'Innovation in Construction' ICE
11th January 2012

Centre for
Smart Infrastructure and Construction

An Innovation and Knowledge Centre

Introduction to the Cambridge IKC and applications of sensor technologies to construction

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Context of the IKC: 21st Century Infrastructure and Construction

- A high-quality national infrastructure is essential for supporting economic growth and productivity, attracting globally-mobile businesses to the UK, and for promoting social well-being*
- Modern construction and infrastructure needs to be
  - Optimised in terms of efficiency, cost, low carbon footprint and service quality
  - Robust, resilient and adaptable to changing patterns
  - Innovative across all sectors – driven by business in partnership with government

**A National Infrastructure for the 21st Century.* Council for Science and Technology, 2009

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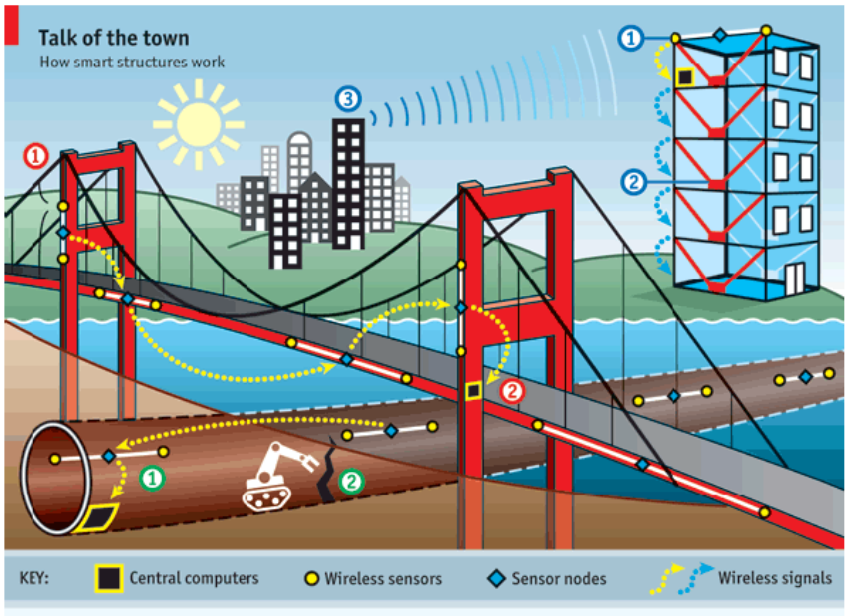

Source: The Economist, Dec 2010

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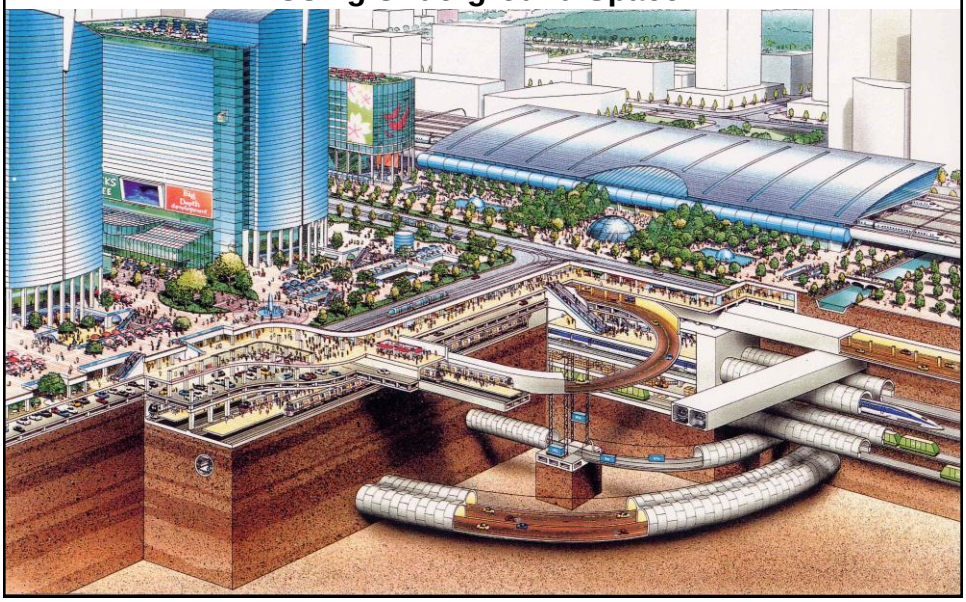
Cities of the Future

