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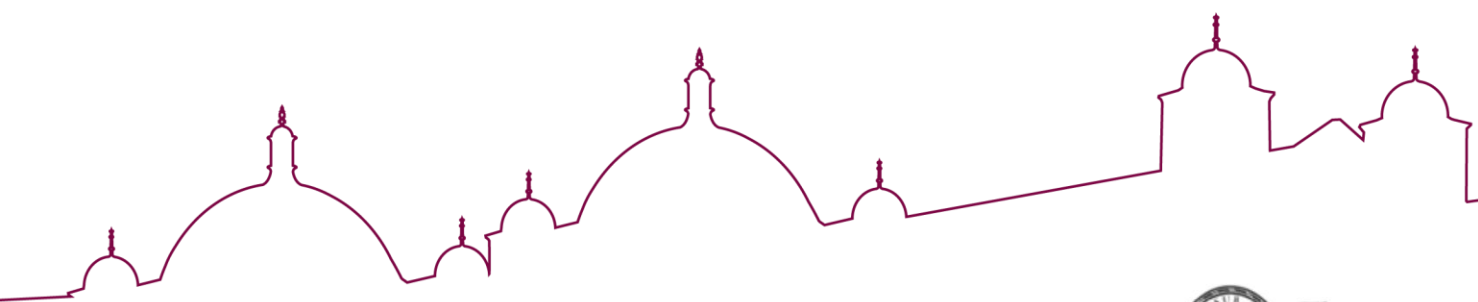
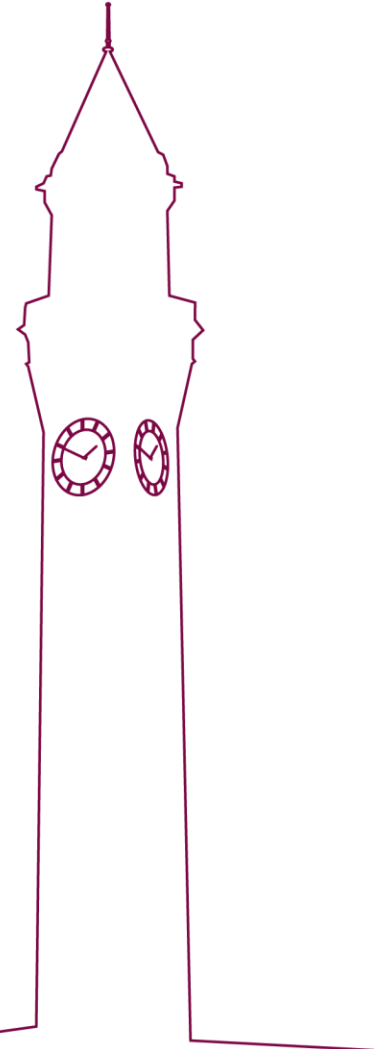
COLLEGE OF
ENGINEERING AND
PHYSICAL SCIENCES

Lessons from the Galligu

The Land Contamination Legacy of the UK's Soap Industry

Professor Nigel Cassidy

Emeritus Professor of Geotechnical Infrastructure Engineering

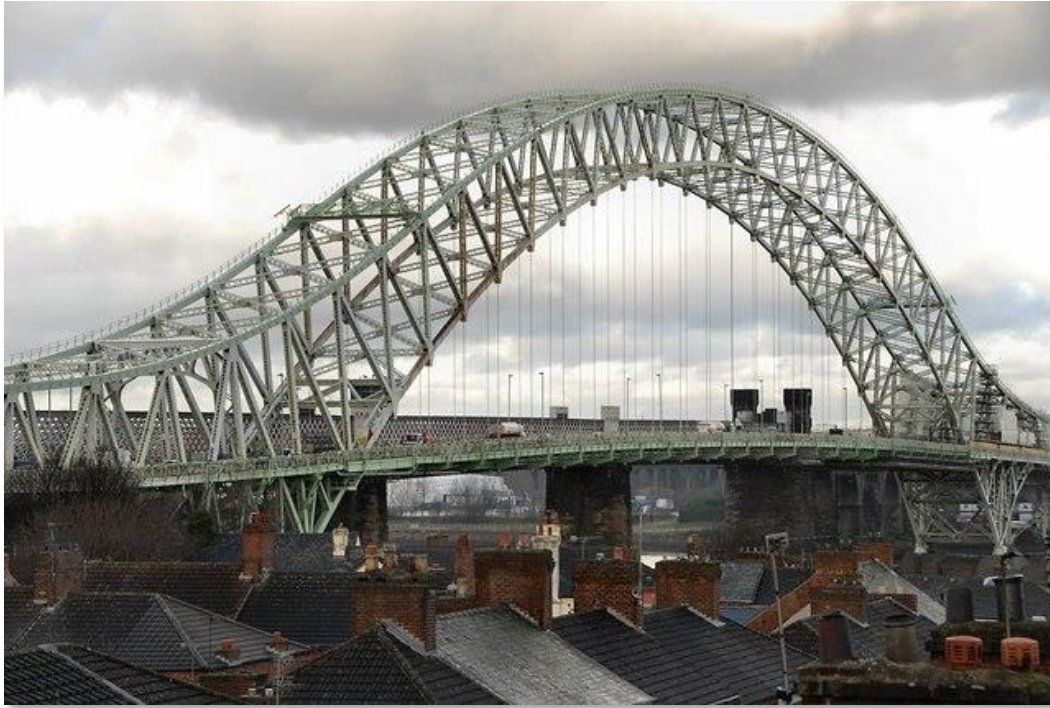


The
Geological
Society



WEST MIDLANDS

The Weird Soils of Widnes – The “Galligu”



What is it?

Where is it?

Why is it a problem?

