The Observational Method in Ground Engineering
- Recent UK Experience

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Introduction

- Background – Peck 1969
- Ciria Report 185 (1999) - Observational Method
- OM Principles
  - Uncertainty
  - Design - Predefined and OM
  - Design Codes
  - Rapid deterioration
  - Trigger Criteria
- Technical and Commercial Risk Management
- Case Histories
History - Key dates

- 40 to 60’s - *Terzaghi and Peck*
- 1969 - *Peck’s Rankine Lecture*
- Early 90’s - *Channel Tunnel, Limehouse Link*

- 1994 - *Geotechnique Symposium in Print*
- 1995 - *EC7 OM Clause*
- 1996 - *ICE and HSE NATM publications*
- 1999 - *CIRIA OM Report No 185*
- 2001 - Managing Geotechnical Risk
Peck (1969) – Eight Ingredients

a) **Sufficient SI** to establish general nature / properties of deposits.

b) Assess **Most Probable** and **Most Unfavourable** conditions.

c) Establish **Design** based on **Most probable**.

d) Select **Monitoring parameters** and calculate values.

e) Calculate values for most unfavourable conditions.

f) Select design **Modification options**.

g) Monitor and **evaluate** actual conditions.

h) **Modify** design to suit actual conditions.
Peck’s OM applications

- **Best way out** OM applications
  - Cleveland Ore Terminal - soft clays – stockpiles of iron ore
  - Cape Kennedy Causeway – Hydraulic fill

- **Ab Initio** OM applications
  - Harris Bank – Chicago strut monitoring
  - Bay Transit Tunnels – Volume loss

- **Pitfalls**
  - Geology could be worse. – buried channels
  - Monitoring – Exclude progressive failure and brittleness.
  - Reporting and interpreting – Timely and robust
  - Design must vary during construction – Contract issues
Ciria Report 185 (1999)

The Observational Method in ground engineering

principles and applications
The Observational Method in ground engineering: principles and applications
D P Nicholson, C-M Tse, and C Penny

- Ch2 Definition and History
- Ch3 Concepts
- Ch4 Technical Considerations
- Ch5 Management Considerations
- Ch6 Contractual Framework
- Ch 7-9 Applications such as :-
  Tunnelling, Excavations, Embankments, Environmental Geotechnics, etc..
The Observational Method in ground engineering is a continuous, managed, integrated, process of design, construction control, monitoring and review which enables previously defined modifications to be incorporated during or after construction as appropriate. All these aspects have to be demonstrably robust. The objective is to achieve greater overall economy without compromising safety.

The Method can be adopted from the inception of a project or later if benefits are identified. However, the Method should not be used where there is insufficient time to implement fully and safely complete the planned modification or emergency plans.
The OM Process for Ab initio approach
Concepts (Ch 3)

- **Uncertainty**
- Design - Predefined and OM
- Design Codes
- Rapid deterioration
- Trigger Criteria
- Implementation of Modifications
- Value Management

- Talk based on *Ab Initio* application
- Most OM applies to temporary works
Uncertainty in the Ground

- **Geological**
  - eg- Complex geology and hydrogeology.

- **Parameter and modelling**
  - eg- Undrained soil verses drained.

- **Ground treatment**
  - eg - Grouting, dewatering.

- **(Construction Uncertainty)**
  - eg – complex temporary work
Geological Uncertainty - Weathered Chalk

Driven piles - length variation
Parameter Uncertainty – Undrained soil
Two props “progressively modified” to one
Ground Treatment Uncertainty

Ground Water control

Philippines - dry dock

-Additional Well points for drawdown
Construction Uncertainty - Cofferdam
Dredging - dock silt and fill compaction
Concepts (Ch 3)

- Uncertainty
- Design - Product and Process
- Design Codes
- Rapid deterioration
- Trigger Criteria
- Implementation of Modifications
- Value Management
The Design Product

- The Design Product is:- Drawings, Calcs, Spec etc.

- HSE CDM Regs (1994) (Construction Design and Management)
  - Design includes: drawings, design details, specifications and BOQ
  - Address Buildability
    - Identify hazards
    - Assess risks – Risk register
  - Design and construction links via:-
    - ‘Health and Safety Plan’
    - Planning Supervisor

- Stronger design and construction links
**Predefined Design Process**

- Permanent works
- One set of parameters
- One design / predictions
- Outline of construction method

- Contractors temp design / method statement
- Monitoring checks predictions not exceeded

- Emergency plan

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**The OM Process**

- Temporary works
- Two sets of parameters
- Two designs and predictions
- Integrated design and construction methods

- Methods relate to triggers
- Comprehensive and robust monitoring system
- Review and modify process
  - contingency plan
  - improvement plan
- Emergency Plan
Design Codes - Comparison with Peck’s (1969) OM and Current Codes

- **Peck (1969)**
  - OM conditions/values
    - Most Probable
    - Not used
    - Most Unfavourable

- **UK Codes**
  - CIRIA 580, BS 8110, BS 8002
  - Eurocode – EC7
    - Not used
    - Mod conservative or Characteristic
      - Worst credible
Recognised prediction is difficult in Geotechnics – OM used in these cases.

