SMATCH Benchmark

Cruas NPP Analyis

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Outline

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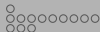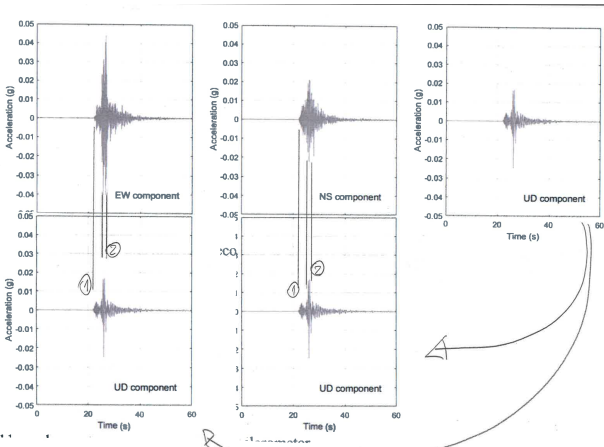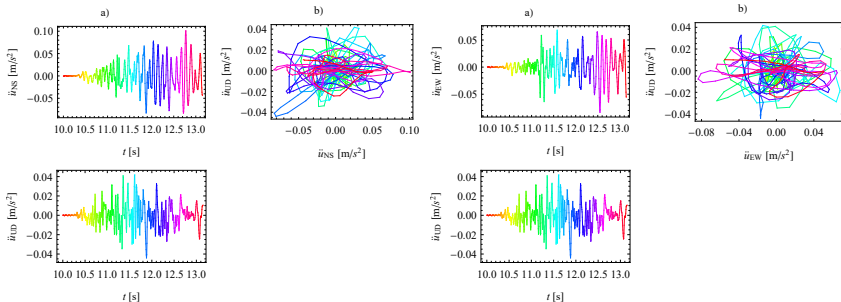
Motivation

Motivation

- Develop realistic models for Cruas NPP

- Assess effects of model sophistication on analysis results

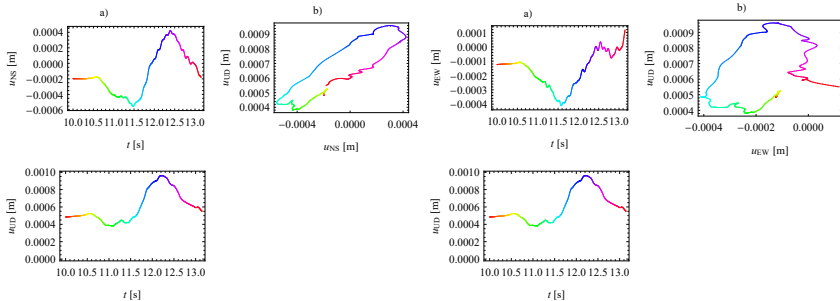- Communicate need for realistic, nonlinear analysis

- Predict and inform, Engineer needs to know!
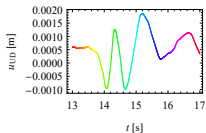
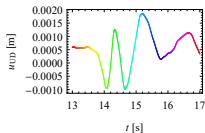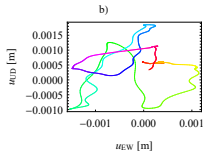# Outline

Le Teil EQ, Ground Motions at Cruas NPP

Seismic Motions

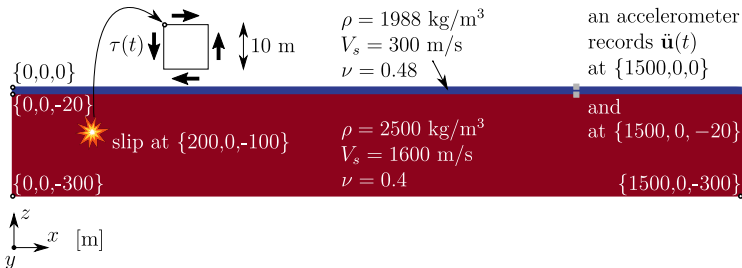# Le Teil EQ, Acceleration, Station #1, $10 - 13$s

