Federal State Autonomous Educational Institution of Higher Education
"Peoples' Friendship University of Russia"

Academy of Engineering

Recommended by ISSC

THE WORKING PROGRAM OF THE DISCIPLINE

Name of the discipline Applications of Finite Element Method for Civil Engineering problems

Program specialization (profile)

08.04.01 Civil Engineering

Orientation of the program (profile):

Civil Engineering and Built Environment ,
Mechanics of materials and engineering structures,
Built environment of smart city

1. Goals and objectives of the discipline:

The purpose of mastering the discipline "Applications of Finite Element Method for Civil Engineering problems" is to gain knowledge, skills, 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.

The main objectives of the discipline Applications of Finite Element Method for Civil Engineering problems are the following. FEM 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 OP VO:

The discipline "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.

n/π	a Code and name of the competence	Previous disciplines	Subsequent disciplines (groups of disciplines)
General professional competencies			
	GPC -1;	Introductory calculus , integration, differential equations); Computer aided design; Engineering statics	Introduction to finite element analysis, Direct stiffness approach: Spring elements , Bar and truss elements , Introduction to differential equations and strong formulation. Stiffness of Truss Members,
	PC -1; PC-2; PC-11; PC-12	Basics of Linear Algebra; Introductory calculus (differentiation, integration, differential equations); Computer aided design; Engineering statics	Analysis of Truss, Stiffness of Beam Members, Finite Element Analysis of Continuous Beam, Plane Frame Analysis, Analysis of Grid and Space Frame

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

The discipline Applications of Finite Element Method for Civil Engineering problems" the made of prestressed reinforced concrete" is aimed at developing the following competencies among students. He is able to solve the problems of professional activity on the basis of the use of theoretical and practical foundations, the mathematical apparatus of fundamental sciences. (GPC-1)
Conducting applied research in the field of engineering and technical design for urban planning activities (PC-1)
Development of project products based on the results of engineering and technical design for urban planning activities (PC-2)

-Preparation of the section of project documentation for metal structures of buildings and structures (PC-11)
Study of the object of urban planning activity to obtain information about the state and predicted properties of the foundation, foundation structures and underground structures (PC-12)

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 3 credit units.

Type of educational work	Total hours	Modules			
		6			
Classroom Practice in Obtaining Professional Skills and Professional Experience (Research Practice). **lessons (total)**	48	48			
Including:	-	-	-	-	-
Lectures	16	16			
Practical lessons (PL)	32	32			
Seminars (S)	-	-			
Laboratory work (LW)	-	-			
Independent work (total)	24	exam			
Total labor intensity hour	108	108			
credits	3	3			

5. Content of the discipline

5.1. Contents of discipline sections

№	The name of the discipline section	Section content (topics)
1.	**Plane Stress and Plane Strain Theory**	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.	**Introduction to the finite element method**	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.
3.	**Potential energy and approximate analysis.** **.**	This section will enable the student to: a) Develop the expressions for strain energy, work done and potential energy for beam and bar problems b) Understand and apply the concept of minimum potential energy. c) Understand the Rayleigh-Ritz method as an introduction to the finite element method
4.	**Finite element formulation and application of bar elements**	This section will enable the student to: a) Recognize the displacement field and shape functions used in the formulation of a bar finite element. b) Derive the stiffness matrix as well as load vector due to various load conditions acting on a bar element. c) Perform a finite element analysis for a complete bar problem in order to evaluate displacements and stresses along the length of the bar. d) Judge on the accuracy of a specific bar element mesh used to solve a certain bar problem..
5.	**Introduction to theory of elasticity.**	This section will enable the student to understand the basic equilibrium and kinematic equations, the constitutive relations as well as the potential energy expression for 2-D plane stress and plane strain elasticity problems
6.	**Shape functions for 2-D problems**	. This section will enable the student to: a) Recognize various types of elements used to solve 2-D plane problems. b) Recognize the natural coordinate systems, the shape functions used in various 2-D plane elements. c) Evaluate the Jacobian expression for various 2-D plane elements
7.	**Finite element formulation and application by constant stress triangular (CST) element**	This section will enable the student to: a) Derive the stiffness matrix as well as the load vector due to various load conditions acting on a CST element. b) Know how to handle the effect of inclined boundaries. c) Perform finite element analysis of 2-D problems using CST elements.
8.	**Practical consideration in modelling.**	This section will enable the student to: a) Recognize some basic considerations when laying out a finite element mesh including element size and grading. b) Know how to number a finite element mesh in order to optimize the computer storage and the running time

