THE FIRST HIGHER TECHNICAL UNIVERSITY IN RUSSIA

MINISTRY OF EDUCATION AND SCIENCE OF THE RUSSIAN FEDERATION
Federal State Budgetary Educational Institution of Higher Education
"Saint-Petersburg Mining University"

IOM3 PD APPROVED

The Institute of Materials, Minerals and Mining

Approved by
Vice-Rector for Educational Activity
Prof. V.A. SHPENST

01/12/2016

# Professional training program

## «ENGINEERING AND GEOLOGICAL RESEARCH FOR CONSTRUCTION»

**Qualification: «Specialist in Engineering Geology and Geotechnics»**

**Field of training: 21.05.02 «Applied Geology», specialization «Groundwater Exploration and Engineering Geological Investigations»**
**Attendance: full-time**

**Course leader:**

R.E. Dashko, Professor of Hydrogeology and Engineering Geology Department

**Course developers:**

Ya.A. Karpova, Assistant of Hydrogeology and Engineering Geology Department

I.V. Alekseev, Assistant of Hydrogeology and Engineering Geology Department

Saint-Petersburg
2016

## General provisions

### 1.1. Training objective:

The purpose of this course is to help course listeners gain theoretical and practical knowledge and skill, needed to study engineering-geological and geotechnical features of territory profile under investigation as well as structure, condition and physical-mechanical properties of rocks and soils composing the profile with the aid of state-of-the-art equipment designed to qualitatively and quantitatively forecast development laws of engineering-geological processes, as a result of interaction between underground environment and constructions with various applications; to ensure long-term stability of the latter in the context of active techogenesis; and to provide adequate scope of knowledge and skill in carrying on professional activity of engineers and technicians.

### 1.2 Competencies to be developed

Main professional competencies are presented in the table.

| Competency # | Type of professional activity | Competence description |
|---|---|---|
| 1. | - Specialists – engineering geologist, mining engineer. (groundwater exploration and engineering geological investigations, mining art).<br><br>- Special divisions managers of enterprises involved in natural resources sector | ***Project management***<br>1.1. Study, critically analyse scientific and technical information of local and foreign experience in the field of engineering-geological investigations.<br>1.2. Ability to develop technical specifications and research requests of engineering-geological, hydrogeological and geoecological investigations for the purpose of studying multicomponent underground space.<br>1.3. Readiness to substantiate technical decisions in technological processes development and to choose technical tools and technologies with due consideration of engineering-geological, hydrogeological and ecological consequences of their application.<br>1.4. Carry out elaboration of plan, design and estimate, procedural documentations for engineering-geological projects. |

| Competency # | Type of professional activity | Competence description |
| --- | --- | --- |
| 2. | - Specialists – engineering geologist, mining engineer.<br>(Groundwater exploration and engineering geological investigations, mining).<br><br>- Special divisions managers of enterprises involved in natural resources sector | ***Performance of field, laboratory and cameral works***<br>2.1. Organise, conduct and abandon filed works.<br>2.2. Ensure compliance of used laboratory and filed equipment with up-to-date international standards.<br>2.3. Enable engineering-geological data processing for preparation of reviews, reports and scientific publications consistent with recent trends in Engineering Geology.<br>2.4. Project and perform analytical, simulation and experimental investigations in the field of studying rocks and soils physical-mechanical properties in the context of techogenesis of underground space components, critically assess results of such studies.<br>2.5. Be able to utilize modern information technologies in geological profiles drawing and soils-structures interaction modelling.<br>2.6. Be able to use technical tools to acquire main parameters of disperse soils physical-mechanical properties and to predict development of processes determining buildings long-term stability.<br>2.7. Perform introduction of new methods and technologies: soil testing and modern equipment mastering, implementing more sophisticated methods of work performance and engineering-geological data handling. |

| Competency # | Type of professional activity | Competence description |
|---|---|---|
| 3. | - Managers and leading specialists of service engineering-geological companies and mineral establishments | ***Organizational and technical support of divisions activity***<br>3.1. Ensure safety of engineering-geological works, performed by subordinate employees.<br>3.2. Participate in developing planning and technical events, focused on rational use and integrity of engineering-geological data acquired.<br>3.3. Maintain control of project activities designed to introduce implementation of enhanced engineering-geological data acquisition.<br>3.4. Be able to generalise, analyse and acquire information, set objectives and choose solution approaches.<br>3.5. Be able to systematise and summarize information concerning enterprise resources creation and use.<br>3.6. Ensure observance of mining laws. Environment protection legislation, health and fire safety regulations in the process of engineering-geological works. |

