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Guidance for Local Road Design (GLRD)

6. GEOTECHNICAL INVESTIGATIONS AND TESTING

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1 Introduction

1.1 General

The Guidance for geotechnical investigations are an integral part of the Guidance for Local Road Design (GLRD). A precondition to prepare reliable technical documentation is previously executed geotechnical investigations, required for preparation of the adequate phase of the local road design.

The type, scope and method of execution of investigation works, above all, depend on:

- Field conditions under which investigation works will be carried out.
- Scope of investigation in compliance with the level of design documentation (preliminary design, design for works execution, rehabilitation design, etc.)
- Type of structures and expected loads of soil.

The Guidance primarily refer to the Road Design Manual in the Republic of Serbia, 2 Geotechnical and hydrological investigations and testing, Belgrade 2012, and therefore to the corresponding technical regulation which governs and conditions this field through appliance of the adequate SRPS EN and SRPS EN ISO standards (see SRDM 2, item 2.1.1.2).

2 Stages of Geotechnical investigations

Geotechnical investigations for road route design are primarily related to and depends on;

- Selected corridor for the road route
- Selected excavation technology and category and type of soil
- Stability of slope angles of cuts and side cuttings, and the required protective measures
- Technologies for construction of embankments and measures for protection of grade slopes
- Potential needs to improve soil characteristics (replacement, improvement measures...)
- Possible presence of groundwater and types of protection against water.
- Type of materials for construction of road and envisaged borrow pits
- Selected location for disposal of surplus material
- Environmental impact

When it comes to investigations for construction of structures (bridges, supporting structures, tunnels), the scope and type of investigations depend on:

- Conditions, types and depth of foundation
- Soil bearing capacity and settlement
- Excavation technologies
- Soil improvements
- Disposal of surplus material
- Environmental impact

Investigation works are executed in accordance with the table below:

Table 1 Stages of Investigations

Investigation Stage	Purpose
Preliminary investigations	General knowledge of geological composition of the soil aiming at: – selection of the most suitable construction method – decision on the suitability of the location of the envisaged construction – specifying the preliminary design for the structure's foundations, i.e. the construction method of geotechnical structures

	– defining the type and scope of investigations in the subsequent stage by taking into account the Main design
Main investigations	Obtain all necessary geotechnical data for integrated design of the road route and foundations of structures on the route.
Supplementary investigations	Supplement investigations according to the subsequently defined need, e.g. in the following cases: – if the analysis of previously obtained data points to their unreliability or deficiency – the design or location of the road or structure has changed – the conditions and relations in the field have changed – other considerable changes in the project have occurred (loads, technological procedures, stages of the execution of works, etc.), requiring additional geotechnical data – the terrain on the micro-location of the envisaged investigations works is inaccessible.

In the course of execution of works on construction of local road and related structures, the following investigations are carried out:

- Current investigation
- Control investigation

According to the stage of preparation of design documentation for local road, the stages of geotechnical investigation works are defined.

Table 2 Design stages and related geotechnical investigation stages

Design stage	Geotechnical investigation stage
Conceptual design	Preliminary investigations
Preliminary design	Main investigations
Design for construction permit, Design for execution	Main (and supplementary) investigations
As-built design	Current and control investigations

3 Execution of Geotechnical investigations

3.1.1 Preparation of geotechnical investigations

Execution of geotechnical investigation implies the following:

- Geotechnical investigations are planned and implemented by an authorized and licensed institution and expert in the field of geotechnical investigations.
- The equipment used for investigations shall be verified and duly calibrated by a certification body.
- Geotechnical investigations are executed in compliance with procedures guaranteeing quality of the works executed.
- The investigation includes the existing historical geotechnical data for the location in question
- Proper minutes are made of each geotechnical investigation procedure performed.

- The investigation program includes collection of relevant geotechnical data for adjacent structures.
- Geotechnical investigation assumes technology analysis for execution of works on construction of a local road, as well as field conditions for execution of investigation works.
- All field and laboratory investigations are executed and interpreted pursuant to applicable regulations for that field.
- At each stage related to the designed road and/or structure, geotechnical investigations must provide appropriate information on the soil and ground water in the construction zone of influence, and ensure interpretation of soil composition as well as selection of characteristic values of material parameters, which represent a basis for geotechnical calculations. For complex facilities or routes of roads going through complex geological conditions, from the very beginning of soil investigation it is necessary to monitor relevant geotechnical phenomena such as soil movements, variations of the ground water level, variations of pore pressures, etc.

3.1.2 Collection of existing data (historical construction)

Collection of existing data is carried out in the office and implies the following:

- Review of the area along the rod route or/and structure
- Review of existing geological and morphological maps
- Review of results of previous investigation stages
- Review of investigation works results on the adjacent structures
- Review of reports on auscultation of adjacent structures
- Collection of satellite, aerial and other photos of the area
- Preparation of a detailed plan of field investigation works
- Preparation of a detailed program of laboratory investigation works

3.1.3 Field investigation works

Field investigation implies the following:

- Review and analysis of the terrain with detection of characteristic morphological - geological, hydro-geological and other relevant occurrences.
- Geological, engineering, hydrological mapping of the locality along and across with regard to the road route.
- Investigation excavations (excavations, sampling, measurements, keeping records).
- Investigation drilling (drilling, coring, inventory, measurements). Execution of geotechnical measures in boreholes (penetration test, geophysical test etc.) Installation of inclinometer, piezometer and other measuring equipment.
- Execution of geo-mechanical investigations and results collection:
    - Standard penetration test SPT
    - Field test with a wing probe
    - Dynamic probing DPL, DPM, DPH, DPHS
    - Cone penetration test CPT (CPTU, SCPT)
    - Pressuremeter PMT
    - Dilatometer DMT, SDMT, RDT
    - Plate loading test (circular plate PLT)

- Hydro-geological investigations
    - Measuring piezometer levels and determining the profiles of pore pressures in the soil
    - Waterproofness measurements
    - Sampling of underground water for chemical and bacteriological analyses
    - Hydro-geological classification and protection of underground water
    - Geophysical investigations
    - Other tests as needed and interpretation of collected data (geoelectricity, georadar, geoseismic, etc).

- Other field testing (measurements, data processing and analysis of results)

- Geodetic measurements
- Inclinometer measurements
- Extensimeter measurements
- Static and dynamic load tests of piles, pile driving tests
- Investigations of geotechnical anchors
- Installation of test probes before construction of embankment
- Other special geotechnical measurements, mechanical and chemical auscultation

4 Laboratory Tests

Laboratory tests are performed on samples collected in the field using the procedures provided within Table 3.

Table 3 - Types and forms of laboratory tests and sample types:

	Undisturbed	Disturbed			
Soil properties / sample quality class	**1**	**2**	**3**	**4**	**5**
Unchanged soil properties					
Particle size	+	+	+	+	
Moisture	+	+	+		
Density, relative density, waterproofness	+	+			
Compressibility, shear strength	+				
Properties that can be determined					
Sequence of layers	+	+	+	+	+
Boundaries of layers - broad	+	+	+	+	
Boundaries of layers - fine	+	+			
Atterberg limits, particle density, organic content	+	+	+	+	
Moisture	+	+	+		
Density, relative density, porosity, waterproofness	+	+			
Compressibility, shear strength	+				
Category of sampling (drilling) according to EN ISO 22475-1*	**A**				
		B			
					C

The sampling methods for sample categories A, B and C are defined in accordance with SRPS EN ISO 22475-1 / 6 standards and correspond to the type of soil in which sampling is performed. Class 1 and 2 samples (sampling category A) are reference for geotechnical tests.

