HERIOT WATT UNIVERSITY

Speaker:

Professor Peter Woodward

Institute for Infrastructure and Environment
Heriot-Watt University

Distinctly Ambitious
www.hw.ac.uk

Professor Ian May

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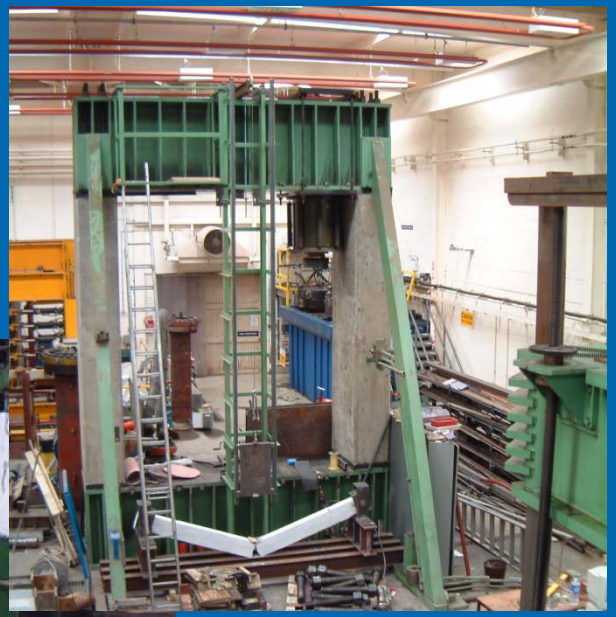
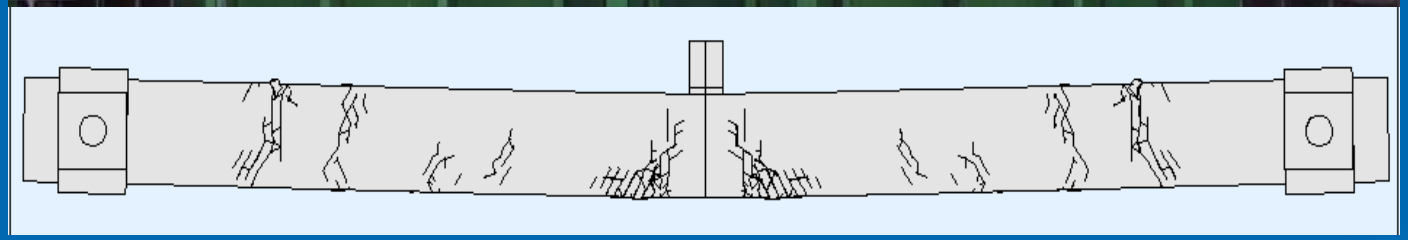
High Mass Low Velocity Impact Testing

Drop-hammer test rig, data gathered includes high speed video, data gathered at 1M bits per second. Numerical modelling using discrete/finite elements



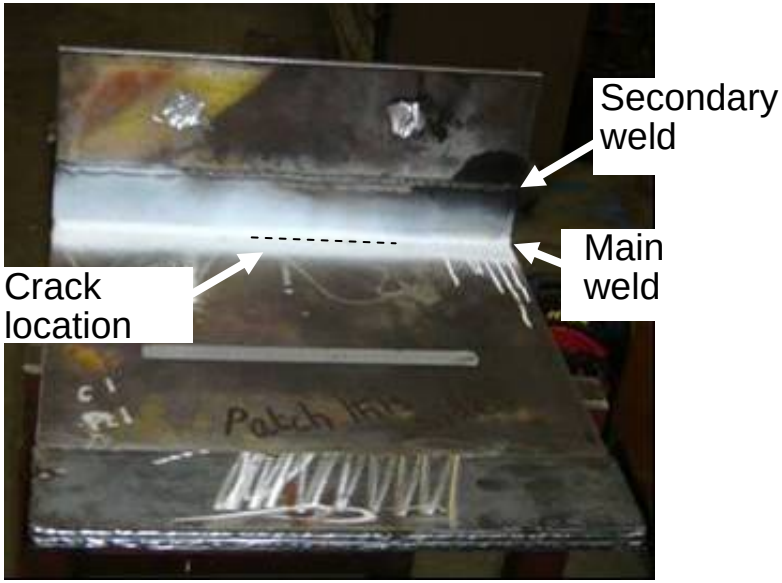


The use of advanced carbon composites for the repair of fatigue cracks in steel structures.

I M May*, M Roy**, C Lang* and R A Khan*.
*Heriot Watt University,
Edinburgh. UK.
**QinetiQ, Rosyth,
Dunfermline, UK.

The use of advanced carbon composites for the repair of fatigue cracks in steel structures

- Fatigue testing on representative specimens
  - Welded test pieces representing typical ship details and crack locations



The use of advanced carbon composites for the repair of fatigue cracks in steel structures

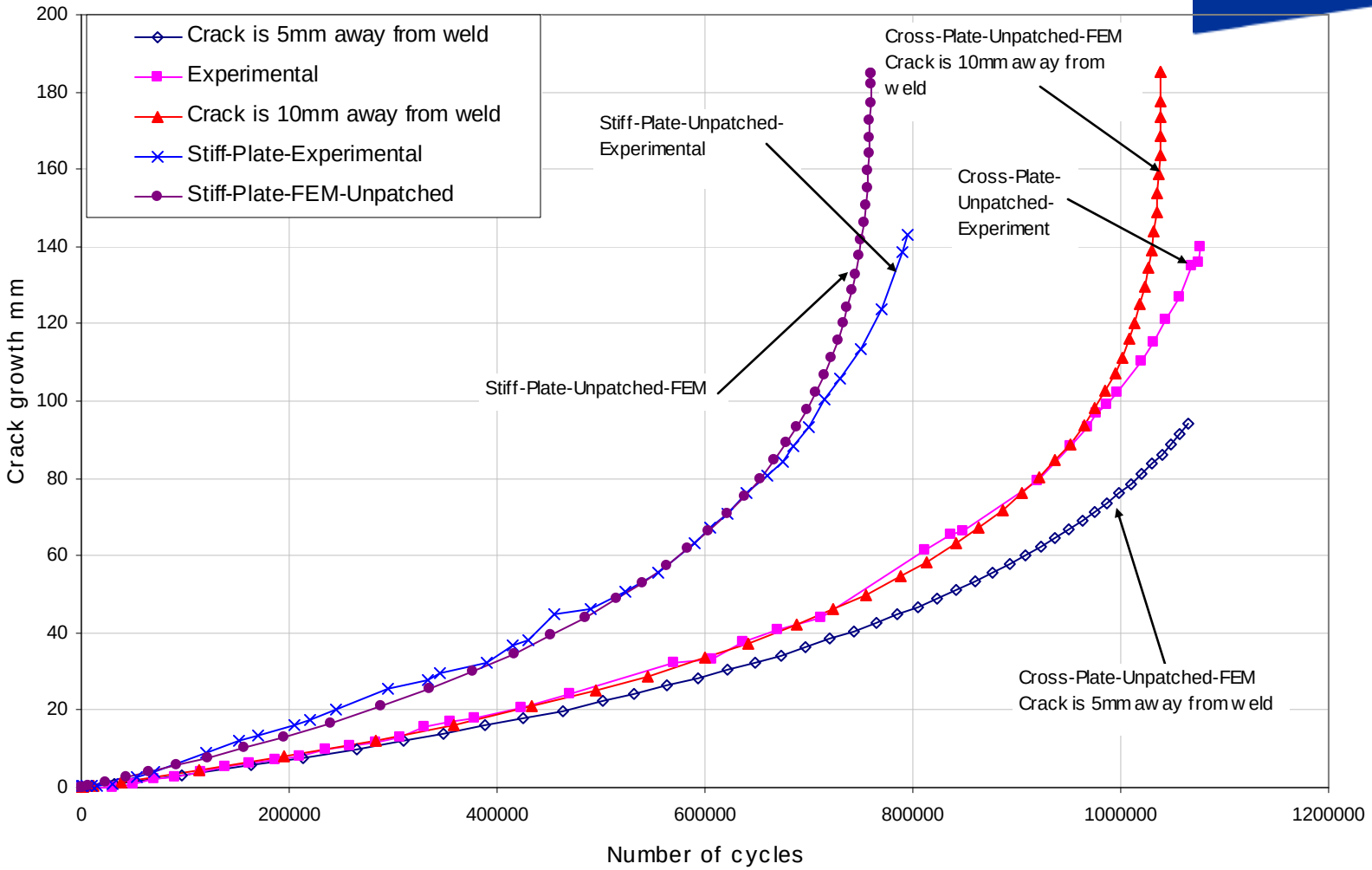
Strain gauges

Plate with stiffeners

Cruciform plate

QinetiQ

The use of advanced carbon composites for the repair of fatigue cracks in steel structures



Half crack growth comparison for F.E. Analysis and Experiment.

