UTM
www.utm.my

SBEQ1822 / SBEC1822
Materials & Specifications

Soil

as an Engineering Material

UTM
www.utm.my

To a civil engineer a SOIL is :-

- an accumulation of mineral or rock particles
- un-cemented or weakly cemented
- unconsolidated or poorly consolidated has voids filled with air or water formed by natural weathering processes
- can be in-situ or reworked by transport and deposition
- can be sorted or unsorted

UTM
www.utm.my

Why do we care about soil?

- Soil resources were and are a central factor in shaping human history and development.
- Survival of humans and animals is dependent on light, water, air and soil.
- Good, productive soil is a basic human need.
  - Grow our food, clean our water, clean our air

What does soil DO?'

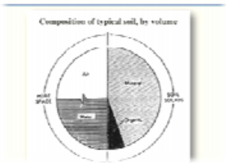
1. Soil serves as a natural medium for the growth of plants,
2. regulates and purifies water,
3. recycles organic wastes and nutrients,
4. provides habitat for soil organisms, and
5. serves as physical support for building and construction.

= Soil functions

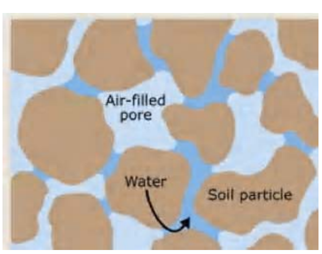
What is Soils?

The unconsolidated mineral and organic material on the immediate surface of the earth that serves as a natural medium for plant growth

Soil = solids + pore space



*Solids = Mineral + Organic matter
*Pore space = Air + Water



"Soil is a mixture of weathered rock, decayed organic matter, mineral fragments, water and air"

Soils forming factors

Where did Soil came from?

Soil has been formed by 5 major factors:

1. Parent material (original form)
2. Climate (precipitation and temperature effects)
3. Macro- and microorganisms
4. Topography (elevation, slope, position)
5. Time

Soil layers

UTM

www.utm.my

Soil texture

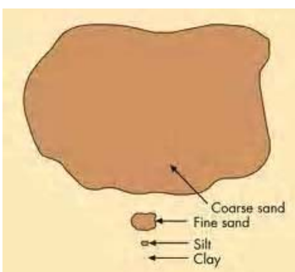
Soil texture is the percentage of sand, silt and clay in a given soil

- Sand 0.05 mm to 2 mm
- Silt 0.002 mm to 0.05 mm
- Clay <0.002 mm

Clays can hold water & have high water content compared to sand and silt

UTM

www.utm.my



UTM

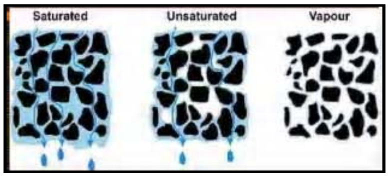
www.utm.my

Why is soil texture is important?

- The texture of soil affects many processes that occur within the soil e.g. Infiltration rates and water holding capacity (WHC)

*WHC = how well the soil stores the water

*Infiltration = how fast the water enters the soil surfaces



Types of soil structure

2 broad groups – plus any mixture between

granular	clay rich
coarse	fine
cobbles, gravel, sand, silt	clays
rocks & quartz	clay minerals
non cohesive	cohesive

air and water can be present

WATER is key factor in soil behaviour

Granular soils

- no cohesion (unless clay present)
- shear strength depends on internal friction Φ (30° to 45°) (grain shape, angularity, size, grading, packing density)
- settlement usually small
- Φ gives natural slope angle

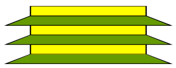
Clay soils

The most "interesting" and challenging for civil engineers

clay minerals are microscopic (<0.002mm) sheet like minerals complex silicates formed from breakdown of feldspars and other minerals

silica (silicon & oxygen)

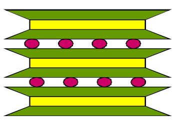
alumina (aluminium, oxygen & hydrogen



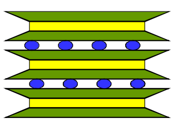
these units are combined in layers

How the units are combined gives rise to different clay minerals

Kaolinite has hydrogen between each pair of units



Illite includes iron & magnesium in basic structure with potassium in between



Montmorillonite has same units as illite but water is between units this is a very weak bond