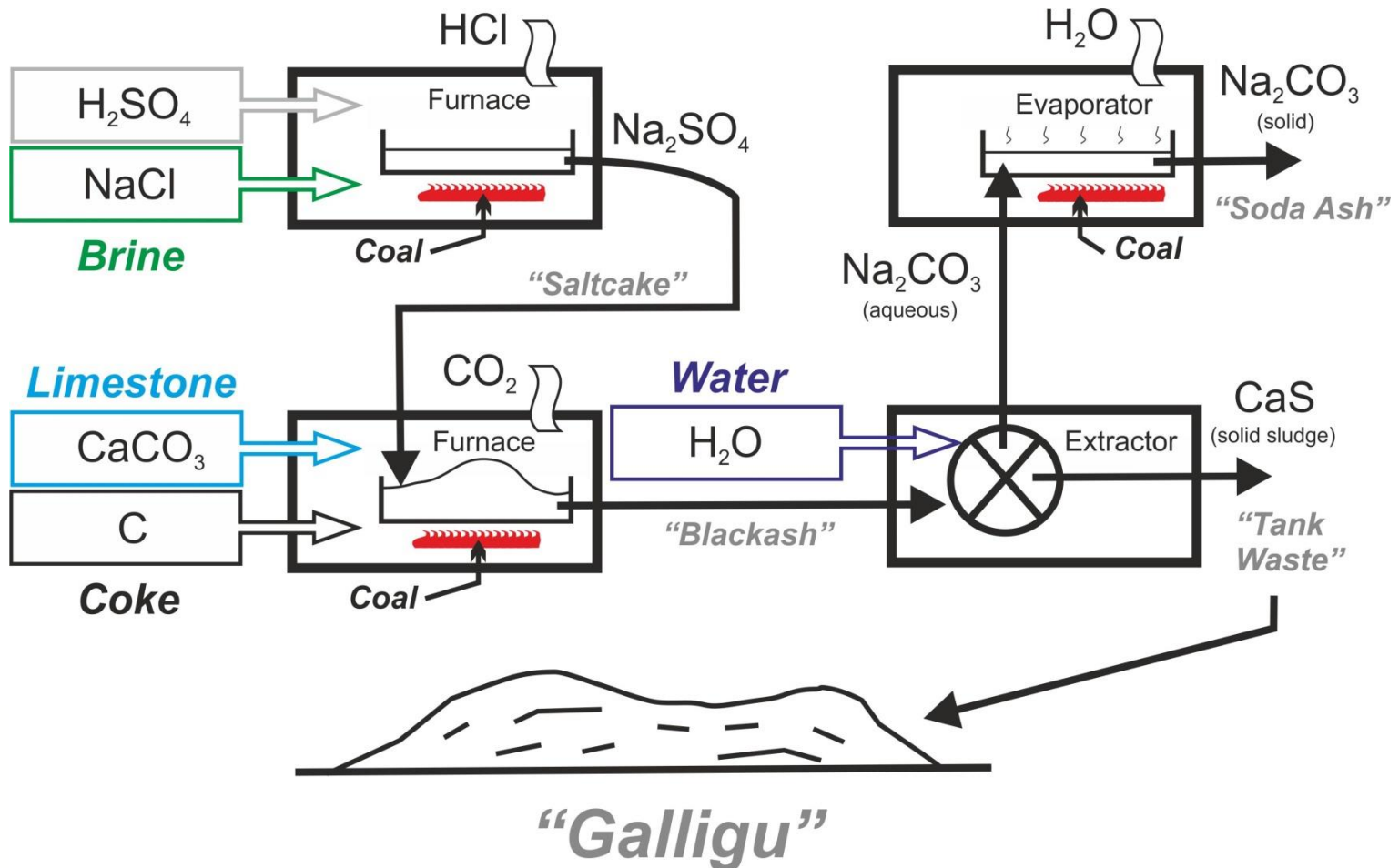
How do we fix it?

Are we looking at the issue properly or is it another legacy in the making?

“It is true that those coming to Widnes even from very dark and gloomy skies enter that town and with certain awe and horror... and wonder if life can be sustained there” (R. A. Smith 1876 Royal Commission on Noxious Vapours)“

What is the “Galligu”

A legacy of the 19th Century chemical industry and the LeBlanc alkali chemical process – the conversion of common **salt** into soda ash using sulphuric acid, **limestone** and **coal**. Two tons of tank waste for each ton of Soda Ash



Where is the “Galligu”

Key Factors for Soda Ash Industry locations...

Coal – lots of it

Salt - in the form of Brine

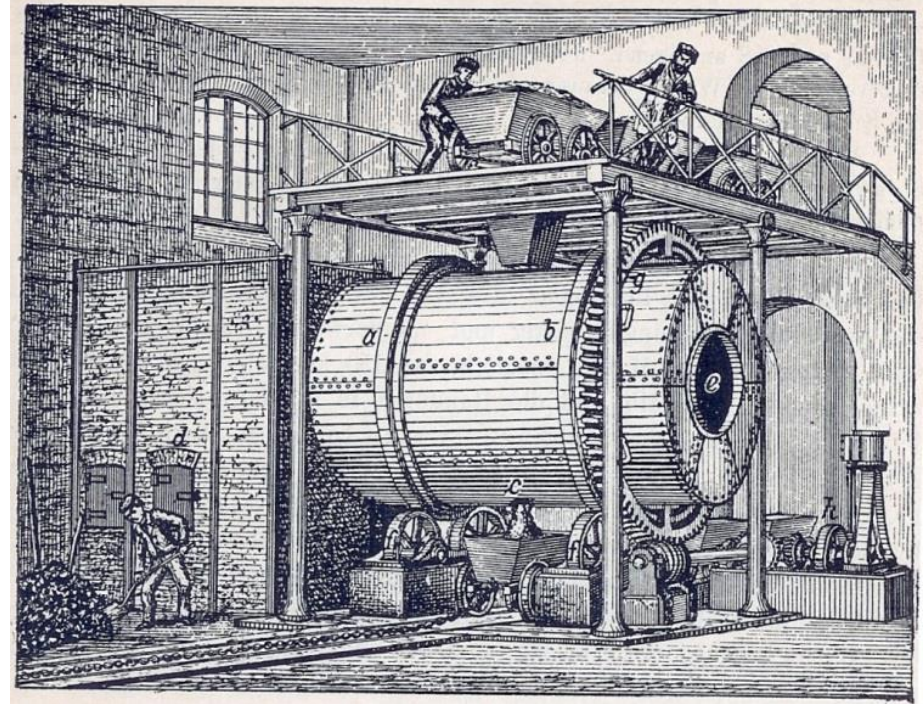
Limestone - less important than coal

Water – for the process

Transport – Canals, ports

Labour - Cheap, plentiful, poor

Land – for the factory and dumping



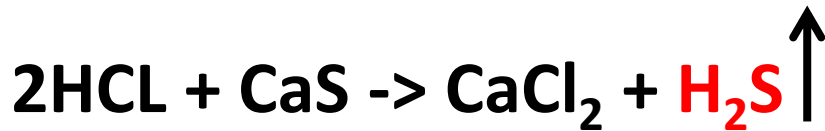
UK Sites – Cheshire (Widnes-Runcorn-St Helens); Bolton, Manchester; Glasgow; Gateshead; West Midlands - Black Country.

What is the problem with the “Galligu”

The Calcium sulphate muddy wastes were indiscriminately tipped over adjacent land areas (with other waste)

Deposits 3-10m deep and can cover >200 acres. In Widnes/Runcorn, originally used to reclaim salt marshes on the banks of the Mersey.

Produces toxic leachates and hydrogen sulphide odours – it smells.



“For every ton of soda made approximately double its weight of galligu – as it was locally called – a thick and evil smelling mud, had to be dumped But even when laid out on a waste land, from this nauseating sludge seeped the continual odour of rotten eggs. Finally however, the stuff dried; and even then it remained a potential menace. For it was liable to heat in the sun, catch fire and give off the instant and corrosive gas sulphur dioxide.”