Procedures and methods of laboratory tests:

- Analysis of samples taken from the field according to the program of geo-mechanical laboratory tests
- Laboratory tests of soil material samples
  - Classification
  - Determination of density

    - Determination of material strength
    - Stiffness test
    - Waterproofness test
    - Determination of chemical composition
    - Suitability of material for construction of embankment / bed
- Laboratory tests of samples of rock material
    - Preparation of samples
    - Petrographic mineralogical tests
    - Determination of material strength
    - Stiffness test
    - Suitability of material for construction of embankment / bed
    - Suitability of the material for further processing and preparation of aggregates
- Laboratory geological tests
- Laboratory investigation and determination of parameters affecting the environment
    - Organic composition
    - Chlorides
    - Sulfates
    - Carbonates
    - Heavy metals
    - PH value

5 Geotechnical Investigation Procedures

Geotechnical investigations are performed by an authorized and licensed organization, based on a program which is an integral part of the Terms of Reference for preparation of infrastructure structure design.

In order to orient the designers during the designing process in a proper manner, the geotechnical investigations are performed before the designing process. For this purpose, appropriate studies are being prepared as follows:

- Study on results of geotechnical investigations
- Study on road and structures construction conditions in road-functioning structures, as an analysis of previously collected results

Both studies are an integral part of the design and the procedure of their preparation is shown in Table 4 below:

Table 4 Procedure for preparation of geotechnical investigation Study

Stage	*Purpose*	*Contractor*	*Required documentation*	*Research methods*	*Final document*	*Technical control*
Preliminary Preparatory works for investigations	Preliminary analysis of the technical documentation and geotechnical conditions in terms of planned investigations. The aim of this stage is preparation of the call for proposals for preliminary geotechnical investigations.	The expert service Employer or a consultant company designated at the Consultant's request.	The latest version of the technical documentation (layout, longitudinal section, cross sections) Archival geotechnical data (if applicable).	Selection of cabinet wok methods (see 3.1.2). Review and reconnaissance of the terrain (see 3.1.3)	Program of geotechnical investigation	Recommended for complex geotechnical route conditions
Preliminary investigations	Acquisition of basic data on composition and characteristics of soil (see Table 1).	A research institution with appropriate references in the field of	The latest version of the technical documentation (layout, longitudinal	Selection of method of work in office (see 3.1.2). Geological	Study on results of preliminary geotechnical investigations	The final study is the subject of internal technical control. The control

	Acquisition of the appropriate data for preparation of the main investigation programs.	geotechnical investigations.	section, cross sections) Archival geotechnical data (if applicable).	mapping (see 3.1.3). [Selection of other filed investigation methods, laboratory tests and calculation-based analyses].	for the route or structures and geotechnical report on conditions of construction of the road or structure.	method is defined by the expert service of the Employer.
Main investigations	Provision of all required data on soil properties on the road route and structure locations (see Table 1).	A research institution with acknowledged references in calls for proposals.	The latest version of the technical documentation (layout, longitudinal section, cross sections of the road and/or facility) Reports on results of preliminary geotechnical investigations Other relevant data (foundation loads, available time for consolidation, etc.)	Selection of method of work in office (see 3.1.2), detailed geological mapping (see 3.1.3), selection of other in-situ investigations and laboratory tests (see **Error! Reference source not found.**),	Study on results of the main geotechnical investigations for the route or facilities and geotechnical report on conditions of construction of the road or structure.	Final studies are subject of internal technical control. The control method is defined by the expert service of the Employer.
Additional investigations	To supplement the database with data from previous investigation stages (see Table 1).	A research institution with appropriate references (if possible the same institution that has performed the main investigations.	The latest version of the technical documentation (layout, longitudinal and cross sections), reports on results of preliminary and main geotechnical investigations, geotechnical report on conditions of construction of the road or facility route. Data on amendments of the technical documentation and other reasons for execution of additional investigations. Special requirements of the responsible designer.	Selection of method of work in office (see 3.1.2), detailed geological mapping (see 3.1.3), selection of other in-situ investigations and laboratory tests (see **Error! Reference source not found.**),	Study on results of supplementary geotechnical investigations Geotechnical report on conditions of construction of the road or structure.	Final studies are subject of internal technical control. The control method is defined by the expert service of the Employer.
Geotechnical monitoring of the road or structure condition after construction	The main purpose of geotechnical monitoring is inspection of functional capacities of the road route and/or specific structures, and inspection of the conformity with	A contractor with references in the field of geotechnical, geodetic and/or other needed types of measurement	Main design, as-built design. Reports on results of the main (and additional) geotechnical investigations. Geotechnical	Review of the existing technical documentation. Designing and establishment of the technical monitoring	Periodical reports on results of geotechnical monitoring of the road and/or structure. Final report on geotechnical monitoring of	The final report on geotechnical monitoring of the road and structures condition after construction, is subject of internal technical control. The control

	the designed behavior. The monitoring results ensure a rational approach to rehabilitation, if needed.	and implementation of geotechnical monitoring.	report on conditions of construction of the road or structure route. Terms of reference for execution of geotechnical monitoring.	system. Periodical measurements on the structure. Interpretation of measurement results. Preparation of the report with a proposal of measures and/or further monitoring.	the structure in the period (from…to…) with a proposal of measures and further measurement.	method is defined by the expert service of the Employer.

6 Contents of Geotechnical Reports

Preparation of Geotechnical Study is the final stage of the geotechnical investigation process. Geotechnical Study is of crucial importance for all subsequent stages of preparation of design technical documentation, stages of construction and supervision.
The Study is divided into two parts:

• Study on results of geotechnical research

• Geotechnical Study on conditions of construction of the road or structure.

The Study must be comprehensible for the Designer.

6.1 Study on Results of Geotechnical investigations

Geotechnical studies are prepared for the needs of designing and construction:

- Road route
- Bridges and other road related structures
- Borrow pits and disposal locations
- Particular parts of the road that deviate from standard construction procedures (landslides, appliance of geo-synthetic measures, etc.)

The Study comprises:

- A review of all available geotechnical data together with geological characteristics and other relevant information
- Geotechnical data analyses

6.1.1 Review of Geotechnical Data

Review of Geotechnical data include:

- A factual report on all field and laboratory tests
- Report containing data on the applied investigation methods and procedures in-situ and laboratory tests

The factual report comprises the following data:

- List of all participants involved in geotechnical investigations
- Purpose and scope of geotechnical investigations
- Time period in which the field and laboratory tests were carried out
- Results of the terrain reconnaissance of a wider area, with a focus on the presence of ground water, terrain and adjacent structures stability slope instability and other
- Historical data
- Geological structure of the area together with fault lines
- Geodetic data
- Information from available aerial photos

- Available seismic data
- Sampling procedures, transport and storage of samples
- Data on the used field equipment
- Tabular presentation of the scope and quantity of executed in-situ and laboratory tests as well as records on the field records by the supervising staff
- Data on oscillations of the ground water levels before and after investigation works
- Graphic data of the borehole profiles together with photos of the core, including adequate description of ground layers
- Data on radioactivity, if present
- Data on soil sensitivity to freezing.

