Dynamic interaction of cracks and rigid-line inclusions

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The purpose of the research is to formulate the boundary element method (BEM), develop a computer code, and analyze dynamically loaded linear-elastic and isotropic plates containing cracks and rigid, thin, and straight inclusions. The inclusions, which are also called rigid-line inclusions or anticracks, can be used to model very stiff fibres, for example carbon nanotubes. There is assumed to be a perfect connection between inclusions and the deformable matrix and the coincidence of the crack surfaces in the unloaded state. The time- dependent problem is solved using the Laplace transform method. The boundary integral equations are used to determine the relationship between the boundary tractions and displacements. Additionally, equations of motion are applied for rigid inclusions. In order to analyze the problem using the BEM, the boundaries of the plate, cracks, and inclusions are divided into boundary elements. Boundary integral equations are used for the nodes on the external boundaries of the plate, cracks, and inclusions. Unknown quantities in the presented method are displacements and tractions along the boundaries. Solutions in the time domain are obtained using the numerical inverse Laplace transform. Stress concentrations occur at the tips of cracks and inclusions, and stress intensity factors are calculated using displacements of crack surfaces and tractions along inclusions.

The author used in the past separately the Laplace transform BEM for plates containing cracks [1] and inclusions [2]. This work is an extension of the previous works on static interaction of cracks and rigid- line inclusions [3-4] and a first attempt to analyze the dynamic interaction. Influences of the configuration, distances and length of cracks and inclusions on stress intensity factors and displacements will be shown.

The boundary element method is a very efficient method for modeling elastic bodies that contain cracks and rigid inclusions. The modeling of such materials is significantly simplified in comparison to domain methods, for example the finite element method, because nodes are situated only along the external boundaries, crack edges and inclusions. The numbers, positions, shapes, and dimensions of cracks and inclusions can be modified very simply. Stress intensity factors can be calculated with great accuracy.

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[1] P. Fedeliński, M.H. Aliabadi, D.P. Rooke, The Laplace transform DBEM method for mixed-mode dynamic crack analysis, *Comput. Struct.* **59**(6), 1021-1031, 1996. https://doi.org/10.1016/0045-7949(95)00347-9

[2] P. Fedeliński, Analysis of carbon nanotube-reinforced composites subjected to impact loads by the BEM, *Acta Mech. Autom.* **19**(4), 585-596, 2025. https://doi.org/10.2478/ama-2025-0066

[3] Dong C.Y., Lo S.H., Cheung Y.K., Interaction between cracks and rigid-line inclusions by an integral equation approach, *Comput. Mech.* **31**(3), 238-252, 2003. https://doi.org/10.1007/s00466-003-0427-2

[4] P. Fedeliński, Computer modeling and analysis of microstructures with fibres and cracks, *J. Achiev. Mater. Manuf. Eng.* **54**(2), 242-249, 2012.