J.M. Cohan, The life of Ludwig Mond 1956



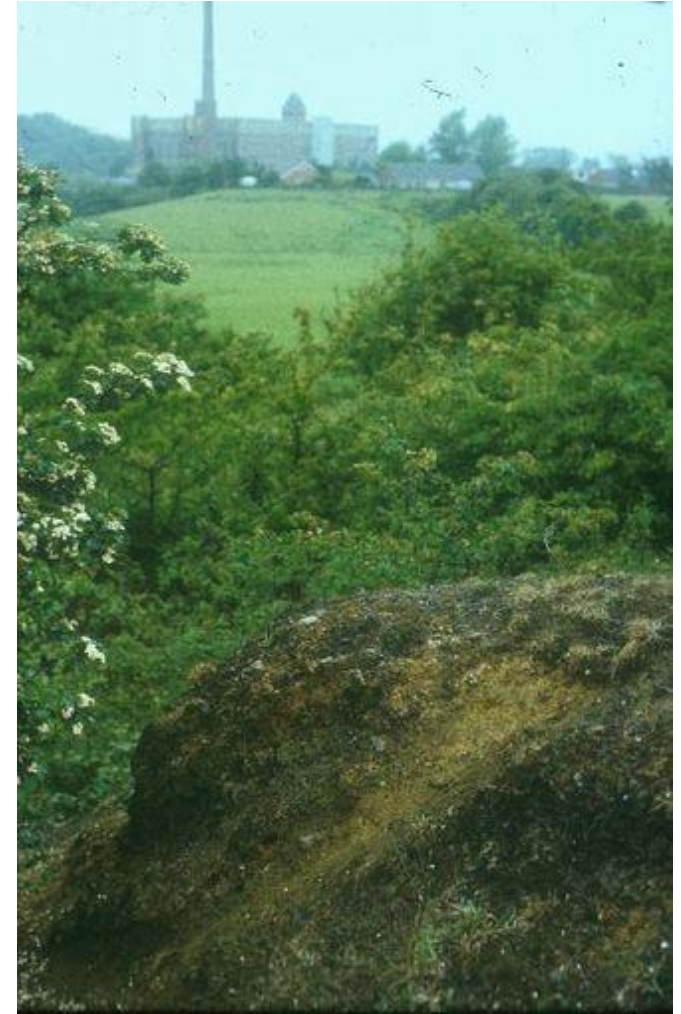
Nob End – nr. Bolton : a classic legacy site

Mid-18th Century Leblanc Soda Ash manufacturing site on the confluence of Rivers Irwell & Croal.

Demolished end 19th Century, waste site since. 8ha of dumped waste.



Nob End c1961



Nob End – time heals?

1974



Phil Sharples 2016 ; “Nob End, History Management and Development”

Nob End – now

SSSI and nature reserve – a calcareous grassland with large numbers of Orchids.

Consequence of >100 years of weathering converting Calcium Sulphates into Calcium Carbonate.



Bing Maps



A problem then, now and for the future...





GPR surveys at St Michael's golf course, Widnes
2000s

Built on 10m of Galligu deposits – significant
contaminated land issues.

Closed 2004, remediated and re-opened in
2020 as a 1MW solar power farm



Galligu – Strange Stuff

Oxidised ground state – Forms a stiff ‘granular’ mass with quasi-elastic and/or *anti-thixotropic* properties.

Reduced ground state – Exhibits pseudo-plastic and/or *positive thixotropic* behaviour, particularly when saturated.

Get either a decrease in viscosity with time for a constant shear rate or...

a decrease in viscosity with increasing shear rate



+



=

Galligu – Properties

➤ Geomechanical Lab Tests

- Chemical Waste **G of 2-30 MPa (0.2 - 4.3% Strain)**
- Sandy Clay **G of 3-15 MPa (0.2 – 1.5% Strain)**

➤ Moisture Content (waste) : ~17%

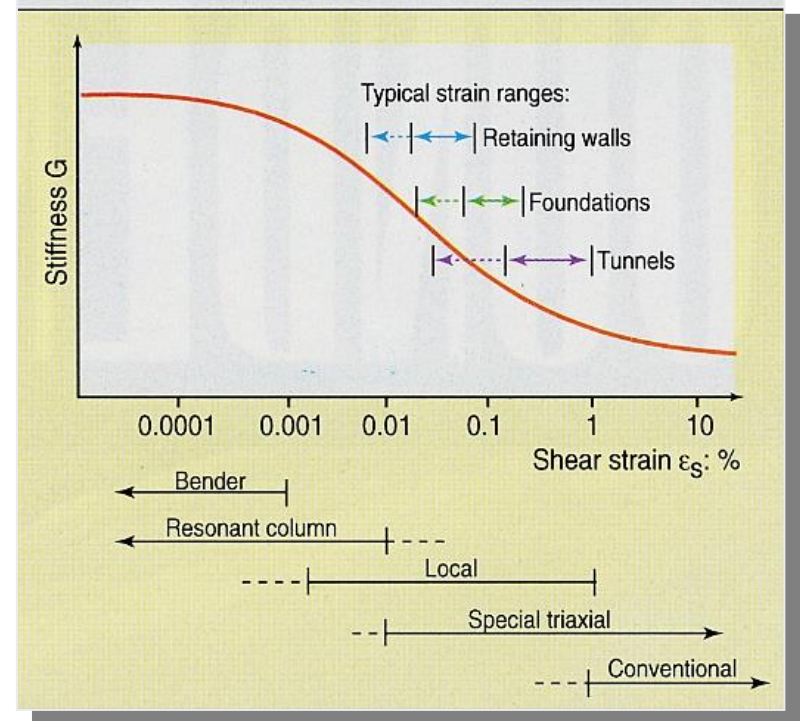
Unsaturated, ~37% Saturated

➤ PH (waste) : 11.6

➤ EC – 1000+ mS/m

➤ Density – similar to alluvial silts and clays

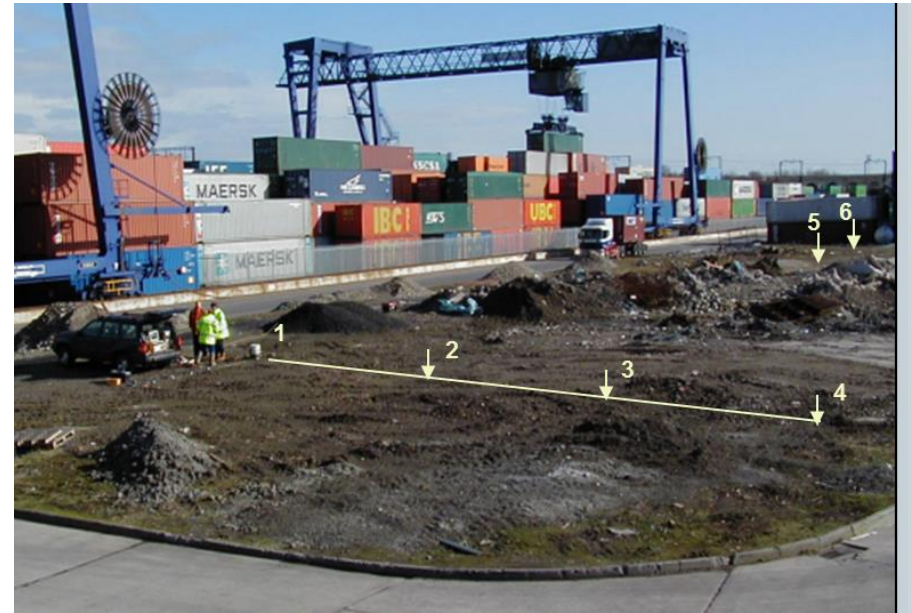
➤ Difficult to measure and quantify geotechnical and geophysical properties



