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Some Aspects of Infrastructure Resilience Research at Manchester

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Summary of Research Areas

- Flooding risk management research consortium (FRMRC)
- Smoothed Particle Physics (SPH)
- Marine energy
- Coastal structures
- Extreme loading on structures (explosion, blast, fire)
- Structural conservation and durability
- Geotechnics (Soil treatment and strengthening)
- Electricity resilience/Climate change (under the ARCC banner)

FRMRC: Leader of SWP2 – Coastal Flooding (Prof Stansby)

FRMRC flood risk management research consortium

SWP2 Coastal Flooding

Universities of Manchester and Oxford, and HR Wallingford – WP2.1
University of Plymouth – WP2.2
Proudman Oceanographic Laboratory and University of Bristol – WP2.3

Cornwall 1990

Gt Yarmouth 1953

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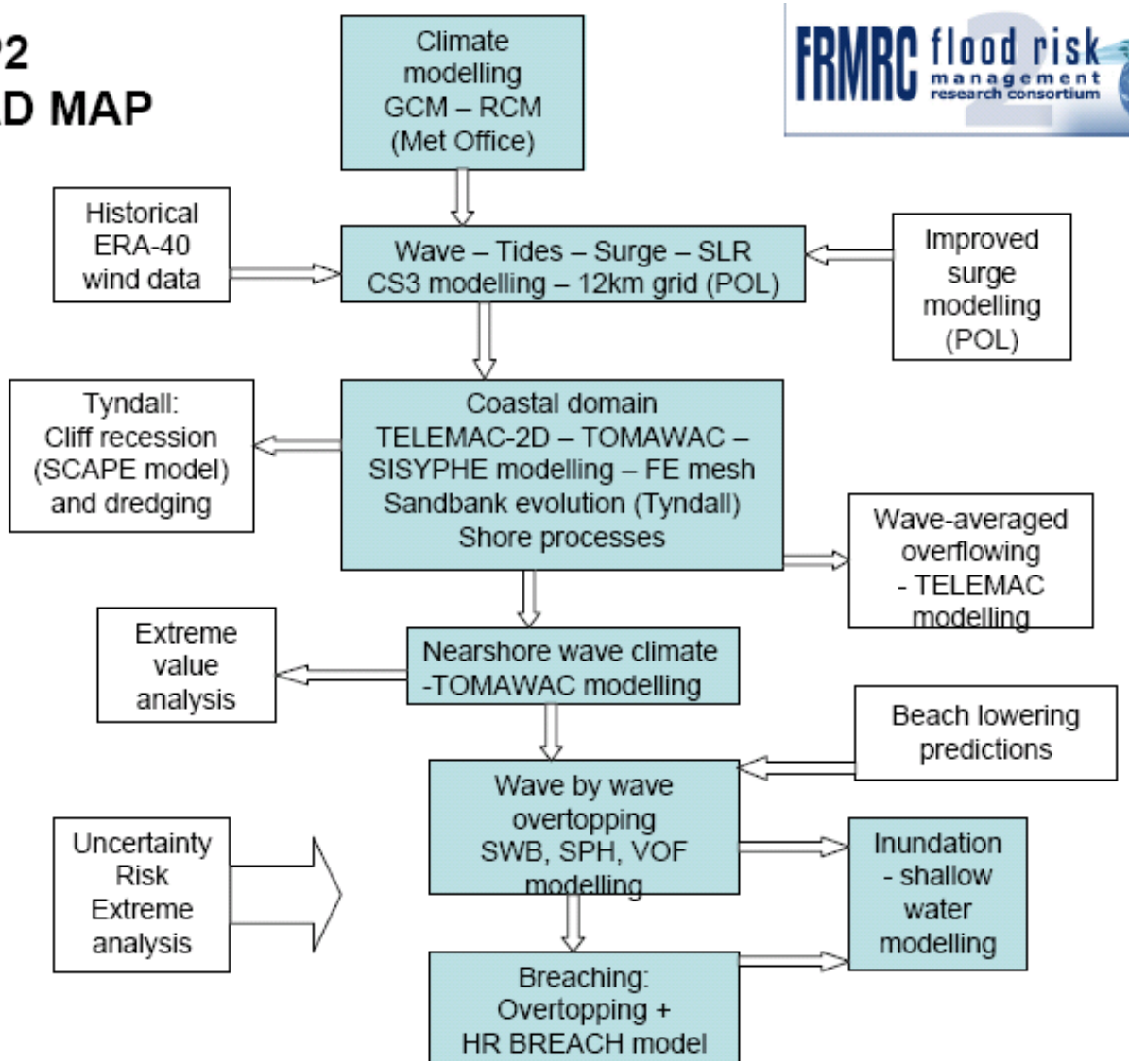
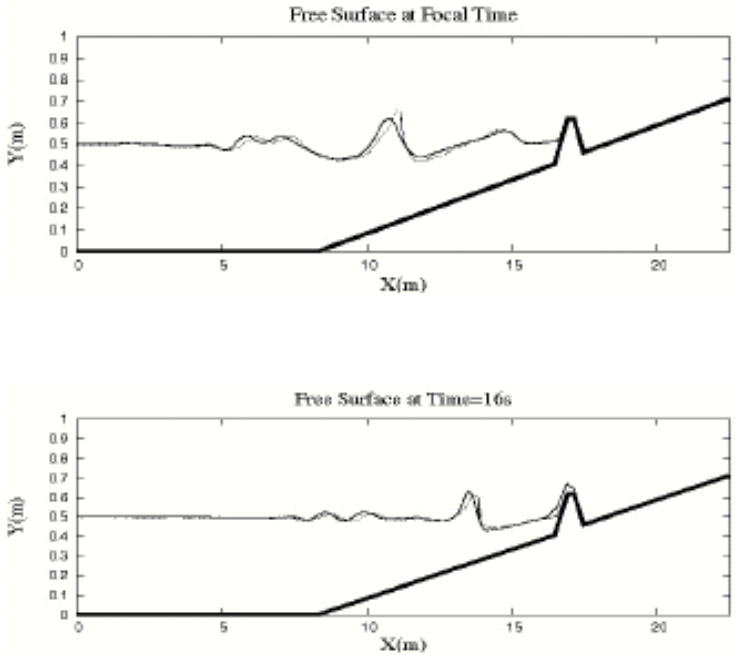
SWP2 ROAD MAP



