

WORK PROGRAMME OF THE ACADEMIC DISCIPLINE

Modeling of a Soil-Structure Interaction System

type of discipline, code for EP	<i>compulsory, EC 1</i>
semester	<i>2</i>
number of ECTS credits	<i>4</i>
form of final semester control	<i>differentiated test</i>
language of instruction, teaching and assessment	<i>English</i>
department	<i>Geotechnics, Underground Structures and Hydrotechnical Construction</i>

for higher education applicants:

level of higher education	<i>second (master's degree)</i>
branch of knowledge	<i>G Engineering, manufacturing and construction</i>
specialty	<i>G19 Building and Civil Engineering</i>
educational programme	<i>Industrial and Civil Engineering</i>
form of study	<i>full-time</i>

2025 – 2026 ACADEMIC YEAR

Developers:

Vadym ALEKSANDROVYCH, PhD (Eng.), Associate Professor,
Head of the GUS & HC Dpt.



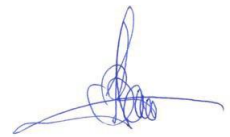
The work programme was approved at the proceedings of the **Department** of
Geotechnics, Underground Structures and Hydrotechnical Construction

Minutes dated «25» August 2025 No. 1

The work programme of the discipline corresponds to the Educational Programs:
Industrial and Civil Engineering, Urban Engineering and Services, Civil Engineering

Head of the specialty support group

Glib VATULIA, D.Sc., Professor of Building Structures Dpt.



Deputy Director of SC&EE

Kateryna SOROKINA, PhD (Eng.), Associate Professor



1. The purpose of the discipline

The purpose of teaching the discipline is to train construction specialists who have the skills to calculate the structure and its basis as a single system in accordance with the current regulatory documents in construction. As a result of studying the discipline, applicants should know that the building and its foundation should be considered in combination. Be able to perform modeling of the "building-base" system to take into account their mutual influence on the stress-strain state of the building elements and the foundation, as well as to assess the mutual influence of buildings that are constructed in dense building conditions.

2. Interdisciplinary connections

The study of this discipline is directly based on: basic knowledge of the design and calculation of building structures, bases and foundations; technologies and organization of construction processes, the use of basic types of building materials and products.

3. Learning outcomes

Programme learning outcome	Teaching methods	Forms of evaluation	Learning outcomes of the discipline
PLO 01. Design buildings and structures (according to specialization), including using computer design software systems, in order to ensure their reliability and durability, making rational design and technical decisions, technical and economic justification, taking into account the features of the construction object, determining the optimal mode of its functioning and implementation of resource and energy saving measures.	Verbal, visual, practical, analytical. Reproductive (explanatory-illustrative). Lecture notetaking, problem-solving, studying modeling methods, completing research assignments, independent work.	Oral or written questioning, testing, written assessment, graphical assessment, practical verification of skills and abilities, solving experimental and research problems, review of completed practical and individual assignments.	PLO 01.1 Design buildings and structures using modern software systems for strength analysis and structural design to ensure the reliability and durability of buildings and structures, making rational design and technical decisions and their feasibility study. PLO 01.2 Make effective and resource-saving design decisions based on the analysis of the stress-strain state of finite element models of the "base-foundation-structure" system, which consider the features of the construction object in order to ensure the optimal mode of its life cycle and functioning.

PLO 02. Apply specialized conceptual knowledge, including modern scientific achievements, as well as a critical understanding of modern problems in the field of construction and civil engineering to solve complex problems of professional activity.			PLO 02.1 Use specialized conceptual knowledge of skewed-element modeling and strength analysis using modern computer-aided design software systems to solve complex problems of professional activity. PLO 02.2 Use modern scientific achievements and critical understanding of modern problems in the field of construction and civil engineering in the design of construction and civil engineering objects.
PLO 06. Apply modern mathematical methods for statistical data analysis, calculation, and optimization of design parameters and technological construction processes of buildings and structures.			PLO 06.1 Analyze the stress-strain state of the finite-element model of the "base-foundation-structure" system at different stages of its life cycle for calculation and optimization of design parameters and construction technological processes.

