RoaDex final seminar
Inverness, 21 May 2012
Roads on Peat - outline

- ROADEX and peat
- Environmental considerations
- Engineering & risk management
- Construction methods
- Maintenance of roads on peat
- Examples of good practice
- Conclusions
Roads on Peat: Peat across the Northern Periphery

- Palsa mires
- Fens
- Raised bogs
- Blanket Bogs

Mire zones across northern Europe, Succow & Jeschke 1990
ROADEX Roads on Peat

4 reports on the website:

- ROADEX II Report, 2005
  “Dealing with Bearing Capacity Problems on Low Volume Roads Constructed on Peat”

- ROADEX II Guidelines, 2005
  “Guidelines for the Management of Peat Slips on the Construction of Low Volume/Low Cost Roads over Peat”

- ROADEX III Executive Summary, 2006
  “Managing Peat Related Problems on Low Volume Roads”

- FCE/SNH Report, 2010
  “Floating Roads on Peat”
Roads on Peat - eLearning

Contents:
- Peat
- Behaviour of peat
- Environmental considerations
- Geotechnical risk management
- Engineering considerations
- Investigations & surveys
- Construction of roads on peat
- Maintenance of roads on peat
- Monitoring
- Records
Roads on Peat - eLearning

Task work group:
- Haraldur Sigursteinsson, ICERA
- Gunnar Zweifel, Trafikverket
- Peter Carlsten, Trafikverket
- Ron Munro, MCL
What can go wrong:

Peatslide, Ireland, 2009

Failure triggered here

Verge loaded with 1m of excavated peat
What can go wrong – the movie:

Peatslide, moving on a slope of 2%
What can go wrong:

Road under construction

Gjábakkavegur peatslide, Iceland, October 2009
Environmental considerations

- Usually a protected area/ecology/habitat
- Sensitive to changes in hydrology
- Disturbance
- Pollution
- Construction
- Drainage
Roads on peat considerations

Drainage/hydrology:

- Floating road – no ditches
- Shallow ditches rather than deep ditches
- Oversizing culverts to permit settlement

Dealing with surface flows of water:
- Hanging culvert in a geogrid

Stone filled ditch wrapped in geotextile
Drainage/hydrology - existing roads
Buoyancy effects on peat

Road on a sound foundation

Floating road on peat

Effects of new drains on a floating road

18kN/m³

18kN/m³

18kN/m³

10kN/m³

10kN/m³

P Carlsten SGI
Engineering considerations of peat:

- predominantly water + dead plant fragments
- up to 95% water, moisture content up to 2000%
- variable shear strength, 2kPa to 40kPa
- subject to consolidation & compression
- leading to settlement & deformation

➜ a challenging material for road construction
Behaviour of peat when loaded: Strain/settlement

Log Time

0 10 days 100 days 1,000 days 10,000 days

(0) (10 days) (100 days) (1,000 days) (10,000 days)

Vertical strain/settlement

$\varepsilon_i$, instantaneous strain

$\varepsilon_p$, primary strain

$\varepsilon_s$, secondary strain

“tertiary strain” $\varepsilon_t$
Behaviour of peat when loaded: Monitoring of settlement

Settlement plate
- simple plate and rod

CONSOIL Hydrostatic Profiler
- polyethylene tube with a portable pull-through sensor

Settlement plate v. log time

Tube settlement cross-section, Iceland
Behaviour of peat when loaded: Preloading/strengthening

Settlement graph for a 2m embankment with a 1.5m surcharge

Preload settlement using a 2m embankment with a 1.5m surcharge, down to required settlement

Settlement for 2m embankment with 1.5m surcharge, then removed

Settlement for a 2m thick embankment after 30 years

Settlement for a 2m thick embankment with 1.5m surcharge after 30 years

Behaviour of peat when loaded:

- Preloading/strengthening
Loading peat: Stage construction

Stage construction embankment
Icelandic preload method:
Preloading Method
Investigations and surveys

Minimum:

- Desk study
- Site walk through
- Depth probing (or GPR)
- Sampling for
  - Classification
  - Water content
Water content influences:

Water content & solids by volume

Legend:
- Volume of peat solids
- Volume of clay solids
- Volume of moraine solids
- Volume of water

