

# Seismic Energy Flow and Balance in Earthquake Soil Structure Interaction, ESSI Systems

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SMiRT26

# Outline

Introduction

Plastic Energy Dissipation

Summary

# Motivation

Improve modeling and simulation for infrastructure objects

Reduce modeling uncertainty

Control timing and location of seismic energy dissipation

Goal is to Predict and Inform

# Dedication

Robert P. Kennedy, 1939-2018



"Response of a soil structure system is nonlinear, and I would really like to know what that response is!"

Nebojša Orbović, 1962-2021



"As an engineer, I have to know what are response sensitivities to modeling choices and model parameters."

# Hypothesis

Interplay of the Earthquake, Soil/Rock and Structure in time domain, plays a major role in successes and failures

Timing and spatial location of energy dissipation determines location and amount of damage

If timing and spatial location of the energy dissipation can be controlled, directed, we could optimize soil structure system for

- + Safety
- + Economy

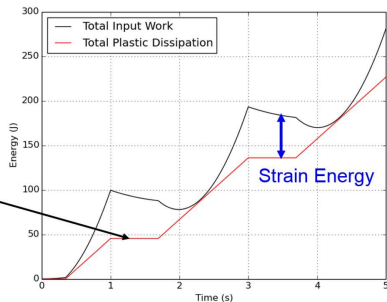
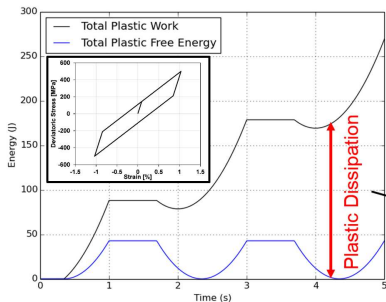
# ESSI: Energy Input and Dissipation

- + Energy input: earthquake, dynamic forcing
- Energy dissipation outside SSI domain:
  - SSI system oscillation radiation
  - Wave reflection
- Energy dissipation/conversion inside SSI domain:
  - Inelasticity, plasticity of soil, contacts, interfaces, joints, structure, foundation, dissipators
  - Viscous coupling, porous solid-pore fluids, solids/structures-external fluids
- ± Numerical, algorithmic energy dissipation/production

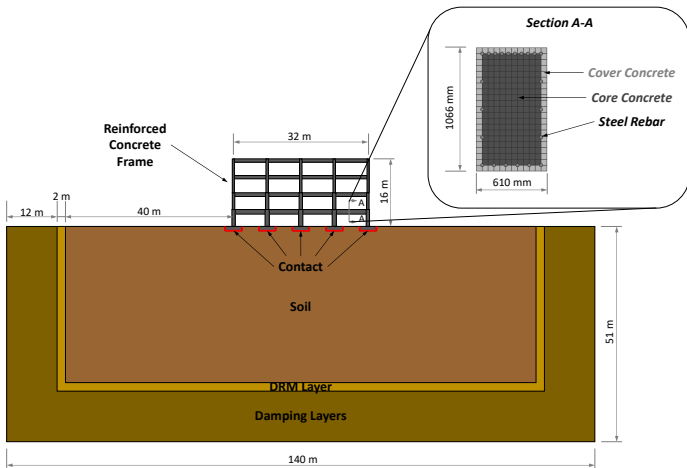
# Plastic Energy Dissipation

Plastic work is NOT plastic dissipation !

Surface area of  $F - \Delta$  or  $\sigma - \epsilon$  is NOT plastic dissipation !

