Green Building, Materials and Civil Engineering

Editors: Jimmy C.M. Kao, Wen-Pei Sung & Ran Chen

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Preface

On the successful basis of GBMCE 2011, 2012, 2013, the 2014 4th International Conference on Green Building, Materials and Civil Engineering (GBMCE) was held August 21–22, 2014 in Taiwan. The aim was to provide a platform for researchers, engineers and academics as well as industry professionals from all over the world to present their research results and development activities in green building, materials and civil engineering. The conference aims mainly at promoting the development of green building, materials and civil engineering, strengthening the international academic cooperation and communications, and exchanging research ideas. Submitted conference papers were reviewed by technical committees of the conference.

This book brings together 190 peer-reviewed papers on Green Building, Energy, Environment, Materials and Civil Engineering. This book provides the readers a broad overview of the latest advances in the field of Materials, Energy, Environment and Civil Engineering. We hope that this collection of papers will contribute in stimulating debate among scholars, researchers and academics and that you find them interesting and thought-provoking.

On behalf of the guest editors for this conference proceeding, we would like to thank the conference organization staff, and the members of the International Technological Committee for their hard work. We look forward to seeing all of you next year at GBMCE 2015.

Wen-Pei Sung
National Chin-Yi University of Technology
August, 2014

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Analysis of reinforced concrete building structures using simple models

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ABSTRACT: This paper presents a finite element method to solve the axial, shear and moment coupled model for analysis of nonlinear structures. The Timoshenko fiber beam element was formulated according to force-based approach. The geometric nonlinearity or the P-Delta effect is considered in the formulation. The model is general and described for cyclic loading. The developed technique is useful to analyze structural components with any type of material. Comparisons with experimental results showed very good predictions with the numerical model. Both prepeak and post peak behavior was predicted well.

Keywords: finite element, beam model, P-Delta, nonlinear analysis

1 INTRODUCTION

The finite element analysis has become an important tool for understanding the behavior of structures. Fiber beam models are simplified versions of the finite element method used to reduce the computational cost. Fiber beam models use detailed geometry and material models to obtain an accurate representation of yielding and nonlinear behavior along the length of the member. Details of the section and geometry of the structural component and properties of the materials are essential components to build the fiber models; generally they are available and simple to obtain. Fiber models are also computationally efficient because of their minimal storage and processing requirements.

The analysis of Reinforced Concrete (RC) structures is highly nonlinear due to nonlinear nature of material and composite action of the concrete and steel materials. Various modeling approaches have been taken, differing such as constitutive modeling, formulation (displacement based, force based) and element preference (continuum model, lumped model, fiber model) (Vecchio & Collins 1986, Hsu & Zhu 2002, Balakrishnam & Murray 1988, Niwa et al. 1981, Barzerar & Schnobrich 1986, Stevens et al. 1987). In this research fiber model approach was used. The fiber model for Reinforced Concrete (RC) structures was developed by dividing each element into several sections along the member (Figure 1). The sections at each end of the element were further divided into several fibers which represent concrete and steel (Bazant & Bhat 1977). The strain in each fiber is calculated from the centroidal section strain and curvature with the help of the plane section remaining plane assumption. The stresses and modulus of fibers were calculated from the fiber strain values. The constitutive relation of the section is derived by integration of the response of the fibers; the response of elements is also derived by integration of the response of sections along the length of the element. Mullapudi & Ayoub (2010a) formulated the displacement and force based two-dimensional (2-D) element based on the Timoshenko beam theory, with a fiber section accounting for axial and shear effects.

The nonlinear model is implemented in a computer program for the static analysis of Reinforced Concrete (RC) structures. This paper focuses on analytical modeling of highly nonlinear structural components with an efficient model which can be used to reduce the run time while maintaining accurate results.

The continuous material models such as microplane models, plasticity models with yield surface deals with several parameters and often needs thorough knowledge of the user and not efficient. Single or multi crack models (de Borst & Nauta 1985; Tots 1988) are useful but the crack pattern need to know in advance and continuous re-meshing is required. The lumped models are computationally efficient but they are unable to consider the gradual spread of nonlinearity along member length and uncertainties exist in assigning the required parameters of the model (Kanaan & Powell, 1973). In this research smeared crack approach with fiber formulation is used which is an efficient method while maintaining the required accuracy. For strain softening, the results with the fiber beam element are mesh dependent and as the size of the element reduces to zero, displacements localize into regions with zero volume (Bazant 1976). In this research, mesh sensitivity is conducted to simulate the experimental results.