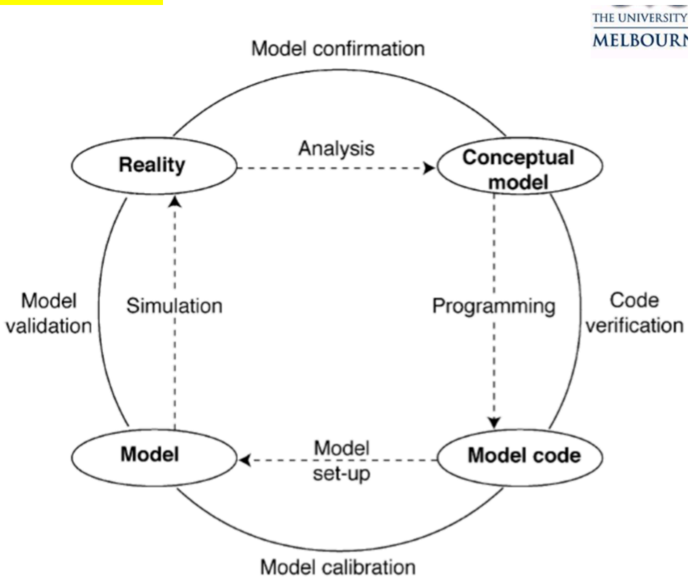
I. Introduction

1. The shallow subsurface
    - Soil and bedrock (sedimentary, igneous, metamorphic)
    - Thin layer of poorly indurated materials on a more-or-less solid base: very different mechanical and fluid flow properties
    - Soil properties vary dramatically over year.
2. Role of geotechnical engineer
    - Site characterization: stability, durability, and prediction of side effect of engineering measure
    - Risk assessment: earthquakes, landslides, sinkholes, liquefaction, debris flows, rock falls, …
    - Construction/restoration
    - Water capture and storage/flood control
    - Energy extraction and storage
    - Sustainability and environmental impact
    - Design and implementation of embankment, tunnels, dikes & levees, channels, reservoirs, landfills,
    - Monitoring and maintenance of engineered system
    - Improvement of existing infrastructure
    - Modelling and simulation, forecasting, what-if? Uncertainty analysis.

3. Simulation Process and Terminology

- Conceptual model
- Discretisation and code
- Code verification (benchmarks based on performance criteria)
- Domain of applicability
- Specific model: set-up, calibration, validation, simulation, analysis, confirmation.



4. Simulation vs physical experiment

Physical experiments	Numerical simulation
• Limits on complexity (limits of observability)	• Complete observability • Extreme conditions

• Hidden properties • Extreme conditions cannot be modeled. • Non-uniqueness of effects • Interpretability (turn off) • Scaling issues	• Progressive reduction is possible Limit: • Inaccurate representation of process • Linearization of non-linear phenomena • Round-off and truncation errors • Discretization dependent behaviour

5. **IDEAL Framework**
    - Identify: the root cause
    - Define: express problem in quantitative technical terms, employing mathematical, logical framework
    - Explore: a portfolio of options to solve problem
    - Act: on your plan
    - Lean: evaluated your methodology, experiment conducted,…
6. **Scientific Method**
    - Ask a question
    - Do a Background Research
    - Construct a hypothesis
    - Test with an experiment
    - Analyzed your data and draw a conclusion
    - Communicate your result

Laboratory note book: throughout the process, the scientist keeps a journal containing all of important ideas and information. This journal is a laboratory note.

Seepage Force, Quicksand and control seepage

1. Effective stress

$$\sigma' = \frac{\sum N'}{A}$$

Total stress: $\sigma = \frac{P}{A}$

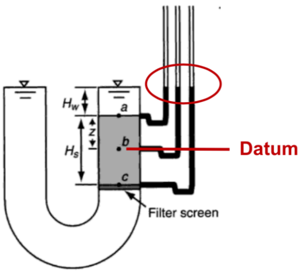
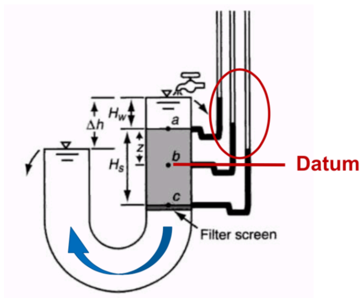
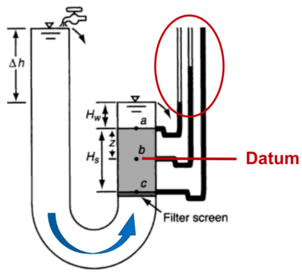
$$P = \sum N' + uA$$

$$\boldsymbol{\sigma = \sigma' + u}$$

2. Stress in soils

- Pore water pressure: $u = \rho_w gh = \gamma_w h$
- Total vertical stress: $\sigma_v = \rho gh = \gamma h$
- Effective vertical stress: $\sigma_V' = \sigma - u$
- Effective horizontal stress: $\sigma_h' = K_O \sigma_V{}'$
- K_o coefficient of lateral earth pressure at rest

3. Stress in soils

	Hydrostatic conditions	Downward Seepage	Upward Seepage
$i = \frac{\Delta h}{H_s}$			
Total head	$h_b = H_w + z = \frac{u_b}{\gamma_w}$	$h_b = H_w + z - iz = \frac{u_b}{\gamma_w}$	$h_b = H_w + z + iz = \frac{u_b}{\gamma_w}$
PWP	$u_b = (H_w + z)\gamma_w$	$u_b = (H_w + z - iz)\gamma_w$	$u_b = (H_w + z + iz)\gamma_w$
Total stress	$\sigma_{v,b} = \gamma_{sat} z + H_w \gamma_W$	$\sigma_{v,b} = \gamma_{sat} z + H_w \gamma_W$	$\sigma_{v,b} = \gamma_{sat} z + H_w \gamma_W$
Eff stress	$\sigma_v' = z(\gamma_{sat} - \gamma_w)$	$\sigma_{v,b}' = z(\gamma_{sat} - \gamma_w) + iz\gamma_w$	$\sigma_{v,b}' = z(\gamma_{sat} - \gamma_w) - iz\gamma_w$