FORENSIC ENGINEERING FOR GEOTECHNICAL ENGINEERS

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4.6 Karstic formation

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4.11 Sequence of construction

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Circumstances to geo-failure-3:

4.13 Induced failure

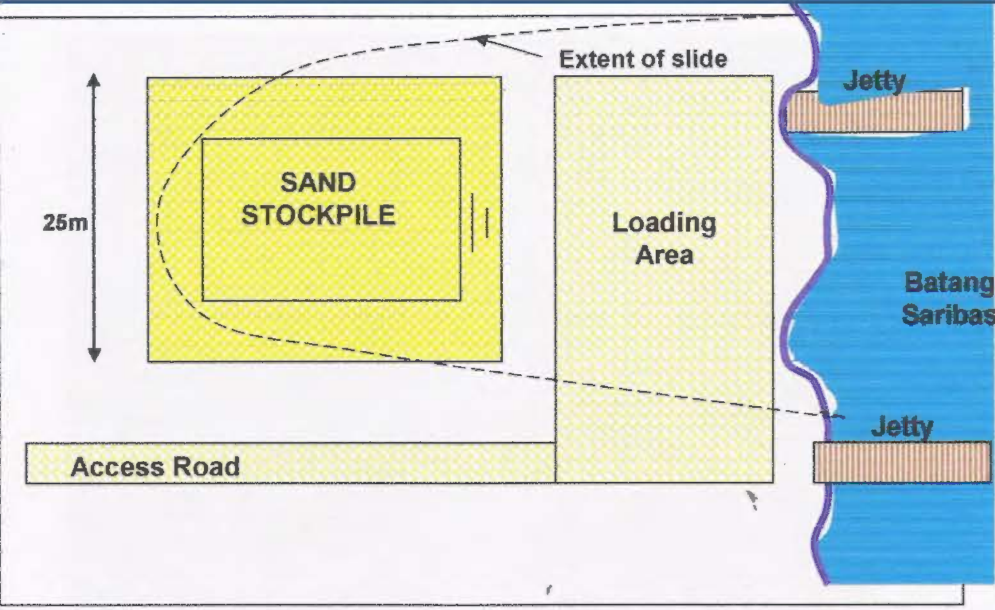
4.14 Geological feature

4.15 Varied ground condition

4.16 Groundwater lowering

4.1 Surcharge load

- Excessive surcharge load
- Large stockpile on soft grd



Plan of Stockpile & Jetty Area

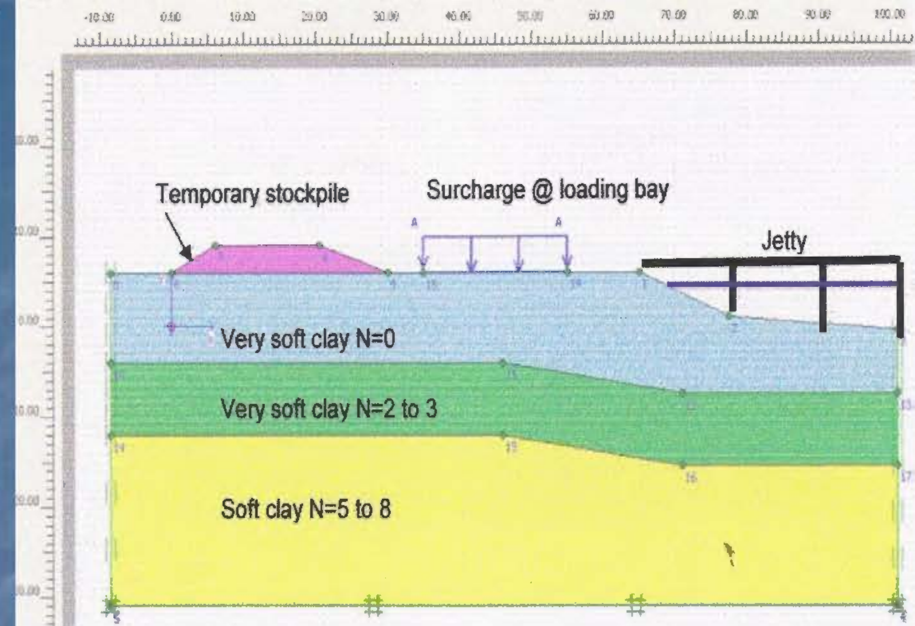
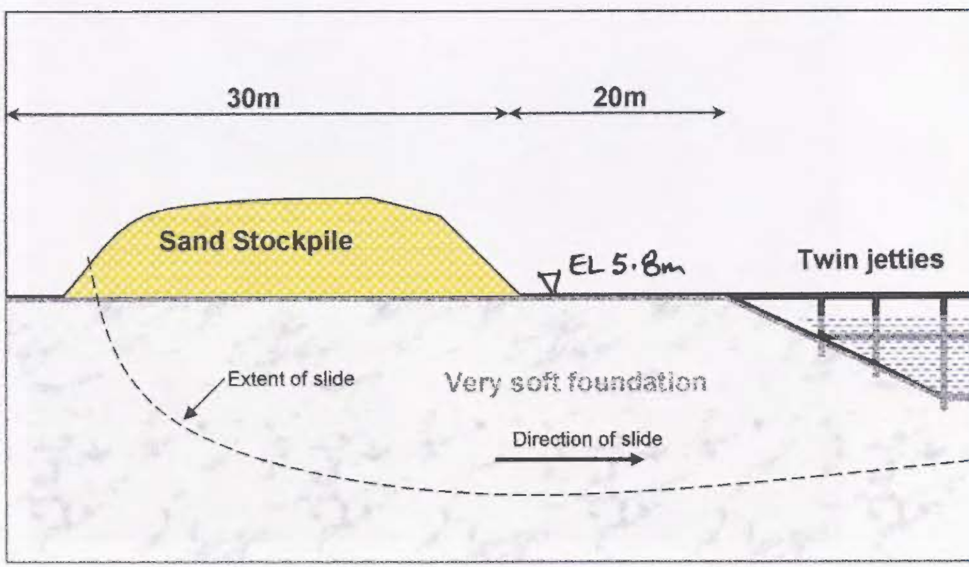
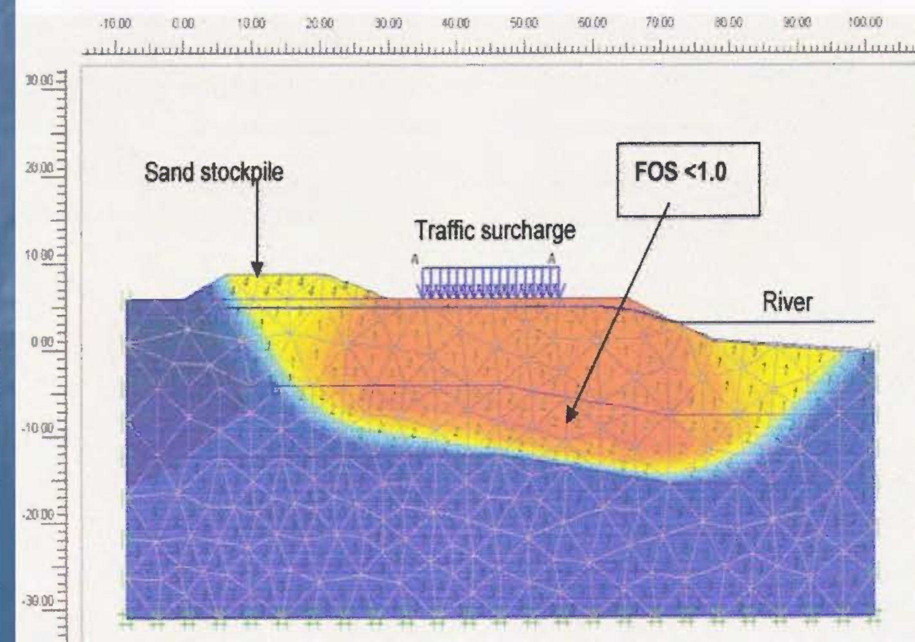


