Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 5, No. 10, October, 2019

Non-Smooth Behavior of Reinforced Concrete Beam Using Extended Finite Element Method

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Received 13 May 2019; Accepted 17 September 2019

Abstract

Flexure members such as reinforced concrete (RC) simply supported beams subjected to two-point loading were analyzed numerically. The Extended Finite Element Method (XFEM) was employed for the treatment the non-smooth h behaviour such as discontinuities and singularities. This method is a powerful technique used for the analysis of the fracture process and crack propagation in concrete. Concrete is a heterogeneous material that consists of coarse aggregate, cement mortar and air voids distributed in the cement paste. Numerical modeling of concrete comprises a two-scale model, using mesoscale and macroscale numerical models. The effectiveness and validity of the Meso-Scale Approach (MSA) in modeling of the reinforced concrete beams with minimum reinforcement was studied. ABAQUS program was utilized for Finite Element (FE) modeling and analysis of the beams. On the other hand, mesoscale modeling of concrete constituents was executed with the aid of ABAQUS PYTHON language and programing using excel sheets. The concrete beams under flexure were experimentally investigated as well as by the numerical analysis. The comparison between experimental and numerical results showed that the mesoscale model gives a better indication for representing the concrete models in the numerical approach and a more appropriate result when compared with the experimental results.

Keywords: Extended Finite Element Method; Mesoscale Modeling; Reinforced Concrete Beams; Non-Smooth Behaviour.

1. Introduction

Concrete is the most widely used construction material because of its versatility, durability, sustainability and economy. Concrete is a mixture of aggregates and sand held together by a binder of cementitious paste. The paste is typically made up of Portland cement and water and may also contain supplementary cementing materials (SCMs), such as fly ash or slag cement, and chemical admixtures. To represent the mechanical behavior of this material precisely, it must be treated as a multiphase material, and its behavior should be like material like concrete as a result from the behavior of these components taken together. Many scales in modeling are used to represent the heterogynous material like concrete such as macro, meso and micro scale modelling. In the traditional numerical modeling, concrete was modelled using the macroscale, whereas, microscale modeling was used in very limited cases. The mesoscale is a scale that falls between the macro-and micro-scales [1]. In this paper, two reinforced concrete beams with dimension (350×200×2200) mm were subjected to two-point loads and analyzed numerically using the XFEM. The results of this analysis were compared with the experimental results of the same reinforced concrete beam with approximately the same composition.

In general, meso-scale modeling can be classified into two types: (1) The continuum models, (2) The lattice models.

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http://dx.doi.org/10.28991/cej-2019-03091408