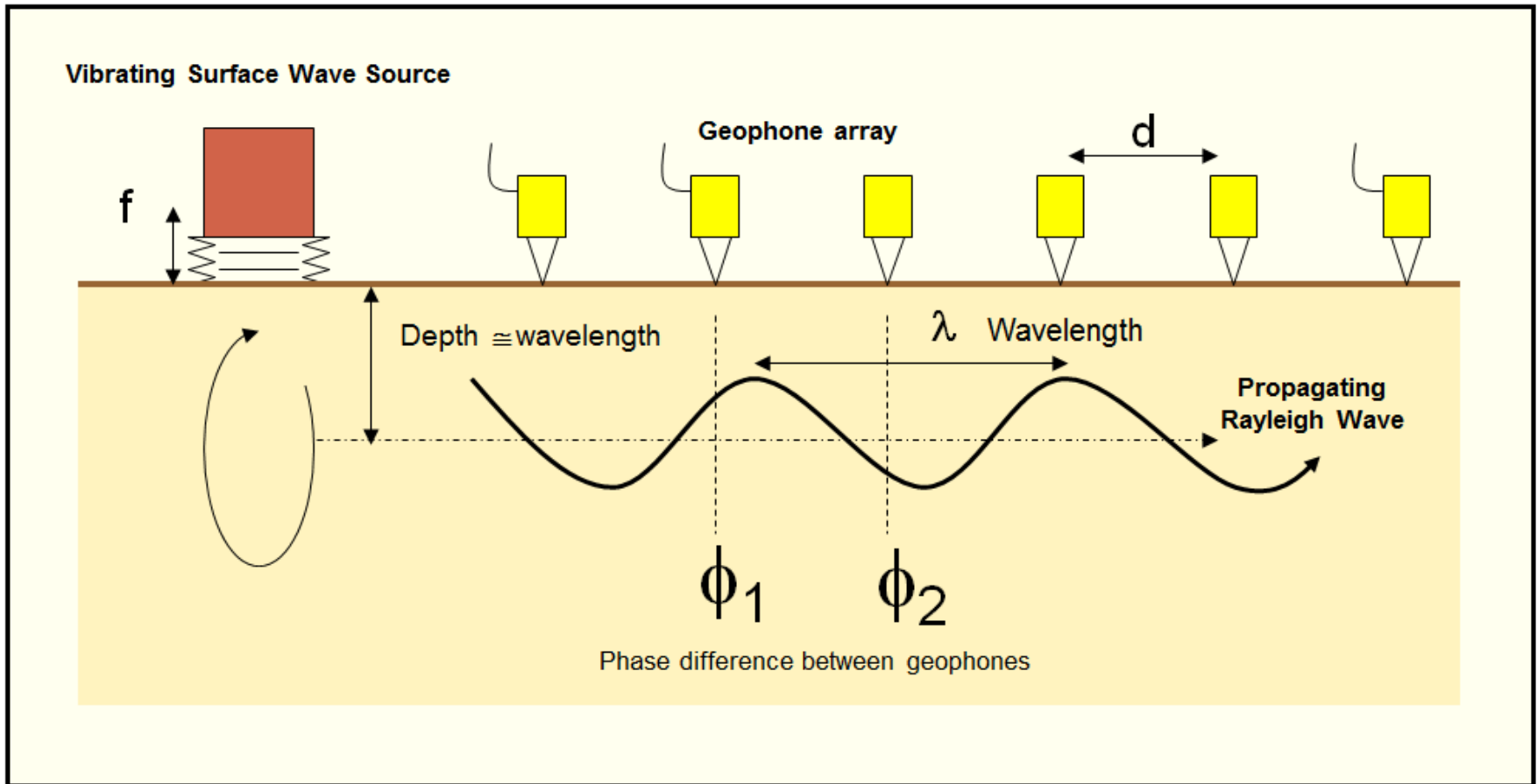
20 years ago...

O' Connor's Freight Terminal

Proposed development area : funding issues because of the operational and environmental problems of the Galligu.



Continuous Surface Wave Seismics - CSWS



Source generates Rayleigh waves (vertically polarised surface waves) at a given frequency, f . Sweep the frequency at each survey.

