THE WORKING PROGRAM OF THE DISCIPLINE

Name of the discipline Advanced structural mechanics

Рекомендуется для направления подготовки/специальности

08.06.01 Engineering and construction technologies

Направленность программы (профиль)

Building designs, buildings and constructions (реализуется на английском языке)

1. Goals and objectives of the discipline:

The purpose of mastering the discipline «Advanced structural mechanics» is to gain knowledge, skills, skills and experience in the field of calculation of load-bearing structures for strength, rigidity and stability, in particular design and calculation of the main types of plane rod systems and structures that characterize the stages of the formation of competencies and ensuring the achievement of the planned results of the development of the educational program.

The main objectives of the discipline are:
- study of the principles and methods of calculating structures to determine the stress-strain state from specified external influences (force, kinematic and temperature);
- the acquisition of the ability to draw up and analyze the design schemes of various structures for their calculation for given impacts;
- the acquisition of knowledge necessary to solve a certain number of problems in structural mechanics using small computing means;
- the acquisition of the ability to assess the correctness of the calculation results.

2. Place of discipline in the structure of EP VO:

The discipline «Advanced structural mechanics» refers to the variable part of block 1 of the curriculum.

Table 1 shows the previous and subsequent disciplines aimed at the formation of discipline competencies in accordance with the competence matrix of EP HE.

Table No. 1

Prior and subsequent disciplines aimed at the formation of competencies

№	Code and name of competence	Preceding disciplines	Subsequent disciplines (groups of disciplines)
General cultural competences			
General professional competencies			
	GPC-1	Methodology of Scientific Research. Technology and Organization of Construction. Analysis and Design of Structural Systems. Scientific Research.	Building designs, buildings and constructions: the theory of buildings and structures. Scientific Research. State Exam. PhD Qualification Thesis and Presentation.
	GPC-2	Methodology of Scientific Research. Technology and Organization of Construction. Analysis and Design of Structural Systems. Scientific Research.	Building designs, buildings and constructions: the theory of buildings and structures. Scientific Research. Scientific Research 2. State Exam. PhD Qualification Thesis and Presentation.
Professional competencies (type of professional activity of a civil engineer)			
	PC-1	Methodology of Scientific Research. Scientific Seminar. Technology and Organization of Construction.	Scientific Seminar. Building designs, buildings and constructions: the theory of buildings and structures. Practice in Obtaining Profes-

		Analysis and Design of Structural Systems. Scientific Research.	sional Skills and Professional Experience (Research Practice). Scientific Research. Scientific Research 2. State Exam. PhD Qualification Thesis and Presentation.
	PC-2	Scientific Research.	Practice in Obtaining Professional Skills and Professional Experience (Research Practice). Scientific Research. Scientific Research 2. State Exam. PhD Qualification Thesis and Presentation.
Vocational Competencies of Specialization Structural mechanics			

3. Requirements for the results of mastering the discipline:

The process of studying the discipline is aimed at the formation of the following competencies:

GPC-1 - possession of the methodology of theoretical and experimental research in the field of construction.
GPC-2 - possession of the culture of scientific research in the field of construction, including the use of the latest information and communication technologies.
PC-1 - possession of methods for the development of scientific and methodological foundations of research, improvement, theoretical, experimental and feasibility study of the use of various technical solutions and technologies in construction.
PC-2 - possession of linear and nonlinear mechanics of structures and structures, physical and mathematical models, analytical and numerical methods of their calculation, including the calculation of structures and structures for reliability in extreme operating conditions.

As a result of studying the discipline, the student must:
Know:
- basic principles and methods of calculating building structures.
- the principles of drawing up and analyzing design schemes for various structures and structures for their calculation for given impacts.
- the main approaches required to solve a certain number of problems in structural mechanics using small computing tools (calculators).
Be able to:
- to determine the main external influences on the structure - power, temperature, settlement of supports.
- to carry out calculations of statically definable bar plane structures such as multi-span beams, trusses, arches, frames.
- to correctly select the material of construction, depending on the characteristics of its work.
Own:
- the skills of correct assessment of the stress-strain state of the structure.
- the ability to assess the correctness of the calculation results.
- the skills of applying the results of calculating building structures for their competent architectural and construction design.

4. Scope of discipline and types of educational work

The total workload of the discipline is 4 credit units.

