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ФИО: Ястребов Олег Александрович  
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**Federal state autonomous educational institution of higher education  
Russian peoples' friendship university  
(RUDN university)**

*Academy of Engineering*

(наименование основного учебного подразделения (ОУП)-разработчика ОП ВО)

## **THE WORKING PROGRAM OF THE DISCIPLINE**

### **РАБОЧАЯ ПРОГРАММА ДИСЦИПЛИНЫ**

2.1.1. Building designs, buildings and constructions / Строительные  
конструкции, зданий и сооружения (англ.)

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(наименование дисциплины/модуля)

**Рекомендована МССН для направления подготовки/специальности:**

2.1.1. Building designs, buildings and constructions / Строительные  
конструкции, зданий и сооружения (англ.)

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(код и наименование научной специальности)

**Освоение дисциплины ведется в рамках реализации основной профессиональной образовательной программы высшего образования (ОП ВО):**

Building designs, buildings and constructions

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(наименование программы аспирантуры)

**2023 г.**

**1. Goals of the discipline / цель освоения дисциплины**

The purpose of mastering the discipline «Building designs, buildings and constructions» is to gain knowledge, skills, and experience in the field of calculation of structures and structures that characterize the stages of competence formation and ensure the achievement of the planned results of the development of the educational program and also preparation for the candidate's examinations and obtaining knowledge, skills and experience in the field of construction.

**The main objectives** of the discipline "Building designs, buildings and constructions: the theory of buildings and structures" are the following. Finite element method in the calculations of building structures is an experimental and theoretical science, where experimental data and theoretical studies are widely used. Various structures and structures, the design and construction of which is engaged in the engineer, must be designed for strength, rigidity, stability. This discipline teaches the student the correct selection of finite elements and their sizes for solving specific construction problems using the method of forces or displacements.

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

The discipline "Building designs, buildings and constructions" refers to the variable part of Block 1 of the curriculum. Its study is based on the material of previous disciplines, and it is also the basis for the study of subsequent disciplines of the curriculum, a list of which is presented in table 1.

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

The discipline "Finite Element Method for Civil Infrastructure" / "Finite element Method for civil infrastructure" refers to the variable part of Block 1 of the curriculum. Its study is based on the material of previous disciplines, and it is also the basis for the study of subsequent disciplines of the curriculum, a list of which is presented in table 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			
	PC-1	it is expected that the students should be exposed to Structural Analysis, Matrix Algebra & Basic Mathematics courses Basics of Linear Algebra; Introductory calculus	Introduction to finite element analysis , Direct stiffness approach: Spring elements , Bar and truss elements , Introduction to differential equations and strong formulation
	PC-4	Occurrence and consequences of earthquakes; Seismological foundations of earthquake-resistant construction; Propagation of waves caused by earthquakes.	Basic Concepts of Finite Element Analysis, Introduction to Elasticity, Steps in Finite Element Analysis Virtual Work and Variational Principle. Application of Finite element method for stability and dynamic structures.

		<ul style="list-style-type: none"> <li>- Determination of parameters that determine the impact of earthquakes;</li> <li>Methods for calculating soil interaction;</li> </ul>	Active and passive methods for identifying structures from earthquakes; Determination of the size of soil structures for earthquakes; Examples from engineering practice. Design and analysis of plastic structures to maintain performance and / or safety.
	PC-5	<ul style="list-style-type: none"> <li>- Classification of buildings by structural systems. Multi-storey and high-rise buildings with a metal frame.</li> <li>- Composite frames: decks, beams, columns, foundations. Ensuring the spatial rigidity of frame buildings. Vertical and horizontal connections of the building.</li> </ul>	<ul style="list-style-type: none"> <li>Determination of the loads acting on the building. Methods for the analysis of structural systems. Frames of multi-storey buildings. Accounting for the plastic work of the material.</li> <li>- Design of light metal structures: light beams, light trusses and frames. Lightweight structural metal shells.</li> </ul>
	PC-6	<ul style="list-style-type: none"> <li>Classification of buildings by structural systems. Multi-storey and high-rise buildings with a metal frame.</li> <li>- Composite frames: decks, beams, columns, foundations. Ensuring the spatial rigidity of frame buildings. Vertical and horizontal connections of the building.</li> </ul>	Principle of minimum potential energy and weak formulation, Finite element formulation of linear elasto-statics, Constant strain triangle, Quadrilateral element
	PC-17	Basics of Linear Algebra; Introductory calculus (differentiation, integration, differential equations); Computer aided design; Engineering statics	Practical considerations in FEM modeling, Convergence of analysis results, Higher order elements, Isoparametric formulation, Numerical integration
	PC-19	Basics of Linear Algebra; Introductory calculus (differentiation, integration, differential equations); Computer aided design; Engineering statics	Stiffness of Truss Members, Analysis of Truss, Stiffness of Beam Members, Finite Element Analysis of Continuous Beam, Plane Frame Analysis, Analysis of Grid and Space Frame
<b>Vocational Competencies of Specialization Structural mechanics</b>			

