Fiber-based nonlocal formulation for simulating softening in reinforced concrete beam-columns

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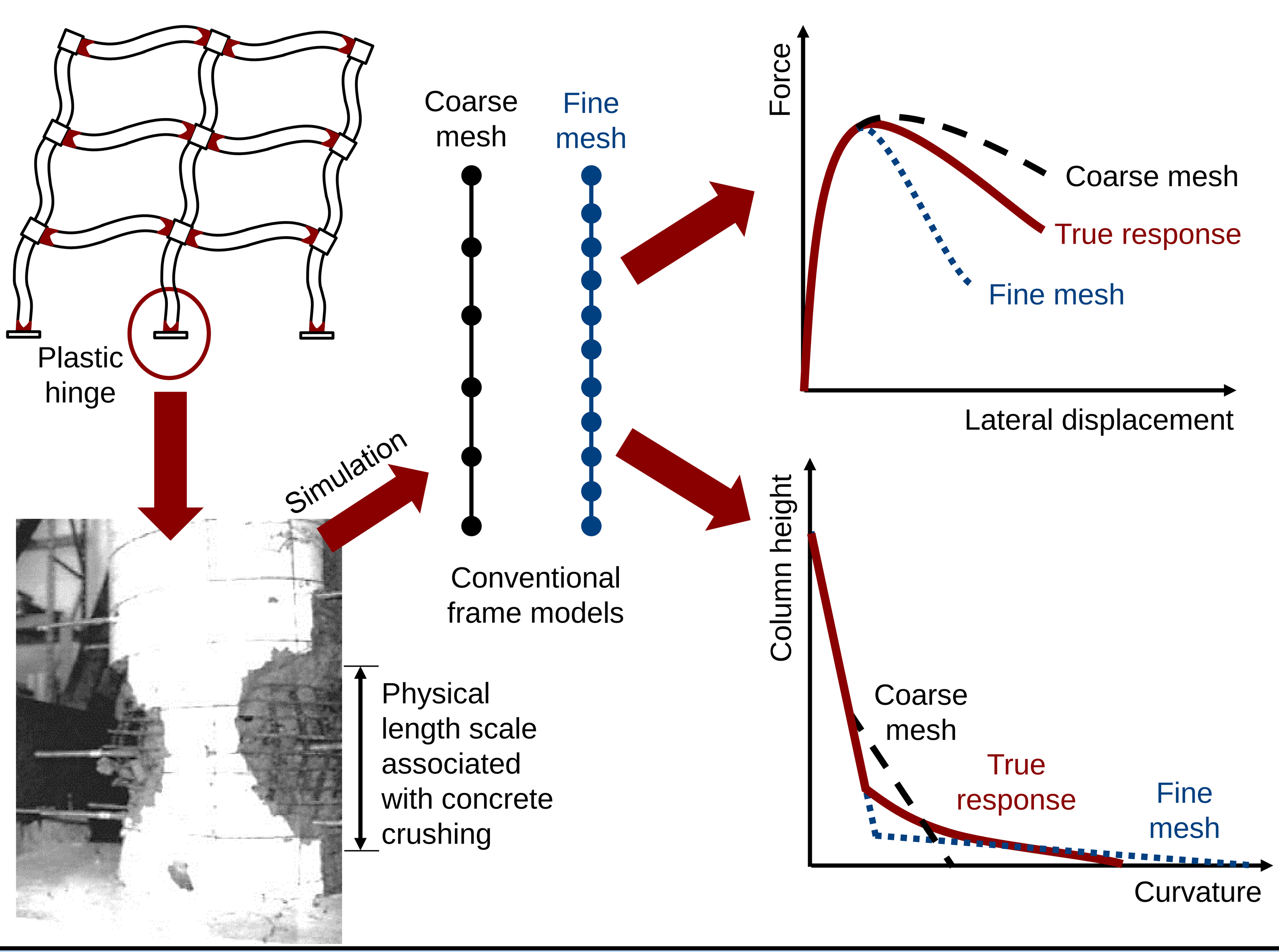
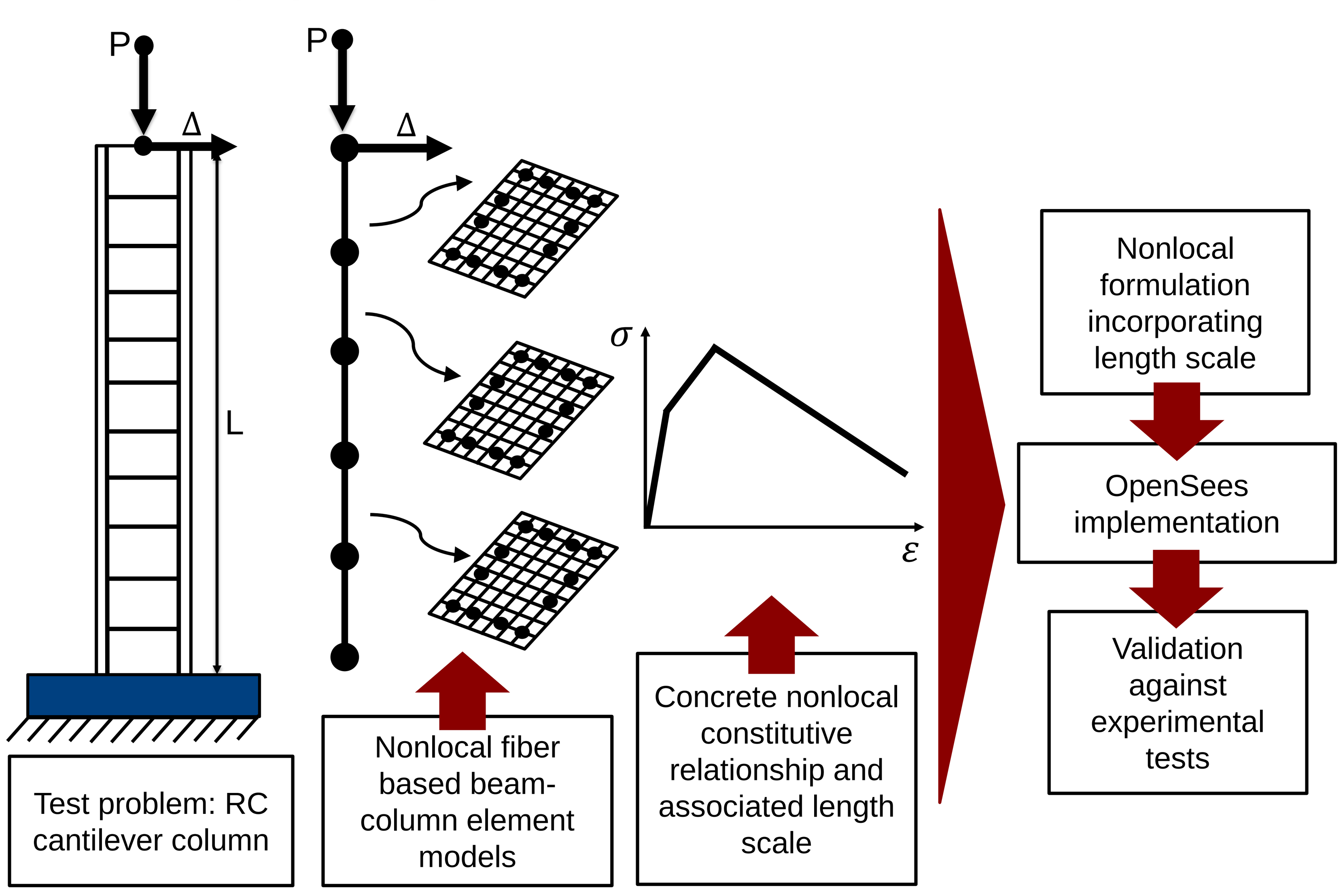
Introduction