Type of educational work	Total hours	Semesters				
		4				
Classroom Practice in Obtaining Professional Skills and Professional Experience (Research Practice). **lessons (total)**	76	76				
Including:	-	-	-	-	-	
Lectures	38	38				
Practical lessons (PL)	38	38				
Seminars (S)	-	-				
Laboratory work (LW)	-	-				
Independent work (total)		32				
Total labor intensity hour	144	144				
credits	4	4				

5. Content of the discipline

5.1. Contents of discipline sections

№	The name of the discipline section	Section content (topics)
1.	**Finite element analysis of structures**	Linear theory of space trusses and properties of bar elements. Linear theory of space frames and properties of frame members. Linear theory of plates and properties of finite plate elements. Linear theory of folded plates and properties of finite folded plate elements. Systems of linear equations: structure, solution, accuracy. Control of accuracy with adaptive methods. Data base, algorithms and interfaces for finite element applications on computers. Examples of practical applications in structural engineering.
2.	**Structural dynamics**	Linear and nonlinear equations of motion for load bearing systems. Spatial and time discretisation of dynamic boundary value problems. Methods of solution for linear and nonlinear problems. Modal analysis with the finite element method. Time history analysis with the finite element method. Constructed facilities with wind and wave excitation. Constructed facilities subjected to traffic loads and ground vibration. Constructed facilities subjected to earthquake loadings. Computer models for dynamic analysis.
3.	**Structural stability**	Concepts of structural stability: singularity, instability, imperfections, load perturbation. Linear and nonlinear formulations of stability problems. Second order stress analysis of plane frames. Second order stability analysis of plane frames. First order theory of space frames with uniform and non-uniform torsion. Second order stress analysis of space frames. Second order stability analysis of space frames (torsional-flexural buckling). Bifurcation theory and load path continuation. Buckling of thin plates. Introduction to the buckling of arches and shells. Computer implementation and testing of all methods.
4.	**Nonlinear structural analysis**	Geometrically nonlinear theory of elasticity. Theory of plasticity, damage and failure, nonlinear constitutive laws.

		Geometrically nonlinear theory of space trusses: formulation, finite elements. Nonlinear load-displacement behaviour, limit points (snap-through, bifurcation). Incremental-iterative methods of solution for nonlinear quasi-static problems. Geometrically nonlinear theory of frames: formulation, finite elements, nonlinear. Load-displacement behaviour, limit points (snap-through, bifurcation). Physically nonlinear behaviour of trusses and frames, tension-only members. Computer models and interfaces for nonlinear truss and frame analysis. Examples of practical applications in structural engineering.

5.2. Sections of disciplines and types of classes

No.	Discipline section No.	Lec-tures.	Practice	Lab. works	Semi-nars	Independent work of students	Total hour.
1.	**Finite element analysis of structures**	10	10	0	0	8	28
2.	**Structural dynamics**	8	8	0	0	8	24
3.	**Structural stability**	10	10	0	0	8	28
4.	**Nonlinear structural analysis**	10	100	0	0	8	28

6. Laboratory workshop
No laboratory workshop provided.

7. Practical exercises (seminars)

No.	Discipline section No.	Subjects of practical classes (seminars)	Labor capacity (hour.)
1.	**Finite element analysis of structures**	Linear theory of space trusses and properties of bar elements. Linear theory of space frames and properties of frame members. Linear theory of plates and properties of finite plate elements. Linear theory of folded plates and properties of finite folded plate elements. Systems of linear equations: structure, solution, accuracy. Control of accuracy with adaptive methods. Data base, algorithms and interfaces for finite element applications on computers. Examples of practical applications in structural engineering.	
2.	**Structural dynamics**	Linear and nonlinear equations of motion for load bearing systems. Spatial and time discretisation of dynamic boundary value problems. Methods of solution for linear and nonlinear problems. Modal analysis with the finite element method. Time history analysis with the finite element method. Constructed facilities with wind and wave excitation. Constructed facilities subjected to traffic loads and ground vibration. Constructed facilities subjected to earthquake loadings. Computer models for dynamic analysis.	
3.	**Structural stability**	Concepts of structural stability: singularity, instability, imperfections, load perturbation. Linear and nonlinear formulations of stability problems. Second order stress analysis of plane frames. Second order stability analysis of plane frames. First order theory of space frames with uniform and non-uniform torsion. Second order stress analysis of space frames.	

