

#### 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)

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

#### SWP2 Coastal Flooding



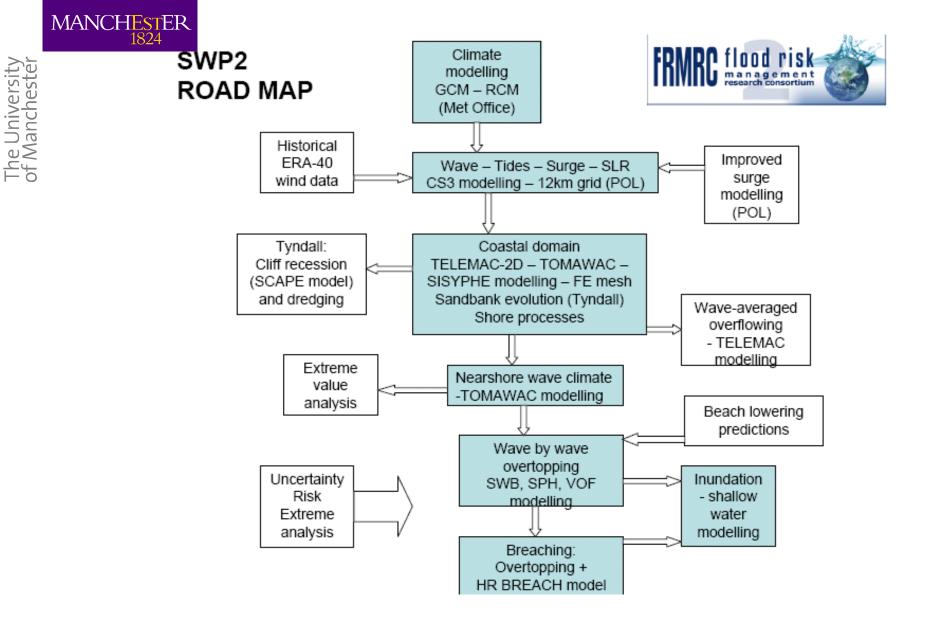
Universities of Manchester and Oxford, and HR Wallingford – WP2.1 University of Plymouth – WP2.2 Proudman Oceanographic Laboratory and University of Bristol – WP2.3



Cornwall 1990

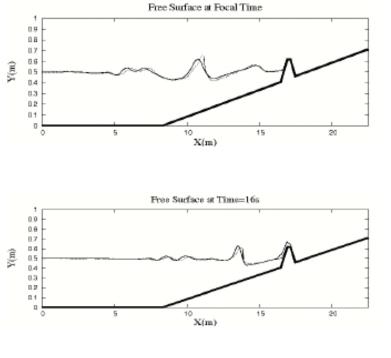
Gt Yarmouth 1953

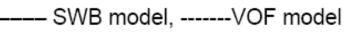




Example of wave overtopping modelling (Boussinesq, SWB, and VOF modelling)

Wave group with A<sub>N</sub>=11.4 cm focussed at 2.5m inshore of beach toe







But new SPH modelling improvements in accuracy and efficiency

# **DualSPHysics online**

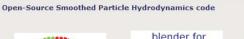
#### www.sphysics.org



#### **SPHysics**



- SPHYSICS Home
- Developers
- Downloads
- SPHYSICS FAQ
- SPHYSICS Forum
- Visualization
- Code History
- Future
- Developments
- Contributors
- Recent changes
  Training Courses
- Help
- Help
- search



SPHysics - SPH Free-surface Flow Solver





1. Welcome to SPHysics

SPHYSICS Home Page

(Redirected from Main Page)

- 2. Developers (photos) and Contributors
- 3. Code Features
- 4. Downloads (serial, parallel, GPU, hybrid-coupling)
- 5. Documentation
- 6. SPHysics FAQ
- 7. SPHysics Forum
- 8. Visualization: Images & Videos
- 9. Code History & Fixed Bugs (UPDATES)
- 10. Future Developments & Releases
- 11. Publications using the SPHysics code
- 12. Training Courses
- 13. How to reference SPHysics
- 14. Help and Info about SPHysics website



