Managing Geotechnical Risks in Civil Engineering Projects

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Lecture given to Capstone projects students

Content

- What is the main responsibility of civil engineers?
- What is Geotechnical Risk?
- Geotechnical Risks – Examples
- How to manage geotechnical risks

What is the main responsibility of civil engineers?

To plan, develop and maintain the build environment is the main responsibility of civil engineers.

Managing risks

What is risk?

there are things we know we know.

there are some things we do not know.

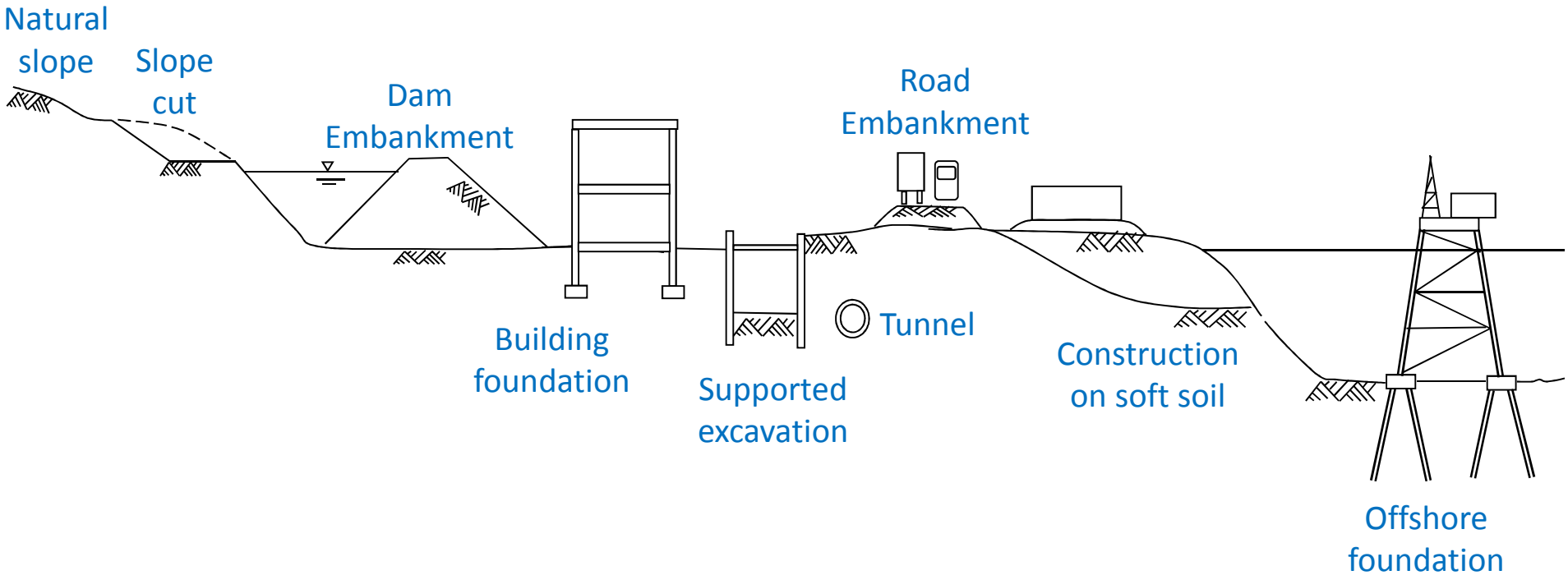
But there are also unknown unknowns - - the ones we don't know we don't know.....”

Risk is controlling the known unknowns and reducing risk is trying to minimise the unknown unknowns

What is Geotechnical risk?

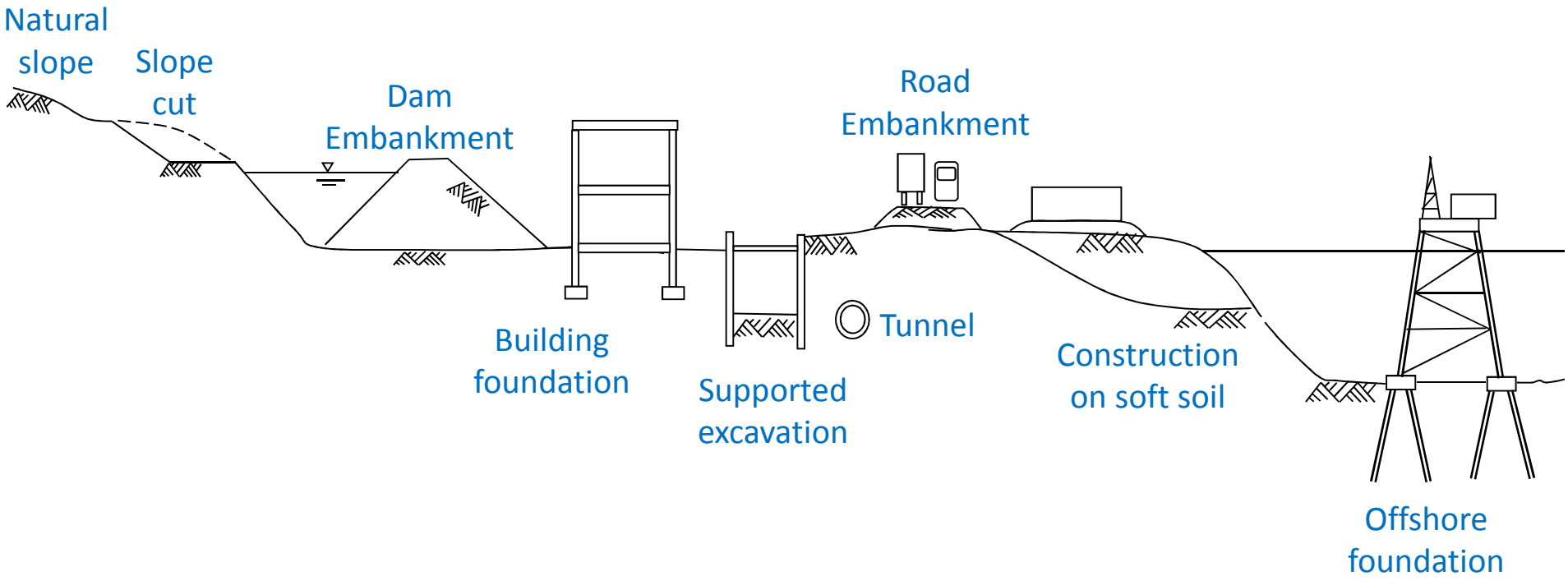
- Do you think of any civil engineering project which is not:

  built on ground: foundations to buildings, bridges.
  built in ground: tunnels, culverts, basements.
  built with ground materials: roads, runways, embankments, dams.
  Supported by ground materials: retaining walls, quays.



What is Geotechnical risk?

- All civil engineering projects (buildings, roads, bridges, dams, tunnels and water tanks ..) are constructed **on** , **with**, or **in** the **ground**.
- Civil engineers are required to identify and avoid the major **risks** posed by **ground conditions**. DO YOU THINK OF ANY RISK?



What is Geotechnical risk?

Ground related problems can adversely affect:

- Project Cost,

What is Geotechnical risk?

