National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute"

Department of Geoengineering

SPECIALIZED COURSE ON UNDERGROUND CONSTRUCTION

Working program of the academic discipline (Syllabus)

Details of the academic discipline	
Level of higher education	***Second (master's)***
Branch of knowledge	*18 Production and technologies*
Specialty	*184 Mining*
Educational program	*Geoengineering*
Discipline status	*Normative*
Form of education	*Intramural (day)*
Year of training, semester	*1st year, autumn semester*
Scope of the discipline	*3.5 credits/105 hours (36 hours of lectures, 36 hours of practical work, 33 hours of independent work)*
Semester control/ control measures	*Test, Modular control work, Computational work*
Lessons schedule	*http://roz.kpi.ua/*
Language of teaching	*English*
Information about head of the course / teachers	*Lecturer: Doctor of Technical Sciences, Professor Kostiantyn Tkachuk, kkttkk297@gmail.com* *Practical / Seminar: Doctor of Technical Sciences, Professor Kostiantyn Tkachuk, kkttkk297@gmail.com*
Placement of the course	*https://classroom.google.com*

Program of educational discipline

1. Description of the educational discipline, its purpose, subject of study and learning results

The purpose of the academic discipline is to form students' abilities to:

- *CK1. Ability to identify, pose, solve problems and make informed decisions in professional activities.*
- *CK2. Ability to perform theoretical and experimental studies of parameters and modes of operation of systems and technologies of mining and geoconstruction enterprises.*
- *CK4. Ability to develop project documentation (technical assignment, technical proposals, sketch project, technical project, working project) for mining and geoconstruction systems.*
- *CK5. Ability to organize production processes and technical management of systems and technologies of mining and geoconstruction enterprises.*
- *CK6. The ability to perform design work for special construction methods, mineral development facilities, to take special measures for the reconstruction of underground structures and mining enterprises.*

- *CK7. Ability to implement general principles of complex optimization during project development.*

Program learning results:

- *PH6. Identify, pose, solve problems and make informed decisions in professional activities.*
- *PH7. Carry out theoretical and experimental studies of parameters and modes of operation of systems and technologies of mining and geoconstruction enterprises.*
- *PH10. Organize production processes and technical management of systems and technologies of mining and geoconstruction enterprises.*
- *PH11. Carry out design works for special construction methods, mineral development facilities, take special measures for the reconstruction of underground structures and mining enterprises.*

2. Pre-requisites and post-requisites of the discipline (place in the structural and logical scheme of training according to the relevant educational program)

Pre-requisites: *It is based on the studied professional educational components of bachelor's training.*

Post-requisites: *is basic for the preparation of the qualification work.*

3. Content of the academic discipline

Topic 1. General principles of construction of underground structures in difficult conditions.

Topic 2. Construction of pits by the sinking method.

Topic 3. The "wall in the ground" method.

Topic 4. Special engineering measures during the construction of pits (drainage of pits).

Topic 5. Construction of open pits.

Topic 6. The theory of soil pressure on flexible enclosure structures of pits.

Topic 7. Loads and typical calculation schemes of pit fences.

Topic 8. Calculation and construction of tubular reinforced concrete elements of collector tunnel frames.

Topic 9. Methods of calculations of multi-anchor schemes of pit fencing.

Topic 10. Theory of soil anchor calculations.

4. Educational materials and resources

Basic literature:

1. *Underground Engineering for Sustainable Urban Development. URL: https://www.pdfdrive.com/underground-engineering-for-sustainable-urban-development-e157631027.html*
2. *Engineering Geology for Underground Rocks. URL: https://www.pdfdrive.com/engineering-geology-for-underground-rocks-e30629835.html*
3. *Hencher S. Practical Rock Mechanics. URL: https://www.pdfdrive.com/practical-rock-mechanics-e186096352.html*
4. *Underground Engineering: Planning, Design, Construction and Operation of the Underground Space. URL: https://civilnode.com/download-book/10232812648649/underground-engineering-planning-design-construction-and-operation-of-the-underground-space*
5. *Handbook on Tunnels and Underground Works. URL: https://www.taylorfrancis.com/books/edit/10.1201/9781003256175/handbook-tunnels-*

underground-works-renato-casale-daniele-peila-andrea-pigorini-enrico-maria-pizzarotti-emilio-bilotta-claudio-giulio-di-prisco-salvatore-miliziano

