Reinforced Water, Edinburgh
11th March 2008

Peat Slope Failures in Ireland & Stability Assessment

Noel Boylan
University College Dublin

Supervisor: Dr. Mike Long

UCD School of Architecture, Landscape and Civil Engineering.

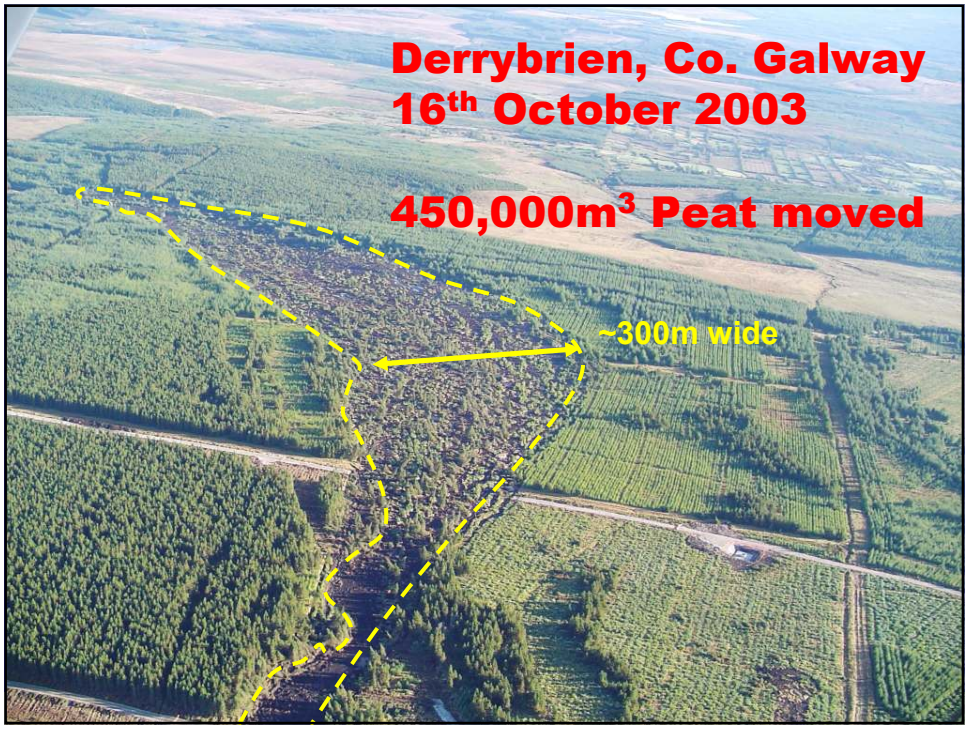
Scoil na hAiltireachta, na Tírdhreacha agus na hInnealtóireachta Sibhialta UCD.

Presentation Outline

- Background
  - Peat Slope Failures in Ireland
- Engineering Stability Assessment
- Undrained Shear Strength (s_u)
- Recent Research
  - UCD-DSS
  - Full Flow Penetrometers