QinetiQ

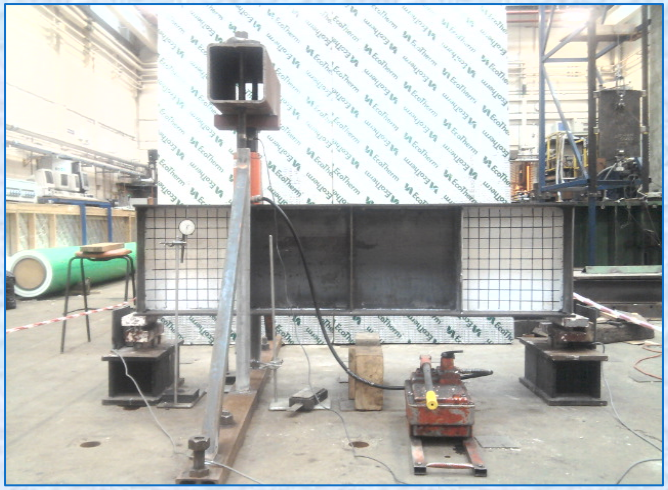
Fibre-Reinforced Polymer (FRP) Composites for Strengthening / Stiffening of Steel Bridge Members

Prof. Ian M. May, Muhammad Aslam Bhutto

Objectives:

- To investigate the use of carbon and glass fibre reinforced polymers (CFRP and GFRP) for strengthening of steel bridge members;
- To develop testing and monitoring procedures; and
- To improve the existing guidance for design of strengthening.

Testing



Test Set-up

Control Specimen (Failure Load, FL= 230 kN)

GFRP-strengthened Specimen (FL = 277 kN)

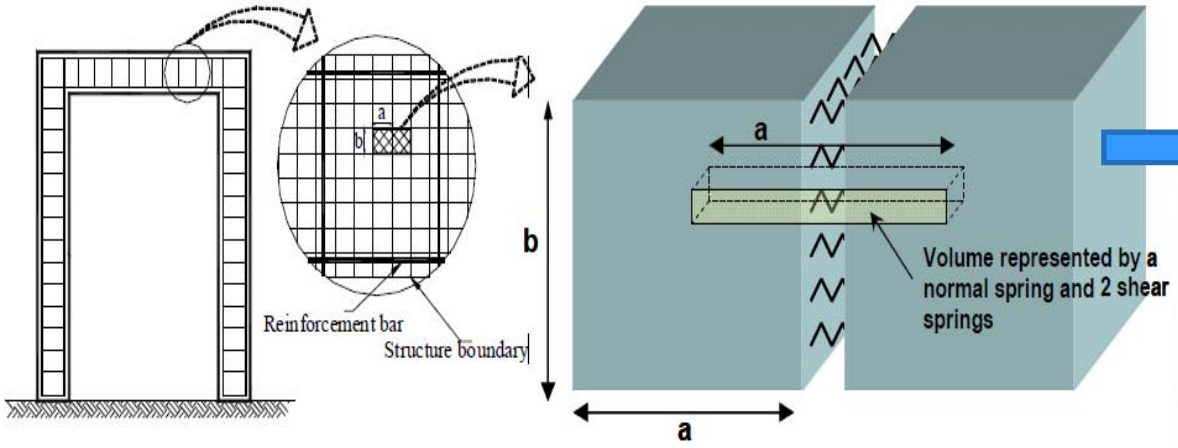
Carbon Fabric-strengthened Specimen (FL = 287 kN)

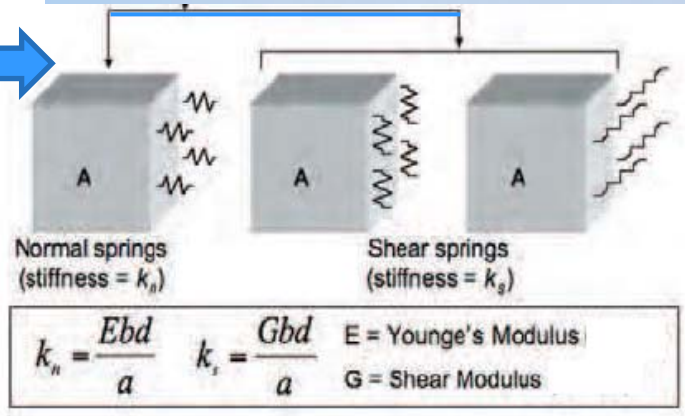
Seismic Progressive Collapse of Reinforced Concrete Framed Structures

Samah Al-Hafian , Professor Ian M May

Applied Element Method

The Applied Element Method (AEM) has been developed by Tagel-Din and Meguro





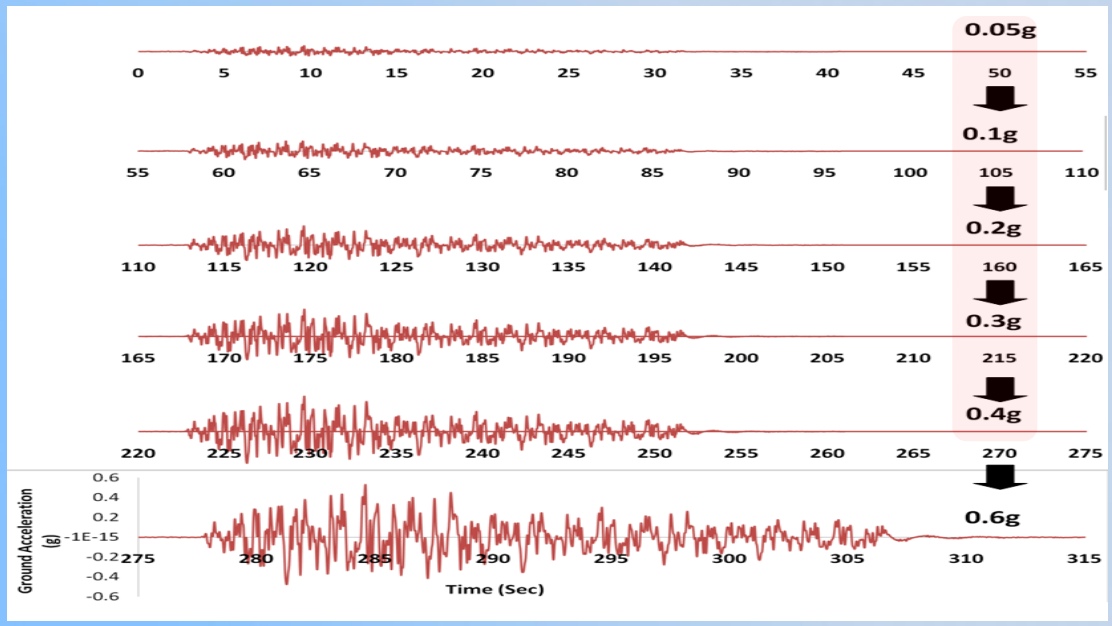
a. Element generation for AEM

b. Spring distribution and area of influence of each pair of springs

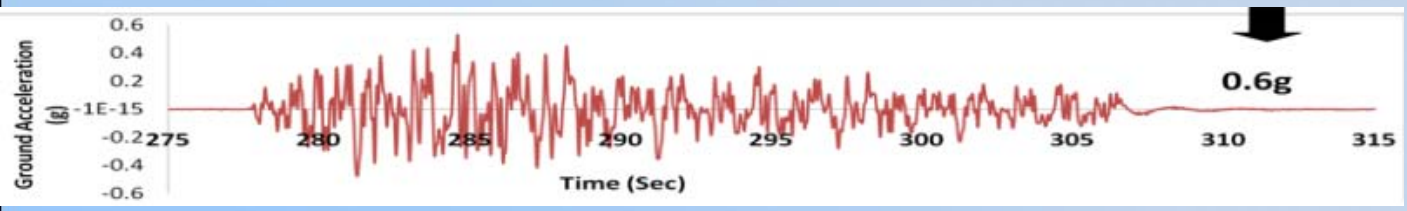
Verification of the AEM Model

shaking table model

A test of a full-scale under seismically designed reinforced concrete frame structure was performed **on AZALEE shaking table in (CEA) Laboratory in France in 2004 as part of the European ECOLEADER project** (European Consortium of Laboratories for Earthquake and Dynamic Experimental Research).