6. *Underground Construction (Tunneling). URL: https://www.osha.gov/sites/default/files/publications/osha3115.pdf*

Educational content

5. Methods of mastering an educational discipline (educational component)

To master the educational component, partly search and research methods of education

	The name of the topic of the lecture and a list of main questions
Lecture 1	**Topic 1. General principles of construction of underground structures in difficult conditions.** Buried and underground structures. Open and mining method of work. Complex engineering and geological conditions of the site. Complex man-made conditions of the site. Features of construction in conditions of dense construction. Technological excavations: pits and trenches. Physical phenomena during the development of pits. The main methods of arranging pits. Methods of draining pits.
Lectures 1–3	**Topic 2. Construction of pits by the sinking method.** Types of lowering wells. Geometrical parameters and main structural parts of lowering wells. Gravity wells. Ways to reduce friction on lowering surfaces: creation of ledges, washing, coating with resins, thixotropic shirts, vibration. Advantages and disadvantages of modern technologies with thixotropic shirts. Well sinking technologies.
Lectures 4-6	**Topic 3. The "wall in the ground" method.** General information about the peculiarities of building structures using the "wall in the ground" method. Basic principles of the method. Constructions erected by this method. Peculiarities of fixing trench walls with clay solution. Crust and compacted zone. The influence of trench geometry on its stability. Equation of stability of trench walls. Reduction of loads on the side of the trench. Application of spacer grippers. Pile walls: single and intersecting. A monolithic wall in the ground". Wall reinforcement. Methods of laying concrete. Arrangement of joints. Prefab "wall in the ground". Panel mounting methods. Concreting panel joints. Anti-filtration diaphragms. Diaphragms from lumpy clay, loamy soil, clay paste, universal solution that hardens slowly, monolithic concrete. Polymer films. Arrangement of foundations by the "wall in the ground" method.
Lectures 7-9	**Topic 4. Special engineering measures during the construction of pits (drainage of pits).** Pit drainage methods: passive, active, combined. Principles of calculations of drainage systems. Use of anti-filtration diaphragms and artificial waterproof screens. Open drain, its features and scope of application. Deep water lowering by artesian wells, its features and field of application.

Lectures 10-12	**Topic 5. Construction of open pits.** Determination of the geometry of pits with slopes. Schemes of mounting slopes. Mechanical sealing. Drainage during loading. Plate mounting. Fastening with geotextile. Chemical fixation of weak layers. Calculations of deep pits: the limit state method, the method of circular cylindrical, logarithmic and broken surfaces.
Lectures 13-14	**Topic 6. Theory of soil pressure on flexible enclosure structures of pits.** Methods of accounting for soil friction and flexible fencing structures. Analysis of the influence of friction according to the Muller-Breslau formula. Accounting for friction according to Sokolovsky's theory of the limit state of the soil environment.
Lecture 15	**Topic 7. Loads and typical calculation schemes of pit fences.** Calculations of loads on the enclosure structures of pits. The main calculation schemes of pit enclosure structures.
Lecture 16	**Topic 8. Calculation and construction of tubular reinforced concrete elements of collector tunnel frames.** General characteristics of the technology and its advantages. Normative and calculated constant loads on the tube section of the tunnel frame (in different geological conditions).
Lecture 17	**Topic 9. Methods of calculations of multi-anchor schemes of pit fencing.** Analytical method according to the Jacobi scheme, graphoanalytic method according to the Jacobi, Lohmeyer scheme. Fields and conditions of application of the above methods.
Lecture 18	**Topic 10. Theory of soil anchor calculations.** Determination of the design force for one anchor.

	Name of the subject of practical classes and list of main questions
Practical classes 1-3	Calculations of a lowering well in a thixotropic jacket.
Practical classes 4-5	Determination of methods of testing solutions using the "wall in soil" method. Studying the methods of calculating the recipes of trenching solutions.
Practical classes 6-7	Calculations of the stability of trenches using the "wall in soil" method.
Practical classes 7-10	Calculations of fencing structures with single-anchor schemes (Jacobi scheme, Lohmeyer scheme).
Practical classes 11-12	Calculation of the stability of pit slopes.
Practical classes 13-14	Calculation of simple fastening of the pit.
Practical classes 15-16	Calculations of fencing structures with cantilever calculation schemes.
Practical classes 17-18	Calculations of soil anchor elements.