6.1.2 Analysis and assessment of geotechnical data

An analysis and assessment of geotechnical data must comprise:

- Detailed review of field and laboratory testing, in order to detect inaccuracies and incorrect procedures, as well as their exclusion from the assessment procedure
- A review of obtained results of geotechnical parameters
- Determination of a program and list of additional field and laboratory tests in the following design stages, accompanied by appropriate clarifications for their implementation
- Tabular and graphic presentations of results of field and laboratory investigations
- Histograms presenting the range of values of the most significant data and their distribution
- Depth of the ground water level and its seasonal fluctuations
- Profile of the foundation soil that clearly presents soil layers
- Detailed description of individual soil layers with classification, their physical features, stiffness, strength, waterproofness
- Specification on observed irregularities in terms of presence of different materials and caverns.

6.2 Geotechnical Study on conditions of construction of a road or structure in the function of road

A geotechnical Study on conditions of construction of a road or road related structure must comprise data, calculation-based methods including assessmentresults and recommendations for use of the material and safety factor.

The accuracy of data processing is adjusted to the type of investigation.

The geotechnical Study with construction conditions, primarily refers to the report on geotechnical investigations (item 6.1) and includes:

- Description of the location and its environment
- Description of soil conditions
- Description of designed structure, together with loads
- Design values of soil and rock mass characteristics, along with the required explanations and clarifications
- Statement on the applied regulations and standard;
- Comment on location suitability in relation to the construction of the said structure and the acceptable risk level
- Geotechnical calculations and drawings
- Recommendations for design of structure foundations
- List of structures requiring particular technical monitoring during construction, including the location (sections) of the road route and type of control
- Program of supervision and technical monitoring during construction as well as the method of documenting the control.

In relation to supervision and technical monitoring, the geotechnical Study on conditions of construction must define the following:

- Purpose of each series of monitoring and measurements
- Parts of construction to be monitored, as well as locations of measurements

- Frequency of measurements
- Method of analysis and assessment of obtained results values
- Scope of required values of obtained measurement results
- Time duration after completion of the road and road related structures
- List of persons responsible for measurements and monitoring, interpretation of obtained results as well as for maintenance of measurement equipment.

7 Type of Investigations

7.1 Envisaged Scope of the Main Geotechnical Investigations

7.1.1 Field Investigations

The program of main investigations should be prepared on the basis of findings of preliminary investigations.

The scope of investigations depends on:

- The quantity of previously conducted investigations
- Type of soil
- Scope and significance of the design
- Envisaged soil loading.

Planning of investigation test should take into account the applicable technical standards and prior knowledge of the problem, hence, the scope of work should be adjusted accordingly. The proposal for the scope of field investigations is provided within item 8.2.

In case of geologically and morphologically complex areas, it is recommended to already in the stage of previous investigations, drill deep boreholes together with installation of inclinometers and piezometers for long term, and auscultatory measurements throughout all stages of project implementation, after construction and during exploitation. The results of these measurements are of particular importance for any rectifications that may occur due to soil movement.

7.1.2 Laboratory Investigations

The planning of laboratory tests should take into account the type of structure, soil loading, natural soil composition and soil characteristics.

Laboratory investigations shall be in any case adjusted to the findings of field investigations in a way that will ensure their supplementing. Prior to the beginning of laboratory testing, preliminary knowledge of the soil profile, shape of terrain and which soil layers are relevant for road foundation, is required.

The scope of laboratory tests must ensure a reliable determination of the characteristics of all layers that are under the road structure and road-functioning structures.

A recommended scope of laboratory tests is defined in Table 5.

Table 5 Recommendations on the scope of laboratory tests for each soil layer

Type of test **Soil**	Previously obtained data on materials are in place	
	No	Yes
Particle size distribution	4-6	2-4
Moisture	on all samples of class 1 to 3	
Strength index	on all samples of class 1	
Atterberg limits	3-5	1-3
Content of organic substances	3-5	1-3
Bulk density	For each test	
Relative density	As required	

Particle density	2	1
Compressibility	2-4	1-3
Shear strength	2-4	1-3
Undrained strength	3-6	1-4
Proctor test	3	
CBR	3	
Permeability	3-5	1-4

Type of test **Rock**	Previously obtained data on materials are in place	
	No	Yes
Moisture	1 test/meter of borehole	
Bulk density and porosity	1 test/2 m of borehole, at least 1 test for each rock type	
Swelling	3	
Uniaxial strength	2-6	1-4
Point load index	5-10	
Direct shear test	5	

7.1.3 Geological Investigations

7.1.3.1 Structural Geological Investigations

The purpose of structural geological investigations is to obtain geological structures of the terrain under the road base and road-related structures. For that purpose, it is necessary to classify the geology of the road according to lithological groups and divisions, aimed at interpretation of the terrain according to hydrological and engineering geological properties.

The final objective of structural geological investigations is to determine the potential impacts to the complexity of construction due to occurrence of instability along a tectonic contact, possibility of land sliding etc.

7.1.3.2 Engineering Geological Investigations

The primary purpose of the Engineering Geological investigations is:

- Based on the geological structure of soil, the conditions for construction of the road and road-related structures are determined in different stages of investigations.
- Based on the geo-mechanical and geophysical characteristics, the average values for the lithological composition within one group are determined.

The following data are obtained with engineering geological investigations:

- Engineering geological properties (mapping)
  - Shape of terrain
  - Morphological properties of are around the road
  - Inclination of natural slopes
  - Vegetation on terrain
  - Sensitivity to external impacts (disintegration, erosion or land sliding)
  - Cracks
  - Average thickness of layers of degraded materials
  - Type of layers of degraded materials
  - Method of degradation and decomposition
  - Assessment of the ground stability
  - Types of possible phenomena of reducing the natural equilibrium
- Assessment of geotechnical characteristics

    - Classification of rock mass (descriptive and in numeric forms)
- Seismic characteristics
    - Classification of soil in accordance with Euro code 8

7.1.3.3 Purpose of Hydro-Geological investigations

Hydro-geological investigations are aimed at:

- Protection of road from underground waters:

  Timely forecast of hydrogeological conditions is required for appropriate technical solutions for construction of road under conditions of considerable impact of ground water on road base and carriageway.

- Protection of underground water against impacts of the water flowing from the carriageway.

  Ground water should be protected against direct or indirect harmful effects in order to protect the environment. The level of protection against impacts shall be prescribed depending on the quality of groundwater that needs to be maintained. Investigations are carried out to assess the condition and protection for a longer hydrological period.

7.1.3.4 Program of Hydro-Geological Investigations and contents of HG Study

The Programme of the Hydro-Geological investigations include:

- Regional overview of geological conditions;
- Regional hydrological overview (direction of flow of underground water, the depth of saturated and non-saturated layer in the ground, soil capacity etc.);
- Hydrological measurements (permeability measurements by pumping tests, permeability measurements by pouring tests, measurements in piezometers);
- Overview of protection areas and other water supply from underground water;
- Forecast of hydrological conditions along the road route;
- Classification of hydro-geological conditions along the route in order to prepare appropriate measures for protection of underground water.

More details on the methods of hydrogeological investigations are elaborated under chapter - Drainage.

7.1.4 Geophysical Investigations

7.1.4.1 Purpose of Geophysical investigations

The purpose of geophysical investigations is the following:

- Data collection on the geological area of road construction
- Preparation of geological profiles in addition to the data obtained from boreholes
- Collection of quantitative data on mechanical characteristics of soil and rock masses (geo-seismic methods)
- Determine the micro - locations for drilling (geotechnical works)
- Determine the locations for boreholes aimed to observe certain anomalies.

7.1.4.2 Geophysical methods

- Electrical resistivity
- Seismic methods
- Electromagnetic methods (ground penetrating radar)
- Borehole-logging
- Establishing the technical conditions of boreholes

7.1.5 Geomechanical Investigations

7.1.5.1 Field Investigations

A review of technical investigations to determine the soil characteristics is provided in Table 6.

