Short presentation of research projects

Principal investigator: Prof. Dragan Ribarić
* IP-06-2016-4775 - ASSUMED STRAIN METHOD IN FINITE ELEMENTS FOR LAYERED PLATES AND SHELLS WITH APPLICATION ON LAYER DELAMINATION PROBLEM – ASDEL

Principal investigator: Prof. Ivica Kožar
* 7926 - SEPARATION OF PARAMETER INFLUENCE IN ENGINEERING MODELLING AND PARAMETER IDENTIFICATION – SEPAEMPI

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ASSUMED STRAIN METHOD IN FINITE ELEMENTS FOR LAYERED PLATES AND SHELLS WITH APPLICATION ON LAYER DELAMINATION PROBLEM – ASDEL

Project summary

The ASDEL project is concerned with the development of the novel ways in numerical modeling of the layered plate and shell structures. The basic premise of the project is a combination of the linked interpolation and assumed strain concept of the layered structures with the contact conditions between the layers that may be defined in a variety of ways. Particular emphasis is put on the damage-type delamination involving a mixed-mode cohesive-zone modelling for the contact interface.
Specific objectives of the project are in development of novel lower- and higher-order triangular and quadrilateral plate finite elements based on linked-interpolation and assumed-strain concepts (O1) and in the development of layered plate elements involving rigid and elastic connection between layers (O2) or connections with a cohesive-zone damage-type constitutive laws (O3). Various experimental setups to validate performance of the numerical models were or will be performed including delamination experiments (O4). Than the hopefully successful layered model will be applied to shell structures with flat (O5) or curved shapes (O6).

Principal investigator and team members (University of Rijeka, Faculty of Civil Engineering)

Principal investigator:	Dragan Ribarić
Academic staff:	Gordan Jelenić, Leo Škec
Research Associates/Assistants:	Maedeh Ranjbar, Marin Grbac, Ivan Hlača

Research outcome:

The project ASDEL is actually completing its third year of implementation. Two doctoral students were employed on the project and financed with separate Croatian Science Foundation contracts (DOK-contracts). Regarding the preset objectives some results have already been achieved. Analytical solution for a bi-linear cohesive-zone model in mode-I delamination have been presented in [1, 2] and applied on a model for the standard double cantilever beam test [3]. The results of this model have experimentally been verified in [4]. Plate element models with linked interpolation and assumed strain assumption was tested in the dynamic problems in [5]. Some plate and layered models were presented in international and domestic conferences for theoretical mechanic in Split, Osijek, Zagreb and Krakow (Poland).

References

1. Škec, Leo. "Identification of parameters of a bi-linear cohesive-zone model using analytical solutions for mode-I delamination." Engineering Fracture Mechanics 214 (2019): 558-577.

2. Leo Škec, Giulio Alfano, Gordan Jelenić. "On Gc, Jc and the characterisation of the mode-I fracture resistance in delamination or adhesive debonding. " Engineering Fracture Mechanics 214 (2019): 558-577.

3. Leo Škec, Giulio Alfano and Gordan Jelenić. "Enhanced simple beam theory for characterising mode-I fracture resistance via a double cantilever beam test." Composites Part B 167 (2019): 250–262.

4. Hlača, Ivan, Marin Grbac, and Leo Škec. "Determining Fracture Resistance of Structural Adhesives in Mode-I Debonding Using Double Cantilever Beam Test." Zbornik radova (Faculty of Civil Engenering in Rijeka) 22.1 (2019): 59-74.

5. Grbac, Marin, and Dragan Ribarić. "Natural Frequencies of the Moderately Thick Plate Models with Uniformly Distrubuted Mass." Zbornik radova (Faculty of Civil Engenering in Rijeka) 21.1 (2018): 13-30.

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SEPARATION OF PARAMETER INFLUENCE IN ENGINEERING MODELLING AND PARAMETER IDENTIFICATION – SEPAEMPI

Principal investigator: Prof. Ivica Kožar, D. Sc., Faculty of Civil Engineering, University of Rijeka.

Objective

The material under consideration is a composite material consisting of high performance concrete matrix with embedded (steel) fibers. In order to make an effective model, parameters have to be identified from experiments, e.g., using inverse procedures. The two main project goals are separation of influence of the friction forces in FRC (Fiber Reinforced Concrete) and relating the 3-point bending and pull-out models for fibers (in FRC). Our parameter identification model is going to separate friction forces from plastic forces (straitening of fibers during pull-out) in bond-slip behaviour of fibers.

Numerical model

The novelty of the approach is that no linearization is performed, structure is modelled as a dynamic system described with a system of nonlinear differential equations. The presented mathematical formulation is general and allows for both displacement and force types of loading that could be freely mixed and for simultaneous use of both Kelvin and Maxwell structure elements/cells. The model is based on dynamic systems approach with the solution being a mixture of numerical procedure and symbolic representation.

Novelty of the proposed project is development of a procedure that could separate the influence of certain parameters in the model. There are methods that are already used for that purpose but are not suitable for civil engineering materials because they are based on large data sets. Here, we do not have a vast number of test results; we are going to overcome the problem by producing own experiments and procedures based on a combination of deterministic and stochastic material description.

The main difficulty in determination of parameters and loading is that in most cases they could not be directly measured, e.g., wind loads, and similar. In most cases we measure displacements, velocities or accelerations or a combination.

Special procedure has to be formulated for extraction of relevant parameters from indirect measurements, the so called "inverse procedure". The main difficulty with inverse procedure is that it is generally unstable, i.e., sensitive to errors in measurements. The new model presents a generalization of the previous model since now we are dealing with a mixture of deterministic (bending formulation) and stochastic parameters (fiber pull-out behaviour). It is a novel numerical model for steel-fiber reinforced concrete under static and dynamic loading.

Additional aspects

In addition, our model for concrete will be generalized with formulation of the forward and inverse problem for description of viscosity in asphalt mixtures. In addition, we will try to apply our novel method for formulation of an inverse model capable of exposing the dependence between various model parameters and their influence onto the total creep behaviour of concrete; this objective is supposed to be extremely difficult due to a large number of interrelated parameters (temperature, humidity, stress, etc.).