GEOTECHNICAL ENGINEERING

Hydrogeological engineering MSc.

2018/19 II. semester

COMMUNICATION FILE OF THE COURSE

University of Miskolc
Faculty of Earth Science and Engineering
Institute of Environmental Management

Contents

1. Course description, Responsible Instructor, Number of lectures and seminars, Credits

<table>
<tr><td rowspan="2">Course Title: Geotechnical engineering

Instructor: Dr. Viktoria Mikita, assistant professor</td><td>Code: MFKHT720025

Responsible department/institute: Department of Hydrogeology and Engineering Geology</td></tr>
<tr><td>Type of course: Compulsory</td></tr>
<tr><td>Position in curriculum (which semester): 2</td><td>Pre-requisites (if any): MFKHT710008</td></tr>
<tr><td>No. of contact hours per week (lecture + seminar): 2+1</td><td>Type of Assessment (examination/ practical mark / other): exam</td></tr>
<tr><td>Credits:4</td><td>Course: full time</td></tr>
<tr><td colspan="2">Course Description:
The students will be familiar with the basic concepts of geotechnical engineering, with the principles of designing and with the construction methods of different buildings and objects.
The short curriculum of the subject:
Review of foundation studies. Legal and authorization background. EUROCODE 7. Concrete as building material. Engineering design, stresses and loads. Design of concrete and reinforced concrete structures. Design of retaining walls. Jet-grouting. Building of slurry wall. Digging/excavations. Building of water-supply and channeling networks. Underground structures. Utility ducts. Hydraulic engineering structures: river walls, dams, controlling objects.
Practical work: self-made solutions of simple case-study problems</td></tr>
<tr><td colspan="2">Compatencies to evolve:
Knowledge:
T3 – Thorough understanding of the concepts and principles of engineering geology and civil engineering and their processes.
T6 – Knows basic requirements of environmental protection, quality control, consumer protection, product liability, equal access approach, occupational health and safety, technical and economic legislation and engineering ethics.
T7 – Have knowledge of a wide range of problem-solving techniques for research or academic work.
T8 - Have general and specialist management skills to manage complex design work.
Ability:
K2 – Ability to process information from the knowledge frontiers of professional experience of the discipline, ability of problemsolving, and interpreting hydrogeological issues.
K4 – Ability to effectively apply water production techniques and knowledge of modern well construction technologies.
K7 – Prepared to identify and solve geotechnical problems.
K8 – Able to solve mining and pit dewatering problems at a high level
K10 – Prepared to effectively apply relevant national and European professional, environmental and conservation legislation
K12 – Ability to work in compliance with EU legislation, to cooperate with foreign partners to solve the tasks required by the EU Water Framework Directive
K13 – The ability to independently participate in and manage research, development and expertise in the field of hydrogeology
K14 – Ability to lead and participate in complex design work and project management in water management and water supply
K15 - Ability to solve complex problems in a flexible way through creative problem solving, to work in a team, to think and cooperate effectively with representatives of other disciplines (e.g. environment, quality, consumer protection, human health, construction, etc.)
Attitude:
A1 – Open-minded and receptive, active in learning about professional and technological methodological developments in the fields of geosciences and environmental engineering, and in solving geological problems from an engineering perspective</td></tr>
</table>

A2 – Open and sensitive to problems and sustainability issues related to the environment and its elements
A3 – Have the motivation to work in a changing work, geographical and cultural contexts
A4 – Deep commitment and professional solidarity
A5 – It is committed to lifelong learning, diversity and values
A6 – Respect and act in accordance with the ethical principles and written rules of work and professional culture, and be able to adhere to them when managing small teams
A7 – Adhere to and comply with health and safety, environmental protection, quality assurance and control requirements.
A8 – Characterised by intuition, consistency and a willingness to learn.
A9 – In addition to his technical and engineering background, he also has an interest in science.
Autonomy and responsibility:
F1 – Act independently and proactively to solve professional problems.
F2 – Have a responsible attitude towards the environment.
F3 – Takes decisions independently and in consultation with other disciplines (mainly legal, economic, energy and environmental), for which it takes responsibility.
F4 – In decisions, takes into account the principles and application of environmental protection, quality, consumer protection, product liability, equal access, health and safety at work, technical, economic and legal regulation and engineering ethics.
F5 – Committed to sustainable natural resource management practices.
F6 – He/she is responsible claims in expert oppinions, professional judgements and for the work carried out under his/her supervision.

Assessment and grading:

Students will be assessed with using the following elements.