Example of wave overtopping modelling

(Boussinesq, SWB, and VOF modelling)

Wave group with A_N=11.4 cm focussed at 2.5m inshore of beach toe



——— SWB model, -------VOF model

But new SPH modelling improvements in accuracy and efficiency

DualSPHysics online

www.sphysics.org

Our Motivation for SPH

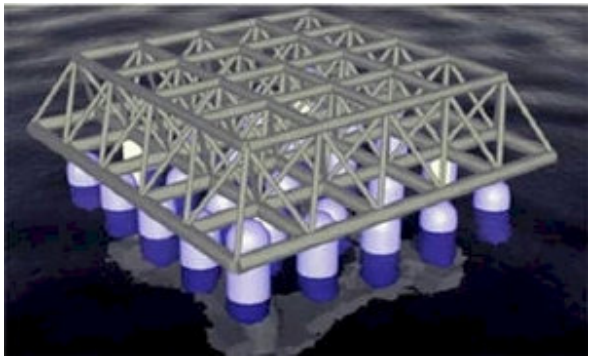
- **Free-surface flows** are rarely singly connected, e.g. beaches & wave energy devices

Breaking waves on beaches

(Photo courtesy of F. Raichlen)

Overtopping:

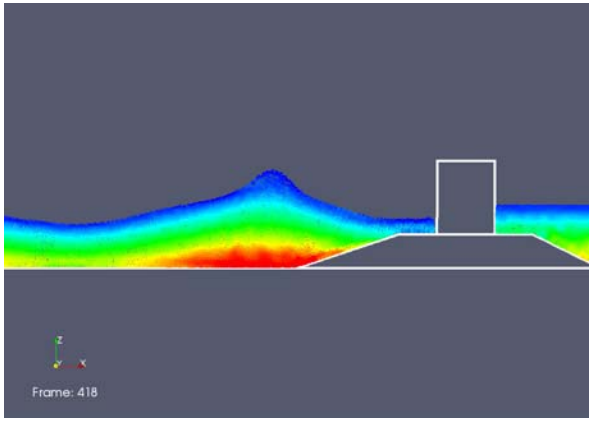
Wave Energy Devices: Manchester Bobber

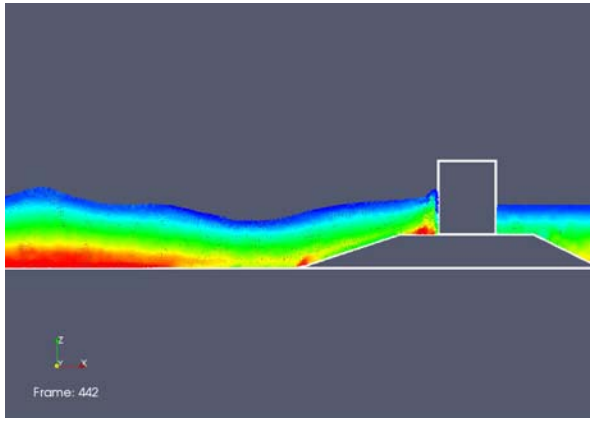


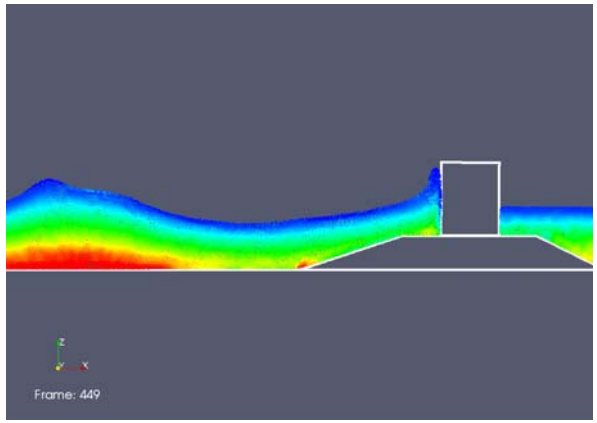
Very complex Multi-phase Multiscale nonlinear problems

