

Description of the academic discipline. The course training program of the educational component "Metal Structures" is developed on the basis of the educational and professional program "Building and Civil Engineering" and the curriculum of the specialty G19 "Building and Civil Engineering".

The educational discipline "Metal Structures" is one of the main disciplines that form a specialist in the field of construction. Based on the knowledge and skills acquired by students while studying the discipline, the future specialist, when working in design organizations, will develop a part of the projects related to the design of load-bearing metal structures. When working in operational units, knowledge of the discipline is necessary to determine the composition of metal structures of buildings and structures.

The issues of materials of metal structures (steel, aluminum alloys), calculation models of metal structures, which are reduced to the conditions of their actual operation, metals as homogeneous, isotropic and continuous materials, which allows for a fairly accurate theoretical description of their operation in the elastic region and beyond the limits of elasticity, as well as the use of metal structures in buildings and engineering structures, are considered.

Field of study, specialty, educational program, educational degree		
Educational degree	<i>Bachelor</i>	
Specialty	<i>G19 «Building and Civil Engineering»</i>	
Educational program	<i>Building and Civil Engineering</i>	
Characteristics of the academic discipline		
Type	mandatory	
The total number of hours	180	
Number of ECTS credits	6	
Number of content modules	3	
Course project (term paper) (if available)	1	
Control form	<i>test, exam</i>	
Academic discipline indicators for full-time and part-time forms of higher education		
	Full-time form of higher education	Part-time form of higher education
Course (year of training)	3	3
Semester	5, 6	5, 6
Lectures	<i>15/30 h.</i>	<i>2/6 h.</i>
Practical, seminar classes	<i>15/30 h.</i>	<i>2/6 h.</i>
Laboratory classes		
Independent work	<i>30/60 h.</i>	<i>67/97 h.</i>
Number of weekly classroom hours for full-time higher education	<i>2/4 h.</i>	

1. Purpose, competencies and program outcomes of the academic discipline

The purpose of studying the discipline is to ensure the level of knowledge of students in the field of designing metal structures, taking into account the requirements of manufacturability, transportation, installation and technical operation.

To bring the educational process closer to the real activities of design organizations and provide applicants with the necessary information for independent development of design documentation when performing course and diploma projects. Thus, the purpose of studying the discipline is to obtain theoretical knowledge and acquire practical skills, choose a rational solution for metal structures for designing buildings and engineering structures. Ability to use the State Building Codes of Ukraine, State Standards of Ukraine, catalogs of typical decisions.

Objectives of the discipline: acquisition of skills in designing and calculating structures; mastering calculation methods and rules for designing load-bearing elements and various types of connections of separate elements in the structure; mastering the rules for designing and calculating structural connection nodes in the structure, taking into account the conditions of production, installation and technical operation of buildings and structures.

List of academic disciplines that precede the study:

EC1 Physics, EC2 Descriptive Geometry and Engineering Graphics, EC3 Higher Mathematics, EC4 Chemistry, EC8 History and Philosophy of Construction, EC12 Fundamentals of the Theory of Elasticity and Plasticity in Construction, EC13 Theoretical and Structural Mechanics, EC16 Architecture of Buildings and Structures.

Acquisition of competencies:

integrated competence (IC): The ability to solve complex specialized construction and civil engineering problems in the learning process, which involves the application of a complex of theories and methods for determining the strength, stability, deformability, modeling, strengthening of building structures; subsequent safe operation, reconstruction, erection and installation of buildings and engineering structures; application of computer-aided design systems in the construction industry.

General competencies (GC):

GC02. Knowledge and understanding of the subject area and professional activity.

GC04. Ability to communicate in a foreign language.

GC06. Ability to search, process and analyze information from various sources.

GC07. Basics of inter-social interaction

Special (professional) competencies (SC):

SC01. Ability to use conceptual scientific and practical knowledge in mathematics, chemistry and physics to solve complex practical problems in the field of construction and civil engineering

SC03. Ability to design building structures, buildings, structures and engineering networks (according to specialization), taking into account engineering and technical and resource-saving measures, legal, social, environmental, technical and economic indicators, scientific and ethical aspects, and modern requirements of regulatory documentation in the field of architecture and construction, environmental protection and occupational safety.

SC04. Ability to select and use appropriate equipment, materials, tools and methods for designing and implementing technological processes of construction production.

SC07. Ability to take responsibility for making and taking decisions in the field of architecture and construction in unpredictable work contexts.

SC11. Possess methods of design, modeling and construction using automated design and calculation systems for building structures of buildings and engineering structures of industrial, agro-industrial, transport and civil purposes.