Figure C-1 : Finite Element Model of the riverbank with sand stockpile



Cross-section through stockpile and jetty



4.2 Soft ground related

- Under-estimation of soft ground strength
- Ignorance of adverse effects
- Lack of engineering supervision/control
- No warning in document
- Un-detailed method statement
- No provision of temporary support


P13
P11
P9
P7
Induced surrounding ground movement towards the central un-braced excavation
Source: Contractor's photo 5th Mar'07
KOMATSU

Source: Contractor's photo of 9 Feb '07

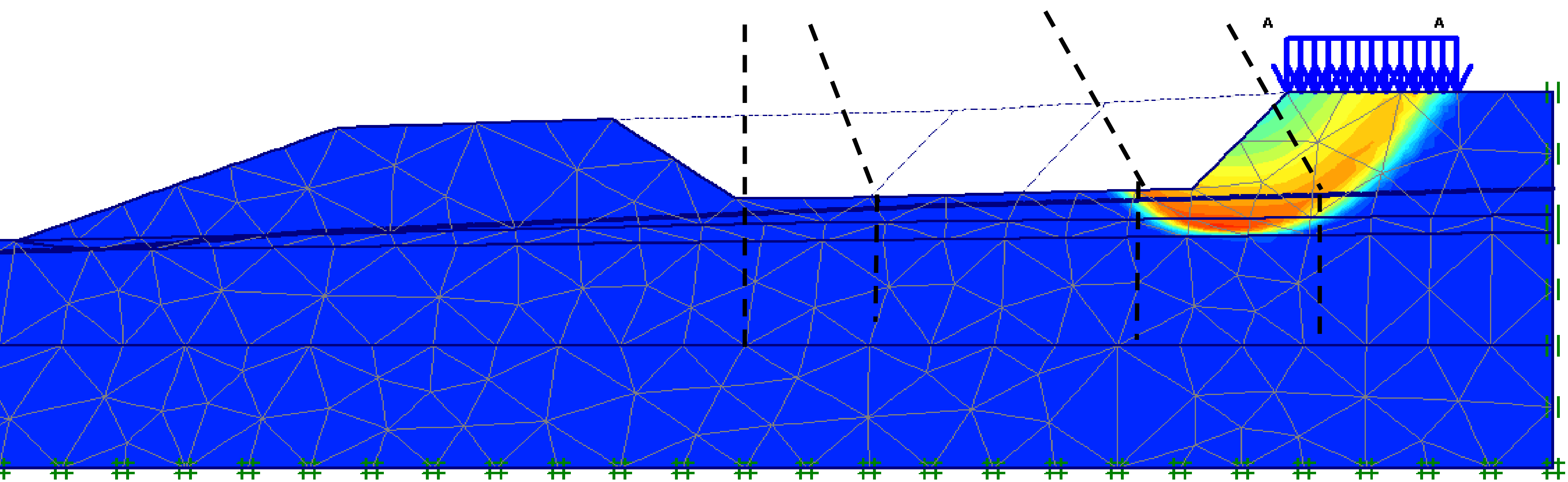
Source: Contractor's photo 1st Mar'07

Source: Site visit 12 Jun '07

4.3 Construction methodology

- Construction mtd inducing failure
- Underlying thin soft layer
- Machine load
- Steep excavated slope


First row piles not much affected
All piles are tilted/damaged
Pile Row D
Excavation Stage (3)
Source: Maphilindo's record photo
FOS<1.0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A

