EWCE-343

GEOTECHNICAL AND FOUNDATION ENGINEERING

Syllabus

- Introduction
- Types of Foundation
- Bearing capacity of shallow foundation
- Settlement and distortion of foundation
- Design and construction of footing and raft

References

- Foundation Analysis and Design by **Joseph E. Bowles**
- Foundation Engineering by Peak, Hanson, Thornburn
- Principles of Foundation Engineering by B M Das
- Geotechnical Engineering-**Principles and Practices by Donald P. Coduto**
- Foundation Engineering-Principles and Practices by **Donald P. Coduto**

We will try to discuss the followings:

- **Definition.**
- Importance.
- **Issues to be addressed**.
- **Design Process**.
- Leaning Tower of Pisa
- Father of Geotechnical Engineering
- **Requirement of Geotechnical Engineers in any Civil Engineering Project.**

Introduction of Geotechnical Engineering

Define Geotechnical Engineering.

- Branch of civil engineering that **deals with soils**, **rocks** and under ground **water**; and **their relation** to **design, construction** and **operations** of engineering projects.

Bedrock & its importance

- Bedrock is **rock** or **comparatively harder stratum** **beneath** the surface materials of loose deposit such as soils, sands, sediments **which carry the structural loads**.

- **Identifying bedrock** is **an important part of geotechnical engineering** as **it supports structures** such as buildings, bridges etc.

- **Depth of bedrock** can be determined by digging, drilling and other geophysical methods.

Importance of studying of Geotechnical Engineering

Almost all of the **civil engineering project must be supported by the ground**, hence all of us require at **least some knowledge** on geotechnical engineering.

Issues to be addressed by the Geotechnical Engineers: (SSG –ISFR-TEC)

- What are the **soils and rocks** in the **subsurface** at the **construction site**?
- Can the soils and rocks beneath the construction site **can safely support** the projects?
- What **groundwater conditions** **currently exist**, how might they **change in the future**, and **what impact** do they have on the projects?
- What will be the **impact of any planned** **excavation**, **grading** and **filling**.
- Are the **natural or proposed earth slopes are stable**? If not, what must to be done to stabilize?

- What **types of foundations** **are necessary** to support the planned structures, and how **should to design them**?

- If the **project requires retaining walls**, what **kind** would be best and how to **design** them?

- If the project **requires a tunnel** or underground opening, how should it be excavated?

- How will the **site respond to potential earthquake**?

- Has the **ground become contaminated** with chemical or biological materials? Do they these materials represent **health or safety hazard**? If so, what must be done to rectify them?

Issues to be addressed by Geotechnical Engineers (summary): (SSG –ISFR-TEC)

- **Subsurface** conditions
- **Safely support** the project
- **Groundwater** conditions
- **Impact** planned soil disturbance
- **Earth slopes** stable
- **Foundation** Type
- **Retaining wall**
- **Tunnel** or opening in the ground
- **Earthquake**
- **Contaminated** ground

Geotechnical Engineering in Design & Execution Process:

Step-1:

- Geotechnical engineering design process begin **by assessing the under ground conditions and engineering properties of various strata at project sites.**

-Process is known as '**site exploration and characterization**' – **most important** task because it provides input data for all subsequent steps.

-It involves drilling vertical holes called '**exploratory boring**' in the ground obtaining testing sample.

-**Testing** the collected sample in a laboratory.

-May also involve **conducting tests in situ.**

Step-2:

- **Perform engineering analyses** based on the information gained from site exploration and characterization program.

-Analyses are collectively known as **'soil mechanics'** which include **empirical**, **analytical** methods.

Step-3:

- **Analysis of results to develop geotechnical input** for design purpose.

a. Design process also requires the application of **engineering judgement, experience from previous projects**, and **economics**.

b. Regardless of the results from the analyses, geotechnical engineers are reluctant to deviate too far from design criteria that have proven worthy in the past.

c. This is why, **understanding customary standard of practice is very important.**

Step-4:

- **Geotechnical engineers work as part of a team.**

a. Team which is also includes **other professionals** such as **structural engineers**, **architects** and **others**.

b. Many deign issue can be **revolved only through group efforts,** so the **final drawings and specifications** reflect the combined expertise of many individuals**.**

Step-5:

- **Geotechnical service during construction phase** include the followings:

a. **Examining the soil and rock conditions** actually encountered and comparing them with those anticipated in the design.

b. **Comparing the actual performance** with that anticipated design.

c. **Providing quality control testing**.