Seismic Motions

Le Teil EQ, Displacement, Station #1, $10 - 12s$

Seismic Motions

Le Teil EQ, Displacement, Station #1, $13 - 17s$
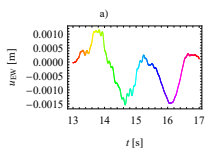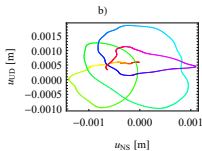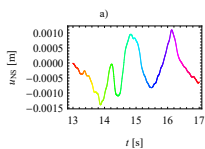
ESSI, Simplified Le Teil EQ Regional Model

$\rho = 1988$ kg/m^3
$V_s = 300$ m/s
$\nu = 0.48$

$\tau(t)$ 10 m

{0,0,0}
{0,0,-20}

slip at {200,0,-100} $\rho = 2500$ kg/m^3
$V_s = 1600$ m/s
{0,0,-300} $\nu = 0.4$

an accelerometer
records $\ddot{\mathbf{u}}(t)$
at {1500,0,0}

and
at {1500, 0, −20}

{1500,0,-300}

z
x [m]
y

Seismic Motions

ESSI Le Teil, Acc. 1.3km away, Rock ($-20m$)

at $\boldsymbol{x}$ = {1500,0,−20} m
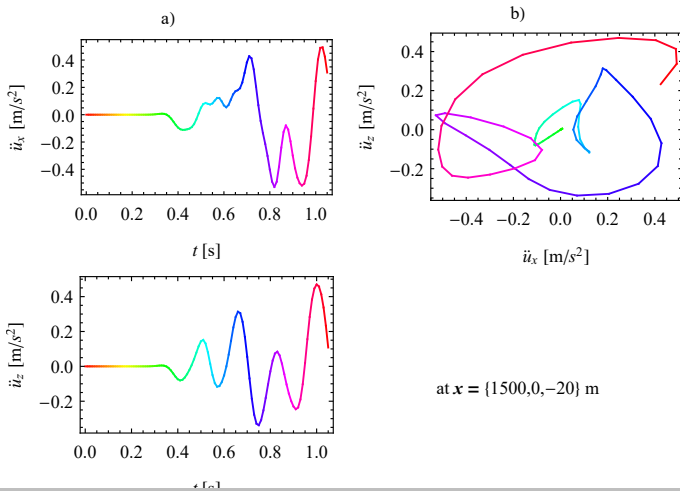
Seismic Motions

ESSI Le Teil, Disp., 1.3km away, Rock ($-20m$)

at $x = \{1500, 0, -20\}$ m

Jeremić et al.

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ESSI Analysis for SMATCH

Seismic Motions

1C vs 3C Free Field Motions

- One component of motions, 1C from 6C
- Excellent fit, wrong physics
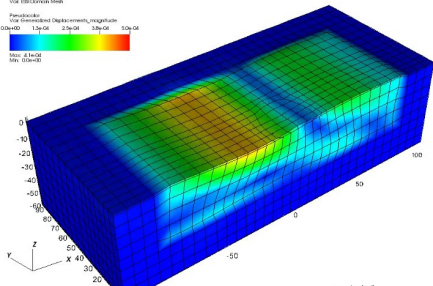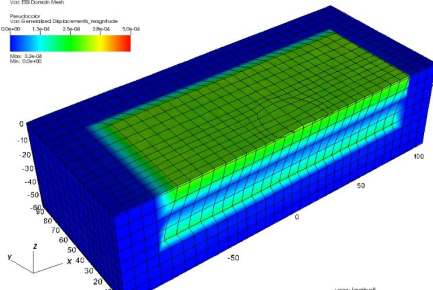
(MP4) (MP4)