SPH: Is one of the few simulation techniques that can handle these situations

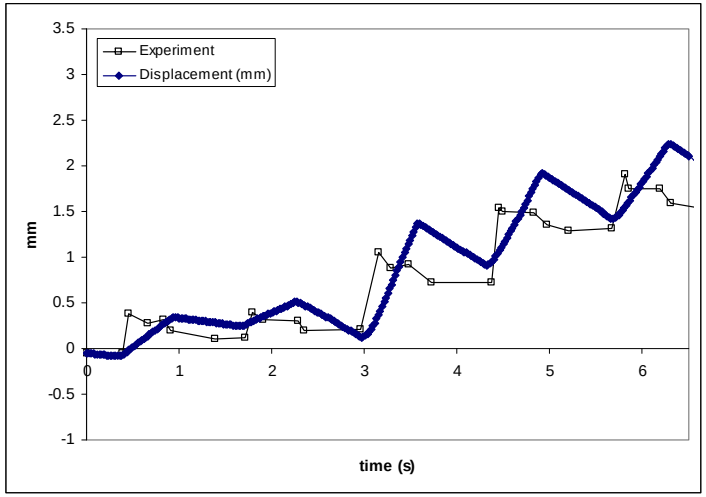
Previous Validation: Caisson Breakwater



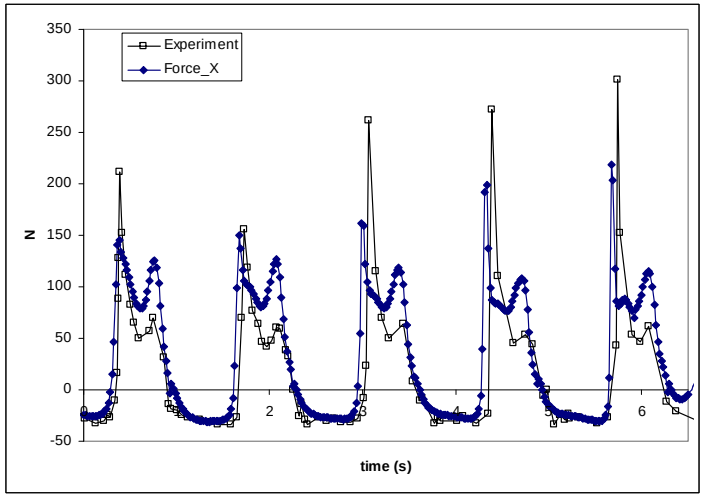




Displacement comparison

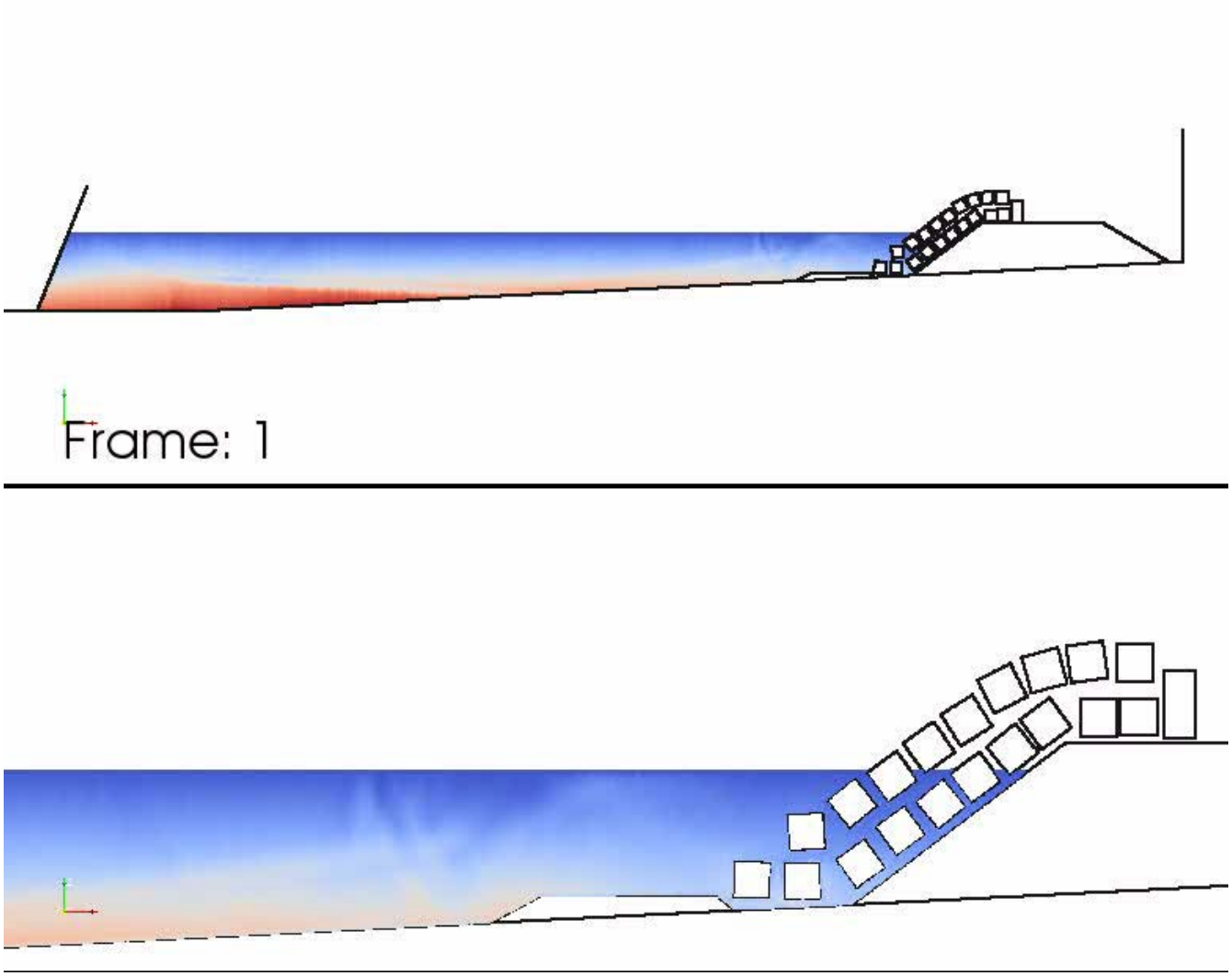


Force comparison

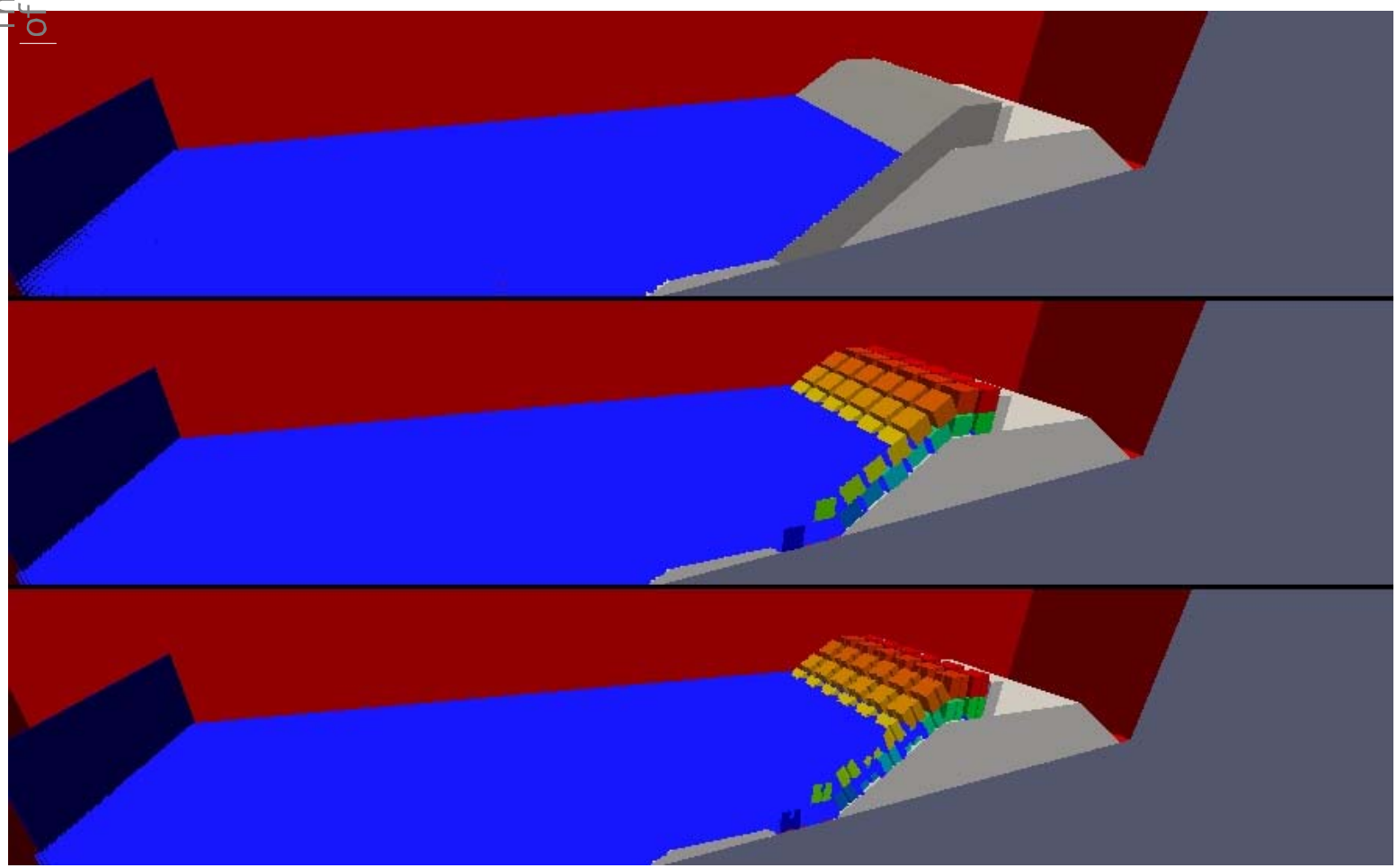