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#### The SPHysics Code

SPHysics is a platform of Smoothed Particle Hydrodynamics (SPH) codes inspired by the formulation of Monaghan (1992) develo University of Vigo (Spain), the University of Manchester (U.K.) and the University of Rome La Sapienza (Italy). Developed over Eulerian methods can be difficult to apply, such as waves, impact of dam-breaks on off-shore structures. We are excited to ar versions can be found under (**Future Developments & Releases**).

v2.2.1 Serial Code UPDATE RELEASED: January 2011 v2.0 Parallel Code RELEASED: January 2011

v1.0 DualSPHysics CPU-GPU Code RELEASED: January 2011

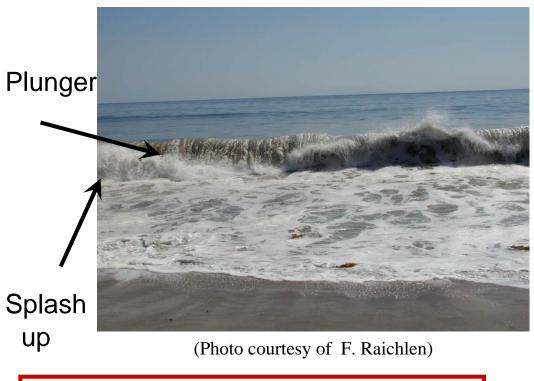
Download SPHysics

Combining The Victori

# **Our Motivation for SPH**

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

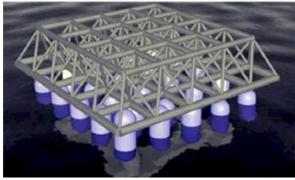
Breaking waves on beaches



Very complex Multi-phase Multiscale nonlinear problems **Overtopping**:



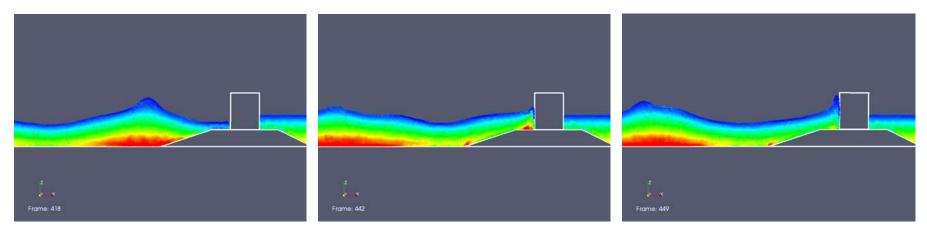
#### Wave Energy Devices: Manchester Bobber

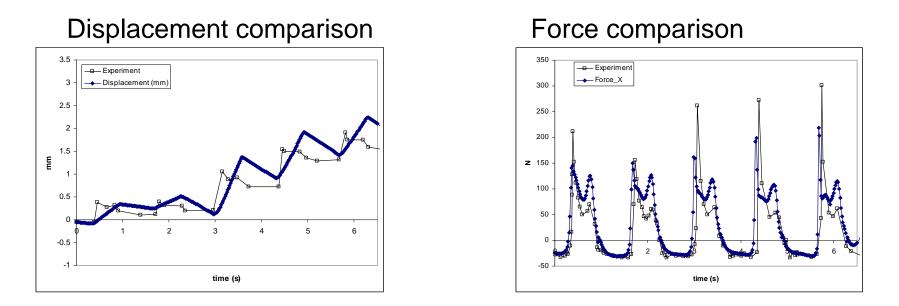


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**SPH**: <sup>Vic</sup> Is one of the few simulation techniques that can handle these situations

# **Previous Validation: Caisson Breakwater**

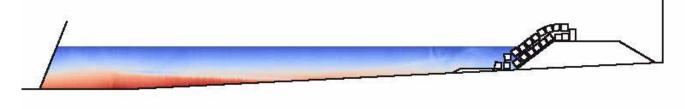




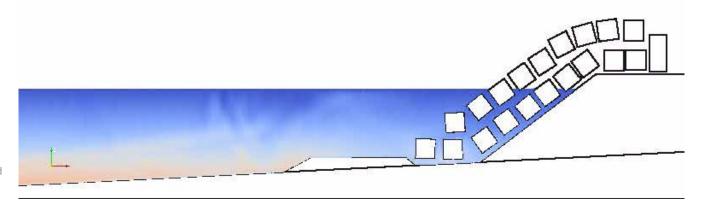
- Full degrees of freedom simulations using the same coefficient of friction
- Comparison with experiments: movement 1% movement of caisson width



