Accepted Manuscript

A Two-Scale Stochastic Framework for Predicting Failure Strength Probability of Heterogeneous Materials

Manik Bansal, I.V. Singh, B.K. Mishra, Kamal Sharma, I.A. Khan

PII: S0263-8223(17)31508-8
DOI: http://dx.doi.org/10.1016/j.compstruct.2017.07.044
Reference: COST 8699

To appear in: *Composite Structures*

Received Date: 12 May 2017
Revised Date: 7 July 2017
Accepted Date: 17 July 2017

A Two-Scale Stochastic Framework for Predicting Failure Strength Probability of Heterogeneous Materials

Manik Bansal[#], I.V Singh[#*], B.K. Mishra[#], Kamal Sharma[$] and I.A. Khan[$]

[#]Department of Mechanical and Industrial Engineering,
Indian Institute of Technology Roorkee, Roorkee 247667, Uttarakhand, India,
Phone: 91-1332-285888, Fax: 91-1332-285665
[$]Reactor Structures Section, Reactor Safety Division, BARC, Mumbai, India
[*]Corresponding author. E-mail: indrafme@iitr.ac.in

ABSTRACT

In the present study, a two-scale stochastic framework has been proposed for predicting the failure strength probability of heterogeneous materials. The analysis at both scales (meso and macro) is performed under plane stress condition. The meso-scale analysis is performed by XFEM whereas the macro-scale analysis is performed by FEM. The heterogeneities (pores and reinforced particles) are considered at meso-scale. The effect of shape, size, clustering and volume fraction of heterogeneities is analyzed at meso-scale. A new scheme is developed for modeling the arbitrary shape heterogeneities using periodic B-splines. An adaptive hanging node mesh refinement technique is employed to reduce the computational cost. Maximum principal stress failure criterion has been implemented for modeling both tensile and compressive behaviors at meso-scale. The volume fraction of pores and reinforcement particles is distributed stochastically to the elements at macro-scale. The average volume fraction of the pores is taken as 8%, 10%, 12% and 14% whereas the average volume fraction of the reinforced particles is kept constant at 20%. The statistical analysis of numerical data is performed through normal and Weibull distribution fits. K-S goodness of fit predicts that the numerical data is better fitted by the normal distribution.

Keywords: Stochastic analysis; Tensile strength; Compressive strength; Elastic modulus; Arbitrary shape heterogeneities; XFEM; Adaptive hanging node

1. INTRODUCTION

Due to high strength to weight ratio, the composite materials are widely used in engineering applications. The composite materials dominate the aerospace, defense and energy sectors due to their good strength, creep, fatigue and wear resistance at higher temperatures (Barekar *et al.*, 2009) as compared to metals and alloys (Junior *et al.*, 2009). Some of the prominent materials like ceramic composites (Grigoriev *et al.*, 2010) and nuclear graphite (Murti and Charit, 2008) are suitable for high temperature applications. These materials possess brittle or quasi-brittle behavior with a large scatter in strength (Nemeth *et al.*, 2010; Tracy and Daly,