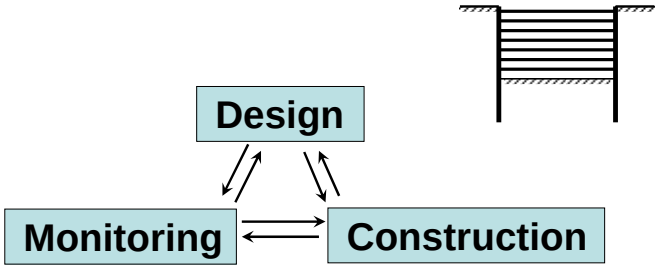
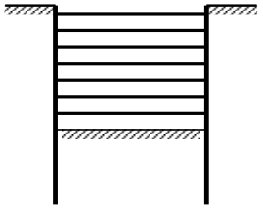
Observational Approach in Deep Excavation



1

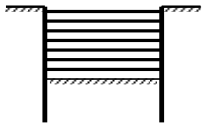
In a perfect world …….



All we need is one analysis & one design!

2

In the imperfect world …. with imperfect design!



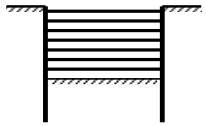
Too many uncertainties:

- Soil conditions
- Ground water
- Loading
- Construction sequence
- Workmanship
- Time delay
- 3-D effect
- Proficiency of designer
- Limitations of software

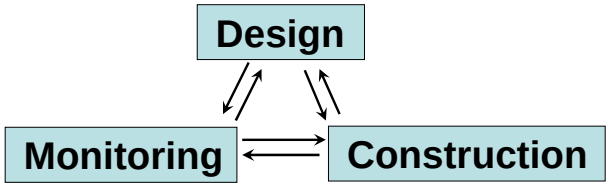
Not easy to account for all these uncertainties in the design.

3

In the imperfect world …….

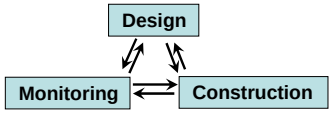


- **Watch every steps carefully.**
- **Make adjustments when necessary.**
- **Improvise as excavation proceeds.**



4

Role & Responsibility



Team	Role and Responsibility
Design	• **Produce a good design** • Monitor performance of system • Modify design
Construction	• **Build according to design** • Monitor performance of system • Feedback problems & unusual findings
Monitoring	• **Install and monitor instruments** • Feedback problems & unusual findings

5

What is Observational Approach?

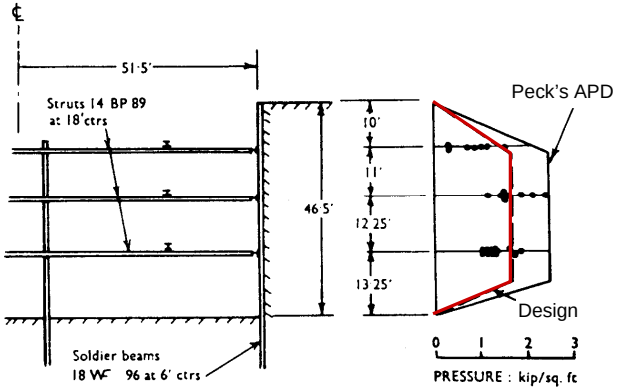
It is a check-and-balance process that enable us to:

- Check adequacy of the design
- Anticipate potential problems
- Modify the design where necessary
- Optimise the design
- Make contingency plan
- Avoid unnecessary delay

6

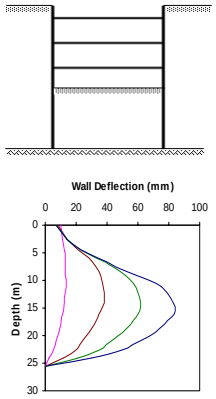
An Example on Application of Observational Method

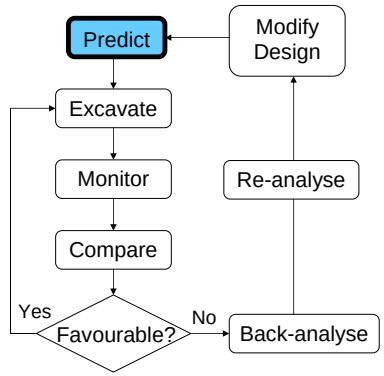
(9th Rankine Lecture by R. B. Peck, 1969)