Interpretation

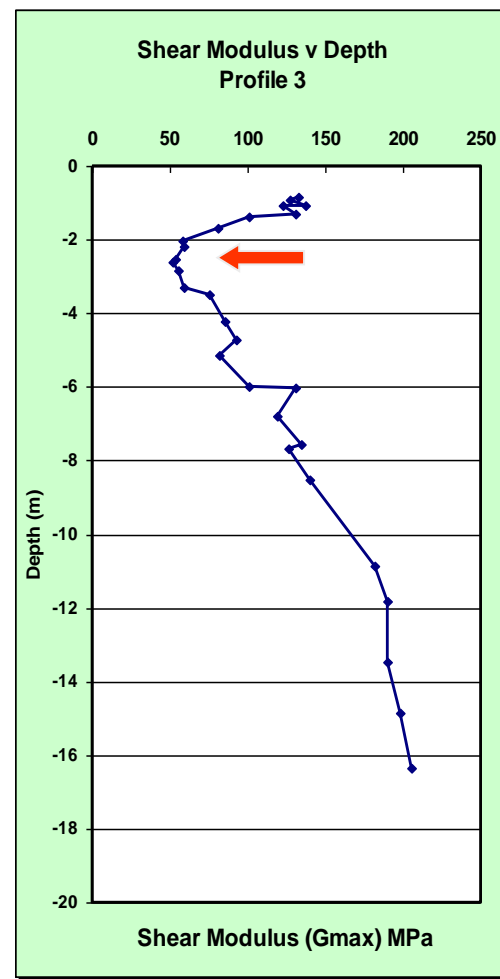
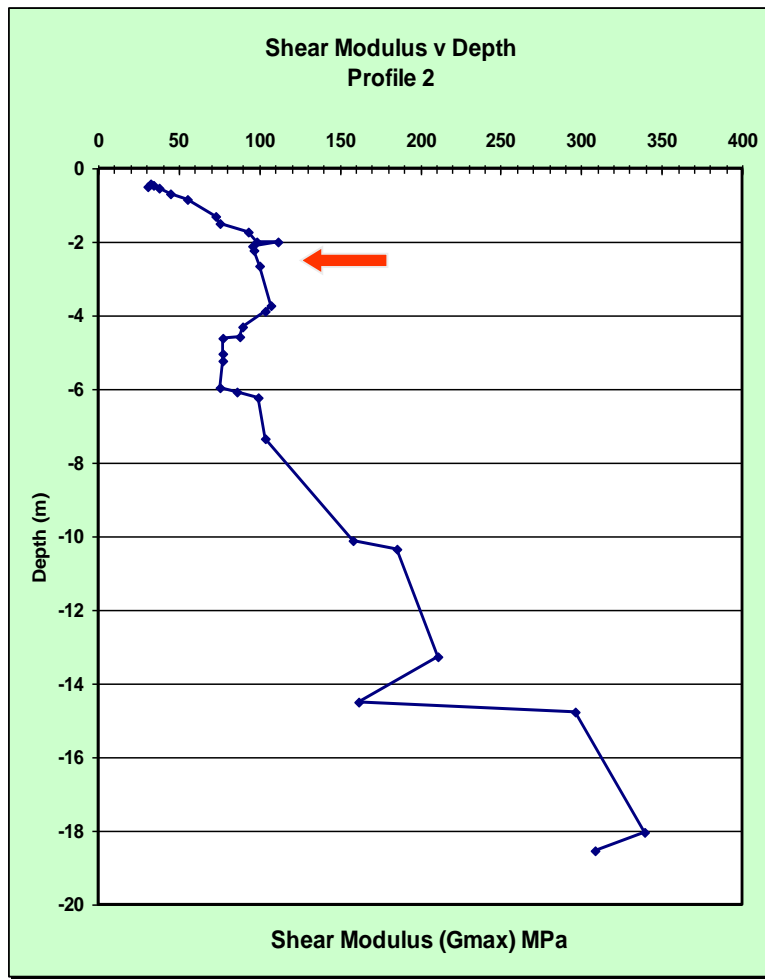
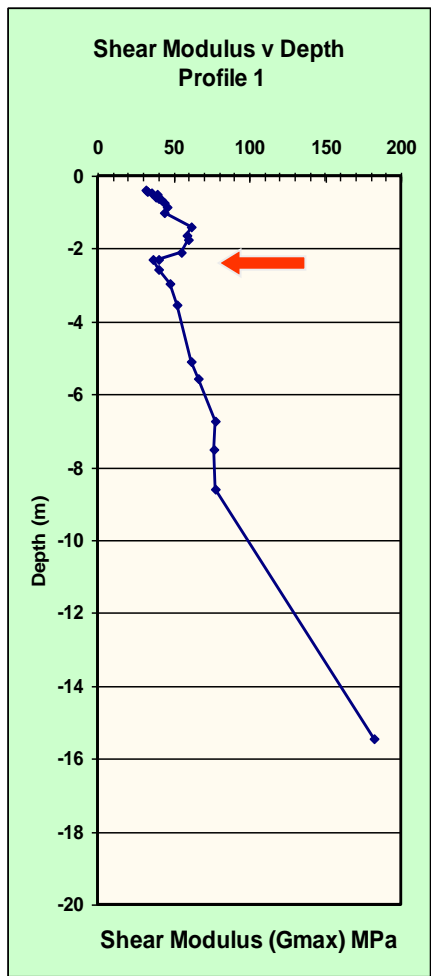
- A Fourier analysis of each geophone record provides the phase relationship – from this we get the wavelength, λ and Rayleigh wave velocity, V_r .
- Elastic theory (via Poisson's ratio) allows us to determine the Shear wave velocity, V_s
- Then, max Shear Modulus or stiffness G_{\max} can be determined by

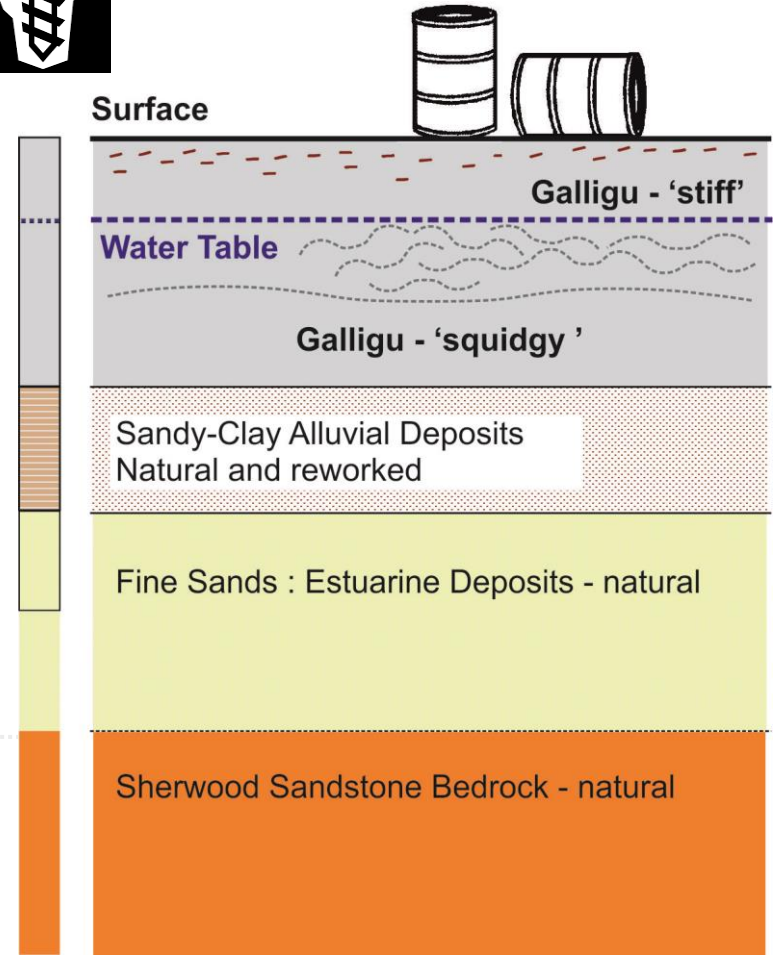
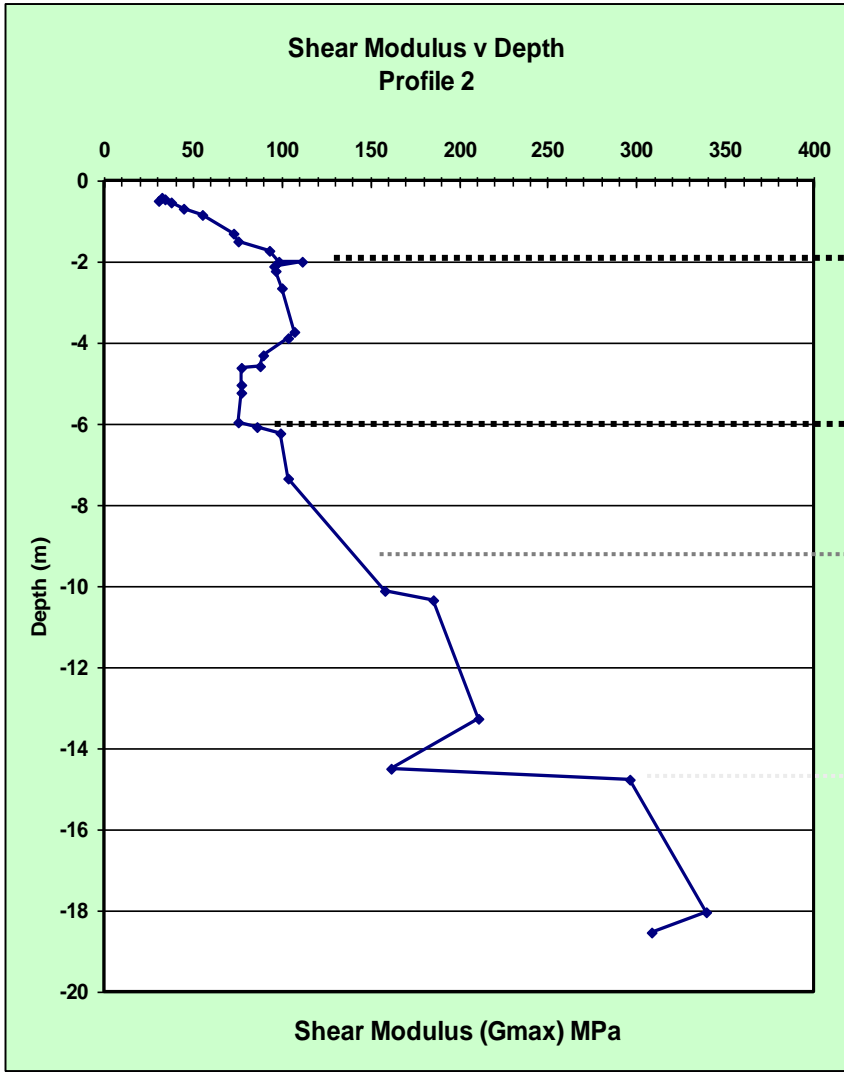
$$G_{\max} = \rho V_s^2$$

