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Reduced Order Fastener Models

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Abstract:
The development of finite element models to simply and effectively reproduce load displacement behavior and failure of fasteners and their validity is examined. The Cohesive Zone Model (CZM) is of particular interest. CZMs are assessed in pure tension and shear, as well as mixed mode loading. The CZM provides a simple and effective model for pure tensile and shear behavior, but tends to have issues reproducing experimental data under mixed mode loading conditions.

Figure 1: Previous fastener models. Left: plug with plasticity modeled. Right: spot weld with prescribed load vs displacement

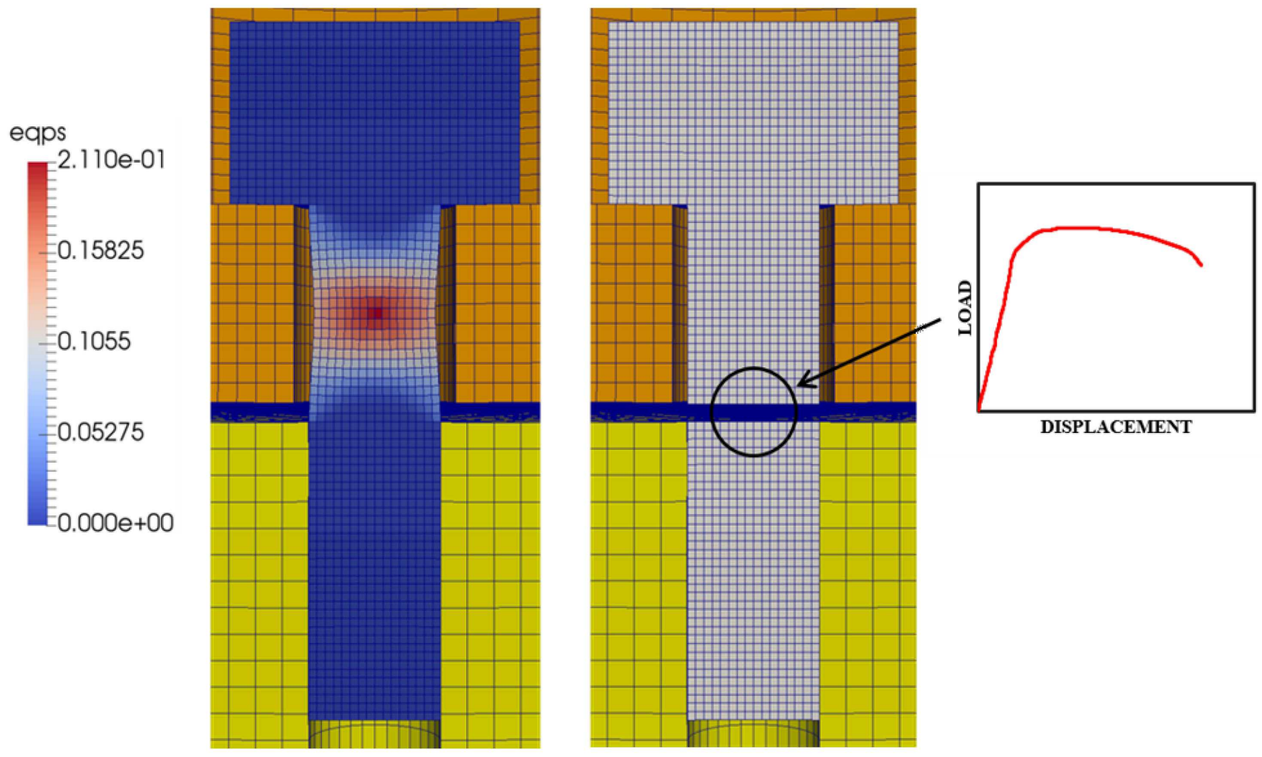
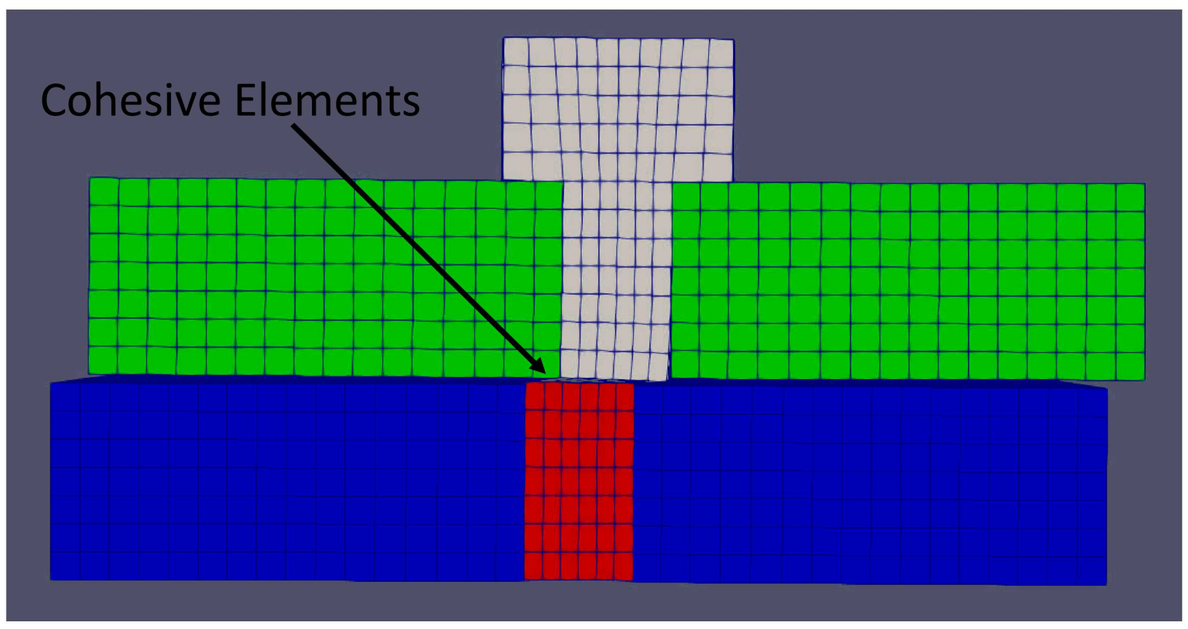


