GEOTECHNICAL ENGINEERING

Environmental engineering MSc.

2023/24 II. semester

COMMUNICATION FILE OF THE COURSE

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

Contents

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

Course Title: Geotechnical engineering	**Credits: 4**
Type of course: compulsory/elective (delete that is not relevant)	Neptun code: MFKHT720025

Type (lec. / sem. / lab. / consult.) and Number of Contact Hours per Week: **2 lec. + 1 sem.**

Type of Assessment (exam. / pr. mark. / other): **exam.**

Students will be assessed with using the following elements.

Reports:	20 %
Midterm exam	30 %
Exam	50 %
Total	100%

Students must achieve 60% of the mid-term exam and reports score, the exam result has to reach minimum 50%.

Grading scale:

% value	Grade
85 -100%	5 (excellent)
75 – 84%	4 (good)
65 - 74%	3 (satisfactory)
50 - 64%	2 (pass)
0 - 49%	1 (failed)

Position in Curriculum (which semester): **2nd**

Pre-requisites *(if any)*: -

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:

The subject follows the geotechnical tasks of the construction works, starting from the planning of the geotechnical preparatory activity through the model calculations to the technical supervision. The course introduces the student to the process of geotechnical design, the related standard environment and its application. The presentation of failure and serviceability limit states and the design methods defined by EC7 are part of the course. During the semester, the students' task is to perform design tasks for STR, GEO, EGQ, HYD and UPL limit states. Technological and design questions and types of flat slabs, as well as their dimensioning for subsidence and ground breaking, will be introduced during the course. Students can learn about the basics of stability tests for their natural and artificial copper. In addition to deep foundation technologies, the aim of the course is to introduce planning tasks.

The 3-5 most important compulsory, or recommended **literature** (textbook, book) **resources**:

- J.A. Knappett, R.F. Craig: Craig’s soil mechanics, Eight edition, Spon Press, London 2012.
- Atkinson, J.: The Mechanics of Soils and Foundations. Taylor and Francis, London, 2007.
- Braja M. D.: Advanced soil mechanics, Spon Press, 2008
- Aysen A.: Soil mechanics, Basic concepts and engineering applications, Taylor&Francis, 2002.

- 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

Competencies to evolve:

T1 – The environmental engineer knows, and apply the scientific and technical theory, and practice. Active professional English language skills.

Responsible Instructor (*name, position, scientific degree):*

Tamás Kántor Dr., assistant professor

Other Faculty Member(s) Involved in Teaching, if any (*name, position, scientific degree*):

Viktória Mikita Dr., assistant professor

Topics of the subject (by hours)

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

Date	Topic of lecture and seminar
2024.02.15.	Introduction (requirements, thematic, time schedule, Geotechnical Engineering)
2024.02.22.	Stress fields in soil, earth pressures (geostatic earth pressure; Rankine's earth pressure theory; earth pressures as a function of wall movement) (HW)
2024.02.29.	Basics of geotechnical design (general characterization of EuroCode; limit states; design methods; characteristic value; design value; partial safety factor)
2024.03.07.	Shallow foundations (types of shallow foundations; design process of shallow foundations; settlement of shallow foundations; bearing capacity of shallow foundations)
2024.03.14.	Practice – Calculation
2024.03.21.	Deep foundations (types of deep foundations; deep foundation technologies)
2024.03.24.	**Break**
2024.04.04.	**Break**
2024.04.11.	Stability of self-supporting soil masses (types of slope movements; factors influencing stability; stability testing methods)
2024.04.18.	Practice – Calculation
2024.04.25.	Retaining structures (types of retaining structures; design of retaining structures; stresses around retaining structures)
2024.05.02.	Practice – Calculation
2024.05.09.	Midterm exam 1st chance
2024.05.16.	Midterm 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 $\rho = 1{,}983\ g/cm^3$, $h = 4{,}7\ m$

  $\sigma_z = 93{,}2\ kN/m^2$

- Passive earth pressure, if $\sigma_z = 188\ kN/m^2$, $\varphi = 25{,}7^o$, $c = 18\ kPa$

  $\sigma_{xp} = 533{,}2\ kN/m^2$

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

  E = 2,56 MPa

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

  $\sigma_{x0} = 111{,}6\ kN/m^2$

- K_0, K_a and K_p, if $\varphi = 31{,}1^o$
  $K_0 = 0{,}483$
  $K_a = 0{,}319$
  $K_p = 3{,}137$