7.1.5.2 Laboratory Investigations

A review of laboratory investigations for soil classification is given in

Table 67.

Table 68 provides an overview of laboratory methods for testing physical and mechanical properties of samples.

Table 6 Overview of field investigations

Field investigation method[1]	Possibility of attaining quality results														
	Sampling														
	Soil and rock														
	Category A	Category B	Category C	CPT and CPTU	Pat[ch]	RDT	Dilatometer	Spi[ted]	DPL/DPM	DPH/DPSH	FVT	DMT	PLT	Open system	Closed system
Basic Information															
Type of soil	K1 S1	K1 S1	K2 S2	K2 S2	K3 S3	-	K3 S3	K2 S1	K3 S3	K3 S3	-	K2 S2	-	-	-
Type of rock	R1	R1	R2	R3[e]	R3	R2	-	-	-	-	-	-	-	-	-
Extension of layers[1]	K1 S1 R1	K1 S1 R1	K3 S3 R2	K1 S1	K3 S3 R3	R3	K3 S3	K2 S2	K1 S2	K1 S2	-	K2 S1	-	-	-
Ground water level	-	-	-	K2	-	-	-	-	-	-	-	-	-	K1 S2 R2	K1 S1 R1
Pore pressure	-	-	-	K2 S2	S3	-	-	-	-	-	-	-	-	K1 S2 R2	K1 S1 R1
Soil Characteristics															
Particle size	K1 S1 R1	K1 S1 R1	R2	-	-	-	-	K2 S1	-	-	-	-	-	-	-
Moisture	K1 S1 R1	K2 S1 R1	K3 S3	-	-	-	-	K2 S2	-	-	-	-	-	-	-
Waterberg limits	S1	S1	-	-	-	-	-	S2	-	-	-	-	-	-	-
Density	K2 S1 R1	K3 S3 R1	-	K2 S2	-	-	-	K2 S2	K2	K2	-	K2 S2	-	-	-
Shear strength	K2 S1 R1	-	-	K2 S1	K1 S1	-	-	K2 S3	K2 S3	K2 S3	S1	K2 S1	K1 S1 R2	-	-
Compressibility	K2 S1 R1	-	-	K1 S2	K1 S1	R1	S1	K2 S2	K2 S2	K2 S2	-	K2 S1	K1 S1	-	-
Permeability	K2 S1 R1	-	-	K3 S2	S3	-	-	-	-	-	-	-	-	K2 S3	K2 S2
Chemical tests	K1 S1 R1	K1 S1 R1	-	-	-	-	-	K2 S2	-	-	-	-	-	-	-

[a] Terminology and abbreviations: see 2.1.1 [b] In horizontal and vertical direction [c] Depends on the type of pressure meter [d] Assuming that a sample is retained [e] For soft rock only	Applicability R1 high for rock (R=rock) R2 medium for rock R3 low for rock K1 high for coarse grained soil K2 medium for coarse grained soil K3 low for coarse grained soil S1 high for fine grained soil S2 medium for fine grained soil S3 low for fine grained soil 1) Definition of coarse and fine grained soils according to ISO 14688-1. 2) Depending on ground conditions (type of soil, ground water conditions) and planned structure, selection of investigation methods will vary and may differ from this table.

Table 7 Laboratory tests for soil classification (pursuant to SRPS EN 1997-2:2014)

Parameter	Type of soil							
	Clay			Silt			Sand, gravel	
	Type of sample			Type of sample			Type of sample	
	Undisturbed	Disturbed	Remolded	Undisturbed	Disturbed	Remolded	Disturbed	Remolded
Geological description and classification of soil	+	+	+	+	+	+	+	+
Moisture	+		o	+	o	o	o	o
Bulk density	+	o		+	o	-	-	-
Minimum and maximum densities	-	-	-	o	o	o	+	+
Waterberg limits	+	+	+	+	+	+	-	-
Particle size distribution	+	+	+	+	+	+	+	+
Undrained shear strength	+	-	-	o	-	-	-	
Permeability	+	-	-	+	o	o	o	o
Sensitivity	+	-	-	-	-	-	-	-

+ normal to determine

o possible to determine, not necessarily representative

— not applicable

NOTE: for some types of soil further tests may be considered, such as determination of organic content, particle density and activity.

Table 8 Laboratory tests for definition of physical and mechanical properties of soil (in accordance with SRPS EN 1997-2:2014)

Geotechnical parameter	Type of soil					
	Gravel	Sand	Silt	Normally consolidated clay	Over consolidated clay	Peat, organic soils
Odometer modulus (E_{ked}), compression index (C_c) (one-dimensional compressibility)	(OED) (TX)	(OED) (TX)	OED (TX)	OED (TX)	OED (TX)	OED (TX)
Elasticity modulus (E), shear modulus (G)	TX	TX	TX	TX	TX	TX
Drained (effective) shear strength (c', φ')	TX SB	TX SB	TX SB	TX SB	TX SB	TX SB
Residual shear strength (ca_{re}, $'P_R$)	RS (SB)	RS (SB)	RS (SB)	RS (SB)	RS (SB)	RS (SB)
Undrained shear strength (c_u)	-	-	TX DSS	TX DSS	TX DSS	TX DSS

			SIT	(SB) SIT	(SB) SIT	(SB) SIT
Bulk density (ρ)	BDD	BDD	BDD	BDD	BDD	BDD
Coefficient of consolidation (c_v)			OED TX	OED TX	OED TX	OED TX
Permeability (k)	TXCH PSA	TXCH PSA	PTC TXCH (PTF)	TXCH (PTF) (OED)	TXCH (PTF) (OED)	TXCH (PTF) (OED)
— not applicable ( ) partly applicable						

Abbreviations:

BDD ... Bulk density determination

DSS ... Direct simple shear test

OED ... Odometer test

PTF ... Permeability test in the falling head permeameter

PTC ... Permeability test in the constant head permeameter

RS ... Ring shear

SB ... Translational shear box test

SIT ... Strength index tests (in the preliminary phase only)

PSA ... Particle size analysis

TX ... Triaxial test

TXCH ... Permeability constant head test in the triaxial cell

7.1.6 Quality of Execution of Geotechnical Investigations

When performing field and laboratory investigations, the following conditions should be met for fulfillment of quality control:

- The procedure of implementation of all geotechnical investigations and single responsibilities of all contractors of specific investigations must be clearly defined.
- Appropriate qualification structure of the persons perfroming the investigations.
- Only technically flawless and standardized equipment may be used for execution of investigations.
- Provision of regular control and equipment calibration by an authorized and certified institutions.
- Provision of data for review on the technical characteristics of equipment, calibration certificates and manuals for utilization.
- For all investigations, records of investigations should be kept in accordance with the Rulebook defined by relevant standards and manuals. All records must be regularly filled in and stored in the original form within the investigation documentation.
- All records on investigations must be kept and stored in a way that will ensure at any time undoubted acquisition of data on the entire course of investigations, on the person who performed the investigation works, as well as on all conditions that might influence the course of works, in compliance with the set standards.
- Investigations works may only be carried out under weather conditions on field and laboratory conditions that are optimal for work and that do not influence the results. The conditions under which the investigation work is performed are entered in the records (temperature, humidity, etc.)
- Each procedure must have identification number.
- All samples must be labelled and code.
- The investigation procedure is subject to the Supervision control.

