**Coupled Systems Mechanics,** *Vol. 8, No. 4 (2019) 289-298*
DOI: https://doi.org/10.12989/csm.2019.8.4.289 

# Mesoscopic analysis of reinforced concrete beams

Tintu Shine A.L.[1a], Fincy Babu[2b] and Dhileep M.[*3]

[1]*Department of Civil Engineering, Viswajyothi College of Engineering and Technology, Ernakulam, India*
[2]*Kerala Rural Water Supply and Sanitation Agency, Kerala, India*
[3]*Department of Civil Engineering, Muthoot Institute of Technology & Science, Ernakulam, India*

*(Received January 13, 2019, Revised May 11, 2019, Accepted May 17, 2019)*

**Abstract.** Reinforced concrete can be considered as a heterogeneous material consisting of coarse aggregate, mortar mix and reinforcing bars. This paper presents a two-dimensional mesoscopic analysis of reinforced concrete beams using a simple two-phase mesoscopic model for concrete. The two phases of concrete, coarse aggregate and mortar mix are bonded together with reinforcement bars so that inter force transfer will occur through the material surfaces. Monte Carlo's method is used to generate the random aggregate structure using the constitutive model at mesoscale. The generated models have meshed such that there is no material discontinuity within the elements. The proposed model simulates the load-deflection behavior, crack pattern and ultimate load of reinforced concrete beams reasonably well.

**Keywords**: mesoscopic analysis; reinforced concrete beam; deep beam; two-phase

## 1. Introduction

Concrete is the most widely used material for construction. It is a composite material with complex behavior and a highly heterogeneous microstructure. For obtaining a better understanding of the macroscopic constitutive behavior of concrete, the effects of microstructure and properties of the individual components of concrete on the macroscopic material behavior have to be taken into account. Mesoscopic models have proven to be the most practical and useful approach to study the nonlinear behavior of concrete composition on the macroscopic properties (Nagarajan *et al.* 2010). A numerical approach to investigate the property of concrete at the mesoscopic level is given by Roelfstra (1989). A method of random computer generation of the particle system meeting the prescribed particle size distribution was developed by Bazant *et al.* (1990), using the assumption that the particles are elastic in nature and have only axial interactions, as in a truss. A lattice model is presented by Schlangen and Mier (1992) for the simulation of typical failure mechanism and crack face bridging in concrete. The influence of lattice element type and lattice orientation on the fracture pattern (Schlangen and Garboczi 1997) was investigated by simulating a shear loading experiment on a concrete plate.

A random aggregate generation procedure based on Monte Carlo's simulation principle was

∗Corresponding author, Associate Professor, E-mail: dhileepm@mgits.ac.in
[a]Assistant Professor, E-mail: tintus@vjcet.org
[b]Project Commissioner, E-mail: fincybabu@yahoo.com


http://www.techno-press.org/?journal=csm&subpage=8 ISSN: 2234-2184 (Print), 2234-2192 (Online)

https://doi.org/10.12989/imm.2010.3.1.023

Prasad, B.K.R. and Sagar, R.V. (2006), "Numerical modeling of fracture and size effect in plain concrete", *Inst. Eng. India J.*, **86**(2), 182-186.

Rodrigues, E.A., Manzoli, O.L., Bitencourt Jr, L.A.G. and Bittencourt, T.N. (2016), "2D mesoscale model for concrete based on the use of interface element with a high aspect ratio", *Int. J. Solid Struct.*, **94-95**, 112-124. https://doi.org/10.1016/j.ijsolstr.2016.05.004.

Roelfstra, P.E. (1989), "A numerical approach to investigate the properties of concrete-numerical concrete", Ph.D. Thesis, EPFL, Lausanne, Switzerland.

Sagar, R.V., Prasad, B.K.R and Karihaloo, B.L. (2010), "Verification of the applicability of lattice model to concrete fracture by AE study", *Int. J. Fract.*, **161**(2), 121-129. https://doi.org/10.1007/s10704-009-9431-7.

Schlangen, E. and Garboczi, E.J. (1997), "Fracture simulations of concrete using lattice model, computational aspects", *Eng. Fract. Mech.*, **57**(2/3), 319-332. https://doi.org/10.1016/S0013-7944(97)00010-6.

Schlangen, E. and van Mier, J.G.M. (1992), "Simple lattice model for numerical simulation of fracture of concrete materials and structures", *Mater. Struct.*, **25**(9), 534-542. https://doi.org/10.1007/BF02472449.

Sreedevi, V.M. (2010), "Development of the mesoscopic structure of concrete for fracture simulation", M. Tech Thesis, National Institute of Technology, Calicut, India.

Wang, X., Yang, Z. and Jivkov, A.P. (2015), "Monte Carlo simulations of mesoscale fracture of concrete with random aggregates and pores: a size effect study", *Constr. Build. Mater.*, **80**, 262-272. https://doi.org/10.1016/j.conbuildmat.2015.02.002.

Wang, Z.M., Kwan, A.K.H. and Chan, H.C. (1999), "Mesoscopic study of concrete I: Generation of random aggregate structure and finite element mesh", *Comput. Struct.*, **70**(5), 533-544. https://doi.org/10.1016/S0045-7949(98)00177-1.

Wriggers, P. and Moftah, S.O. (2006), "Mesoscale models for concrete: Homogenisation and damage behavior", *Finite Elements Anal. Des.*, **42**, 623-636. https://doi.org/10.1016/j.finel.2005.11.008.

Ying, Z.Q., Du, C.B. and Sun, L.G. (2007), "Mesoscopic numerical simulation method for fracture of concrete", *Key Eng. Mater.*, **344-345**, 213-216.

*CC*