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

  $\sigma_{z0} = 456\ kN/m^2$

- Effect of external stress, if $p = 456\ kN/m^2$, $\sigma_z / p = 0{,}757$

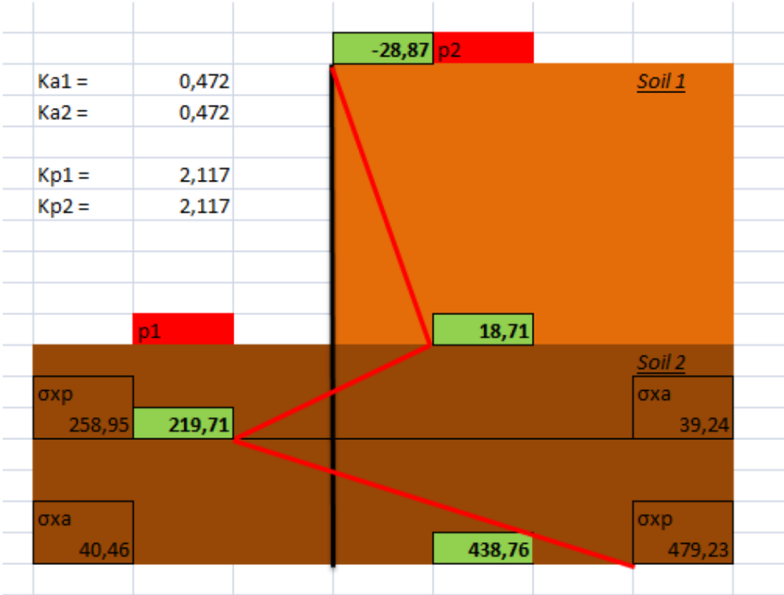
  $\sigma_{z1} = 345{,}2\ kN/m^2$

- Strain in X direction, if $\sigma_z = 677\ kPa$, $\sigma_x = 415\ kPa$, $\sigma_y = 369\ kPa$, $E = 3{,}8\ MPa$, $\upsilon = 0{,}31$

  $\varepsilon_x = 2{,}39\ \%$ (= 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.

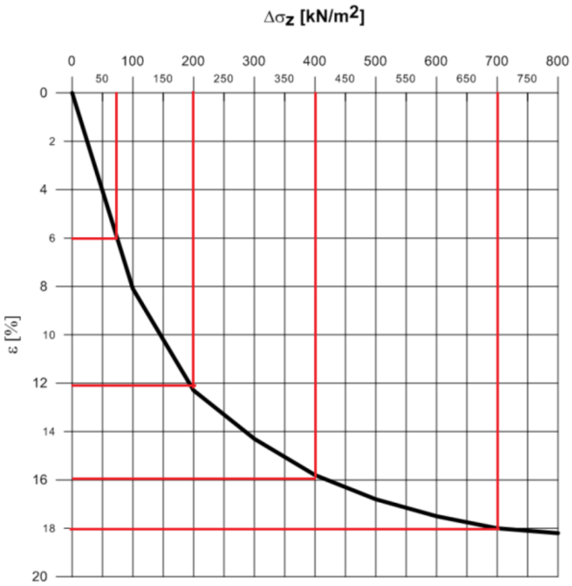
1. phase: F_1 = 1,875 MN
2. phase: F_2 = 3,125 MN
3. phase: F_3 = 5,000 MN
4. phase: F_4 = 7,500 MN

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

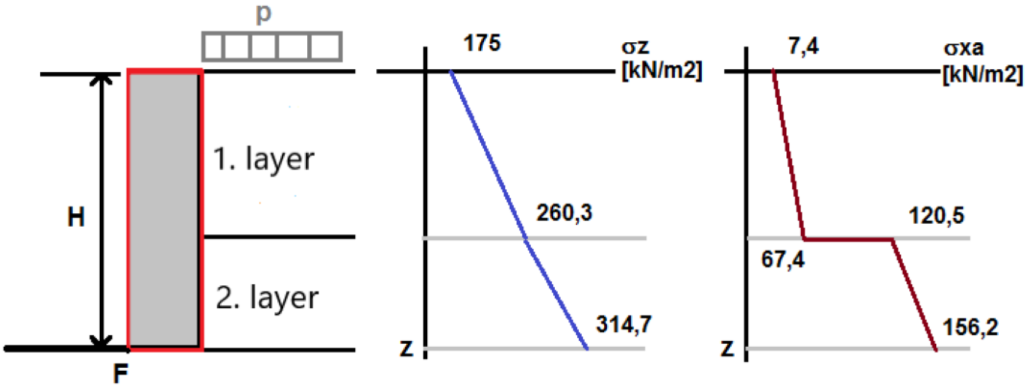
h_1 = 3,3 m	**$\Delta\varepsilon_1$ = 0,06**	**s_1 = 0,198 m**
h_2 = 3,102 m	**$\Delta\varepsilon_2$ = 0,06**	**s_2 = 0,186 m**
h_3 = 2,916 m	**$\Delta\varepsilon_3$ = 0,04**	**s_3 = 0,117 m**
h_4 = 2,799 m	**$\Delta\varepsilon_4$ = 0,02**	**s_4 = 0,056 m**

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!