7

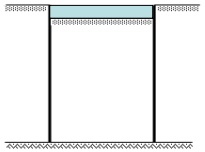
Implementation of Observational Approach

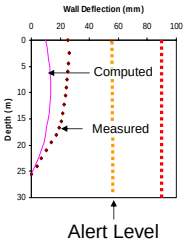


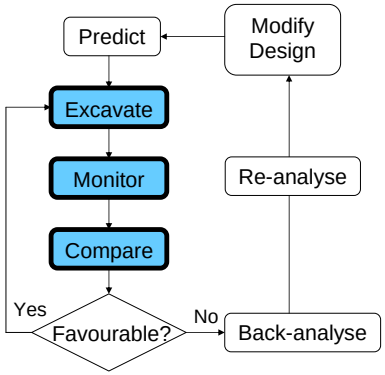


8

Designer, Contractor and Instrumentation Specialist have to work together!

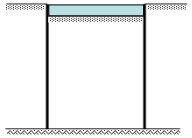


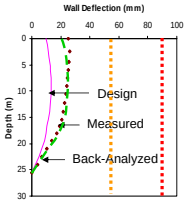


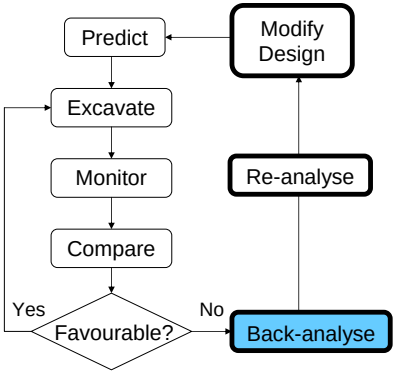


9

Back-Analysis: To calibrate input parameters to produce reasonable agreement with field measurements.

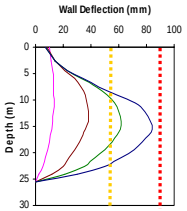


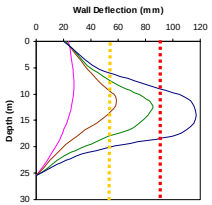


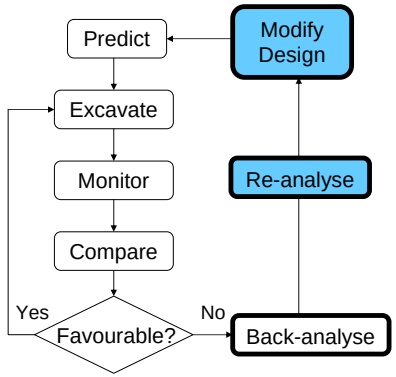


10

Re-Analysis: Use calibrated parameters to re-analyse

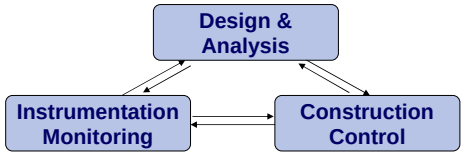


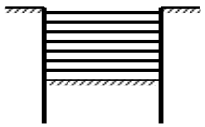




11

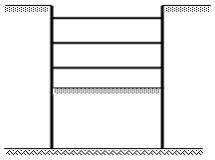
Designing Temporary Work is a Continuous Process





12

Singapore Authorities have already implemented the Observational Approach



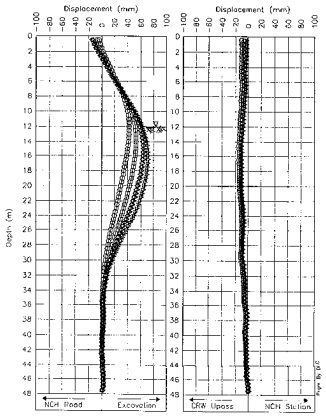
Is it being implemented properly?

Building Control Authority

- **Alert Level**
- **Work Suspension Level**

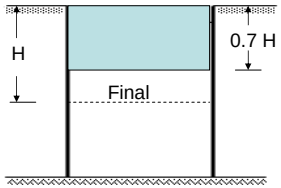
13

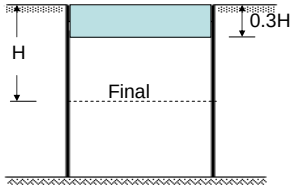
Is the wall deflection below alert level?



14

Which scenario is of greater concern to you?





