A COUPLED FINITE ELEMENT AND MESH-FREE METHOD FOR SOLID AND SHELL DYNAMIC EXPLICIT ANALYSIS

Cheng-Tang Wu[a], **Yong Guo**[a], **Mark E. Botkin**[b] **and Hui-Ping Wang**[b]

[a]Livermore Software Technology Corporation
7374 Las Positas Road
Livermore, CA 94550
ctwu@lstc.com, yguo@lstc.com

[b]GM R & D Center
Mail Code 480-106-256
Vehicle Analysis and Dynamics Lab
Warren, MI 48090-9055
mark.e.botkin@gm.com, hui-ping.wang@gm.com

The mesh-free method, a new approach to solid and structural analysis has been extensively investigated in the past few years. These efforts have shown that numerous difficulties encountered in the finite element analysis such as mesh distortion and the burden associated with the quality of mesh discretization become trivial in a mesh-free computation. In contrast, the finite element method is well established and has been refined over a long period with respect to efficiency and robustness. Considering these advantages, the coupling of the finite element and mesh-free method becomes attractive for industrial applications. In this paper, we present a coupled finite element and mesh-free method for the general dynamic explicit analysis in solid and shell. Special attention is given here to the shear deformable mesh-free shell formulation and the coupling method.

In the first part, a first order shear deformable mesh-free shell formulation is developed. Two methods of shell surface representation based on the existing finite element mesh are described. A parameterization algorithm utilizes an angle-based triangular flattening scheme proposed by Sheffer et al. [1] to construct the surface parameterization. Different from the parameterization algorithm, a local projection algorithm is proposed to reconstruct the shell surface locally by projecting the surrounding nodes onto the element plane. The moving least-squares interpolation [2] is adopted for both the displacement and the surface approximation. To avoid locking phenomena, a selective reduced integration procedure is employed. In the second part, a simple coupled finite element and mesh-free method is proposed to maintain the smoothness of the mesh-free approximation as well as to reduce the computation time. In order to meet the integration constraint in the Galerkin approximation [3] and also to avoid the instability due to the possible under-integration quadrature used in the mesh-free computation, a local boundary integration scheme is used for the spatial integration. In considering the derivation of a lumped mass matrix in the dynamic explicit analysis, an averaged mass matrix is established. Finally, the performance is evaluated through a series of benchmark problems.

References

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