Challenges in simulating earthquake-induced ductile fracture in steel structures

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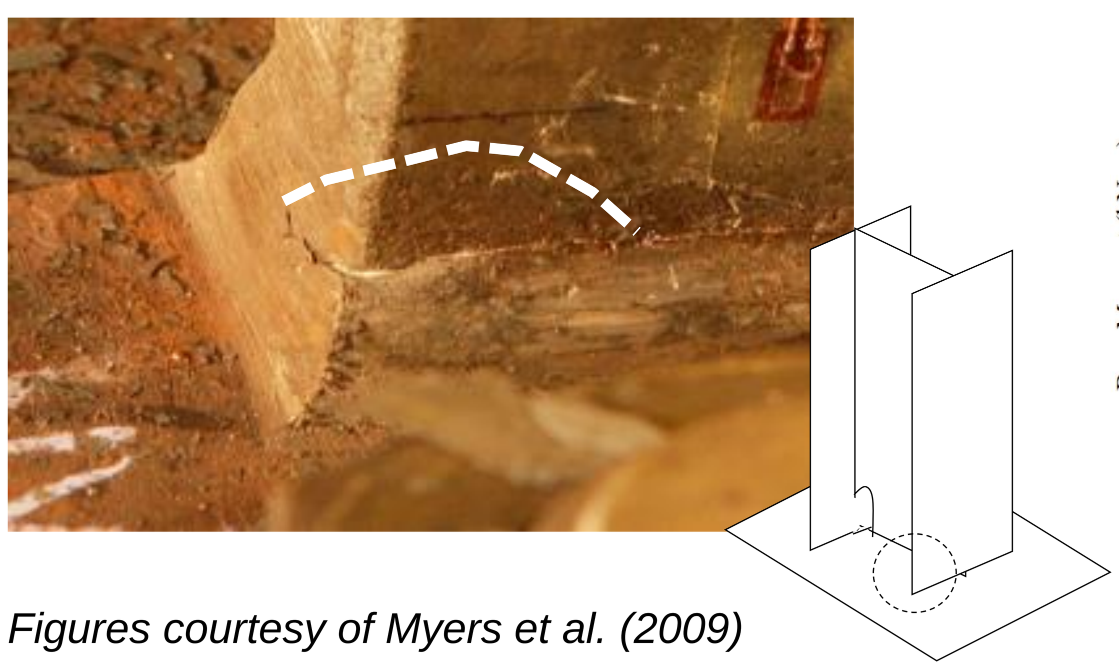
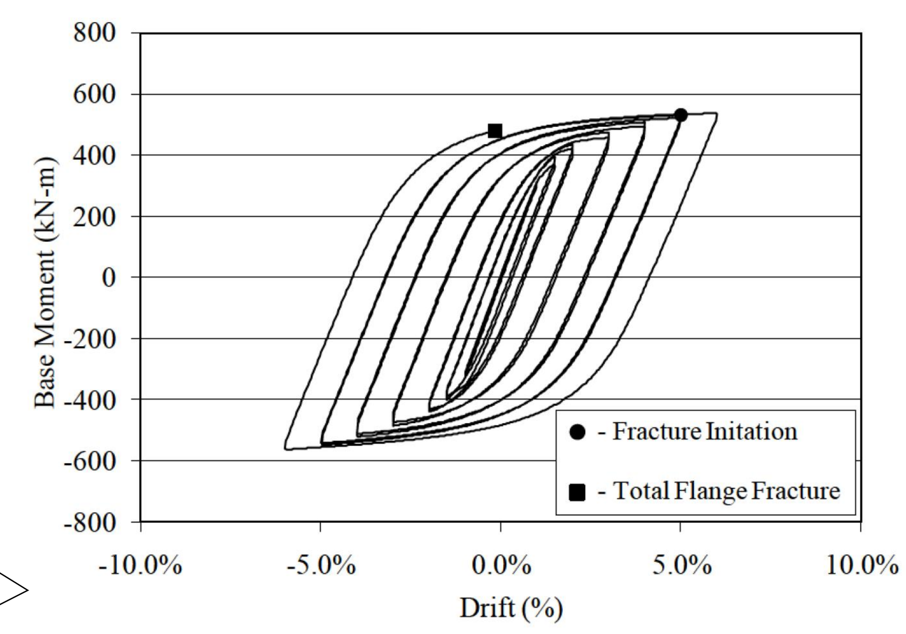
1. Simulation of ductile fracture propagation under Ultra-Low Cycle Fatigue (ULCF):