- Full degrees of freedom simulations using the same coefficient of friction
- Comparison with experiments: movement 1% movement of caisson width

Zeebrugge Breakwater



Zeebrugge Breakwater in 3-D



Smooth

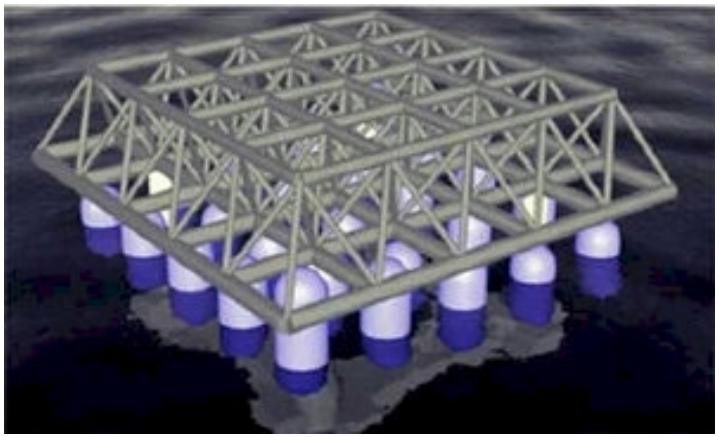
Cubes

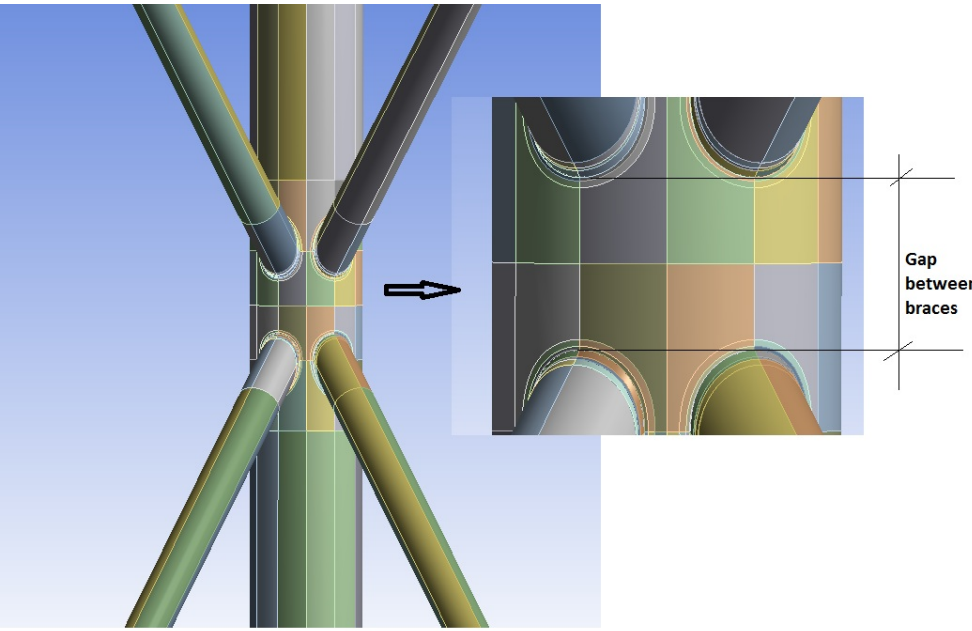
Antifer

Altomare et al. (2011)