- 1) Establish limits of behaviour.
- 2) Acceptable probability actual behaviour within limits.
- 3) Monitoring plan, response times and contingencies.
- 4) Contingencies adopted if real outside acceptable range.
UK Design Codes - Soil Strength Parameters

Soil Strength Parameter Results

(Eg Undrained strength, SPT etc)
Ideal EC7 Predicted versus Measured Performance

- **GREEN**: "Ideal" distribution of measured deflections
- **AMBER**: Predicted most probable value
- **RED**: Most Unfavourable (ULS)

No. of readings vs. Deflection ($\delta$)

- Predicted EC7 Characteristic Value (SLS)
- 5%
Trigger Criteria

Traffic light conditions include:-

- **Green** = Safe site condition.
- **Amber** = Decision stage
- **Red** = Implement planned modifications
- **Emergency**
  (Not normally part of OM. Required under CHSW Reg (1996). Relates to Ultimate Limit State.)
Trigger Criteria Example: Tunnelling

- **ULS** (adjacent buildings & project structure)
- **SLS** (adjacent buildings)

**Emergency Trigger**

- **Red trigger**
- **Amber trigger**

**Behaviour**

**Discovery**

**Decision**

**Implementation**

**Time**

**Trend rate – important**

**Emergency plan implementation**

**Without modification**

**With planned modification**

**Without modification**

**With planned modification**
Multi stage Construction
OM Limitation - Rapid Deterioration

‘...... the Method should not be used where there is insufficient time to implement fully and safely complete the planned modification or emergency plans.....’ (CIRIA, 1999)

Deterioration rate depends on:

- Ground conditions (ductile/brittle soil behaviour)

- Groundwater conditions (rainfall/burst water mains)

- Temporary surcharges

- Construction sequence and programme
Implementation of the OM

- Construction Implementation

  - Peck, (1969)
    - Starts with most probable (MP) conditions

    - Starts with characteristic (Moderately Conservation) conditions.
    - Progressive Modification to Most Probable
Failure characteristics

- **Ductile behaviour**
  - Significant displacement to mobilise peak strength => possible warnings
  - e.g. Soft clays, Sands, Ash, Previous failures (residual strength mobilised)
  - Cyclic loading – “creep”
  - Also seasonal changes (wetting/drying)
  - OM applicable

- **Brittle behaviour**
  - Rapid, run-away failures
  - Low displacement to mobilise peak strength => Minimal warning
  - e.g. Stiff clays
  - Also ‘high rainfall - slope flooding’
  - OM not applicable?
Technical & Commercial Risk Management

Design Uncertainty
- Geology
- Soil Parameters
- Structural Performance
- Ground Treatment

Construction Control
- Client / Construction Teams
- Workmanship Supervision
- Monitoring & Review
- Programme

Risk

OM Technical Balance

Management
Technical & Commercial Risk Management

COSTS
EXTRA SI
EXTRA DESIGN
EXTRA MONITORING / REVIEW

SAVINGS
COST DIFFERENCE
PREDEFINED DESIGN - OM

OM Commercial Project Risks
Contractual (Ch 6)

- Types of Contracts.
- Contractual Difficulties using OM.
- Contractual Risks.
- Strategies.
  - Traditional Contracts
    - VE Clauses
    - Novation
    - Partnering
  - Design and Build
    - Strong Interface Manager.
Tunnels (ch. 7)

- Mainly NATM
- Design and Planning
  - JLE NATM tunnels Post Heathrow
- Monitoring
- Review process
Excavations (Ch 8)

- Cuttings
  - Slopes
  - Soil Nails
  - Contingencies - dewatering

- Retaining walls
  - Cantilever
  - Multipropped
  - Contingencies: - Berms and soft propping
Other Applications (Ch 9)

- **Ground Treatment**
  - Grouting
  - Dewatering
  - Deep compaction

- **Embankments**
  - Soft clays

- **Environmental**
  - Containment
  - Clean up

- **Structures**
  - Bridges and Dams
  - Tunnelling effects

Compensation Grouting
Conclusions (Ch10)

The CIRIA Report has achieved the following objectives:

- Established a definition of the OM Process.
- Clarified Uncertainty and Risk Management.
- Integrated OM into design codes and site control procedures.
- Provided technical, managerial and contractual guidelines for the team.
- Summarised applications/case histories.
Thank you for your Attention.