Scenario 1

Current Level = 30 mm

Design Level = 100 mm

Scenario 2

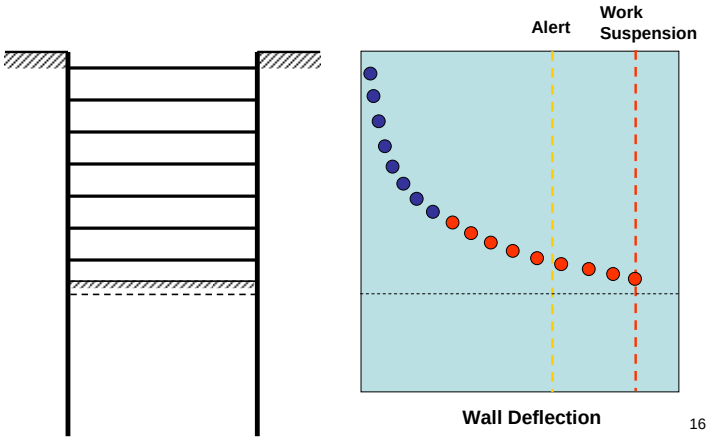
Current Level = 70 mm

Design Level = 100 mm

15

1st Scenario: False Security ?

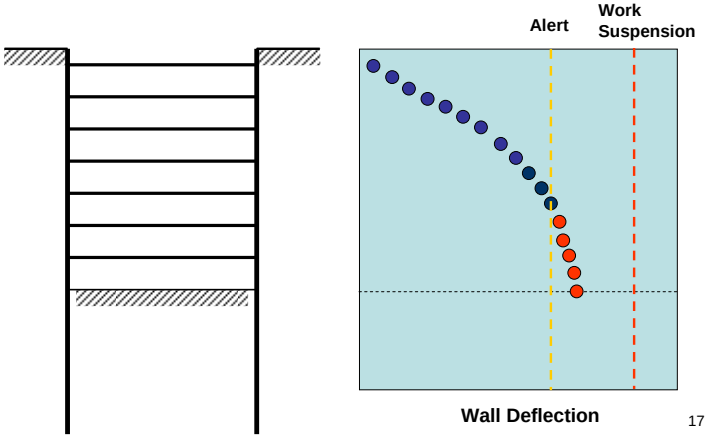
[Current = 30 mm Design = 100 mm]



16

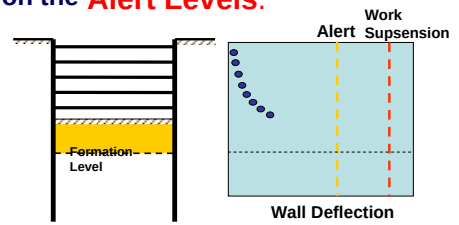
2nd Scenario: False Alarm ?

[Current = 70 mm Design = 100 mm]

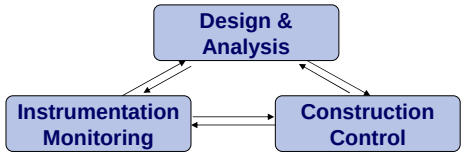


17

1. Don't just focus on the Alert Levels.

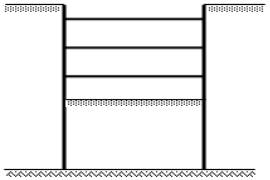


2. Proper implementation of the observational method is the key to a successful excavation.



18

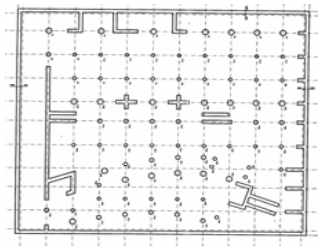
When should we start the Observational Approach?



- Before installation of instruments?
- Before excavation?

19

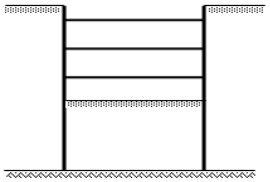
Making good use of the Piling Data



- Request piling to be done around the perimeter first.
- Give better picture of soil conditions.
- Provide better estimation of wall penetration.
- Optimise the design with new soil data.

20

Construction of Temporary Retaining Walls

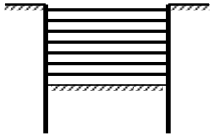


- Installation records of the sheetpile, soldier piles and kingposts provides valuable information on depth of competent ground.
- Construction records of diaphragm wall will also reveal the soil conditions around the site.