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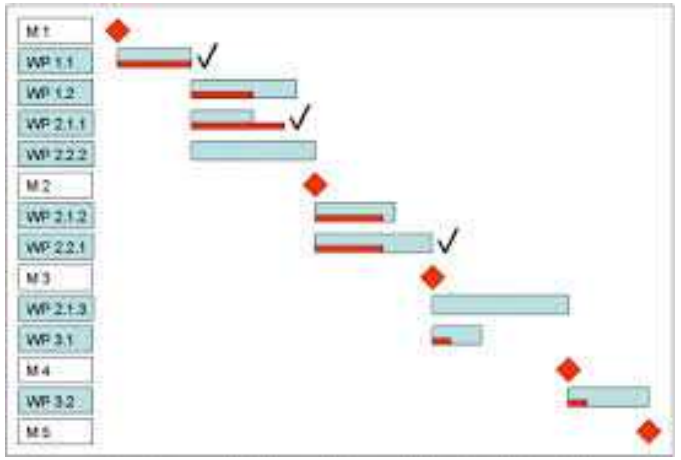
- Project Cost,
- Completion Times (program),



What is Geotechnical risk?

Ground related problems can adversely affect:

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- Health and Safety,

What is Geotechnical risk?

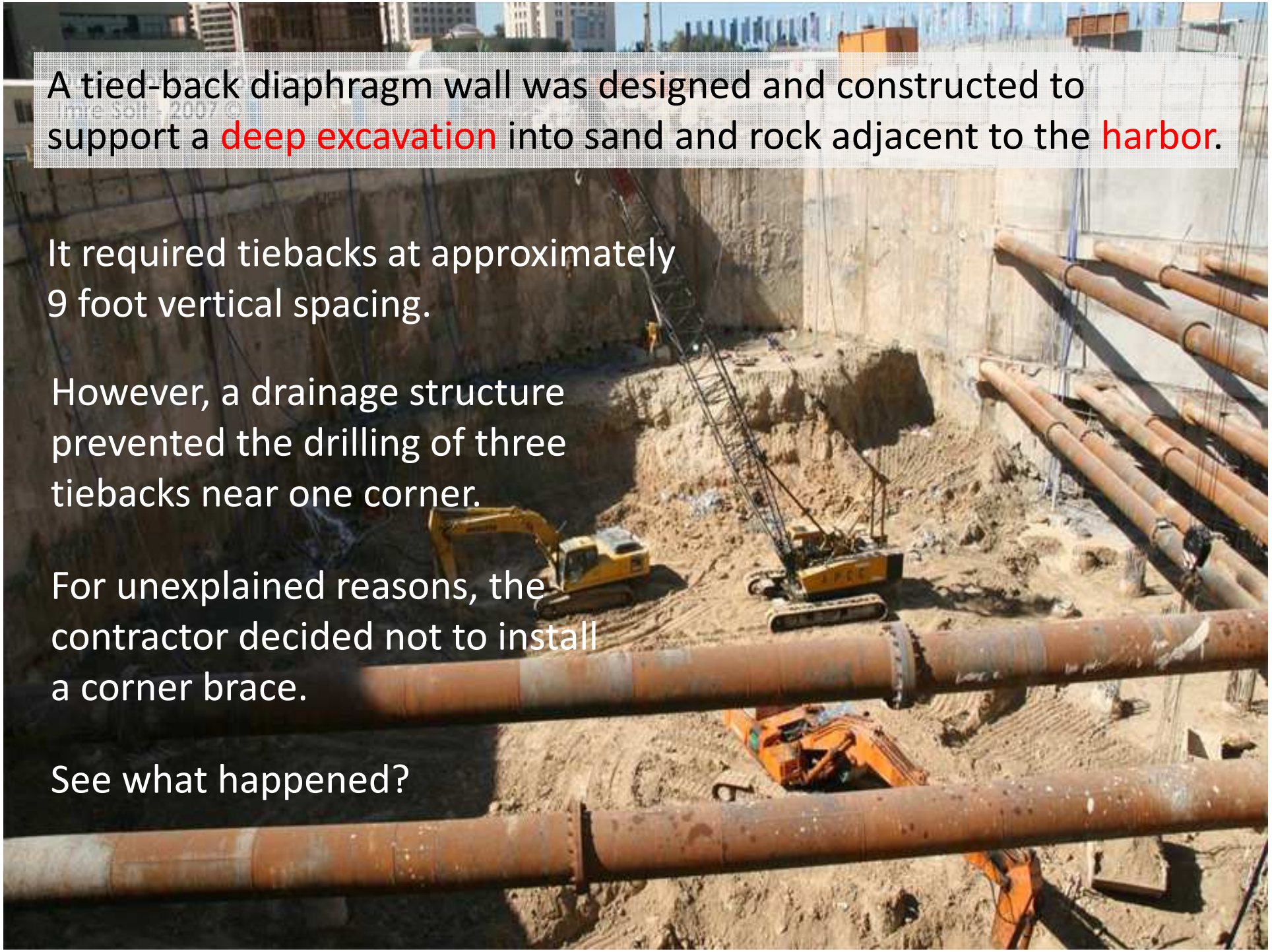
Ground related problems can adversely affect:

- Project Cost,
- Completion Times (program),
- Health and Safety,
- Quality and fitness for purpose,
- Environmental Damage.