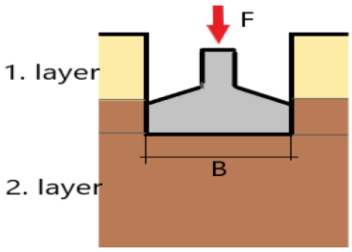
ze = **4,81m** **(z1 = 2,15m; z2 = 2,85m; z3 = 5,65m; z4 = 6,1m)**

Fe = **534,5 kN** **(F1 = 31,9 kN; F2 = 129,1 kN; F3 = 325,4 kN; F4 = 48,2 kN)**

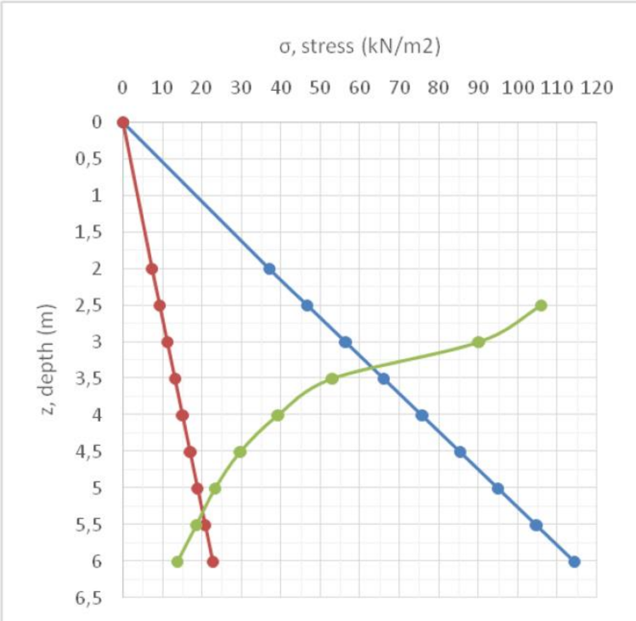
	soil type	h_i (m)	ρ_i (g/cm3)	ϕ_i (°)	c_i (kN/m2)
1. layer	clay	4,3	1,983	10	69
2. layer	silt	2,7	2,016	12	31
p =	175 kN/m2				

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_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

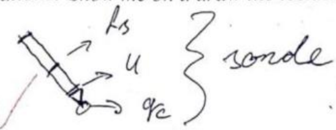
UNIVERSITY OF MISKOLC
Institute of Environmental Management
Department of Hydrogeology and
Engineering Geology

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; [fs] - skin friction; [qc] - 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..)

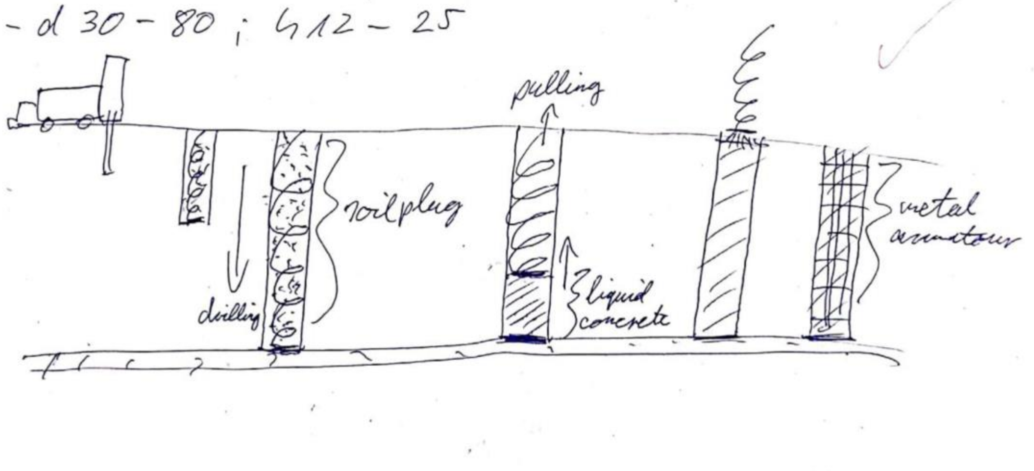
Parameters
[u] → difference between granular and cohesive soil