Where the density, ρ , is estimated or measured.

- As the frequency is lowered, the sub-surface is 'sampled' at increasing depths. A depth is assigned to each stiffness calculation by applying an inversion routine that relates frequency/wavelength to depth.
- **Result – get a Stiffness v's Depth profile.**

Results





How do we fix the “Galligu”



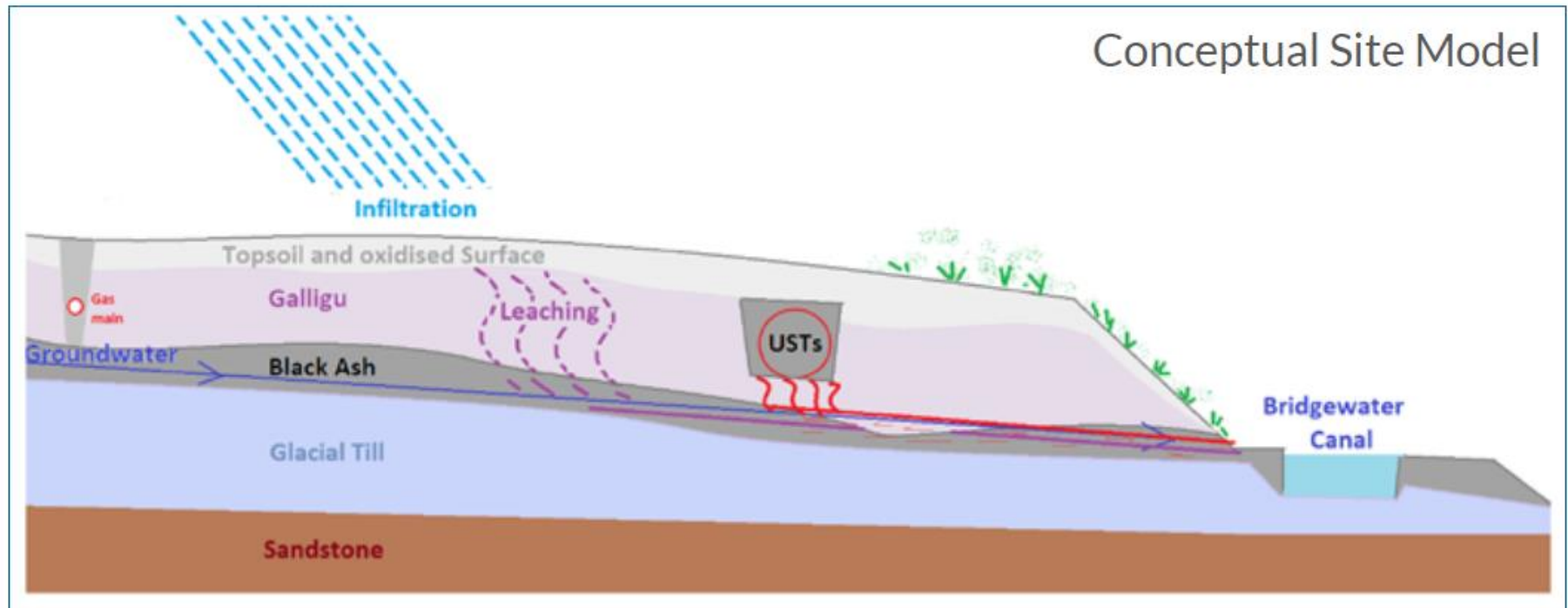
Cement-based soil stabilisation

Principle into Practice

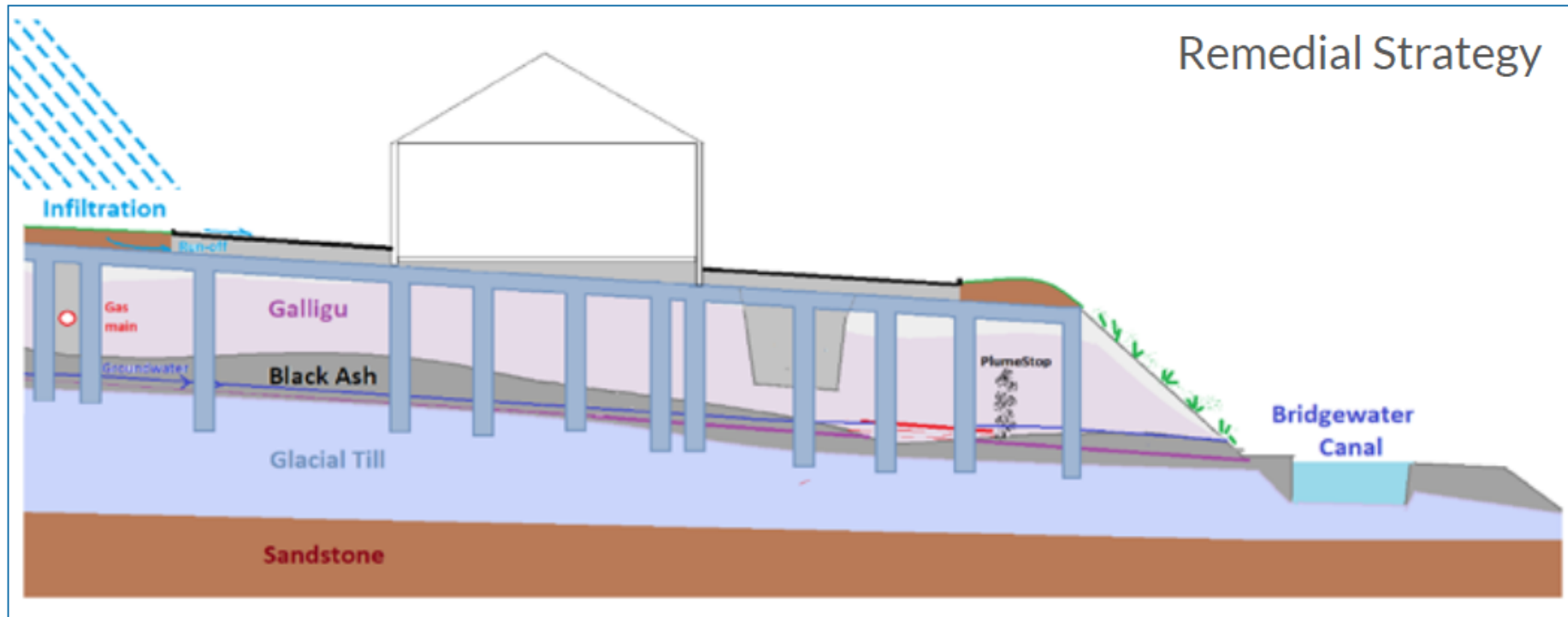
2017 Redevelopment of former Bus Depot on Galligu in Widnes.

