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Review of PhD Thesis

Cohesive Particle Model using Discrete Element Method on the Yade Platform

submitted by

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Introduction

The thesis deals with numerical modelling of materials. The models are composed of discrete rigid particles connected by deformable links. The author presents an original approach to modelling of concrete and similar materials under extreme loading that may lead to disintegration (fragmentation) of the material.

The development of concrete structures results in two main areas. 1. Development of new materials with refined composition and excellent mechanical properties and 2. design of advanced structures, where reserves are minimized and qualities of materials are used as much as possible. Numerical modelling is one of the most important design tools, which makes it possible to find an optimal structural arrangement. Therefore the topic of the thesis under consideration is extremely up to date and important for future development of materials subjected to extreme loading and development of advanced concrete structures. Numerical modelling helps to understand the material and structural performance, which leads to better efficiency of experimental works necessary for practical verification of material and structural performance.

Contents of the thesis

The thesis has two main parts and four appendices. The total amount of the submitted thesis exceeds 250 pages; however, a substantial part includes program descriptions and explanations.

In the part 1, the author describes discrete methods in general and compares their advantages and disadvantages with a classical continuum mechanics. Later the work is focused to the discrete element method, formulation of the problem. The mutual interaction

of particles is defined. The attention is paid to important issues - like the detection of collisions, analysis of strains, analysis of stress, integration of motion equations, and presentation of boundary conditions. In the chapter 3, there is a description of a concrete particle model. The individual sections deal with cohesive and non-cohesive contacts, contact parameters and stress analysis. Finally the model calibration is presented.

The second part of the thesis deals with a software implementation of the model using the Yade platform. The architecture of the code and overall organization of the numerical analysis are described. Finally the user's and programmer's manuals are presented.

Appendices are related to problems of programming.

Achieved results

The author developed a material model based on the Discrete Element Method. The general model developed for cohesive materials was then used for concrete. The formulation was implemented to a computer code. The model was calibrated and verified using basic loading situations.

Significance of the thesis for design practice and for future development

The numerical modelling is extremely important for the development of new materials and structures. It can replace a significant portion of experimental work and investigate relations, which could hardly be found in another way. The discrete element model of concrete can fit well the local performance of concrete. The modelling of local effects seems to be the most suitable area for application in practice. It can be concluded that the thesis contains new knowledge in the field of numerical modelling. A new tool for numerical analysis of concrete structures was developed, which can be used for future numerical studies of local performance of concrete structures.

Formal arrangement of the thesis and language standard

The thesis is written formally correctly. The text is transparent, figures are easy to understand and a complete arrangement is well organized. The second part of the thesis could be partly transferred to appendices, but it is only a small comment. The English is correctly used. Only some misprints could be avoided by more detailed spell check.

Comments and recommendations

In the section 2.3.2. Shear strain, there are used two approaches - an incremental algorithm (sect. 2.3.2.1) and a total algorithm (sect. 2.3.2.2.). It would be interesting to explain the advantages of each algorithm and specify when they are suitable for application.

The model is calibrated for basic loading situations; however, an example of an analysis of a real concrete structure is missing. There is a comment in the conclusion that the confidentiality reasons did not allow to show direct applications. This fact unfortunately

reduces the excellent impression of the thesis. At least some results could have been shown.
It would be worth to support the author in his effort to develop his model further more, as he declares in the conclusion.

Conclusion
The submitted thesis describes a particle based model using a Discrete Element Method. The model was implemented using the Yade platform. The author brought new original results and showed his ability to solve complex scientific problems. He satisfied the conditions for the defence of his thesis. Therefore,

I recommend awarding the doctoral degree (Ph.D.) to Mr. Vaclav Smilauer under the condition of the successful defence of his thesis.

Prague, May 27, 2010