Attendance:	15 %
Short quizzes	10 %
Midterm exam	40 %
Final exam	35 %
Total	100%

Grading scale:

% value	Grade
90 -100%	5 (excellent)
80 – 89%	4 (good)
70 - 79%	3 (satisfactory)
60 - 69%	2 (pass)
0 - 59%	1 (failed)

Compulsory or recommended literature resources:

- Aysen A.: Soil mechanics, Basic concepts and engineering applications, Taylor&Francis, 2002.
- Jonathan Knappett, R.F. Craig: Craig’s Soil Mechanics, Eighth Edition, 2012.
- Charles W. W. Ng., Menzies B.: Advanced unsaturated soil mechanics and engineering, Spon Press, 2007.
- Jiang M., Liu F., Bolton M.: Geomechanics and geotechnics: from micro to macro, Taylor and Francis 2010.
- Orr T. L. L., Farell E. R.: Geotechnical design to EUROCODE 7, Springer-Verlag, London 1999.
- I. Vanícek, M. Vanícek: Earth Structures. Springer, ISBN: 978-1-4020-3963-8, 2008. pp. 497-606

2. Topics of the subject (by hours)

Geotechnical engineering.
Topics of the subject (Plan of the semester)
Spring semester
Hydrogeological engineering MSc, 2. semester

Week	Topic of lecture and seminar
02.14.	Introduction (requirements, thematic, time schedule, Geotechnical Engineering)
02.21.	Earth pressures and calculations I.
02.28.	Earth pressures and calculations II.
03.07.	Retaining structures
03.14.	Shallow foundations
03.21.	Consultation
03.28.	Deep foundations
04.04.	Geotechnical monitoring
04.11.	Site-investigations
04.18.	Stability of self-supporting soil masses
04.25.	Consultation
05.02.	Mid-term exam 1st chance
05.09.	Rector holiday
05.16.	Mid-term exam 2nd chance

3) Sample of a mid-term exam

GEOTECHNICAL ENGINEERING
MID-TERM EXAM
2018-05-07

1. Calculate the results of following examples!

- Geostatic pressure, if ρ = 1,983 g/cm^3, h = 4,7 m

- Passive earth pressure, if σ_z = 188 kN/m^2, φ = 25,7º, c = 18 kPa

- Compression module, if $\Delta\varepsilon$ = 8,3 %, $\Delta\sigma_z$ = 213 kPa

- Earth pressure at rest, if φ = 27º, c = 18 kPa, σ'_z = 145 kN/m^2, $\sigma'_{z,\,max}$ = 287 kN/m^2

- K_0, K_a and K_p, if φ = 31,1º

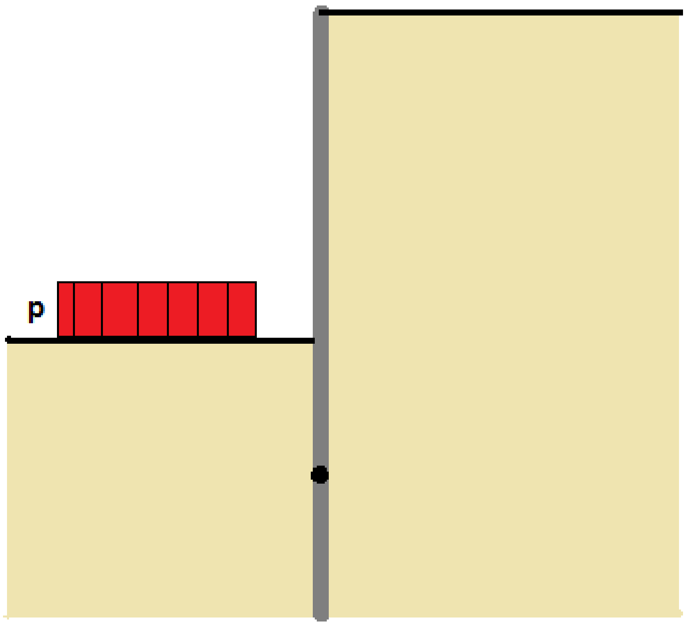
- Pressure under the point foundation, if B = 2,4 m, L = 2,7 m, F = 2 954 880 N

- Effect of external stress, if p = 456 kN/m^2, σ_z / p = 0,757

- Strain in X direction, if σ_z= 677 kPa , σ_x= 415 kPa, σ_y= 369 kPa, E= 3,8 MPa, υ= 0,31

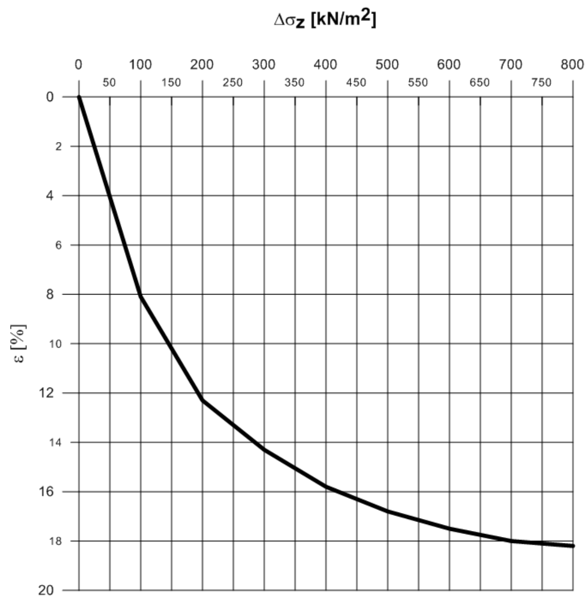
2. Define (calculate and draw) the stress distribution around the given sheet pile after the following data!