Proposed Renewal of Tokyo Station Area Using Underground Space



London Underground
Victoria Station Upgrade
Building Information Modelling
(courtesy Mott MacDonald)

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The Vision

- Smart infrastructure to transform industry
- Cradle-to-grave through whole life cycle
- Develop and commercialise emerging technologies
  - latest sensor technologies
  - data management tools
  - manufacturing techniques and tools
  - supply chain management processes
  - management of the built environment
- Interdisciplinary
- Exploitation in very large market

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Innovation & Knowledge Centre
Smart Infrastructure and Construction

- Exploitation and knowledge transfer to UK construction & infrastructure industry in new way
- Training, skill development and people pipeline
- Technology demonstrations
- Development of industry networks
  - a new Smart Infrastructure industry
  - spin-out companies

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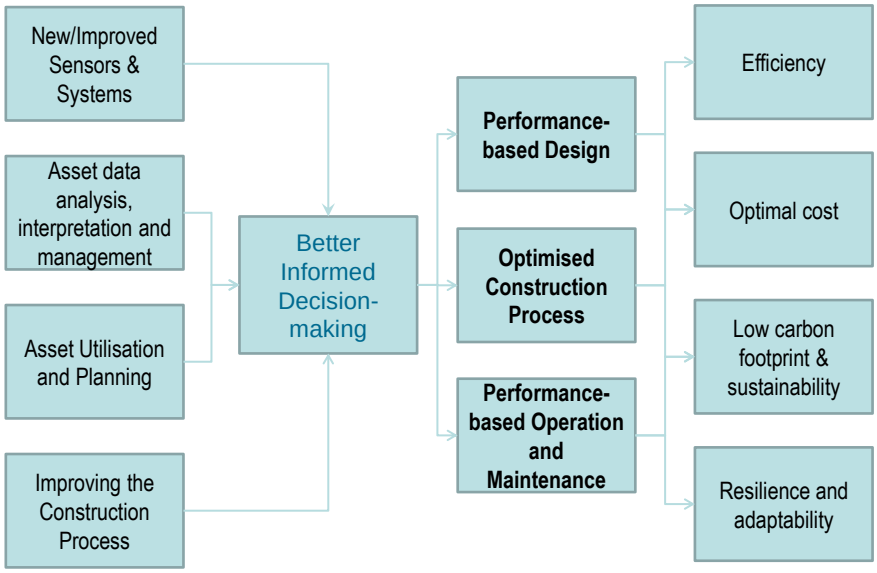

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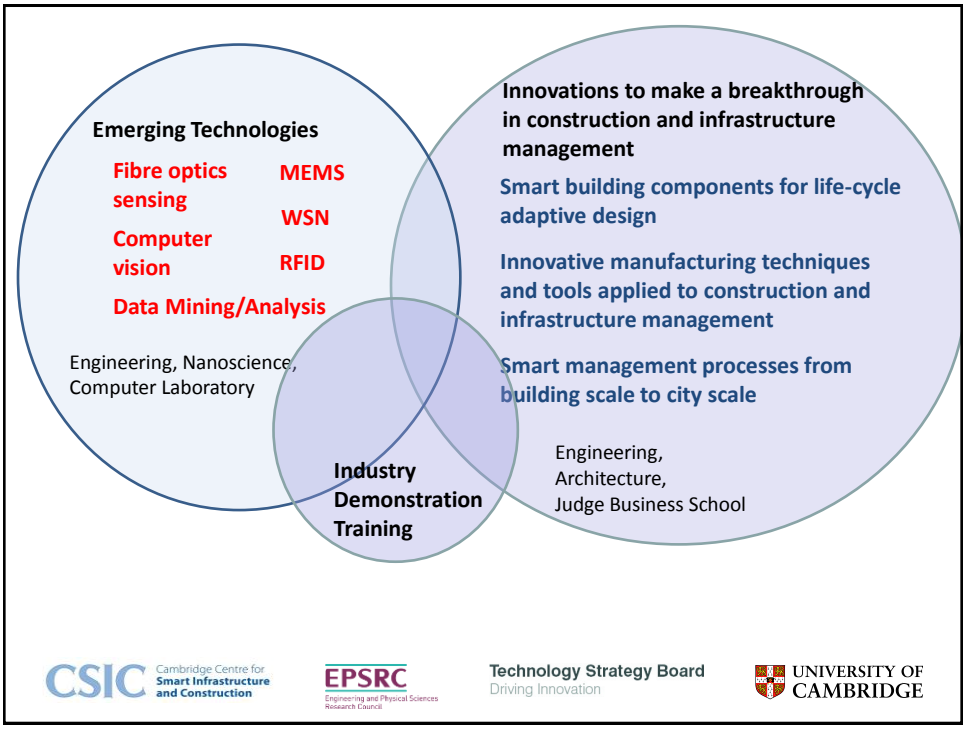