Step-6:

- Occasionally geotechnical **services continue beyond the end of construction.**

a. Sites **prone to long-term settlements** may require monitoring for months or years of construction.

b. **Investigations of facilities that have not performed** satisfactorily and development of remedial measures.

Geotechnical Engineering Design Process - Summary

Step-1: Process begin **by assessing the under ground conditions and engineering properties** of various strata at project sites.

Step-2: Perform **engineering analyses** based on the information gained from site exploration and characterization program.

Step-3: **Analysis of results to develop geotechnical input** for design purpose.

Step-4: Geotechnical engineers work as **part of a team**.

Step-5: Geotechnical service **during construction** phase.

Step-6: Occasionally geotechnical services **continue beyond the end of construction.**

The Leaning Tower of Pisa

Most famous example of soil related problems:

WHY does the Tower of Pisa lean?

- Tower of Pisa came into the story in **1173, when construction began.**
- Due to the soft ground, it had **begun to lean by the time its builders got to the third storey, in 1178**.
- **Shifting soil** had destabilized the tower's foundations.
- Over **the next 800 years**, it became clear the **55-metre** tower wasn't just leaning but was **actually falling** at a rate of **1-2mm/year**.

- Today, the Leaning Tower of Pisa is **more than 5m off perpendicular.**

- Its architect and engineer tried to **correct this by making the remaining stories shorter on the uphill side** – but to no avail. It kept leaning more and more.

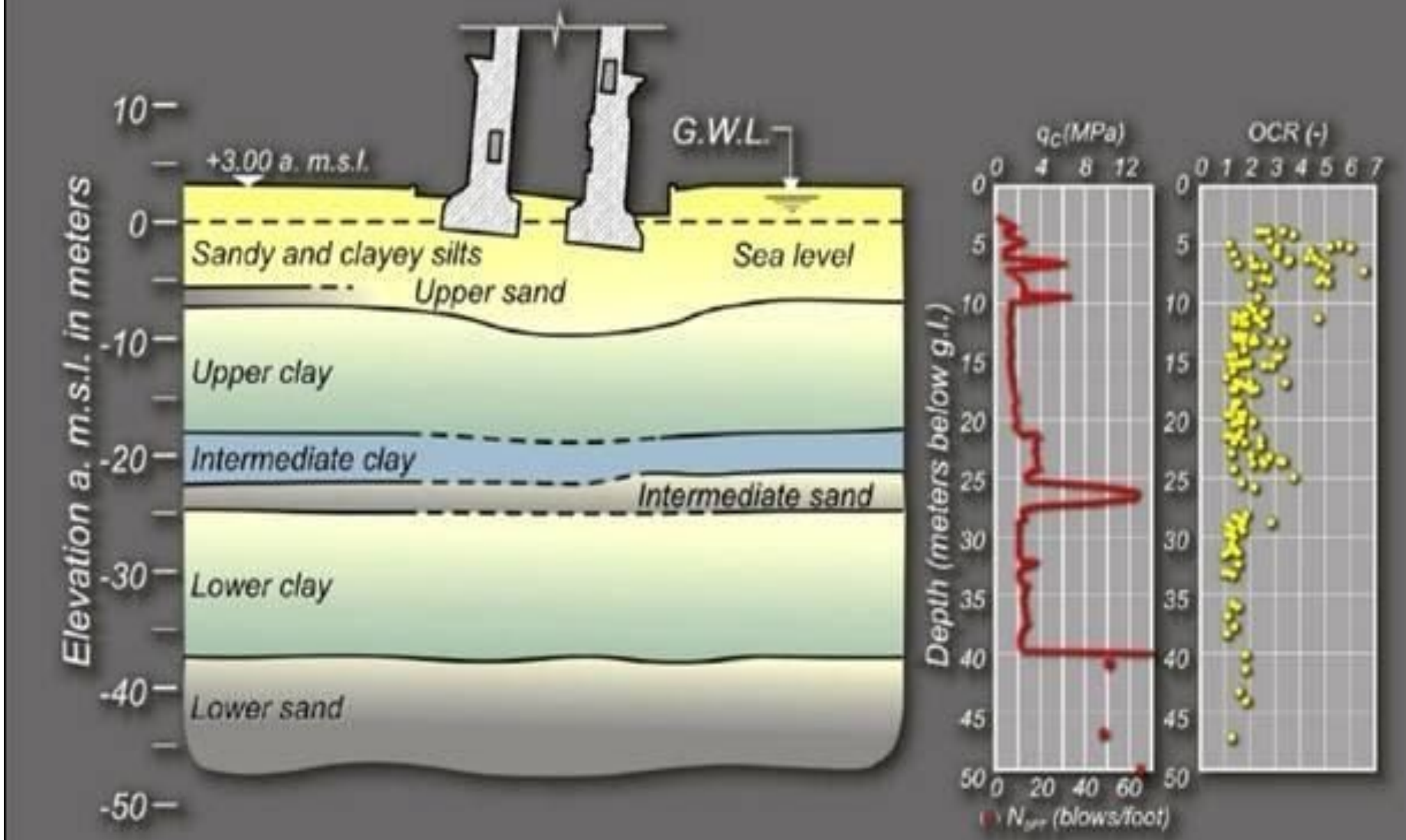
- Lean, **first noted when three of the tower's eight stories** had been built, resulted from the foundation stones being laid on soft ground consisting of **clay, fine sand**.