H = 5,1 m (depth of excavation)
D = 4,9 m (driving depth)
z = 2,7 m (point of rotation, above the bottom of the sheet pile)
ρ = 1,975 g/cm^3
p = 50 kN/m^2
Φ = 21°
c = 21 kPa

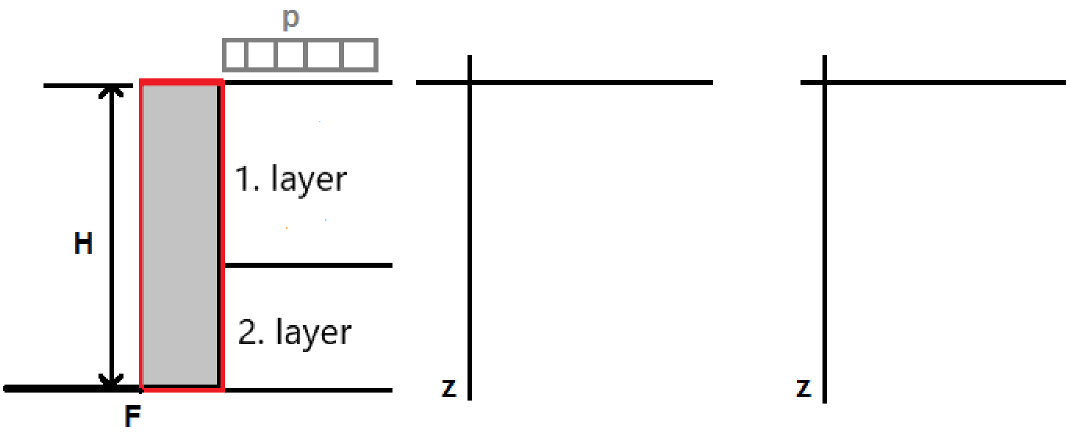


3. A bridge pier is standing on a 5 x 5 m point foundation. Calculate the settlement of it during the phases of construction work!
The previous site investigations show that there is only on compressible layer under the surface which has a 3,3 m thickness. After the oedometric test the compression curve is given (find below).
The construction is divided for four phases and during each phases there is an additional external force. (find below) At the end the total force will be 17,5 MN on the foundation.

1. phase: F_1 = 1,875 MN
2. phase: F_2 = 3,125 MN
3. phase: F_3 = 5,000 MN
4. phase: F_4 = 7,500 MN



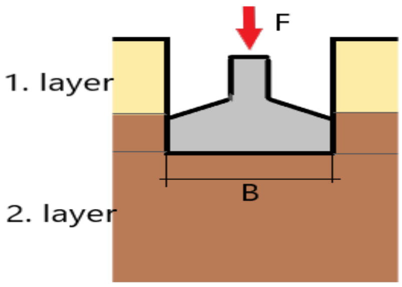
4. Define the active earth pressure distribution next to the retaining structure and the resulting force of active earth pressure and its acting depth!



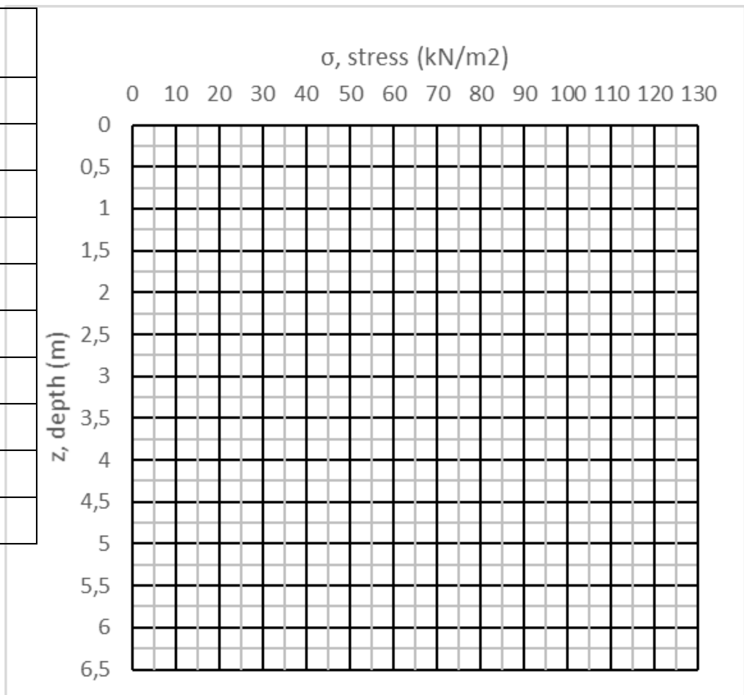
	soil type	h_i (m)	ρ_i (g/cm3)	ϕ_i (°)	c_i (kN/m2)
1. layer	clay	4,3	1,983	10	69
2. layer	silt	2,7	2,016	12	31
p =	175 kN/m2				

