Development and applications of trimmed hexahedral elements in three-dimensional finite element simulations

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In this study, trimmed hexahedral elements are generated by cutting a simple block consisting of regular hexahedral elements with a computer-aided design (CAD) surface. Trimmed hexahedral elements or polyhedral elements are then placed at the boundaries of a finite element model, and regular hexahedral elements remain in the interior region. Polyhedral elements can improve the freedom in meshing complex-shaped models by placing arbitrary-shaped polyhedrons in accordance with the surface geometries. The construction of shape functions of polyhedral elements is not straightforward as in conventional finite elements. Shape functions for trimmed hexahedral elements are developed by using moving least square approximation with harmonic weight functions based on an extension of Wachspress coordinates to curved faces. Trimmed hexahedral elements satisfy the continuity, the compatibility and the completeness conditions for a convergence of solutions and a seamless connection to conventional finite elements. In addition, a consistent numerical integration can be performed by taking tetrahderal sub-domains in a polyhedron as integration domains with no discontinuity. Numerical examples show the effectiveness and efficiency of the present method for problems with arbitrary shaped domains.