### 3. Requirements for the results of mastering the discipline:

*The course " Building designs, buildings and constructions " / " Building designs, buildings and constructions " is aimed at students following competences:*

*PC-1- ability to demonstrate knowledge of fundamental and applied disciplines graduate programs.*

*PC-4- the ability to conduct surveys to assess the status of natural and natural-anthropogenic objects, the definition of the initial data for the design and design of the study and the monitoring of objects, patent research, to prepare specifications for the design;*

*GPC-5 - The ability to conduct surveys to assess the state of natural and natural-man-made objects, determine the initial data for the design and design justification and monitoring of objects, patent research, prepare design assignments. knowledge of methods of design and monitoring of buildings and structures, their structural elements, including methods of computational justification, including the use of universal and specialized software and computer-aided design systems.*

*PC-6- possession of knowledge of design methods and monitoring of buildings and structures, their structural components, including methods design study, including the use of universal and specialized software and computer systems of computer-aided design.*

*PC-17- ability to develop conceptual, technical and business projects of complex objects, including using computer-aided design (PC-4);*

*PC-19- ability to develop methods, plans and programs of scientific research and development, to prepare jobs for artists, to organize experiments and tests, to analyze and generalize the results ;*

*PC-19- ability to develop the physical and mathematical (computational) models of phenomena and objects related to the profile .*

.As a result of studying the discipline, the student must:

#### **Know:**

- in the field of methods of mathematical analysis.
- know the state standards and be able to use them.
- basic methods of calculation and design of building structures.
- know the main theoretical provisions of the discipline:
- requirements for products and quality of information and theoretical support of the calculation base.
- knowledge of specialized software and computing systems.

#### **Be able to:**

- use modern information technologies.
- be able to use the appropriate computer developments.
- use modern software and computing systems for the calculation of building structures.
- use information technology to solve specific tasks.
- use information technology to solve specific tasks;
- use information technology in professional activities

#### **.Own:**

- application of theoretical knowledge in practice.
- search for the necessary information.
- use of the latest automated projecting systems.
- use of information support in the calculation of structures and structures.
- organization of high-quality calculation of structures and structures.
- search for new software and computing systems to solve the tasks.

#### 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			
		3			
<b>Classroom Practice in Obtaining Professional Skills and Professional Experience (Research Practice). lessons (total)</b>	50	50			
Including:	-	-	-	-	-
<i>Lectures</i>	16	16			
<i>Practical lessons (PL)</i>	34	34			
<i>Seminars (S)</i>	-	-			
<i>Laboratory work (LW)</i>	-	-			
<b>Independent work (total)</b>		ЭКЗАМЕН			
Total labor intensity	144	144			
hour	4	4			
credits					

#### 5. Content of the discipline

##### 5.1. Sections of disciplines and types of classes

№	The name of the discipline section	Section content (topics)
1.	<b>Plane Stress and Plane Strain Theory (theory of elasticity)</b>	- Plane stress and plan strain approximations. Coordinate systems. Displacement of material points. State of strain. State of stress. Stress equilibrium at a point. Topic 1.2. Constitutive equations. Boundary conditions. Differential form of the governing equations. Weighted residual method. Integral form of the governing equations.
2.	<b>Finite Element Tools: Special topics in the design of metal structures and Special topics in the design of reinforced concrete structures</b>	- Finite element concept. Description of finite element shape. Quadrilateral elements. Triangular elements. Interpolation of variables in finite elements. - Differentiation of functions in finite elements: Differentiation of shape functions. Differentiation of behavioral variables -Integration of functions in finite elements: Integration over quadrilateral elements; Integration over triangular elements. - Numerical integration. One-dimensional Gauss integration: Gauss integration in quadrilaterals; Gauss integration in triangles. Frames of multi-storey buildings. Accounting for the plastic work of the material. - Design of light metal structures: light beams, light trusses and frames. Lightweight structural metal shells. - Construction of multi-storey industrial buildings. Purpose of the building. Sizing. Number of floors. Column grid. Main supporting structures. - Multi-storey prefabricated frame. Constructive schemes of multi-storey frames with ready-made elements. Connections of multi-storey prefabricated frames. - Multi-storey monolithic and prefabricated monolithic construction. Units of monolithic multi-storey frames. Rebar nodes. - Practical calculation of multi-storey frames. Preselection of sections of frame elements. Computer simulation of RC frames