5. Define the depth of limit of calculation (m_0) in the following situation!

ρ_1 [g/cm^3] = 1,850
ρ_2 [g/cm^3] = 1,930
F [kN] = 610
B [m] = 2,4
L [m] = 2,4
1. layer = 0,0 - 2,0 m
2. layer = 2,0 - 6,0 m
Found. level = 2,5 m



$z_{surf.}$ [m]	$z_{found.}$ [m]	σ_{z0} [kPa]	$\sigma_{z0}/5$ [kPa]	z/B [-]	σ_{zi}/p [-]	σ_{zi} [-]
0,0	-					
2,0	-					
2,5	0,00					
3,0	0,25					
3,5	0,75					
4,0	1,25					
4,5	1,75					
5,0	2,25					
5,5	2,75					
6,0	3,25					



Key of mid-term exam

GEOTECHNICAL ENGINEERING
MID-TERM EXAM
2018-05-07

1. Calculate the results of following examples!

- Geostatic pressure, if ρ = 1,983 g/cm^3, h = 4,7 m

  σ_z = 93,2 kN/m^2

- Passive earth pressure, if σ_z = 188 kN/m^2, φ = 25,7°, c = 18 kPa

  σ_{xp} = 533,2 kN/m^2

- Compression module, if $\Delta\varepsilon$ = 8,3 %, $\Delta\sigma_z$ = 213 kPa

  E = 2,56 MPa

- Earth pressure at rest, if φ = 27°, c = 18 kPa, σ'_z = 145 kN/m^2, $\sigma'_{z,\,max}$ = 287 kN/m^2

  σ_{x0} = 111,6 kN/m^2

- K_0, K_a and K_p, if φ = 31,1°
  K_0 = 0,483
  K_a = 0,319
  K_p = 3,137

- Pressure under the point foundation, if B = 2,4 m, L = 2,7 m, F = 2 954 880 N

  σ_{z0} = 456 kN/m^2

- Effect of external stress, if p = 456 kN/m^2, σ_z / p = 0,757

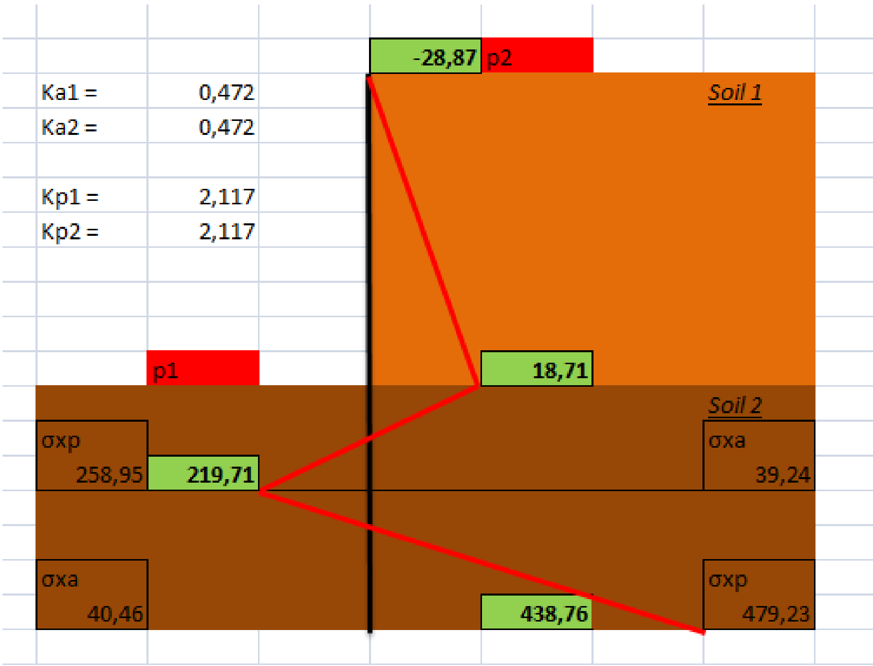
  σ_{z1} = 345,2 kN/m^2

- Strain in X direction, if σ_z= 677 kPa , σ_x= 415 kPa, σ_y= 369 kPa, E= 3,8 MPa, υ= 0,31

  ε_x = 2,39 % (= 0,0239)

2. Define (calculate and draw) the stress distribution around the given sheet pile after the following data!

The units of pressure results are in kN/m^2.