Renewable Energy Structures

- Manchester bobber
- Wind turbine tower structure
- Wave energy





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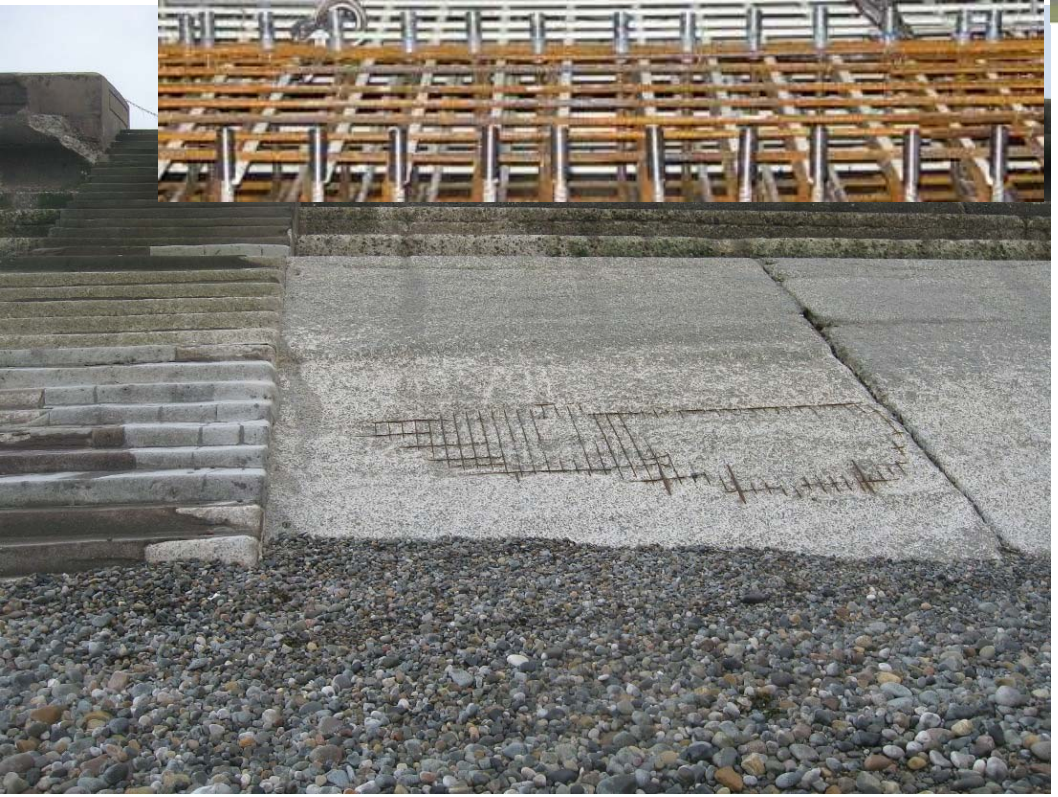
Maritime Structures



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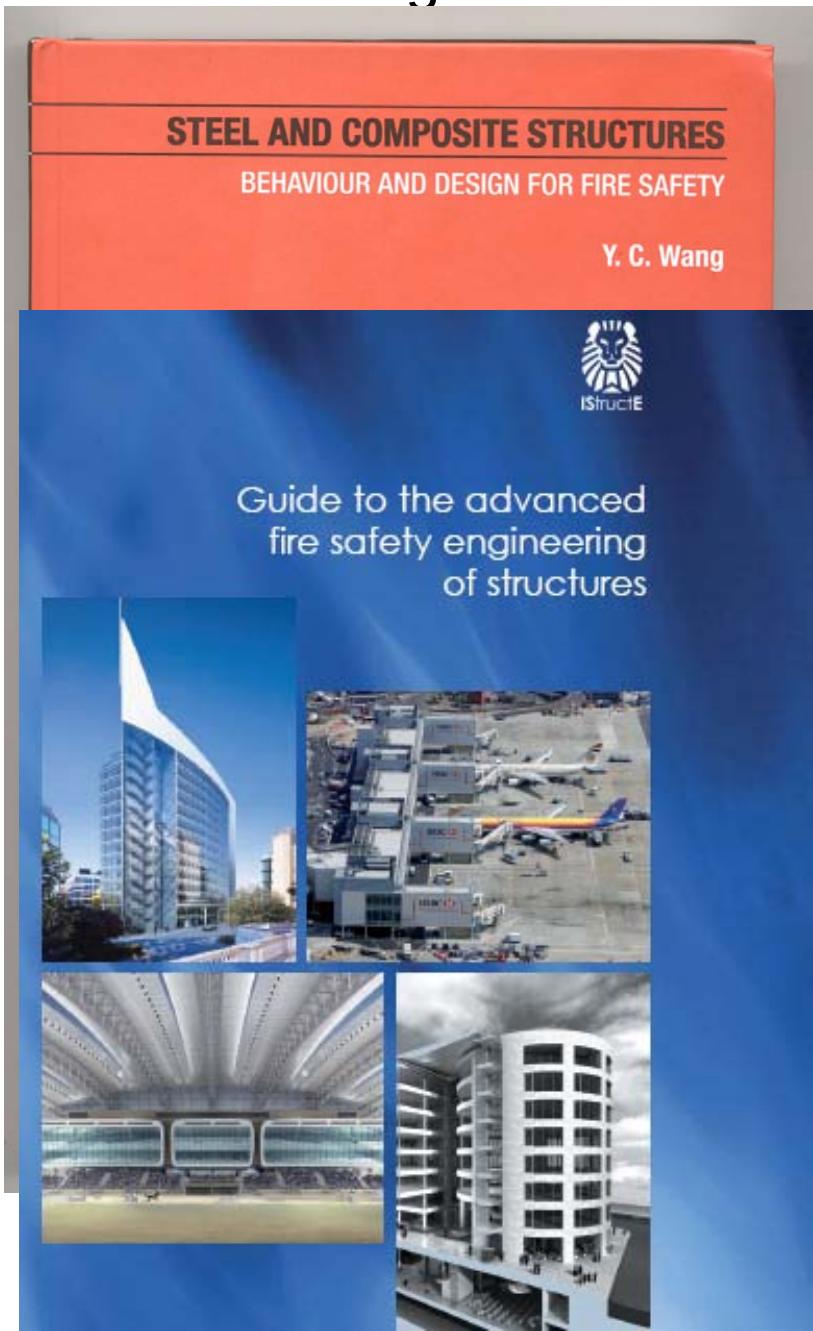
Structures under extreme loading - fire