---

Clays can hold water & have high water content

Amount of water allows solid, plastic or liquid states

Plastic Limit & Liquid Limit can be defined & used

clay soils are **COHESIVE (consistent)**, due to interparticle bonds

both shear strength and cohesion are a function of water content

when water content is high clays become liquid with zero cohesion & shear strength

Drainage rates from clays are very low – give a major problem

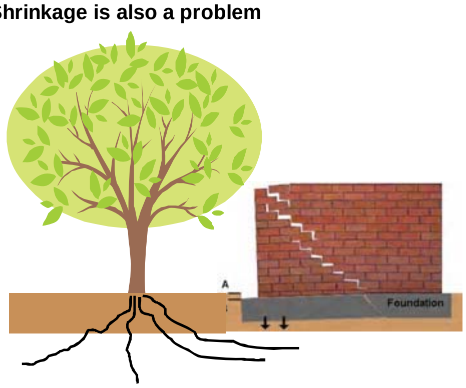
Differential Settlement is a Particular Problem

4m

58m

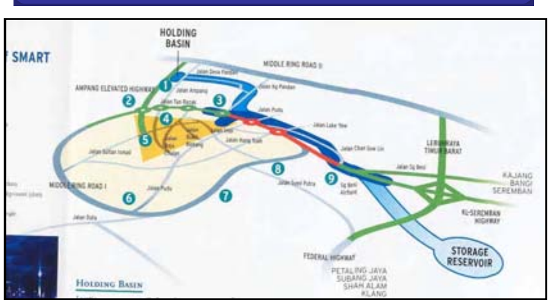
14,000t

Clay Shrinkage is also a problem

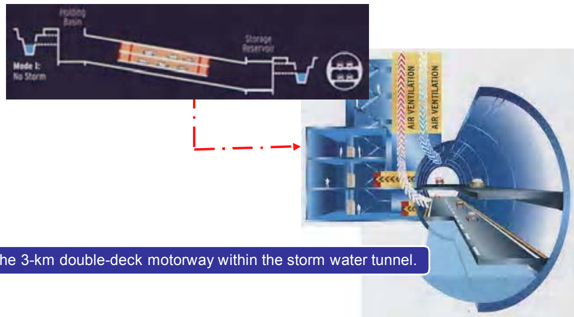


tree removal can also be problematic

Stormwater Management and Road Tunnel (SMART) Project

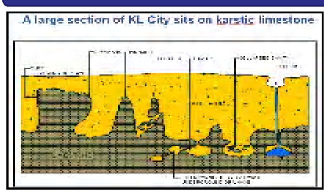


What is the unique feature of this project ?



The 3-km double-deck motorway within the storm water tunnel.

Method of Construction



Kuala Lumpur city sits on karstic limestone geology with high ground water table - karstic limestone include cliffs, pinnacles, cavities, collapsed cavities and sinkhole.

Due to the nature of the soil condition, a construction method that would have minimal negative impact on the geological condition of the soil is selected.

After much research, study and survey, the **Slurry Shield TBM** was chosen.This machine is designed to overcome problems of groundwater drawdown.

Stormwater Management and Road Tunnel (SMART) Project

- **Slurry Shield TBM (Tuah and Gemilang) was chosen as the construction method on Karstic limestone geology condition in Kuala Lumpur.**
- **The total cost of the project is around RM 2 billion.**
- **The project started on 1st January 2003 completed in December 2006**

TBM TUNNEL – SOUTH DRIVE

Tunnel Boring Machine broke through at South Junction Box on 04/06/05

Soil Erosion

The loss of soil from the landscape

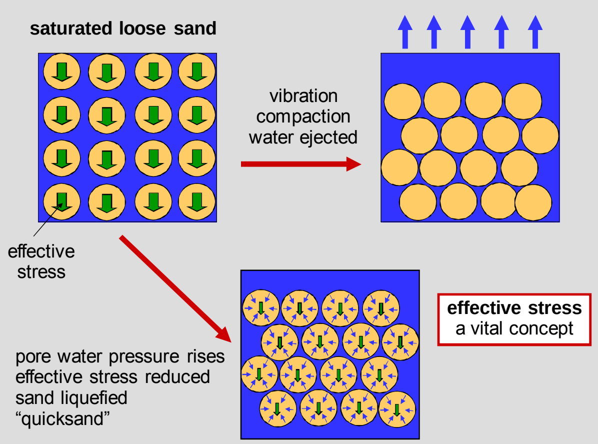
Caused by:
- Water movement
- Wind
- Man /mechanical (e.g. construction sites)