3. A bridge pier is standing on a 5 x 5 m point foundation. Calculate the settlement of it during the phases of construction work!
The previous site investigations show that there is only on compressible layer under the surface which has a 3,3 m thickness. After the oedometric test the compression curve is given (find below).
The construction is divided for four phases and during each phases there is an additional external force. (find below) At the end the total force will be 17,5 MN on the foundation.

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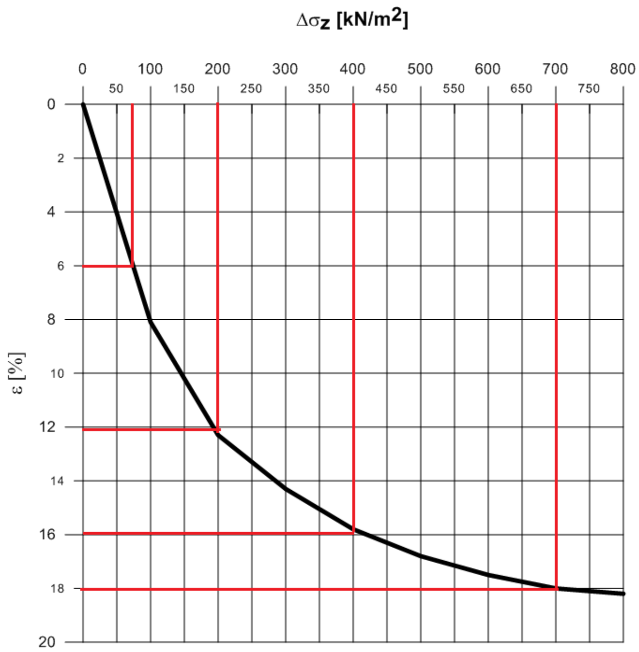


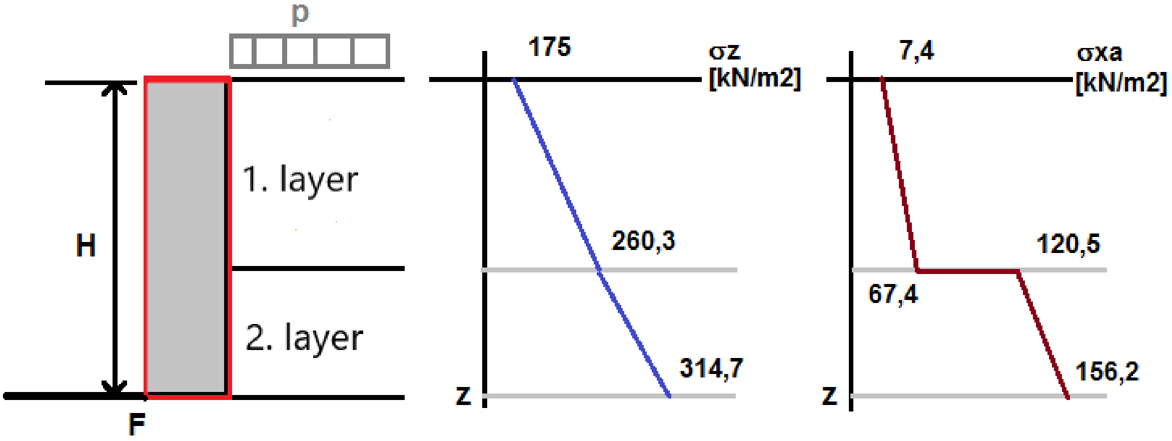
σ_{z1} = 75 kN/m^2
σ_{z2} = 125 kN/m^2
σ_{z3} = 200 kN/m^2
σ_{z1} = 300 kN/m^2

h_1 = 3,3 m	**$\Delta\varepsilon_1$ = 0,06**	**s_1 = 0,198 m**
h_2 = 3,102 m	**$\Delta\varepsilon_2$ = 0,06**	**s_2 = 0,186 m**
h_3 = 2,916 m	**$\Delta\varepsilon_3$ = 0,04**	**s_3 = 0,117 m**
h_4 = 2,799 m	**$\Delta\varepsilon_4$ = 0,02**	**s_4 = 0,056 m**

h_{end} = 2,743 m

Σs = 0,557 m

4. Define the active earth pressure distribution next to the retaining structure and the resulting force of active earth pressure and its acting depth!



ze = 4,81m (z1 = 2,15m; z2 = 2,85m; z3 = 5,65m; z4 = 6,1m)
Fe = 534,5 kN (F1 = 31,9 kN; F2 = 129,1 kN; F3 = 325,4 kN; F4 = 48,2 kN)

	soil type	h_i (m)	ρ_i (g/cm3)	ϕ_i (°)	c_i (kN/m2)
1. layer	clay	4,3	1,983	10	69
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5. Define the depth of limit of calculation (m_0) in the following situation!