Dry density v. water content

Legend:
- SGI, 1998
- Radford & Rush, 1964

Void ratio v. water content

Legend:
- Mass of peat solids
- Mass of clay solids
- Mass of moraine solids
- Mass of water
Roads on peat

Estimation of primary settlement
(Swedish Transport Administration method)

First layer settlement >70%

\[ U = 1 - 0.6 \cdot \left( \frac{0.52 \cdot w^{0.75}}{H^2 \cdot q^{0.5}} \right)^t \]
RoaDex Network Implementing Accessibility

**RoaDs on peat**

Estimation of primary settlement (Swedish Transport Administration method)

Subsequent layers and preloading

\[
U = 1 - 0.6 \cdot e^{-\left(\frac{0.52 \cdot H^{0.75}}{H^2 \cdot q^{0.5}}\right) t}
\]

THICKNESS OF PEAT, M*

WATER CONTENT (%)

APPLIED LOAD (kPa)

TIME (days)
Risk Management

- Experienced designers
- Experienced contractors
- Good planning
- Awareness of the hazards and impacts
- Sound mitigation measures
- Careful construction techniques
- Contingency planning
- Monitoring of the work on site

Geotechnical risk management
Geotechnical risk management

“No construction project is risk free. Risk can be managed, minimised, shared, transferred or accepted. But it cannot be ignored”

‘Constructing the Team’ report, 1994

Ways of managing risk:

Avoiding it – by eliminating the uncertainty or using an alternative approach.

Transferring it – by transferring the liability of the risk to another party, e.g. a specialist sub-contractor or consultant.

Mitigating it – by reducing the risk to an acceptable level by making it less likely that the event will occur.

Accepting it, and managing it – by accepting that the risk is reasonable given the cost, or the effect on time or quality, or life.
Geotechnical risk management

The Geotechnical Risk Register

Risk (R) = Probability (P) x Impact (I)

<table>
<thead>
<tr>
<th>PROBABILITY (P)</th>
<th>IMPACTS (can be amended to suit contract circumstances)</th>
<th>IMPACT (I)</th>
<th>Calculated RISK R=PxI</th>
<th>Degree of Risk</th>
<th>Suggested Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Likely &gt;75%</td>
<td>&gt;10 weeks added to planned completion date</td>
<td>&gt;€1M</td>
<td>17 to 25</td>
<td>Unacceptable</td>
<td>If risk cannot be reduced project should not proceed</td>
</tr>
<tr>
<td>Likely 50-75%</td>
<td>&gt;4 weeks added to planned completion date</td>
<td>€100K to €1M</td>
<td>13 to 16</td>
<td>Unacceptable</td>
<td>Work must not start until risk has been reduced</td>
</tr>
<tr>
<td>Probable 25-50%</td>
<td>&gt;4 weeks&lt;1wk added to planned completion date</td>
<td>€10k to €100k</td>
<td>9 to 12</td>
<td>Significant</td>
<td>Reduce risk. (Mitigate or transfer.)</td>
</tr>
<tr>
<td>Unlikely 10-25%</td>
<td>1 to 4 weeks on activity: no change to planned completion date</td>
<td>€1k to €10k</td>
<td>5 to 8</td>
<td>Tolerable</td>
<td>Consider risk reduction measures</td>
</tr>
<tr>
<td>Negligible &lt;10%</td>
<td>&lt;1 week to activity: no change to planned completion date</td>
<td>&lt;€1000</td>
<td>1 to 4</td>
<td>Trivial</td>
<td>Monitor work</td>
</tr>
</tbody>
</table>

**Hazard:** an activity or condition with a potential for adverse consequences.

**Risk:** the potential that the hazard will lead to a loss - generally expressed as “probability” x “impact”, or “likelihood” x “consequence”
Susceptibility mapping for peatslide

Mouchel, SNH/FCE seminar 2009
## Geotechnical Risk Register

### Geotechnical Risk Management

The Geotechnical Risk Register

Risk (R) = Probability (P) x Impact (I)

