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

Department of Geoengineering

Designing of special purpose underground structures

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	*Selective*
Form of education	*Intramural (daytime)/extramural/distance/mixed*
Year of training, semester	*1 year of study, spring semester*
Scope of the discipline	*4 credits*
Semester control/control measures	*Credit/Modular control work*
Lessons schedule	*http://rozklad.kpi.ua/*
Language of teaching	*English*
Information about head of the course/ teachers	Lecturer: Professor of the Department of Geoengineering, Doctor of Technical Sciences, Professor, Tkachuk Kostyantyn Kostyantynovich, kkttkk297@gmail.com Practical/Seminars: Professor of the Department of Geoengineering, Doctor of Technical Sciences, Professor, Tkachuk Kostyantyn Kostyantynovich, kkttkk297@gmail.com
Placement of the course	Available on the Sikorsky platform. The access code is provided by the teacher at the first lesson.

Program of educational discipline

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

The educational discipline "Design of special purpose underground structures" combines knowledge of construction and geotechnological directions for a better understanding of the ways of effective design of special purpose underground structures.

The purpose of the educational discipline *is for students to study the basics of design and construction technologies of special-purpose underground structures in various conditions of the geological environment.*

The subject of study of the discipline *is special-purpose underground structures, techniques and technologies of their construction, fastening and maintenance in operational condition.*

Program learning results

knowledge:

- *purpose and historical development of special purpose underground structures;*
- *underwater tunnels and methods of their construction;*
- *types and methods of construction of underground hydraulic structures;*
- *types and methods of construction of underground power structures;*
- *constructions and methods of building dams;*
- *types and methods of construction of underground garages and parking lots;*
- *types and methods of construction of underground storages of liquefied hydrocarbons;*
- *types and structural parameters of civil defense underground storage facilities;*

– *renovation of ancient underground structures and new possibilities of their use;*
– *directions of prospective development of geoconstruction technologies.*

skill:

– *evaluate the historical stages and prospects of the development of underground structures and construction technologies;*
– *characterize the types and functions of special underground structures and methods of their construction;*
– *justify effective constructions of special purpose structures;*
– *justify the methods of construction of special purpose objects in different geological environments;*
– *choose material- and energy-saving geoconstruction technologies;*
– *justify the parameters of special purpose underground structures;*
– *calculate the parameters of the tunnel type production;*
– *calculate the parameters of the underground storage;*
– *evaluate parameters of geoconstruction technologies.*

experience:

– *a systematic vision of the interrelationships of natural, technological and structural and functional factors in the design of underground structures;*
– *assessment of geological conditions for the construction of underground facilities;*
– *substantiation of methods of design and construction of special purpose structures;*
– *generalization and analysis of architectural and planning decisions of special purpose structures;*
– *comparative assessment of geoconstruction technologies and technical and economic indicators of construction.*

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

The discipline requires students to study natural and technical sciences at the bachelor's level. When studying it, knowledge and skills acquired in the disciplines "Building materials and structures of underground structures", "Engineering geology", "Geomechanics", "Geoengineering of a metropolis" and others are used. The theoretical knowledge and practical skills obtained in the course of studying the discipline can be used in the preparation of a master's thesis.

3. Content of the academic discipline

Topic 1. Introduction. Special purpose buildings: classification and functions. Historical tour of the development of underground structures.
Topic 2. Underwater tunnels.
Topic 3. Underground hydraulic structures.
Topic 4. Underground power facilities.
Topic 5. Underground storage of hydrocarbons.
Topic 6. Underground garages and parking lots.
Topic 7. Military facilities and civil defense storage facilities.
Topic 8. Renovation of ancient underground structures.
Topic 9. Prospects for development of underground space.

4. Educational materials and resources

Literature

1. Zhen-Dong Cui, Zhong-Liang Zhang, Li Yuan, Zhi-Xiang Zhan, Wan-Kai Zhang. Design of Underground Structures. Beijing: China Architecture & Building Press. 2020. 888 p.

2. J. Zhao, J.N. Shirlaw, Krishnan R. Tunnels and Underground Structures. Rotterdam: A.A. Balkema. 2000. 700 p.

3. R. K. Goel, Bhawani Singh, Jian Zhao. Underground Infrastructures: Planning, Design, and Construction. Elsevier: Butterworth-Heinemann. 2012. 352 p.