6. Independent work of a student/graduate student

The student's independent work is the main means of assimilation of educational material in the time free from educational classes and includes:

	Type of independent work	Number of hours of IWS
1	Preparation for classroom classes	20
2	Preparation for MCW	7
3	Preparation for the test	6

Policy and control

7. Policy of academic discipline (educational component)

The system of requirements for the student:

- *in the case of distance learning, at the time of each lesson, both lecture and practical, the student must have the Zoom application installed on the device from which he works and visual presence in the video conference mode must be ensured;*
- *the student must familiarize himself with the syllabus on the "Sikorsky" platform (remote resource Google classroom) or in the "KPI Electronic Campus" system;*
- *the teacher uses his own presentation material at the lecture; uses Google Class to teach the material of the current lecture, additional resources; the teacher opens access to a certain Google Class directory for sending the results of calculation work and answers to MCW;*
- *Modular control works are written in lectures without the use of aids (mobile phones, tablets, etc.); the result is send in a file to the appropriate Google Class directory;*
- *incentive points are awarded for: active participation in lectures; preparation of reviews of scientific papers; presentations on one of the topics of the IWS discipline, etc. The number of encouraged points is more than 10;*
- *students are obliged to adhere to the general moral principles and rules of ethical behavior specified in the Code of Honor of the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".*

8. Types of control and rating system for evaluating learning results (RSE)

Current control. Completion of practical tasks (3 practical works for 15 points each). MCW is divided into two parts (conducted directly in a practical session in the presence of a teacher, 20 points), calculation work - 15 points.

MCW consists of test tasks of two levels of difficulty. The first difficulty level contains 15 questions, each of which offers multiple answers, only one of which is correct. Each correct answer is valued at 1 point. The second level of difficulty involves solving the problem and choosing the correct answer based on the results of the solution, such a task is evaluated at 5 points. For those students who could not complete it on time, a separate time is assigned at the end of the semester.

Calendar control. It is conducted twice a semester as a monitoring of the current state of the implementation of the syllabus conditions. The condition for a positive first and second calendar control is to obtain at least 50% of the maximum possible rating at the time of the corresponding calendar control.

Semester control. Test.

A student's credit module rating is calculated of 100 points. The starting rating (during the semester) consists of points that the student receives for:

- performance 2 MCW in practical classes (preparation of individual work);
- performance of practical works (3 works);
- performance of calculation work (CW);

Conditions for admission to credit: completed and credited practical work, MCW, CW and the sum of points must be at least 60 points. If a student receives less than 60 points, he performs credit work.

The credit is made in writing form. The credit task consists of 2 theoretical and 1 practical task.

Answers are evaluated according to the following criteria:

– "excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal view are provided;

– "good" - a sufficiently complete answer (at least 75% of the required information), which is completed in accordance with the requirements for the "skills" level or contains minor inaccuracies;

– "satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotype" level and containing some errors;

–"unsatisfactory" - unsatisfactory answer - 0 points.

For extramural education

Current control: Practical works, requirements for them and evaluation criteria are similar to those for full-time education and are given above.

Semester control: credit. Conditions for admission to semester control: completed and credited practical work.

Students who have met the admission requirements take the credit. The sum of points for assessment is added to the assessment for practical work and transferred to the final assessment according to the table.

The sum of points on the test is transferred to the examination grade according to the table:

Number of points	*Estimate*
100-95	Excellent
94-85	Very good
84-75	Good
74-65	Satisfactorily
64-60	Sufficiently
Less than 60	Unsatisfactorily
Admission conditions not met	Not allowed

Working program of the academic discipline (syllabus):

Compiled by Associate Professor, Candidate of Technical Sciences, L.V. Shaidetska

Approved by the Department of Geoengineering (protocol № 18 of June 17, 2022)

Agreed by the Methodical Commission of the Educational and Scientific Institute of Energy Saving and Energy Management (protocol № 12 of June 24, 2022)