**1.3. Mastery of course requirements**

With the purpose of acquiring professional skills listed in the table and corresponding professional competencies a course listener should:

**Become familiar with:**

– features of interaction between constructions with various applications and underground environment as a multicomponent system;

– management of complex engineering-geological investigations meant to acquire information about engineering-geological and hydrogeological conditions of a territory and to forecast their change during facilities construction and maintenance depending on technological mode of their operation;

– substantiating scope of work and its rational volume as well as procedures of engineering-geological investigations depending on complexity of engineering-geological conditions and critically rating of designed project and their ecological impact on underground environment;

– elaboration of operations assuring facility stability and appropriate functioning depending on complexity of engineering-geological, hydrogeological and ecological conditions.

**Acquire skills of:**

– substantiating scope and volume of engineering-geological works for project and detailed design development, meeting the requirements of current standards (rules and regulations of engineering surveys, public standards, etc.);

– employing methods of engineering-geological works (survey, geophysical activity, drilling, field trials) studying composition, condition and physical-mechanical properties of rocks and soils in their natural occurrence;

– determining parameters of rocks and soils composition, condition and physical-mechanical properties using state-of-the-art methods and equipment;

– forecasting and estimating hazard of engineering-geological processes with different genesis in regard to various facilities stability;

– preparing maps, graphs and diagrams and other documentation from field and laboratory engineering-geological tests;

– determining the most rational and effective ways of engineering-geological works management and expansion.

**Gain knowledge of:**

– up-to-date techniques used to process results of field and laboratory engineering-geological tests; preparing and writing reports about engineering-geological conditions of studied territory depending on complexity of project designed, taking into account technogenesis of underground space during its development;

– subsurface ecology and its role in engineering-geological investigations and forecasting long-term stability of various types facilities;

– engineering-geological features of underground space development and use within urban and industrial areas with complex engineering-geological conditions;

– main rules and software used to process and interpret engineering-geological information;

– new tendencies in Engineering Geology in the world and in Russian Federation.

### 1.4. Course description

| **Type of work** | **Total hours** |
|---|---|
| **Total course volume** | **144** |
| Auditorium training | 64 |
| Laboratory and practical training | 64 |
| Self-guided work | 12 |
| Pass-fail exam | 4 |

**1.5. Curriculum**

| No. | Program units | Hours total | Of which | | Competencies to be developed ( as per list 1.2) |
|---|---|---|---|---|---|
| | | | Lectures | Practical (laboratory) training | |
| 1. | Unit 1. Main applied research fields of Engineering Geology School at the Mining University | 4 | 4 | - | 1.1-1.3, 2.3, 3.1, 3.3 |
| 2. | Unit 2. Engineering prospecting for civil works and industrial construction | 32 | 8 | 24 | 2.1, 2.3, 2.5, 2.7, 3.1-3.3, 3.5 |
| 3. | Unit 3. Comparative evaluation of foreign and national standards of rocks and soils study for the purpose of construction | 8 | 8 | - | 1.1, 2.2, 2.4, 3.1-3.2, 3.4 |
| 4. | Unit 4. Hydrogeology in civil and industrial engineering | 20 | 12 | 8 | 1.1-1.3, 2.3, 2.6, 3.1-3.5 |
| 5. | Unit 5. Studying physical-mechanical properties of rocks and soils based on physical modelling of interaction between constructions and underground space as a multicomponent system | 40 | 12 | 28 | 1.3, 1.4, 2.2, 2.4-2.5, 3.2-3.4 |
| 6. | Unit 6. Engineering Geology and Ecology of underground space | 16 | 16 | - | 1.1-1.2, 2.2, 2.3, 2.6, 2.7, 3.2-3.4 |
| 7. | Unit 7. Forecasting engineering-geological processes on the basis of engineering surveys results for civil and industrial engineering | 12 | 12 | - | 1.1, 2.1-2.3, 2.5, 3.2 |
| 8. | Unit 8. Use of engineering-geological and hydrogeological information in construction stability calculations, including application of modern computer-modelling programmes | 12 | 8 | 4 | 1.1-1.3, 2.2, 2.3, 2.6, 3.2, 3.5, 3.6 |

### 1.6. Final assessment

Final assessment of the course – pass-fail exam.