SC12. Ability to carry out and organize technical operation, inspection, reconstruction of buildings and engineering structures, ensure durability, reliable and further safe operation of facilities and engineering networks of agro-industrial and other sectors of the economy.

Program learning outcomes (PLO):

PLO02. Participate in research and development in the field of architecture and construction.

PLO05. Use and develop technical documentation at all stages of the life cycle of construction products

PLO07. Collect, interpret and apply data, including by searching, processing and analyzing information from various sources.

PLO08. Rationalize the use of modern building materials, products and structures based on knowledge of their technical characteristics and manufacturing technology.

PLO09. Design construction structures, buildings, structures, engineering networks and technological processes of construction production, taking into account engineering and technical and resource-saving measures, legal, social, ecological, technical and economic indicators, scientific and ethical aspects, and modern requirements of regulatory documentation, time and other restrictions, in the field of architecture and construction, environmental protection and occupational safety

PLO14. To ensure the safe and reliable operation of construction structures of buildings, structures and engineering networks and, if necessary, to carry out their strengthening (full or partial replacement) using economically justified and expedient methods of reconstruction

PLO17. Mastering the skills of effective independent work (course and diploma design) or in a group (laboratory work, including leadership skills during their performance); performance under time constraints with an emphasis on professional integrity and academic integrity.

2. Program and structure of the academic discipline

Names of content modules and topics	Number of hours												
	full-time							part-time					
	Weeks	total	including					total	including				
			l	p	lab	Ind.	s.w.		l	p	lab	Ind.	s.w.
2	3	4	5	6	7	8	9	10	11	12	13	14	
Module 1. <i>Elements of metal structures and their welding</i>													
Topic 1. Requirements for the	2	17	4	4	-	-	9	14	1	-	-	-	13

properties of metals for building metal structures. Determination of the weldability of steel													
Topic 2. Drawing up variants of working platform schemes	3	17	4	4	-	-	9	15	1	-	-	-	14
Total for module 1	5	34	8	8	-	-	18	29	2	-	-	-	27
Module 2. <i>Metal structures of buildings and structures</i>													
Topic 1. Calculation of rolling simple and continuous beams. Determination of loads, and choice of steel grade.	4	9	2	2	-	-	5	21	-	1	-	-	20
Topic 2. Technical and economic parameters. Comparison of variants.	5	9	2	2	-	-	5	-	-	-	-	-	-
Topic 3. Calculation of the main beams with optimal solutions application	6	13	3	3	-	-	7	21	-	1	-	-	20
Total for module 2	10	31	7	7	-	-	17	42	-	2	-	-	40
Total hours 5 semester	15	65	15	15	-	-	35	71	2	2	-	-	67
Module 3. <i>Structural forms of metal structures</i>													
Topic 1. Calculation of the supporting beam part, flanges' joints, local stability of the web.	2	12	4	4	-	-	4	13	1	1	-	-	11
Topic 2. Calculation assembly joint of the main beam on high-strength bolts.	4	12	4	4	-	-	4	13	1	1	-	-	11
Topic 3. Calculation connection first beam to the main beam on normal exactness bolts	6	12	4	4	-	-	4	13	1	1	-	-	11

Topic 4. Design and calculation of the columns. Determining the load. Rating scheme of the column.	8	12	4	4	-	-	4	13	1	1	-	-	11
Topic 5. Selection of cross-section dimensions for open-web and solid columns	10	12	4	4	-	-	4	13	1	1	-	-	11
Topic 6. Types of columns bases. Calculation of the column's base plate dimensions in plan and thickness.	12	10	4	4	-	-	2	14	1	1	-	-	12
Topic 7. Calculation and design of column's head	14	10	4	4	-	-	2	-	-	-	-	-	-
Topic 8. Schemes, types of cross sections of elements bracings, setting of section due to ultimate flexibility.	15	5	2	2	-	-	1	-	-	-	-	-	-
Total for module 3		85	30	30	-	-	25	79	6	6	-	-	67
Course Project. Working platform of industrial buildings		30	-	-	-	-	30	30	-	-	-	-	30
Total hours		180	45	45	-	-	90	180	8	8	-	-	164

3. Lecture topics

№	Topic name	Number of hours
1	Requirements for the steel properties of metal structures.	2
2	Electric welding, welding connections in construction, their types.	2
3	Technological capacities factory production and welding of metal constructions' elements.	2
4	Factory and assembly welds and joints. Calculation of welded joints.	2
5	Types of metal beams and their design taking into account optimization.	2
6	Drawing variant schemes of working platform.	1
7	Types of working platforms' coverings and their calculations.	2