<table>
<thead>
<tr>
<th>No</th>
<th>HAZARD</th>
<th>CAUSE</th>
<th>BEFORE CONTROLS</th>
<th>CONSEQUENCE</th>
<th>RESPONSE (avoid, transfer, mitigate, accept &amp; manage)</th>
<th>AFTER CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Unexpected ground conditions</td>
<td>Ground conditions encountered on site differ from those indicated in the project ground investigation.</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>Construction delayed. Design review required with possible changes in design. Project cost and timescale increased</td>
</tr>
<tr>
<td>2</td>
<td>Flooding</td>
<td>Prolonged rain, Rise in groundwater levels within bog. Local watercourses break banks.</td>
<td>3</td>
<td>4</td>
<td>12</td>
<td>Permanent works damaged. Work stops. Increased costs for repair of the Works. Project delayed</td>
</tr>
<tr>
<td>3</td>
<td>Site clearance</td>
<td>Clearance of vegetation from within the site limits ahead of the permanent Works</td>
<td>4</td>
<td>3</td>
<td>12</td>
<td>Damage to fibrous surface of peatbog. Removal of surface rootmat. Design of Works affected</td>
</tr>
<tr>
<td>4</td>
<td>Placing of fill on geotextile</td>
<td>Rupture, puncture or tearing of the permanent geotextile</td>
<td>4</td>
<td>4</td>
<td>16</td>
<td>Damage to permanent Works. Fill material laid directly on to bog surface. Failure of subgrade</td>
</tr>
</tbody>
</table>
Contingency planning:

- Zone 1
- Zone 2
- Zone 3
- Zone 4

Barrage location

Public Road

Barrage location

Public Road
ROAD CONSTRUCTION

Methods of construction

- Peat excavation
- Peat displacement
- Peat left in place
ROAD CONSTRUCTION

Methods of Construction - Peat left in place

- Strength Improvement
  - Preloading
  - Surcharging
  - Stage Construction

- Load Modification
- Reinforcement
- Vertical Drainage
- Piling
- Stabilisation

- Geosynthetics
- Raft Construction

- Profile Lowering
- Pressure Berms
- Slope Reduction
- Lightweight Fill
- Offloading
Budget v. Timing:

- Advance earthworks ahead of road construction – add 3 years
- Vertical drainage to speed settlement – add €€€€€
- 2-lane road in Iceland constructed by preloading – 1 year
- Low volume wind farm road immediate loading by 150 tonne trucks
Examples of practices in the ROADEX areas
ROADEX demonstration project
Assessment of an existing roads on peat
N59 Newport - Mulranny, Co Mayo, (15km)

The ROADEX method:

- Map the weak sections of road and **FOCUS** in on them
- Understand the processes causing the problems
- Innovate - find new ‘fit for purpose’ structures and treatments
ROADEX demonstration project

N59 Newport - Mulranny, Co Mayo, (15km)

Surveys March 2011:

- standard GPR survey in both directions
- deep GPR survey for presence of peat in both directions
- GPR cross-sections at selected locations
- laser scanner survey in both directions
- FWD survey in one direction at 50m centres
ROADEX demonstration project

40m long pocket of peat under an existing road
Example: N59 Newport - Mulranny

GIS map of SOFT SUBGRADE areas
N59 Newport to Mulranny
County Mayo
Example: N59 Newport - Mulranny

TOTAL RISK CLASSIFICATION
N59 Newport to Mulranny
County Mayo
RoaDex Network Implementing Accessibility

RoaDs on Peat
WideninG an existing road

Outline of new widened road

Existing floating road
Rocks on Peat
Widening an existing road
**Rocks on Peat**
Widening an existing road

Outline of new widened road

Fine material removed from road shoulder

Geotextile placed on exposed surface
Roads on Peat
Widening an existing road
Roads on Peat
Widening an existing road
Roads on Peat
Widening an existing road

- Outline of new widened road
- New road layers constructed across full width of road including steel grid
- Existing floating road
Roads on peat - summary

- Collect data
- Understand the ground conditions
- Respect the established hydrology
- “Do no more harm”
- Think about geotechnical risk management
- Monitor the works during and afterwards
- Keep records & share knowledge
ROADEX II: B871 Rosail embankment replacement
Thank you

www.ROADEX.org