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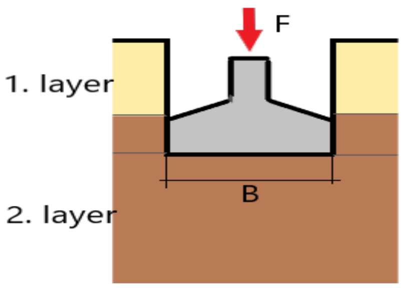
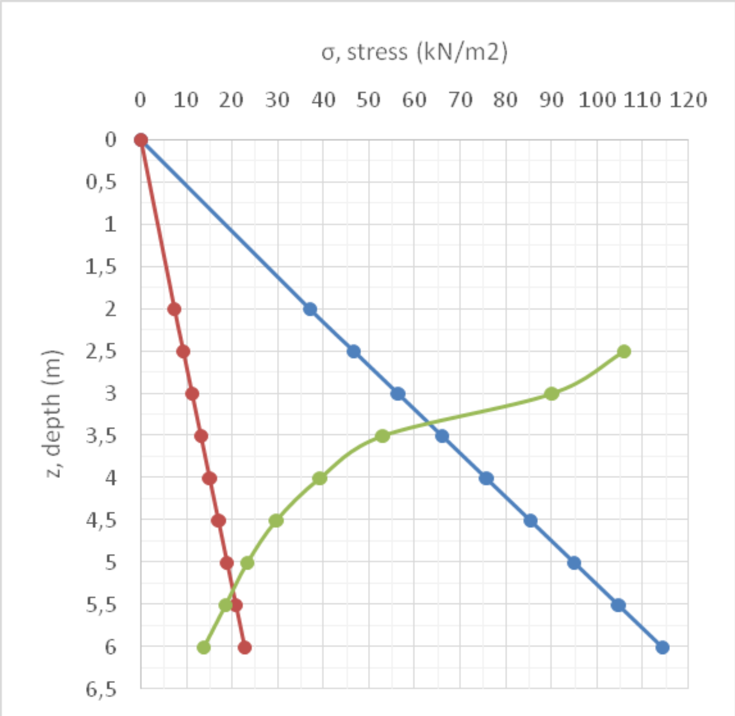


$Z_{surf.}$ [m]	$z_{Found.}$ [m]	σ_{z0} [kPa]	$\sigma_{z0}/5$ [kPa]	z/B [-]	σ_z/p [-]	σ_{zi} [kPa]
0	-	0	0	-	-	-
2	-	37,00	7,40	-	-	-
2,5	0	46,65	9,33	-	-	105,9
3	0,25	56,30	11,26	0,10	0,85	90,0
3,5	0,75	65,95	13,19	0,31	0,50	53,0
4	1,25	75,60	15,12	0,52	0,37	39,2
4,5	1,75	85,25	17,05	0,73	0,28	29,7
5	2,25	94,90	18,98	0,94	0,22	23,3
5,5	2,75	104,55	20,91	1,15	0,18	18,5
6	3,25	114,20	22,84	1,35	0,13	13,8



The depth limit of calculation is m_0 = 5,4 m

4) Sample of an exam

MISKOLCI EGYETEM
Környezetgazdálkodási Intézet
Hidrogeológiai-Mérnökgeológiai
Intézeti Tanszék

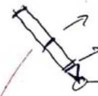
UNIVERSITY OF MISKOLC
Institute of Environmental Management
Department of Hydrogeology and
Engineering Geology

GEOTECHNICAL ENGINEERING
Exam
2018-06-19

92 / (5)

Answer shortly (10-15 sentences) the following questions! If possible, draw a diagram, or a curve for demonstration!

1. *Describe the Geotechnical Categories (GC's), based on the EUROCODE 7! (examples, design requirements, design procedure)*
2. *Describe the passive earth pressures after Rankine's theory in case of cohesive soils ($c>0$, $\Phi>0$)*
3. *How do you use the method of Block when evaluating slope stability? What are the main forces around the soil wedge (draw them)?*
4. *Show me the CPT(u) test! (Parts of it, measured parameters, handling of its results, advantages vs. disadvantages)*
5. *When do we have to use Deep foundations? Show me on a draw the technological steps of the construction of a CFA pile!*



4. CPT → cone penetration test

- it is a statical, indirect, in-situ measurement
- in this method, we have to press a standard cone into the soil with a relatively thin metal rod, and we measure the force for pressing down
- basic idea that we have to separate 3 parameters; there are [u] - pore press by water; [f_s] - skin friction; [q_c] - resistivity of the top of cone

Advantage: easy to make it; relatively cheap; nowadays professions have a lot of experience for this method, so we can use it exactly; we can get several inform with this measurem.