Geotechnical Risks – examples

Infinity Tower Shoring Collapse, Dubai, U.A.E


Dubai Construction Update
Imre Solt - 2007 ©

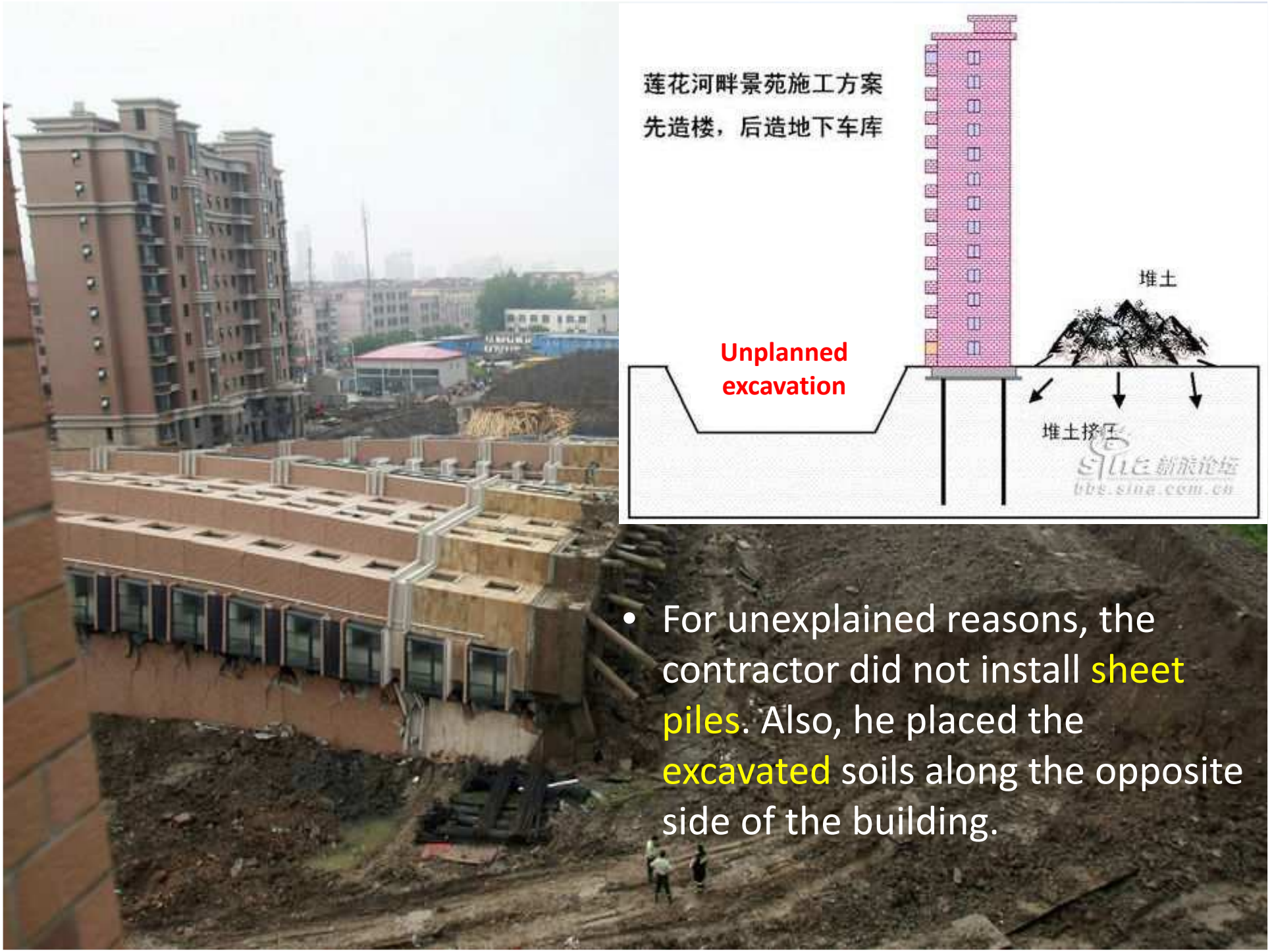

A tied-back diaphragm wall was designed and constructed to support a deep excavation into sand and rock adjacent to the harbor.
It required tiebacks at approximately 9 foot vertical spacing.
However, a drainage structure prevented the drilling of three tiebacks near one corner.
For unexplained reasons, the contractor decided not to install a corner brace.
See what happened?


Dubai Construction Update
Imre Soti - 2007

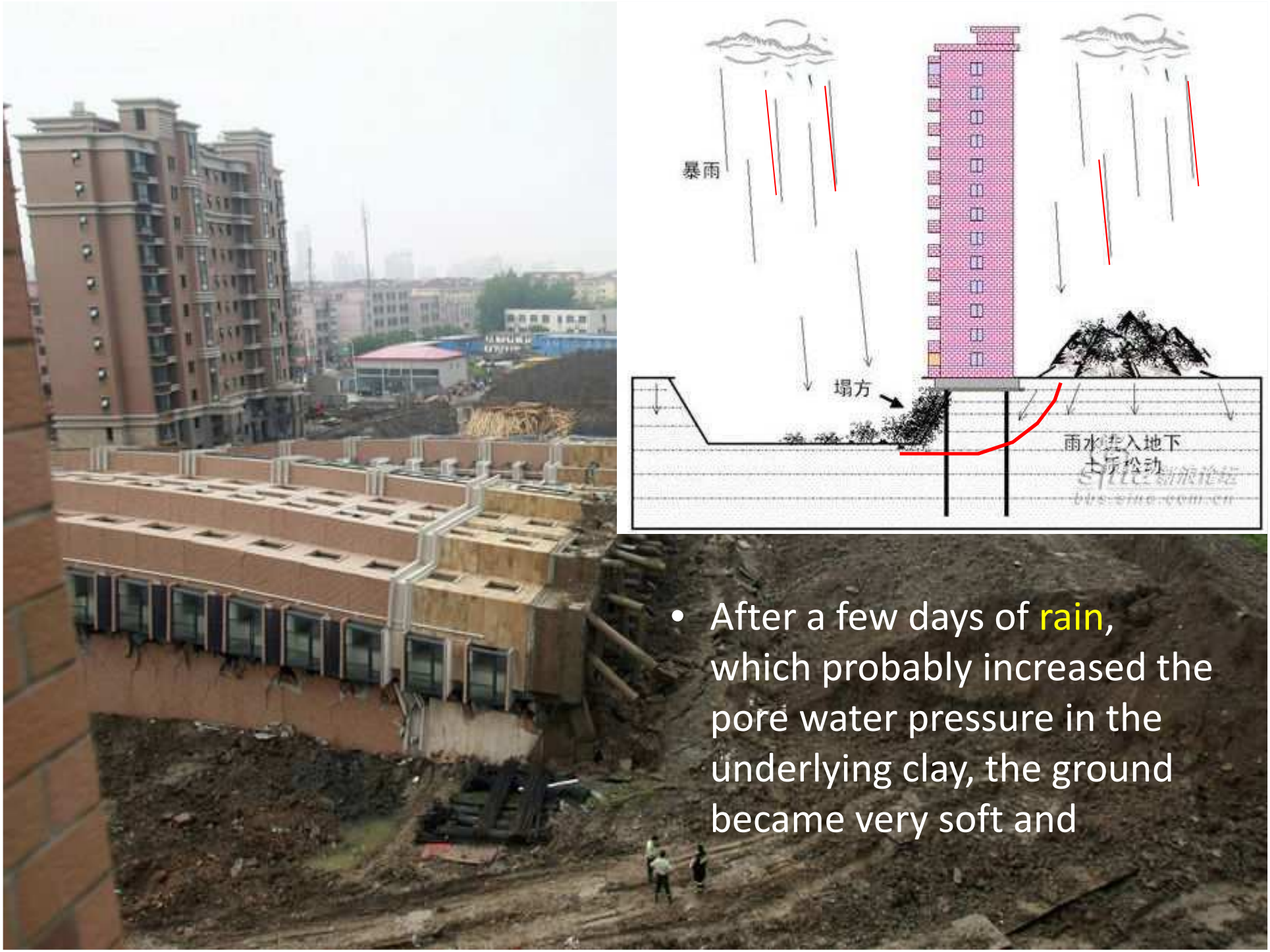

2007 2 7

Building Collapse
Lianhuanan Road Tower, Shanghai City, China (2009)

- An apartment tower was near completion, but the contractor needed to excavate for an adjacent parking garage.



- For unexplained reasons, the contractor did not install sheet piles. Also, he placed the excavated soils along the opposite side of the building.



- After a few days of rain, which probably increased the pore water pressure in the underlying clay, the ground became very soft and

- And a shear failure developed from the stockpile to the excavation.
- With insufficient lateral resistance the ground collapsed shearing the pile foundation.

- The building was supported on a hollow core precast concrete pile which appears to be illegal in China.

Slope Failure in Nachterstedt, Germany 2009


The town of Nachterstedt is located in northeast Germany, near the city of Magdeburg. The area was used for coal mining for 120 years. In the early 1990's the mining was discontinued. Nachterstedt was built on a hill consisting of spoils from the mining pit.
Image © 2009 GeoContent
© 2009 Europa Technologies
© 2009 Tele Atlas
© 2009 PPWK
©2009 Google
Imagery Date: 2000
lat 51.810192° lon 11.339945° elev 70 m
Eye alt 3.15 km