21

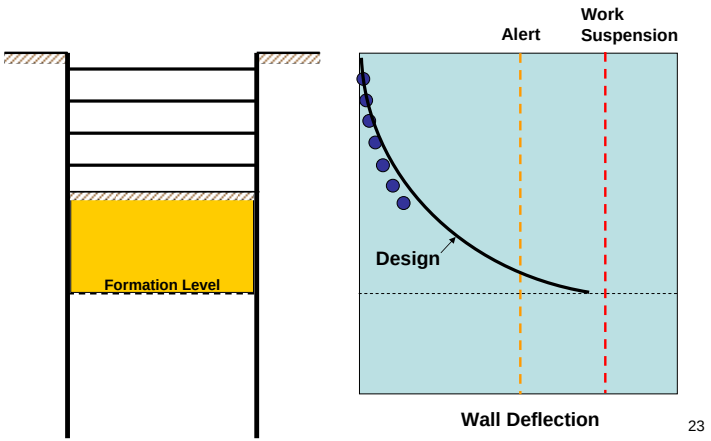
During excavation, the design team needs feedback to verify the design assumptions.

- Soil conditions
- Wall deflections
- Ground settlements
- Strut forces
- Cracks on wall
- Piezometric levels
- Unusual findings



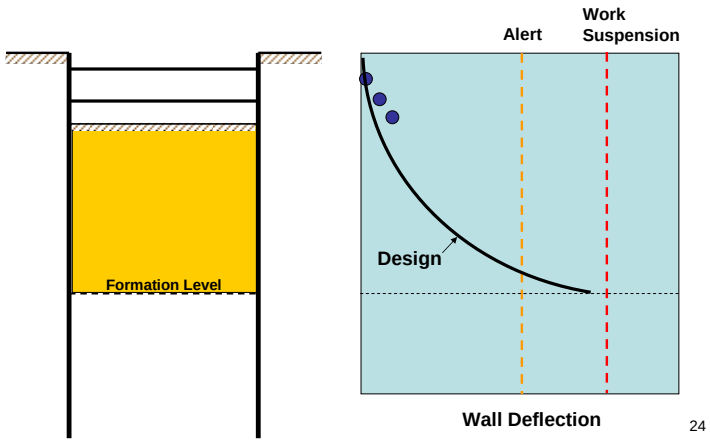
22

Favourable Results → Excavation can proceed



23

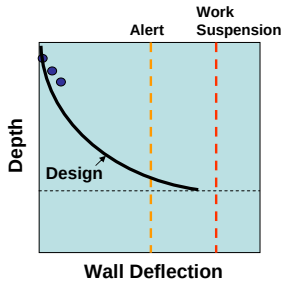
Unfavourable Results → Need back-analysis

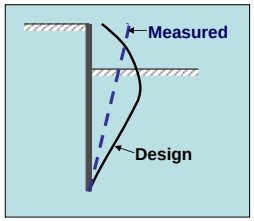


24

When should we do back-analysis?

1. When we were asked by the authority.
2. When the wall deflection exceeds design.
3. When the shape of deflection profile deviated from the design profile.





25

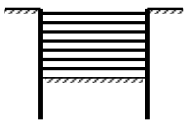
Technical Officers & Site Engineers play an important role in the design and safety of temporary works. However, they must be:

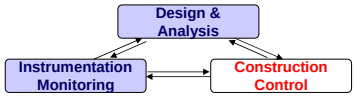
- Properly trained;
- Properly briefed in their duties;
- Properly supervised; and
- Properly equipped:
  - Digital camera with voice recording
  - Design drawings (reduced size)
  - Soil profile & boring logs

26

Important to check whether the construction is done according to design:

- **Member size and grade of steel**
- **Quality of workmanship**
- **Installation of strut without delay**
- **Proper preloading**
- **Waler and stiffener**
- **Over-excavation**
- **Surcharge**

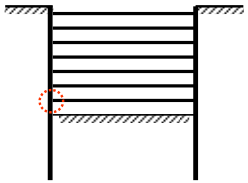




27

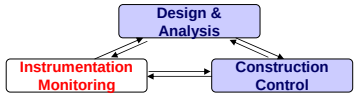
Cause for major alarm?

Any actions taken?