8	Calculation of rolling simple and continuous beams.	2
	Total hours 5 semester	15
9	Calculation of the main beams with optimal solutions application. Determination of the cross section dimensions, change the beam cross section dimensions by the beam length.	4
10	Calculation of the supporting beam part, flanges' joints, local stability of the web.	4
11	The calculation of assembly joints.	4
12	Design and calculation of the columns. Determining the load. Rating scheme of the column.	4
13	Selection of cross-section dimensions for open-web and solid columns.	4
14	Types of columns head. Calculation and design of column's head.	2
15	Calculation of the column's base. Designing lateral bracings between columns.	2
16	The process of welded structures manufacturing.	2
17	Metal structures of multistoried buildings' frames, their types and erection diagrams.	2
18	Plated constructions, their types. Determination of wall thickness vertical cylindrical tank.	2
	Total hours 6 semester	30
	Total hours	45

4. Topics of practical classes

No.	Topic Name	Number of Hours
1	Requirements for the properties of metals used in structural steel building structures	2
2	Steel structure, chemical composition, and physical-mechanical properties of metals. Determination of steel weldability	2
3	Electric welding, welded joints in construction, and their types	2
4	Factory and assembly welds and joints. Calculation of welded joints.	2
5	Drawing variant schemes of working platform	2
6	Determination of loads and steel selection	2
7	Design of simply supported and continuous rolled steel beams	2
8	Determination of Technical and economic parameters. Comparison of variants.	1
	Total hours – Semester 5	15
9	Calculation of the main beams with optimal solutions application	2
10	Determination of the cross-section dimensions, change the beam cross section dimensions by the beam length.	2
11	Design of the support section of the main beam	2
12	Design of flange welds and provision of local web stability	2
13	Design of the arrangement of stiffeners for the main beam	2
14	Calculation assembly joint of the main beam on high-strength bolts	2
15	Design in-level connections between floor beams and the main beam	2
16	Design of top-mounted connections between floor beams and the main beam	2
17	Determination of design combinations of internal forces acting in the sections of an open-web column	2

18	Design and calculation of an open-web column for the working platform frame	2
19	Design and calculation of a solid-web column for the working platform frame	2
20	Design and calculation of the column head for an open-web column	2
21	Design and calculation of the column base for an open-web column	2
22	Design and calculation of the column base for a solid-web column	2
23	Horizontal and vertical bracing of the working platform frame. Design of frame bracing	2
	Total hours – Semester 6	30
	Total Hours	45

5. Topics for independent work

No.	Topic Name	Number of Hours
1	Materials for steel structures and connections. Design properties of materials and connections	10
2	Design of steel structural members under axial tension. Design of members with solid cross-sections	10
3	Design of steel structural members under axial tension. Design of members with built-up (latticed) cross-sections	10
4	Design of steel structural members subjected to bending. Classification of bending members	10
5	Design of steel structural members subjected to axial force and bending moment. Stability analysis of members with solid cross-sections	10
6	Design of steel structural members subjected to axial force and bending moment. Stability analysis of members with built-up (latticed) cross-sections	10
7	Course Project	30
	Total Hours	60

6. Methods and means of diagnosing learning outcomes:

- test;
- exam;
- module tests;
- tests;
- defense of practical work, course work
- oral examination.

7. Teaching methods:

- problem-based learning method;
- practice-oriented learning method;
- project-based learning method;
- research-based learning method;
- teamwork method.

8. Assessment of learning outcomes

The assessment of the knowledge of a higher education applicant is carried out on a 100-point scale and is translated into a national assessment in accordance with the current "Regulations on Examinations and Tests at the NULES of Ukraine"

8.1. Distribution of points by types of educational activities

Type of Learning Activity	Learning Outcomes	Assessment
Module 1. Elements of metal structures and their welding		
Practical Class 1. Requirements for the Properties of Metals Used in Structural Steel Construction	Understand the materials used for steel structures (structural steels and aluminum alloys). Analyze the design model of steel structures according to actual service conditions. Analyze the structure and quality of steel depending on carbon content.	20
Practical Class 2. Steel Structure, Chemical Composition, and Physical-Mechanical Properties of Metals. Determination of Steel Weldability	Understand the structure of steels, their chemical composition, physical and mechanical properties, and methods for determining steel weldability.	20
Practical Class 3. Electric Arc Welding, Welded Joints in Construction, and Their Types	Determine methods of connecting steel structural elements depending on the design solution, service conditions under loading, ease of fabrication, and the location of construction work (shop or field conditions).	20
Practical Class 4. Factory and assembly welds and joints. Calculation of welded joints.	Perform the design of butt welds and fillet welds.	20
Module Test 1		20
Total for Module 1		100
Module 2. Metal structures of buildings and structures		
Practical Class 5. Drawing variant schemes of working platform	Be able to design beam floor systems with steel decking (standard and complex types) and reinforced concrete decking. Understand the arrangement of floor beams and secondary beams and determine the optimal spacing of secondary beams.	20
Practical Class 6. Determination of Loads and Steel Selection	Be able to determine design loads and select appropriate steel grades. Understand the determination of allowable deflection limits and the selection of the optimal design resistance and steel strength class.	20
Practical Class 7. Design of Simply Supported and Continuous Rolled Beams	Be able to determine the linear weight of beams and calculate characteristic and design loads, including self-weight. Determine bending moments. Analyze beam cross-section selection	20