8 Annex

8.1 Content of Reports

General requirements in regard to the contents of specific reports are defined in Items 6.1 and 6.2. Examples of the contents of specific reports are given below:

Geotechnical report for road route (8.1.1):

- Report on results of geotechnical investigations for road route
- Geotechnical report on conditions of route construction

Geotechnical report for the structure (bridge) (**Error! Reference source not found.**):

- Report on results of geotechnical investigations for bridge
- Geotechnical report on conditions of bridge construction

8.1.1 Geotechnical Report for Road Route

Book 1: Report on geotechnical investigations results

1. INTRODUCTION
   - 1.1 Purpose and scope of the investigations
   - 1.2 Period of the execution of investigations
   - 1.3 Expert associates
   - 1.4 Applicable standards and regulations

2. TYPES AND SCOPE OF INVESTIGATIONS
   - 2.1 Review of previous investigations
   - 2.2 General geotechnical experience from the location
   - 2.3 Investigations for the road design
     - 2.1.1 Field investigations
     - 2.1.2 Laboratory tests

3. REVIEW OF BASIC INVESTIGATION RESULTS
   - 3.1 Geomorphologic characteristics of the terrain
   - 3.2 Geological structure
     - 3.2.1 Lithostratigraphic structure
     - 3.2.2 Tectonic setting
   - 3.3 Hydro-geological properties
   - 3.4 Contemporary geological processes and occurrences (landslides, rock falls, erosions, etc.)
   - 3.5 Seismicity of the location

4. ASSESSMENT OF GEOTECHNICAL PARAMETERS BASED ON THE INVESTIGATION RESULTS
   - 4.1 Review of laboratory and field testing results with comments
   - 4.2 Analysis of the results of testing of physical and mechanical properties of soils and rocks with a proposal of characteristic values

5 CONCLUSIONS

6 MAIN GRAPHIC ENCLOSURES
   - 6.1 Geological and engineering-geological map
   - 6.2 Longitudinal engineering-geological section along the route
   - 6.3 Characteristic cross sections (especially on locations of all cuttings and embankments, all landslides and areas of soft soil).

7 OTHER ENCLOSURES
   - 7.1 Reports on individual investigation works (drilling, laboratory testing, field measurements,

geophysical measurements, etc.)

Book 2: Geotechnical report on conditions of route construction

1 INTRODUCTION

2 ANALYSIS OF GEOTECHNICAL PARAMETERS
- 2.1 Division of route into sections
- 2.2 Geotechnical model for each sections with selection of characteristic and design properties for geotechnical calculations

3 GEOTECHNICAL ANALYSES AND CALCULATIONS
- 3.1 Calculation of settlements and consolidation
- 3.2 Analyses of embankment stability
- 3.3 Analyses of cutting stability

4 GEOTECHNICAL CONDITIONS AND RECOMMENDATIONS FOR EXECUTION OF WORKS
- 4.1 Conditions of execution of cuttings and side cuttings
- 4.2 Conditions of execution of embankments
- 4.3 Specific route problems (protection from surface and ground water, cuttings in soft soil, cuttings on unstable slopes)
- 4.4 Usability of local materials

5 RECOMMENDATIONS FOR SUPERVISION, MONITORING AND MAINTENANCE
- 5.1 Identification of geotechnical risks and risky locations
- 5.2 Design of geotechnical monitoring
- 5.3 Recommendations for the supervising engineer
- 5.4 Recommendations for maintenance

6 PROPOSAL OF THE GROUND INVESTIGATIONS PROGRAM IN THE UPCOMING STAGE

7 CONCLUSIONS

8 MAIN GRAPHIC ENCLOSURES
- 8.1 Layout of the route on the engineering-geological map
- 8.2 Longitudinal geotechnical section along the route
- 8.3 Characteristic geotechnical cross sections

9 OTHER ENCLOSURES
- 9.1 Results of computational analyses (stability of slopes, estimation of settlements, consolidation, etc.)
- 9.2 Summary of the geotechnical design for the Employer (see item 6.2**)**

8.1.2 Geotechnical Report for structure

Book 1: Report on geotechnical investigations results

1 INTRODUCTION
- 1.1 Purpose and scope of the investigations
- 1.2 Period of the execution of investigations
- 1.3 Expert associates
- 1.4 Applicable standards and regulations

2 TYPES AND SCOPE OF INVESTIGATIONS
- 2.1 Review of previous investigations
- 2.2 General geotechnical experience from the location
- 2.3 Investigations for the structure design

2.3.1 Field investigations
2.3.2 Laboratory tests

3 REVIEW OF BASIC INVESTIGATION RESULTS
3.1 Geomorphologic characteristics of the terrain
3.2 Geological structure
3.3 Hydro-geological properties
3.4 Contemporary geological processes and occurrences (landslides, rock falls, erosions, etc.)
3.5 Seismicity of the location

4 ASSESSMENT OF GEOTECHNICAL PARAMETERS BASED ON THE INVESTIGATION RESULTS
4.1 Review of laboratory and filed testing results with comments
4.2 Analysis of the results of testing of physical and mechanical properties of soils and rocks with a proposal of characteristic values

5 CONCLUSIONS

6 MAIN GRAPHIC ENCLOSURES
6.1 Geological and engineering-geological map
6.2 Longitudinal and cross engineering geological section(s) of ground on the location of the facility

7 OTHER ENCLOSURES
7.1 Reports on individual investigation works (drilling, laboratory testing, field measurements, geophysical measurements, report on load piles test, etc, ...)

Book 2: Report on conditions for construction of structure

1 INTRODUCTION

2 ANALYSIS OF GEOTECHNICAL PARAMETERS
2.1 Geotechnical soil model on the location of the structure
2.2 Selection of characteristic and design values of physical and mechanical properties for geotechnical calculations

3 GEOTECHNICAL ANALYSES AND CALCULATIONS
3.1 Calculation of settlements and consolidation of the structure
3.2 Calculation of the bearing capacity of foundations (piles)
3.3 Calculation of settlements and consolidation of the connecting embankment
3.4 Analyses of embankment stability
3.5 Analysis of the facility and soil interaction (for example: influence of the order of execution of works – embankment, facility)

4 GEOTECHNICAL CONDITIONS AND RECOMMENDATIONS FOR EXECUTION OF WORKS
4.1 Proposal of the foundation type of the structure
4.2 Conditions for execution of works

5 RECOMMENDATIONS FOR SUPERVISION, MONITORING AND MAINTENANCE
5.1 Identification of geotechnical risks and hazardous locations, stages
5.2 Design of geotechnical monitoring
5.3 Recommendations for the supervising engineer
5.4 Recommendations for maintenance

6 PROPOSAL OF THE GROUND INVESTIGATION PROGRAM IN THE UPCOMING STAGE

7 CONCLUSIONS

8 MAIN GRAPHIC ENCLOSURES
- 8.1 Structure layout on the engineering-geological map
- 8.2 Longitudinal and cross geotechnical sections of soil on the location of the structure

9 OTHER ENCLOSURES
- 9.1 Results of computational analyses (bearing capacity, settlements, consolidation, overall stability)
- 9.2 Summary of the geotechnical design for the Employer (see item 6.2)

8.2 Informative Scope of field investigations (extract from EN 1997-2:2014)

For geotechnical investigations on roads and road-related structures (bridges, tunnels) Eurocode 7-2 in its Annex B proposes the following scope of investigations:

8.2.1 Distance between investigation works

The distance between investigation boreholes or other adequate investigation methods:

- along linear structures (roads, pipelines, channels, tunnels, retaining structures) – on each 20 to 200 m,
- bridges: from 2 to 6 at each foundation,
- facilities of large structures: at the distance of up to 60 m.