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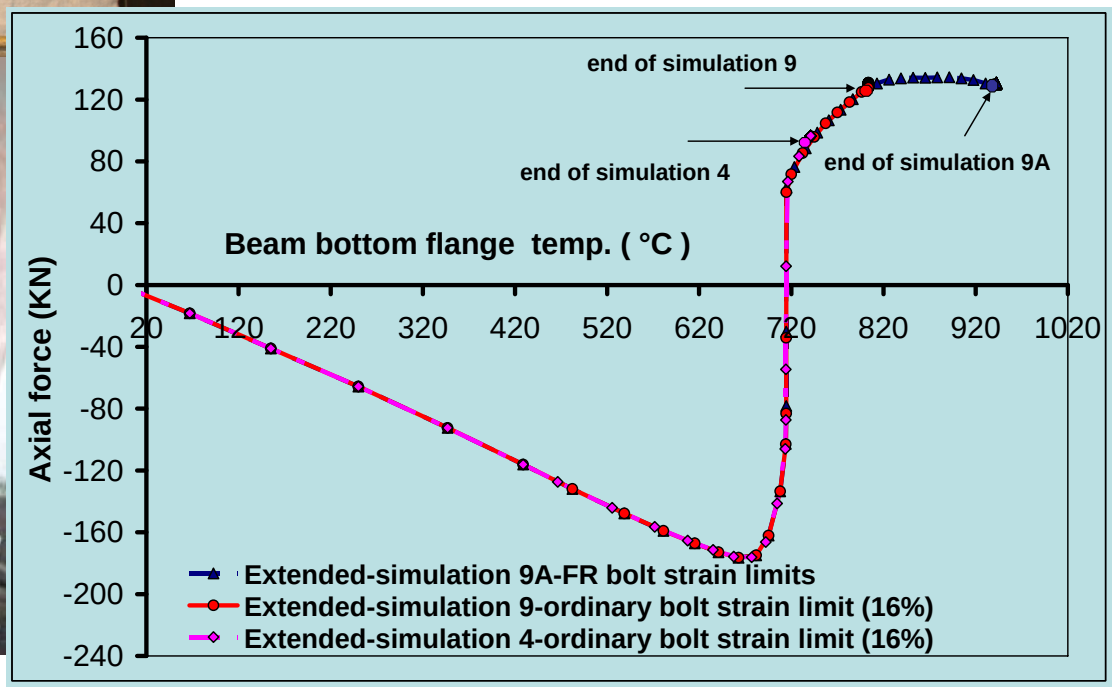
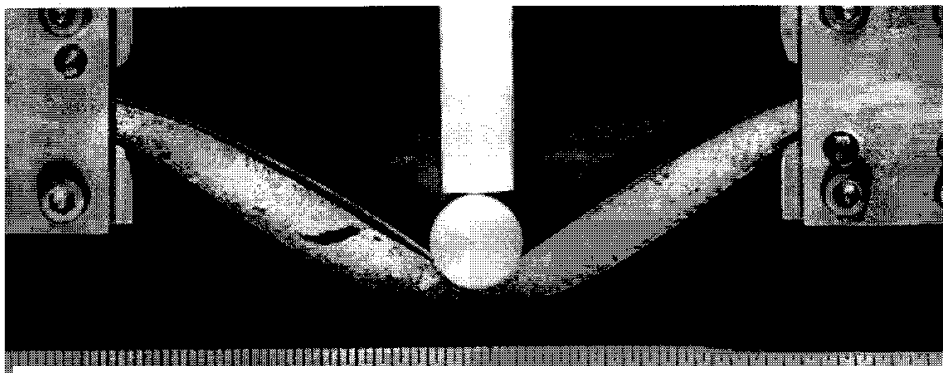
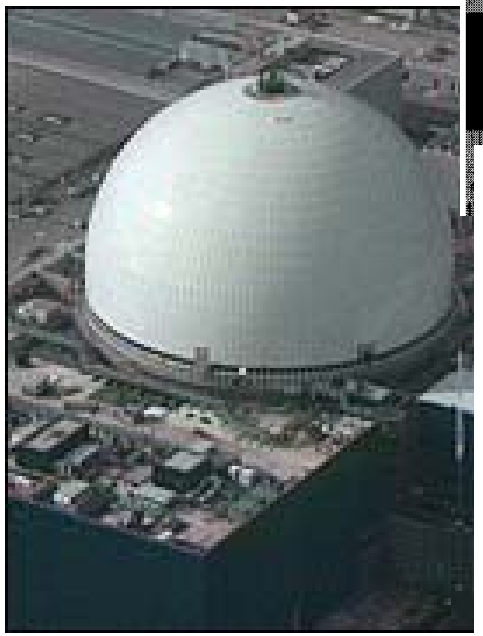
Robustness of Structures in Fire

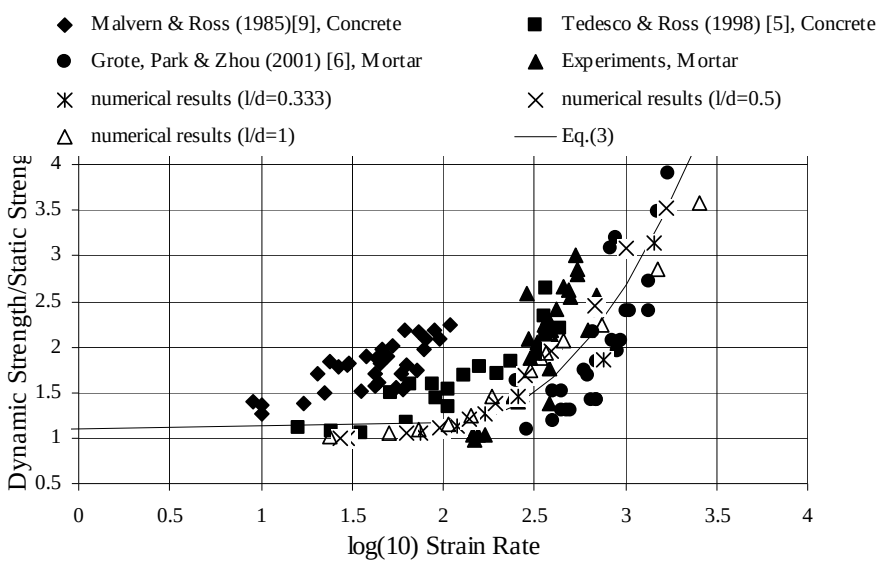


Structural Integrity under Impact and Blast Loads

1. Protection of Nuclear Facilities against Impact Threat
   - Protective design of concrete penetration and perforation against missiles
   - Impact resistance of nuclear waste package
2. Energy absorption
3. Material characterisation