#### Zeebrugge Breakwater



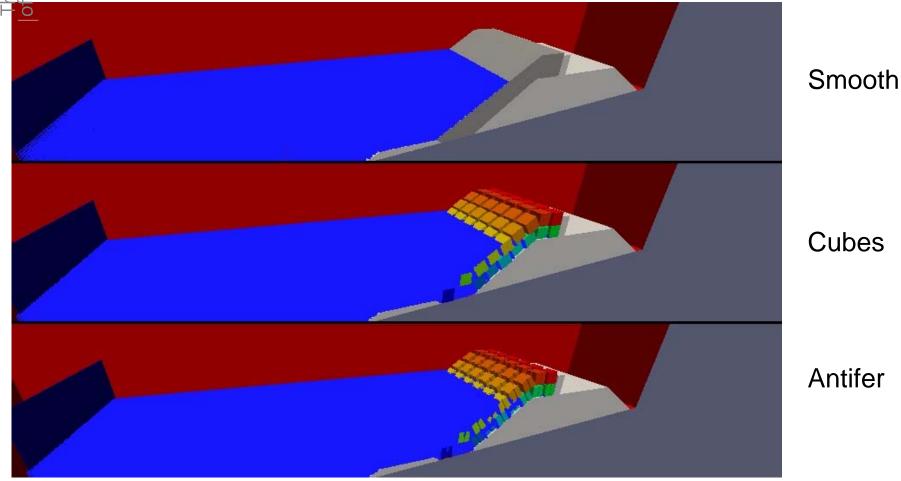




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#### Zeebrugge Breakwater in 3-D