Project with Geotechnical and Environmental Associates (GEA), REGENESIS and Deep Soil Mixing Ltd. 2018 Ground Engineering Awards Finalist

Soil/cement soil stabilisation panels and sub-surface Liquid Activate carbon plume barriers



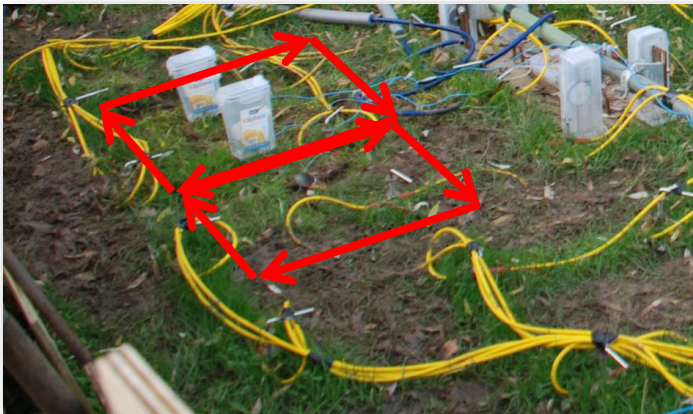
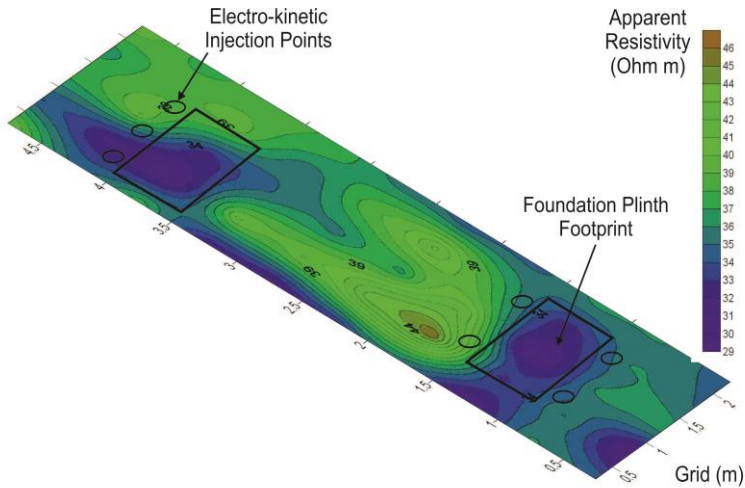
Soil Remediation Approach



A 'grid' of mixed soil-cement panels across site provides stable platform. In-situ mixing process with low levels of ground disturbance. All good but...

- What about long-term shear stress loading impact?
- Stiff oxidised top layer been removed, what about the 'new' surface layer?
- What monitoring is taking place to evaluate performance over time?

What can we do next?

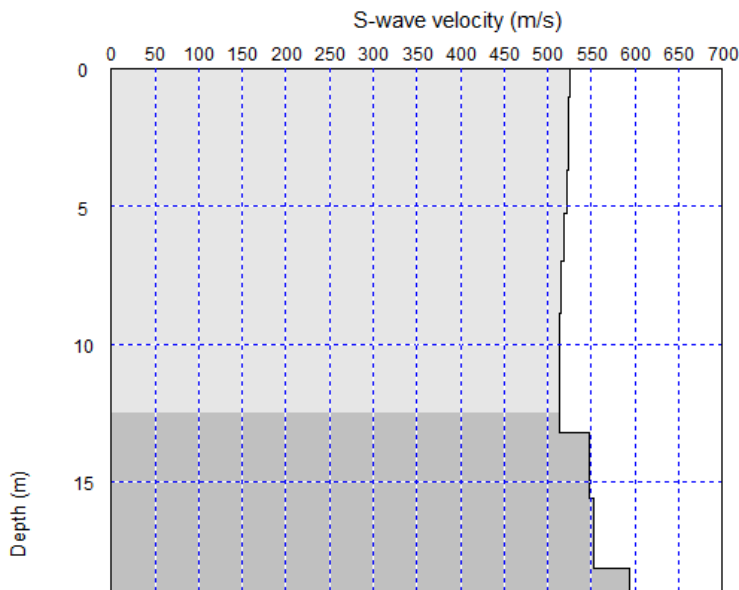


In-situ Electro-Kinetic Stabilisation – proved in the geotechnical remediation of London clays (Ian Jefferson, University of Birmingham)

A new way of ground monitoring?



