LS-DYNA® ALE Nodal Coupling

Hao Chen, Jason Wang

Livermore Software Technology Corporation
7374 Las Positas Rd
Livermore, CA 94551

Abstract

*LS-DYNA ALE solver has been used extensively on modeling fluid and gas behaviors. The accompanying FSI solver has been successfully applied on series of engineering problems such as tank sloshing, tire hydroplaning, bottle dropping, HE blasting, etc. The FSI solver, invoked by the *CONSTRAINED_LAGRANGE_IN_SOLID card, is intended to couple between ALE fluid elements and Lagrange structure segments.*

*The LS-DYNA Discrete Elements recently developed has been successfully simulating sand undertaking explosion shockwaves from land mine detonations. In such models, sand is modeled as a group of discrete rigid particles. The pressure wave propagates in the sand through the penalty springs between discrete sand particles. The land mine is modeled by *MAT_HE using ALE multi-material element formulation. However, the existing FSI package can not handle the coupling between the ALE high explosives and sand particles as the FSI algorithm is segment based. This means that the Lagrange structure has to be a set of segments.*

The new nodal based coupling was developed so that the interaction between ALE fluids and node-based discrete elements could be resolved. The constraint-based coupling algorithm was implemented as the first phase of the development.

*The keyword is named *ALE_COUPLING_NODAL_CONSTRAINT. It has a similar input format and parameter list as the *CONSTRAINED_LAGRANGE_IN_SOLID card. Preliminary studies of method effectiveness have been done through an in-house land mine blast problem. The results agreed well with empirical data obtained through *LOAD_BLAST_ENHANCED.*

Introduction to LS-DYNA ALE/FSI

When conducting a fluid-structure interaction analysis in LS-DYNA ALE, normally the fluid is modeled using solid element formulation 11 (multi-material ALE) or 12 (single-material formulation). Here multi or single refers to number of different fluids exist in the ALE mesh.

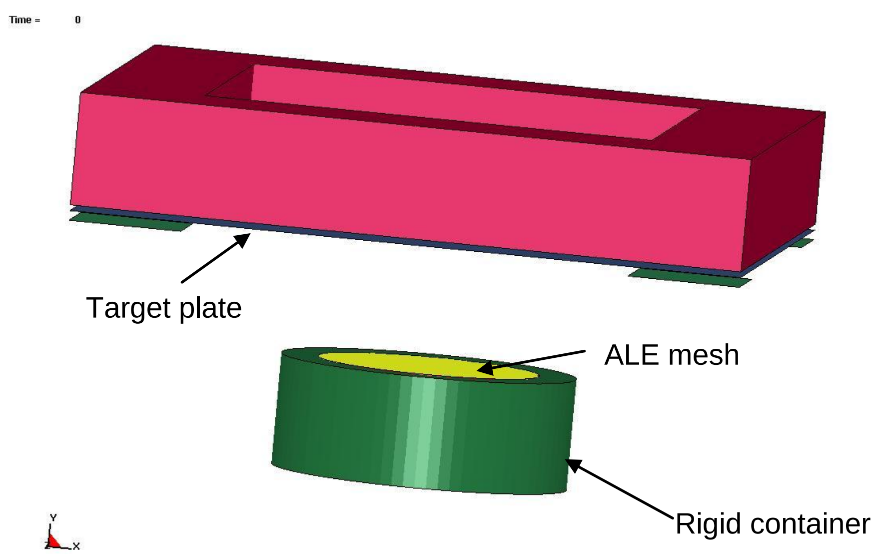
We use the keyword card called *CONSTRAINED_LAGRANGE_IN_SOLID to enable the FSI between a Lagrange structure and ALE fluids. The Lagrange structure consists of a set of coupling segments. On each segment, we then generate coupling points by a N by N grid. As the structure geometry is represented by a set of segments, we call this coupling algorithm segment-based. Segment-based algorithm has been working well but has its limitations. It can not deal with discrete element formulations such as SPH and the newly developed LS-DYNA Discrete Elements.