4. Programme of the discipline

Module 1. Modeling of a Soil-Structure Interaction System

Content module 1 Creation of a geotechnical massif model

The history of the development of soil models is reviewed. Existing approaches to modeling a linearly deformable layer and a half-space are analyzed and compared. Finite element methods for solving the three-dimensional problem of the theory of elasticity are analyzed. Methods for determining the modulus of subgrade reaction are studied. Methods for creating soil base models are studied.

Content module 2 Modeling of the calculation system “base-foundation-building”

The criteria for choosing the design model of the basis are analyzed. Methods of constructing a grid of finite elements on a plane and the application of bedding coefficients are considered. The formation of design models from three-dimensional elements is studied. Types of design schemes of buildings are considered. The creation

of a design model "building – foundation", load and calculation of structural elements of the building, analysis of forces in structures taking into account the difference in settlement of columnar foundations, analysis of forces in structures taking into account the stiffness of the slab foundation, analysis of the influence of compliance of the base in the calculation of the building on stability are carried out.

Content module 3 Geotechnical forecast of the impact of new construction on existing structures

Methods of taking into account the mutual influence of foundations and buildings are considered. The choice of methods for laying foundations is analyzed, taking into account the impact on adjacent buildings and probable changes in engineering-geological and hydrogeological conditions. Engineering surveys in the conditions of compacted development, measures to preserve the objects of the adjacent territory, destructive processes in the soils of the site, changes in the steady-state level of groundwater, pollution of soils, surface and underground waters are studied.

5. Structure of the academic discipline and time allocation

Content modules	Number of hours				
	total	lectures	practice	lab	independent work
MODULE 1	120	16	32	-	72
Content module 1	30	5	10	-	15
Content module 2	45	6	12	-	27
Content module 3	30	5	10	-	15
Individual task	-				-
Final semester control	15				15

6. Themes of the lectures

Theme	Contents (plan)	Number of aud. hours
Content module 1		
Topic 1. Development of 2D Soil Base Models	History of the development of soil models. Models of Winkler, Pasternak, variable moduli of subgrade reaction, linearly deformable half-space, and linearly deformable layer of finite width and finite distributing capacity.	2
Topic 2. Development of 3D Soil Base Models	Finite elements for solving 3D problems in the theory of elasticity. Creation of a 3D soil base model.	3
Content module 2		
Topic 3. Selection of a Soil Base Model	Criteria for selecting a computational soil model, the "Zapros" program, the	2

	"KROSS" program, generation of a finite element mesh in a plane, application of the modulus of subgrade reaction, creating analysis models from 3D elements.	
Topic 4. Analysis of the Soil-Foundation-Structure System	Types of structural analysis models for buildings, creating a "soil-foundation-structure" analysis model, loading and analysis of structural elements, analysis of internal forces considering differential settlement of isolated foundations, analysis of internal forces considering raft foundation stiffness, analysis of the influence of foundation compliance on the building's stability analysis.	4
Content module 3		
Topic 5. Assessment of the Mutual Influence of Buildings	Methods for accounting for the mutual influence of foundations and buildings, selection of foundation construction methods considering the impact on adjacent buildings and potential changes in engineering-geological and hydrogeological conditions.	2
Topic 6. Monitoring of Adjacent Development and Territory	Geotechnical investigations in dense urban environments, measures for the preservation of adjacent structures, destructive processes in the site's soils, changes in the established groundwater level, contamination of soil, surface water, and groundwater.	3

7. Themes of the practical classes

Theme	Contents (plan)	Number of aud. hours
Content module 1		
Topic 1. Construction and analysis of the soil base model in the form of a linearly deformable layer of finite width	Using Scad++, create and analyze soil base models in the form of a linearly deformed layer of finite width with variable boundary conditions.	4
Topic 2. Construction of a soil model using the subgrade reaction modulus	Construct a soil base model using the modulus of subgrade reaction.	6

