ZAPOTEC: A COUPLED EULERIAN-LAGRANGIAN PROGRAM FOR EARTH PENETRATION

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Coupled Eulerian-Lagrangian solution approaches are well suited for modeling earth penetration problems. These problems are characterized by the time-dependent, coupled interaction between the penetrator and target materials. For earth penetration applications, the target material (e.g., soil) is best modeled using an Eulerian solution approach due to the large material deformations involved. Conversely, the penetrator is best modeled using a Lagrangian approach as structural response is of primary interest. A coupled approach utilizes the strengths of both the Eulerian and Lagrangian solution methods to address problems not readily solved by either method alone. In this paper, we describe the development of Zapotec, a coupled Eulerian-Lagrangian computer program for solving the aforementioned class of problems.

Zapotec is a framework that tightly couples the CTH and PRONTO codes. CTH, an Eulerian shock physics code with Adaptive Mesh Refinement (AMR) capability, performs the Eulerian portion of the analysis, while PRONTO, an explicit finite element code, performs the Lagrangian analysis. Zapotec controls the coupling between the two codes. In a Zapotec analysis, both CTH and PRONTO are run concurrently. For a given time step, Zapotec maps the current configuration of a Lagrangian body onto the fixed Eulerian mesh. Any overlapping Lagrangian material is inserted into the Eulerian mesh with the updated mesh data passed back to CTH. The presence of this inserted Lagrangian material may be used to trigger AMR in the portions of the CTH mesh overlapped by the Lagrangian mesh. Other 'indicators' (pressure gradients, material interfaces, etc.) may also be used to cause CTH mesh refinement in a Zapotec calculation. Once the material insertion is complete, the external loading on the Lagrangian material surfaces is then determined from the stress state in the Eulerian mesh. These loads are passed back to PRONTO as a set of external nodal forces. Once the coupled treatment is complete, both CTH and PRONTO are run independently over the next time step.

The coupling algorithm appears to be quite robust and its effectiveness is demonstrated for earth penetrating weapon applications. In particular, we demonstrate the effectiveness of Zapotec for modeling impacts of ogive-nose penetrators into earth. Comparisons are drawn with the measured depth of penetration as well as with the measured deceleration history. We also compare the results from an AMR calculation with those from a 'Flat Mesh' calculation demonstrating the similarity of the results and the reduced computational time required when using the AMR capability.

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