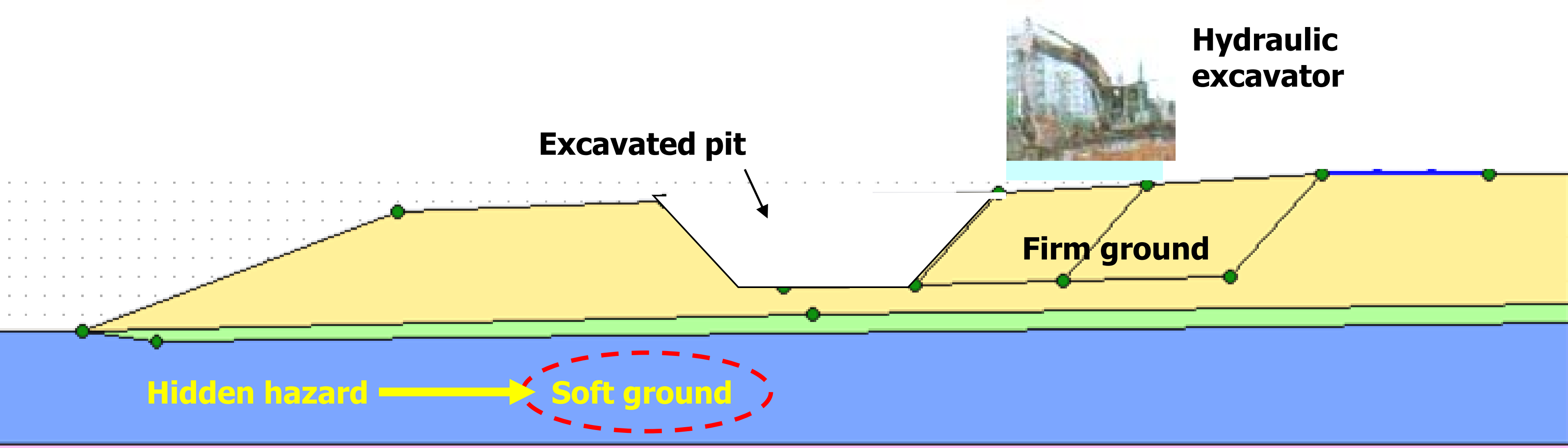
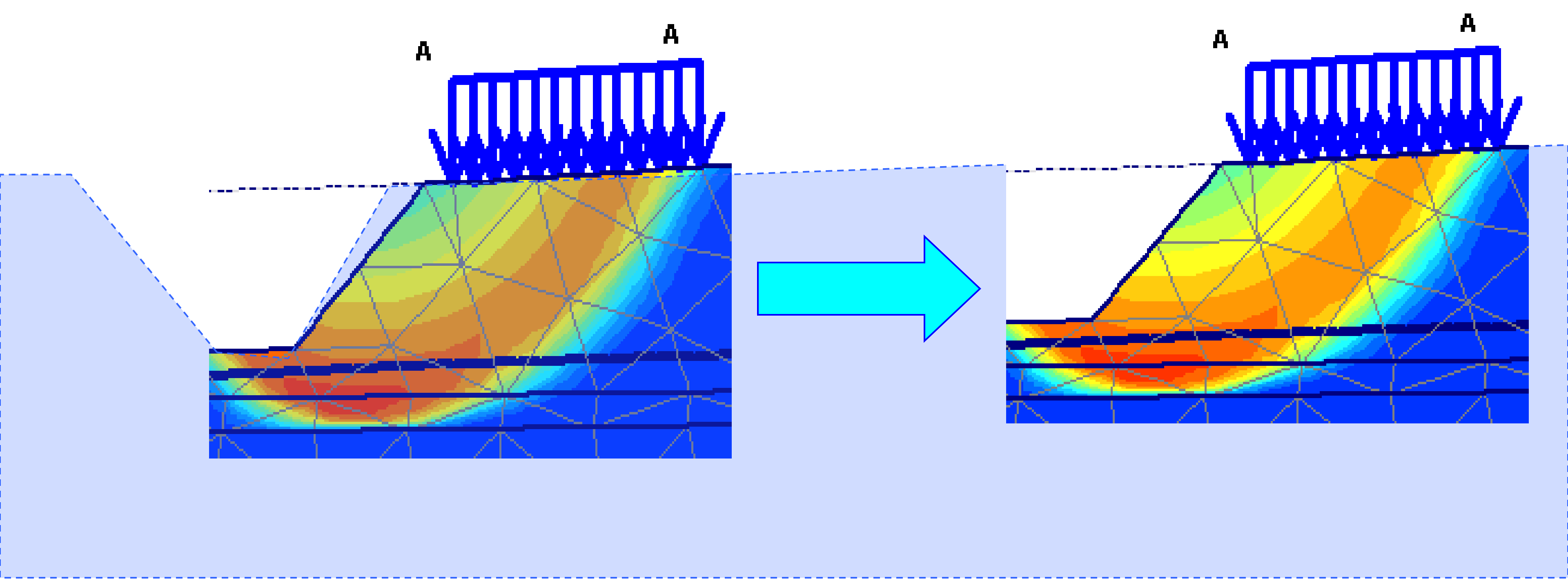
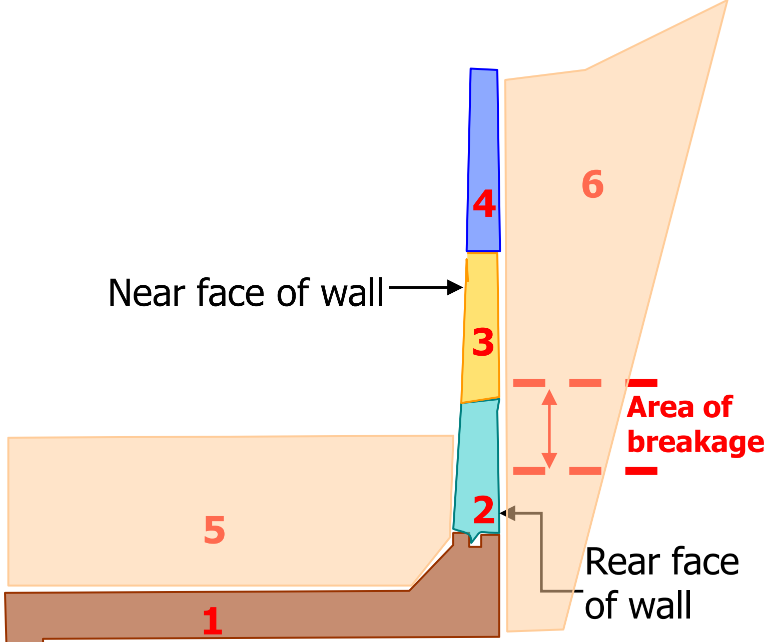


Illustration on the hidden hazard below excavation level

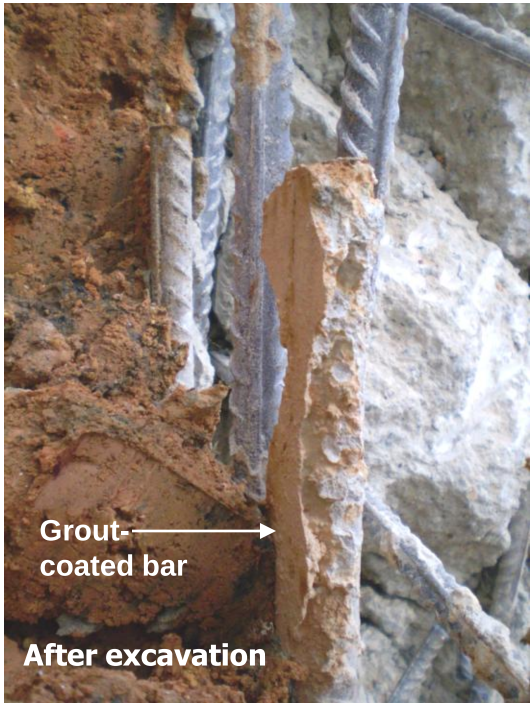


4.4 Workmanship

- Poor workmanship
- Inadequate concrete cover
- Movement of formwork



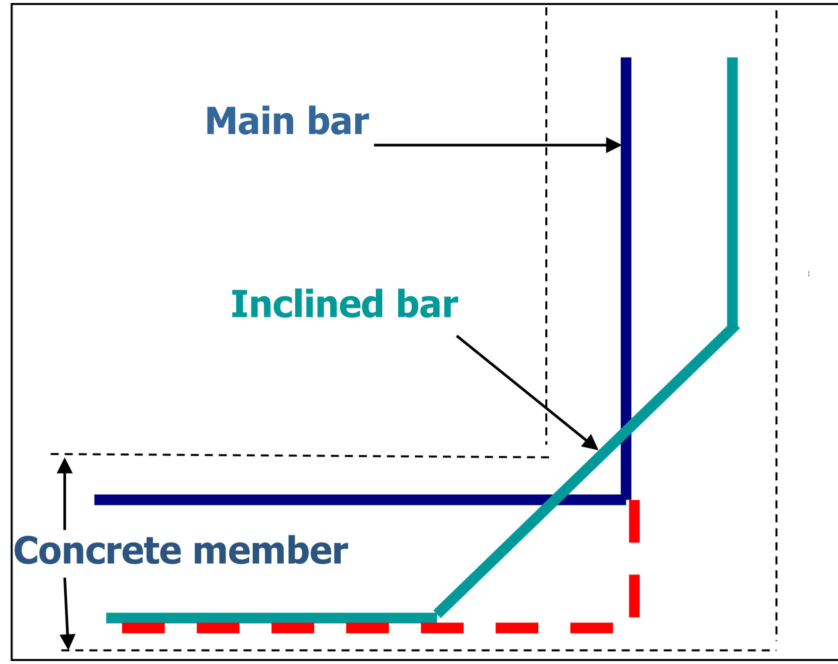
Construction sequence in 6 stages
and the observed breakage area



4.5 Detailing

- Unclear detailing in critical areas
- Misconception of redundant bars
- Symmetrical structure but different loading
- Unchecked drafting works


Source: Site visit of 7 Jan '06


Main bar
Inclined bar
Concrete member


Tilted wall
Tension crack
Source: Maphilindo's record photo of 19 Dec '05
Mode of structural failure


Vertical escarpment
Discrete soil fragments
Source: Contractor's record photo of 18 Dec '05
Mode of soil/structural failure
2005/12/18 18:02

4.6 Karstic formation

Undulating limestone bedrock

Wrong procedure of pile set

Over-driven piles

Not conforming to local practice

Lack of engineering supervision

4.7 Inconsistency

- Change of personnel
- Undisclosed design document
- Assumed foundation
- Designer not visiting site