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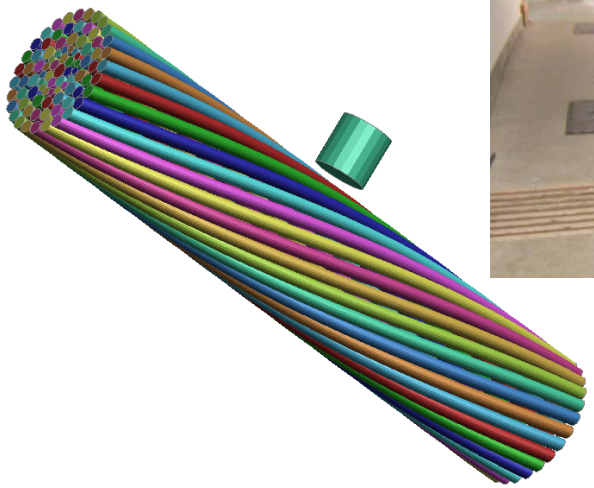
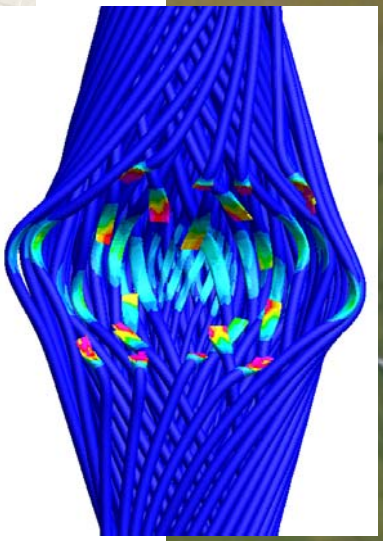
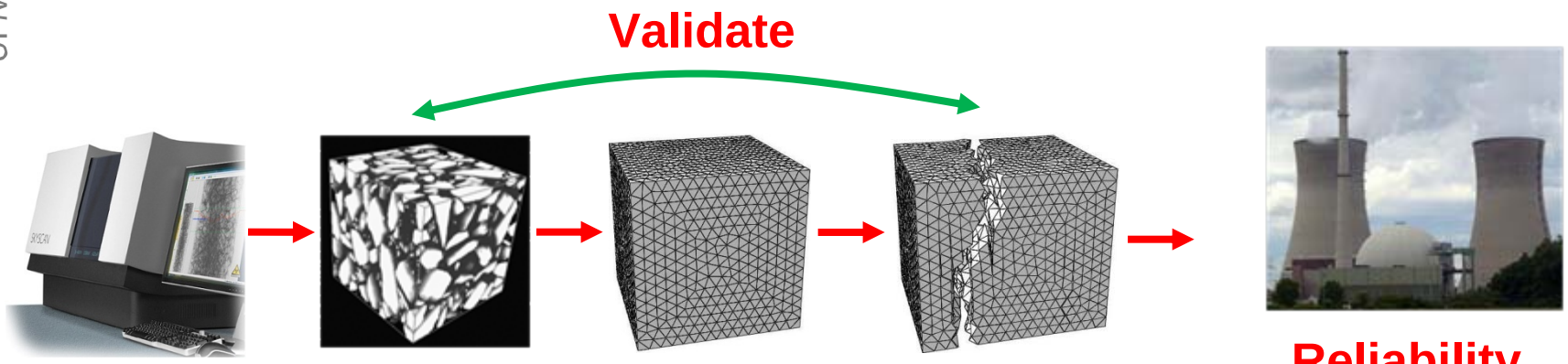
Cable Structures under Impact





1328 m/s

Integrated Modelling



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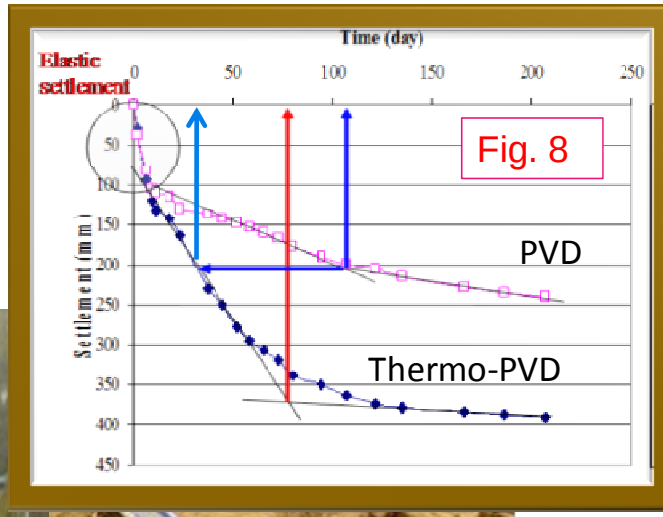
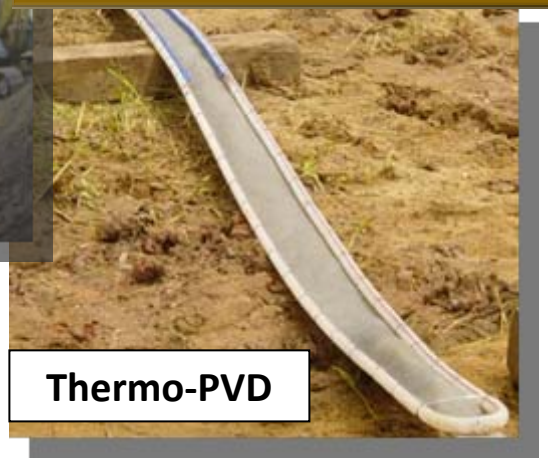
Development of an innovative thermal ground improvement technique

Main contributions:

Exploiting the THM behaviour of soft clays to optimize the performance of PVD-Preloading ground improvement method.