Figure 2: Cohesive zone plug model. A cohesive zone connects the top and bottom sections of the plug, modeling the nonlinear behavior of the whole fastener.



Introduction:

Modeling fastener behavior in a full system is a challenging task, as computational limits require fasteners and joints to be coarsely meshed. Previous attempts at modeling a reduced order fastener have involved using spot welds and plugs (Fig. 1). Other reduced order model are explored in shear and tensile loading conditions.

Methods:

Hex meshed fastener plug models were created with cohesive elements halfway through the shank. All test cases were simulated in Sierra SM using implicit where possible, and explicit where contact was required. Load displacement data outputs from the simulations were compared with experimental test cases.

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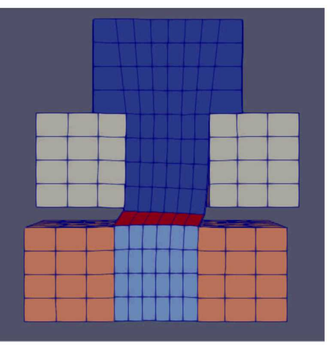

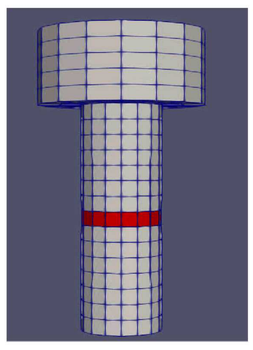

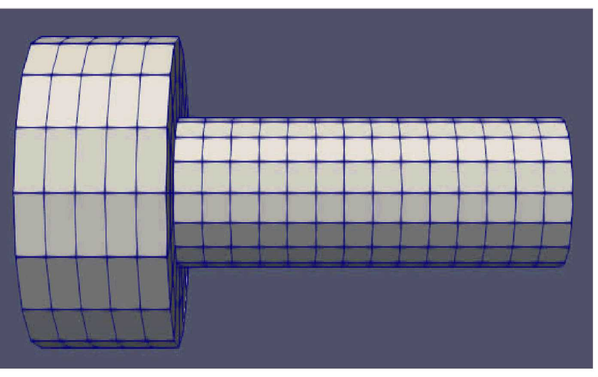

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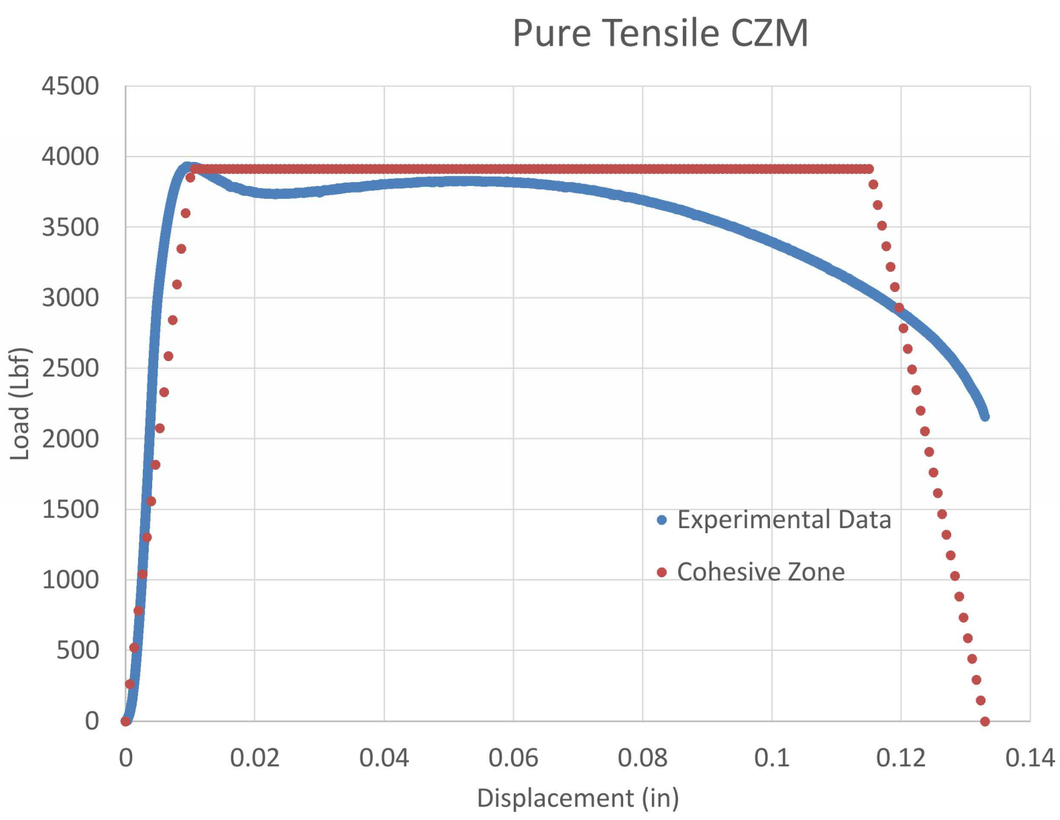