Niigata Earthquake, 1964, Japan

Sand Boils, Niigata, 1964

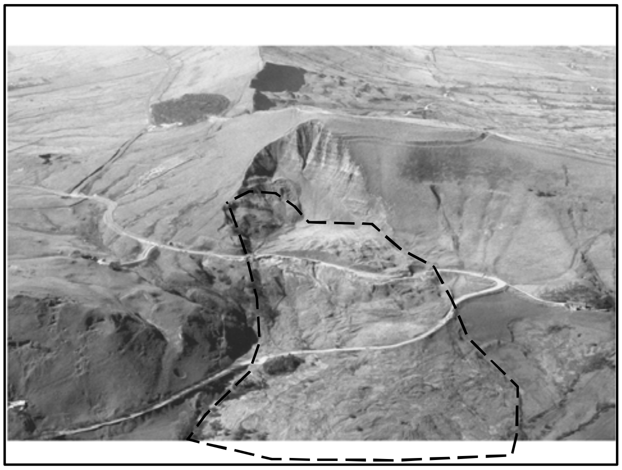
saturated loose sand

loosely consolidated sand
vibration produced compaction
pore pressure increased
water forced out
erupted at surface, “sand boils”
effective stress near zero
sand liquefied
buildings foundered

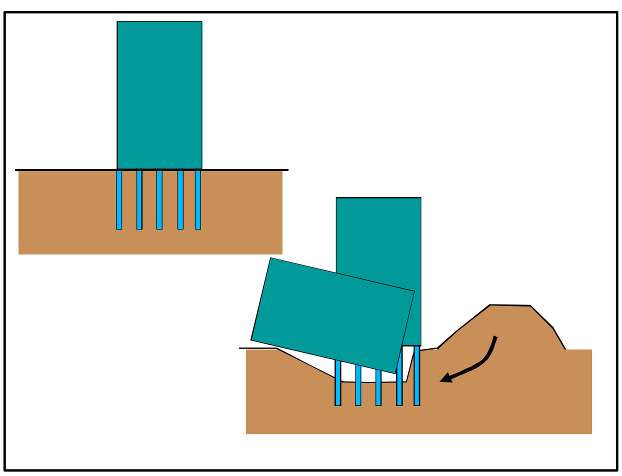


Slope Failure in Clay Soils

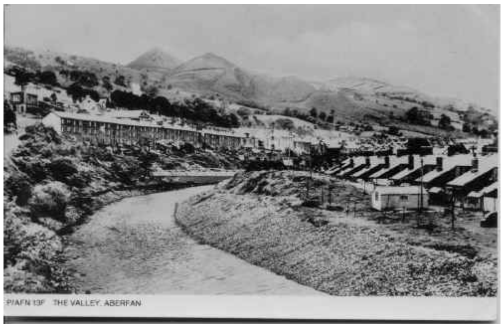
Landslide - slow
Flowslide - fast



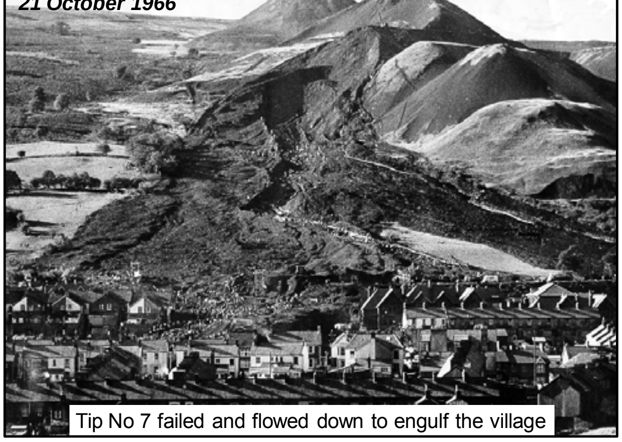
Shanghai, 27 June 2009, 13-storey apartment building



