

FUNDAMENTALS OF GEOTECHNICAL ENGINEERING

Lesson 1. Introduction. Purpose of Geotechnical Engineering.

Jesús M^a Hernández
M^a Helena Fernandes
Department of Mechanical Engineering
Faculty of Engineering



image by Elmer Romero from Pixabay under Pixabay License

OCW2020



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.



LESSON OVERVIEW

This lesson provides an introduction to geotechnical engineering. First, its purpose and relationship with Soil Mechanics and Rock Mechanics are explained. Then, different engineering areas where Geotechnical Engineering is necessary are shown: building, underground works, tunnels, etc. After that, the evolution of the regulations in this area in Spain is presented. Finally, the classical example of the leaning tower of Pisa is explained.

LEARNING OUTCOMES

On completion this lesson, the student will be able to:

- ✓ Know the purpose of Geotechnical Engineering.
- ✓ Know the different engineering areas where Geotechnical Engineering is necessary.
- ✓ Know the regulations where Geotechnical Engineering is used.
- ✓ Know and understand the behaviour of the leaning tower of Pisa.



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.



CONTENTS

1. Geotechnics.
2. Site exploration and characterization.
 - Buildings.
 - Underground works.
 - Tunnels.
 - Roads, railways, airports, ports.
 - Retaining structures.
 - Slope stability.
3. Regulations.
4. Case: the leaning tower of Pisa.



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

GEOTECHNICS

GEOTECHNICS



Soil Mechanics

Rock Mechanics



Main purpose:

Site exploration and characterization for:

- Buildings.
- Underground works, tunnels.
- Roads, railways, airports.
- Retaining structures.
- Slope stability.

Soil is a natural aggregate of mineral grains that can be separated by such gentle mechanical means as agitation in water.

Rock is a natural aggregate of minerals connected by strong and permanent cohesive forces that, in order to undergo significant changes in its structure when water is present, it needs a period of time longer than the lifespan of a building.

Technical Building Code. Foundations.

1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (I). BUILDINGS.

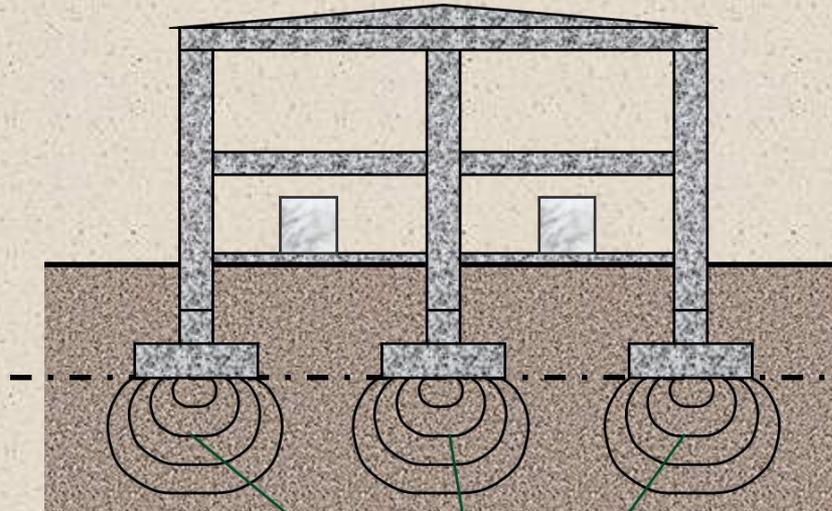
✚ Any building is tied to the ground in some manner using foundations. Its main purpose is to transmit the structural loads avoiding, at the same time, the collapse of this soil/rock. The design of these foundations depends on the characteristics of the soil: density, porosity, presence of water ...

✚ Therefore, it is highly recommended to explore and characterize the underlying soil/rock to ensure a proper building performance.

✚ Anyway, new problems can arise after construction, as in Mexico city.



Mexico city is sinking 10 cm/year.



Supporting plane of the foundation

Subsurface stresses



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (II). UNDERGROUND WORKS.

✚ Underground works are excellent examples of the need for site exploration and characterization. These civil engineering works are developed into the soil/rock and in these cases, excavation and support are critical phases, which clearly depend on the properties of soil/rock. Some examples of underground works are mining, hydropower plants, tunnels for roads, railways, metro ...