Content module 2		
Topic 3. Construction of the "soil-foundation-structure" model	Create a "soil-foundation-structure" analysis model. Perform load calculations for the building frame using the "Vest" program. Determine wind, snow, and self-weight loads. Apply these loads to the created model.	6
Topic 4. Calculation and analysis of the "soil-foundation-structure" model	Perform the analysis of the building's structural elements; analyze internal forces considering the differential settlement of isolated foundations; analyze internal forces considering the stiffness of the raft foundation; analyze the influence of foundation compliance on the building's stability analysis.	6
Content module 3		
Topic 5. Analysis of the mutual influence of adjacent building foundations	Model the loads from the foundations of an adjacent building using the finite element method. Analyze their combined effect on the stress-strain state of the soil base and structures. Build a model of the soil foundation using volumetric elements.	6
Topic 6. Analysis of stress distribution in a linearly deformable soil layer model	Construct a "soil-foundation-structure" computational model with the soil base represented as a linearly deformable layer of finite distributing capacity. Analyze the influence of the boundary conditions of the soil base model on the stress-strain state of the system.	4

8. Individual task (IT)

Not provided

9. Methods of control and the procedure for assessing learning outcomes

Methods of ongoing assessment:

- Monitoring the completion of practical and independent tasks – oral questioning; written assessment; graphical assessment (tables, diagrams, charts, schemes);
- Practical evaluation of skills and competencies – model creation, performing calculations, conducting analysis;
- Solving experimental and research problems – graphical assessment (tables, diagrams, charts, schemes).

Methods of modular assessment (by content modules):

- testing;

Methods of final semester assessment:

- Written assessment, graphical assessment.

Structure of the discipline and distribution of points

Content modules	Maximum number of points				
	total	practice	lab	independent work	
				tasks	module control
MODULE 1	100				
Content module 1	20	10		5	5
Content module 2	30	20		5	5
Content module 3	20	10		5	5
Final semester control	30	-	-	-	-

Types of the tasks, means of control and maximum number of points

Types of the tasks and means of control	Distribution of points
Content module 1	20
Practical Assignment #1: To build and analyze a model of the soil base as a linearly deformable layer of finite width (graphical assessment)	5
Independent Work Assignment #1: To compare the results of settlement calculation using analytical and numerical models (written assessment, graphical assessment)	3
Practical Assignment #2: To build a soil base model using the modulus of subgrade reaction (graphical assessment)	5
Independent Work Assignment #2: To calculate the modulus of subgrade reaction using various methods and analyze the results (oral questioning, graphical assessment)	2
Test on theoretical material for CM1	5
Content module 2	30
Practical Assignment #3: To create a "soil-foundation-structure" design model (graphical assessment)	10
Independent Work Assignment #3: To perform modifications to the superstructure part of the "soil-foundation-structure" design model (graphical assessment)	2
Practical Assignment #4: To perform the calculation of the building's structural elements (written assessment, graphical assessment)	10

Independent Work Assignment #4: To analyze the stress-strain state of the created design models, considering the interaction with the soil mass using the modulus of subgrade reaction (oral questioning, graphical assessment)	3
Test on theoretical material for CM2	5
Content module 3	20
Practical Assignment #5: To analyze the influence of adjacent buildings on the SSS of the "soil-foundation-structure" system; to build a soil model using volume elements (oral questioning, graphical assessment)	5
Independent Work Assignment #5: To analyze the application of different superstructure models and their influence on the SSS of the SFS system (oral questioning, graphical assessment)	2
Practical Assignment #6: To analyze the influence of the boundary conditions of the soil base model using volume elements on the stress-strain state of the SFS system (oral questioning, graphical assessment)	5
Independent Work Assignment #6: To analyze the application of different soil base models and their influence on the SDS of the SFS system (written assessment, graphical assessment)	3
Test on theoretical material for CM3	5
Final semester control – diff. test (written assessment, graphical assessment)	30
Theoretical question (written assessment)	10
Practical assignment for the assessment of skills and abilities (graphical assessment).	20
TOTAL FOR THE MODULE	100