5.2. Sections of disciplines and types of classes

No.	Discipline section No.	Lectures.	Practice	Lab. works	Semi-nars	Independ-ent work of students	Total hour.
1.	Plane Stress and Plane Strain Theory	2	4	0	0	7	13
2.	Introduction to the finite element method	2	5	0	0	7	14
3.	Potential energy and approximate analysis.	2	4	0	0	7	14
4.	Finite element formulation and application of bar elements	2	4	0	0	7	14
5.	Introduction to theory of elasticity.	2	4	0	0	7	13
6.	Shape functions for 2-D problems	2	5	0	0	7	14
7.	Finite element formulation and application by constant stress triangular (CST) element	2	4	0	0	7	14
8.	Practical consideration in modelling.	2	4	0	0	7	14

6. Laboratory workshop

No laboratory workshop provided.

7. Practical exercises (seminars)
for full-time and part-time education

Item no.	of the discipline section	Topics of practical classes (seminars)	Laborcapacity (hour.)
1	1	Plane Stress and Plane Strain Theory	4
2	2	Introduction to the finite element method	4
3	3	Potential energy and approximate analysis.	4
4	4	Finite element formulation and application of bar elements	6
5	5	Introduction to theory of elasticity.	
6	6	Shape functions for 2-D problems	
7	7	Finite element formulation and application by constant stress triangular (CST) element	
8	8	Practical consideration in modelling.	

7. Practical exercises (seminars)

No.	Discipline section No.	Subjects of practical classes (seminars)	Labor capacity (hour.)

1.	**Plane Stress and Plane Strain Theory**	- 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
2.	**Introduction to the finite element method**	- 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.	2
3.	**Potential energy and approximate analysis.**	This section will enable the student to: a) Develop the expressions for strain energy, work done and potential energy for beam and bar problems b) Understand and apply the concept of minimum potential energy. c) Understand the Rayleigh-Ritz method as an introduction to the finite element method	2
4.	**Finite element formulation and application of bar elements**	This section will enable the student to: a) Recognize the displacement field and shape functions used in the formulation of a bar finite element. b) Derive the stiffness matrix as well as load vector due to various load conditions acting on a bar element. c) Perform a finite element analysis for a complete bar problem in order to evaluate displacements and stresses along the length of the bar. d) Judge on the accuracy of a specific bar element mesh used to solve a certain bar problem..	3
5	**Introduction to theory of elasticity.**	This section will enable the student to understand the basic equilibrium and kinematic equations, the constitutive relations as well as the potential energy expression for 2-D plane stress and plane strain elasticity problems	2
6	**Shape functions for 2-D problems**	. This section will enable the student to: a) Recognize various types of elements used to solve 2-D plane problems. b) Recognize the natural coordinate systems, the shape functions used in various 2-D plane elements. c) Evaluate the Jacobian expression for various 2-D plane elements	2
7	**Finite element formulation and application by constant stress triangular (CST) element**	This section will enable the student to: a) Derive the stiffness matrix as well as the load vector due to various load conditions acting on a CST element. b) Know how to handle the effect of inclined boundaries. c) Perform finite element analysis of 2-D problems using CST elements.	2
8	**Practical consideration in modelling.**	This section will enable the student to: a) Recognize some basic considerations when laying out a finite element mesh including element size and grading. b) Know how to number a finite element mesh in order to optimize the computer storage and the running	3

		time	

8. Material and technical support of the discipline:

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(describes the material and technicalая basesanecessaryая for the implementation of the educational process in the discipline (module)).