Innovative Optical Fibre Sensing

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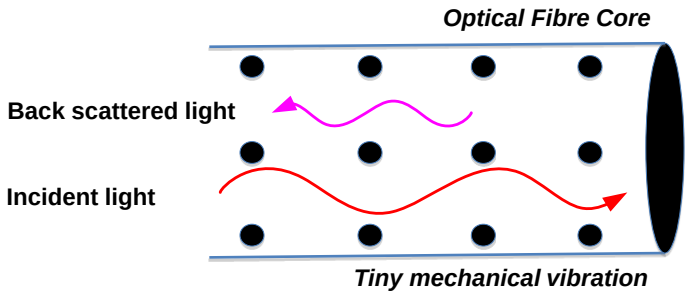
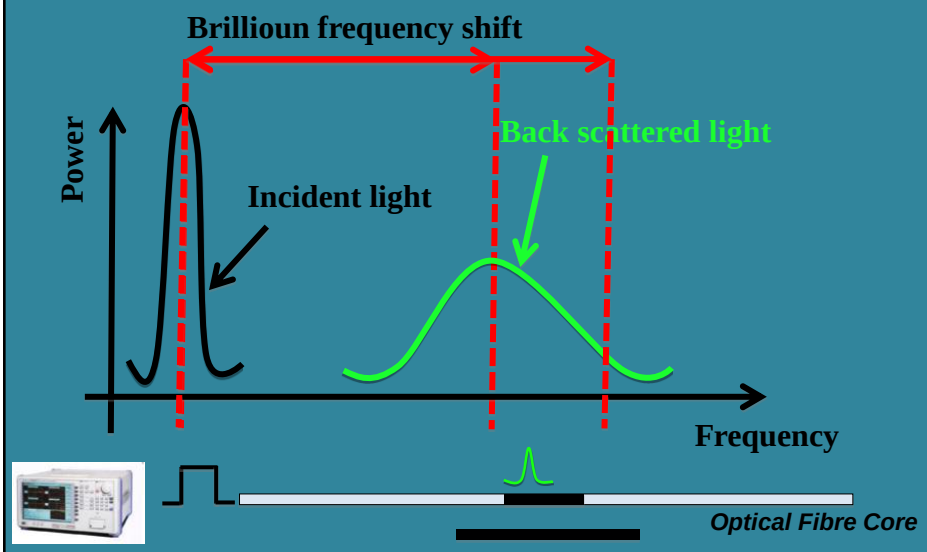
How can optical fibres measure strain?

- Atoms vibrate with very small amplitudes
- Vibrations = fluctuation in the refractive index
- Fluctuation = scattering of the travelling light

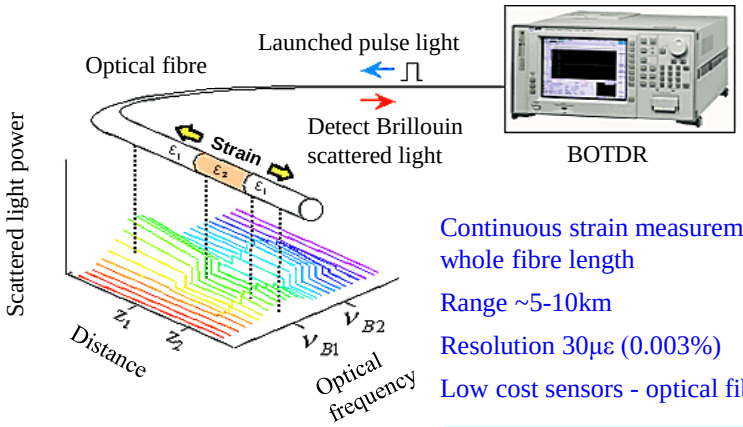


How can optical fibre cores measure strain?