Aberfan – a typical South Wales mining village



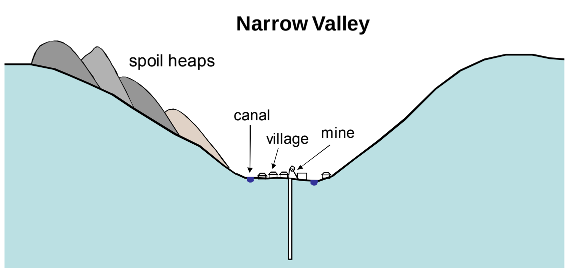
21 October 1966



Tip No 7 failed and flowed down to engulf the village

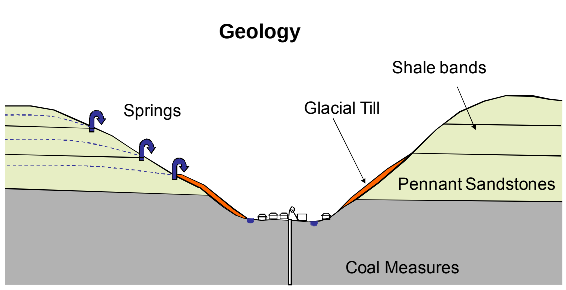
Attempts being made to find survivors

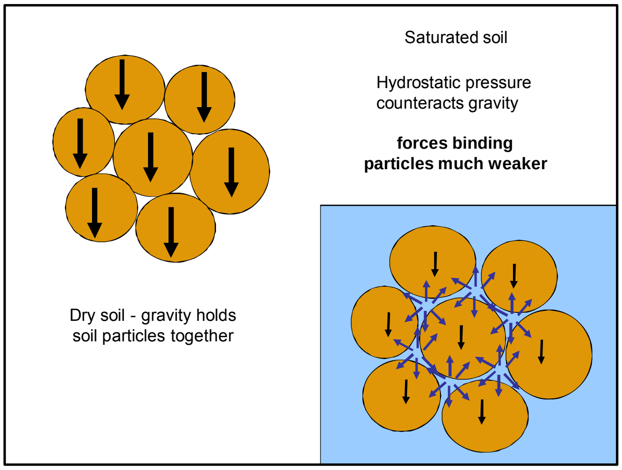
144 killed
including 116 children

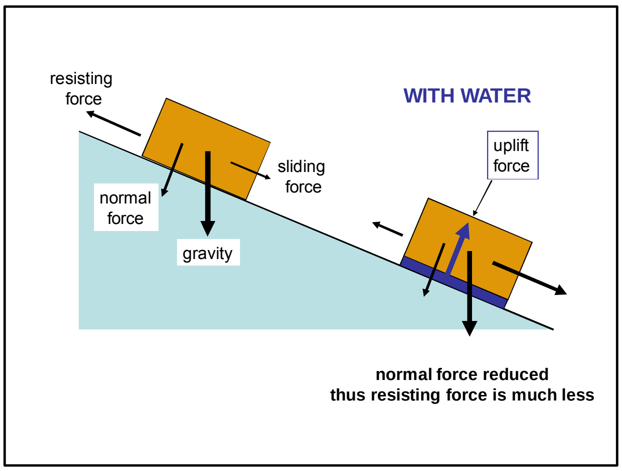


Tramway
to transport the waste
up to the tip complex

They had been in operation
for many decades







A History of Tip Failures

1939 Cilfinnydd – 180,000 tonnes *(few miles to South)*

1944 Aberfan No 4 Tip

1956 Aberfan No 5 Tip

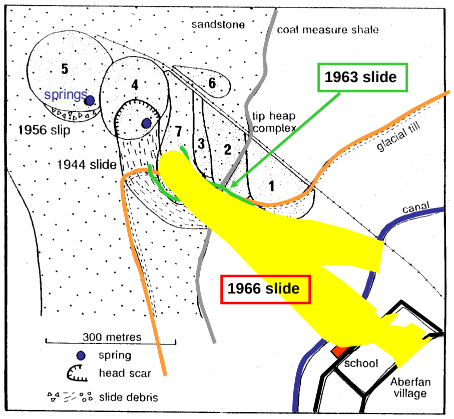
1963 Aberfan No 7 Tip

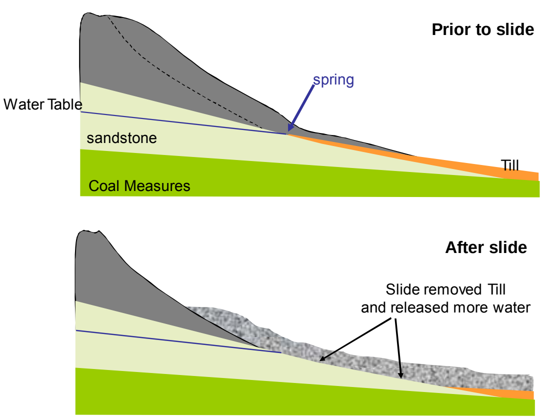
Heavy rainfall in period before slide

Tip saturated

Water table high

Springs flowing at great rate





Investigated by Tribunal which sat for 76 days

Quote

…the Aberfan Disaster is a terrifying tale of bungling ineptitude by many men charged with tasks for which they were totally unfitted, of failure to heed clear warnings and of total lack of direction from above.