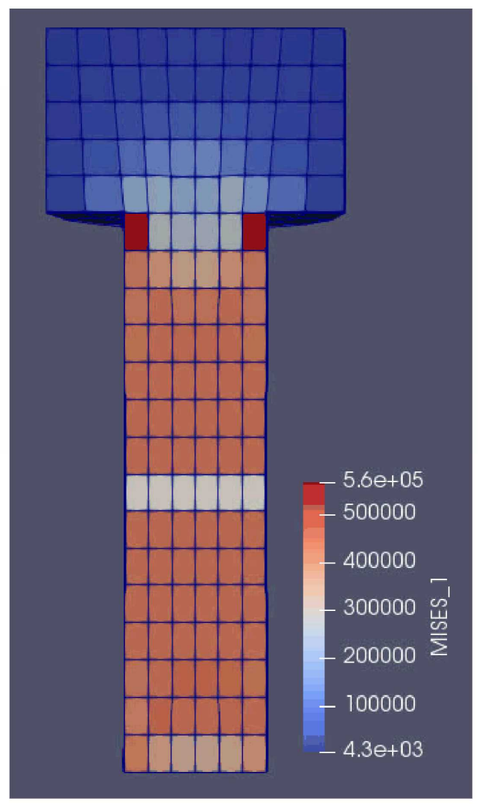

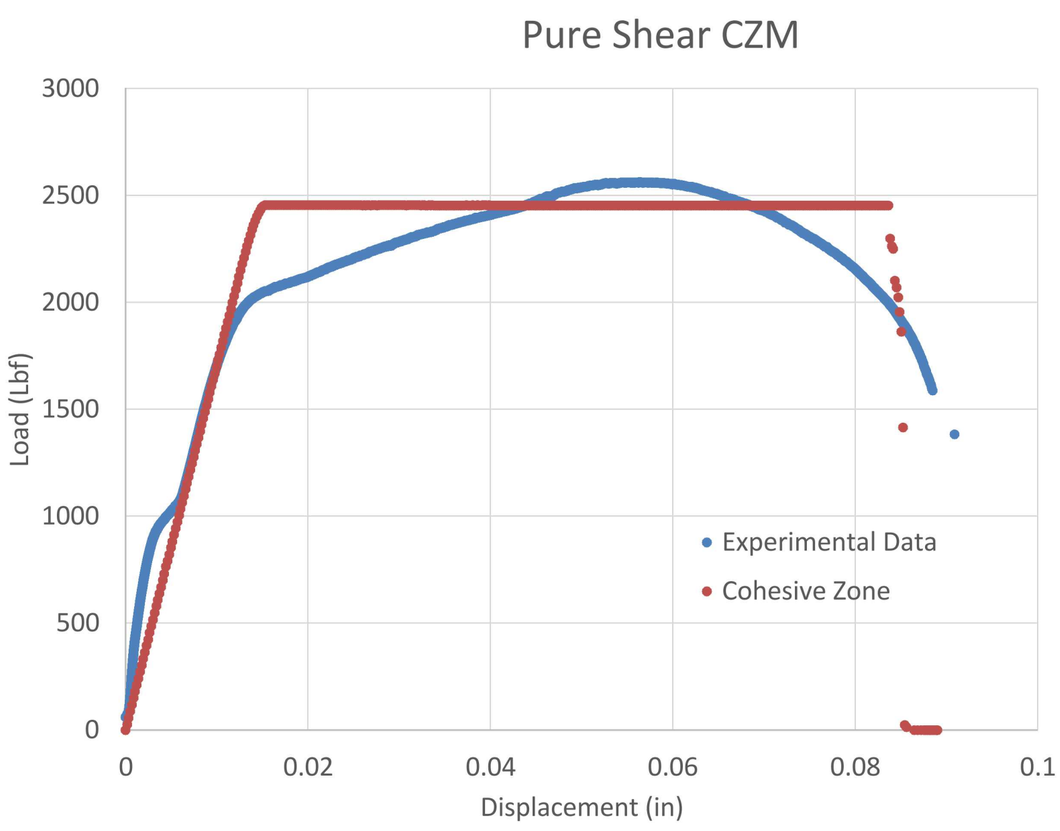

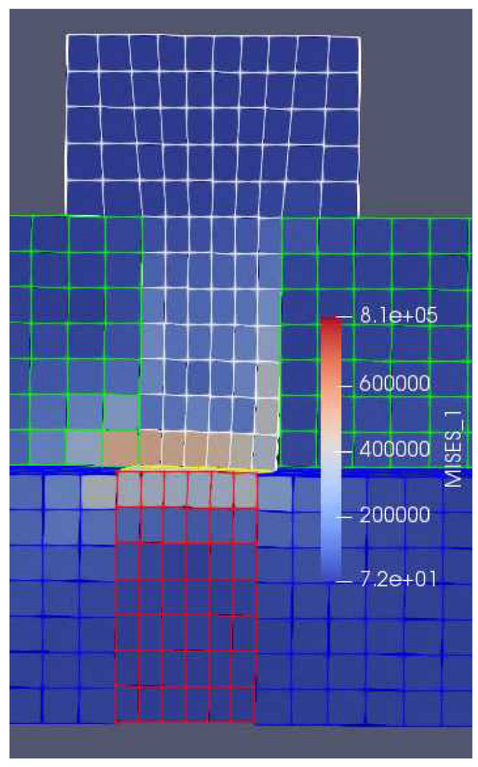

Results and Discussion:

Cohesive zone models are a reasonable approach to modeling reduced order fasteners. They are simple to calibrate and can approximate load displacement, failure, and energy dissipation within a fastener in pure tension and pure shear. Further attempts will be made to make and calibrate models to mixed mode loading and failure.

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