Disadv.: we can't use it in hard soil (debris, marga, gravel..)

Parameters

[u] → difference between granular and cohesive soil

[f_s/q_c] → layer boundary, soil type

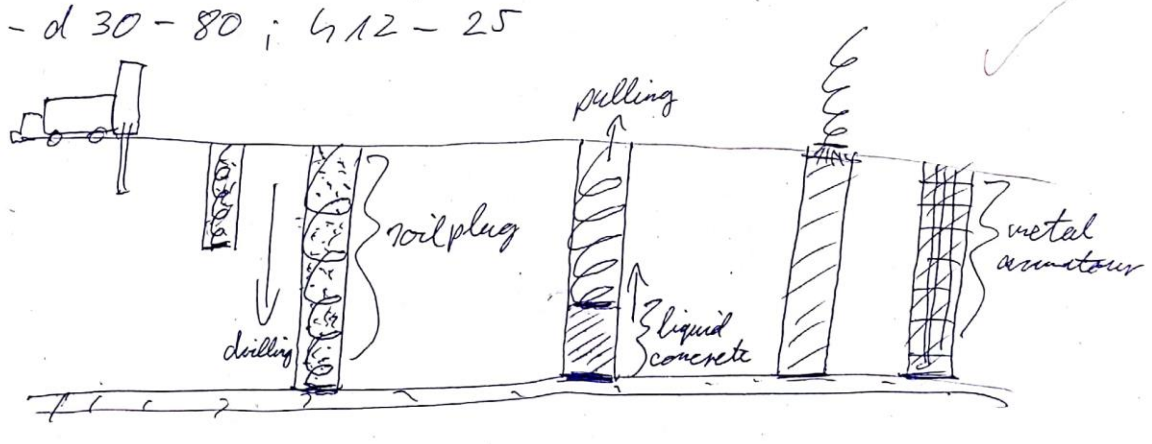
[q_c] → main mechanical inform.; density (and ~~expected~~ approx. to cohesion) carrying capacity of pile

Parts: sonde (measure); armature (for pressing); can be computer (for diagram)

5. Deep foundation

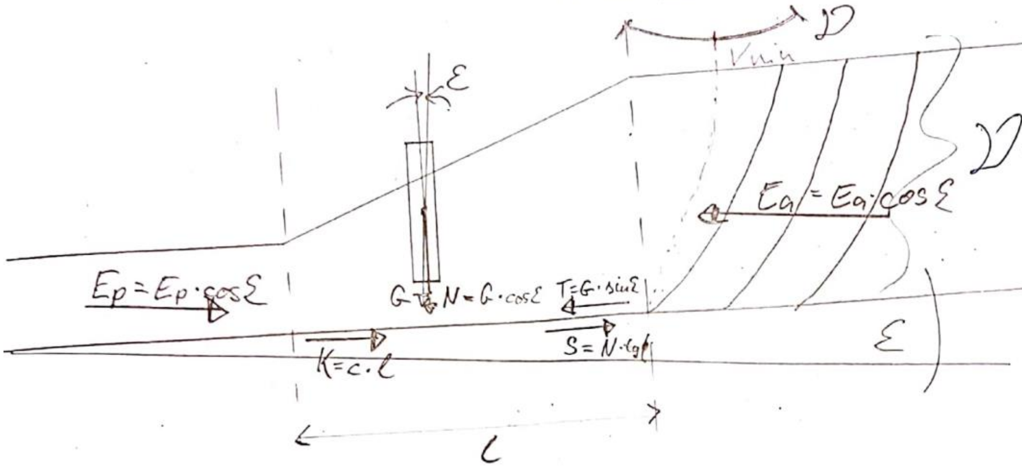
When:
- if the stabil, loadable layer in the deep for building or any geot. works
- if dewatering in shallow foundation have much more cost
- if slipping or ~~unable~~ unfavorable sedimentation takes place in case of shallow f.
- if can be cavitation (for example bridge pile)
- if the deep found. is more economical than shallow

CFA pile
- we use a spiral shape drill
- the soil plug is retaining the wall of borehole
- the concrete added across the drilling rod
- the pressure (from added concrete) and pulling force displacing the soil plug
- ~~arm~~ metal armatour into the liquid concrete
- d 30 − 80 ; l 12 − 25