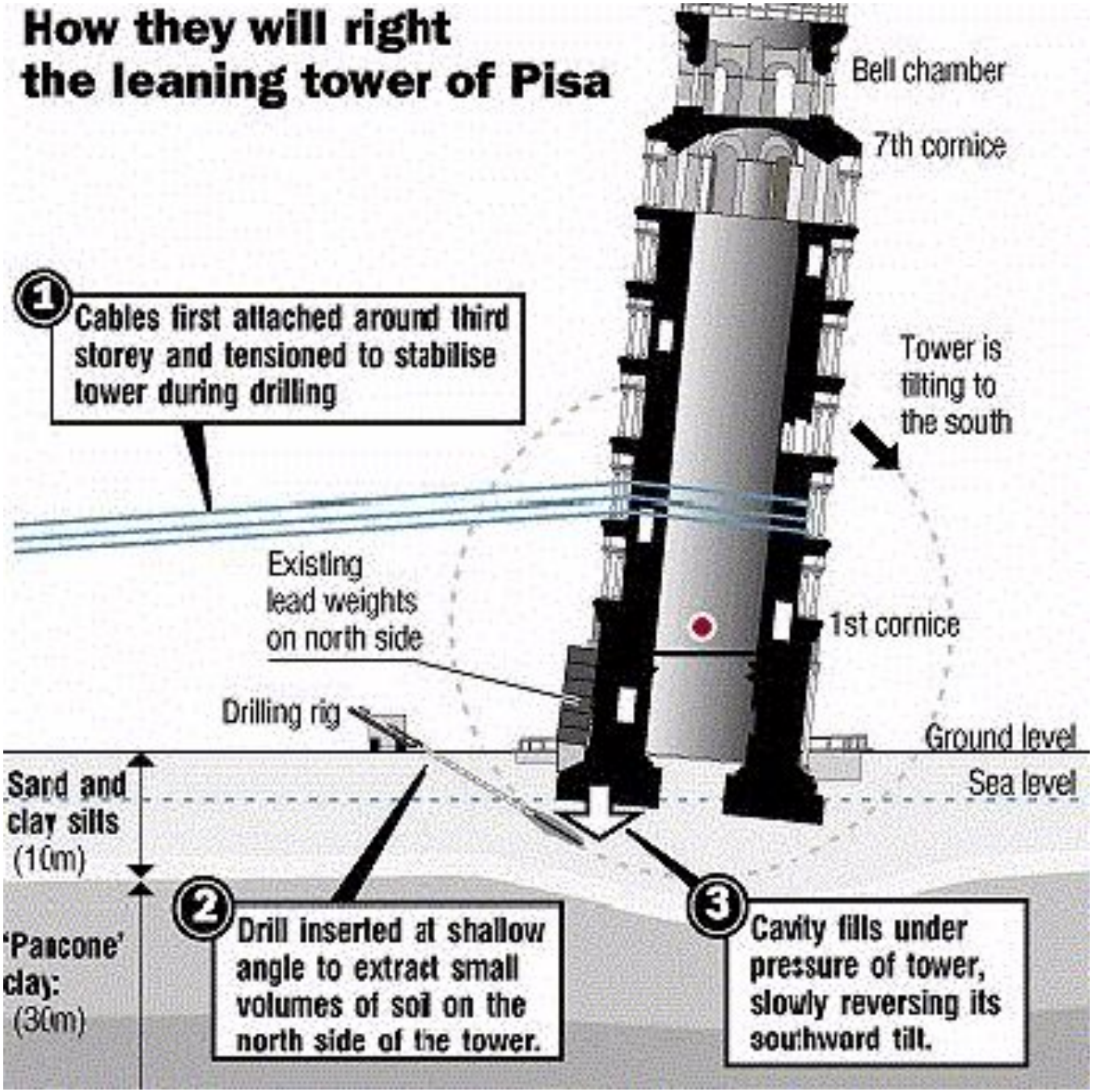
- Next stories were built **slightly taller on the short side of the tower** in an attempt to compensate for the lean. However, the weight of the extra floors caused the **edifice** to sink further and lean more.