Base accelerations of the shaking table (0.05 to 0.4g)



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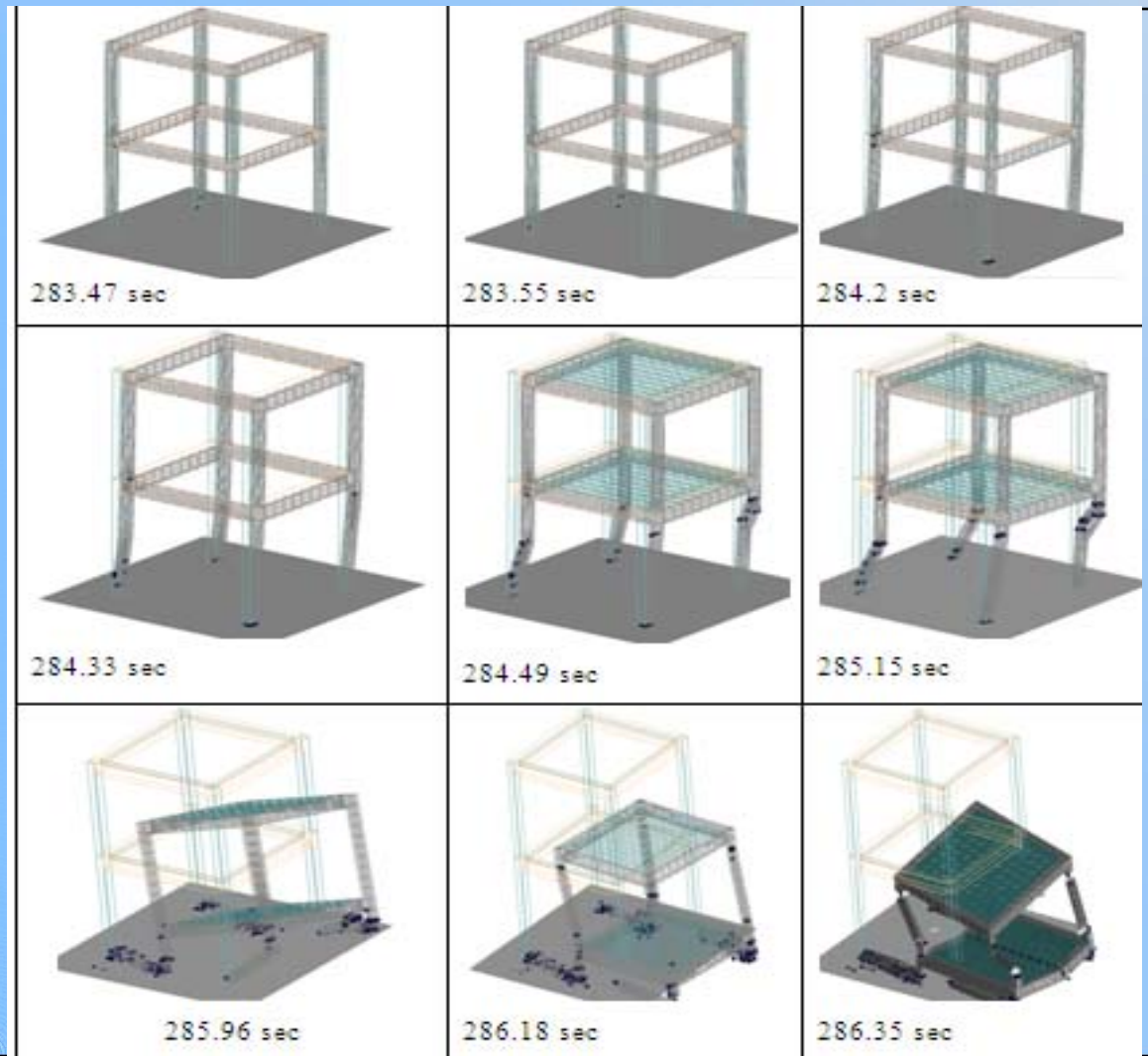
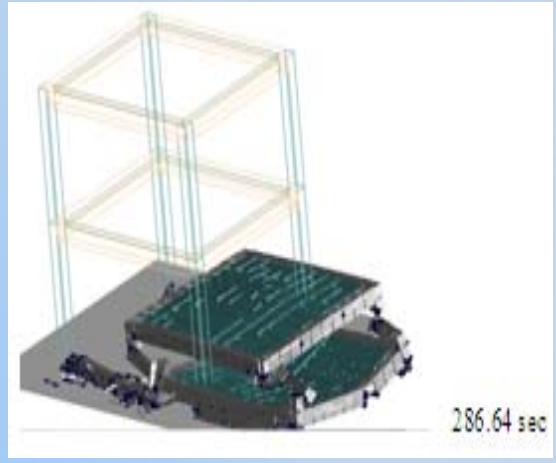
Collapse process at PGA level of 0.6g





Dr Omar Laghrouche

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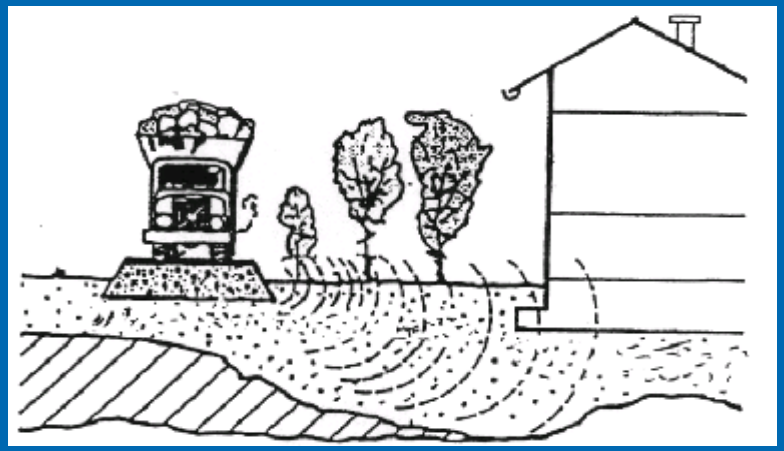
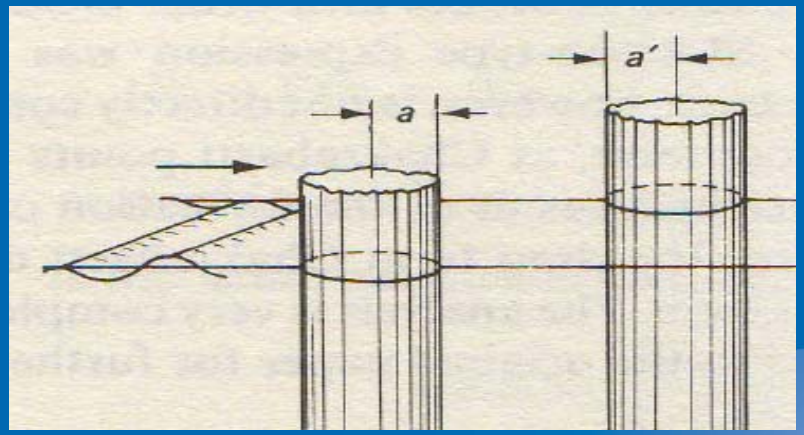
Efficient Numerical Modelling of Wave Problems

- Modelling wave problems by the development of new finite elements which are more efficient than conventional finite elements
- Develop Finite elements containing many wavelengths per nodal spacing and solve high frequency with gross mesh.





Dr Omar Laghrouche

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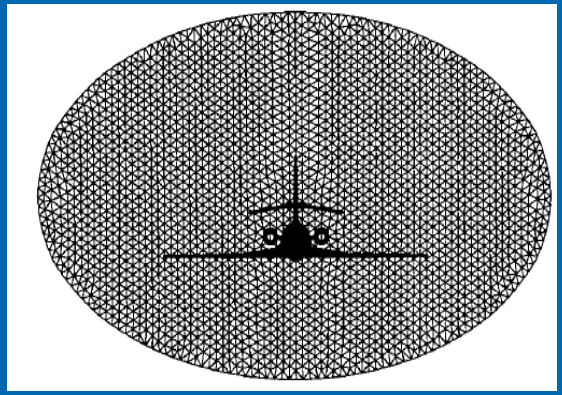
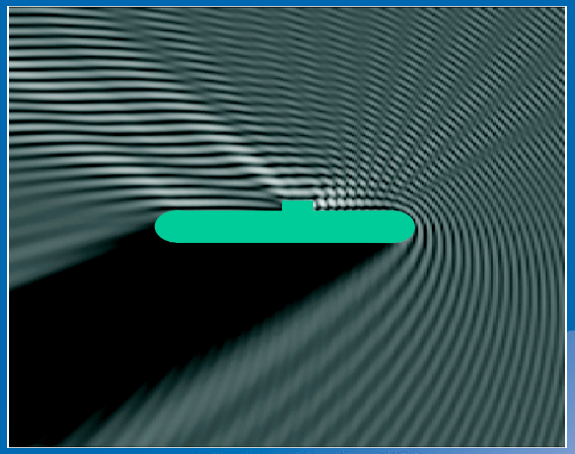
Efficient Numerical Modelling of Wave Problems

- Locally enriched finite elements for harmonic wave problems
- Development of special finite elements for two-dimensional elastic wave problems
- Local and non-local radiation conditions for exterior Helmholtz problems





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Dr John Cairns

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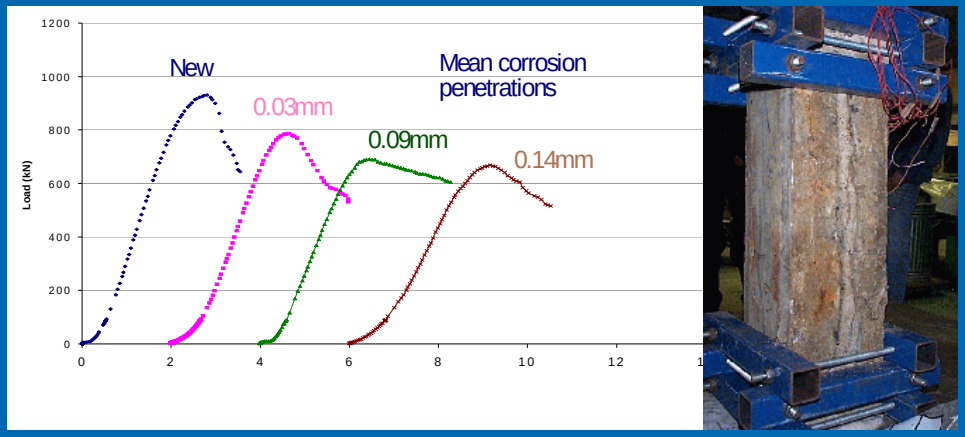
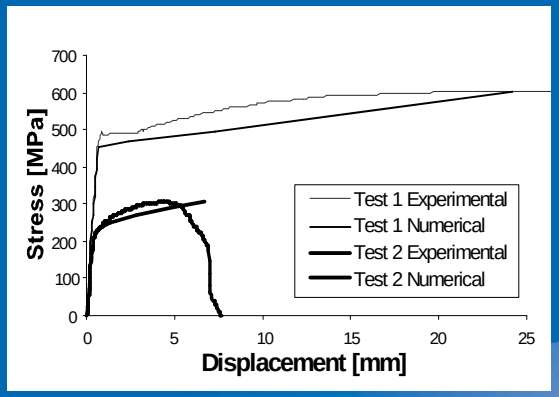
Residual Strength of Corrosion Damaged Structures