ALE Nodal Coupling

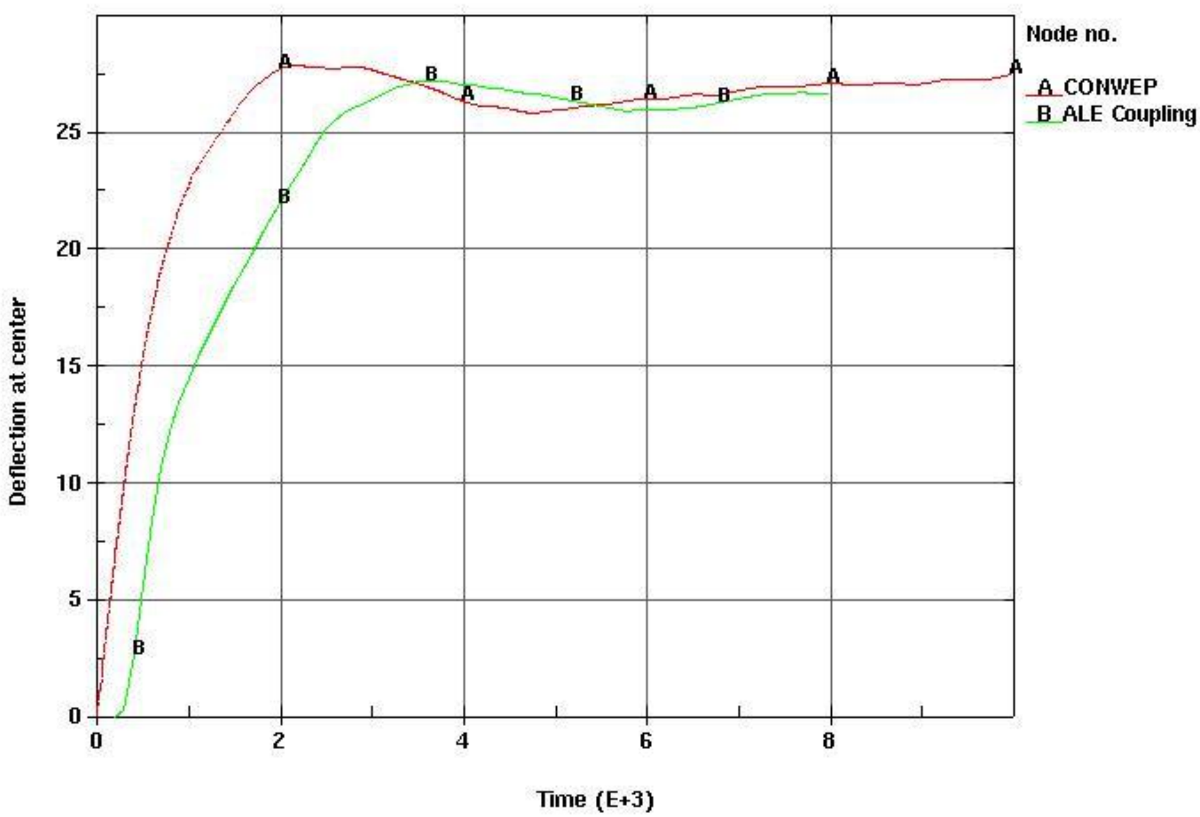
To deal with cases where Lagrange structures are of discrete element formulations, we developed a new ALE coupling algorithm which is node-based. This means the coupling points are now chosen at nodes instead of the N by N grid on segments. The keyword is called *ALE_COUPLING_NODAL_CONSTRAINT.

Numerical Examples

A TNT charge is buried under sand in a rigid concrete cylinder. It detonates and pushes the sand flying away and hitting a plate at certain distance away. The geometry is shown in the picture below.



Sand is modeled as LS-DYNA Discrete Elements. TNT charge is using *MAT_HE + *EOS_JWL and ALE element formulation 11. The other fluid is air using *MAT_NULL+*EOS_LINEAR_POLYNOMIAL. The coupling between sand and TNT charge uses *ALE_COUPLING_NODAL_CONSTRAINT card with both velocity and acceleration constrained. The resultant deflection on the plate agrees well with CONWEP results obtained through *LOAD_BLAST cards.



Future Development

We will continue our developing work to enable penalty base nodal coupling The new keyword is going to be *ALE_COUPLING_NODAL_PENALTY.