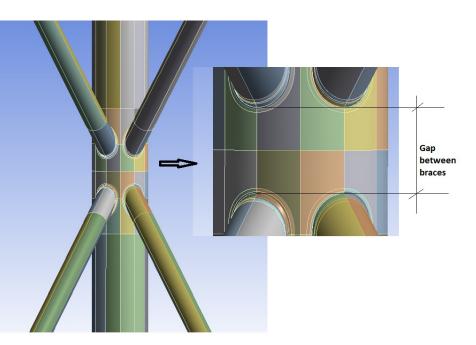


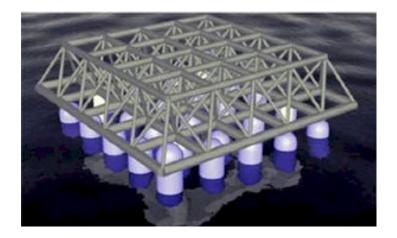




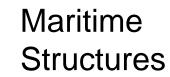
#### **Renewable Energy Structures**

- Manchester bobber
- Wind turbine tower structure
- Wave energy





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MANCHESTER 1824



#### Structures under extreme loading - fire

**STEEL AND COMPOSITE STRUCTURES BEHAVIOUR AND DESIGN FOR FIRE SAFETY** 

Y. C. Wang



Guide to the advanced fire safety engineering of structures











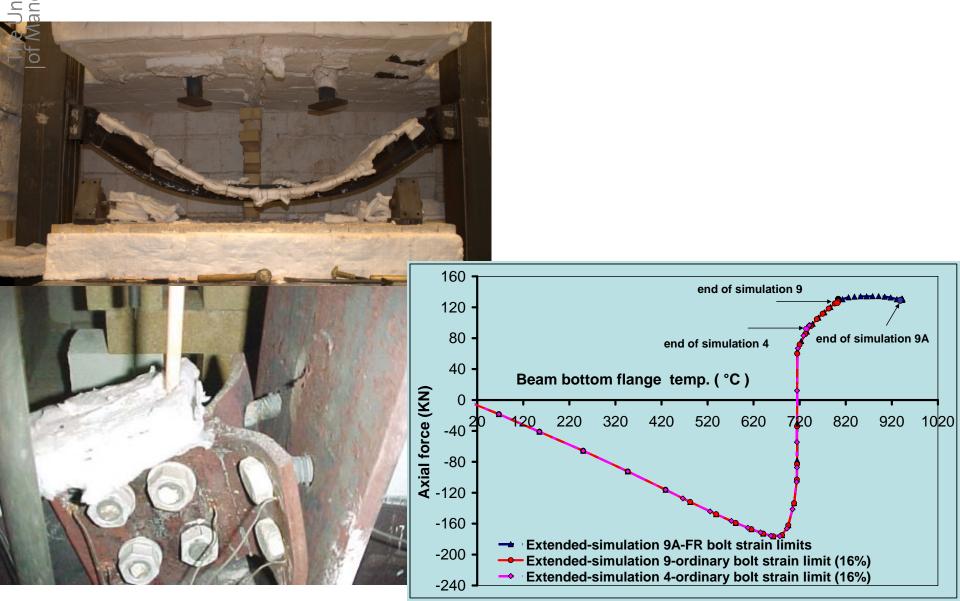


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#### Robustness of Structures in Fire





#### Structural Integrity under Impact and **Blast Loads**

- Protection of Nuclear Facilities against Impact Threat
- Protective design of concrete penetration and perforation against missiles

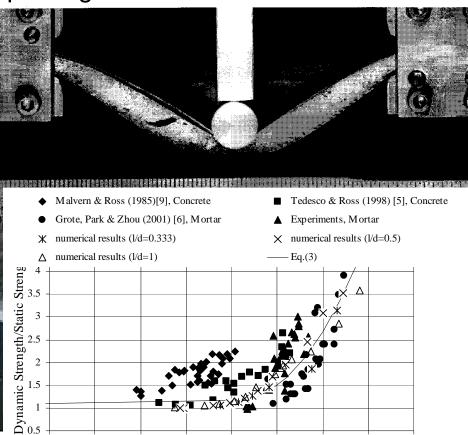
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- Impact resistance of nuclear waste package
- **Energy absorption** 2.
- Material characterisation 3.