Assessment of residual strength of reinforced concrete structures damaged by reinforcement corrosion



Mechanical properties of corroded bar: comparison test and model



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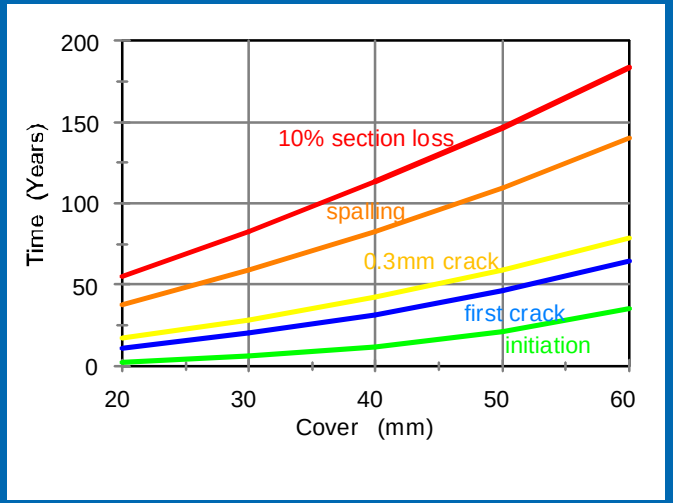
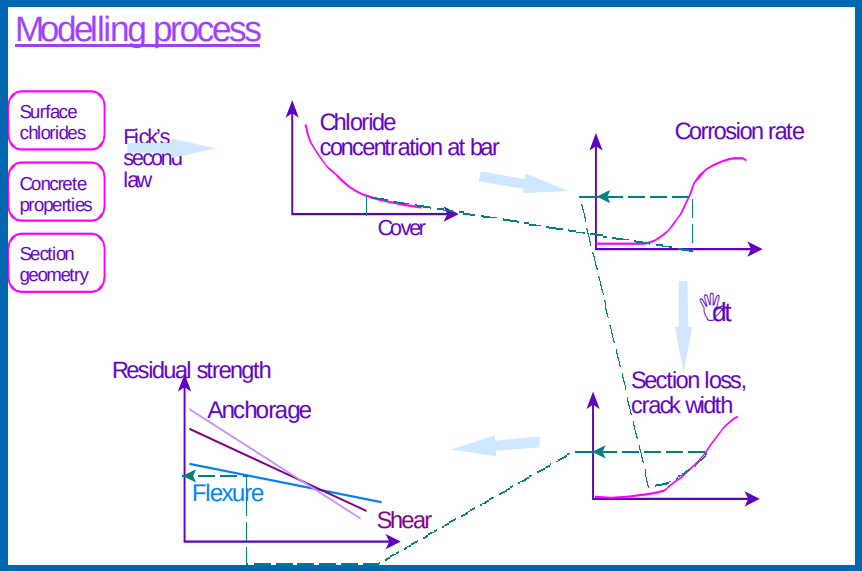
LIFECON: Life Cycle Management of Concrete Structures

To develop a generic model of a life cycle maintenance and management planning System (LMS) that will facilitate change from a reactive to a proactive approach.



Time to attainment of various durability limit states



- Condition monitoring and inspection systems
- Residual capacity assessment
- Validation of systematics

Dr John Cairns

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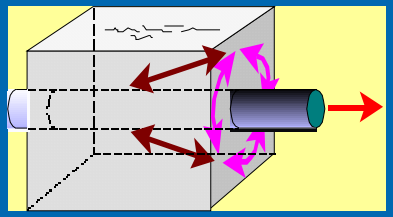
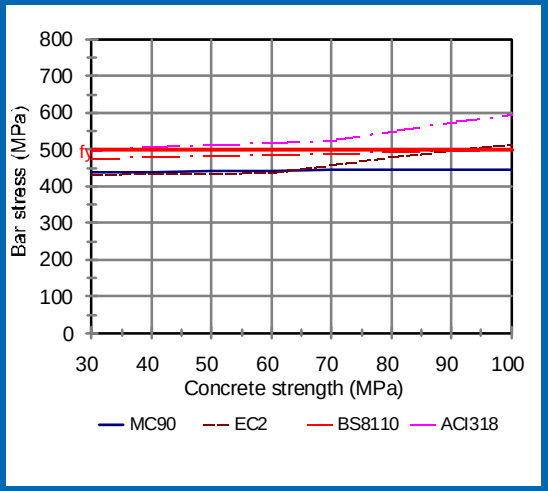
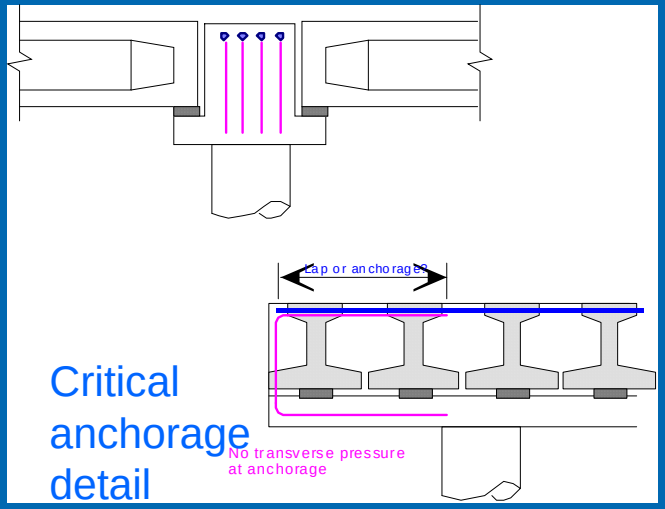
Bond and Anchorage of Embedded Reinforcement

The development of design guidance for inclusion in the new fib Model Code



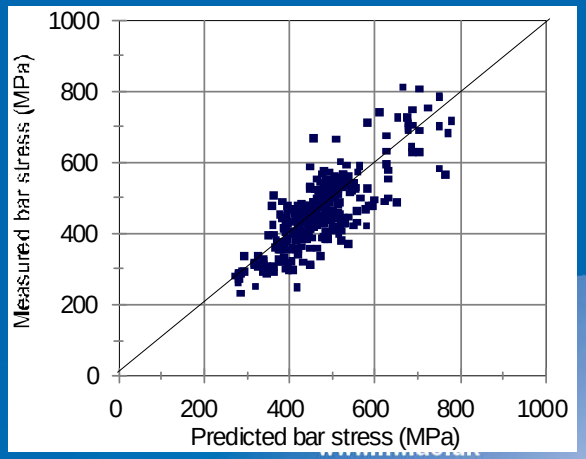


Current rules are unconservative



Critical anchorage detail

Correlation of semi-empirical model with test data



Professor Dimitri Val

EPSRC
Pioneering research and skills

Reliability assessment of ageing infrastructure

- Development of analytical and numerical models of deterioration processes and their structural effects
- Combination of finite element/finite difference analysis with reliability analysis
- Time-variant reliability analysis
- Updating of performance assessment based on inspection/monitoring data and past performance

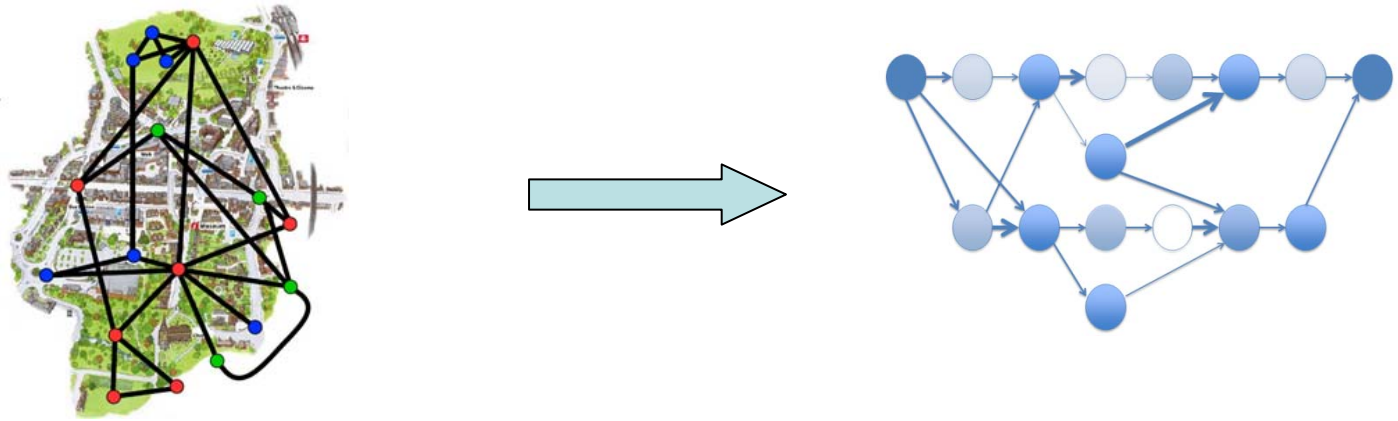
Life-cycle cost/utility analysis and decision making

