The Project

Inter-disciplinary – combines biology, engineering, mathematics and soil science

Managed by a consortium of academics and industrial stakeholders including facility owners, operators and maintainers including
- Network Rail
- Railway Safety and Standards Board
- Metronet Rail SSL (London Underground)
- Highways Agency
- British Waterways
- 6 Universities

£1.1m project; £900k from EPSRC through BKCC
Project aims and objectives

The aims are to build a facility for engineering and biological research and to improve the understanding of the effects of climate change on slopes.

The specific outcomes of the project are to be:

A full-scale, fully instrumented embankment representative of UK infrastructure, planted with representative vegetation with the facility to control climate over half of its length;

A validated hybrid computer model capable of predicting embankment performance under predicted future climates

A methodology for identifying parts of the UK infrastructure that require further investigation

A medium to long term research strategy, including some specific needs-based ‘spin-off’ projects

Information/research needs addressed

• Test facility with known subsurface and history
• Climate control
• Up-to-date climate scenarios
• Modelling to look at long term, mechanisms, influence of soil type, construction method, age etc
• Cross-disciplinary academic collaboration
• Some Stakeholder-defined aims and deliverables
The Embankment

- 90m long
- 6m high
- Side slopes of 1 in 2
- 5m width crest
- Central section - good compaction control
- Outer test plots - end-tipped
- Central section – HA seed mixture
- Outer sections – supplemented with additional species
- Plastic clay
- Under drained?

Embankment Design

Test sections divided using geomembrane

Drain with water volume measurement points every 10m

Gabion “ends” – 5m long
Embankment Design

- Geotextile “separator” layer
- 0.5m topsoil
- 5m
- Plastic lining into draining channel
- 2
- 1
- 6m
- French drain
- Average 0.75m thick rock-fill foundation

Construction of the BIONICS testing facility
Introduction

- Site
- Fill material
- Construction
- On-site testing
- Instrumentation
- Climate system

Nafferton Farm

Bionics embankment site located at Nafferton Farm, Northumberland
Site is an existing agricultural research centre, operated by Newcastle University
Fill material

Fill characterisation has been carried out at Newcastle and Durham Universities

<table>
<thead>
<tr>
<th>Test</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plastic Limit</td>
<td>17%</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>32.5%</td>
</tr>
<tr>
<td>Plasticity Index</td>
<td>15.3%</td>
</tr>
<tr>
<td>Triaxial</td>
<td>c' = 8 kPa, $\phi'$ = 29°</td>
</tr>
<tr>
<td>Permeability</td>
<td>$1.4 \times 10^{-12}$ m/s</td>
</tr>
</tbody>
</table>
Construction

- Membranes
- Compaction of test plots
- Coarse capping layer/topsoil
- Instrumentation

Membranes

The membranes were composed of two layers of Visqueen.

Straw bails were used as formwork for the construction of the impermeable membranes.
Compaction methods

Self propelled roller used on highway specification sections (300mm layers)

Tracked 360 type excavator used on less-well compacted sections (1m layers)

Coarse capping layer/topsoil

Topsoil from the topsoil strip placed on the embankment slopes (200mm thick)

Granular material placed on the embankment crest (500mm thick), material is basalt from Barrasford Quarry, Northumberland and has been chosen as it is mineralogically inert
### On-site testing

**Density**

<table>
<thead>
<tr>
<th></th>
<th>Bulk Density (Mg/M3)</th>
<th>Water Content (%)</th>
<th>Dry Density (Mg/M3)</th>
<th>Air voids (%)</th>
<th>Degree of saturation (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Poor” compaction</td>
<td>1.93</td>
<td>20.7</td>
<td>1.6</td>
<td>6.0</td>
<td>85.3</td>
</tr>
<tr>
<td><strong>Good</strong> compaction</td>
<td><strong>2.01</strong></td>
<td><strong>20.1</strong></td>
<td><strong>1.7</strong></td>
<td><strong>3.2</strong></td>
<td><strong>91.4</strong></td>
</tr>
</tbody>
</table>

**Shear strength**

<table>
<thead>
<tr>
<th>Layer height</th>
<th>Poorly compacted sections</th>
<th>Well compacted sections</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cu (kPa)</td>
<td>Cu (kPa)</td>
</tr>
<tr>
<td>0-1m</td>
<td>min</td>
<td>max</td>
</tr>
<tr>
<td>1-2m</td>
<td>128</td>
<td>142</td>
</tr>
<tr>
<td>2-3m</td>
<td>113</td>
<td>142</td>
</tr>
<tr>
<td>3-4m</td>
<td>95</td>
<td>142</td>
</tr>
<tr>
<td>4-5m</td>
<td>50</td>
<td>142</td>
</tr>
<tr>
<td>5-5.5m</td>
<td>50</td>
<td>142</td>
</tr>
</tbody>
</table>
On-site testing – Soil Suction

Less-well compacted sections

Well-compacted sections

-180
-160
-140
-120
-100
-80
-60
-40
-20
0

Panel 1, Layer 8
Panel 1, Layer 9
Panel 4, Layer 5
Panel 4, Layer 8
Panel 4, Layer 9

Panel 2, Layer 9
Panel 2, Layer 15
Panel 3, Layer 7
Panel 3, Layer 11
Panel 3, Layer 16
Panel 3, Layer 18

0 100 200 300 400
Time (m)

Suction (kPa)
Conclusions

- Embankment closely matching the original specification has been constructed
- On-site testing has shown that lower and more variable strengths and densities have been produced in the less compacted sections
- The presence of higher than expected soil suctions means that an alternative to piezometers need to be used

Instrumentation

Geotechnical Instruments
- Piezometers and suction probes
- Inclinometers
- Magnetic extensometers

Environmental Sensors
- Soil temperature
- Surface soil water profile tubes
- Weather station

Others
- GPS surface movement system under development
- Acoustic movement sensors
- Survey grid
- Infra red laser scanner
Progress and readings taken

**Piezometers**: Flushable piezometers now in place, each piezometer location will be monitored on a bi-monthly basis.

**Suction probes**: Awaiting final pieces of equipment, frequency of monitoring will depend on available human resources.

**Magnetic extensometers**: Up and running, monitored once a month (3 months readings so far).

**Inclinometers**: In-place system installed, manually probed locations monitored once per month.

Environmenta sensors

Soil temperature probes: These make up part of the climate system, this will be installed within the next six months.

Surface water profile gauges: Currently being installed, will be monitored once a month.

Weather Station: Has been up and running for 10 years, data downloaded from station once per month.
Other systems

Embarkment will be 3D laser scanned twice per year
Acoustic systems will be continuously monitored
Embarkment will be surveyed at least twice per year

Climate system

A climate control system (CCS) will be constructed on the embankment at Nafferton Farm.

The system will consist of
• retractable covers
• rainfall sprinklers
• control system
• monitoring system
Climate system

Original CCS supplier, Vega (Denmark), no longer available

Consequently the work has now been split into 3 units for tendering to UK based firms.
- Retractable cover system
- Rainfall sprinkler system
- Control and monitoring system

Two new suppliers of main cover systems
- Orwin Automation
- Northern Welding Services (NWS)

After consultation Orwin Automation now expected to be selected for construction of the CCS.

- Orwin would construct the whole system with the exception of the met sensors.
- The proposed system will be considerably better than the one envisioned at the start of the project.