Audience with a list of material and technical support	**Location**
Lecture hall No. 408 Equipment and furniture: - technical means: - projection screen; - Epson EH-TW 3200 multimedia projector; - a set of specialized furniture: tables, benches, chairs, blackboard.	city of Moscow, Ordzhonikidze str., 3
Training room for seminars, practical classes, current control and intermediate certification No. 418 Equipment and furniture: - training models; - screen; - NEC Z projector; - set of specialized furniture: tables, benches, chairs, blackboard.	city of Moscow, Ordzhonikidze str., 3
Educational and methodical office for independent, research work of students and course design No. 417 (Laboratory of engineering equipment of buildings and Structures) - a set of specialized furniture; - chalkboard, markerboard ; - ASUS computers-5 pcs., ASER monitors-5 pcs.; - Microlab System Subwoofer-1 pc.; - проекторEPSON EB X11 projector	. Moscow, Ordzhonikidze str., 3

9.Informational support of the discipline
(A list of information technologies used in the implementation of the educational process in the discipline (module), including a list of software and information reference systems (if necessary))
a) Software: PowerPoint
b) databases, information and reference systems and search engines:
1. RUDN University Online Library.
2. Guidelines for completing homework.
3. Tasks for completing homework on the personal page of the teaching staff in electronic form.
4. A point-rating system for evaluating students ' knowledge, displayed on the teacher's personal page.

10. Educational and methodological support of the discipline:

a) main literature

1. Advanced Finite Element Method in Structural Engineering. 2009. Publisher: Springer Berlin Heidelberg. ISBN: 978-3-642-00316-5
2. Norrie, D.H. A first course in the finite element method. 3(2)1987. 162–163 p. ISBN:0534552986.
3. Cook, R.D., Malkus, D.S., Plesha, M.E., Witt, R.J. Cook, Malkus, Plesha, Witt - Concepts and Application of Finite Element Analysis - 4a. ed. - J. Wiley - 2002 – 733 2002.

b) 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 Russian University of Friendship of Peoples: 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

11. Methodological guidelines for students on mastering the discipline (module)

Organization of classes on the discipline " Applications of Finite Element Method for Civil Engineering " is carried out according to the following types of academic work: lectures, practical classes.

The implementation of the competence approach in the framework of the preparation direction of 08.04.01 Civil Engineering / Construction provides for a combination in the educational process of contact work with a teacher and extracurricular independent work of students to fully form and develop its professional skills.

Lectures are conducted in the stream audience, including using a multimedia projector in the form of an educational presentation. The main points of lecture classes are outlined by students, individual topics (parts of themes and sections) are proposed for independent study with the obligatory compilation of the abstract (verified by the teacher in the process of current control).

The purpose of practical classes is to receive knowledge with students and develop practical skills of work in the design of building structures. To achieve these goals, both traditional forms of operation are used - solving problems, work with technological equipment / specialized software when performing laboratory work with specialized software when performing a course project, etc.

Independent work covers the study of the learning individuals of the theoretical course. Independent work is carried out in an individual format based on educational and methodological materials of the discipline (applications 2-4). The level of material development on independently studied courses is checked when conducting current control and certification tests (credit) on discipline. Methodological recommendations with student are posted in the TUIS RUDN.

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

Materials for assessing the level of development of educational material of the discipline "Structural Finite Element Method for Civil Infrastructure , including a list of competencies, indicating the stages of their formation, description of the indicators and criteria of assessment of competencies at different stages of their formation, the description of the scales of assessment, typical assignments, or other materials needed for the assessment of knowledge, skills and (or) experience activities that characterize the stages of formation of competences in the process of development of educational programs, instructional materials, procedures evaluation of knowledge, skills and (or) experience activities that characterize the stages of formation of competences, fully developed and available to students on the page of discipline in TUIS RUDN.

Developer:

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