Full-scale embankment test



Journal publications

- **Abuel-Naga, H.M.,** Bergado, D.T., and Chaiprakaikeow, S. (2006). Innovative Thermal Technique for Enhancing the Performance of Prefabricated Vertical Drain System. *Geotextile and Geomembranes*, 24(6), 359-370.
- Pothiraksanon, C., Saowapakpiboon, J., Bergado, D. T., Voottipruex, P., and **Abuel-Naga, H. M**. (2010) Soft ground improvement with solar-powered drainage. Ground Improvement, ICE, 163(1), 23 –30
- Pothiraksanon, C., Bergado, D.T., **Abuel-Naga, H.M**. (2010). Full scale Thermo-PVD embankment. Soils and Foundations. 50 (5), 599-608

Landfill engineering: composite liners

Main contributions:

- Building a novel cell for measuring water retention curve of GCLs at different environmental conditions
- Proposing an accurate calibration protocol for the thermo-couple psychrometer sensor
- Developing of a new soil suction sensor (commercialization stage)

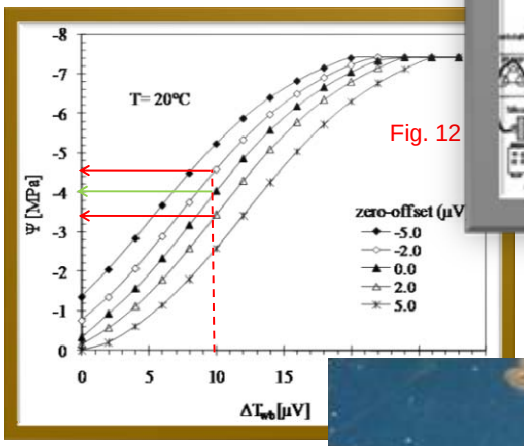
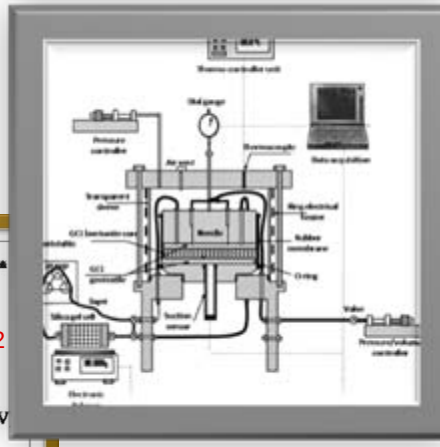


Fig. 12



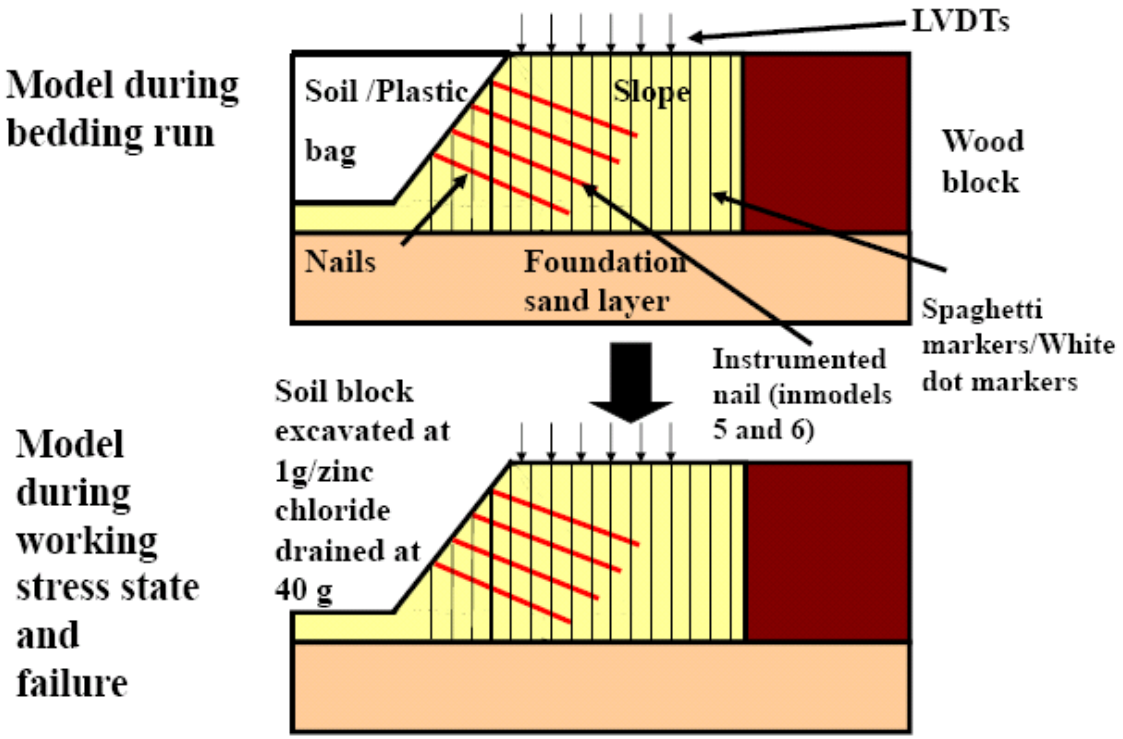
Journal publications

•**Abuel-Naga, H.M.,** and Bouazza, A. (2009) Numerical Characterization of Advective Gas Flow through Gm\Gcl Composite Liners Having a Circular Defect in the Geomembrane. Journal of Geotechnical and Geoenvironmental Engineering, ASCE. 135(11), 1661-1672.

•**Abuel-Naga, H.M.,** and Bouazza, A. (2010) Laboratory technique for measuring water retention curve of Geosynthetics Clay Liners. Geosynthetics International. 17(5), 1-10.

•**Abuel-Naga, H.M.,** and Bouazza, A. (2011) Effects of Temperature and Thermal Gradient on Thermocouple Psychrometer Measurements. Geotechnique. (In press)

- Performance of geosynthetic clay liners to landfills
- Seabed soil-pipeline interactions under lateral buckling conditions
- Uplift resistance of subsea pipelines in cohesionless soil
- Performance of soil-nailed structures in clay



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Other Related Research – ARCC (Adaptation and Resilience to a Climate Change)

- SCORCHIO: Sustainable Cities: Options for Responding to Climate Change Impacts and Outcomes
- COPSE: COincident Probabilistic climate change weather data for a Sustainable built Environment
- RESNET: Resilient Electricity Networks for Great Britain