Brillioun frequency shift is proportional to strain

Brillouin optical time domain reflectometry (BOTDR)



Continuous strain measurement over whole fibre length

Range ~5-10km

Resolution 30με (0.003%)

Low cost sensors - optical fibre

Optical Fibre Distributed Sensing

Optical fibre installation by Cambridge University to monitor and interpret joint movement in London Underground tunnel

Tube Lines

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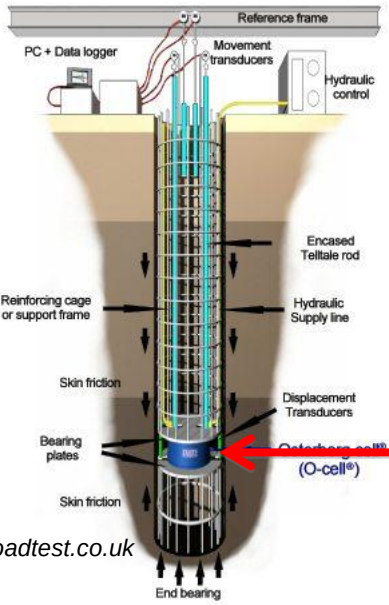

Innovative interpretation of pile load test using Osterberg Cell (O-Cell) and fibre optic sensors

O-Cell

© *www.loadtest.co.uk*

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Innovative application of fibre optic sensing for pile testing for Francis Crick Institute, London

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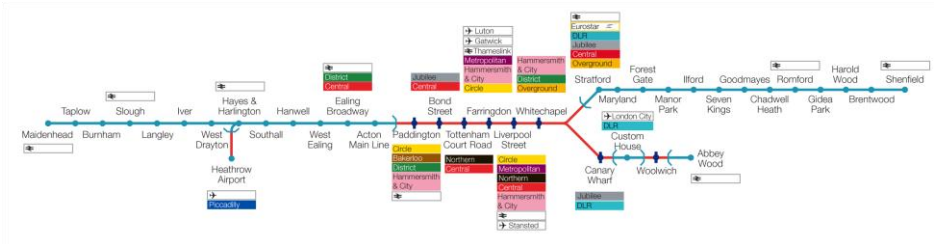
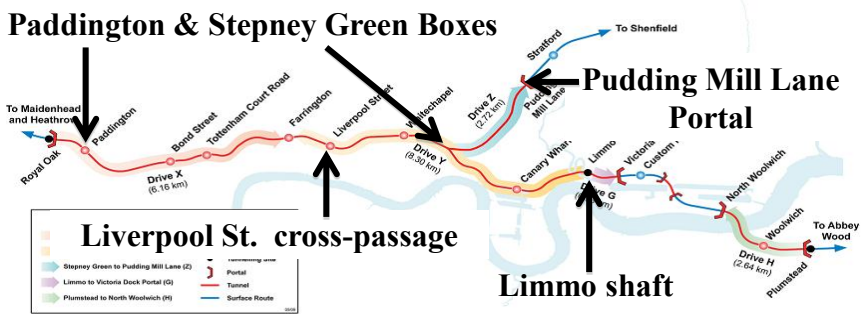
Innovative applications of fibre optic sensing on Crossrail





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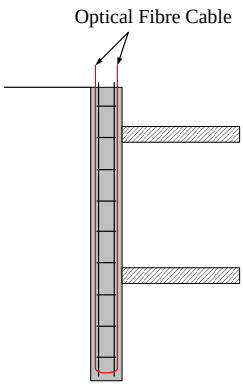
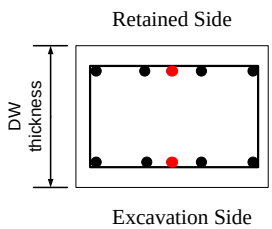
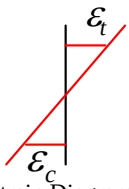
Innovative application of fibre optic sensing for Crossrail's Pudding Mill Lane Portal diaphragm walls