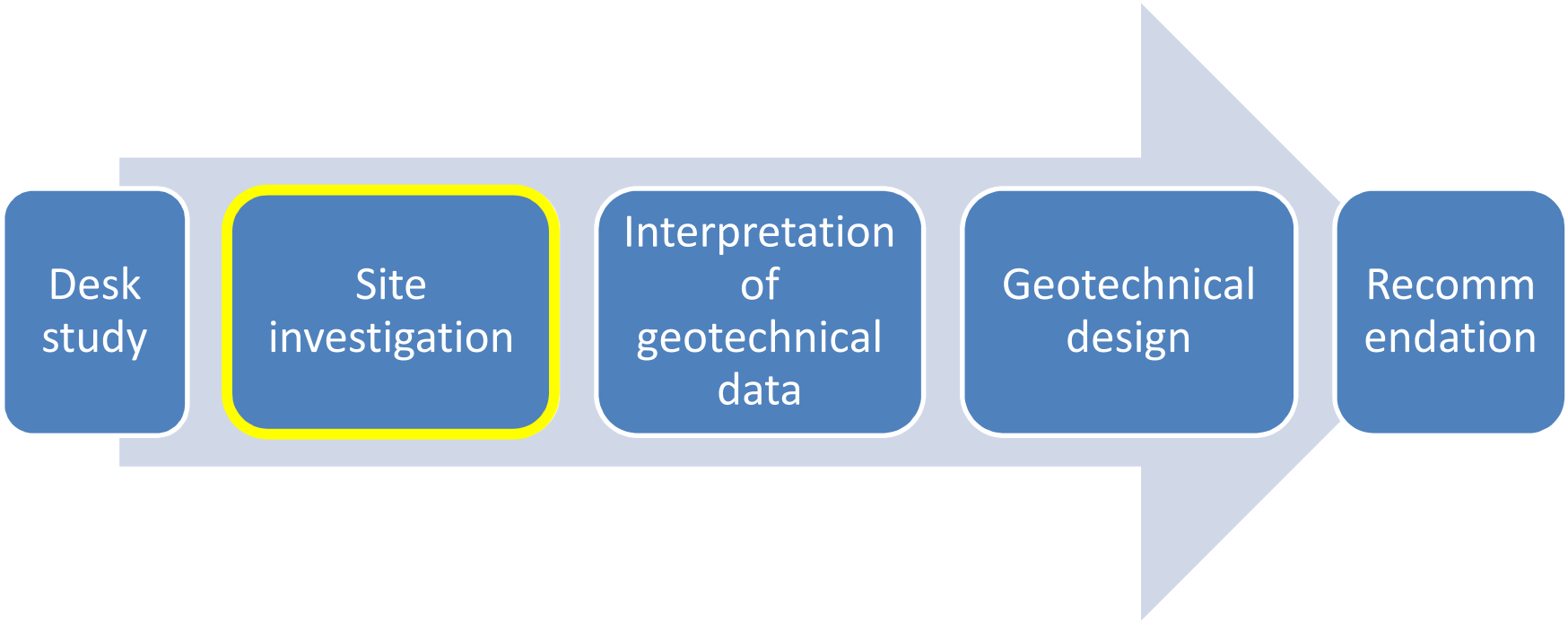
The slope that failed in July 2009 was part of the mining spoils dump site, which was created in the 1920's. Proper compaction of the mining spoils is questionable since there were no records maintained when the dump was created.

A resident stated that he noticed cracks in his garage and a sink hole in his yard a few years ago but did not notify any authorities. Test borings were taken a year ago, which exposed voids in the soil.


© AP

How to manage geotechnical risks?

There are a number of documents and standards available which provide clear guidance on processes to enable potential geotechnical risks to be identified and managed:

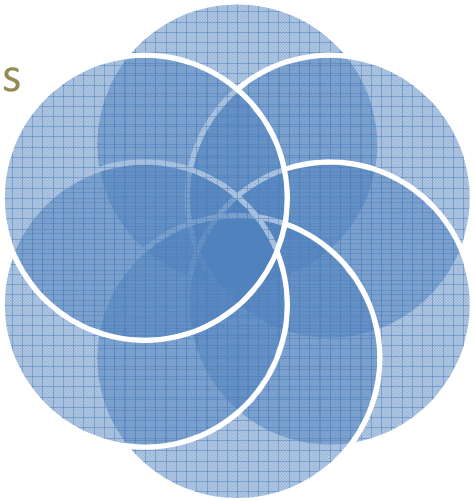


Site investigation - objectives

What is site investigation and Why do we need it for?

Suitability: of site for the proposed construction?

Effect of changes: How will the design affect adjacent properties and the ground water?



Design parameters: such as strength, compressibility, permeability & other parameters used for geotechnical design

Type of design solution: e.g. type of foundation: shallow or deep.

Geo-materials: available on site which can be re-used?

Site Investigation

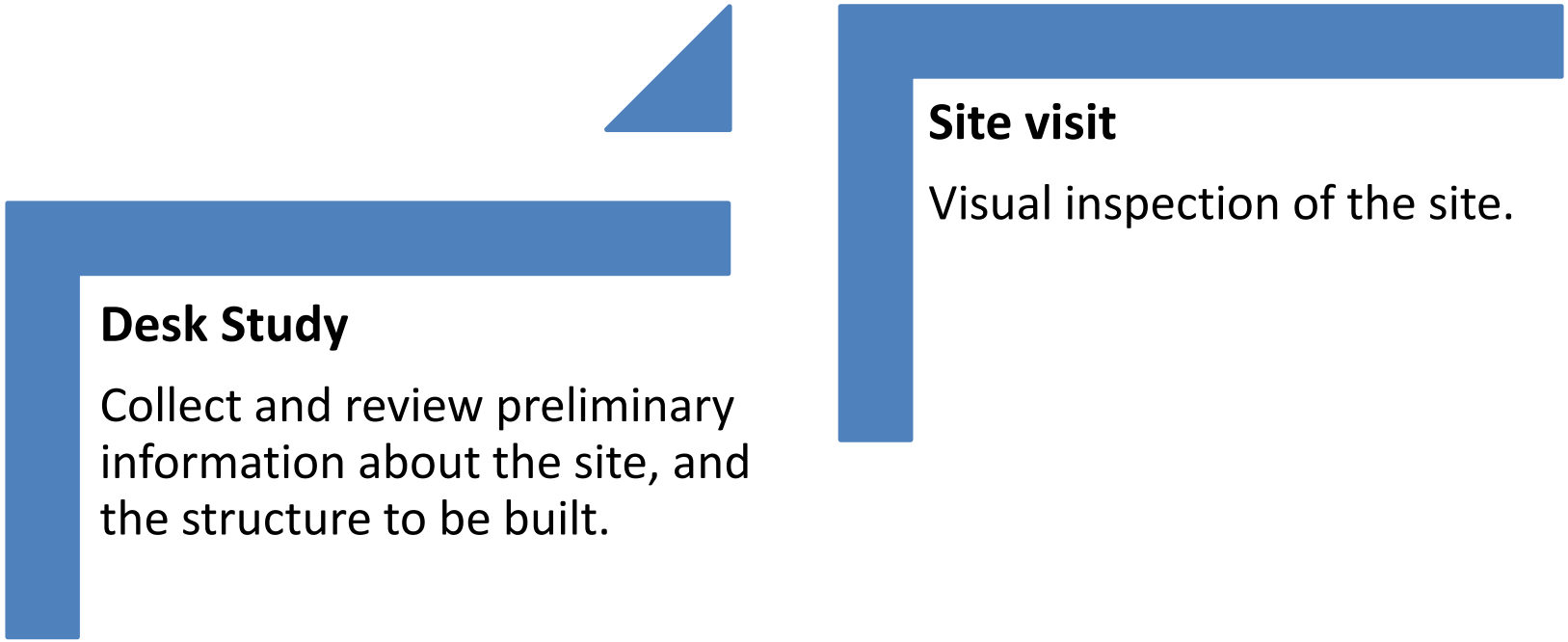
Ground or Ground-water conditions: that would affect the design and construction? e.g. expansive soil, collapsible soil, high ground water…

Site investigation - objectives

Site Investigation

Site investigation - program

- Before conducting the Site Investigation, the program usually include: Desk Study and Site visit.