Not villains but decent men, led astray by foolishness or by ignorance or by both in combination, are responsible for what happened at Aberfan.

Blame rested with the National Coal Board

No controls on tipping

Warning signs ignored

Knowledge was available but those responsible were ignorant

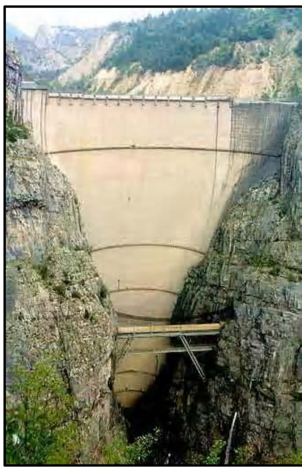
Vaiont Dam Italy

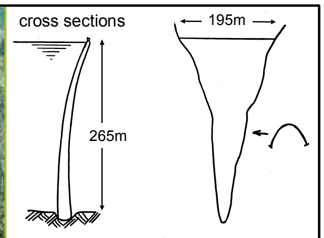
in Italian Dolomites

- completed in 1960
- water supply and electricity
- one of several dams

highest thin wall double curvature dam (when built)

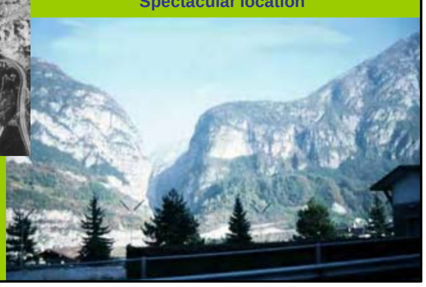
265m high
190m wide
3m thick at top





before construction

Spectacular location



On evening of 9 October 1963

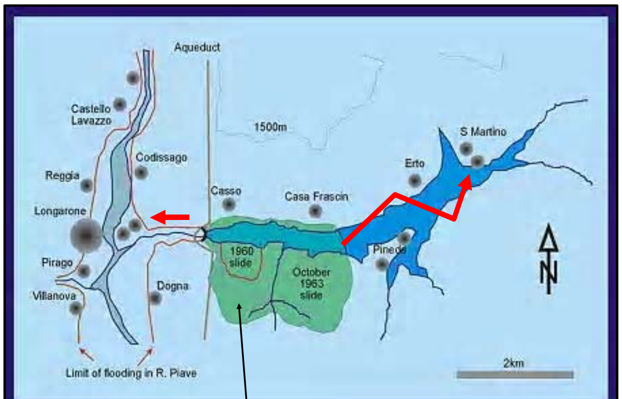
World's worst dam disaster

Longarone and several other villages were flooded when a massive landslip went into reservoir.