- Combination of life-cycle cost analysis with realistic deterioration models
- Consideration of different human attitudes towards risk
- Development of efficient maintenance/repair policies

Professor Dimitri Val

Modelling infrastructure systems and their interdependencies

- Development of network models for infrastructure systems (e.g., water, energy, transport)
- Modelling interdependencies between different systems, including cascading failures
- Modelling effects of natural hazards on infrastructure systems, in particular associated with climate change



Dr Zhen Chen’s

- The Effective Design and Delivery of Megaprojects in the European Union
  - Founded by the European Cooperation in Science and Technology (COST), under FP7, 2011 to 2015.
  - Case studies into megaprojects
    - Innovative structure design
    - Structure maintenance

Dr Zhen Chen's

- Reliability Analysis of Retaining Structure Systems in Deep Foundation Construction
  - Funded by Qingdao Technological University, Tongji University and the Ministry of Education in China (1993-1998), linked to EU COST Action TU1003 Megaproject (2011-2015).
  - New method for the reliability assessment of retaining structure systems in deep foundation construction, covering earth-structure interactions.
    - Raffles City Shanghai (51-storey commercial complex).
    - Run-Yang Bridge (the world's fourth longest suspension bridge; average excavation depth is 48 meters).

Professor John McCarter, Professor Malcolm Chrisp, Dr Gerry Starrs

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Cementitious Materials

The Group has both laboratory and field programmes investigating:

EPSRC Pioneering research and skills

- rheological properties
- the hydration and microstructure
- behaviour of waste materials
- quality control of fresh concrete
- durability and performance of concrete, including,
  - permeability and diffusion
  - efficiency of surface treatments
- Conductive fibre reinforced cement matrices (c-FRC)

John McCarter, Malcolm Chrisp, Gerry Starrs

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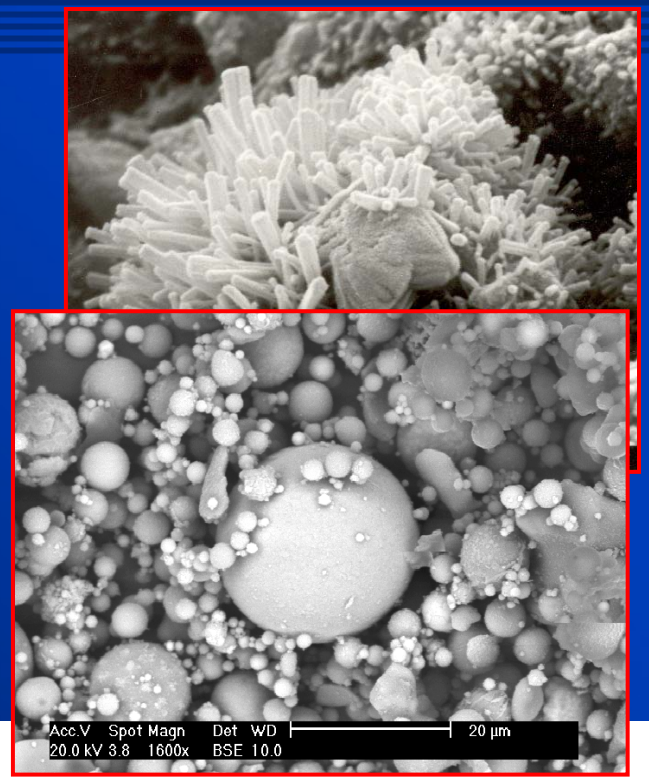
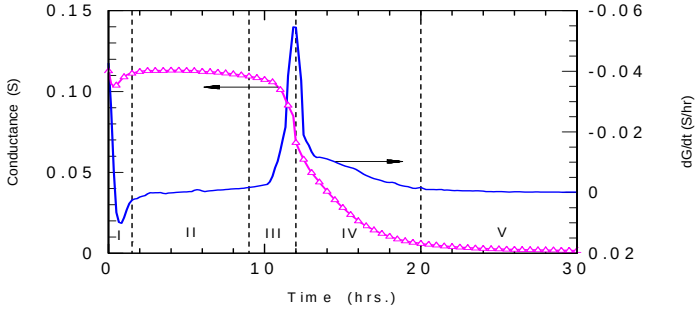
Materials and GeoMechanics
Hydration of Cementitious Materials

- monitoring the stages/sequence of hydration of ordinary Portland cement from initial gauging through setting and early hardening
- evaluation / quantification of the influence of chemical and mineral admixtures on OPC hydration
- ‘OPC-free’ cementitious materials (alkali-activated systems).





John McCarter, Malcolm Chrisp, Gerry Starrs

Materials and GeoMechanics
Durability and performance of concrete

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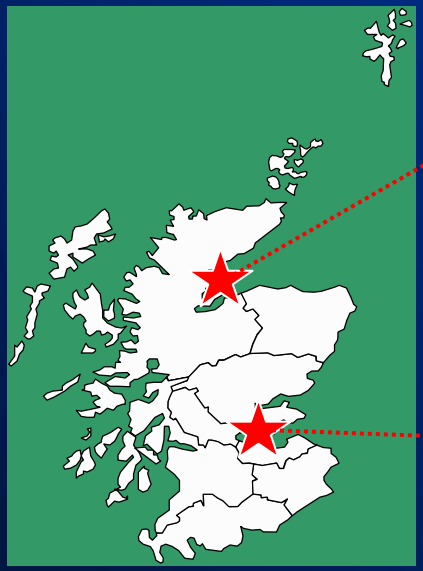

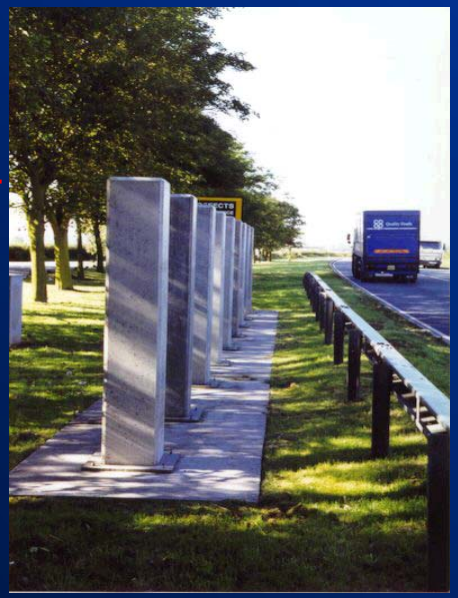

- Study of concrete performance under real environmental exposures
- Development of integrated monitoring systems for new and existing reinforced concrete structures

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Pioneering research and skills

John McCarter, Malcolm Chrisp, Gerry Starrs

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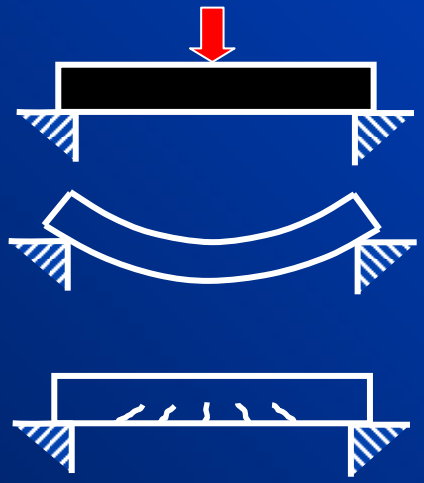
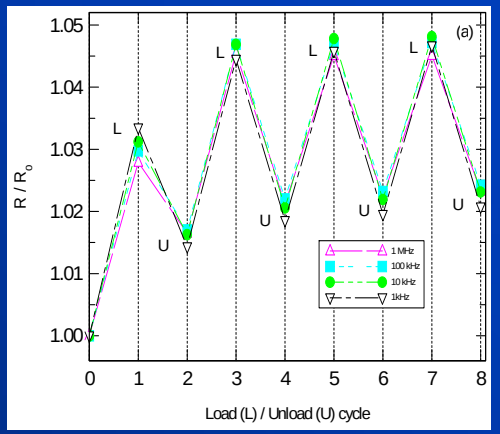
Materials and GeoMechanics

Multi-functional Materials

Cement-matrices containing short fibres (carbon, steel) in the correct volume make these materials electrically conductive and could create a new range of structural materials with multi-functional capabilities.