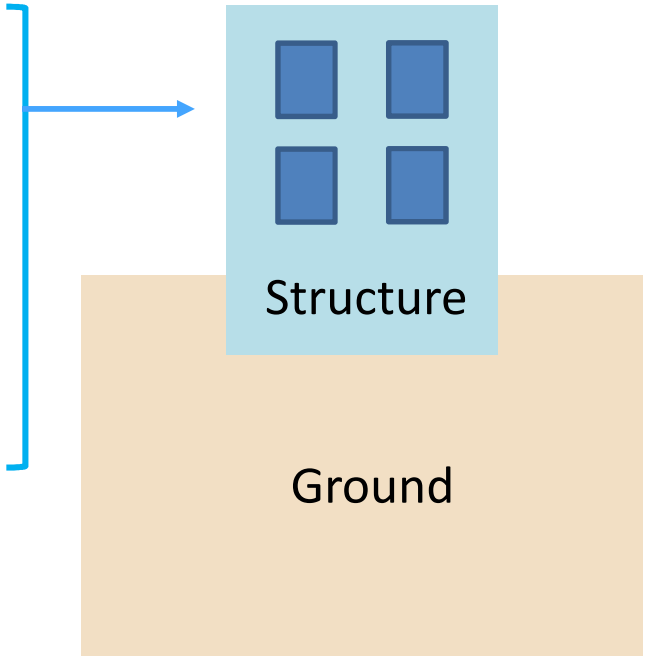


Desk Study

Collecting general information about the **structure**, **from** the architectural and structural design:

Information about the Structure

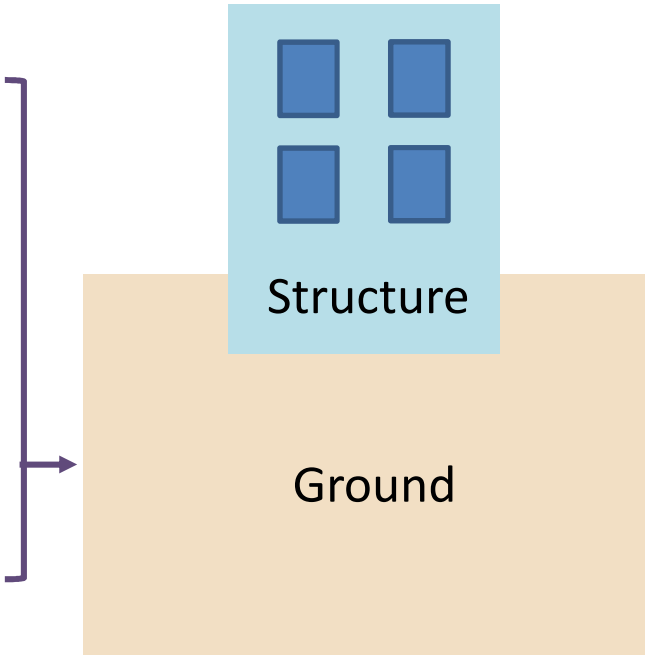
- **Type, dimensions,** and **use** of the structure, and any special architectural considerations.
- the **load** that will be transmitted by the superstructure to the foundation system
- the **requirements** of the local building **code** (e.g. allowable settlement)



Desk Study

Collecting general information about the **ground**:

- the **geological** conditions of the ground (e.g. layers, Geological features, Ground water, Flood & Earthquake risk in the area, ..).
- the **historical use** of the site – if previously used as quarry, agricultural land, industrial unit with contamination issue, man-made fill/slope, etc.



Ariel Photograph taken for a site – shows a possible sinkhole

Site visit

The Site Reconnaissance is normally in the form of a **walk-over survey** of the site.

What things do I need to look for?

Engineer during Site Visit

Site visit

Important evidence to look for is:

1. **Stratification of soil:** from deep cut, such as those made for the construction of nearby highway or other projects – if any.
2. **Slope**: signs of slope instability include bent trees, shrinkage cracks on the ground and displaced fences or drains.

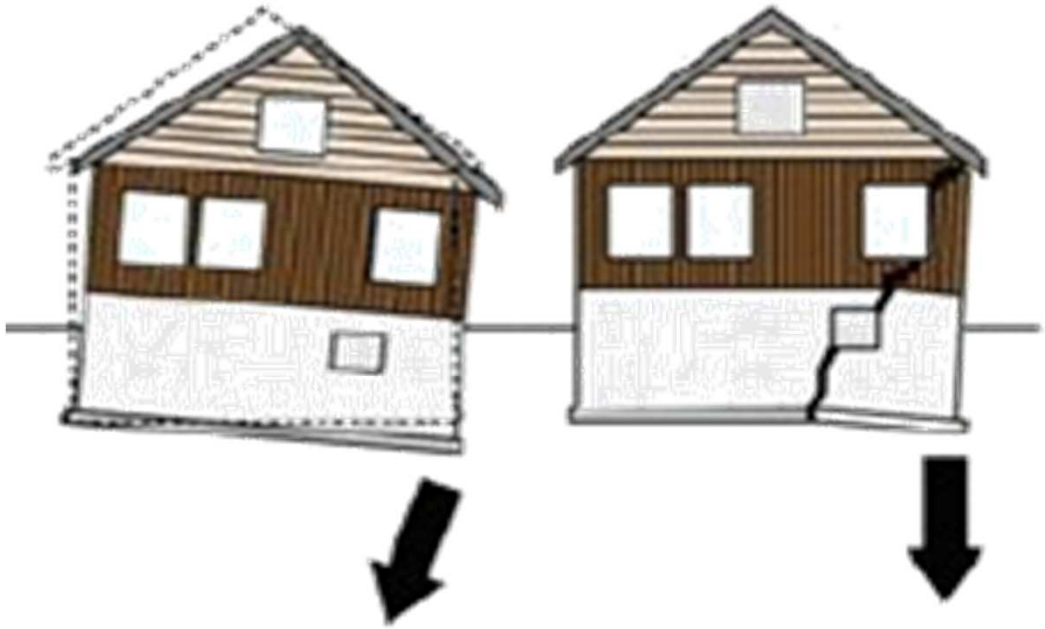
Stratification of soil

Signs of slope instability

Site visit

Important evidence to look for is:

3. **Structures:** type of buildings in the area and the existence of any cracks in walls or other problems. You may need to ask local people.



Tipping settlement (often without cracks)

Differential settlement (with cracks)

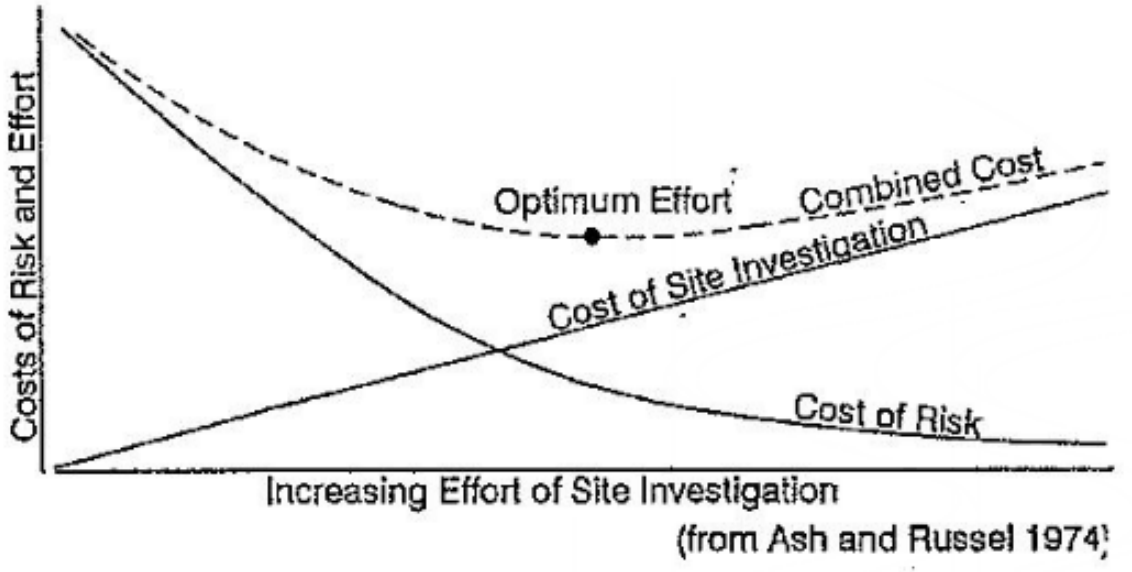
Indication of possible ground-related problem

