Ministry of science and higher education of the Russian Federation Peter the Great St. Petersburg polytechnic university

Institute of Civil Engineering

ACTING

Director of ICE M.V. Petrochenko «Ob» december .20-2/r.

PROGRAM

entrance test for applicants to the magistracy in the direction of training / educational program

08.04.01_12 «Civil engineering» (International Educational Program)

Code and name of the direction of training / educational program

Saint Petersburg 2024

1. DISCIPLINES INCLUDED IN THE PROGRAM OF ENTRANCE EXAMINATIONS TO THE MASTER'S PROGRAM

- 1.1. Construction materials
- 1.2. Building structures
- 1.3. Construction technology
- 1.4. Project management

2. CONTENT OF ACADEMIC DISCIPLINES

2.1. Construction materials

- 1. Classification of construction materials.
- 2. Basic terms and definitions.
- 3. Basic properties of construction materials.

3.1 Relationship between the composition and structure of materials and their properties.

- 3.2 General patterns of formation of properties.
- 3.3 Basic properties of construction materials and methods of their assessment.
- 4. Raw material base for the production of construction materials.
 - 4.1 Natural stone building materials.
 - 4.2 Rocks as the main base for the production of building materials.
 - 4.3 Igneous, sedimentary and metamorphic rocks.
- 5. Metals and metal alloys used in construction.
 - 5.1 Carbon and alloy steels and cast irons.
 - 5.2 Non-ferrous metals and alloys.
 - 5.3 Steel reinforcement for reinforced concrete structures.
- 6. Ceramic materials and products.
 - 6.1 Classification of ceramic materials.
 - 6.2 Raw materials. Production of ceramic products.
- 7. Wood-based materials.
 - 7.1 Features of the structure and properties of wood.
 - 7.2 Properties of wood.
- 8. Organic binders and materials based on them.
 - 8.1 Bitumen and tars.
 - 8.2 Asphalt concretes and mortars.
 - 8.3 Polymer-based materials.
 - 8.4 Plastics.
- 9. Mineral binders and materials based on them.
 - 9.1 Classification.
- 9.2 Air binders (gypsum binders, air lime, magnesia binders, liquid glass, hydraulic lime, Roman cement).
 - 9.3 Hydraulic binders.

9.4 Portland cement and its varieties. Chemical and mineral composition of Portland cement. Types of cements.

9.5 Active mineral additives and cements based on them.10. Concretes and mortars.

10.1 Materials for the preparation of concrete and mortar.

10.2 Concrete mix.

10.3 Types of heavy concretes and mortars.

10.4 Lightweight concretes on porous fillers.

10.5 Cellular concretes.

10.6 Dry construction mixes.

Reference:

1. BAE 639-Construction Materials.pdf http://iqytechnicalcollege.com>BAE 639-Construction ...

2.«Construction Materials: Their Nature and Behaviour, Fifth Edition»MariosSoutsosиPeterDomone.https://books.google.ru/books?id=vpdRAAAAMAAJ&hl=ru&source=gbs_navlinks_s

3. «Construction Materials: Their Nature and Behaviour, Fifth Edition» Marios

Soutsos и Peter Domone. https://doi.org/10.1201/9781315164595

4. Construction Materials And Equipment 2nd Edition https://engineerrefe.com/book/construction-materials-and-equipment/

2.2. Building structures

2.2.1. Reinforced Concrete Structures

1. Advantages and disadvantages of reinforced concrete structures.

2. Mechanical properties of concrete under compression, tension, and shear. Grades of concrete.

3. Deformational properties of concrete, stress-strain curve, influence of loading conditions, deformation modules.

4. Creep of concrete and its influence on the performance of reinforced concrete structures.

5. Types of reinforcement, stress-strain curve, factors ensuring the bond between reinforcement and concrete.

6. Reinforced concrete beam behavior (without pre-stressing).

7. Flexure theory of reinforced concrete.

8. Basics of the limit state method: groups of limit states, loads and load combinations, normative and design resistances, safety factors.

9. Limit states design method.

10. Doubly reinforcement Beams. Strength verification and reinforcement selection.

11. Calculation of T and I-beams.

12. Causes of inclined crack formation. Influence of shear and principal stresses. Shear stresses in reinforced beams.

13. Critical sections for shear. Shear strength provided by concrete and shear reinforcement.

14. Calculation for crack formation.

15. Opening of normal cracks, influence of various factors, methods to reduce crack opening.

16. compression plus bending of reinforced concrete elements with rectangular crosssection; influence of flexibility, calculation based on deformed state; cases of small and large eccentricities; equilibrium equations.