Pollatomish, Co. Mayo 19th September 2003


~40 Failures
~11 Failure Occurred in Peat

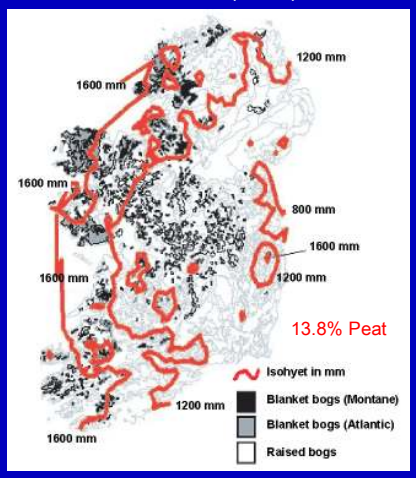

Derrybrien, Co. Galway
16th October 2003
450,000m3 Peat moved
~300m wide

Derrybrien

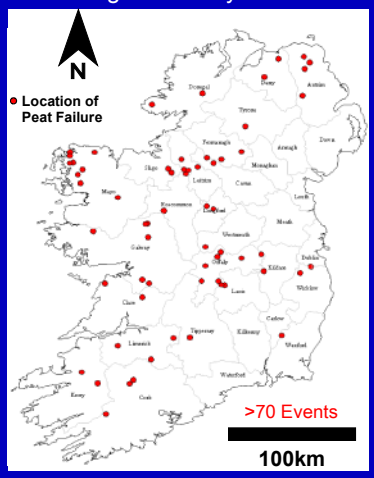
Head of Failure ~40m Wide

Peat Slope Failures in Ireland

Peat Distribution & Annual Rainfall
Ward et al. (2007)



National Landslide Database
Geological Survey of Ireland



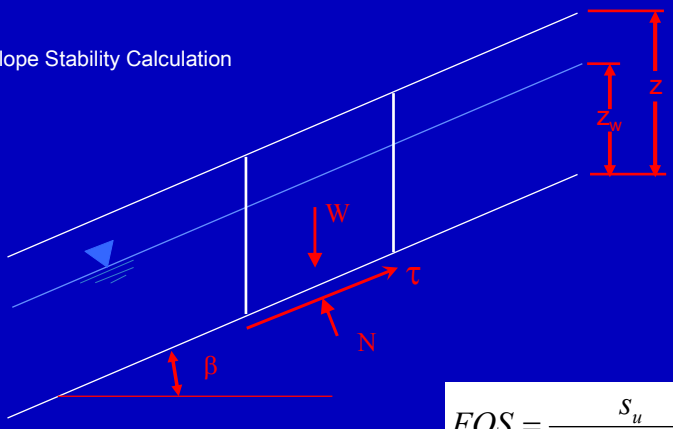
Assessment of Peat Stability - Ireland

- Planning Guidelines[1] for windfarm developments require an assessment of peat stability to take place
- Qualative Risk Assessments generally used to assess risks from array of causal factors
- Current (recent) practice is to carry out Engineering stability assessments using results of in-situ vane tests ($s_{u\text{-}vane}$)

[1]DOEHLG (2006) Wind Energy Development Guidelines

Engineering Stability Assessment

Infinite Slope Stability Calculation



$$FOS = \frac{s_u}{\gamma z Sin\beta Cos\beta}$$

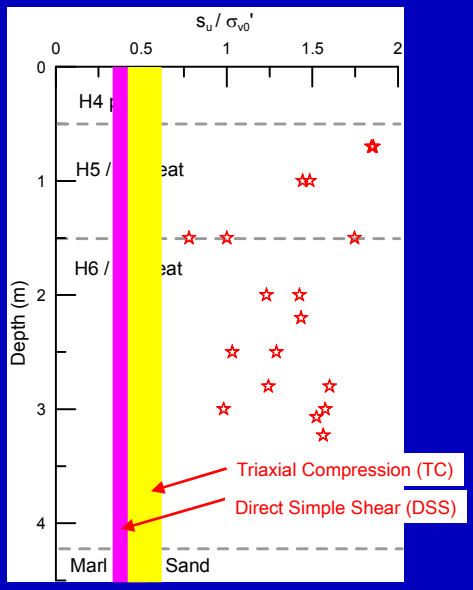
$$FOS \geq 1.4$$

Passive resistance and vertical portions of failure surface ignored. Z/L generally much less than 0.1 for peat failures.