		Second order stability analysis of space frames (torsional-flexural buckling). Bifurcation theory and load path continuation. Buckling of thin plates. Introduction to the buckling of arches and shells. Computer implementation and testing of all methods.	
4.	**Nonlinear structural analysis**	Geometrically nonlinear theory of elasticity. Theory of plasticity, damage and failure, nonlinear constitutive laws. Geometrically nonlinear theory of space trusses: formulation, finite elements. Nonlinear load-displacement behaviour, limit points (snap-through, bifurcation). Incremental-iterative methods of solution for nonlinear quasi-static problems. Geometrically nonlinear theory of frames: formulation, finite elements, nonlinear. Load-displacement behaviour, limit points (snap-through, bifurcation). Physically nonlinear behaviour of trusses and frames, tension-only members. Computer models and interfaces for nonlinear truss and frame analysis. Examples of practical applications in structural engineering.	

8. Material and technical support of the discipline:

Auditorium with a list of logistics	Location
Lecture room - Specialized room number 298 - "Modeling of large-span building structures" Equipment and furniture: - a set of specialized furniture; - chalk board; - projection screen; - multimedia projector EPSON EMP-X5.	Moscow, st. Ordzhonikidze, 3
Classroom for practical training, monitoring and intermediate certification - Computer class No. 352 Laboratory of Hydrological and Technical Safety of Hydraulic Structures. Equipment and furniture: - a set of specialized furniture; - chalk board; - interactive whiteboard PolyVision Webster TSL 610; - Toshiba TLP XC3000 multimedia projector; - roll-up wall screen Draper Luma 178x178; - computer Pirit Codex 1226 - 1 pc .; - sound amplifying equipment GENIUS SP-i350 - 1 piece; - Xerox 3125 printer - 1 pc .; - Scanner Epson 10V Photo - 1 pc .; - plotter HP DesignJet 130+ NR (A1) - 1 pc .; - Pirit Doctrina computers - 9 pcs.; - LCD ViewSonic 22 "VA2216w monitor - 9 pcs.; - 19 "NEC monitor - 1 pc.	Moscow, st. Ordzhonikidze, 3
Educational-methodical room for independent, research work of students № 352 - computer class of the Laboratory of Hydrological and Technical Safety of Hydraulic Structures.	Moscow, st. Ordzhonikidze, 3

Equipment, furniture, technical means: - a set of specialized furniture; - chalk board; - interactive whiteboard PolyVision Webster TSL 610; - Toshiba TLP XC3000 multimedia projector; - roll-up wall screen Draper Luma 178x178; - Pirit Codex 1226 computer - 1 pc .; - sound amplifying equipment GENIUS SP-i350 - 1 piece; - Xerox 3125 printer - 1 pc .; - Scanner Epson 10V Photo - 1 pc .; - plotter HP DesignJet 130+ NR (A1) - 1 pc .; - Pirit Doctrina computers - 9 pcs .; - LCD ViewSonic 22 "VA2216w monitor - 9 pcs .; - 19 "NEC monitor - 1 pc. (RUDN University software: Plaxis 2D Suit (Network license). Plaxis Professional (version 8) + Plaxis Dinamics Modul + PlaxFlow (version 1) - Education Registration number 90-07-019-00261-3 MS-office corporate, Registration code: 86626883 Parent program: 86493330 Status: Active).	

9. Information support of the discipline

a) software
Specialized software for conducting lectures and practical classes, completing coursework and independent work of students:
RUDN University software: Plaxis 2D Suit (Network license). Plaxis Professional (version 8) + Plaxis Dinamics Modul + PlaxFlow (version 1) - Education Registration number 90-07-019-00261-3
MS-office corporate, Registration code: 86626883
Parent program: 86493330
Status: Active).

b) databases, reference and search systems
- electronic fund of legal and normative-technical documentation
http://docs.cntd.ru/
- Yandex search engine https://www.yandex.ru/
- Google search engine https://www.google.ru/
- SCOPUS abstract database http://www.elsevierscience.ru/products/scopus/
- Site of the Ministry of Construction and Housing and Communal Services of the Russian Federation http://www.minstroyrf.ru/
- Electronic library system RUDN - EBS RUDN
http://lib.rudn.ru/MegaPro/Web
- EBS "University Library Online" http://www.biblioclub.ru
- EBS Yurayt http://www.biblio-online.ru
- EBS "Student Consultant" www.studentlibrary.ru
- EBS "Doe" http://e.lanbook.com/