### 1.7. Certificates

On successful completion of the training course listeners obtain standard documents acknowledging their advanced training.

### 1.8. Academic staff involved in educational process

| No. | Last, first and middle name | Education (higher education institution, year of completion, speciality) | Position, science degree, academic title; work experience in this or similar area, years | List of main scientific and educational publications |
|---|---|---|---|---|
| Course leader | | | | |
| 1. | Dashko Regina Eduardovna | Higher, Leningrad Mining Institute, 1972, mining engineer-geologist. | Professor of Hydrogeol. and Eng. Geol. department, Doctor in Geol. and Mineral. Sc., Professor; exp. more than 50 years | More than 330 scientific papers |
| Course lecturers | | | | |
| 1. | Dashko Regina Eduardovna | Higher, Leningrad Mining Institute, 1972, mining engineer-geologist | Professor of Hydrogeol. and Eng. Geol. department, Doctor in Geol. and Mineral. Sc., professor; exp. more than 50 years | More than 330 scientific papers |
| 2. | Pospekhov Georgiy Borisovich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2003, Master in geology | Director of Engineering Research Centre, associate professor of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 12 years | More than 20 scientific papers |
| 3. | Telegin Aleksandr Nikolaevich | Higher, Leningrad Mining Institute, 1958, mining engineer-geophysicist | Professor of department of Geophysical and Geochemical Methods of Exploration, Doctor in Geol. and Mineral. Sc., professor; exp. more than 56 years | More than 80 scientific papers |
| 4. | Ustugov Dmitriy Leonidovich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 1998, engineer-hydrogeologist | Chief of Hydrogeol. and Eng. Geol. department, associate professor, Candidate in Geol. and Mineral. Sc., exp. more than 15 years | More than 20 scientific papers |

| | | | | |
|---|---|---|---|---|
| 5. | Norova Larisa Pavlovna | Higher, Leningrad Mining Institute, 1976, engineer-hydrogeologist | Associate professor of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 30 years | More than 100 scientific papers |
| 6. | Nikolaeva Tatyana Nikolaevna | Higher, Leningrad Mining Institute, 1986, mining engineer-hydrogeologist | Associate professor of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 25 years | More than 100 scientific papers |
| 7. | Schidlovskaya Anna Valerievna | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 1996, mining engineer-hydrogeologist | Associate professor of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 15 years | More than 50 scientific papers |
| 8. | Kotukov Pavel Vasilievich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2006, Master in processes and technology | Associate professor of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 9 years | More than 35 scientific papers |
| 9. | Norvatov Yuliy Aleksandrovich | Higher, Leningrad Mining Institute, 1976, mining engineer-hydrogeologist | Professor of Hydrogeol. and Eng. Geol. department, Doctor in Geol. and Mineral. Sc., professor; exp. more than 50 years | More than 200 scientific papers |
| 10. | Kotlov Sergey Nikolaevich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2008, Master in processes and technology | Associate professor of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 7 years | More than 30 scientific papers |
| 11. | Karpova Yana Aleksandrovna | Higher, Saint-Petersburg State Mining University, 2011, mining engineer-geologist | Assistant of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. more than 5 years | More than 20 scientific papers |
| 12. | Straupnik Igor Albertovich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2007, mining engineer | Assistant of Well Drilling department, Candidate in Eng. Sc, exp. more than 7 years | More than 25 scientific papers |
| 13. | Pankratova Kseniya Viktorovna | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2010, Master in processes and technology | Assistant of Hydrogeol. and Eng. Geol. department, Candidate in Geol. and Mineral. Sc., exp. | More than 40 scientific papers |