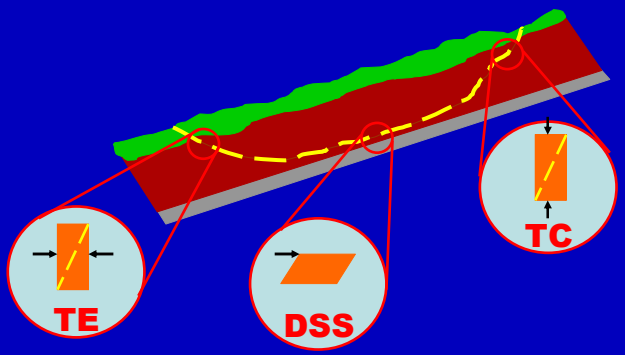
In-situ Vane Tests

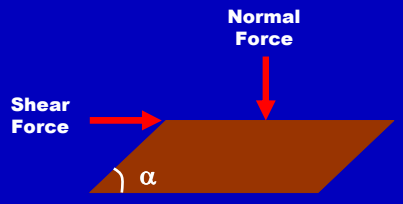
- Current (recent) practice is to use s_u from field vane tests
- FVT known to be misleading in peat
  - Anisotropy of peat due to fibres…. s_u/σ'_v = 1-2
  - Compression of peat by vane….failure surface differs from theoretical
  - Voids open up behind the vane facilitating drainage
  - s_u reduces with increasing vane diameter
  - Doesn't seem appropriate as dominant failure is horizontal sliding

Insitu Vane Tests



Strength appropriate to failure surface





DSS Testing of Peat

- Some Experience of DSS testing of Peat

Carlsten (2000), Farrell et al. (1998), Zwanenburg (2005)

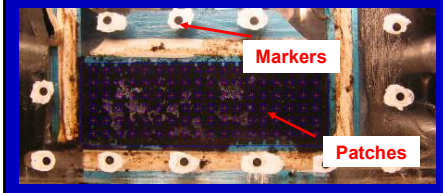
- Largely carried out at high stress levels above insitu condition to define s_u / σ'_v relationship
- Need to develop apparatus to test a low stress levels (deJong, 2007)

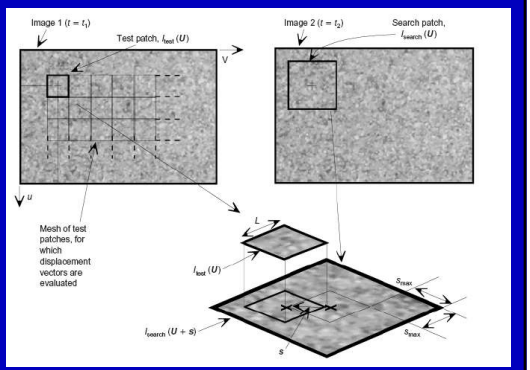
Development of DSS for Peat

- Criteria for DSS to satisfy:
  - Simulate the low apparent effective stresses that peat experiences insitu (≈2-5kPa)
  - Method to ensure that peat is indeed undergoing shear strain and not slipping at patten
  - Monitor deformation of peat to learn about peat strength

UCD-DSS Apparatus

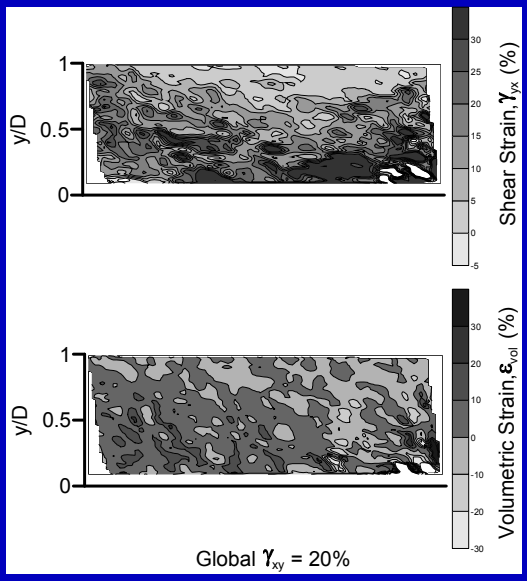
UCD-DSS Deformation Analysis



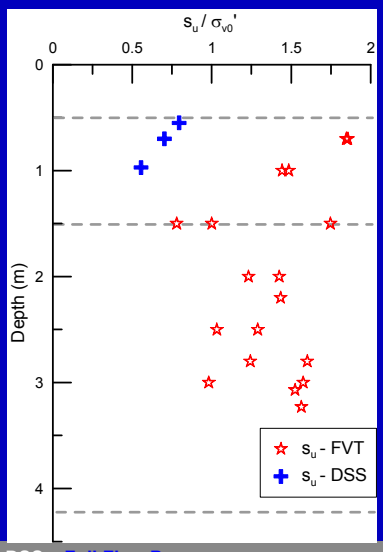


1. Break image up into a fine mesh (White et al., 2003)
2. Using cross-correlation techniques, find location of each square in second image
3. Close range photogrammetry to calibrate strains
4. Plot strains & contours of shear strain