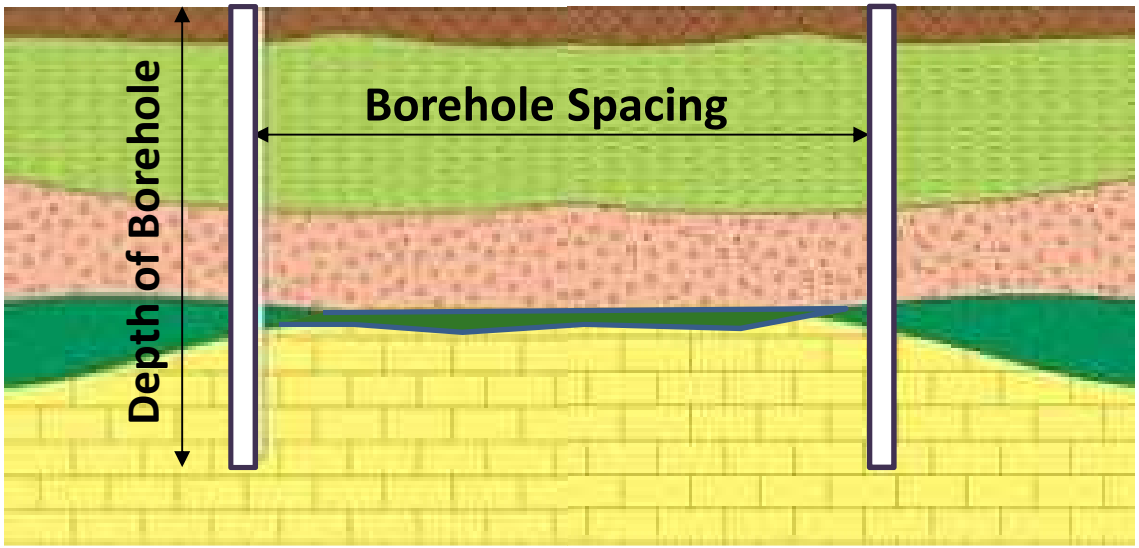
Site visit

Other important evidence to look for is:

4. **Mining:** The presence of previous mining is often signs of subsidence and possibly disused mine shafts. Open cast mining is indicated by diverted streams replaced or removed fence/hedge lines.
5. **Hydrogeology**: Wet marshy ground, springs or seepage, ponds or streams and Wells.
6. **Topography:** possible existence of drainage ditches or abandoned debris or other man-made features.
7. **Vegetation:** may indicate the type of soil.
8. **Access**: It is essential that access to the site can be easily obtained. Possible problems include low overhead cables and watercourses.