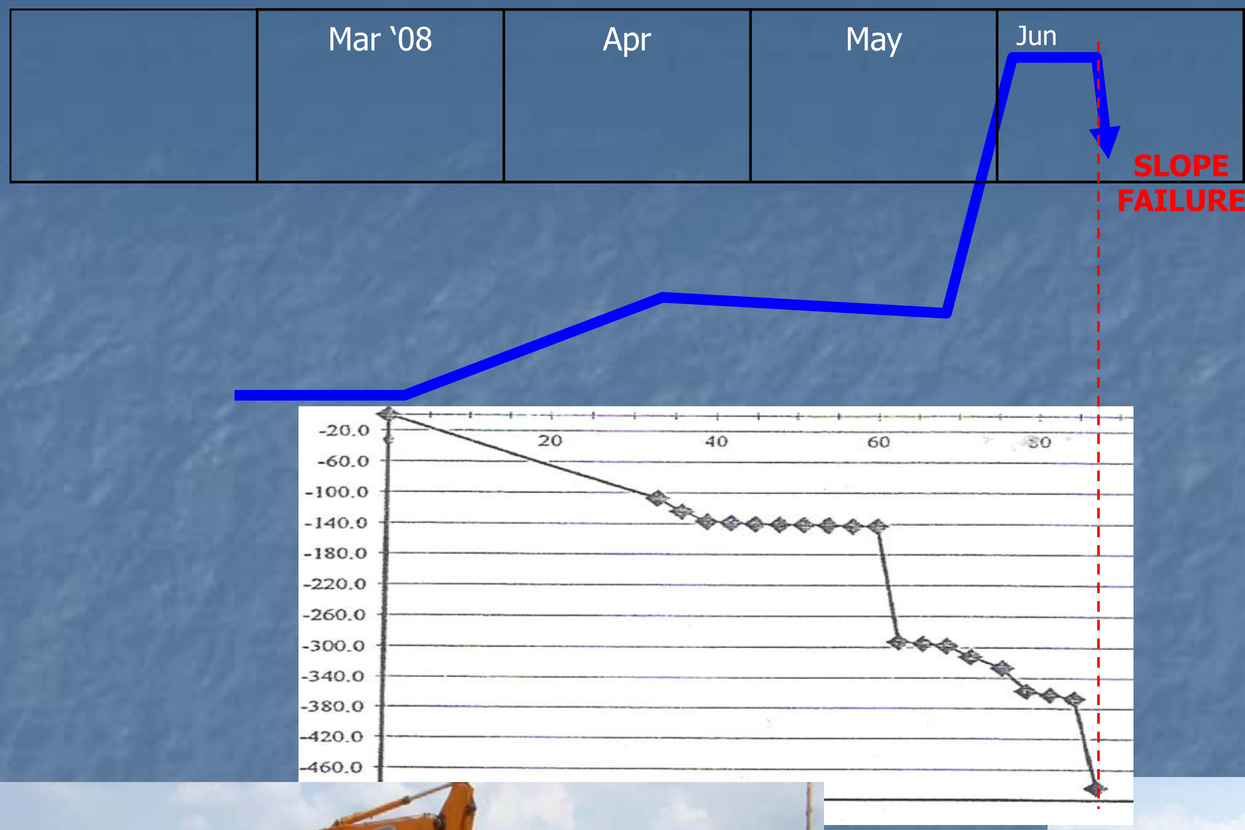
4.8 Not designed for

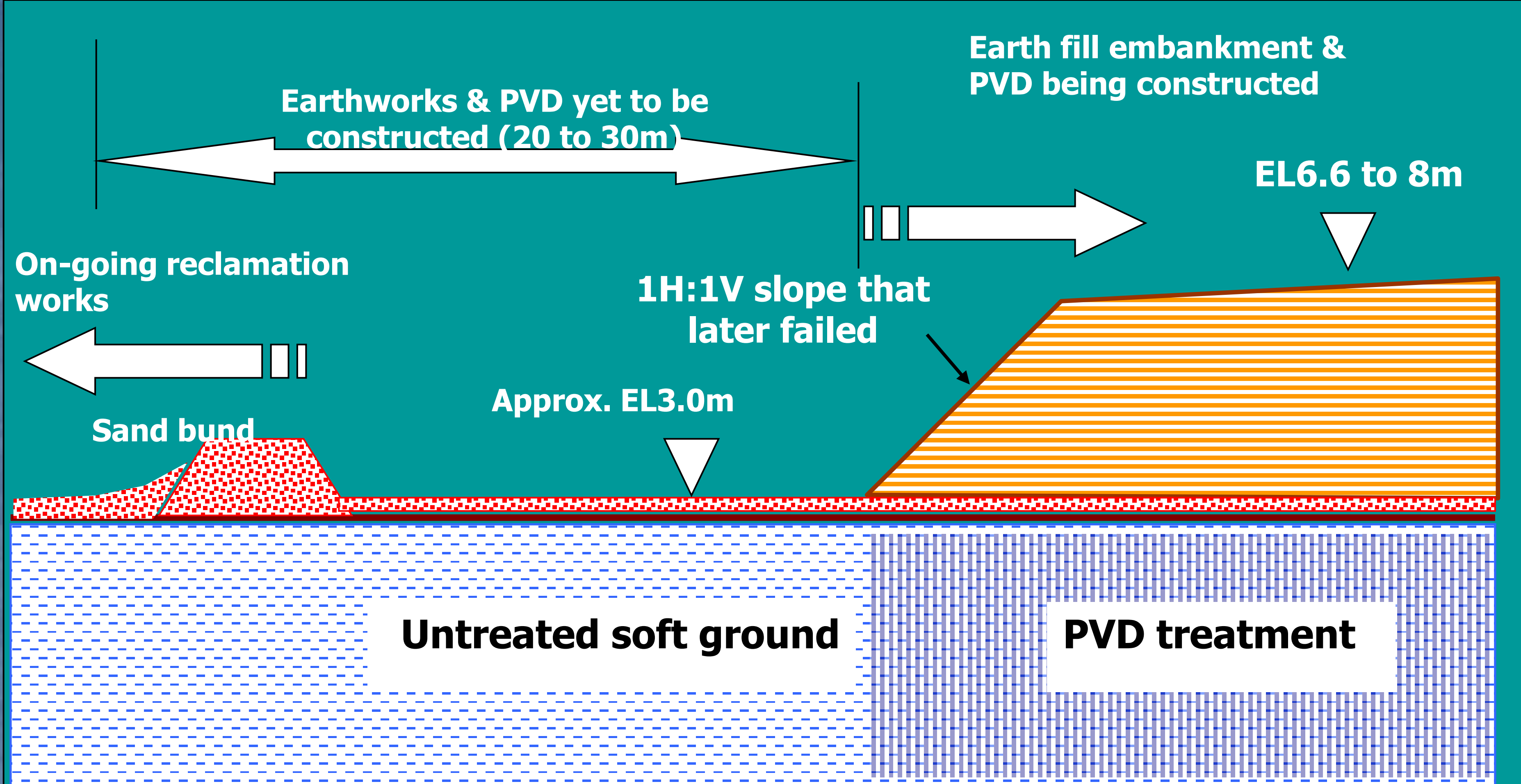
- Simple design but multiple functions
- Perhaps no design
- Extreme changes in boundary condition
- Under-capacity for flood, overtopping
- Unstable slope