Leaning Tower of Pisa



SUBSOIL PROFILE AND SOIL PROPERTIES




How they will right the leaning tower of Pisa
Bell chamber
7th cornice
1 Cables first attached around third storey and tensioned to stabilise tower during drilling
Tower is tilting to the south
Existing lead weights on north side
1st cornice
Drilling rig
Ground level
Sea level
Sand and clay silts (10m)
'Pancone' clay: (30m)
2 Drill inserted at shallow angle to extract small volumes of soil on the north side of the tower.
3 Cavity fills under pressure of tower, slowly reversing its southward tilt.

Historical development

Karl Von Tezaghi (1883-1963): Called Father of Geotechnical Engineering.

- **Set the tone and direction of the profession,** and
- **promoted it as a legitimate branch of Civil Engineering**.

Born & Interest:

- **Prague**, part of Austria.
- Undergraduate in **ME**
- Served in CE firms, **specialized in RCC**
- **Ph D in RCC**, special interest in Geology
- Focused attention on rational design on **earth work** and **foundation**



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Karl Terzaghi



The Engineer as Artist

Richard E. Goodman
Foreword by Ralph Peck

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Historical Development

- **In 1916**, **accepted teaching** as profession in **Istanbal** at Imperial School of Engineering, subsequently at Robert College.

- **Research on** **behavior of soils** including **piping failures** in sand under dams and **settlement on clays**.

- The **work on clay,** lead to his **theory of Consolidation**.

Historical Development

Publications:

- First comprehensive book, '**Erdbaumechanik auf Budenphysikalicher Grundlage'** (**The Mechanics of Earth Construction Based on Soil Physics, Terzaghi 1925a)** published in Viena.

- A series of English Articles in American Journal of Engineering News Record. (Terzaghi 1925b)

- A paper in the Journal of the Boston Society of Civil Engg. (Terzaghi 1925c).

Historical Development

-In 1929, **returned to Vienna** and began to serve as a Prof at a Tech University, then to **USA**, accepted **Professorship at Harvard University.**

- Continued teaching, lecturing and consulting.

- Terzaghi came at right time with necessary skills, rising the subject to and establish Geotechnical Engineering as a rational and legitimate branch of CE.

Requirements of Geotechnical Engineers

Requirements of Geotechnical Engineers in any Civil Engineering Projects.

Geotechnical Engineering Knowledge

- Virtually **all the civil engineering projects** like buildings, bridges, dams, tunnels etc **require geotechnical engineering knowledge in design and construction.**

Avoidance of Failures

- Geotechnical Engineers **try to avoid failures** like **undermining houses**, **dam failure**, **settlement beyond limit** etc.

Failure of structure by undermining



Requirements of Geotechnical Engineers

Assessment of Subsurface Conditions

- Geotechnical Engineers **use a variety of techniques to assess the subsurface conditions** like **field reconnaissance**, **drilling exploratory boring**, **testing sample in the lab**, **monitoring ground instruments** etc.

Involvement in Construction

d. Geotechnical Engineers **also actively involve in constructions**, like reinforcing soils by geogrids, geotextile etc.

So far we have to learned the followings :

- **Definition.**
- Importance.
- **Issues to be addressed**.
- Design Process.
- Leaning Tower of Pisa
- Father of Geotechnical Engineering
- **Requirement of Geotechnical Engineering in any Civil Engineering Project.**

Thank You