- Strain sensing - for structural vibration control, traffic monitoring
- Damage sensing – both thermal and mechanical in relation to structural health monitoring





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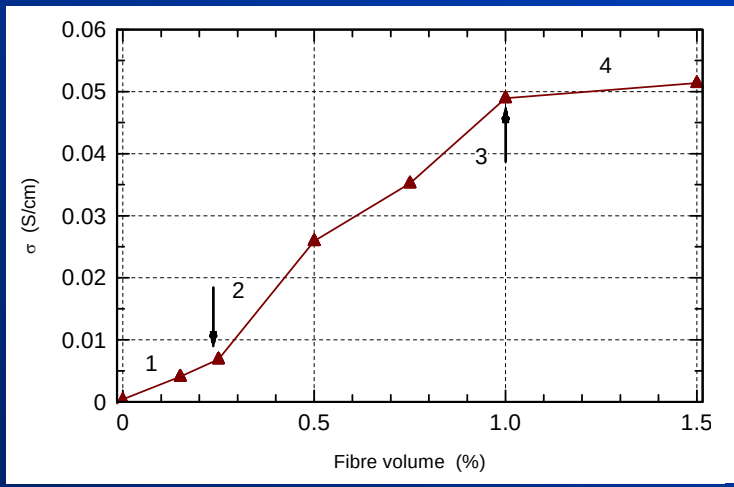
Materials and GeoMechanics

Multi-functional materials

- electrical grounding; lightening protection or static charge dissipation
- electromagnetic interference (EMI) shielding
- *c-FRC* can reflect electromagnetic signals
- using *c-FRC* as a heating element
- cathodic protection



Conduction and percolation in c-FRC

Dr Gabi Medero

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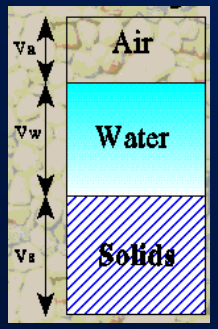
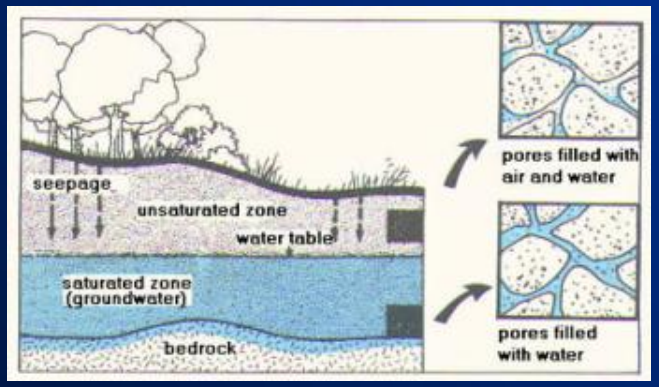
Geotechnical Engineering

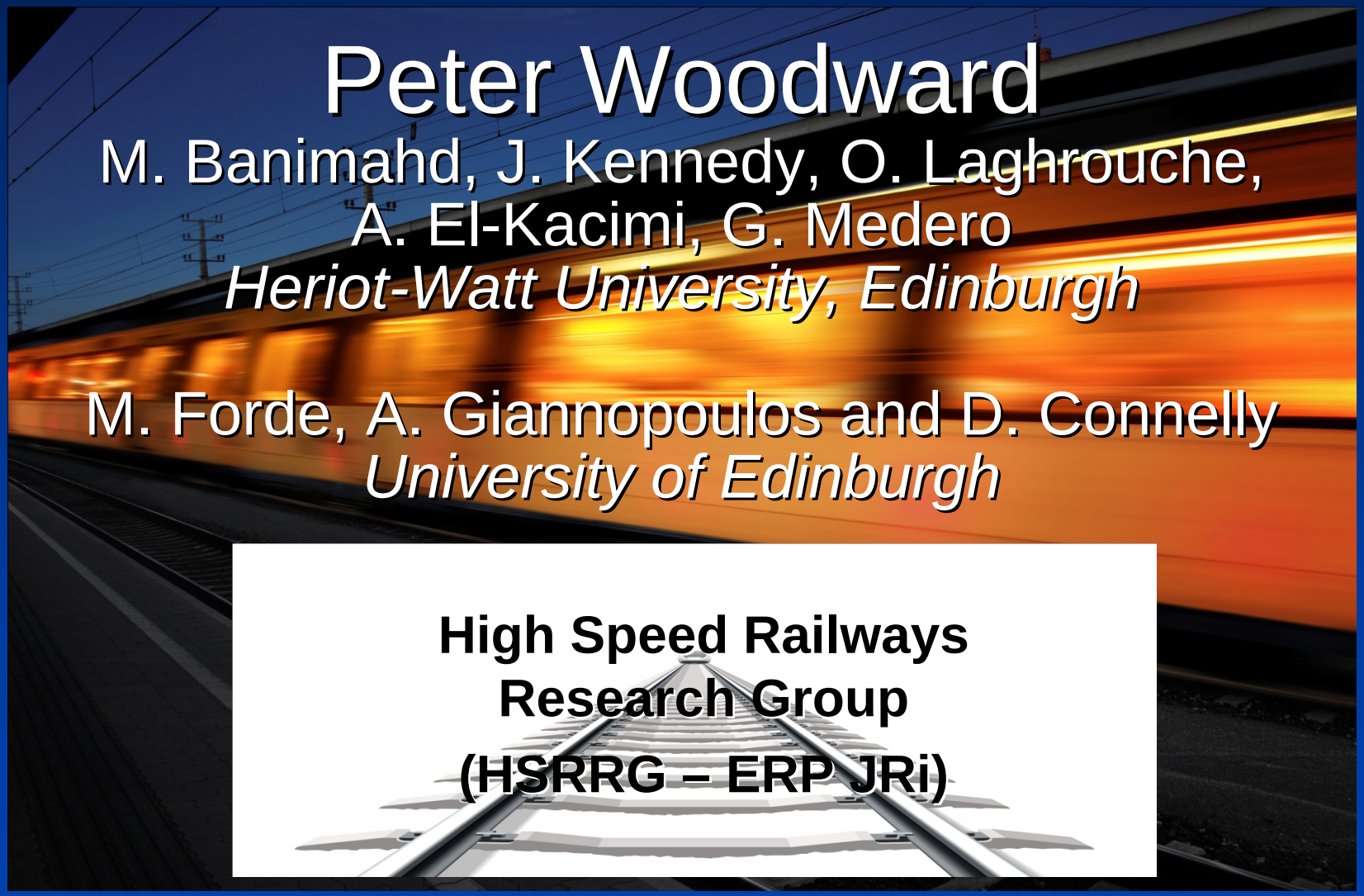
Partially Saturated Soils

Partially saturated soil is the most common material encountered in the field of geotechnical engineering; climatic change also makes this topic highly relevant.

Work focuses on the thermo-hydro-mechanical behaviour of partially saturated soil including contaminated soils under unsaturated conditions.







Peter Woodward

M. Banimahd, J. Kennedy, O. Laghrouche, A. El-Kacimi, G. Medero
Heriot-Watt University, Edinburgh

M. Forde, A. Giannopoulos and D. Connelly
University of Edinburgh

High Speed Railways Research Group

(HSRRG – ERP JRi)

DART3D Model of Ground Vibration and Propagation

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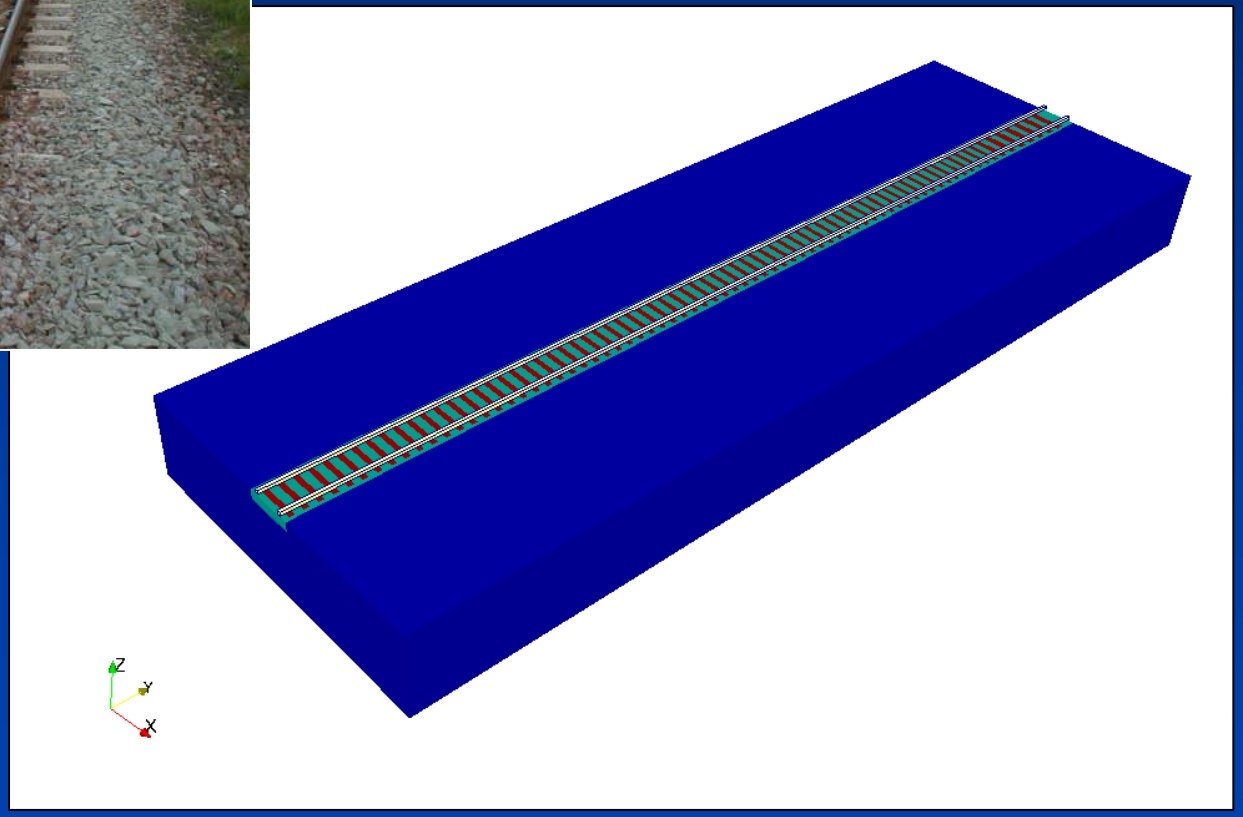