Ensuring the resilience of civil structures against seismic and other hazards requires accurate performance assessment of structures and their anticipated inelastic response under extreme loading conditions. State-of-the-art simulations of extreme limit states in structures face numerical challenges that preclude rigorous prediction of softening (degrading) structural response: sensitivity to the finite element mesh size and spurious localization of the deformation field. The nonlocal continuum theory is adopted to enhance reinforced concrete frame models and enable robust simulation of response degradation and structural collapse.



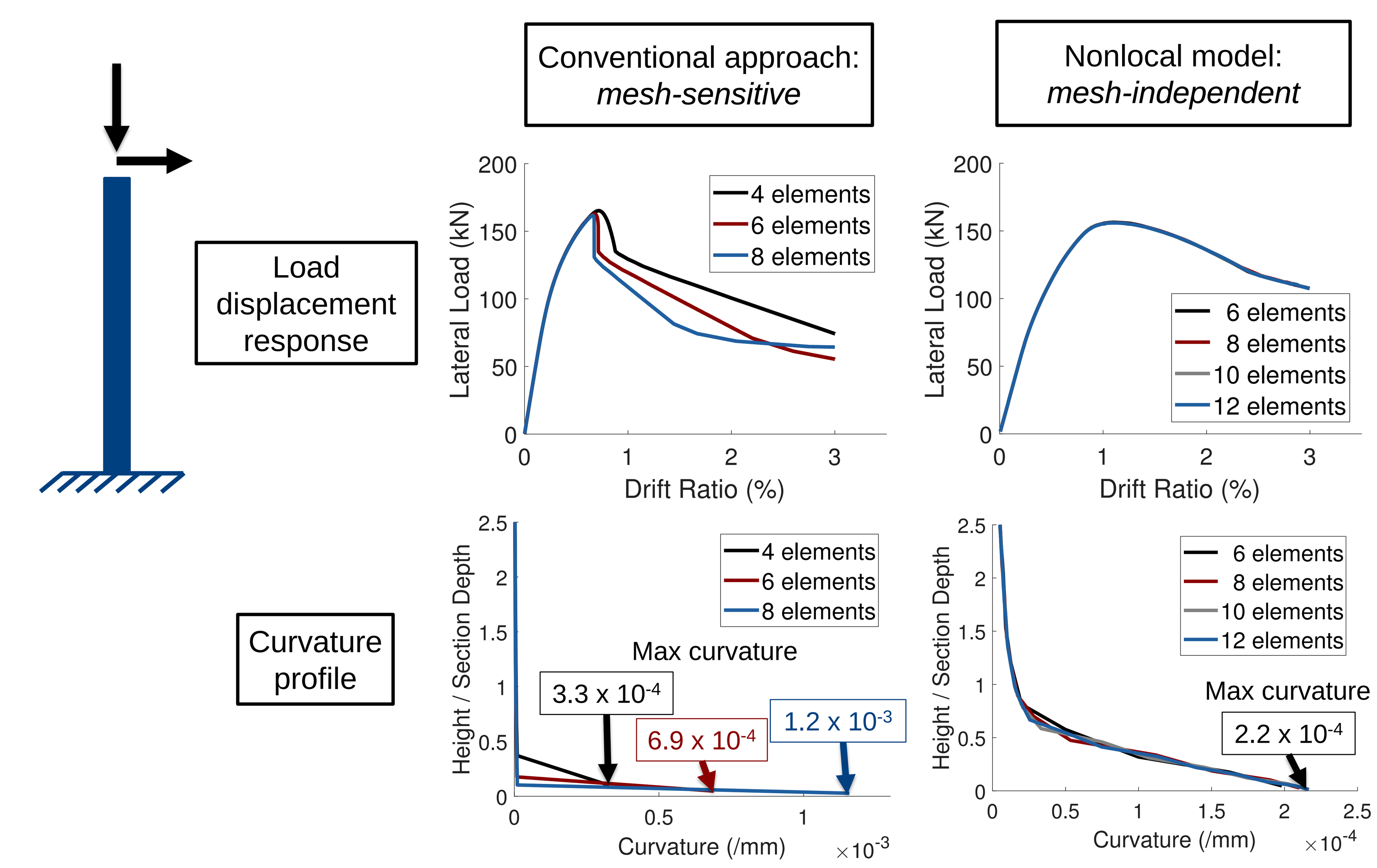
Theory and implementation

- The nonlocal theory imbeds a physically meaningful characteristic length into the simulation model to eliminate mesh sensitivity and spurious strain localization.
- The nonlocal formulation is implemented in fiber-based frame-element models in the open source analysis platform OpenSees.



