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AN SGBEM FORMULATION FOR COHESIVE DELAMINATION MODEL WITH COULOMB FRICTION

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Recently, the advance in analysis and development of composite laminate structures has considerably influenced the applicability of composite materials in aeronautical and aircraft industry. Therefore, considering the mathematical models and developing of numerical algorithms for investigation of the interface fracture problems in such structures seems to be crucial. The interface as a contact boundary zone of a layered structure has been modelled as an infinitesimally thin cohesive layer which can be partially or completely damaged. The numerical implementation considers the cohesive-type contact which includes nonlinear phenomenon of friction and also elasto-viscosity. A mathematical model for analysis of delamination problems has been developed and implemented into the program MATLAB by means of the Symmetric Galerkin Boundary Element Method. The approach enables to exploit an energetic formulation, which governs the process of interface rupture.

The energetic formulation of delamination model with cohesive contact
The interface Γ_c is considered as an infinitesimally thin cohesive layer represented by a continuous spring distribution with normal and tangential stiffnesses k_n and k_s, respectively. The interface failure mechanism is described by an interface *damage variable* ζ. Assuming the new quadratic term ζ^2 with cohesive stiffness parameters k_{n_2} and k_{s_2}, the required *nonlinear dependence* of investigated parameters was obtained, see Figure 1(b) [1]. Let us assume the formulation of the *stored energy functional* $\mathcal{E}$ of the system at time *time* τ as

$$\mathcal{E}(\tau,\mathbf{u},\zeta) = \int_{\Omega^A} \frac{1}{2}\epsilon^A{:}\mathrm{C}^A{:}\epsilon^A \mathrm{d}\Omega + \int_{\Omega^B} \frac{1}{2}\epsilon^B{:}\mathrm{C}^B{:}\epsilon^B \mathrm{d}\Omega + \int_{\Gamma_c} \frac{1}{2}[\zeta(k_{n_1} + \zeta k_{n_2})[\mathbf{u}]_n^2 + \zeta(k_{s_1} + \zeta k_{s_2})[\mathbf{u}]_s^2 + k_g([\mathbf{u}]_n^-)^2]\mathrm{d}\Gamma. \quad (1)$$

The dissipation potential can express as

$$\mathcal{R}(\mathbf{u};\dot{\mathbf{u}},\dot{\zeta}) = \int_{\Gamma_c} -\mu k_g[\mathbf{u}]_n^- \cdot |[\dot{\mathbf{u}}]_s| + G_d|\dot{\zeta}| + \alpha|\dot{\zeta}|^2 \mathrm{d}\Gamma + \tau_R \int_{\Omega^A} \frac{1}{2}\dot{\epsilon}^A{:}\mathbf{C}^A{:}\dot{\epsilon}^A \mathrm{d}\Omega + \tau_R \int_{\Omega^B} \frac{1}{2}\dot{\epsilon}^B{:}\mathbf{C}^B{:}\dot{\epsilon}^B \mathrm{d}\Omega. \quad (2)$$

The present formulation of multidomain contact problem has been tested numerically by a computer code, which was implemented in MATLAB. An example analysis presents the response of the cohesive contact model in combination with nonlinear effect of a friction and elasto-viscosity [2]. The geometry in the present example includes two rectangular domains mutually joined and put on each other. The applied loading is assumed on the top domain in two subsequent steps, see Figure 1(a). First, a vertical compress loading is applied which leads after the rupture of the interface to a receding contact problem. Second, a loading equivalent to standard pull-push shear test well known from several engineering applications is applied afterwards.

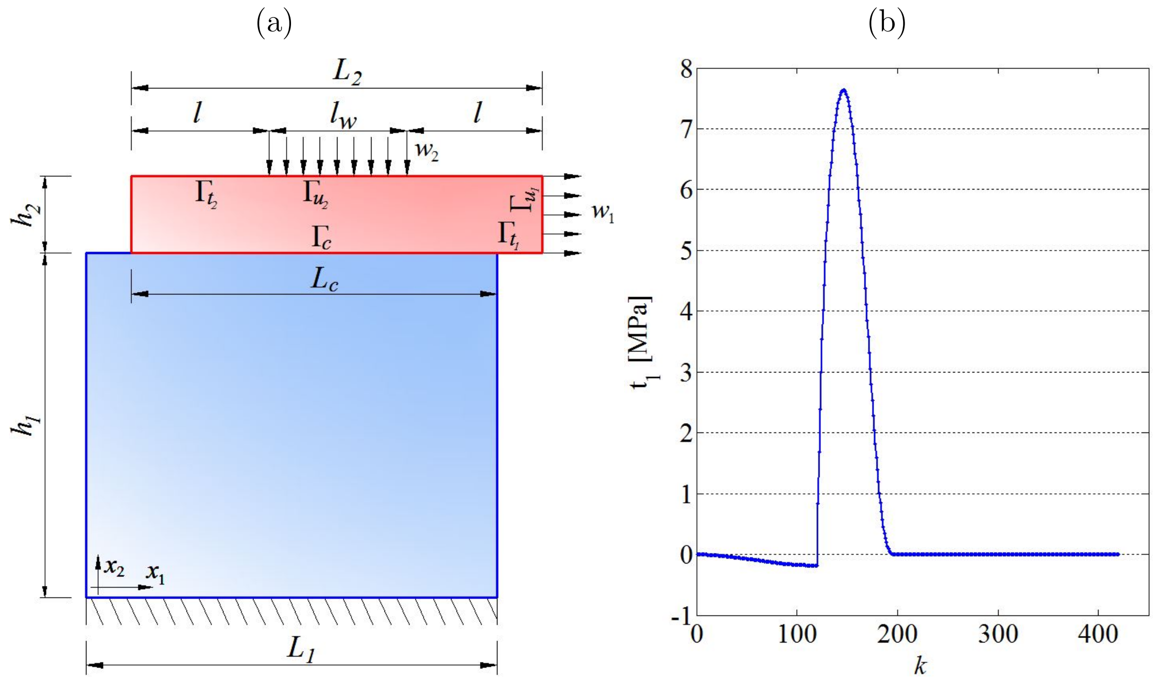

Figure 1: (a) Geometry of the multidomain contact model, (b) Distribution of stress t_1 at load step k.

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