Educational content

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

Lecture classes

№ in order	The name of the topic of the lecture and a list of main questions
Lecture 1	**Introduction. Special purpose buildings: classification and functions. Historical tour of the development of underground structures** Concise content of the course, its connection with other disciplines. Classification of buildings and structures. Special purpose underground structures and their functions. Assessment of geological conditions for the construction of underground facilities. Historical overview of the development of special purpose underground structures.
Lecture 2	**Underwater tunnels** Peculiarities of the geological environment. Types and designs of underwater tunnels. Construction technology. Eurotunnel under the English Channel. Seikan tunnel under Sangar Bay. Japanese "Aqualine". Tunnel under the Bosphorus. Projects of new underwater tunnels. Prospects of underground crossings of the Dnipro.
Lectures 3-4	**Underground hydraulic structures** Types and methods of construction of underground hydraulic facilities. Sewage collectors. Hydro tunnels. Reservoirs. Treatment plant. Trench construction methods. Microtunneling. Puncture. Pushing Directional drilling.
Lectures 5-6	**Underground power facilities** Underground hydroelectric power stations. Underground nuclear power plants. Spatial planning and constructive solutions. Main underground workings. Construction of underground structures of the chamber type (engine rooms). Construction of dams. The specifics of design taking into account the ecological features of construction and operation.
Lectures 7-8	**Underground storage of hydrocarbons** Types, purpose and classification of underground storage facilities. Scope and examples of construction. System of underground storage of hydrocarbons in Ukraine. Construction of underground storages by the mining method. Creation of underground storage facilities in salt deposits. Construction of underground storage facilities using camouflaged explosions.
Lecture 9	**Underground garages and parking lots** Types and classification of underground parking lots and garages. Automated underground parking lots of the revolving (carousel) type. Open and underground construction methods. Assessment of feasibility of construction taking into account natural, technological and structural and functional factors.
Lectures 10-11	**Military facilities and civil defense storage facilities** Types and purpose of underground objects. Special requirements. Underground plants. Command points. Repositories of civil defense. Construction of trunks, tunnels, chambers, backfill pits of military facilities.
Lectures 12-13	**Renovation of ancient underground structures** Historical underground objects. Methods of renovation and adaptation of ancient underground structures. Ensuring the reliability and safety of old underground facilities. Creation of underground tourist routes. Examples of underground museums included in the UNESCO cultural heritage list.
Lecture 14	**Prospects for development of underground space** Directions of prospective development of geoconstruction technologies. Ecological and economic aspects of the use of underground space. Prospects for the development of underground urbanism in Kyiv. Strategic master plans for the development of the underground space of large cities.

Practical classes

№ in order	Tasks that are given for practical classes
Practical class 1	Determination of mountain pressure and stresses arising in the mountain massif.
Practical class 2	Assessment of the influence of mountain pressure and stresses arising in the mountain massif on the choice of the form of fastening and the construction technology of special purpose structures. Determination of the normative load on the underground structure.
Practical class 3	Determination of the length and density of installation of anchors with bearing capacity Pa for special-purpose underground structures.
Practical class 4	Implementation of the principle of "technological flexibility" by combining temporary metal arched flexible fastening and permanent concrete.
Practical class 5	Calculation of monolithic concrete frame parameters of underground structures.
Practical class 6	Construction of underground storage facilities using camouflaged explosions.
Practical class 7	Construction of embankment structures along reservoirs, rivers, seas.
Practical class 8	Construction of underground structures of large cross-sections (engine room chambers of underground power plants).
Practical class 9	Creation of underground storage facilities in salt deposits.
Practical class 10	Using the method of morphological analysis for the evaluation of parking lot construction sites.
Practical class 11	Prospects for the construction of special purpose underground structures in Ukraine.
Practical class 12	Construction of bomb shelters.
Practical class 13	Modular control work.
Practical class 14	**Credit.**

6. Independent work of a student/graduate student

The student's independent work involves:

preparation for classroom classes - 56 hours;

preparation for the Modular control work - 4 hours;

preparation for the credit - 6 hours.

Policy and control

7. Policy of academic discipline (educational component)

At the time of each class, both lecture and practical, the student must have the Zoom application installed on the device from which he works (subject to distance learning), and the course " Design of special purpose underground structures" must be open on the platform " Sikorsky" (the access code to the course is provided at the first lesson according to the schedule). Classes according to the schedule are provided in the classroom or using the Zoom application (subject to distance learning). Syllabus; lecture material; tasks for each practical session; variants of modular control work; variants of the credit test are placed on the "Sikorsky" platform and in the "KPI Electronic Campus" system.