References:

- Arthur H. Nilson, David Darwin, Charles William Dolan. Design of Concrete Structures McGraw-Hill Education, 2010. <u>https://construccion.uv.cl/docs/textos/coleccion03/TEXTO.12.DesingofConcrete</u> <u>Structures.pdf</u>
- 2. Mashhour Ghoneim, Mahmoud El-Mihilmy. Design Of Reinforced Concrete Structure, 2008. https://civiltechnocrats.wordpress.com/wpcontent/uploads/2013/11/24317264-24158249-design-of-reinforced-concretestructure-volume-1-dr-mashhour-a-ghoneim.pdf

2.2.2. Metal Structures

- 1. Concept of Metal Structures (MS). Advantages and Disadvantages of MS
- 2. Algorithm for Designing MS. Design Brief and Its Components
- 3. Structural Scheme of a Single-Story Industrial Building with a Steel Frame. Influence of Thermal Stresses and Displacements on the Structural Scheme
- 4. Concept of Material Bearing Capacity, Design and Normative Resistance Values. Limit State Method
- 5. Loads and Effects. Load Combinations
- 6. Types of Wind Loads
- 7. Procedure for Selecting Enclosure Structures of MS: Roof, Walls, and Half-Timbered Frames
- 8. Design Lengths of Structural Elements
- 9. Truss Calculation in SCAD Software
- 10. Checks for Truss Elements
- 11.Global and Local Stability
- 12.Behavior of Metal Structures Under Load. MS Check According to Limit State Criteria
- 13.Connection of Metal Structures. Welding. Types of Welds. Advantages and Disadvantages of Welded Connections

- 14.Connection of Metal Structures. Bolted Connections. Advantages and Disadvantages of Bolted Connections
- 15.Calculation of Nodes in Metal Constructions. Local Stability Checks
- 16.Calculation and Design of Intermediate Truss Nodes
- 17.Calculation and Design of Support Truss Nodes
- 18.Calculation and Design of Truss Assembly Nodes
- 19. Analytical Calculation of Roof Truss Elements. Upper Chord
- 20. Analytical Calculation of Roof Truss Elements. Lower Chord
- 21. Analytical Calculation of Roof Truss Elements. Braces and Assembly Stand

References:

1. Design of steel structures. Eurocode 3: Part 1-1 – General rules and rules for building/ Luís Simões da Silva, Rui Simões and Helena Gervásio – 2013 – 456 p.

2. Design of steel structures/ S. K. Duggal - 2010 - 181 p.

3. Handbook of structural steelwork. Eurocode edition/ Publication No. 55/13 , BSCA and $SCI-2013-454\ p.$

2.3 Construction technologies

2.3.1 Construction equipment

- 1.1. Construction machines: basic concepts and structural elements.
- 1.2. Construction machines for earthworks: bulldozer, scraper, grader. Purpose and scope.
- 1.3. Single-bucket excavators: "forward shovel", "reverse shovel", "dragline", "grab". Purpose and scope.
- 1.4. Multi-bucket excavators. Types and purpose.
- 1.5. Machines for piling. Types and purpose.
- 1.6. Machines for earthworks in winter conditions. Design features.
- 1.7. Basic construction cranes, technical specifications, selection methods.
- 1.8. What is excavation sheeting used for?

2.3.2 Construction methods in Site Works and Foundations

- 1. What is the nature of the most common type of foundation failure? What are its causes?
- 2. Explain the differences among sand, silt, and clay, both in their physical characteristics and their behavior in relation to building foundations.
- 3. Explain the difference between cohesionless soil and a cohesive soil. Give one example of each soil type.
- 4. Explain the difference between well graded and poorly graded soil. How does their behavior differ?
- 5. What is a test soil boring and why is it performed?
- 6. What is excavation sheeting used for? List three different types of excavation sheeting.