Block method

- we investing a unit, what is separated 3 parts
- the upper (active E_a) and lower (E_p) is defined with forces, and we invest the equilibrium of the middle part
- after defining the forces, we searching for a slope stability factor, especially were is its minimum [ ] ν_{min}

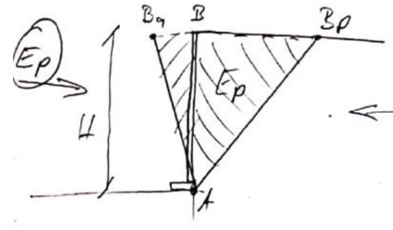


$$\nu = \frac{E_p + K + S}{E_a + T}$$

$$\nu = \frac{K + S + E_p}{T + E_a} = \frac{c \cdot l + N tg\phi + E_p \cos\varepsilon}{G \sin\varepsilon + E_a \cdot \cos\varepsilon} \Bigg\} \nu_{min} = ?$$

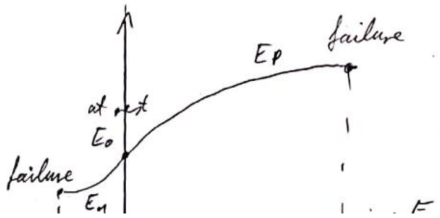
Passive earth pressure

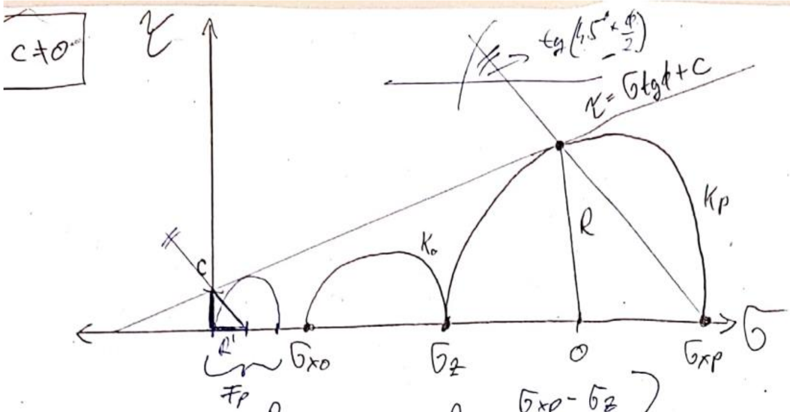
- passive e.p. acting, when a force pressing the wall to the background soil
- relatively high motion mobilising the passive earth p.
- it ~~is~~ can be a useful, retaining force in geotechnic [retaining limits]



$E_a : E_0 : E_p = 0.5 : 1 : 5$

relatively high displacing





$\sigma_{xp} \rightarrow \sin\phi = \dfrac{R}{O} \rightarrow R = \dfrac{\sigma_{xp} - \sigma_z}{2}$

$\rightarrow O = \dfrac{\sigma_z + \sigma_{xp}}{2}$

$\sin\phi \, O = R$

$\sin\phi \, \sigma_z + \sin\phi \, \sigma_{xp} = \sigma_{xp} - \sigma_z$

$\sigma_z + \sin\phi \, \sigma_z = \sigma_{xp} - \sin\phi \, \sigma_{xp}$

$\sigma_z (1 + \sin\phi) = \sigma_{xp} (1 - \sin\phi)$

$$\left| \sigma_{xp} = \sigma_z \underbrace{\left(\frac{1 + \sin\phi}{1 - \sin\phi} \right)}_{K_p} \right|$$

$F_p \rightarrow tg\left(45° + \frac{\phi}{2}\right) = \dfrac{R'}{c}$

$c \cdot tg\left(45° + \frac{\phi}{2}\right) = R'$

$F_p = 2R$

$$\left\| 2c \, \underbrace{tg\left(45° + \frac{\phi}{2}\right)}_{\sqrt{K_p}} \right\|$$

$$\underline{\sigma_{xp} = \sigma_z K_p + 2c\sqrt{K_p}}$$

1) EC7 Geotech. categories: we define 3 cat

	1	2	3
Buildings	small buildings	usual build.	large b.
subsoil	favorable	usual	unfavorable
environment	without effect	normal eff.	spec. eff., have to deal
risk	∅	average	huge risk
test	rutine	labor, field tests	special process
planning	rutine planning	average p.	special planning
monitoring	simple	usual monitoring	special measure
deep found	∅	can be	special and new tech.
example	1-2 floors buildings; 250 kN load; 100 kN/m load; pit or ret. wall till 2 m	earthwork; ground anchoring; pit, retaining wall which greater than class 1	dewatering; landfill; very huge buildings

5. Others

During the exams using of mobile phone, smart devices, notes or copies of books are not acceptable. Violation of the examination order entails the suspension and completion of the writing of the exam.