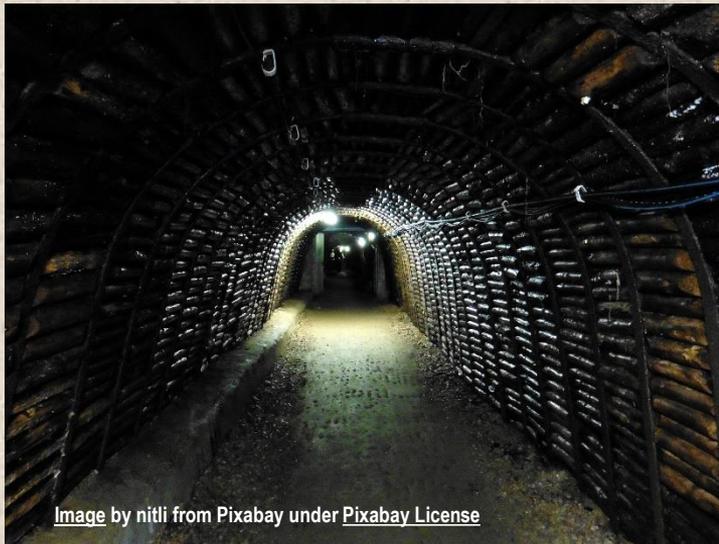


Image by nitli from Pixabay under Pixabay License

Mining



Image by Bishnu Sarangi from Pixabay under Pixabay License

Hydropower plant

1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (III). UNDERGROUND WORKS: TUNNELS.

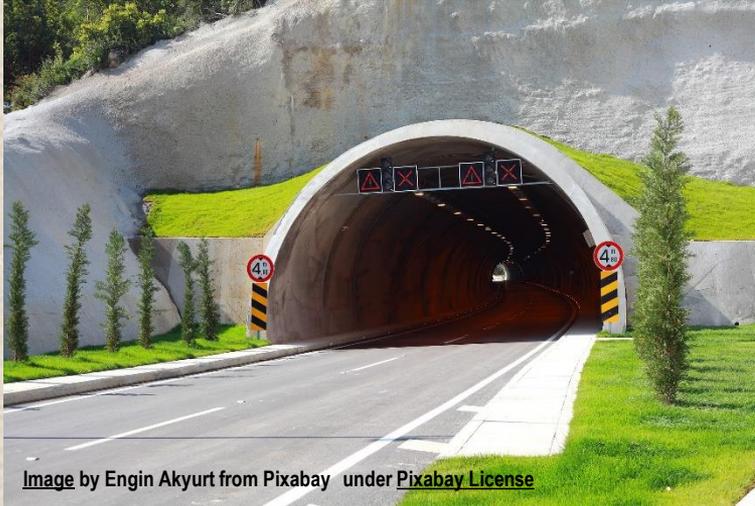


Image by Engin Akyurt from Pixabay under Pixabay License

Tunnel in road

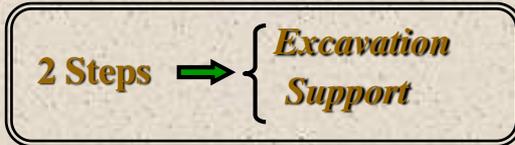


Image by herry wibisono from Pixabay under Pixabay License

Metro



Computer animation: tunnel construction using TBM (tunnel boring machine).

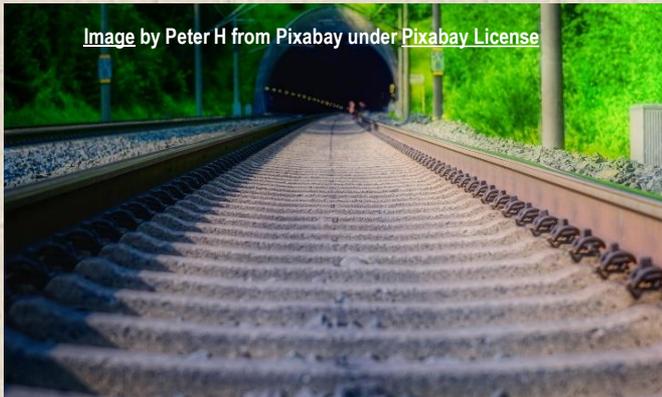


Tunnel construction using the New Austrian Tunneling Method (NATM).