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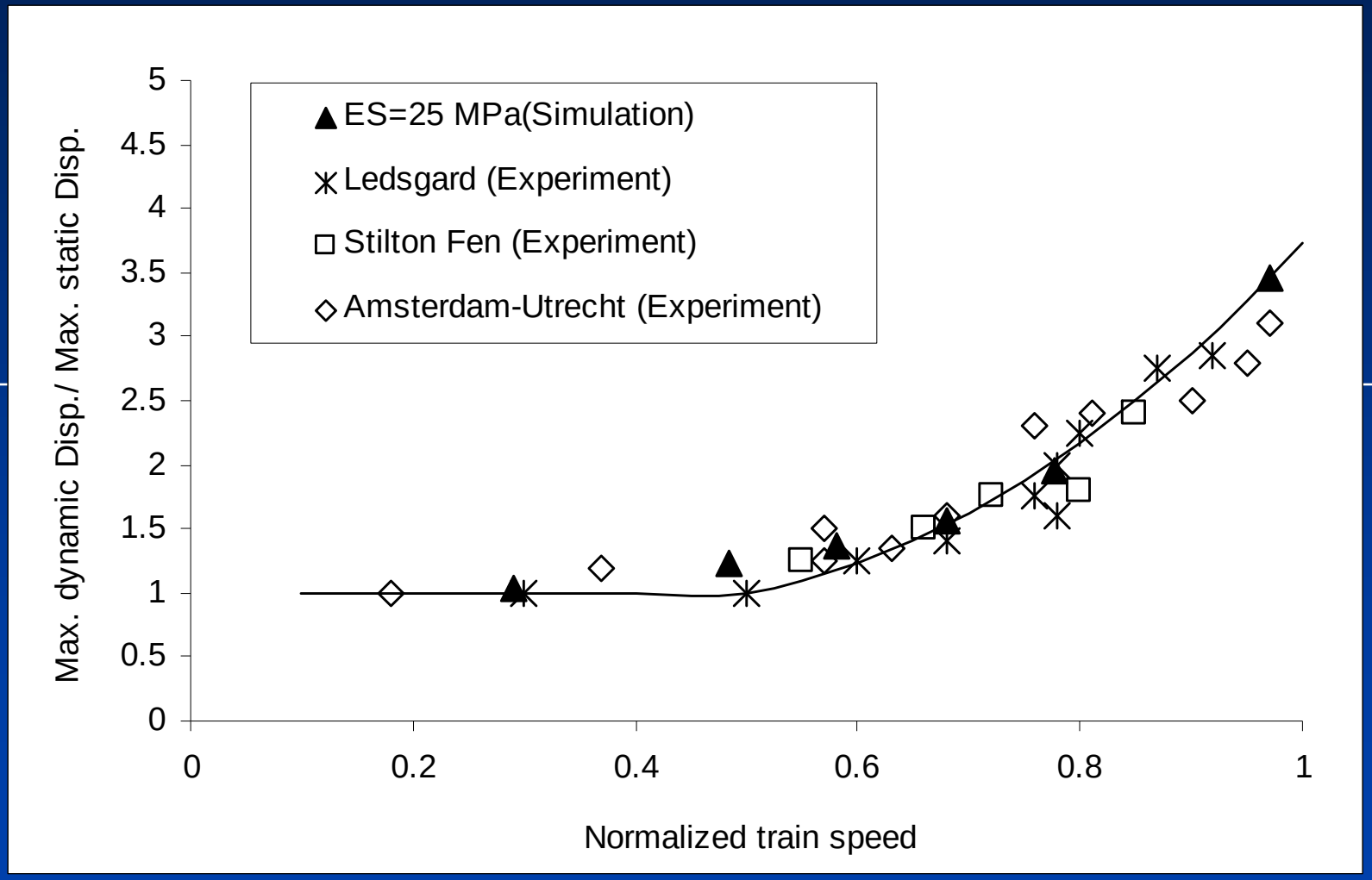
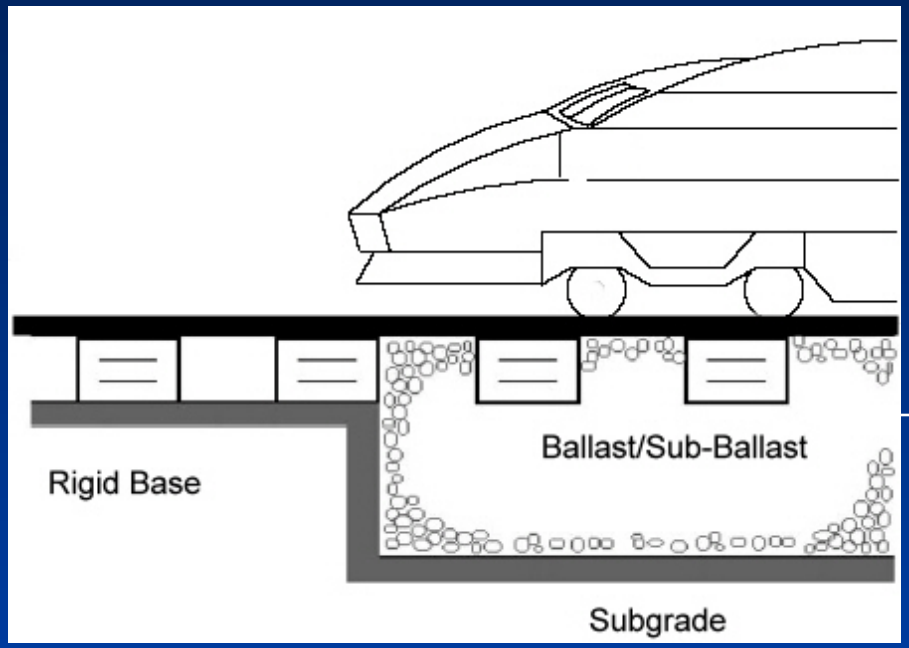
Pioneering research and skills

Field Observation of Speed Effect & DART3D Simulation Results



Banimahd and Woodward (2009) and Banimahd *et al* 2011

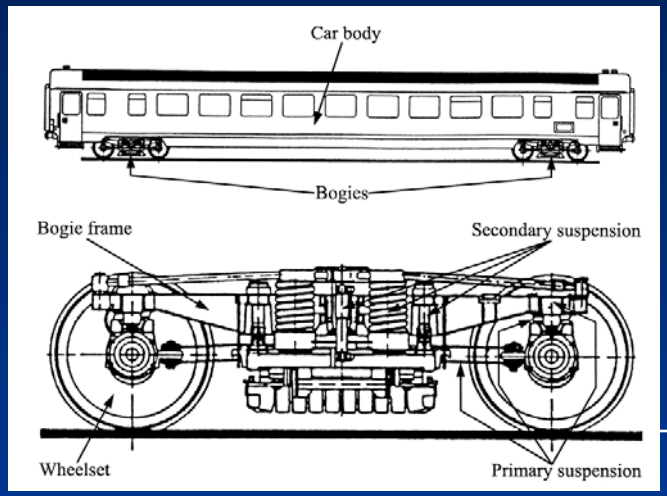
Transition Performance 3D Modelling & Track Remediation



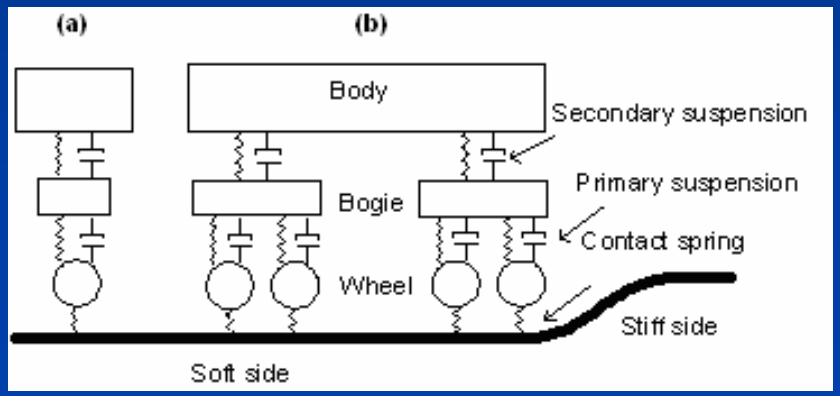
Banimahd and Woodward (2007)