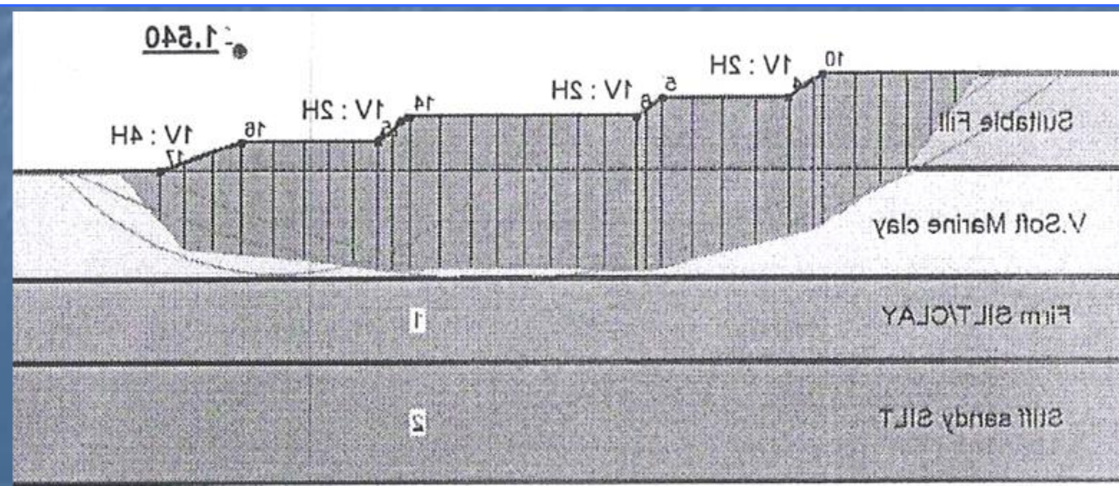
4.9 Time dependent

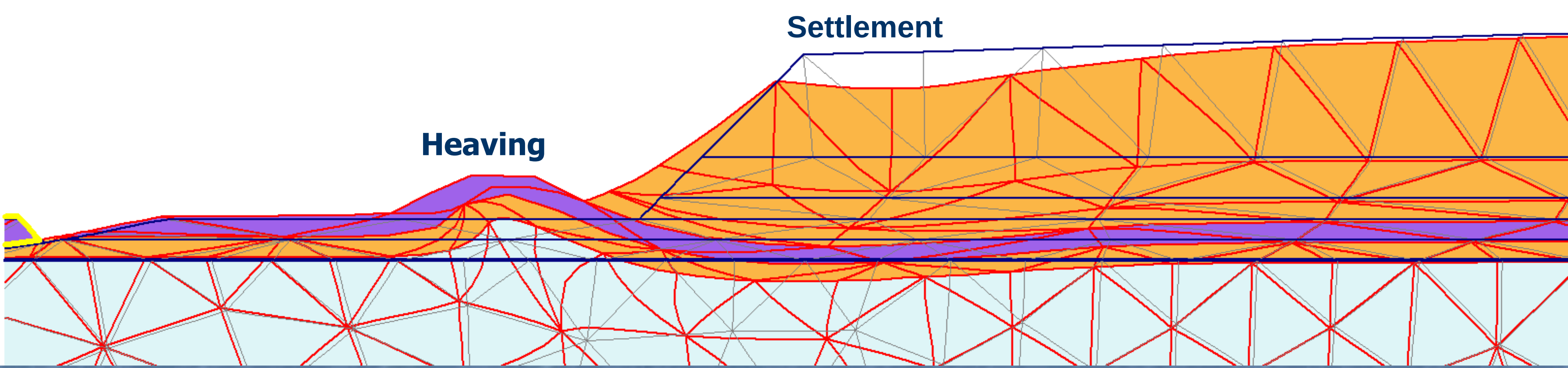
- Unconsolidated foundation
- Rapid build-up, excessive load
- Not responding to instrument results
- Lack of engineering supervision/control

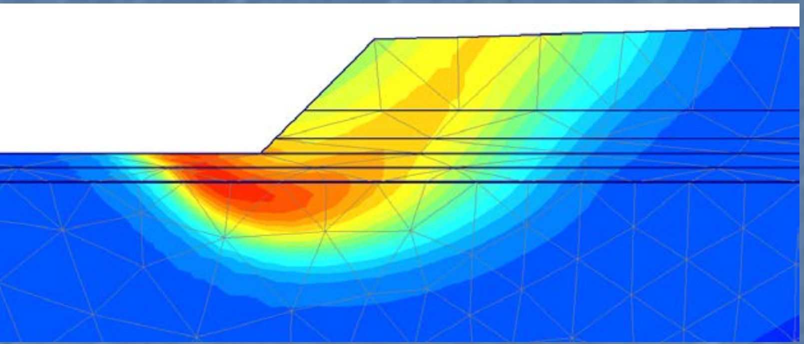

Mar '08
Apr
May
Jun
SLOPE FAILURE
-20.0
-60.0
-100.0
-140.0
-180.0
-220.0
-260.0
-300.0
-340.0
-380.0
-420.0
-460.0
20
40
60

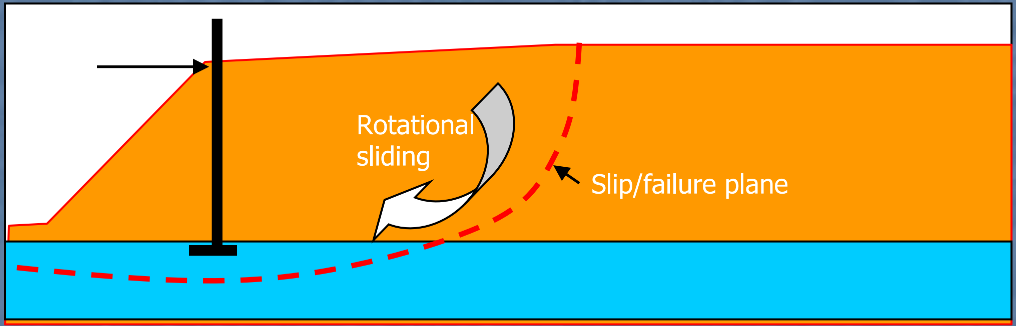


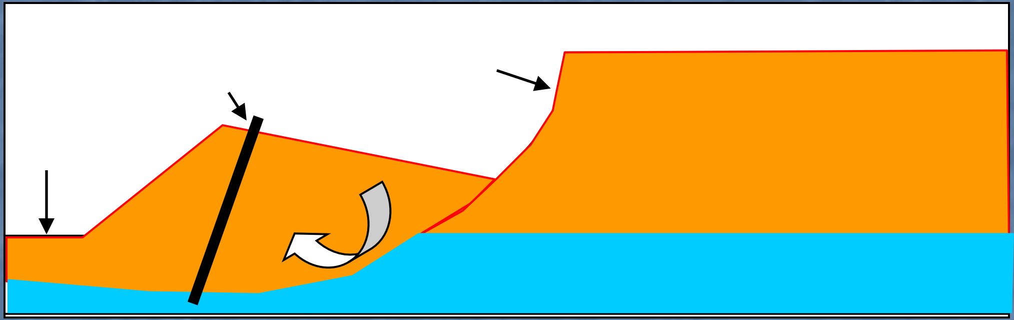
"Reconstruction" of the embankment details before failure