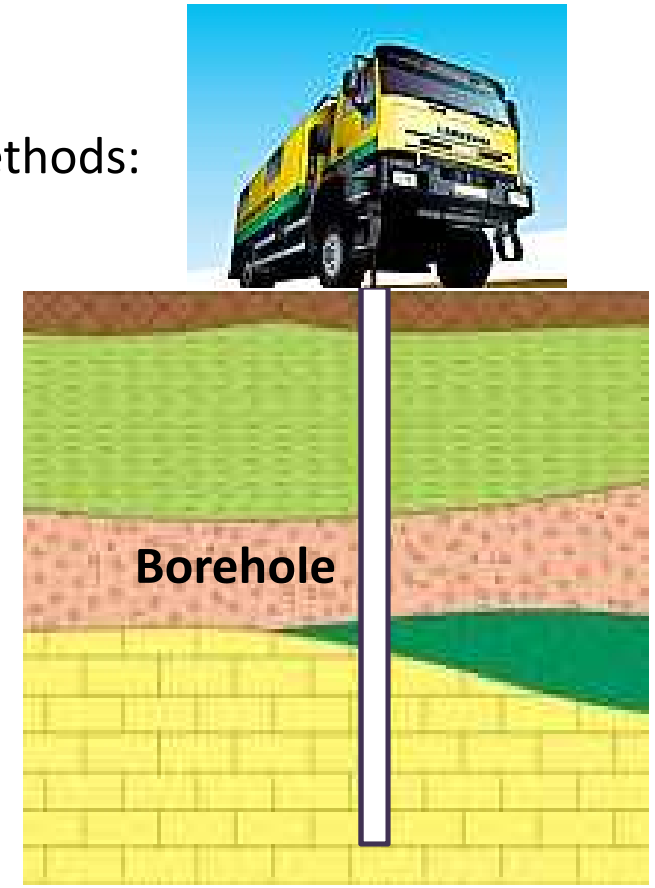
Site investigation - planning





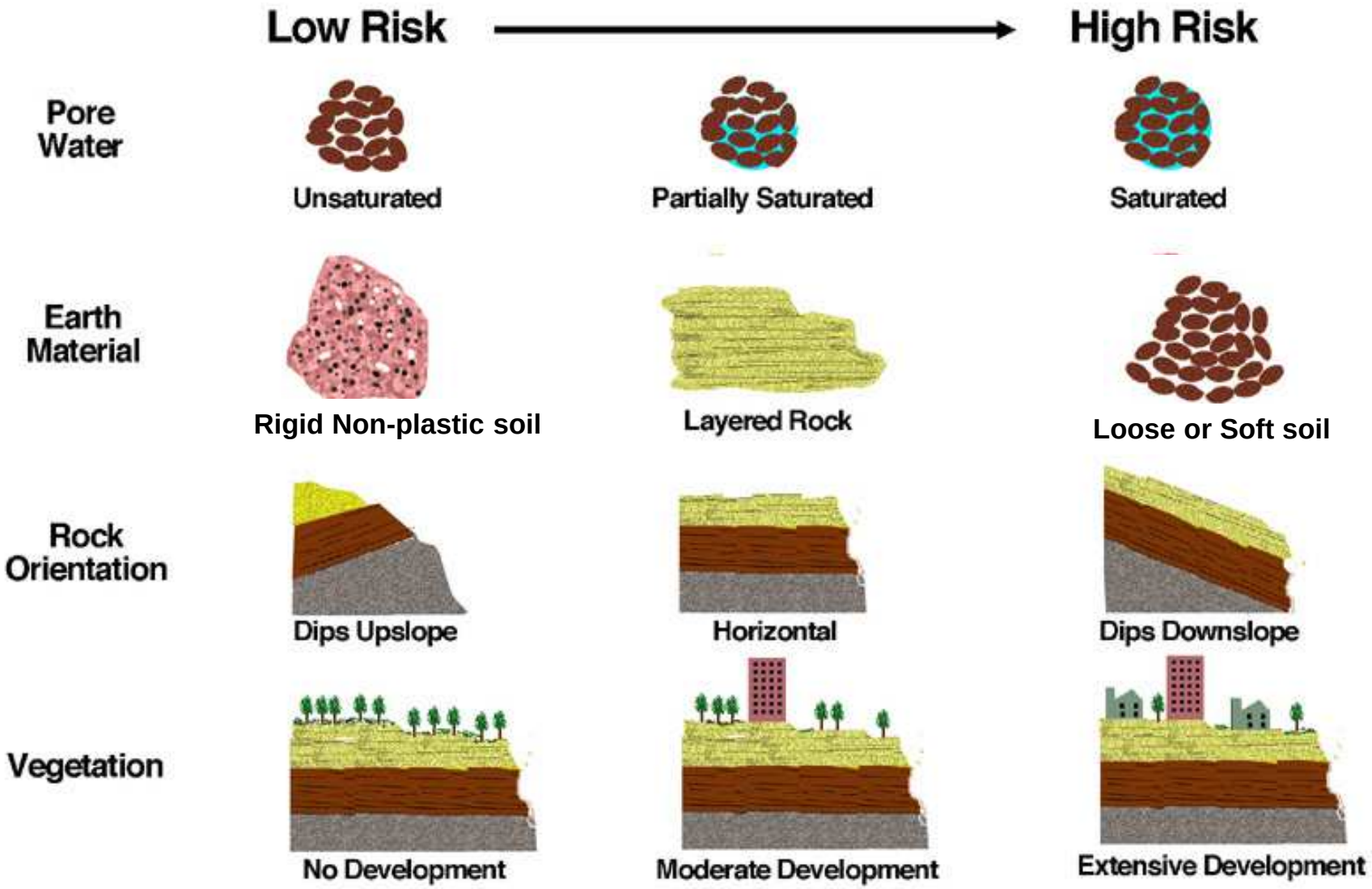
Boreholes

- Boreholes may be excavated by one of these methods:
  1. **Auger Boring**
  2. **Wash Boring**
  3. **Rotary Drilling**
  4. **Percussion Drilling**



- The right choice of method depends on:
  - Ground condition: presence of hard clay, gravel, rock.
  - Ground-water condition: presence of high ground-water table (GWT).
  - Depth of investigation
  - Site access

Identification of geotechnical risks



Principal criteria for foundation design

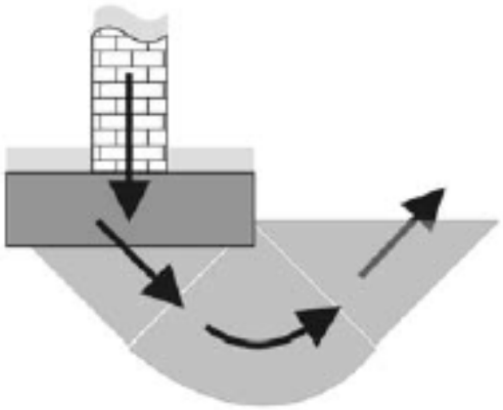
When designing foundations (shape, size, depth, and material), **two** principal criteria must be satisfied:

1. Maintaining **Stability**
2. Limiting **Settlement**

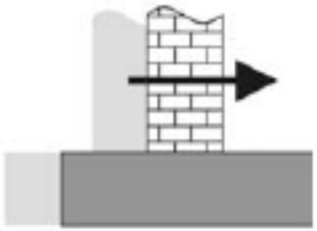
Stability

- There must be an adequate factor of safety against **failure** of the foundation at all known ultimate conditions.
- Possible failures: Bearing, Sliding, Overturning, or Structural failure.

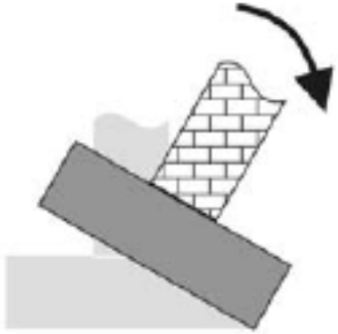
Bearing failure



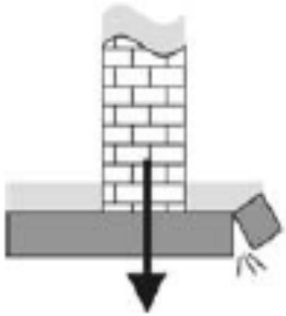
Sliding



Overturning



Structural failure



Principal criteria for foundation design

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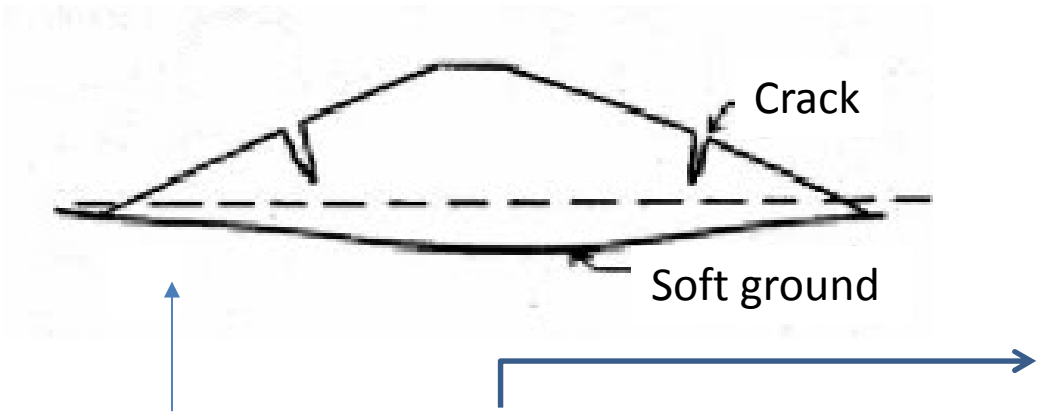
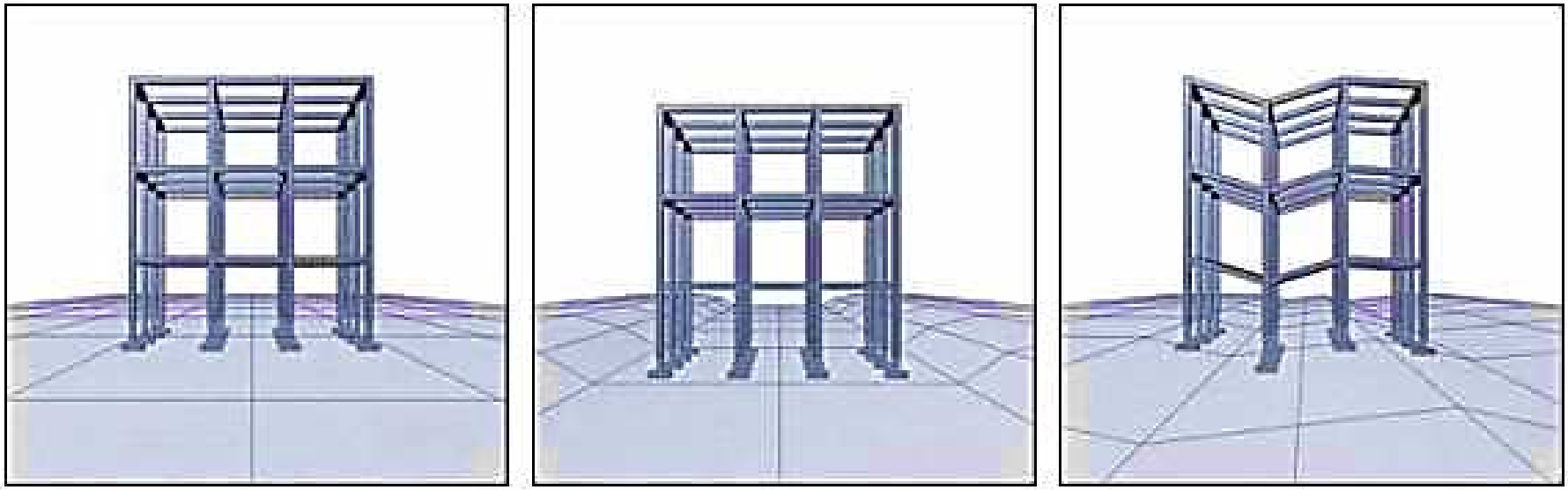