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1.5 log(10) Strain Rate

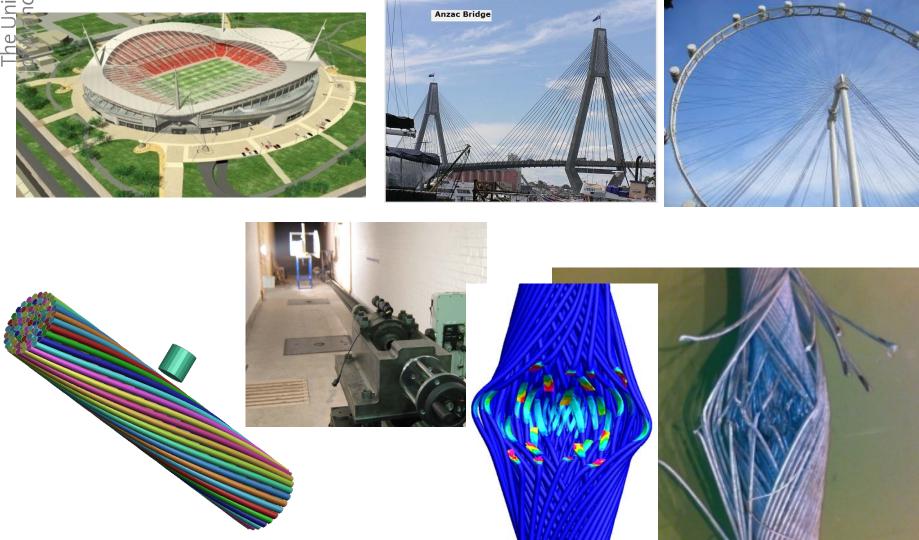
2.5

3

3.5



#### Cable Structures under Impact

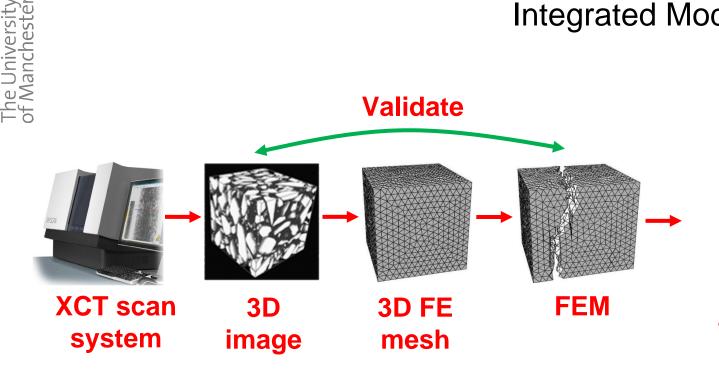


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#### **Integrated Modelling**





Reliability analysis and design of structures



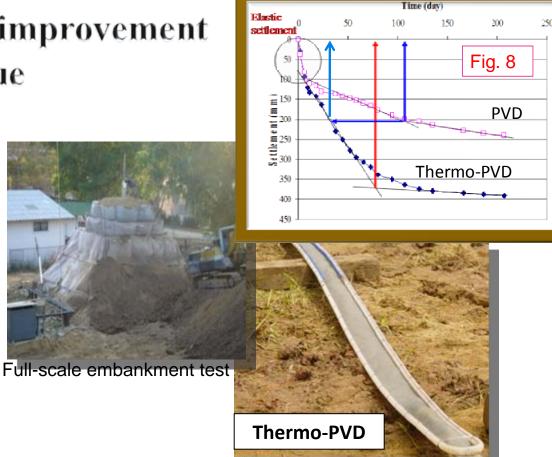
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### Development of an innovative thermal ground improvement technique

# contributions:

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



# Journal publications

- <u>Abuel-Naga, H.M.</u>, 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 <u>Abuel-Naga, H. M</u>. (2010) Soft ground improvement with solar-powered drainage. Ground Improvement, ICE, 163(1), 23 –30
- Pothiraksanon, GreBergado, D.T., <u>Abuel-Naga, H.M</u>. (2010). Full scale Thermo-PVD embankment. Soils and Foundations. 50 (5), 599-608

### Main contributions:

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- 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)

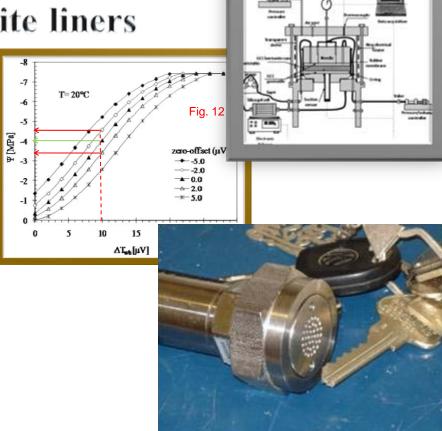
## Journal publications

•<u>Abuel-Naga, H.M.,</u> 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.

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

•<u>Abuel-Naga-H.M.</u>Bouazza, A. (2011) Effects of Temperature and Thermal Gradient on Thermocouple Psychronieter Measurements. Geotechnique. (In press)

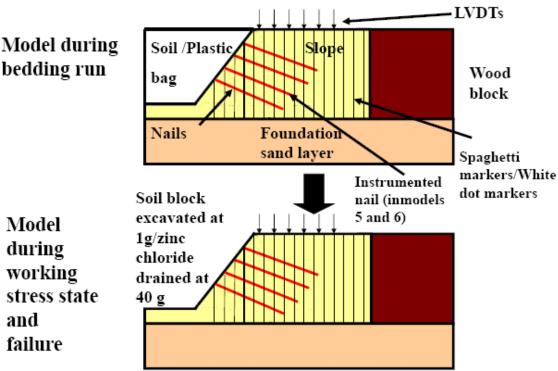
### Landfill engineering: composite liners





- The University of Manchester
- Performance of geosynthetic clay liners to landfills
- Seabed soil-pipeline  $\bullet$ interactions under lateral buckling conditions
- Uplift resistance of • subsea pipelines in cohesionless soil
- Performance of soil- $\bullet$ nailed structures in clay

Model during working stress state and failure





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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