- 7. Under what conditions would you use a watertight barrier instead of well points when digging below the water table?
- 8. In cold climates, how does the frost line affect the placement of shallow footings?
- 9. What footing type is an exception to this general principle?
- 10. What conditions might lead to the choice of a mat foundation for a building?
- 11. If shallow foundations are substantially less costly than deep foundations, why do we use deep foundations?
- 12. What soil conditions favor piles over caissons? What type of pile is especially well suited to repair or improvement of existing foundations and why?
- 13. List and explain some cost thresholds frequently encountered in foundation design.
- 14. Explain the difference between waterproofing and dampproofing. When is one or the other an appropriate choice for protecting a foundation from moisture?
- 15. List two types of waterproofing and describe one possible advantage of each.
- 16. List the components of a typical foundation drainage system and their functions.
- 17. What is filling? Why is fill placed in lifts?

3. Concrete work technologies

- 1. What is the difference between cement and concrete?
- 2. List the conditions that must be met to make a satisfactory concrete mix.
- 3. List the precautions that should be taken to cure concrete properly. How do these change in very hot, very windy, and very cold weather?

4. What problems are likely to occur if concrete has too low a slump? Too high a slump? How can the slump be increased without increasing the water content of the concrete mixture?

- 5. Explain how steel reinforcing bars work in concrete.
- 6. Explain the role of stirrups in beams.
- 7. Explain the role of ties in columns.
- 8. What does shrinkage temperature steel do? Where is it used?

9. Explain the differences between reinforcing and prestressing and the relative advantages and disadvantages of each.

10. Under what circumstances would you use pretensioning, and under what circumstances would you use posttensioning?

11. Explain the advantages of using higher-strength reinforcing bars in concrete that requires very heavy reinforcing

References:

- 1. Fundamentals of Building Construction Edward Allen and Joseph Iano Materials and Methods
- 2. Construction Methods and Management Stephens W. Nunnally
- Bryan, Tony Construction technology : analysis and choice / Tony Bryan. 2nd ed. p. cmc.

- 4. Fundamentals of Building Construction Edward Allen and Joseph Iano Materials and Methods
- 5. Concrete Sustainability Hub: web.mit.edu/cshub/ Portland Cement Association: www.cement.org
- 6. Concrete Reinforcing Steel Institute. Manual of Standard Practice. Schaumburg, IL, Mehta, P. Kumar, and J. M. Monteiro Paulo.
- 7. Fundamentals of Building Construction Edward Allen and Joseph Iano Materials and Methods

4. Project management

- 1. Regulation Support for Construction Management.
- 2. Classification of Construction Facilities.
- 3. Stakeholders in Construction Field;
- 4. Management Structures in Construction;
- 5. Construction Scheduling and Timeline Planning;
- 6. Labor Management in Construction;
- 7. Quality Assurance in Construction;
- 8. Commissioning in Construction;
- 9. Construction Management Plan (CMP);

10. Economic Efficiency Evaluation of New Energy Vehicle Investment Projects in SAIC

- 11. Discount factor
- 12. Static investment payback period
- 13. Return on Investment
- 14. Net present value (NPV)
- 15. Net Present Value Rate
- 16. Internal Rate of Return (IRR)
- 17. Break-even Point (BEP)
- 18. Suggestion

19. Who are the three principal team members involved in the creation of a new building? What are their respective roles?

- 20. What are construction documents? What two items are they comprised of?
- 21. What types of subjects are covered by zoning ordinances? By building codes?
- 22. Compare and contrast design/bid/build and design/build construction.
- 23. What is the difference between lump-sum and cost plus a fee compensation?
- 24. What is the critical path? Why is it important to construction scheduling?

References:

1. Kumar Neeraj Jha Construction Project Management: Theory and Practices, 2015. – 219 pp.

2. Gary L. Richardson and Brad M. Jackson Project Management Theory and

Practice, CRC Press, 2019. – 637 pp.

- 3. Mohamed A. El-Reedy Construction Management for Industrial Projects, 2011. 414 pp.
- 4. Alberto De Marco Project Management for Facility Constructions, A Guide for Engineers and Architects, 2018. 203 pp.

5. Fundamentals of Building Construction Edward Allen and Joseph Iano Materials and Methods

3. ENTRANCE TEST EXAMPLE

Ministry of science and higher education of the Russian Federation Peter the Great St. Petersburg polytechnic university

Institute of Civil Engineering

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ENTRANCE TEST

in the direction of training / educational program

08.04.01_12 «Civil engineering» (International Educational Program)

Code and name of the direction of training / educational program

Tasks examples

Provide several examples of test tasks for the each block with answer options and the correct answer highlighted

4. EVALUATION CRITERIA FOR THE ENTRANCE TEST

The entrance test is a set of test tasks reflecting questions on the main sections of four disciplines:

- Construction materials (25 points);
- Building structures (25 points);
- Construction technology (25 points);
- Project management (25 points).