| | | | | |
|---|---|---|---|---|
| | | | more than 7 years | |
| Partner companies representatives, engaged in program execution | | | | |
| 1 | Schaschkin Aleksey Georgievich | Higher, Saint-Petersburg State University of Architecture and Civil Engineering, 1984, civil engineer | President & CEO of Company Group “Georeconstruction”, associate professor of Foundation Eng. department at Saint-Petersburg State Transport University, exp. more than 30 years | More than 80 scientific papers |
| 2 | Vlasov Dmitriy Yurievich | Higher, Saint-Petersburg State University, 1981, biologist | Professor of Phytopathology and Entomology department at Saint-Petersburg State University, Doctor in Biol. Sc., exp. more than 27 years | More than 125 scientific papers |
| 3 | Oleiynik Nikolay Nikolayevich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2010, engineer-geologist | President & CEO of Close Joint-Stock Company “LenTISIZ”, exp. more than 7 years | More than 3 scientific papers |
| 4 | Plechkova Irina Lvovna | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 1994, engineer-geologist | Chief geologist of Company Group “Georeconstruction”, Candidate in Geol. and Mineral. Sc., exp. more than 25 years | More than 20 scientific papers |
| 5 | Volkova Anastasiya Valerievna | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2001, engineer-geologist | Chief engineer of Joint-Stock Company “Spb NIII EIZ”, Candidate in Geol. and Mineral. Sc., exp. more than 15 years | More than 25 scientific papers |
| 6 | Timchenko Anna Mikhailovna | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2004, engineer-hydrogeologist | “Mining and chemical engineering” Inc., Company Group “FosAgro”, head of department of Geology and Ecology, Candidate in Geol. and Mineral. Sc., exp. more than 10 years | More than 20 scientific papers |
| 7 | Feller Viktor Valerievich | Higher, Plekhanov Saint-Petersburg State Mining Institute (technical university), 2004, engineer | Public Corporation “GasProm”, chief specialist of expert department, Candidate in Eng. Sc., exp. more than 10 years | More than 30 scientific papers |
| 8 | Smirnov Lev | Higher, Leningrad Mining | Chief engineer of | More than |

| | | | | |
|---|---|---|---|---|
| | Konstantinovich | Institute, 1976, engineer-geologist | Close Joint-Stock Company “LenTISIZ”, exp. more than 35 years | 50 scientific papers |

**1.9. Course content**

| Section name of professional themes unit | Training material content, laboratory and practical training, self-guided work | Volume, hours |
|---|---|---|
| **Unit 1. Main applied research fields of Engineering Geology School at the Mining University** | | |
| Theme 1. General knowledge. Main trends. | Founding members of Engineering Geology School at the Leningrad Mining university. Main applied research activity branches of the department in 20th century. Development prospects of the department and Engineering Research Centre at the Mining university. | 2 |
| ***Totally*** | | ***2*** |
| **Unit 2. Engineering prospecting for civil works and industrial construction** | | |
| Theme 1. Engineering survey strategy | Engineering survey – definitions and terminology. Formation of territory engineering-geological conditions. Interaction between engineering constructions and underground space. Structures design levels and thereto related program of engineering-geological survey. | 6 |
| Theme 2. Outline of engineering-geological survey | Main requirements to the scope of engineering-geological works intended to study in an integrated manner engineering-geological conditions of area, construction site or route section of designed project and to acquire reliable engineering-geological information. Data collection and processing of prior engineering survey (publications, file reports etc.); role of regional study materials. Classes of work. | 8 |
| Theme 3. Engineering-geological survey on the territory of building engineering and industrial construction. | Scope, volume and procedures of engineering-geological works at different design levels of engineering survey according to current standards and regulations. Substantiation of engineering-geological works scope, volume and procedures at different design levels and stages of engineering survey for civil constructions, including conduction of soils and groundwater special study. | 8 |
| Theme 4. Engineering-geological survey on route of line structures (roads, pipelines, canals etc.) | Substantiation of engineering-geological works scope, volume and procedures at different stages of designing and maintenance of line structures, which include transport facilities (tunnels, subway running tunnels at different depth), in the field and laboratory environment. | 8 |
| ***Totally*** | | ***30*** |
| **Unit 3. Comparative evaluation of foreign and national standards of rocks and soils study for the purpose of construction** | | |
| Theme 1. Standardization of engineering survey | Main regulatory documents for engineering-geological survey in Russian Federation. Review of effective foreign analogues of regulations. Preparation | 8 |