Deformation Monitoring - Example



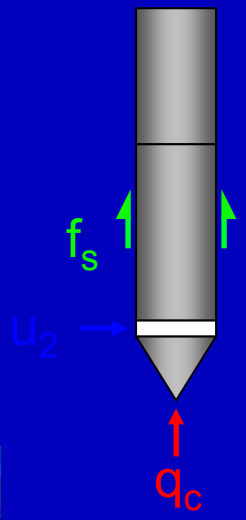
Vane & DSS Results

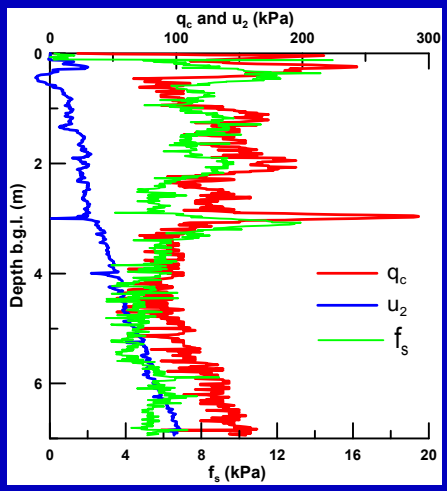


Insitu Testing

- Not always feasible to test large amounts of specimens in laboratory
  - Difficulties obtaining samples
  - Sample Disturbance
  - Difficulties preparing specimen for testing
- Need an insitu test to relate to
  - Problems with cone penetration testing (CPT) in peat

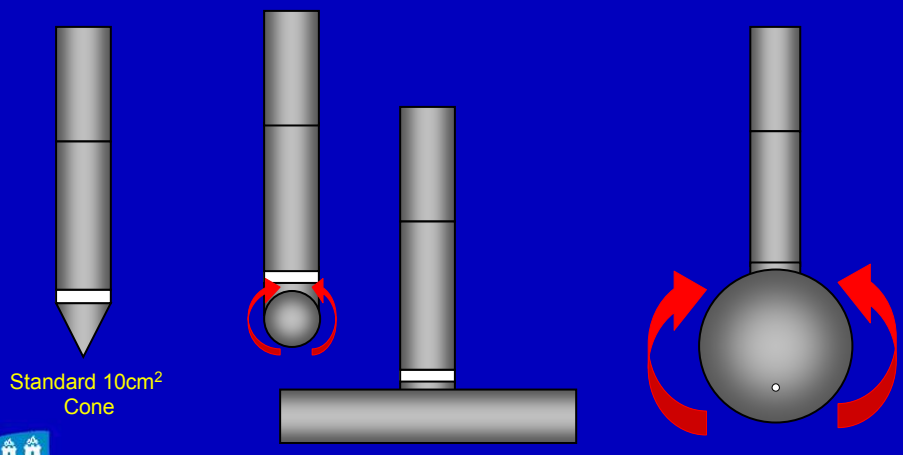
Problems with CPTU in Peat





Problems of negative resistances in peat

Full Flow Penetrometers



Standard 10cm² Cone

T-bar Penetrometer 100cm²

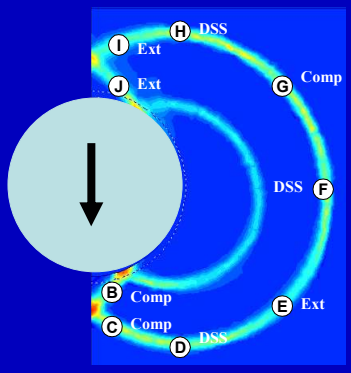
Ball Penetrometer 100cm²

Relationship to Undrained Shear Strength (s_u)