Introduction

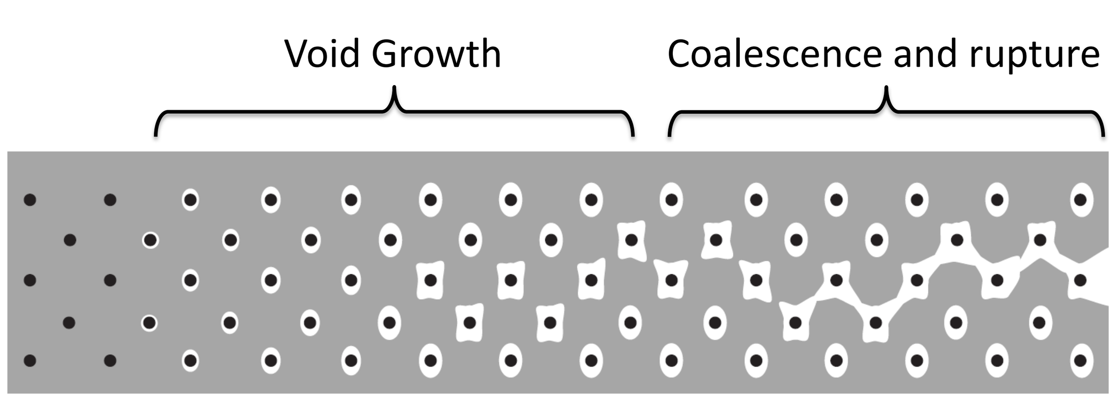
Fracture is a critical limit state that can precipitate structural failure and collapse, and must be considered in a reliability-based performance assessment. But ductile crack initiation itself may not be correlated with the global structural response. Myers et al. (2009) indicates that ULCF initiated 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.

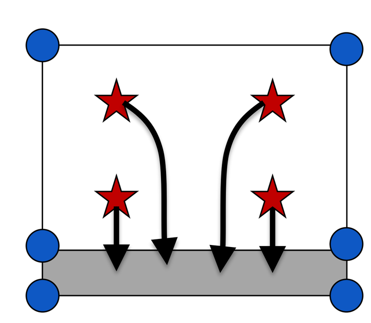




Figures courtesy of Myers et al. (2009)

