

HEX-DOMINANT EXPLICIT METHODS FOR NONLINEAR DYNAMICS USING SECOND-ORDER FINITE ELEMENTS

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ABSTRACT

Hexahedral-dominant modeling methods are becoming increasingly popular, as they strike a balance of meshing ease and accuracy/efficiency by exploiting wedge and/or pyramid elements to transition from hexahedral elements to volumes filled by other types. Unfortunately, first-order tetrahedrals, wedges, and pyramids are frequently very poor performers in such unstructured meshing approaches and first-order elements historically are the only ones contained in explicit solid dynamic programs typically used for high-rate shock-type applications. The preference of first-order elements with explicit methods has frequently been for simplicity and cost, but has also been from the lack of both a satisfactory consistent nodal loading distribution and an acceptable mass lumping technique for serendipity elements. Consistent nodal loads for a uniform traction on a six node triangular face, e.g., of the popular ten node tetrahedron and fifteen and eighteen node wedges, are zero at the vertex nodes. This can be problematic for contact as well as in diagonal lumped mass explicit schemes (vertex nodes will not move until perhaps the next time increment). Pyramid elements are almost nonexistent in explicit codes. This paper solely uses twenty-one node wedge element formulations as part of hexahedral-dominant meshes for fill regions and/or to transition from hexahedral to tetrahedral elements. Several benchmark problems are first used for validation/evaluation and then the elements are used to model a vehicle subjected to underbody blast. The benefits for meshing, improved flexural modeling, and reduced wave-propagation dispersion error, typically exhibited by similar second-order elements (e.g., serendipity) in static/implicit analyses, is demonstrated. In all cases, these elements performed satisfactorily and thus demonstrate their viability and benefits for practical explicit nonlinear solid dynamic applications, especially for fill and transition regions of low interest.