Transition behaviour becomes increasingly important as the train speed increases

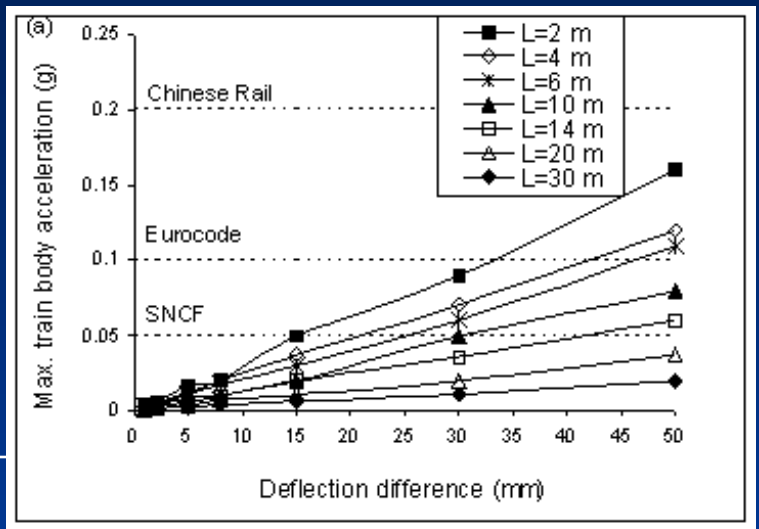
3D Modelling of Track Transitions Using DART3D

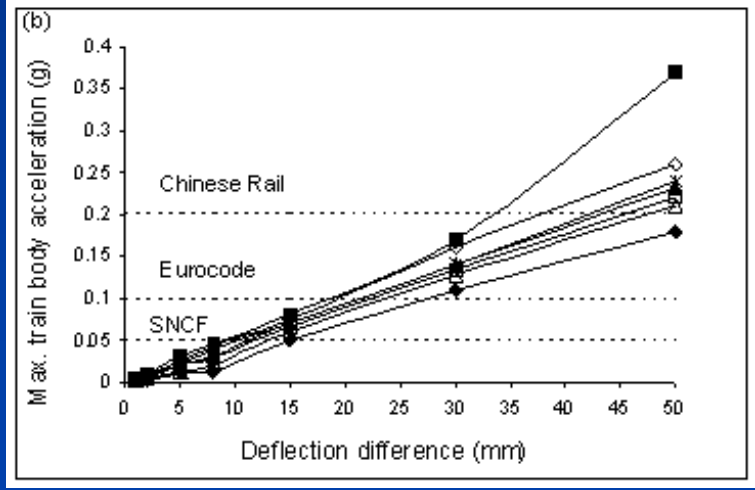


Popp *et al* 1991



Modelled System after Banimahd *et al* 2011





Speed Effect on Transition Length

Industry Funded for 11 Years

Installers are Balfour Beatty Rail

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Patented Technology

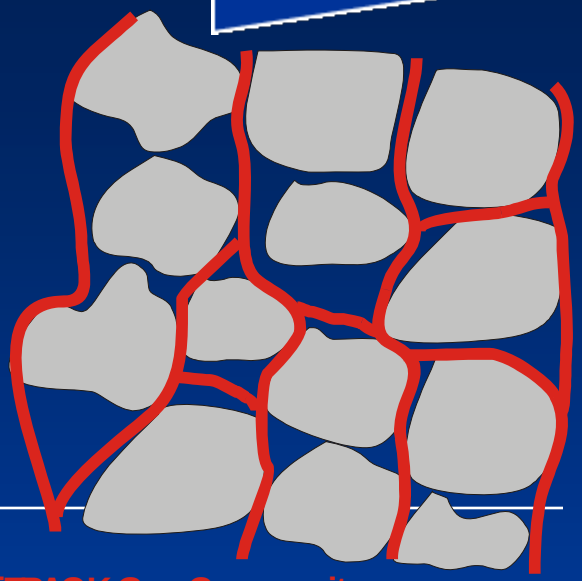
XiTRACK

Heriot-Watt University Technology Spin-out with The Dow Chemical Company

Professor Peter Woodward

Polyurethane Transforms Existing Ballast Into a:

3-Dimensional '*GeoComposite*'



XiTRACK GeoComposite
Linked Elemental Reinforcement in 3D

Polymer GeoComposites

- Polymers formulated for their engineering properties, including all weather applications by The Dow Chemical Company

- Two components combine to give a rapidly reacting polymer

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Example: 3D Ballast Reinforcement at the Transition

Reinforcing the ballast using insitu polymers reduce the ballast movement while ‘capturing’ the track geometry.

Full Scale GRAFT Testing

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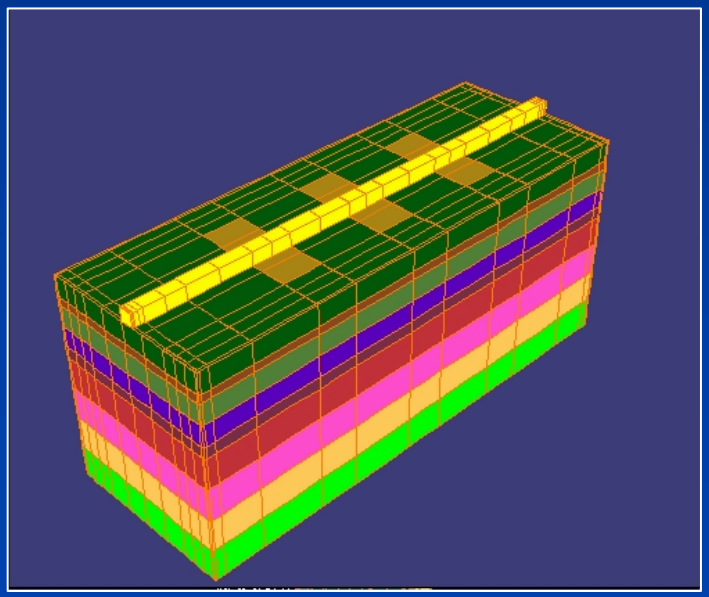

Geopavement & Railway Accelerated Fatigue Testing *(GRAFT)* facility and

SART3D Analysis

EXAMPLE CASE STUDIES OF POLYURETHANE TRACK REINFORCEMENT

Ballast Fluidisation Due to Ballasted Bridge Deck Vibration at High Speeds

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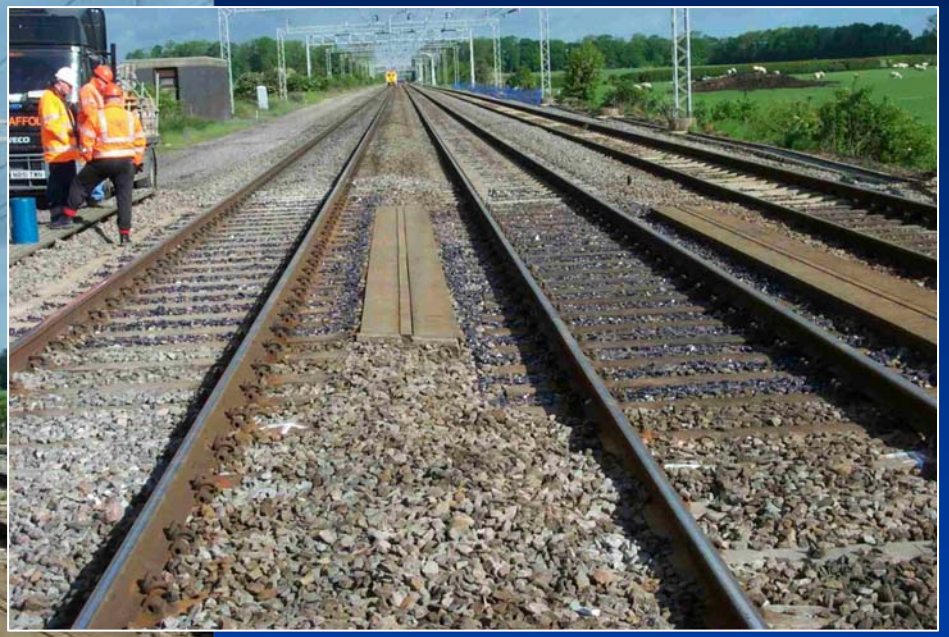

Polymers Used to Prevent Ballast Migration on the Bridge Deck

Crossings / Diamonds / Turnouts

Bletchley WCML
S&C 125mph
(2000)

Knighton Junction
Ladder Turnouts
(2007)

Concept of *'tamperless'* S&C
now a possibility

Dynamic Interaction Issues

Newham Bog
East Coast Main Line

Track Constructed Over Peat Bogs Giving High Track Deflections

Drainage Problems Addressed Prior to Installation

Formation of the polymer/ballast Geopavement in 2008

High-fixity for Tunnel Upgrades

Polymer application and completed project for 124m of double track

Installed by Balfour Beatty Rail

East London Line

Installed by Balfour Beatty Rail

Hoxton Station (supporting the London 2012 Olympics)

Technology now used *Internationally!*

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THANK YOU !