Approach

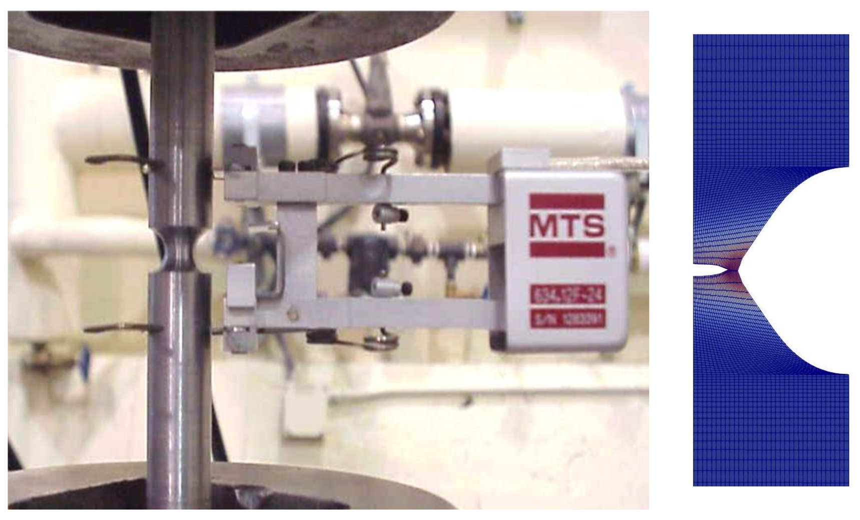


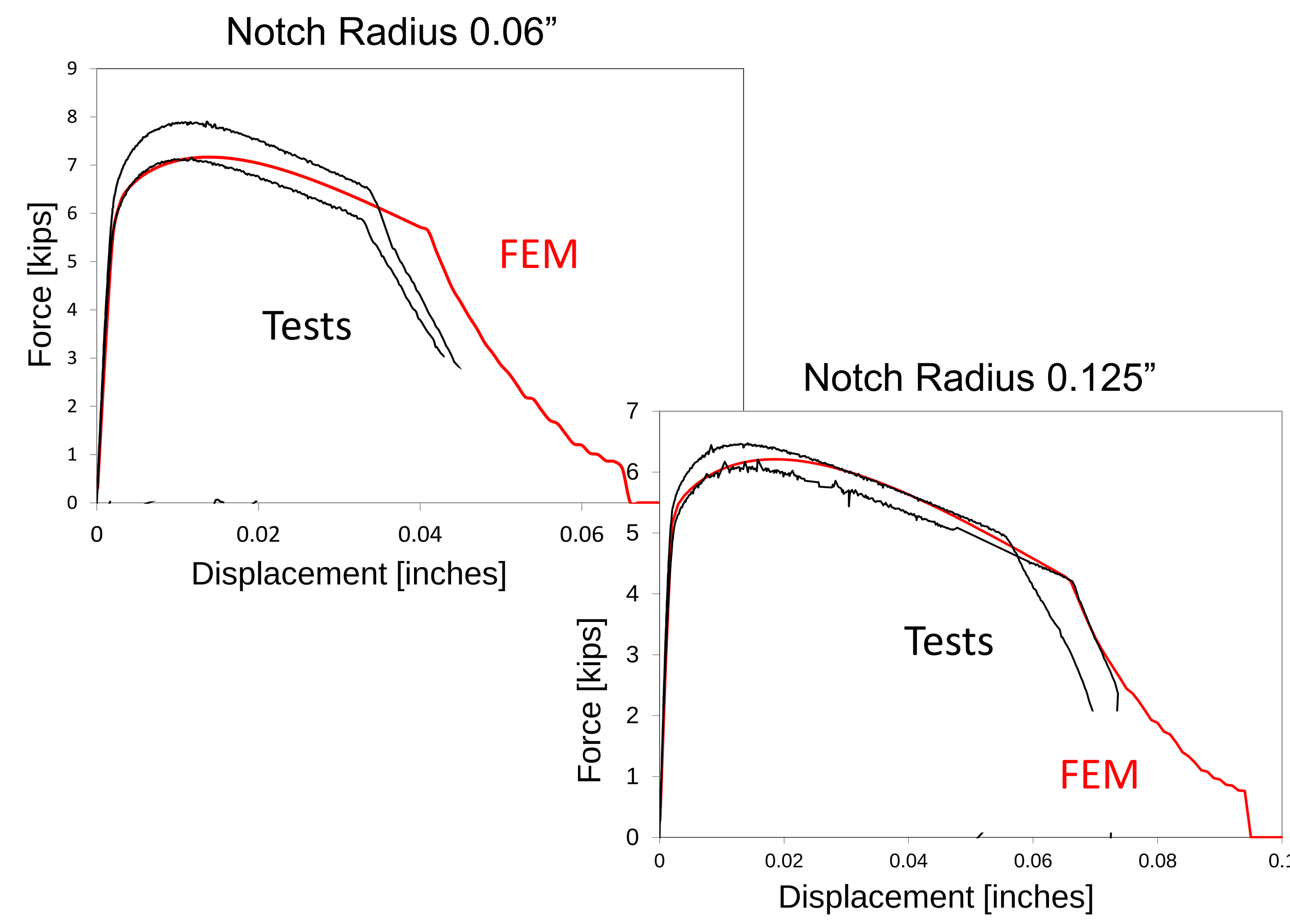


- Ductile damage-based rupture criteria
- Cohesive zone-based material destruction