10. Educational and methodological support of the discipline:

a) <u>main literature</u>
     1.   Engineering Mechanics [Электронный ресурс] : Graduate/advanced undergraduate textbook. - Электронные текстовые данные. - : Springer Berlin Heidelberg, 2009. - Системные

требования: Windows XP и выше. - ISBN 978-3-540-89937-2.
http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=327461&idb=0

b) additional literature
1. Jaap Schijve. Fatigue of Structures and Materials [Electronic resource]: Graduate / advanced undergraduate textbook / S. Jaap. - Electronic text data. -: Springer Netherlands, 2009. - System requirements: Windows XP or higher. - ISBN 978-1-4020-6808-9. http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=327393&idb=0
2. Galishnikova V.V. Computational Mechanics [Text / electronic resource] = Computational Mechanics: Education and Methodical Complex / V.V. Galishnikov. - The book is in English; Electronic text data. - M.: PFUR, 2013 .-- 155 p. - ISBN 978-5-209-05047-6: 194.47.
http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=404256&idb=0
3. Structural mechanics [Text]: Textbook: Transl. from the Russian / Ed. by A.Darkov. - The book is in English. - Moscow: Mir, 1989 .-- 646 p .: il. - 4.40.
4. Taoufik Boukharouba. Damage and Fracture Mechanics [Electronic resource]: Contributed volume / B. Taoufik, E. Mimoun, P. Guy. - Electronic text data. -: Springer Netherlands, 2009. - System requirements: Windows XP or higher. - ISBN 978-90-481-2669-9. http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=327316&idb=0
5. Computational and Experimental Mechanics of Advanced Materials [Electronic resource]: Contributed volume. - Electronic text data. -: Springer Vienna, 2009. - (CISM International Center for Mechanical Sciences; 514). - System requirements: Windows XP or higher. - ISBN 978-3-211-99685-0. http://lib.rudn.ru/MegaPro/UserEntry?Action=Rudn_FindDoc&id=326990&idb=0
6. International Journal for Computational Civil and Structural Engineering https://doaj.org/toc/2588-0195?source=%7B%22query%22%3A%7B%22filtered%22%3A%7B%22filter% 22% 3A% 7B% 22bool% 22% 3A% 7B% 22must% 22% 3A% 5B% 7B% 22terms% 22% 3A% 7B% 22index.issn.exact% 22% 3A% 5B% 222587-9618% 22% 2C% 222588-0195% 22% 5D% 7D% 7D% 2C% 7B% 22term% 22% 3A% 7B% 22_type% 22% 3A% 22article% 22% 7D% 7D% 5D% 7D% 7D% 2C% 22query% 22% 3A% 7B% 22match_all% 22% 3A% 7B% 7D% 7D% 7D% 7D% 2C% 22from% 22% 3A0% 2C% 22size% 22% 3A100% 7D
7. Magazine "The Finite Element Method for Solid and Structural Mechanics" https://www.sciencedirect.com/science/article/pii/B9781856176347000181?via%3Dihub
8. Journal "Structural Mechanics of Engineering Constructions and Buildings" http://journals.rudn.ru/structural-mechanics.

11. Methodical instructions for students on mastering the discipline (module)

Methodological instructions for the implementation of students' IWS are contained in the book: Galishnikova V.V. Computational Mechanics [Text / electronic resource] = Computational Mechanics: Education and Methodical Complex / V.V. Galishnikov. - The book is in English; Electronic text data. - M.: PFUR, 2013 .-- 155 p. - ISBN 978-5-209-05047-6: 194.47.

12. Fund of assessment tools for intermediate certification of students in the discipline (module)

The fund of assessment tools, formed for the current monitoring of progress and intermediate certification of students in the discipline "Advanced structural mechanics / Structural mechanics" is presented in Appendix 1 to the work program of the discipline and includes:
- a list of competencies formed in the course of studying the discipline;
- description of indicators and criteria for assessing competencies, description of assessment scales;
- typical control tasks or other materials necessary to assess knowledge, skills, skills and (or) experience of activities, characterizing the level of competence formation;
- methodological materials that determine the procedures for assessing knowledge, skills, skills and (or) experience of activities, characterizing the level of competence formation.

The program has been drawn up in accordance with the requirements of the ES of HE RUDN.

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