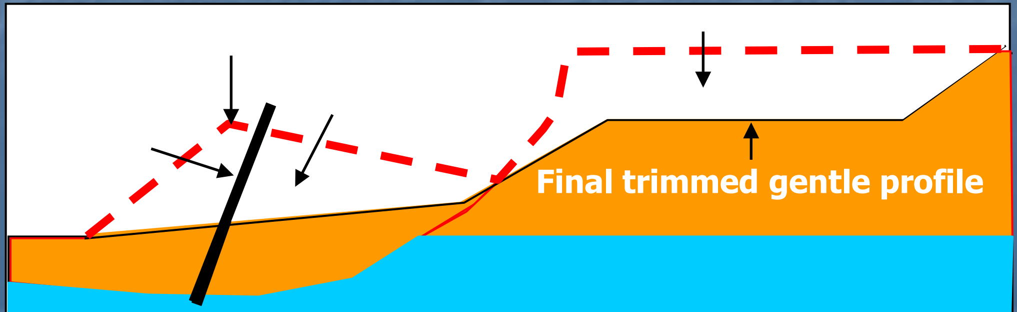



Settlement
Heaving




Rotational sliding
Slip/failure plane

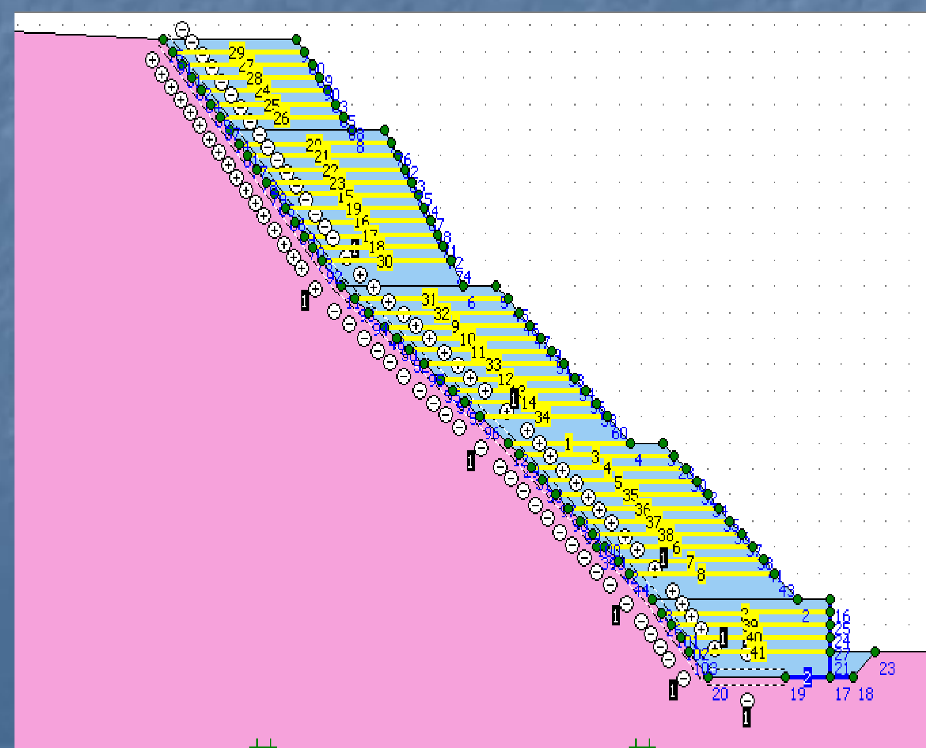



Final trimmed gentle profile

4.10 Repeated failures

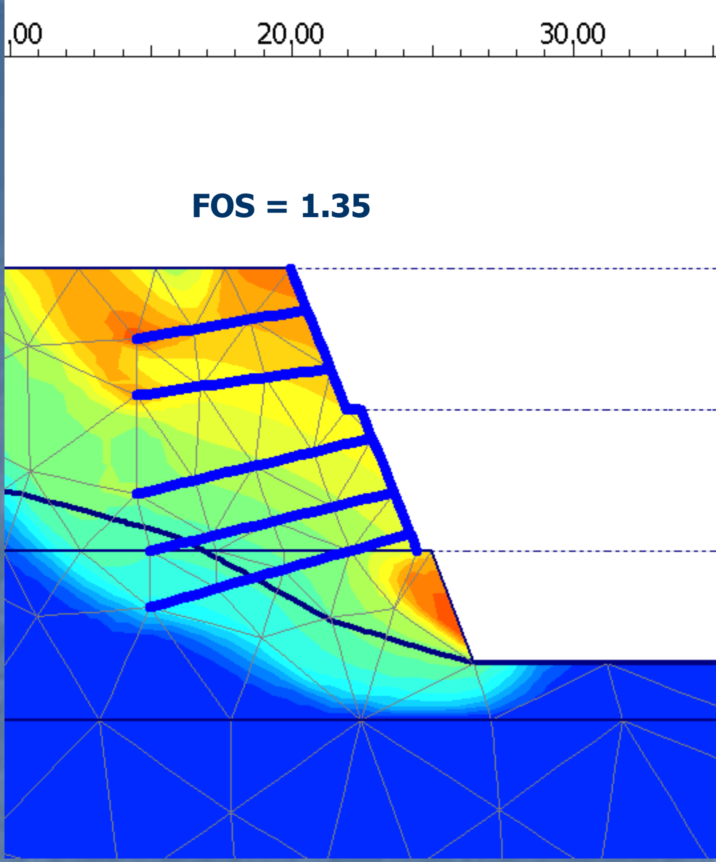
- Reconstruction of failure
- No increase in stability
- No internal reinforcement
- No counter weight