- Measured Resistance requires minimal correction compared to CPTU

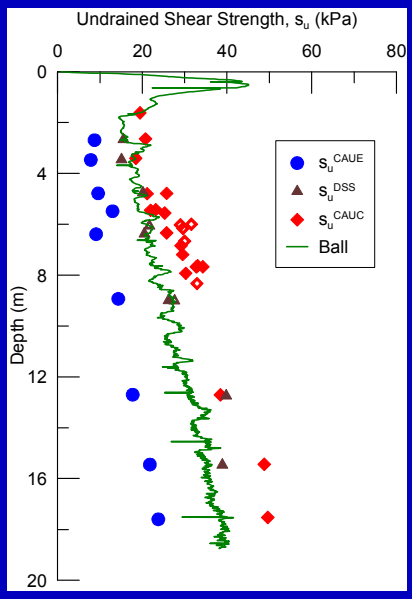
$$s_u = \frac{q_{T-bar}}{N_{T-bar}} \qquad s_u = \frac{q_{Ball}}{N_{Ball}}$$

- Deformation relates closest to $s_{u\text{-}AVG} \approx s_{u\text{-}DSS}$



Randolph & Andersen (2006)

Bothkennar Soft Clay - Ball

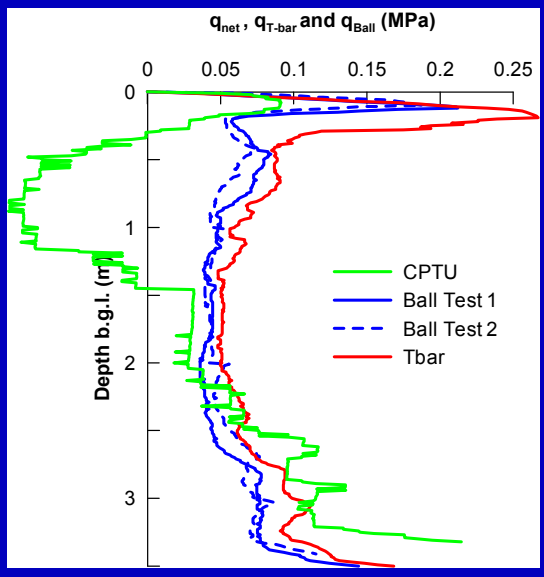


N_{Ball} = 15.3

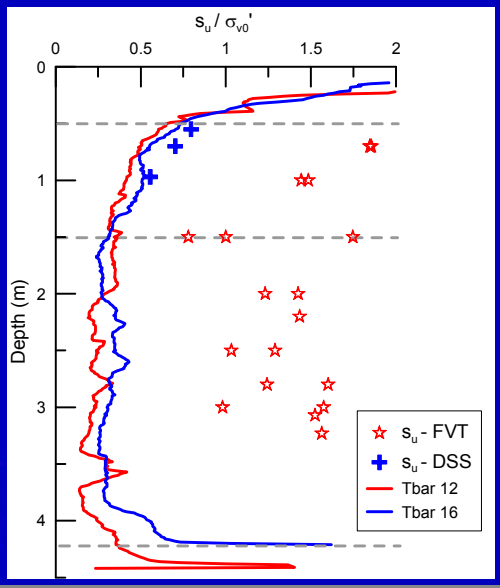
Estimated from Plasticity Solutions
& Strain Rate Effect
& Strain Softening

Good Agreement with $s_{u\text{-}DSS}$

CPTU, Tbar & Ball



Tbar Testing



$N_{Tbar} = 28$

High repeatability of Tbar & Ball
Reduces scatter in s_u/σ'_v

Summary

- In-situ vane tests can be misleading in peat soils
- However, often used in site investigations on peatlands
- Taking into account the strength anisotropy of peat and the nature of deformation in a peat failure – DSS more appropriate test
- UCD-DSS is capable of testing at appropriate stress levels
- Full flow penetrometers can be a useful tool for in-situ measurements and correlation with laboratory data

Thank you for Listening

Acknowledgements

Dr. Paul Jennings (AGEC)

Lankelma Ltd.

BOGLAND Funded by