8.2.2 Depth of investigation works

For certain types of interventions, the following investigation depths are proposed (measured from the lowest point of the foundation or from the bottom of excavation). In cases with several criteria, the criterion yielding the greatest depth is applied.

For particularly high or complex structures at least some investigation works should be carried out to greater depths. The same applies in cases of unfavorable geotechnical conditions (example: weak or compressible strata below strata of higher bearing capacity).

For interventions on the competent soil layer the investigation depth may be reduced to z_a=2 m, but for a certain number of investigations the depth z_a=5 m should be reached.

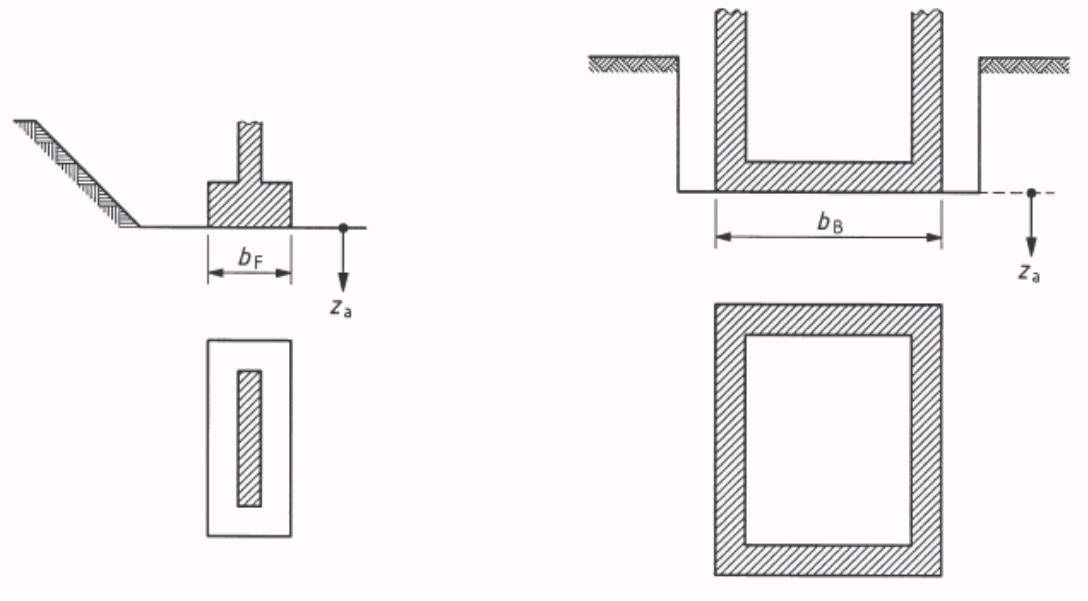
For foundations of structures:

$z_a \geq 6$ m

$z_a \geq 3.0\ b_F$ (b_F is the shorter dimension of foundation).

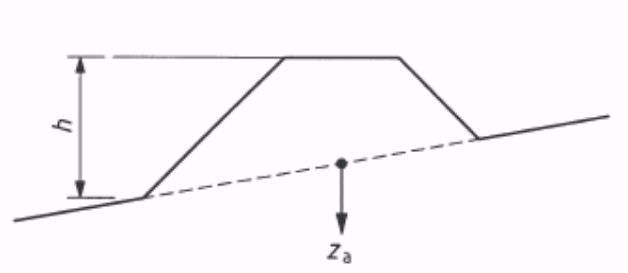
For bed plates and structures with several foundation elements whose effects in deeper strata are superimposed on each other:

$z_a \geq 1.5\ b_B$ (b_B is the shorter dimension of bed plate).



For embankments:

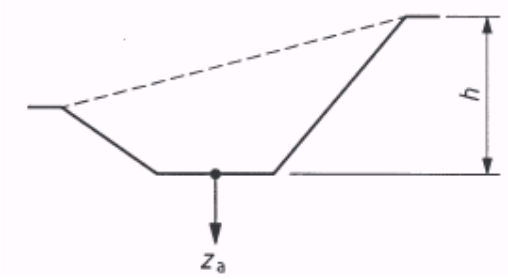
$0{,}8\ h < Z_a < 1{,}2\ h$ (h is the height of embankment)



For excavations:

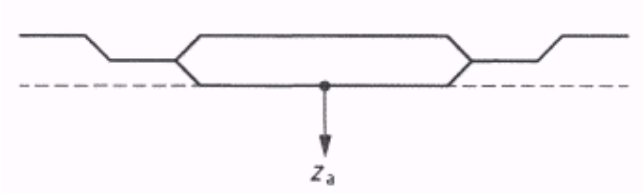
$Z_a \geq 0{,}4\ h$ (h is the depth of excavation)

$Z_a \geq 2$ m



For roads:

$Z_a \geq 2$ m



For excavations with retaining structures where the ground water level is below the bottom of excavation:

$z_a \geq 0.4\ h$ (h is the depth of excavation; t is the depth of the retaining structure below the excavation)

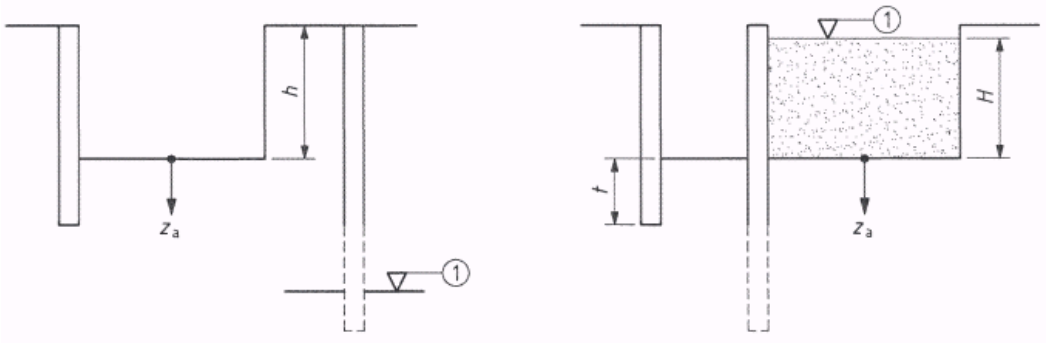
$z_a \geq (t+2.0)$ m.

For excavations with retaining structures where the ground water level is above the bottom of excavation:

$z_a \geq (H+2.0)$ (H is the depth of excavation; t is the depth of the retaining structure below the excavation)

$z_a \geq (t+2.0)$ m (if permeable layers are present up to the structure depth)

$z_a \geq (t+5.0)$ m (if there are no permeable layers up to the structure depth)

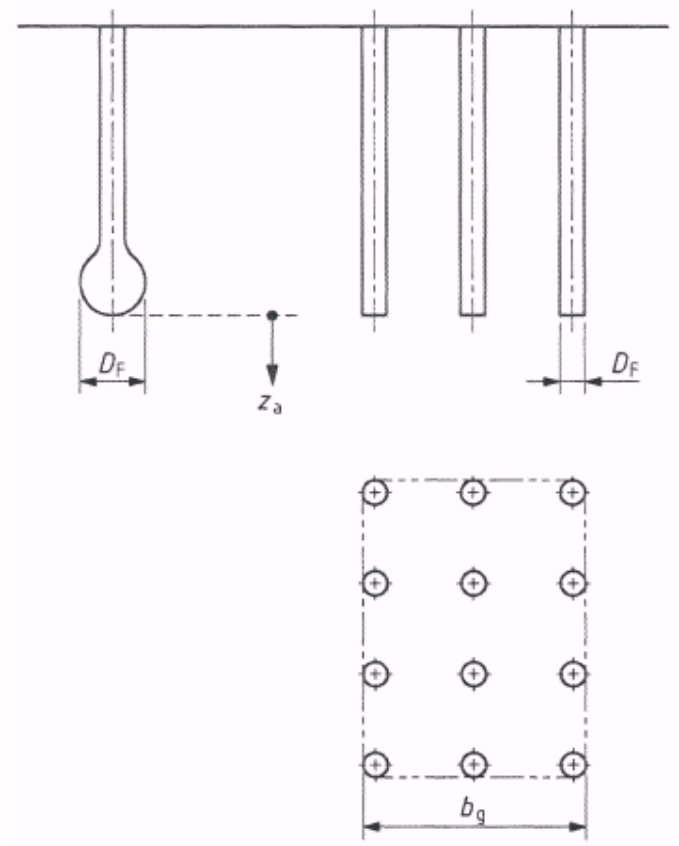


For piles:

$Z_a \geq 5$ m

$Z_a \geq 1{,}0$ bg (bg is shorter dimension of the foundation base on piles)

$Z_a \geq 3{,}0$ DF (DF pile base dimension).


D_F
z_a
D_F
b_g

8.3 Standards

8.3.1 Standards for Field Investigation Works

Identification and classification of soil and rocks	
SRPS EN ISO 14688-1:2018	Geotechnical investigation and testing - Identification and classification of soil - Part 1: Identification and description
SRPS EN ISO 14688-2:2018	Geotechnical investigation and testing - Identification and classification of soil - Part 2: Principles for a classification
SRPS EN ISO 14689-1:2012	Geotechnical investigation and testing - Identification and classification of rock - Part 1: Identification and description

Hydro-geological Investigations	
SRPS EN ISO 22282-1:2015	Geotechnical investigation and testing - Geohydraulic testing - Part 1: General rules
SRPS EN ISO 22282-2:2015	Geotechnical investigation and testing - Geohydraulic testing - Part 2: Water permeability tests in a borehole using open systems
SRPS EN ISO 22282-3:2015	Geotechnical investigation and testing - Geohydraulic testing - Part 3: Water pressure test in rock
SRPS EN ISO 22282-4:2022	Geotechnical investigation and testing - Geohydraulic testing - Part 4: Pumping test
SRPS EN ISO 22282-5:2015	Geotechnical investigation and testing - Geohydraulic testing - Part 5: Infiltrometer test
SRPS EN ISO 22282-6:2015	Geotechnical investigation and testing - Geohydraulic testing - Part 6: Water permeability tests in a borehole using closed systems

Sampling of soil and ground water	
SRPS EN ISO 22475-1:2022	Geotechnical investigation and testing - Sampling methods and groundwater measurements - Part 1: Technical principles for the sampling of soil, rock and groundwater.
SRPS CEN ISO/TS 22475-2:2012	Geotechnical investigation and testing - Sampling methods and groundwater measurements - Part 2: Qualification criteria for enterprises and personnel
SRPS CEN ISO/TS 22475-3:2012	Geotechnical investigation and testing - Sampling methods and groundwater measurements - Part 3: Conformity assessment of enterprises and personnel by third party

Execution of field tests	
SRPS EN ISO 22476-1:2014	Geotechnical investigation and testing - Field testing - Part 1: Electrical cone and piezocone penetration tests
SRPS EN ISO 22476-2:2012	Geotechnical investigation and testing - Field testing - Part 2: Dynamic probing
SRPS EN ISO 22476-3: 2011 / A1 :2014	Geotechnical investigation and testing - Field testing - Part 3: Standard penetration test
SRPS EN ISO 22476-4:2014	Geotechnical investigation and testing - Field testing - Part 4: Ménard pressuremeter test
SRPS EN ISO 22476-9:2020	Geotechnical investigation and testing - Field testing - Part 9: Field vane test
SRPS EN ISO 22476-10: 2018	Geotechnical investigation and testing - Field testing - Part 10: Weight sounding test
SRPS CEN ISO/TS 22476-11:2011	Geotechnical investigation and testing - Field testing - Part 11: Flat dilatometer test
SRPS EN ISO 22476-12:2011	Geotechnical investigation and testing - Field testing - Part 12: Mechanical cone penetration test (CPTM)

Testing of geotechnical structures	
SRPS EN ISO 22477-1:2019	Geotechnical investigation and testing - Testing of geotechnical structures - Part 1: Testing of piles: static compression load testing
SRPS EN ISO 22477-5:2018	Geotechnical investigation and testing - Testing of geotechnical structures - Part 5: Testing of grouted anchors

8.3.2 Standards for Laboratory Testing

Execution of laboratory tests	
SRPS EN ISO 17892-1:2015	Geotechnical investigation and testing - Laboratory testing of soil - Part 1: Determination of water content
SRPS EN ISO 17892-2:2015	Geotechnical investigation and testing - Laboratory testing of soil - Part 2: Determination of density of fine grained soil
SRPS EN ISO 17892-3:2016	Geotechnical investigation and testing - Laboratory testing of soil - Part 3: Determination of particle density
SRPS EN ISO 17892-4:2017	Geotechnical investigation and testing - Laboratory testing of soil - Part 4: Determination of particle size distribution
SRPS EN ISO 17892-5:2017	Geotechnical investigation and testing - Laboratory testing of soil - Part 5: Incremental loading oedometer test
SRPS EN ISO 17892-6:2017	Geotechnical investigation and testing - Laboratory testing of soil - Part 6: Fall cone test
SRPS EN ISO 17892-7:2018	Geotechnical investigation and testing - Laboratory testing of soil - Part 7: Unconfined compression test
SRPS EN ISO 17892-8:2018	Geotechnical investigation and testing - Laboratory testing of soil - Part 8: Unconsolidated undrained triaxial test
SRPS EN ISO 17892-9:2018	Geotechnical investigation and testing - Laboratory testing of soil - Part 9: Consolidated triaxial compression tests on water saturated soil
SRPS EN ISO 17892-10: 2018	Geotechnical investigation and testing - Laboratory testing of soil - Part 10: Direct shear tests
SRPS EN ISO 17892-11: 2018	Geotechnical investigation and testing - Laboratory testing of soil - Part 11: Permeability test
SRPS EN ISO 17892-12: 2018	Geotechnical investigation and testing - Laboratory testing of soil - Part 12: Determination of liquid and plastic limits

Testing of aggregates	
SRPS EN 932-1:2008	Tests for general properties of aggregates - Part 1: Methods for sampling
SRPS EN 932-2:2008	Tests for general properties of aggregates - Part 2: Methods for reducing laboratory samples
SRPS EN 932-3:2008	Tests for general properties of aggregates - Part 3: Procedure and terminology for simplified petrographic description
SRPS EN 932-5:2016	Tests for general properties of aggregates - Part 5: Common equipment and calibration
SRPS EN 932-3:2007	Tests for general properties of aggregates - Part 6: Definitions of repeatability and reproducibility
SRPS EN 933-1:2013	Tests for geometrical properties of aggregates - Part 1: Determination of particle size distribution - Sieving method
SRPS EN 933-2:2021	Tests for geometrical properties of aggregates - Part 2: Determination of particle size distribution - Test sieves, nominal size of apertures
SRPS EN 933-3:2013	Tests for geometrical properties of aggregates - Part 3: Determination of particle shape - Flakiness index
SRPS EN 933-4:2010	Tests for geometrical properties of aggregates - Part 4: Determination of particle shape - Shape index
SRPS EN 933-5:2010	Tests for geometrical properties of aggregates - Part 5: Determination of percentage of crushed and broken surfaces in coarse aggregate particles