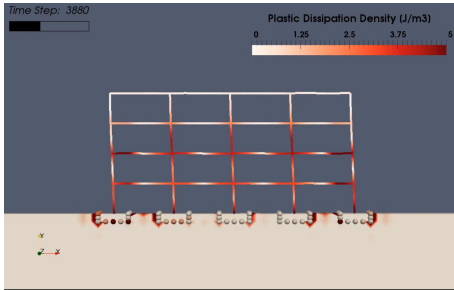


# Concrete Frame Energy Dissipation for Design

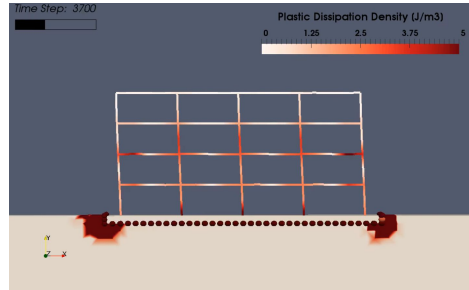




# Concrete Frame: Design Alternatives

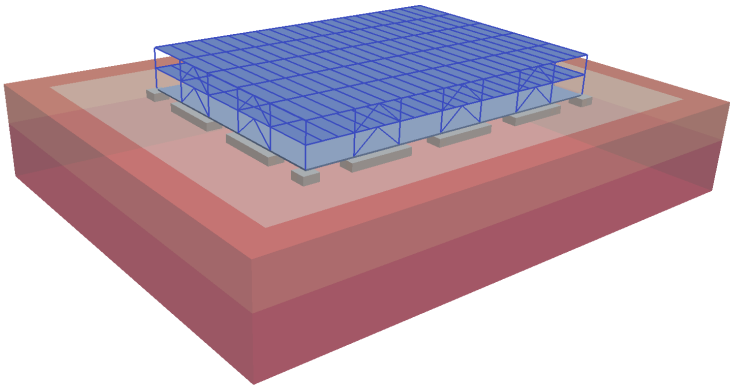


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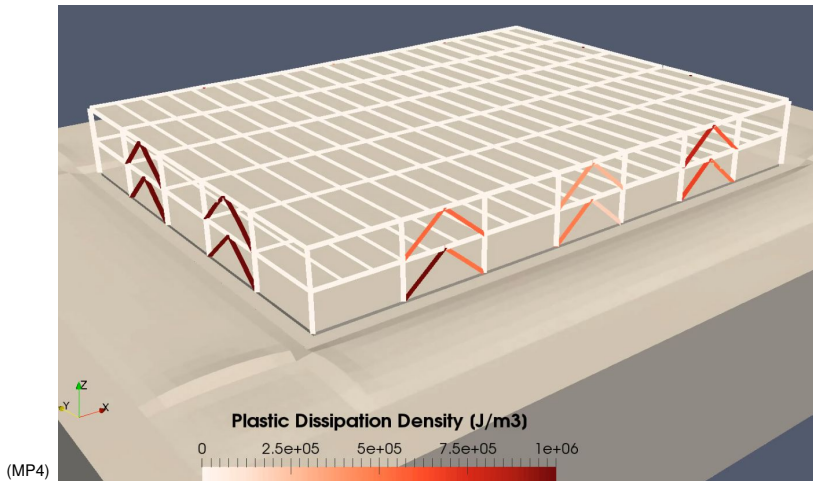


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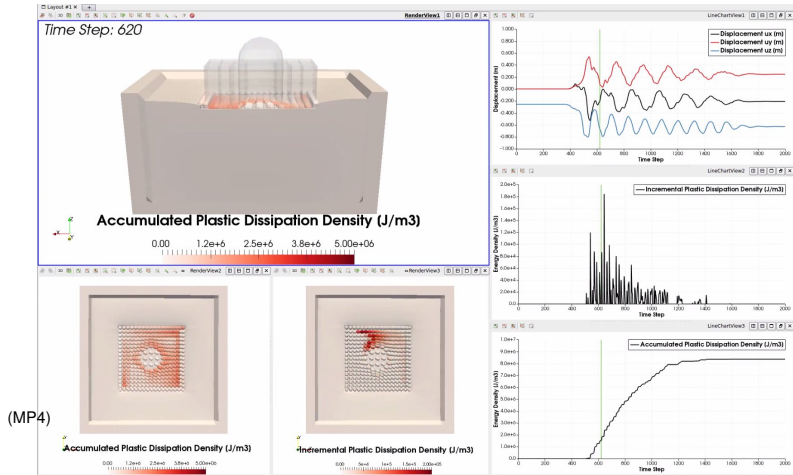
# Steel Building: Buckling Restrained Braces



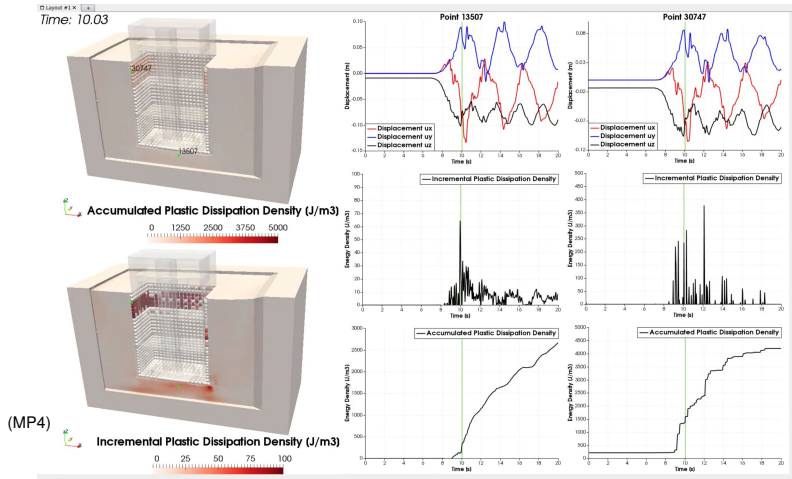
# Steel Building: Energy Dissipation



# NPP: ESSI Energy Dissipation



# SMR: ESSI Energy Dissipation



# Summary

Control seismic energy dissipation

Timing

Location

Improve

Safety

Economy

Energy calculation tools are available within the Real-ESSI

<http://real-essi.us>