

DEVELOPMENT OF PARTICLE-ADDED ELEMENT CONNECTIVITY METHOD FOR TOPOLOGY OPTIMIZATION WITH INTERNAL CONTACT

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Abstract

This study presents a novel numerical framework, termed Particle-added Element Connectivity Parametrization (P-ECP), which is designed to directly incorporate internal contact mechanics within the topology optimization process. By integrating a particle contact methodology with the Element Connectivity Parametrization (ECP) technique, the present framework facilitates a penalty-based node-to-surface contact formulation in the field of structural topology optimization. The particle contact methodology was originally developed for manipulating the trajectories of particles in topology optimization, whereas the ECP method was devised for handling geometric nonlinearities. The incorporation of the ECP method with the particle contact methodology prevents numerical instabilities such as element inversion, ensuring computational stability throughout the optimization process. Within the P-ECP scheme, density-based designs are mapped onto smoothed wall boundaries, and penetration depths are computed via Taylor series expansion to define the contact potential. Furthermore, the derived contact potential is fully differentiable, facilitating both nonlinear structural analysis and gradient-based sensitivity analysis. Finally, various numerical examples are provided to demonstrate the capability of the P-ECP in managing the internal contact interactions in structural topology optimization.