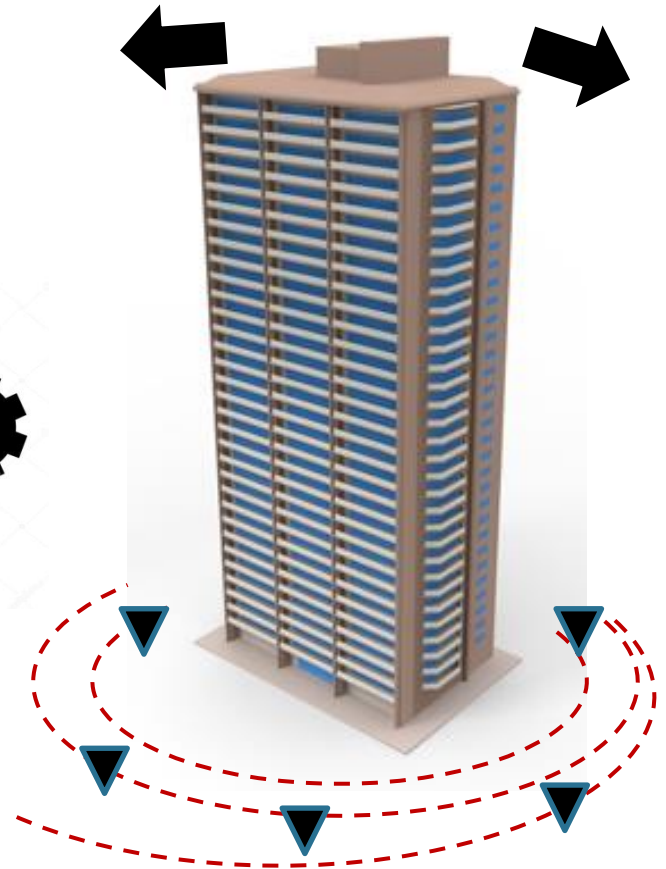
Societal Data



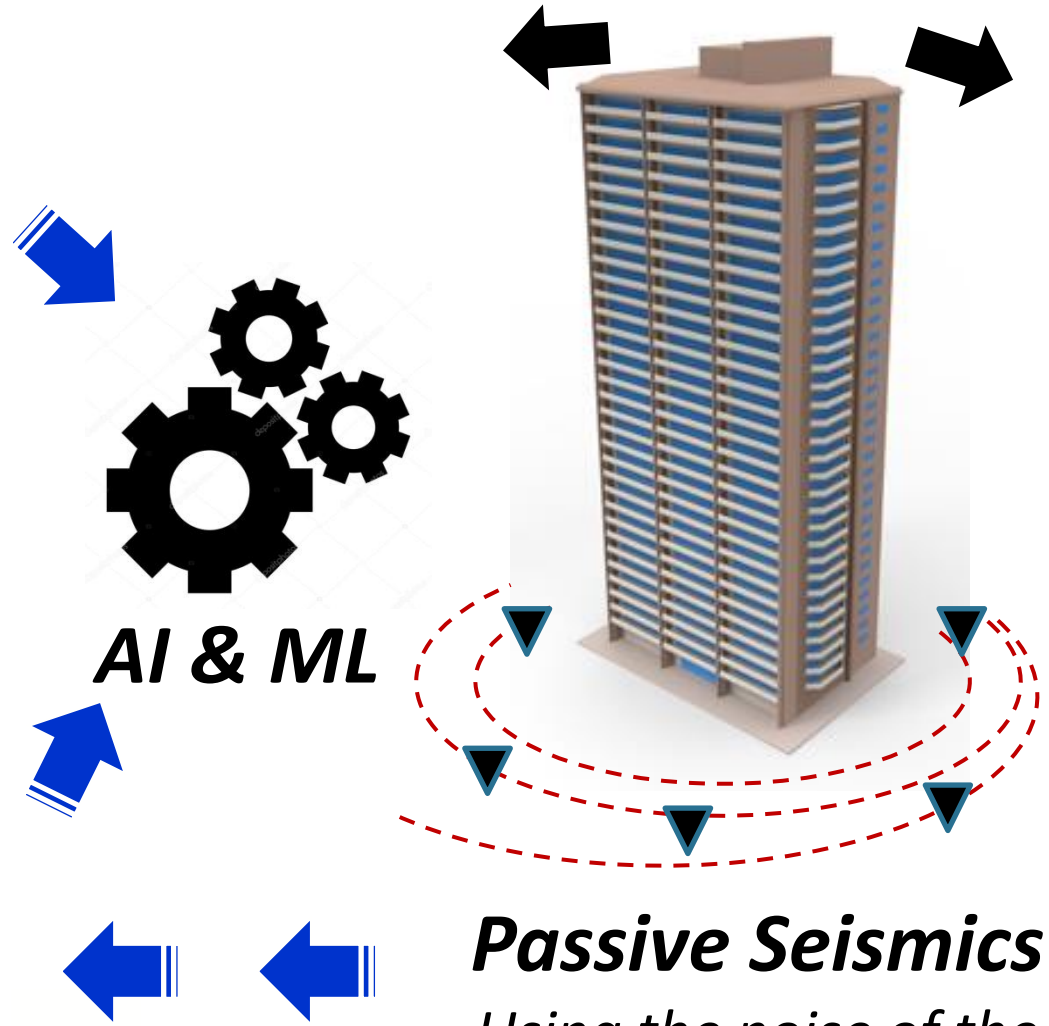
Geo-Data



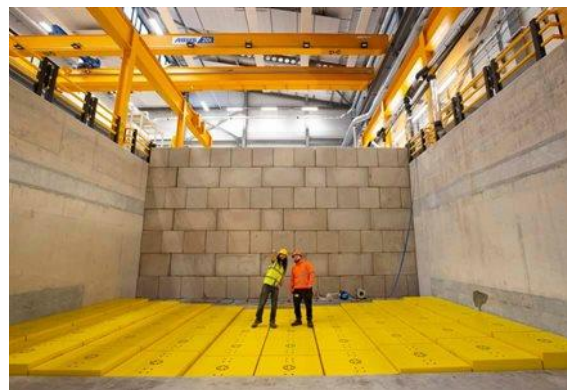
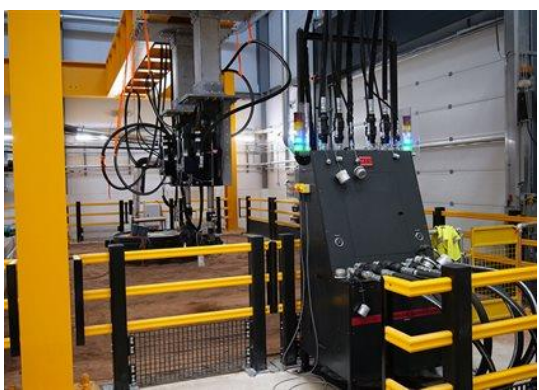
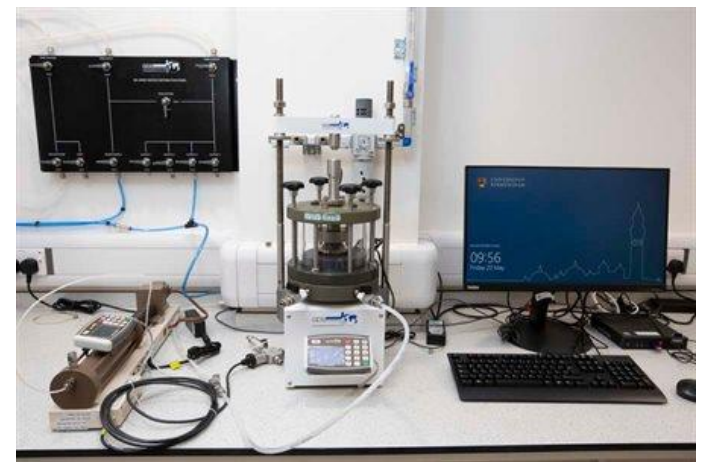
AI & ML



Passive Seismics
Using the noise of the Natural/Built Environment



National Buried Infrastructure Facility



<https://www.birmingham.ac.uk/research/activity/ukcric/nbif>



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