[fs/qc] → layer boundary, soil type
[qc] → main mechanical inform.; density (and ~~respected~~ approx. to cohesion) carrying capacity of pile
Parts: sonde (measure); armature (for pressing); can be computer (for diagram)

5. Deep foundation

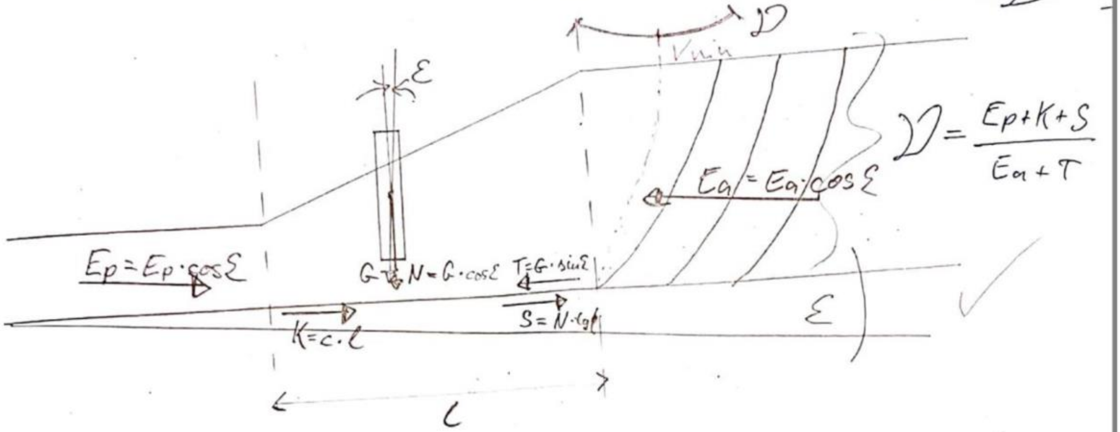
When:
- if the stabil, loadable layer in the deep for building or any geot. works
- if dewatering in shallow foundation have much more cost
- it slipping or ~~unstable~~ unfavorable sedimentation takes place in case of shallow f.
- if can be cavitation (for example bridge pile)
- if the deep found. is 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 ; ф12 – 25



Block method

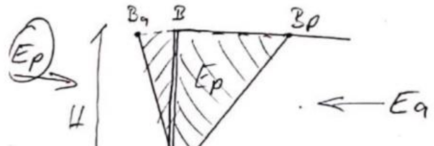
- we investing a unit, what is separeted 3 parts
- the uppler (active E_a) and lower (E_p) is defined with forces, and we invest the equilibrium of the middle part
- after defining the forces, we searching for a slope stability factor, especially were is its minimum [ ] ν_{min}



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

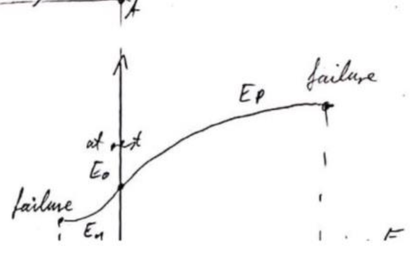
Passive earth pressure

- 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 (between limits)

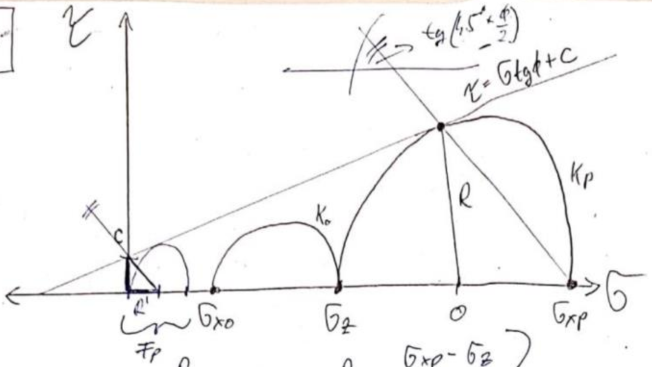


$E_a : E_o : E_p = 0{,}5 : 1 : 5$

↳ relatively high displacing



c≠0



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

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

$\sin\phi \, O = R$

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

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

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

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

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

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

$F_p = 2R$

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

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

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.