Results

- Mesh Independent
- Consistent parameters
- No parameter fudging

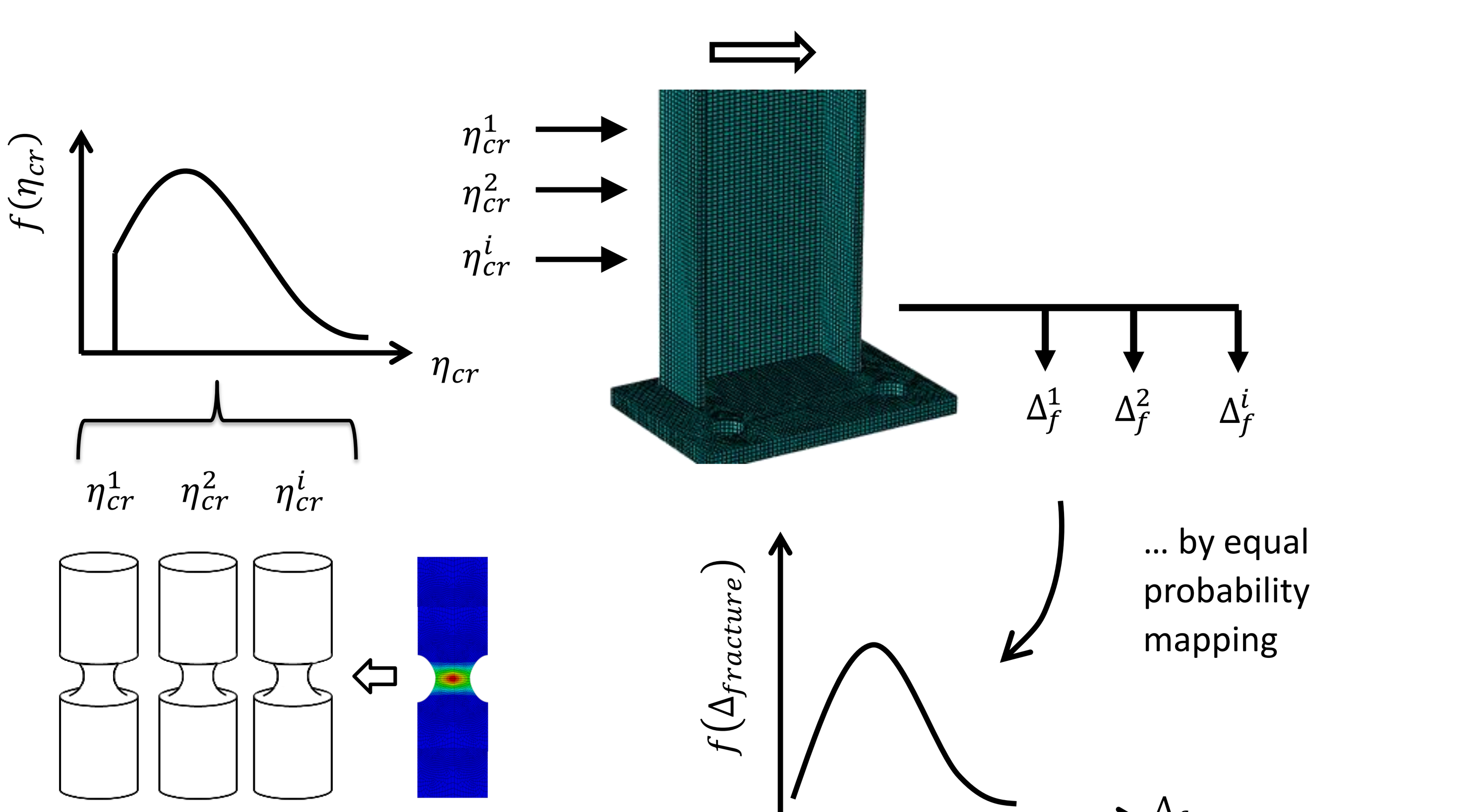




2. Predicting ductile fracture in the presence of spatial variability in toughness:

Introduction

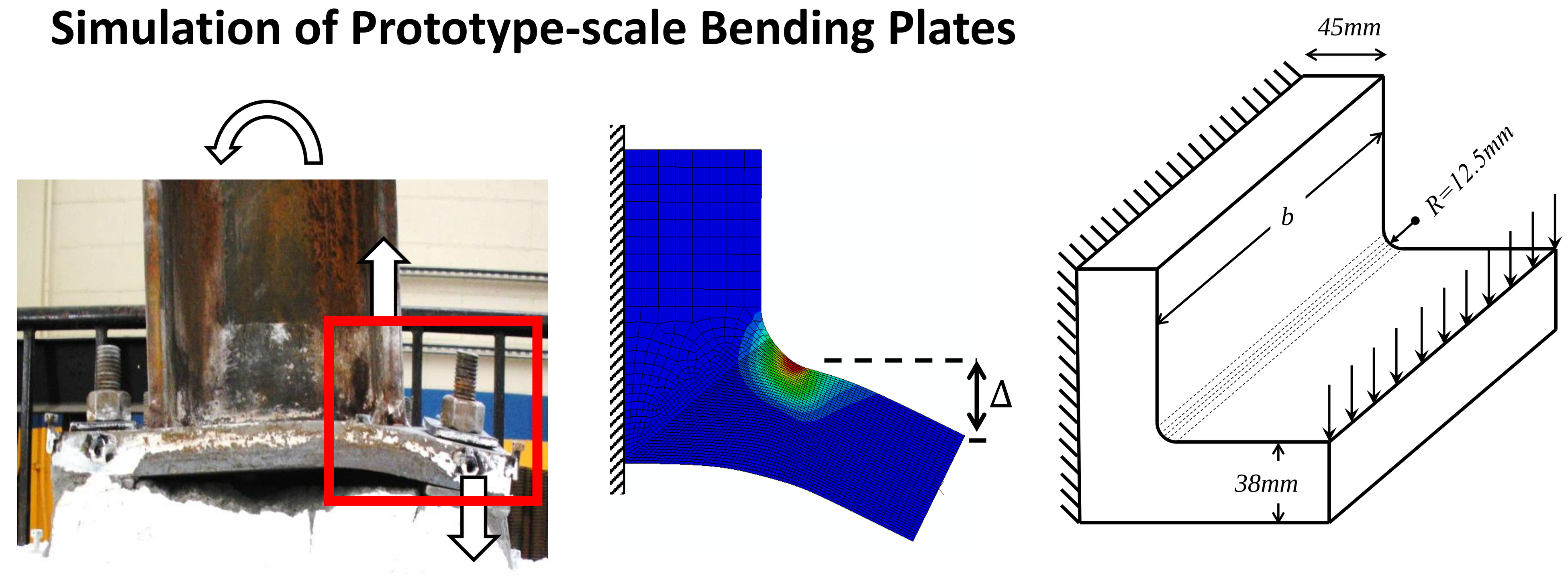
Micromechanical fracture models are increasingly used for predicting ductile fracture in structural steel