During the course " Design of special purpose underground structures", 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".

The deadlines for the completion of each task are specified in the course "Design of special purpose underground structures" on the "Sikorsky" platform.

All students, without exception, are obliged to comply with the requirements of the Regulations on the academic plagiarism prevention system at the National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute".

For participation in the All-Ukrainian Olympiad (competition of scientific works), a student is awarded 5 (I round) or 10 (II round) points. For writing an article and its publication, the student is awarded 10 points (edition included in Scopus or Web of Science) or 6 points (professional publication of Ukraine). 3 points

for publication of report abstracts at a scientific conference. The total amount of incentive points cannot exceed 10 points.

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

Current control: activity in lecture classes (14 lectures × 1 point = 14 points), practical works (12 practical works × 5 points = 60 points), MCW (conducted directly in the practical class, in the presence of the teacher, 26 points).

Practical work is evaluated in 5 points according to the following criteria:

- *"excellent" - a complete answer (at least 90% of the required information), appropriate justifications and a personal opinion are provided - 5 points;*
- *"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 - 4 points;*
- *"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 - 3 points;*
- *"unsatisfactory" - unsatisfactory answer - 0 points.*

MCW is estimated at 26 points and consists of two tasks: theoretical and practical (applied). Each task is evaluated at 13 points according to the following criteria:

- *"excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 13 - 12 points;*
- *"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 - 11 - 10 points;*
- *"satisfactory" - an incomplete answer (at least 60% of the required information), completed in accordance with the requirements for the "stereotypical" level and containing some errors - 9 - 8 points;*
- *"unsatisfactory" - unsatisfactory answer - 0 points.*

For those students who could not complete it on time, a separate time is assigned at the end of the semester.

***Calendar control:** is conducted twice a semester as a monitoring of the current state of fulfillment of the syllabus requirements. 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:** credit. Conditions for admission to the semester control: completed and credited MCW, as well as a rating of at least 36 points.*

Students who have met all the admission requirements and have a rating of 60 or more points receive a rating corresponding to the rating without additional tests. The sum of the rating points received by the student during the semester is transferred to the final grade according to the table.

If the sum of points is less than 60, but greater than or equal to 36, and the MCW has been completed and credited, the student completes the credit control work. In this case, the sum of points for the MCW and for the final test is transferred to the final grade according to the table.

A student who received more than 60 points in the semester, but wants to improve his result, can take part in a credit control work. In this case, the final result consists of the points obtained on the final test and the points for the MCW.

The credit control work is estimated at 74 points. The control task of this work consists of two theoretical questions from the list provided in the appendix to the syllabus and a task.

Each theoretical question is valued at 23 points according to the following criteria:

- *"excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 23 - 21 points;*
- *"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 - 20 - 17 points;*
- *"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 - 16 - 14 points;*
- *"unsatisfactory" - unsatisfactory answer - 0 points.*

The task is estimated at 28 points according to the following criteria:

- *"excellent" - a complete answer (at least 90% of the required information), relevant justifications and a personal opinion are provided - 28 - 25 points;*
- *"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 - 24 - 21 points;*
- *"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 - 20 - 17 points;*
- *"unsatisfactory" - unsatisfactory answer - 0 points.*

For extramural education

Current control: *MCW (26 points). The structure of MCW, its requirements and evaluation criteria are similar to those for Intramural education and are listed above.*

Semester control: *credit. Conditions for admission to the semester control: completed and credited MCW. Students who have fulfilled the conditions for admission to the credit, perform the credit control work. The sum of points for the MCW and for the credit control work is transferred to the final grade according to the table.*

Credit control work is estimated at 74 points as for intramural education. The evaluation criteria are given above.

Table of correspondence of rating points to grades on the university scale:

Number of points	*Rating*
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

9. Additional information on the discipline (educational component)

The list of questions submitted for semester control is given in the appendix to the syllabus.

A student of higher education has the opportunity to take an online course(s) on one or more topics provided by the work program of the academic discipline. The student can choose an online course independently or on the recommendation of a teacher. 1 hour of the course is valued at 0.83 points. The maximum number of hours that can be credited based on the results of non-formal education is 12 hours, accordingly the maximum number of points for such results is 10 points.

Working program of the academic discipline (syllabus):

Compiled by Professor of the Department of Geoengineering, Doctor of Technical Sciences, Professor Tkachuk Kostyantyn Kostyantynovich

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)