28

Instrumentation

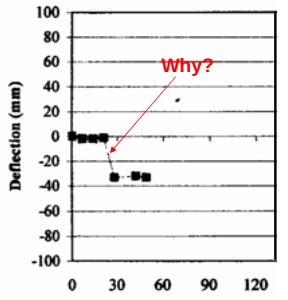


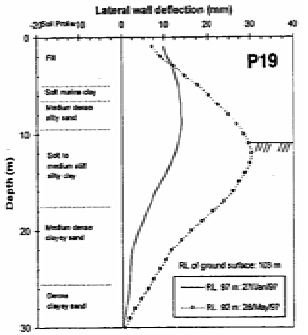
- Properly planned;
- Properly installed;
- Properly monitored according to schedule;
- Properly record site conditions at time of monitoring;
- Properly checked & interpreted;
- Results should be forwarded to developer, designer and contractor promptly; and
- The instrumentation contractor should be under the payroll of the developer.

29

Reliability of Field Measurements

- What causes the sudden jump in readings?
- Any possibility of toe movement at the inclinometer?

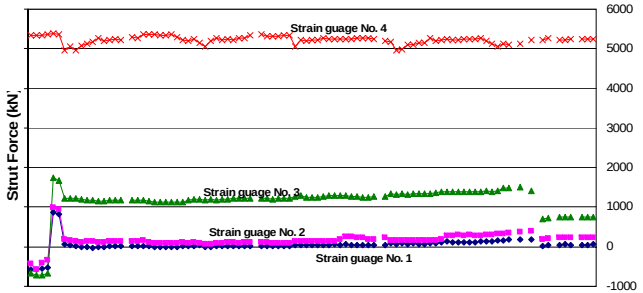




30

Are the measured strut forces reliable?

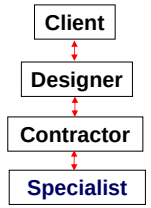
- Are all the strain gauges working properly?
- Are the computations based on correct calibration factors?

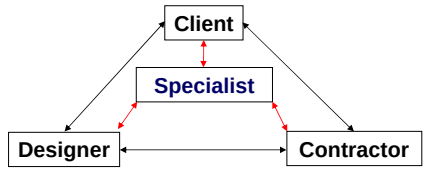


31

What is the contractual arrangement?

- The instrumentation specialist (IS) should be employed directly by the client/developer. They should protect the client's interest.
- This arrangement improves the communication between the IS and client, designer and contractor.
- If the contractor is IS's pay master, there may be a conflict of interest. There are known incidences of foul plays.





32

How to Avoid Failure?

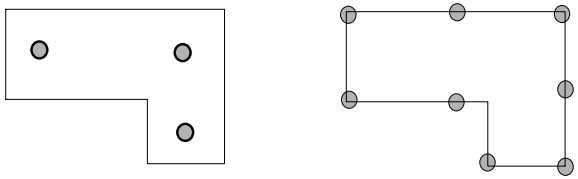
1. Engage a qualified geotechnical engineer to do the design.

A good design is the most effective preventive measure!

33

How to Avoid Failure?

2. Do a proper site investigation!



Cent wise but dollar foolish!

34

How to Avoid Failure?

3. Engage a qualified geotechnical firm to conduct the site investigation.

A design is as reliable as the soil data!

35

How to Avoid Failure?

4. Know the limitations of Your FEA.

Undrained analysis using M-C model

- Gives reasonable results.
- May not match field data at all excavation levels.

Drained analysis using M-C model

- May give questionable results.

36

How to Avoid Failure?

5. Installation and monitoring of instruments should be done by qualified specialists.

Unreliable data can work to your disadvantage:

- Movements too large: False alarm
- Movements too small: False security

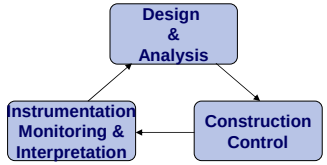
37

How to Avoid Failure?

6. Implement the Observational Approach starting from Day 1.

Don't just focus on the Alert Level!!!

7. Conduct back-analysis and re-analysis "continuously".



38

How to Avoid Failure?

8. Exercise good construction control:
   - Follow the design sequence
   - Construct according to design
   - Avoid over-excavation
   - Avoid stockpiling next to excavation
   - Minimise delay in strutting

39

How to Avoid Failure?

9. When in doubt, engage a qualified geotechnical consultant to get a second opinion!

Last but not the least ….

10. A Healthy Contract $um and a Reasonable Construction Period will help to improve the safety of any deep excavations.

40