3.	<b>Finite Element Networks: Reliability and safety of buildings and structures</b>	<ul style="list-style-type: none"> <li>- Decomposition of a slab. Element shape. Displacement interpolation. Strain interpolation.</li> <li>- Element and system stiffness matrices. Element and system body load vectors. Boundary conditions: Shape of the boundary; System boundary load vector; Boundary conditions at nodes.</li> <li>- Algebraic governing equations. Assembly and solution of the algebraic system equations. Assembly of the system equations. <ul style="list-style-type: none"> <li>- Structure of the system matrix. Solution of linear equations with profile and status. Accuracy and convergence of the finite element method. Stress computation. Criteria for the reliability of buildings and structures. Application of the principle of structure analysis for the most unfavorable combination of loads. The choice of materials for structures that increase their reliability.</li> </ul> </li> <li>- Adoption of design and engineering decisions that reduce the likelihood of progressive collapse.</li> </ul> <p>Selection of optimal technological processes for the manufacture of structures and effective methods of construction of buildings and structures.</p>
4.	<b>Finite Element methods considering the Design of earthquake-resistant structures.</b>	<ul style="list-style-type: none"> <li>- Occurrence and consequences of earthquakes; Seismological foundations of earthquake-resistant construction; Propagation of waves caused by earthquakes.</li> <li>- Determination of parameters that determine the impact of earthquakes; Methods for calculating soil interaction; Design and analysis of plastic structures to maintain performance and / or safety.</li> <li>- Active and passive methods for identifying structures from earthquakes; Determination of the size of soil structures for earthquakes; Examples from engineering practice..</li> </ul>

## 5.2. Sections of disciplines and types of classes

No	Discipline section No.	Lectures	Practices	Lab. works	Seminars	Independent work of students	Total hours
1.	<b>Plane Stress and Plane Strain Theory (theory of elasticity)</b>	4	8	0	0	14	26
2.	<b>Finite Element Tools: Special topics in the design of metal structures and Special topics in the design of reinforced concrete structures</b>	4	10	0	0	14	28
3.	<b>Finite Element Networks: Reliability and safety of buildings and structures</b>	4	8	0	0	14	28
4.	<b>Finite Element methods considering the Design of earthquake-resistant structures.</b>	4	8	0	0	14	28

## 6. Laboratory workshop

No laboratory workshop provided.

## 7. Practical exercises (seminars)

№	The name of the discipline section	Section content (topics)
1.	<b>Plane Stress and Plane Strain Theory (theory of elasticity)</b>	<ul style="list-style-type: none"> <li>- Plane stress and plan strain approximations. Coordinate systems. Displacement of material points. State of strain. State of stress. Stress equilibrium at a point. Topic 1.2. Constitutive equations. Boundary conditions. Differential form of the governing equations. Weighted residual method. Integral form of the governing equations.</li> </ul>
2.	<b>Finite Element Tools: Special topics in the design of metal structures and Special topics in the design of reinforced concrete structures</b>	<ul style="list-style-type: none"> <li>- Finite element concept. Description of finite element shape. Quadrilateral elements. Triangular elements. Interpolation of variables in finite elements.</li> <li>- Differentiation of functions in finite elements: Differentiation of shape functions. Differentiation of behavioral variables</li> <li>-Integration of functions in finite elements: Integration over quadrilateral elements; Integration over triangular elements.</li> <li>- Numerical integration. One-dimensional Gauss integration: Gauss integration in quadrilaterals; Gauss integration in triangles. Frames of multi-storey buildings. Accounting for the plastic work of the material.</li> <li>- Design of light metal structures: light beams, light trusses and frames. Lightweight structural metal shells.</li> <li>- Construction of multi-storey industrial buildings. Purpose of the building. Sizing. Number of floors. Column grid. Main supporting structures.</li> <li>- Multi-storey prefabricated frame. Constructive schemes of multi-storey frames with ready-made elements. Connections of multi-storey prefabricated frames.</li> <li>- Multi-storey monolithic and prefabricated monolithic construction. Units of monolithic multi-storey frames. Rebar nodes.</li> <li>- Practical calculation of multi-storey frames. Preselection of sections of frame elements. Computer simulation of RC frames</li> </ul>
3.	<b>Finite Element Networks: Reliability and safety of buildings and structures</b>	<ul style="list-style-type: none"> <li>- Decomposition of a slab. Element shape. Displacement interpolation. Strain interpolation.</li> <li>- Element and system stiffness matrices. Element and system body load vectors. Boundary conditions: Shape of the boundary; System boundary load vector; Boundary conditions at nodes.</li> <li>- Algebraic governing equations. Assembly and solution of the algebraic system equations. Assembly of the system equations. <ul style="list-style-type: none"> <li>- Structure of the system matrix. Solution of linear equations with profile and status. Accuracy and convergence of the finite element method. Stress computation. Criteria for the reliability of buildings and structures. Application of the principle of structure analysis for the most unfavorable combination of loads. The choice of materials for structures that increase their reliability.</li> </ul> </li> <li>- Adoption of design and engineering decisions that reduce the likelihood of progressive collapse.</li> </ul> <p>Selection of optimal technological processes for the manufacture of structures and effective methods of construction of buildings and structures.</p>