Types of test tasks

By the method of answering, test tasks can be of the following main types: - closed test questions, in which the applicant must choose one correct answer from the proposed options; The test questions are divided into four blocks:

Block 1. Construction materials (25 points).

Number of test tasks- 5, including:

- closed test questions -5.

- 1. Adhesion is ...
 - attraction of molecules of a dissolved substance to the interphase surface
 - interaction of molecules within one phase
 - resistance to separation by contact of bodies
 - interaction between phases
- 2. Concrete mixture is ...

• mixture of cement, water, sand and coarse aggregate before hardening

- hardening product of a mixture of cement, water, sand and coarse aggregate
- mixture of cement, water and additives before hardening
- hardening product of a mixture of cement, water and additives
- 3. Grinding of Portland cement clinker is carried out with the addition of up to 5%...
 - semi-aqueous gypsum
 - dihydrate gypsum
 - dicalcium silicate
 - tricalcium silicate

Block 2. Building structures (25 points).

Number of test tasks- 5, including:

- closed test questions -5.

1. The calculation of reinforced concrete elements based on limit states should be carried out according to the provisions specified below in the options. Identify the incorrect statement.

• The compressive strength of concrete is taken as zero;

- The compressive strength of concrete is represented by stresses equal to the design compressive strength of concrete and uniformly distributed over the hypothetical compressed zone of concrete;
- Tensile and compressive stresses in the reinforcement are taken as no more than the design tensile and compressive strengths, respectively.

2. The deformations occurring in a bending element of a structure under snow load are considered:

- Force-related
- Volumetric
- Elastic

3. The change in shape and size under the influence of various factors is called...

- Elasticity
- Deformability
- Creep
- Plasticity

4. The Piece Mark is necessary for:

- Dividing the truss chords into equal parts
- Balancing forces in assembly joints
- Transporting finished products from production
- All of the above
- 5. The effective length of the bottom chord out of the truss plane is equal to:
 - The length of the bottom chord
 - The distance between the bracings
 - Assumed to be equal to 1
 - The length of the panel
 - 6. To prevent compressive forces caused by temperature effects, bracings between columns should be installed:
 - At the ends of the building
 - In the center of the building
 - In the center and at the ends of the building
 - Not installed at all

Block 3. Construction technology (25 points).

Number of test tasks- 5, including:

- closed test questions -5.

1. A construction machine is a machine:

- 1. for transporting construction workers.
- 2. for performing preparation work.
- **3.** for performing construction operations and actions.
- 4. There is no correct answer among the listed answers.

2. Determine the type of construction machine for developing a narrow trench.

- 1. Grab.
- 2. Scraper.

3. Multi-bucket excavator.

4. There is no correct answer among the listed answers.

3. At what speed should a bucket of concrete mix be lifted to prevent the concrete from setting before concreting begins?

1. More than 90 m/min.

- 2. Less than 90 m/min.
- 3.75 m/min.
- 4. There is no correct answer among the listed answers.

Block 4. Project management (25 points).

Number of test tasks -5, including: - closed test questions -5.

1. What is the definition of the term "tier"?

1. a part of an object formed by its conditional division vertically;

2. a part of a building, the volumes of work on which are performed by a team of permanent composition at a certain rhythm;

3. a part of the work front allocated for a team or one worker;

4. a part of a construction site necessary and sufficient to accommodate workers together with the machines required to perform the work;

2. Which of the participants in an investment and construction project enters into contracts for the performance of engineering surveys and the preparation of design documentation on behalf of the developer?

1. Technical customer;

- 2. Developer;
- 3. Contractor;
- 4. Investor;
- 3. What is a critical path?
- 1. the longest complete path of a project from the initial event to the final one;
- 2. the shortest path of a project from the initial event to the final one;
- 3. tasks on the critical path always have the maximum time reserve;
- 4. all project tasks are always on the critical path;

Total points - 100 points.

Evaluation criteria

For each correctly solved closed test task, 5 points are awarded. If all answer options in the test task are marked as correct, points for the test task are not awarded.