components. Methods to apply these models presume that structural components are spatially homogeneous in terms of material toughness. This presumption conflicts with experimental evidence that shows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



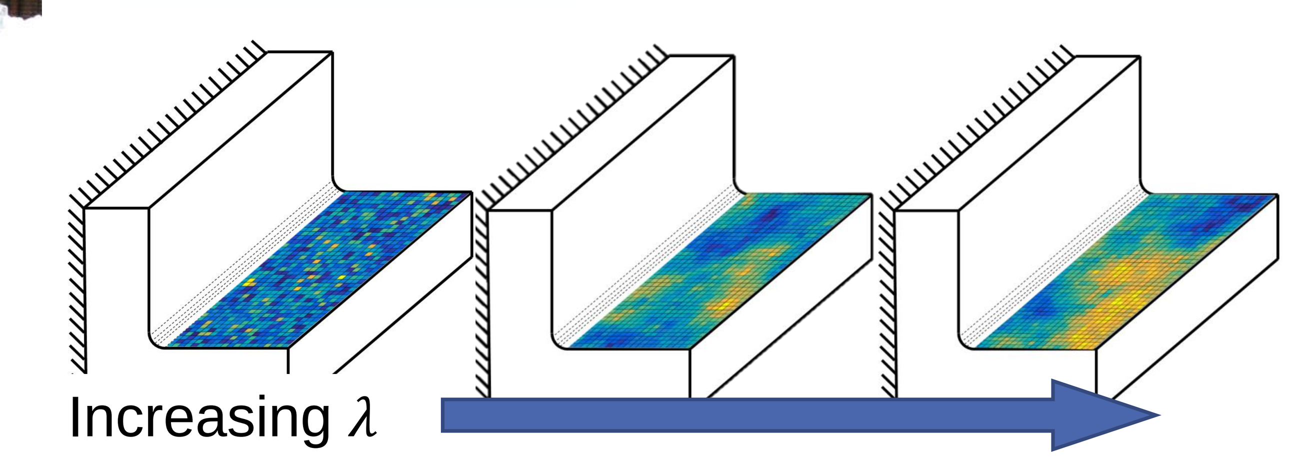
Replicate tests and FE simulations to develop distribution of material parameter