HITACHI



4.11 Sequence of construction

- No indication in drawing
- No enforcement in construction
- Lack of engineering supervision/control
- Client assuming engineer's role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30,00
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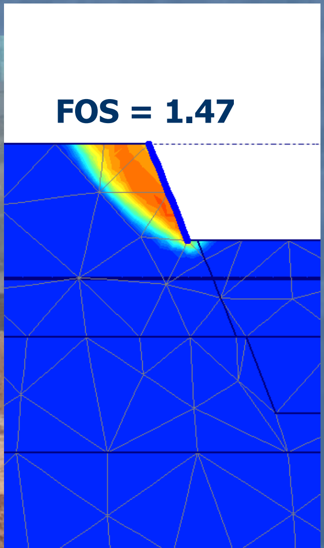
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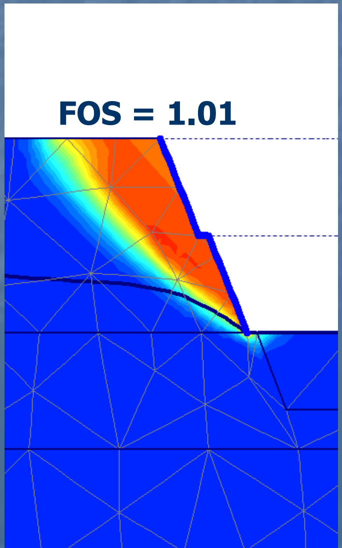
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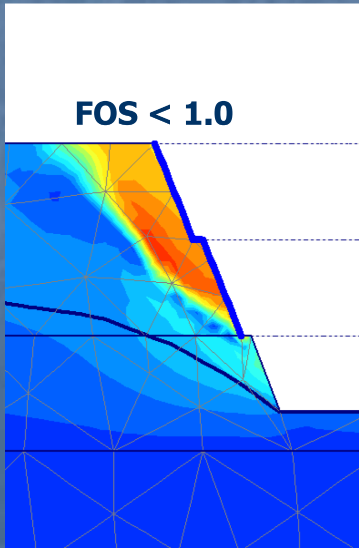
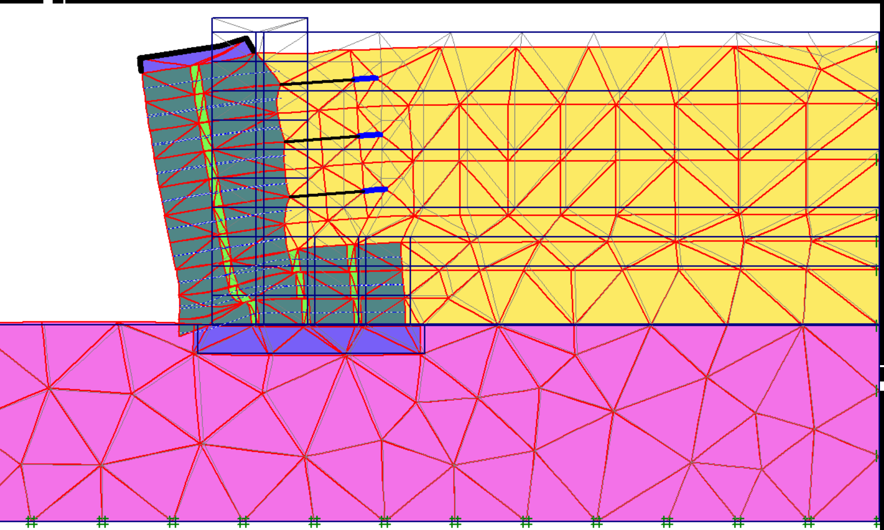

FOS < 1.0

4.12 Innovation

- Unproven design
- No relevant reference code of practice
- No engineering supervision
- Lack of grd water control

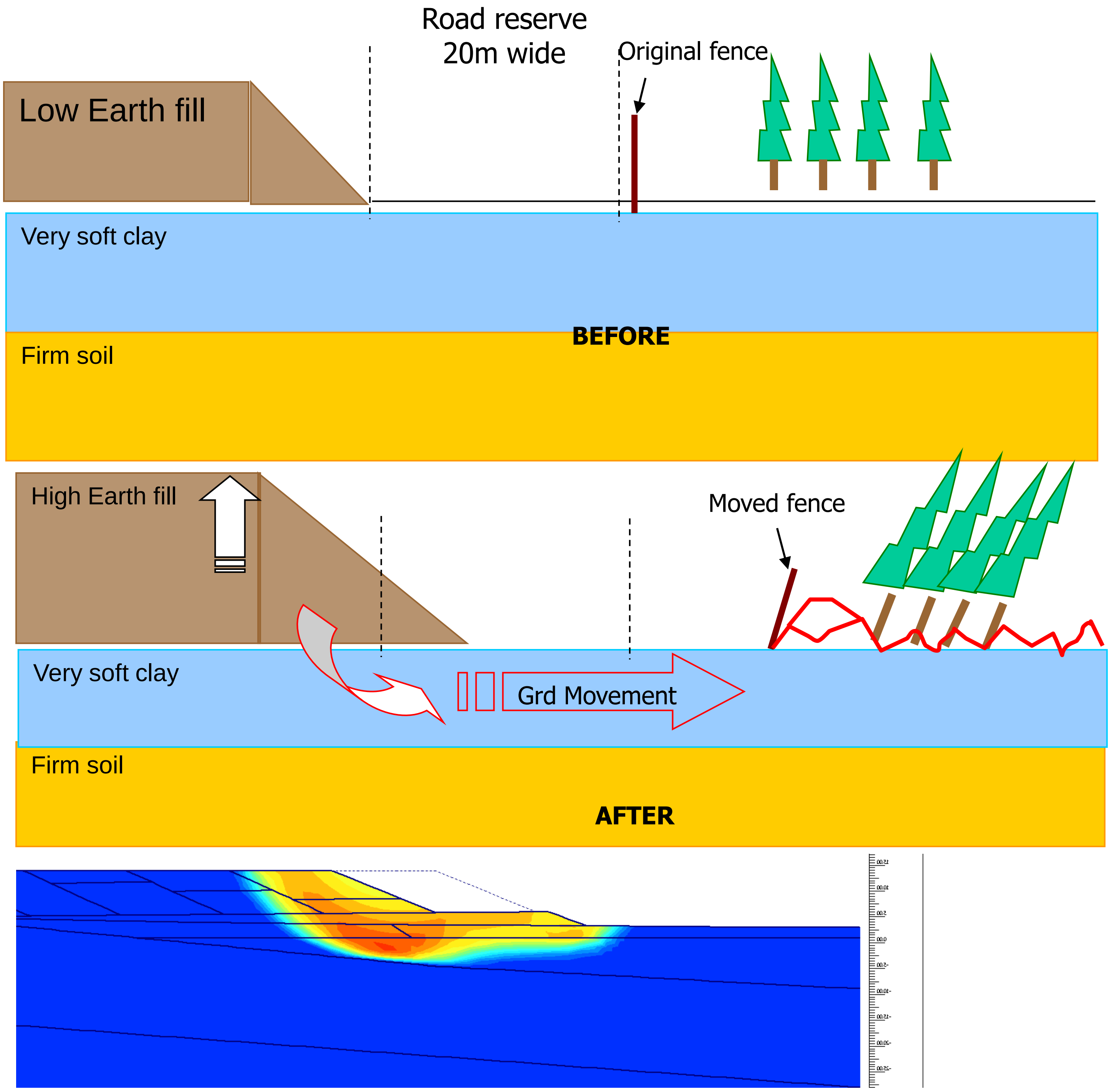


Innovative Rubber-tyre retaining wall

4.13 Induced failure

- Purposely built to fail as cheap means of excavation
- Uncontrolled boundary condition
- Lack of engineering supervision/control


Source: Site visit 2-12-2008



Road reserve
20m wide
Original fence
Low Earth fill
Very soft clay
BEFORE
Firm soil
High Earth fill
Moved fence
Very soft clay
Grd Movement
Firm soil
AFTER