| | | |
|---|---|---|
| | of standards, classifying soils on the territory of Russian Federation. | |
| ***Totally*** | | ***8*** |
| **Unit 4. Hydrogeology in civil and industrial engineering.** | | |
| Theme 1. Filterability of various rock types and its parameters | Methods for determining permeability parameters of soils, fissured rocks in field and laboratory environment. Studying filtration properties of sandy soils in the laboratory, determination of sandy-clayey soils permeability coefficient using different equipment. | 6 |
| Theme 2. Evaluation of construction site hydrodynamic and hydrochemical conditions focused on safety improvement during enabling works and surface building maintenance. | Modelling changes of groundwater hydrodynamic and hydrochemical conditions for the purposes of building long-term stability evaluation. Calculation methods of defining safe water head, determining permissible foundation depth. | 6 |
| ***Totally*** | | ***12*** |
| **Unit 5. Studying physical-mechanical properties of rocks and soils based on physical modelling of interaction between constructions and underground space as a multicomponent system** | | |
| Theme 1. Conceptual issues of rocks and soils classification | Systematization of rocks as research object. General and special classifications. Engineering-geological classification of Savarensky and Lomtadze. | 10 |
| Theme 2. Studying mineralogical and granulometric composition of rocks and soils | Formation and nature of structural bonds in rocks with different genesis and composition. Up-to-date methods for studying particle size distribution of sandy-clayey soils, including use of laser equipment Master-Sizer. Definition of granulometry using direct and indirect methods. | 6 |
| Theme 3. Parameters of physical, water and mechanical properties, their significance in assessing rocks and soils as structure base and medium | Studying main parameters of physical properties in laboratory: strengths and shortcomings. Studying parameters of mechanical properties and shear resistance using modern equipment based on physical modelling of interaction between constructions and multicomponent underground space. Physical-chemical properties of dispersed soils. | 6 |
| ***Totally*** | | ***26*** |
| **Unit 6. Engineering Geology and Ecology of underground space** | | |
| Theme 1. Main contamination sources of geological environment as multicomponent system in urban and industrial regions | Historical aspect of underground environment contamination. Contamination sources of groundwater and sandy-clayey soils in urban and industrial areas. | 10 |
| Theme 2. Influence of organic and inorganic pollutants on soils transformation | Main transformation regularities of physical-mechanical properties of sandy-clayey soils depending on the content of organic matter with natural and technogenic genesis. Change in granulometric composition of sandy soils under the | 6 |

| | | |
|---|---|---|
| | impact of various contaminants. | |
| Theme 3. Influence of acid-base and redox conditions on transformation of clayey and other sedimentary rocks | Natural and technogenic factors, defining formation and transformation of redox and acid-base conditions in subsurface environment. Examples of changing physical-chemical properties that have effect on rocks and soils physical, water and mechanical properties adjustment. | 10 |
| Theme 4. Microbiota in geological environment: positive and negative consequence of its activity | Issue of subsurface environment self-purification and self-regulation, related to microorganisms activity. Engineering-geological processes generated with direct involvement of microbiota. Features of structural materials biocorrosion in subsurface environment upon condition of its contamination. Measures of ensuring constructions stability in the context of geological environment intensive contamination. | 12 |
| ***Totally*** | | ***38*** |
| **Unit 7. Forecasting engineering-geological processes on the basis of engineering surveys results for civil and industrial engineering** | | |
| Theme 1. Engineering-geological surveys in the areas of hazardous processes development | Factors determining hazardous processes formation – karst, gravity induced processes, abrasion, erosion, underflooding and swamp formation, filtration deformations. Ensuring long-term stability of surface and underground facilities with various purposes. Ways to control hazardous processes in the design of constructions with different criticality rating. Regulatory documents analysis. | 8 |
| Theme 2. Engineering-geological surveys in the areas of problematic soils occurrence | Engineering-geological surveys in the areas of collapsing, swelling, saline, organo-mineral, residual and technogenic soils and rocks occurrence. Engineering-geological studies in the areas of problematic soils occurrence Regulatory documents analysis. | 8 |
| ***Totally*** | | ***16*** |
| **Unit 8. Use of engineering-geological and hydrogeological information in construction stability calculations, including application of modern computer-modelling programmes** | | |
| Theme 1. Design concept of constructions with various purposes based on limit states | Calculation stability of surface and subsurface facilities using modern computer-modelling programmes. Computing surface buildings settlements in the design on limit states | 8 |
| Theme 2. Analysing stability of homogenous and heterogeneous slopes | Familiarization with major modern programmes for slopes stability calculation, including cantledged slopes. Computing stability of stratified slopes using up-to-date computer technologies. Computing stability of uniform slopes using up-to-date computer technologies. | 8 |
| ***Totally*** | | ***16*** |
| **Final pass-fail exam** | | **4** |
| **TOTALLY** | | **144** |

## 1.10. Course resources and facilities

Execution of a program comprehends the usage of specialized audiences at Centre of adult professional education fitted with multimedia equipment, laboratories of Engineering

Research Centre tooled up with modern equipment for measurement of rocks and soils physical-mechanical properties, as well as laboratories of water, physical and mechanical properties.

