have been dedicated to improve this equation to capture the moment distribution across the beam length, as well as the mechanistic behaviour of the beam. Based on experimental results of 200mm square section with 0.4% of the balanced reinforcement, Al-Zaid, et. Al., 1991 proposed the following equation to predict I_{eff}:

$$I_{eff} = (\frac{L_{cr}}{L})^a \cdot I_{cr} + (1 - \frac{L_{cr}}{L})^a I_{cr} \quad (2)$$

Where, L, and L_{cr} are un-cracked and cracked length of the member, respectively. The power (a), was taken equal to (M_{cr}/Ma). A ±15% differences were reported between experimental results, and the proposed model for more than 95% of the checked values. Bischoff (2005), based on spring analogy for the cracked, and the un-cracked lengths along the beam suggested that these two zones of stiffness need to be modelled as two springs in series, rather than in parallel as in Branson formula. Accordingly the following formula was proposed:

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