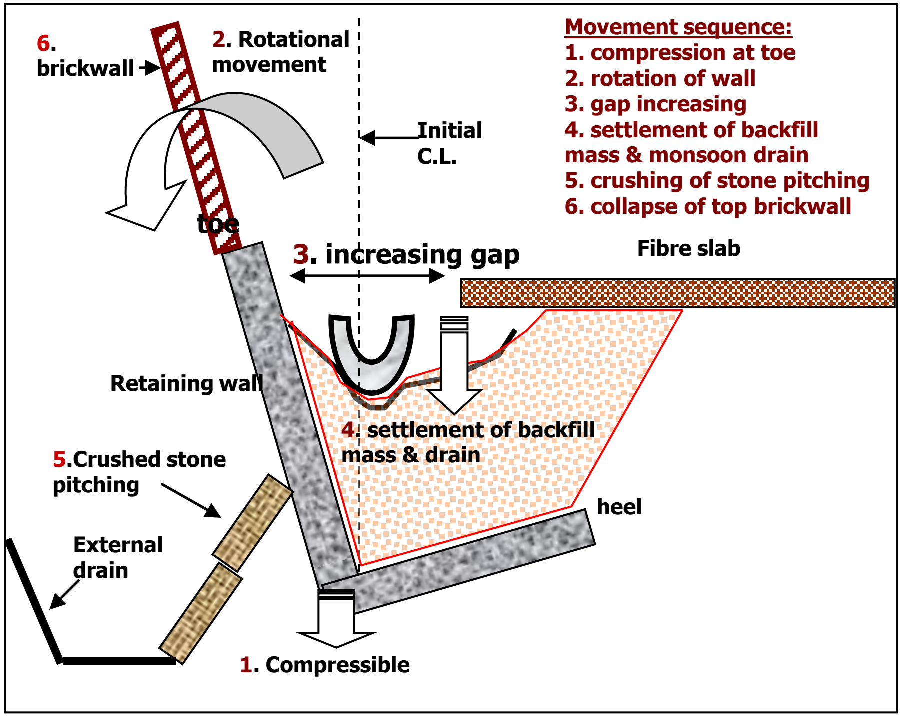
4.14 Geological features

- Unfavourable geological feature
- Geological evolution
- Peculiar material properties
- Pre-existing sheared surfaces
- Fighting against nature

4.15 Varied ground conditions

- Foundation material not the same as anticipated
- Site information not relayed to designer
- Client assuming role of engineer
- Negative effect of value engineering


Top brickwall
Damaged wall


6. brickwall
2. Rotational movement
Initial C.L.
Movement sequence:
1. compression at toe
2. rotation of wall
3. gap increasing
4. settlement of backfill mass & monsoon drain
5. crushing of stone pitching
6. collapse of top brickwall
toe
3. increasing gap
Fibre slab
Retaining wall
4. settlement of backfill mass & drain
5.Crushed stone pitching
External drain
heel
1. Compressible

4.16 Groundwater lowering

- Consequent of neighbouring activity
- Negative impact of grd water lowering
- Presence of band of soft layer
- A case difficult to prosecute

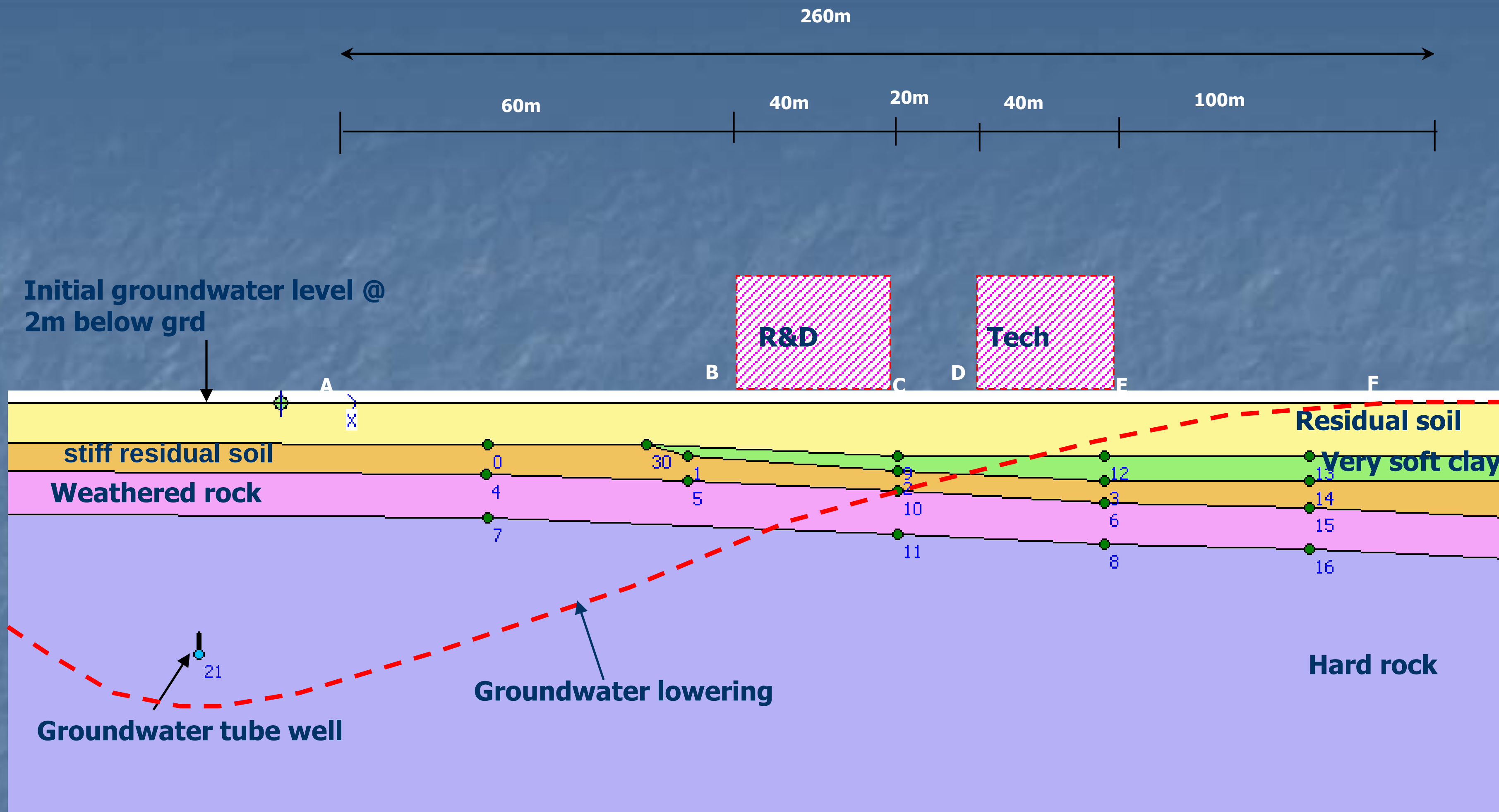


Figure 10.1: Geotechnical FE Model for the groundwater abstraction simulation

Surface point	Settlement (m)
B	0.120
C	0.227
D	0.308
E	0.342
F	0.296

FORENSIC ENGINEERING FOR GEOTECHNICAL ENGINEERS

CONTENTS - 5

5.0 Avoidance/Minimising Geotechnical Failure

- 5.1 Adequate S.I.
- 5.2 Study all plausible collapse mechanism
- 5.3 Proof checking of design; peer review
- 5.4 Attention to detailing
- 5.5 Preferred construction sequence
- 5.6 Limiting construction loads and surcharges

Avoidance/Minimising Geotechnical Failure

5.7 Roles & responsibilities

5.8 Construction supervision/control

5.9 Designer to inspection site

5.10 Relay of information both ways

5.11 Discourage competitive bidding for design profession

5.12 Adopt QA/QC procedures

5.13 Conduct risk assessment

5.14 Data collection on geo-failures

Avoidance/Minimising Geotechnical Failure -2

- S.I. missed in pre-design is S.I. required after design plus 100% cost overrun
- The best way to generate failure is to ignore lessons learnt from failures
- Major problem is making knowledge available to whom who does not know he needs it
- Benefit failures constructively
- Success does not consist in never making mistakes, but in never making the same one a second time

END OF TOPIC