1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (IV). ROADS, RAILWAYS, AIRPORTS, PORTS.

- ✚ In fact, all the civil engineering structures are in contact with the ground in different ways:
 - ✚ As support of the structure/work, as in buildings, roads, railways and ports infrastructures.
 - ✚ By retaining that soil/rock to prevent rockfalls and landslides.



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (V). ROADS, RAILWAYS, AIRPORTS, PORTS.

⚡ If the characteristics of that soil/rock are not determined in a precise way, collapses can occur, with material and personal damages.

⚡ In civil engineering structures, those damages can be huge.



Video: Failure of Cancura Bridge (due to an inadequate soil characterization).



Image by Miroslav M. from Pixabay under Pixabay License

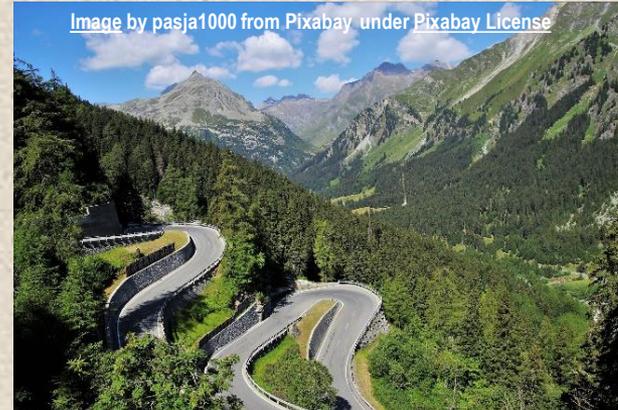


Image by pasja1000 from Pixabay under Pixabay License



Image by Manfred Antranias Zimmer from Pixabay under Pixabay License



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (VI). RETAINING STRUCTURES.

- ✚ Retaining structures are necessary in many civil engineering works. Their purpose is to keep the soil/rock stable next to roads, buildings, etc.
- ✚ Can you imagine the result of a collapse?



Image by StockSnap from Pixabay under Pixabay License



Image by Albrecht Fietz from Pixabay under Pixabay License



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.

SITE EXPLORATION AND CHARACTERIZATION (VII). SLOPE STABILITY.

✚ In these two photographs, we can see the result of instability in soils. Could it have been prevented?



 Video: Landslide/rockfall in Ondarroat (Bizkaia)



 Video: Massive slides.

Image from the United States Geological Survey (USGS) – Public domain
<https://commons.wikimedia.org/w/index.php?curid=1810936>



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.



GEOTECHNICAL ENGINEERING. REGULATIONS.

- **EUROPE.** Eurocode 7: Geotechnical Design. Part 1: General rules. Part 2: Ground investigation and testing.
 - ▶ Part 1 is issued in 2004. EC-7 collects standard practices in geotechnical engineering.
- **SPAIN.** Technical Building Code. Foundations. (C.T.E. DB-SE-Cimientos, 2006):
 - ▶ It is the Spanish document equivalent to the EC-7. Both EC-7 and TBC provide similar procedures and calculation methods, and TBC also includes national annexes.
- **General Regulation of Roads** - Reglamento General de Carreteras.
 - ▶ This is the specific document for roads. One important part is devoted to soil analysis.
- **BASQUE COUNTRY.** Road Structure Regulations - Norma dimensionamiento de firmes (2012).
 - ▶ This document adapts the Spanish one. Some chapters are devoted to ground characterization, identification of soils and available materials.



1. INTRODUCTION. PURPOSE OF GEOTECHNICAL ENGINEERING.



THE LEANING TOWER OF PISA

- Construction: 1173 - 1370.
- ▶ Height (axis): 58.4 m.
- ▶ Base diameter: 19.58 m.
- ▶ Total weight: 141640 kN.
- Hollow cylinder.
- Wall thickness: from 4.1 m to 2.7 m.
- ▶ Maximum tilt: 5.44° .
- ▶ Settlements: from 1.86 m to 3.75 m.
- Stabilized since 1999.



Image by Mark Skillen from Pixabay under Pixabay License



Why does the leaning tower of Pisa lean?
By John Burland



BBC Earth Lab. Why does the leaning tower of Pisa lean?

