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Editorial

Preface

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Abstract. The Special Issue contains six peer -reviewed papers. The papers cover various aspects of computational models of material failure which has been the topic of this special issue. The prediction of fracture and failure of engineering systems and materials has been of interest for many years. Methods to predict material failure can be categorized into continuous approaches to fracture and discrete crack approaches. Gradient-enhanced models, non-local models and phase field models are among the most common representatives of the first class of methods while the extended finite element method (XFEM), meshfree methods, peridynamics or efficient remeshing techniques belong to the latter type. The published papers cover several new methodological aspects of computational methods such as the cracking element method presented by Sun et al., the coupled SFEM-SBFEM by Surendran et al. or new fracture criteria in the context of peridynamics suggested by Zhao. Some contributions also focus on application of computational methods to predict material failure in concrete.

Special Issue: Computational Methods for Material Failure.

1. Introduction

The Special Issue contains six peer-reviewed papers. The papers cover various aspects of applied and computational methods for material failure, including Peridynamic, Self-healing concrete, Autogenous healing, Edge based smoothed finite element method, Scaled boundary finite element method, Cracking elements method, Fracture analysis, Quasi-brittle material and Material nonlinear analysis.

2. Authors and abstracts

1. Jinhai Zhao
Modelling of Crack Growth Using a New Fracture Criteria Based Peridynamics
Peridynamics (PD) is a nonlocal continuum theory based on integro-differential equations without spatial derivatives. The elongation fracture criterion is implicitly incorporated in the PD theory, and fracture is a natural outcome of the simulation. On the other hand, a new fracture criterion based on the crack opening displacement combined with peridynamic (PD-COD) is proposed. When the relative deformation of the PD bond between two particles reaches the critical crack tip opening displacement of the fracture mechanics, we assume that the bond force vanishes. The new damage rule of fracture criteria similar to the local damage rule in conventional PD is introduced to simulate the fracture. In this paper, first, a comparative study between XFEM and PD is presented. Then, four examples, i.e., a bilateral crack problem, double parallel crack, monoclinic crack, and the double inclined crack are given to demonstrate the effectiveness of the new criterion.

2. Chahmi Oucif, Kheira Ouzaa, Luthfi Muhammad Mauludin
Cyclic and Monotonic Behavior of Strengthened and Unstrengthened Square Reinforced Concrete Columns
The use of composite materials is an effective technique to enhance the capacity of reinforced concrete columns subjected to the seismic loading due to their high tensile strength. In this paper, numerical models are developed in order to predict the

experimental behavior of square reinforced concrete columns strengthened by glass fiber reinforced polymer and steel bars and unstrengthened column under cyclic and monotonic loadings, respectively. Two columns are modeled in the present work. The first one corresponds to the column without strengthening subjected to lateral monotonic loading, and the second one corresponds to the column strengthened by glass fiber reinforced polymer and steel bars subjected to lateral cyclic loading. Comparison of the numerical modeling and the experimental laboratory test results are performed and discussed. A good agreement between the numerical and experimental force-displacement responses is obtained. Moreover, improvements in the strength of the reinforced concrete column subjected to the cyclic loading along with the comparison of the behavior of the strengthened column with the unstrengthened reference column are discussed. The results show a good improvement in the load carrying capacity and ductility of the column. The main objectives of this numerical modeling are to contribute the comprehension of the monotonic and cyclic behavior of the square reinforced concrete columns and to compare the numerical results with the experimental ones.

3. Luthfi Muhammad Mauludin, Chahmi Oucif

Modeling of Self-Healing Concrete: A Review

Self-healing concrete (SHC) has received a tremendous attention due to its advanced ability of automatic crack detection and crack repairing compared to the standard concrete. Two main approaches which considered as to-date self-healing mechanisms are autogenous and autonomous healing. In the past several years, the effort of the research has been focused on experimental works instead of numerical models to simulate the healing process. The purpose of this study is to provide a comprehensive comparison of different self-healing concrete (cement based materials) modeling approaches which are available. In this review, special attention is given to the autonomous healing model and a few of recent works related to the autogenous healing model are also investigated. Moreover, this review covers both analytical and numerical simulation methods of self-healing concrete model.

4. M. Surendran, A.L.N. Pramod, Sundararajan Natarajan

Evaluation of Fracture Parameters by Coupling the Edge-Based Smoothed Finite Element Method and the Scaled Boundary Finite Element Method

This paper presents a technique to evaluate the fracture parameters by combining the edge based smoothed finite element method (ESFEM) and the scaled boundary finite element method (SBFEM). A semi-analytical solution is sought in the region close to the vicinity of the crack tip using the SBFEM, whilst, the ESFEM is used for the rest of the domain. As both methods satisfy the partition of unity and the compatibility condition, the stiffness matrices obtained from both methods can be assembled as in the conventional finite element method. The stress intensity factors (SIFs) are computed directly from their definition. Numerical examples of linear elastic bodies with cracks are solved without requiring additional post-processing techniques. The SIFs computed using the proposed technique are in a good agreement with the reference solutions. A crack propagation study is also carried out with minimal local remeshing to show the robustness of the proposed technique. The maximum circumferential stress criterion is used to predict the direction of propagation.

5. Zizheng Sun, Xiaoying Zhuang, Yiming Zhang

Cracking Elements Method for Simulating Complex Crack Growth

The cracking elements method (CEM) is a novel numerical approach for simulating fracture of quasi-brittle materials. This method is built in the framework of conventional finite element method (FEM) based on standard Galerkin approximation, which models the cracks with disconnected cracking segments. The orientation of propagating cracks is determined by local criteria and no explicit or implicit representations of the cracks' topology are needed. CEM does not need remeshing technique, cover algorithm, nodal enrichment or specific crack tracking strategies. The crack opening is condensed in local element, greatly reducing the coding efforts and simplifying the numerical procedure. This paper presents numerical simulations with CEM regarding several benchmark tests, the results of which further indicate the capability of CEM in capturing complex crack growths referring propagations of existed cracks as well as initiations of new cracks.

6. Himanshu Gaur

A New Stress Based Approach for Nonlinear Finite Element Analysis

This article demonstrates a new approach for nonlinear finite element analysis. The methodology is very suitable and gives very accurate results in linear as well as in nonlinear range of the material behavior. Proposed methodology can be regarded as stress based finite element analysis as it is required to define the stress distribution within the structural body with structural idealization and modelling assumptions. The methodology eliminates the lengthy and tedious procedure of step by step and then iterative procedure adopted classically for nonlinear analysis problems. One dimensional problem of a simple bar loaded axially is solved to formulate the basic principles. Two dimensional problem of a cantilever beam bending and a torsional problem are solved for further demonstrating and strengthening the method. Results of torsional problem are verified with experimental results. The method is applicable for material nonlinear analysis only.

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