Type of Learning Activity	Learning Outcomes	Assessment
	considering limited plastic deformations and deflection verification.	
Practical Class 8. Determination of Technical and economic parameters. Comparison of variants.	Be able to calculate techno-economic indicators and compare design alternatives considering: material consumption; cost of erected structures; labor intensity of fabrication and erection.	20
Module Test 2		20
Total for Module 2		100
Study Work		(100 + 100) / 2 × 0.7 = 70
Test		30
Total for Course		100
Module 3. Structural forms of metal structures		
Practical Class 9. Calculation of the main beams with optimal solutions application	Analyze steel selection based on maximum design resistance. Be able to determine girder cross-sectional dimensions and verify strength and stiffness requirements.	8
Practical Class 10. Determination of the cross-section dimensions, change the beam cross section dimensions by the beam length.	Apply cross-section reduction by decreasing flange width under uniformly distributed loading. Calculate cross-section reduction without considering plastic deformations.	8
Practical Class 11. Design of the Support Section of the Main Girder	Be able to design beam support details, including the arrangement and design of bearing stiffeners. Analyze alternative support configurations using end bearing stiffeners or bearing stiffeners located away from the beam end.	8
Practical Class 12. Design of Flange Welds and Provision of Local Web Stability	Design the connection of beam flanges to the web using single-sided or double-sided fillet welds.	8
Practical Class 13. Design of the arrangement of stiffeners for the main beam	Design the arrangement of stiffeners to ensure web stability.	8
Practical Class 14. Calculation assembly joint of the main beam on high-strength bolts	Be able to design the erection splice of the main girder using high-strength bolts.	8
Practical Class 15. Design in-level connections between floor beams and the main beam	Be able to design in level beam-to-girder connections using standard-precision bolts.	8
Practical Class 17. Determination of design combinations of internal forces acting in the sections of an open-web column	Analyze the selection of column cross-section types considering load magnitude, service conditions, fabrication capabilities, and available rolled sections.	8
Practical Class 18. Design and calculation of a solid-web column for the working platform frame	Be able to design solid-web and latticed columns. Design solid columns using rolled or welded I-sections. Design connecting battens for latticed columns.	8

Type of Learning Activity	Learning Outcomes	Assessment
Practical Class 21. Design and calculation of the column base for an open-web column	Be able to design column bases and their connection to foundations. Apply pinned and rigid base-to-foundation connections. Analyze alternative base designs including bases with traverses, milled-end bases, and hinged bases with centering plates.	8
Module Test 3		20
Total for Module 3		100
Study Work		100 × 0.7 = 70
Examination		30
Total for Course		100
Course Project		100

8.2. Scale for assessing knowledge of a higher education applicant

Higher education applicant rating, points	National grading system (exams/tests)
90-100	excellent
74-89	good
60-73	satisfactory
0-59	unsatisfactory

8.3. Assessment Policy

Deadlines and Rescheduling Policy	EXAMPLE: Works submitted after the deadline without good reason are evaluated with a lower grade. Re-siting of modules is carried out with the permission of the lecturer if there are good reasons (for example, illness).
Academic Integrity Policy	EXAMPLE: Cheating during tests and exams is prohibited (including using mobile devices). Term papers, essays must have correct text references to the literature used
Attendance Policy	EXAMPLE: Attendance at classes is mandatory. For objective reasons (for example, illness, international internship) training can take place individually (in online form in agreement with the dean of the faculty)

9. Educational and methodological support:

- electronic training course of the academic discipline (on the educational portal of the NULES of Ukraine eLearn - <https://elearn.nubip.edu.ua/enrol/index.php?id=1066>);
- lecture notes and their presentations (in electronic form);
- textbooks, study guides;
- methodological instructions for completing coursework for full-time and part-time higher education students.

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