Challenges in simulating earthquake-induced ductile fracture in steel structures

V.S. Pericoli¹, X. Lao¹, M. Terashima², A. Zicarelli², G. Deierlein², and A.M. Kanvinde¹

¹Department of Civil and Environmental Engineering, University of California, Davis
²Department of Civil and Environmental Engineering, Stanford University

1. Simulation of ductile fracture propagation under Ultra-Low Cycle Fatigue (ULCF):

Introduction
Fracture is a critical limit state that can precipitate structural failure and collapse, and must be considered in a reliability-based performance assessment. But ductile crack initiation itself may not be correlated with the global structural response. Myers et al. (2009) indicates that ULCF initiated cracks may show significant stable propagation before brittle fracture occurs. This indicates a need for validated models and technologies to simulate ductile crack propagation under ULCF loading.

Figures courtesy of Myers et al. (2009)

Approach
- Void Growth
- Coalescence and rupture
- Solid Element
- Cohesive element
- Ductile damage-based rupture criteria
- Cohesive zone-based material destruction

Results
- Mesh independent
- Consistent parameters
- No parameter fudging

2. Predicting ductile fracture in the presence of spatial variability in toughness:

Introduction
Micromechanical fracture models are increasingly used for predicting ductile fracture in structural steel components. Methods to apply these models presume that structural components are spatially homogeneous in terms of material toughness. This presumption conflicts with experimental evidence that shows significant variability in material toughness. Consequently, accurate and rigorous evaluation of fracture uncertainty is not possible with the current framework.

Simulation of Prototype-scale Bending Plates
- Prototype-scale bending plate
- Same parent distribution of toughness can have different internal correlation structure
- Semivariogram representation, with \( \lambda \) material correlation radius

Results
1. Large degree of sensitivity of \( \Delta f \) to \( \lambda \)
2. Indication of statistical size effect
3. Scaling issue between lab-scale coupons and archetype scale components

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