Grading scale

100-point scale	Level of competence	Four-point / two-point scale	
		exam	test
90-100	high	excellent	passed
82-89	sufficient	good	
74-81			
64-73	average	satisfactory	
60-63			
35-59	low	unsatisfactory	failed
0-34			

10. Material and technical and information support

Methodical support

1. Distance Learning Course "Modeling of the 'Building-Foundation' System" [Electronic resource]. – Available at:
<https://dl.kname.edu.ua/course/view.php?id=2891>

Recommended literature and information resources

1. Aleksandrovykh V. et al. Investigation of the influence of boundary conditions on the deformability of a model of soil base of limited width in the form of a linearly deformable elastic half-plane //IOP Conference Series: Earth and Environmental Science. – IOP Publishing, 2024. – Vol. 1376. – №. 1. – P. 012017.
<https://doi.org/10.1088/1755-1315/1376/1/012017>
2. S.Fialko. Time history analysis of buildings and structures design models in SCAD software on multicore computers / ECMS 2024 : proceedings of the 38th ECMS International Conference on Modelling and Simulation, June 4th-June 7th, 2024 Cracow, Poland / Grzonka Daniel [etc] (red.), Communications of the ECMS, – vol. 38, No. 1, Caserta, ECMS, – 2024, pp.187-193
<https://scs-europe.net/conf/ecms2024/>
3. Fialko S. Parallel finite element solver for multi-core computers with shared memory / Computers & Mathematics with Applications. –Vol. 94. –2021, pp. 1-14.
<https://doi.org/10.1016/j.camwa.2021.04.013>
4. DBN B.2.1-10:2018. Bases and Foundations of Buildings and Structures. Main Provisions. – Kyiv: Ministry of Regional Development of Ukraine, 2018. – 36 p.
https://e-construction.gov.ua/files/new_doc/3019954595758606072/2023-01-20/1a3452ff-56ec-492e-a881-416dcba1604d.pdf
5. DBN B.1.1-45:2017. Buildings and Structures in Complex Engineering-Geological Conditions. General Provisions. – Kyiv: Ministry of Regional Development and Construction, 2017. – 29 p. https://e-construction.gov.ua/files/new_doc/3019941257964160320/2023-01-20/73c4ae2b-f6c2-4c1f-a53e-87cf6470ae5e.pdf
6. DBN B.1.2-5:2007. Scientific and Technical Support of Construction Objects. – Kyiv: Ministry of Regional Development and Construction, 2007. – 16 p. https://e-construction.gov.ua/files/new_doc/3074778358307882794/2023-04-06/d169c363-9531-4a87-8b10-1e706a6d2221.pdf
7. DBN B.1.2-14:2018. General Principles for Ensuring the Reliability and Structural Safety of Buildings and Structures. – Kyiv: Ministry of Regional Development and Construction, 2018. – 30 p. https://e-construction.gov.ua/files/new_doc/3022057264165946908/2023-01-24/70ffd643-c8d7-47d7-92d9-47d0bf543e46.pdf

Hardware, equipment, software products

1. Computer lab, room 405: Intel Core i5-4460 3.2 GHz, 16 GB DDR4 RAM, 120 GB SSD, GeForce GT 730 graphics, Philips 243V monitor (20 units, 2019) with "SCAD Office" version 23.1.1 and "AutoCAD" installed.
2. AutoCAD software (under an agreement between O. M. Beketov NUUE and Autodesk); for remote use, students receive a student version directly from the Autodesk company.
3. "SCAD Office" software version 23.1.1, S64 configuration, license agreement No. 17281 dated 17.02.2021, number of licensed seats – 20; license agreement No. 19275 dated 20.07.2023, number of licensed seats – 20, with the possibility of remote student access to the license keys via the Internet.
4. Microsoft Office 365 (under an agreement between O. M. Beketov NUUE and Microsoft) through the university's corporate profile.