A wall of water went upstream and downstream

2600 people died

Landslide 1.8km X 1.6km - approx 240,000,000 m^3
Water reached 260m above reservoir level and overtopped dam by 100m – dam survived



Area of landslide

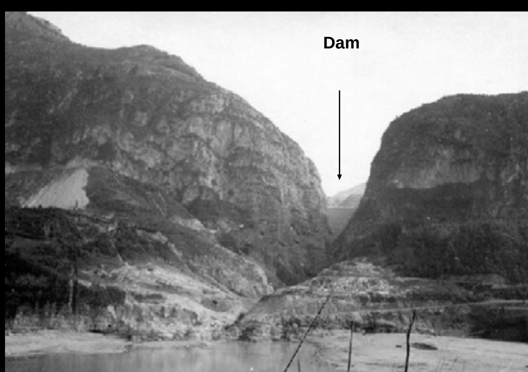
Vajont Dam during filling of reservoir

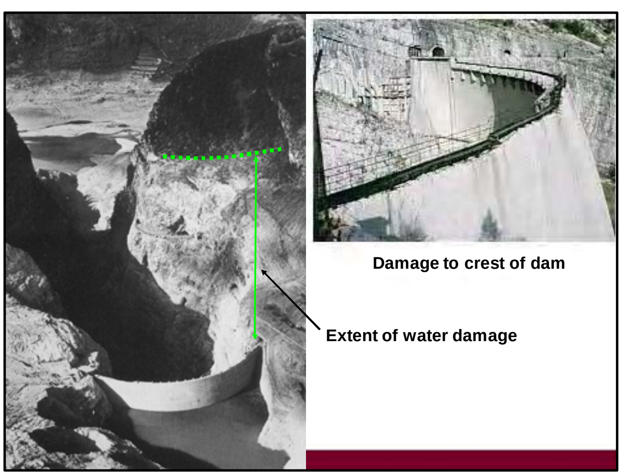
The town of Longarone downstream of the dam

After the slide of October 1963

After the disaster - 2500 people died

Looking for survivors





Damage to crest of dam

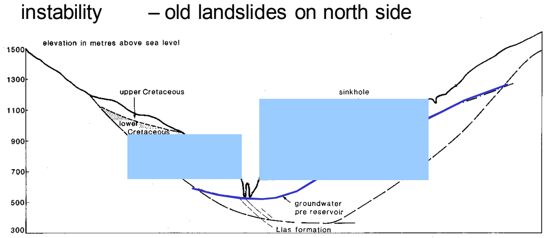
Background to Disaster

rocks – limestones with shale / clay layers

structure – syncline fold - axis parallel to valley

stress – due to folding and rapid erosion

instability – old landslides on north side



Background to Disaster

Chief Engineer unhappy about location during construction

During initial filling smaller landslip movement on south side

Water level was reduced and movement stopped

Decided to try and control movement by varying water levels
- seemed to work and so continued filling
- several studies done by Electricity Industry consultants

Constructed bypass tunnel on north side

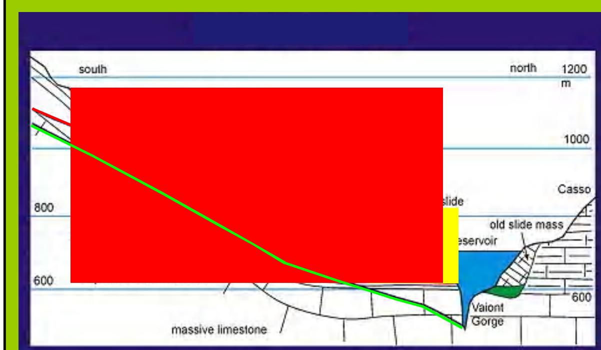
Filling restarted, but by Nov 1962 up to 12mm/day movement so water level lowered.
Movement stopped by April1963 so filled again.

September 1963 moving again at up to 200mm/day so tried to empty

Heavy rainfall end of Sept and early Oct

All animals left the area by early October

1960 landslide



Causes

- deep seated landslide on clay layers between limestone, plus probably new slide
- water from rain and reservoir had reduced effective stress in bedding planes
- rapid drawdown had probably made things worse by inducing additional hydraulic pressures and by removing support

Lessons

- wrong location, no attention to geology
- total underestimation of effects and scale of influence of groundwater (only considered initial landslide)
- ignorance of soil / rock mechanics
- dismissal of unpopular information or opinions
- vested interests outweighed public safety
- poor communications in controlling organisation (up and down)
- lack of responsibility

dam design was superb but in the wrong place

no water – no sandcastles
1 part water, 8 parts sand
suction produced

Soils and Clays a Major Challenge for Civil Engineers

need to fully understand

to ensure YOU get it right

Any Questions?