Fracture fragility of structure

Simulation of Prototype-scale Bending Plates

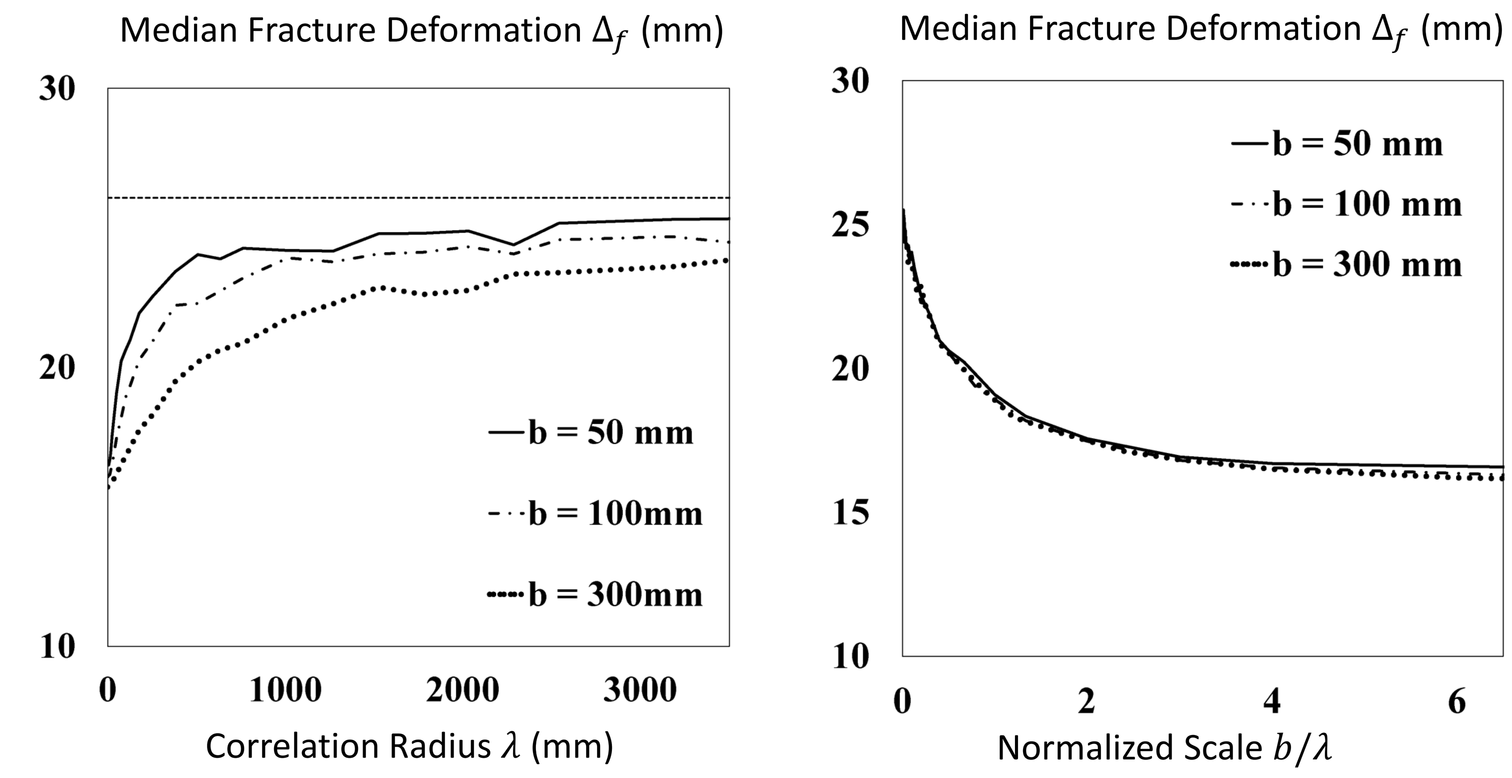


- Prototype-scale bending plate
- Same parent distribution of toughness can have different internal correlation structure
- Semivariogram representation, with λ material correlation radius



Results

1. Large degree of sensitivity of Δ_f to λ
2. Indication of statistical size effect
3. Scaling issue between lab-scale coupons and archetype scale components



Acknowledgments

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