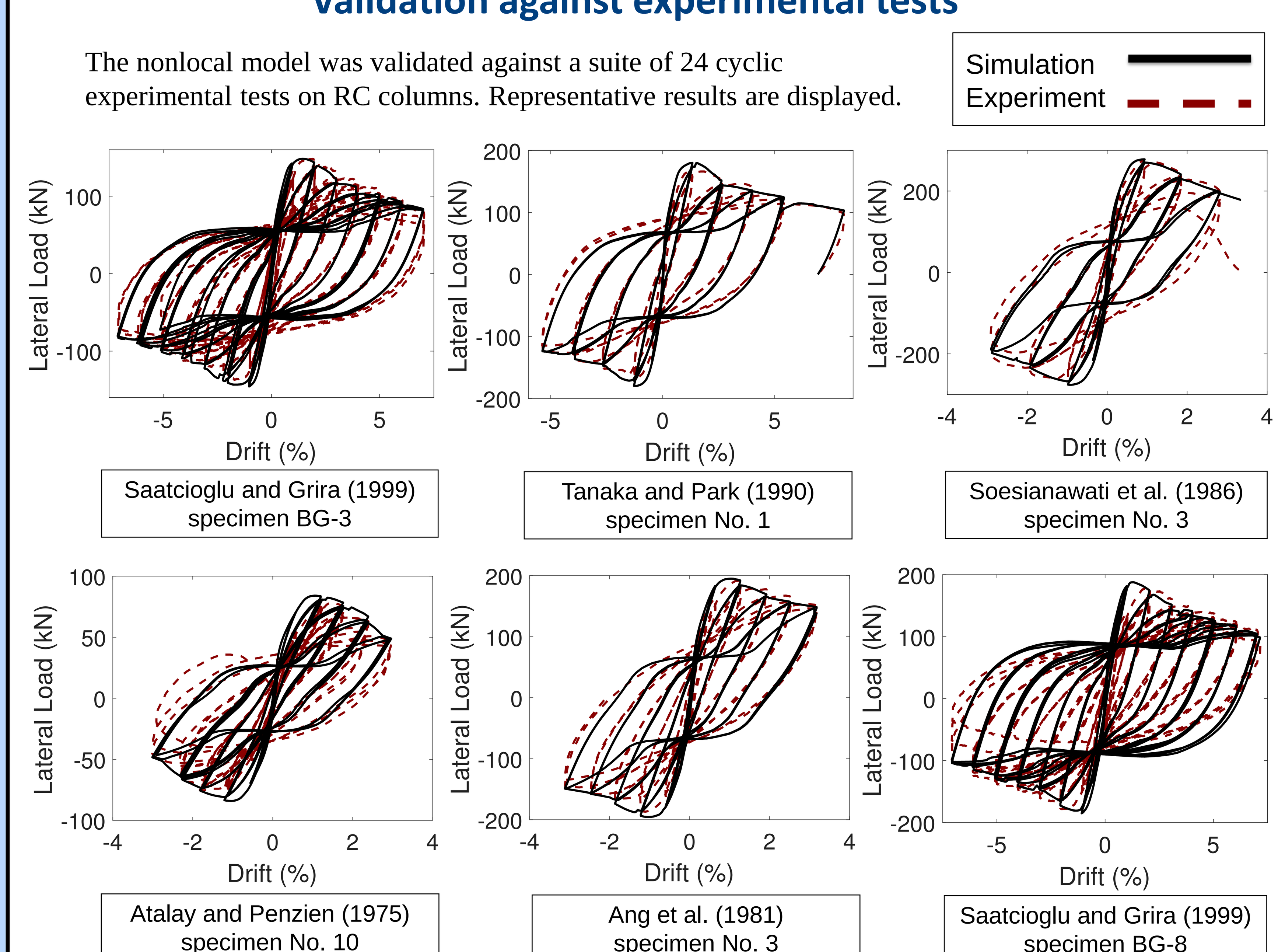
Results

Sensitivity of the simulation results to the number of elements in the mesh



Validation against experimental tests

The nonlocal model was validated against a suite of 24 cyclic experimental tests on RC columns. Representative results are displayed.



Conclusions

- Implementation of the nonlocal theory into reinforced concrete frame-element models enables robust simulation of concrete damage and response degradation, while maintaining the computational efficiency of frame elements.
- Mesh sensitivity and spurious localization of the deformation are eliminated, and a characteristic length scale is imbedded into the model to inform the size of the plastic hinge. This characteristic length should be informed by material properties.
- Ongoing work extends the current formulation to incorporate the damage of steel rebar in the column (rebar buckling in compression or fracture in tension).

Selected references

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Acknowledgments

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