Modeling of Reinforced Concrete Sub-frame Under Cyclic Load Reversals

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A study of the strength and deformation characteristics of reinforced concrete structure under cyclic load reversals by means of a computational model is presented in this article. A beam-column sub-frame tested under reversed cyclic loading at NTU, Singapore was modeled and analyzed using strut-and-tie method to capture its cyclic hysteretic responses and to explore the possible force flows from beam and column to the joint core. The model was developed based on crack patterns observed on the tested concrete specimen, and was analyzed using DRAIN-2DX. The modeling procedure for different truss elements of the model is described herein. The analytical study reveals that the strut-and-tie method is capable of modeling to a satisfactory accuracy the cyclic hysteretic response of a reinforced concrete structure observed in the full-scale test.

Keywords  Strut-and-tie; Modeling; Cyclic; Computer Analysis

1. Introduction

The strut-and-tie approach is a physical method that involves modeling the reinforced concrete member as a truss structure. The complex stress fields inside the structural members when subjected to external forces are simplified into discrete compressive and tensile force paths, which are represented, respectively, by compression struts and tension ties. The longitudinal reinforcement in a member represents the chords of a truss while the transverse reinforcement serves as transverse ties. Concrete in the flexural compression zone can also be considered as part of the longitudinal compression chord member. The diagonal concrete compression struts, which discretely simulate the concrete compressive stress field, are placed to complete the static equilibrium of the truss. These struts and ties are connected at rigid nodal points. With the aid of such a behavioral model, a better visualization and understanding of the internal force distribution and force transfer mechanisms are thus feasible.

The strut-and-tie modeling approach is not only capable of predicting the strength of a localized region in a structure, but also equally applicable to predicting the strength of the entire structure. This method is also appropriate and effective in the analysis and detailing of complex structural regions. However, the utilization of this method to capture the non-linear inelastic and cyclic hysteretic responses of a concrete structure is rather limited. To