### 1.11. Educational and methodological support.

List of recommended educational editions, web-sites and additional literature:

**a) main sources:**

*1. Bondarik G.K., L.A. Yarg. Engineering-geological survey. Handbook. M.: Knijniy Dom Universiteta, 2007.*

*2. Boldirev G.G. Method for studying soils mechanical properties. State-of-the-art. Monography. Penza: PGUAS, 2008.*

3. *Dashko R.E. Rock mechanics. M., Nedra, 1987.*

*4. Dashko R.E., Vlasov D.Yu., Shidlovskaya A.V. Geotechnics and subsurface microbiota: Institute "PI" Georekostruktciya. Spb, 2014. – 280 p.*

*5. Dashko R.E. Geoecology issues in Geotechnics // Дашко Р.Э.* Проблемы геоэкологии в геотехнике// Geotechnical conference proceedings "Historical cities reconstruction and geotechnical engineering", Spb, 2003.

*6. GOST 25100-2011. Soils. Classification.* M.: MNTKS, 2011.

*7. Ivanov I.P. Engineering-geological investigations in mining field. L.: Nedra, 1987.*

*8. Ivanov I.P., Trzcinsky Yu.B. Engineering geodynamics. Spb.: Nauka, 2000.*

*9. Engineering geology J.* №1-4, 2006-2011.

*10. Engineering surveys. Russian analytical journal.* №1-12, 2006-2011.

*11. Lomtadze V.D. Engineering petrology. L.: Nedra, 1970, 1984.*

*12. Lomtadze V.D. Engineering geodynamics. L.: Nedra, 1977.*

*13. Lomtadze V.D. Special engineering geology. L.: Nedra, 1978, 1978.*

*14. Field tests of hydrogeological, engineering-geological, geocryological, engineering-geophysical and ecological studies / Ed. by V.A. Korolev et al. M.: MGU, 2000.*

*15. Construction directives and rules 47.13330.2012. Engineering surveys for construction. General rules. Moscow, 1996.*

*16. Construction rules 11-105-97 Engineering-geological surveys for construction.* Parts I-IV. Moscow, 1997.

*17. Construction rules 11.102.97. Engineering-ecological surveys for construction.* Moscow, 1997.

*18. Tolmachev V.V., Royter F. Engineering karst study. M.: Nedra, 1990.*

*19. Trofimov V.T. Genesis of loessial soils collapsibility. M.: MGU, 1999.*

*20. Trofimov V.T., Korolev V.A., Voznesensky E.A., Golodkovskaya E.A. Soils study / Ed. by V.T. Trofimov. M.: MGU, 2005.*

*21.*

**б) Additional sources:**

*1. Korolev V.A. Monitoring of geological, lithotechnical and ecological-geological systems. Ed. by V.T. Trofimov. Schoolbook for Institutions of Higher Education. M.: KDU, 2007.*

*2. Ryzkov I.B., Isaev O.N. Static soils penetration. M.: ASB, 2010.*

*3. ASTM D2850.* Standard Test Method for Unconsolidated Undrained Triaxial Compression Test on Cohesive Soils. 2007.

4. *ASTMD4767.* Standard Test Method for Consolidated Undrained Triaxial Compression Test on Cohesive Soils. 2007.

5. *ASTMD 1586-99* Standard test method for penetration test and split-barrel sampling of soils. Philadelphia, USA: American Society for Testing and Materials (ASTM),

1999.

6. *ASTMD 1586-08a* Standard test method for standard penetration test (SPT) and split barrel sampling of soils. The American Society for Testing and Materials (ASTM), 2008.

7. *BS 1377-7:1990.* Methods of Tests for Soils for Civil Engineering Purposes. Shear Strength Tests (total stress). -British Standards Institution, 1990.

8. *BS EN ISO 22476-1.* Geotechnical investigation and testing. Field testing. Part 1. Electrical cone and piezocone penetration tests. UK: British Standards Institution, 2005.

9. *BS EN ISO 22476-3: 2005.* Geotechnical investigation and testing. Field testing. Part 3. Standard penetration test. UK: British Standards Institution, 2006.

10. *N 1997-2: 2007-10.* Eurocode 7. Geotechnical design. Ground investigation and testing. 2007.

11. *ENV 1997-2:2000.* Eurocode 7. Geotechnical design. Part 2. Design assisted by laboratory testing.2000.

12. *ENV 1997-3:2000.* Eurocode 7. Geotechnical design. Part 3. Design assisted by field testing. UK: British Standards Institution, 2000.