4.	<b>Finite Element methods considering the Design of earthquake-resistant structures.</b>	<ul style="list-style-type: none"> <li>- Occurrence and consequences of earthquakes; Seismological foundations of earthquake-resistant construction; Propagation of waves caused by earthquakes.</li> <li>- Determination of parameters that determine the impact of earthquakes; Methods for calculating soil interaction; Design and analysis of plastic structures to maintain performance and / or safety.</li> <li>- Active and passive methods for identifying structures from earthquakes; Determination of the size of soil structures for earthquakes; Examples from engineering practice..</li> </ul>
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## 8. Material and technical support of the discipline:

Auditorium with a list of logistics	Location
<p><b>Lecture room</b> - Specialized room number 298 - "Modeling of large-span building structures"</p> <p>Equipment and furniture:</p> <ul style="list-style-type: none"> <li>- a set of specialized furniture;</li> <li>- chalk board;</li> <li>- projection screen;</li> <li>- multimedia projector EPSON EMP-X5.</li> </ul>	<p>Moscow, st. Ordzhonikidze, 3</p>
<p>Classroom for independent work-Computer class No. 352</p> <p>A set of specialized furniture; technical means: PolyVision Webster TSL 610 interactive whiteboard, Toshiba TLP XC3000 multimedia projector, Draper Luma 178x178 roll-up wall screen, Pirit Codex 1226 computer - 1 pc., GENIUS SP-i350 sound amplification equipment-1 pc., Xerox 3125-1 pc. printer, Epson 10V Photo scanner-1 pc., HP DesignJet 130+ NR (A1) plotter-1 pc., Pirit Doctrina computers-9 pcs., ViewSonic 22" LCD monitor VA2216w-9 pcs., 19" NEC monitor-1 pc., chalk board.</p> <p>Plaxis 2D Suit (Network license). Plaxis Professional (version 8) + Plaxis Dinamics Modul + PlaxFlow (version 1) - Education, 25 seats-registration number 90-07-019-00261-3 (2008), Abaqus, 20 seats-registration number 90-07-019-00317-7 (2010), MS-office corporate. (RUDN Software) - Registration Code: 86626883 Parent Program: 86493330 Status: Active</p>	<p>Moscow, st. Ordzhonikidze, 3</p>

## 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](http://www.studentlibrary.ru)

- EBS "Doe" <http://e.lanbook.com/>

## 10. Educational and methodological support of the discipline:

Basic literature:

1. Advanced Finite Element Method in Structural Engineering. 2009. Publisher: Springer Berlin Heidelberg. ISBN: 978-3-642-00316-5
2. Yudina, AF Metallicheskie i zhelezobetonnye konstruksiy [Metal and reinforced concrete structures]. Editing: textbook for universities / A.F. Yudin. - 2nd ed., Rev. and add. - Moscow: Yurayt Publishing House, 2019. -- 302 p. - (Series: Specialist). - ISBN 978-5-534-06927-3. - Text: electronic // EBS Yurayt [site]. - URL: <https://biblio-online.ru/bcode/434494> (date of access: 01.04.2019).
3. KrivoshaPCo, SN Architectural and building structures: a textbook for academic bachelor's degree / SN KrivoshaPCo, VV Galishnikova. - Moscow: Yurayt Publishing House, 2019. -- 460 p. - (Series: Bachelor. Academic course). - ISBN 978-5-534-03143-0. - Access mode: HYPERLINK <https://biblio-online.ru/bcode/432798>
4. Tukhfatullin, BA Numerical methods of calculation of building structures. Finite element method: textbook. manual for academic bachelor's degree / BA Tukhfatullin. - 2nd ed., Rev. and add. - Moscow: Yurayt Publishing House, 2019. -- 157 p. - (Series: Bachelor. Academic course). - ISBN 978-5-534-08899-1. - Access mode: HYPERLINK <https://biblio-online.ru/bcode/442338>

Additional literature:

1. Algorithms for Solving the Parametric Self-Adjoint 2D Elliptic Boundary-Value Problem Using High-Accuracy Finite Element Method [Text] = Algorithms for solving the Parametric Self-Adjoint elliptic boundary value problem in a two-dimensional domain by the high-order finite element method  
// Bulletin of the Peoples ' Friendship University of Russia: Mathematics. Computer science. Physics. - 2017. - no. T. 25 (1). - C. 36-55. <http://dx.doi.org/10.22363/2312-9735-2017-25-1>
2. Gusev Alexander Alexandrovich. Finite Element Method of High-Order Accuracy for solving Two-Dimensional Elliptic Boundary-Value Problems of Two and Three Identical Atoms in a Line : article in English / A. A. Gusev // Bulletin of the Peoples ' Friendship University of Russia: Mathematics. Computer science. Physics. - 2018. - no. t. 26 (3). - p. 226-243.  
<http://journals.rudn.ru/miph/article/view/18988/16003>
3. Solution of the Boundary-Value Problem for a Systems of ODEs of Large Dimension: Benchmark Calculations in the Framework of Kantorovich Method [Text] = Solution of boundary-value problems for systems of ODES of large dimension: reference calculations within the framework of the Kantorovich method. Computer science. Physics. - 2016. - No. 3. - p. 31-37.

<http://journals.rudn.ru/miph/article/view/13387/12817>

4. KrivoshaPCo, SN Construction of buildings and structures: textbook for SPO / SN KrivoshaPCo, VV Galishnikova. - Moscow: Yurayt Publishing House, 2019 .-- 476 p. - (Series: Professional Education). - ISBN 978-5-534-02348-0. - Access mode: HYPERLINK <https://biblio-online.ru/bcode/433396>

5. Dedyukh, RI Materials science and technology of structural materials. Fusion welding technology: textbook. manual for applied baccalaureate / RI Dedyukh. - Moscow: Yurayt Publishing House, 2019 .-- 169 p. - (Series: Universities of Russia). - ISBN 978-5-534-01539-3. - Text: electronic // EBS Yurayt [site]. - URL: <https://biblio-online.ru/bcode/433979> (date of access: 01.04.2019).

6. Yudina, AF Building structures. Editing: textbook for SPO / A.F. Yudin. - 2nd ed., Rev. and add. - Moscow: Yurayt Publishing House, 2019 .-- 302 p. - (Series: Professional Education). - ISBN 978-5-534-07027-9. - Access mode: HYPERLINK <https://biblio-online.ru/bcode/442133>

Resources of the Internet information and telecommunications network»:

1. EBS RUDN and third-party EBS, to which university students have access based on concluded contracts:

- Electronic library system of 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](http://www.studentlibrary.ru)

-EBS" Doe " <http://e.lanbook.com/>

2. Databases and search engines:

- electronic fund of legal and regulatory and 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/>

### **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 evaluation funds formed for the current control of academic performance and intermediate certification of students in the discipline "Finite Element Method for Civil

Infrastructure" is presented in Appendix 1 to the work program of the discipline and includes:

- a list of competencies with an indication of the stages of their formation in the process of mastering the educational program;

- description of indicators and criteria for assessing competencies at various stages of their formation, description of assessment scales;

- standard control tasks or other materials necessary for the assessment of knowledge, skills, and (or) experience of activities that characterize the stages of competence formation in the process of mastering the educational program;

- methodological materials that define the procedures for evaluating knowledge, skills, and (or) experience of activities that characterize the stages of competence formation.