***Embankment** and **building** constructed on soft ground (highly comprisable soil)*

Types of settlements

From **structural** consideration there are two types of settlements:

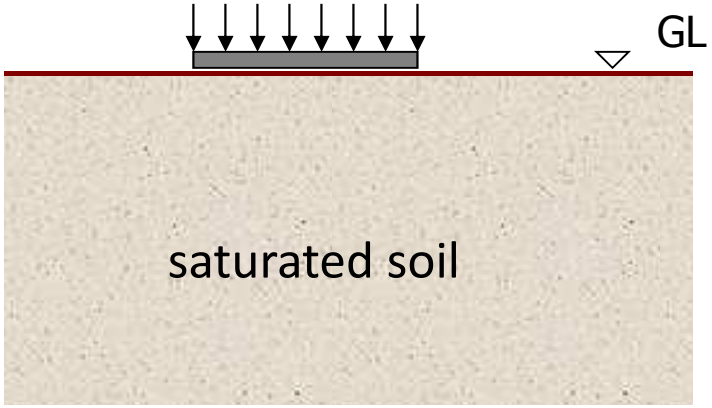
- Uniform settlement → *should be within the acceptable limit - given in the building code*
- Differential settlement → *should be within the acceptable limit - given in the building code*

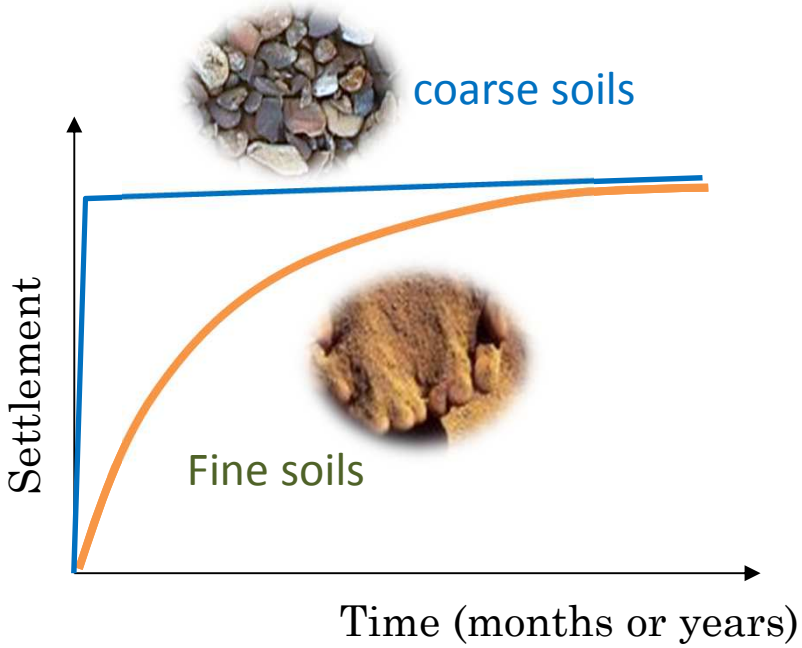


(a) Building before settlement occurs (b) Uniform settlement (c) Differential settlement

Basic consolidation process

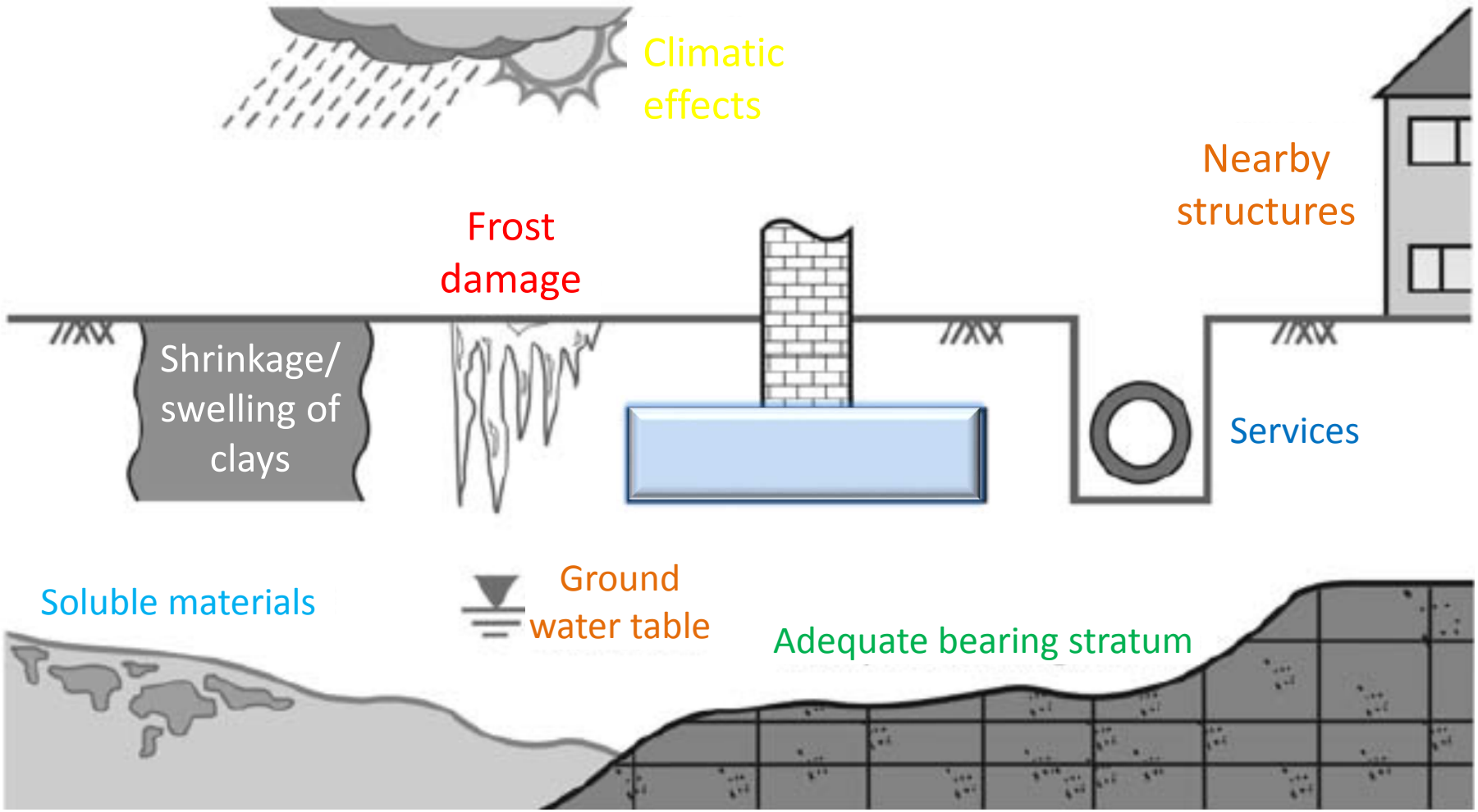
When a saturated soil is loaded,





- in coarse soils (sand & gravel) the settlement takes place instantaneously. How can this be explained?
- in fine soils (clay & silt): settlement takes far much more time to complete. Why?

Other Design Considerations



Assignment

Write a case study about an important risk in a real civil engineering project. Explain this risk and how was managed?
Due date: Thursday 3rd October. Length: about 2-3 pages