Seismic Motions

3C vs 1C NPP ESSI Response Comparison

(MP4)

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ESSI Analysis for SMATCH

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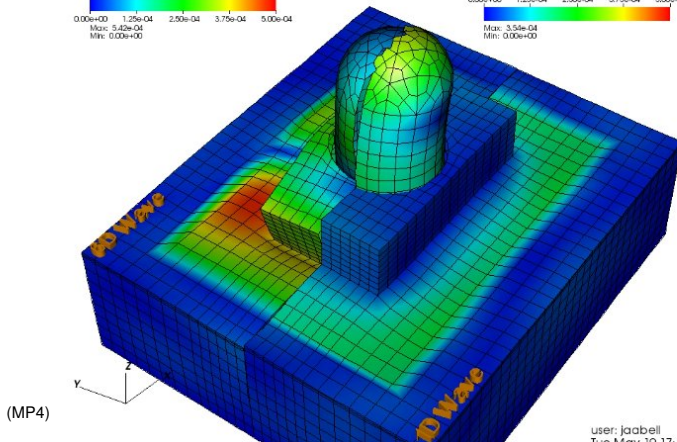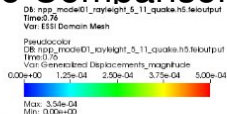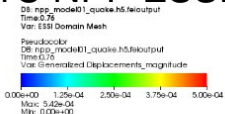
Cruas NPP
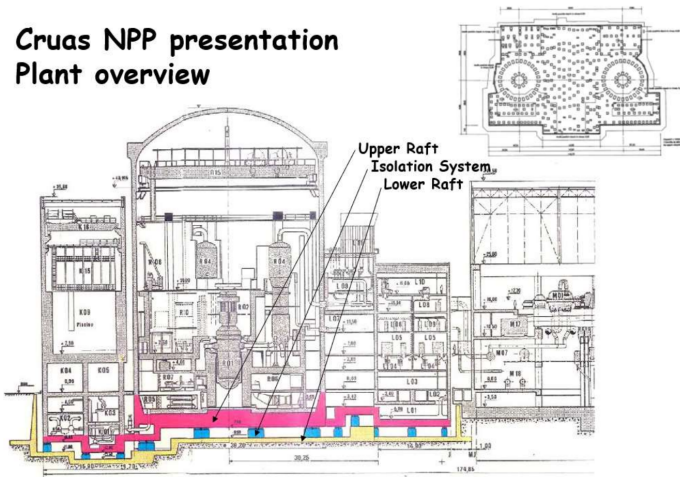
Cruas NPP FEM Model

- Quality Assurance: FEM program Verified and Validated

- Model Components Validation

- Varying model sophistication
    - non-SSI model
    - NPP stick/beam model
    - NPP shells/solids model (SSM). 3D
    - Linear elastic material, 3D
    - Nonlinear, elastic-plastic material SSM, 3D

FEM Model Development, Verification and Validation

Cruas NPP FEM Model

- Seismic motions

    1D/1C seismic motions
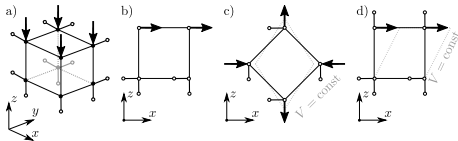   3D/3×1C seismic motions
    3D/3C seismic motions
    As measured and stronger seismic motions
    Shake-out/Stress-test

- Asses effects of

    FEM model sophistication
    Soil inelasticity
    Interface inelasticity
    Isolators: 1D, 2D, 3D
    Motion frequencies, wavelets
    Inclined seismic motions

Outline

Summary

- Le Teil seismic wave field
    - Surface wave: Rayleigh, Love, and Stoneley wave
    - Shallow geology, soft soil layers

- FEM model development
    - Full 3D nonlinear model
    - Model verification and validation
    - Cruas NPP Shake-out/Stress-test

- Education and Training development