➡ **Stresses**

➡ **Deflections**

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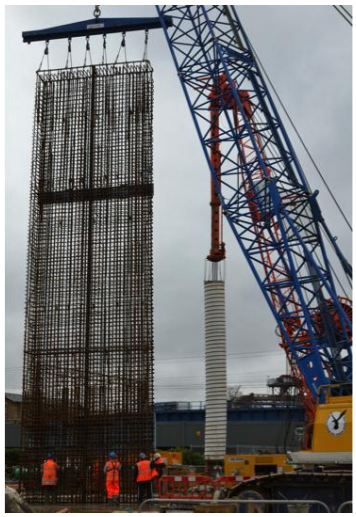

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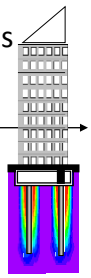
Recent Examples of Application of Optical Fibre Sensing by Cambridge University

- **Tunnels**
  - Thames Link Tunnel at King's Cross
  - Singapore Metro
  - London Underground Jubilee Line
- **Retaining walls**
  - Chelsea in London
  - UCL Hospital
  - Crossrail & Thames Water shafts (in progress)
- **Piles**
  - Bankside 123, Francis Crick and others
  - Energy piles



Recent Examples of Application of Optical Fibre Sensing by Cambridge University

- **Highways Agency road embankments and cuttings**
  - Shallow surface movements
  - Deep seated ground movements
  - Soil nails
- **Pipelines**
  - Thames Water mains

Industry Partners (total support = £7m)

Construction Sector

LAING O'ROURKE, ARUP, SKANSKA, itm, geothermal international, ATKINS, Sol Data, COSTAIN, WSP, CAPITA SYMONDS, PB, Mott MacDonald, bre, Halcrow

Infrastructure Sector

Thames Water, Transport for London, HIGHWAYS AGENCY, Tube Lines, NetworkRail, HUMBERBRIDGEBOARD, TRANSPORT SCOTLAND, TRL, nationalgrid

Manufacturing, Electrical & Information Sectors

RolaTube™, IBM, RedBite, THALES, zühlke, TOSHIBA Leading Innovation, GE Aviation, Omnisense, Senceive, ARM, NXP, Jennic, OpenHub, AEROFLEX

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Demonstration

…in real construction & infrastructure

Demonstrate Practicability

Build Confidence

Early Commercialisation

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Summary

- Emerging technologies already demonstrated
- Latest manufacturing techniques and tools to be applied
- Innovative management from building to city scale
- Smart infrastructure – whole life cycle
- Transform construction and infrastructure industry
- Large market for exploitation – domestic & international

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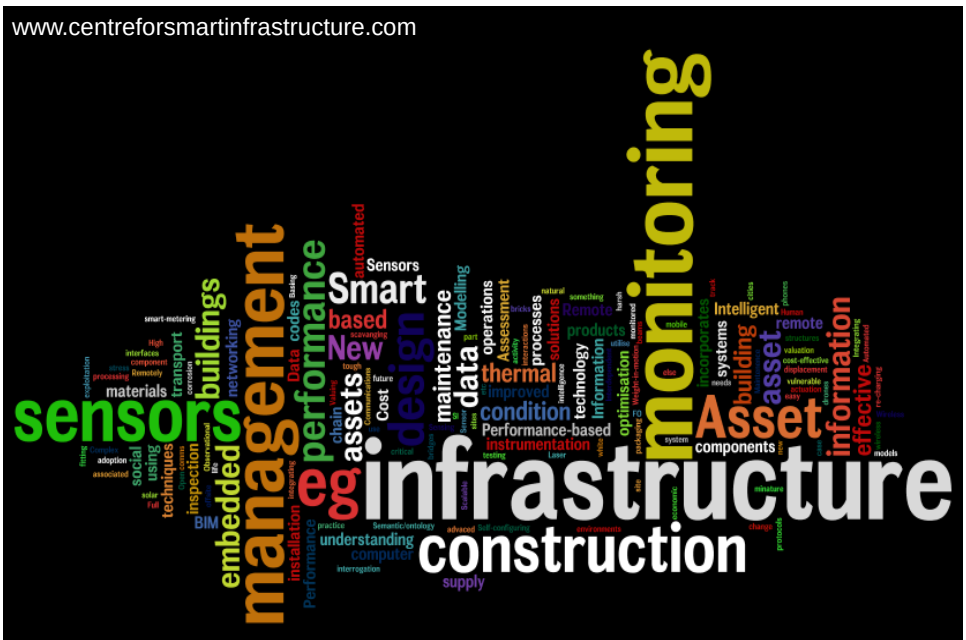

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