SRPS EN 933-6:2016	Tests for geometrical properties of aggregates - Part 6: Assessment of surface characteristics - Flow coefficient of aggregates
SRPS EN 933-7:2007	Tests for geometrical properties of aggregates - Part 7: Determination of shell content - Percentage of shells in coarse aggregates
SRPS EN 933-8:2016	Test for geometrical properties of aggregates - Part 8: Assessment of fines - Sand equivalent test
SRPS EN 933-9:2014	Tests for geometrical properties of aggregates - Part 9: Assessment of fines - Methylene blue test
SRPS EN 933-10:2009	Tests for geometrical properties of aggregates - Part 10: Assessment of fines - Grading of filler aggregates (air jet sieving)
SRPS EN 933-11:2020	Tests for geometrical properties of aggregates - Part 11: Classification test for the constituents of coarse recycled aggregate
SRPS EN 1097-1:2013	Tests for geometrical properties of aggregates - Part 11: Classification test for the constituents of coarse recycled aggregate
SRPS EN 1097-2:2020	Tests for mechanical and physical properties of aggregates - Part 1: Methods for the determination of resistance to fragmentation
SRPS EN 1097-3:2009	Tests for mechanical and physical properties of aggregates - Part 3: Determination of loose bulk density and voids
SRPS EN 1097-4:2008	Tests for mechanical and physical properties of aggregates - Part 4: Determination of the voids of dry compacted filler
SRPS EN 1097-5:2009	Tests for mechanical and physical properties of aggregates - Part 5: Determination of the water content by drying in a ventilated oven
SRPS EN 1097-6:2016	Tests for mechanical and physical properties of aggregates - Part 6: Determination of particle density and water absorption
SRPS EN 1097-7:2008	Tests for mechanical and physical properties of aggregates - Part 7: Determination of the particle density of filler - Pyknometer method
SRPS EN 1097-8:2020	Tests for mechanical and physical properties of aggregates - Part 8: Determination of the polished stone value
SRPS EN 1097-9:2014	Tests for mechanical and physical properties of aggregates - Part 9: Determination of the resistance to wear by abrasion from studded tyres – Nordic test
SRPS EN 1097-10:2016	Tests for mechanical and physical properties of aggregates - Part 10: Determination of water suction height
SRPS EN 1367-1:2010	Tests for thermal and weathering properties of aggregates - Part 1: Determination of resistance to freezing and thawing
SRPS EN 1367-2:2010	Tests for thermal and weathering properties of aggregates - Part 2: Magnesium sulphate test
SRPS EN 1367-3:2008	Tests for thermal and weathering properties of aggregates - Part 3: Boiling test for "Sonnenbrand basalt"
SRPS EN 1367-4:2009	Tests for thermal and weathering properties of aggregates - Part 4: Determination of drying shrinkage
SRPS EN 1367-5:2014	Tests for thermal and weathering properties of aggregates - Part 5: Determination of resistance to thermal shock
SRPS EN 1367-6:2010	Tests for thermal and weathering properties of aggregates - Part 6: Determination of resistance to freezing and thawing in the presence of salt (NaCl)

Investigations of unbound and hydraulically bound mixtures	
SRPS EN 13286-1:2012	Unbound and hydraulically bound mixtures - Part 1: Test methods for laboratory reference density and water content - Introduction, general requirements and sampling
SRPS EN 13286-2:2012	Unbound and hydraulically bound mixtures - Part 2: Test methods for laboratory dry density and water content - Proctor compaction
SRPS EN 13286-3:2012	Unbound and hydraulically bound mixtures - Part 3: Test methods for

	laboratory reference density and water content - Vibrocompression with controlled parameters
SRPS EN 13286-4:2012	Unbound and hydraulically bound mixtures - Part 4: Test methods for laboratory reference density and water content - Vibrating hammer
SRPS EN 13286-5:2012	Unbound and hydraulically bound mixtures - Part 5: Test methods for laboratory reference density and water content - Vibrating table
SRPS EN 13286-7:2012	Unbound and hydraulically bound mixtures - Part 7: Cyclic load triaxial test for unbound mixtures
SRPS EN 13286-40:2012	Unbound and hydraulically bound mixtures - Part 40: Test method for the determination of the direct tensile strength of hydraulically bound mixtures
SRPS EN 13286-41:2012	Unbound and hydraulically bound mixtures - Part 41: Test method for the determination of the compressive strength of hydraulically bound mixtures
SRPS EN 13286-42:2012	Unbound and hydraulically bound mixtures - Part 42: Test method for the determination of the indirect tensile strength of hydraulically bound mixtures
SRPS EN 13286-43:2012	Unbound and hydraulically bound mixtures - Part 43: Test method for the determination of the modulus of elasticity of hydraulically bound mixtures
SRPS EN 13286-44:2012 (withdrawn)	Unbound and hydraulically bound mixtures - Part 44: Test method for the determination of the alpha coefficient of vitrified blast furnace slag
SRPS EN 13286-45:2012	Unbound and hydraulically bound mixtures - Part 45: Test method for the determination of the workability period of hydraulically bound mixtures
SRPS EN 13286-46:2012	Unbound and hydraulically bound mixtures - Part 46: Test method for the determination of the moisture condition value
SRPS EN 13286-47:2012	Unbound and hydraulically bound mixtures - Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling
SRPS EN 13286-48:2012	Unbound and hydraulically bound mixtures - Part 48: Test method for the determination of degree of pulverisation
SRPS EN 13286-49:2012 (withdrawn)	Unbound and hydraulically bound mixtures - Part 49: Accelerated swelling test for soil treated by lime and/or hydraulic binder
SRPS EN 13286-50:2012	Unbound and hydraulically bound mixtures - Part 50: Method for the manufacture of test specimens of hydraulically bound mixtures using Proctor equipment or vibrating table compaction
SRPS EN 13286-51:2012	Unbound and hydraulically bound mixtures - Part 51: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrating hammer compaction
SRPS EN 13286-52:2012 (withdrawn)	Unbound and hydraulically bound mixtures - Part 52: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrocompression
SRPS EN 13286-53:2012	Unbound and hydraulically bound mixtures - Part 53: Methods for the manufacture of test specimens of hydraulically bound mixtures using axial compression

Abrasion of natural rock	
SRPS EN 14157:2017	Natural stone test methods - Determination of abrasion resistance

Determination of pH value and loss on ignition	
SRPS EN 15933:2013	Sludge, treated biowaste and Soil - Determination of pH
SRPS EN 15935:2013	Sludge, treated biowaste and Soil - Determination of loss on ignition

8.3.3 Standards of cabinet work and designing

Graphical symbols on geological maps and sections (does not have mandatory application according to SRPS)	
ISO 710-1	Graphical symbols for use on detailed maps, plans and geological cross-

	sections -- Part 1: General rules of representation
ISO 710-2	Graphical symbols for use on detailed maps, plans and geological cross-sections -- Part 2: Representation of sedimentary rocks
ISO 710-3	Graphical symbols for use on detailed maps, plans and geological cross-sections -- Part 3: Representation of magmatic rocks
ISO 710-4	Graphical symbols for use on detailed maps, plans and geological cross-sections -- Part 4: Representation of metamorphic rocks
ISO 710-5	Graphical symbols for use on detailed maps, plans and geological cross-sections -- Part 5: Representation of minerals
ISO 710-6	Graphical symbols for use on detailed maps, plans and geological cross-sections -- Part 6: Representation of contact rocks and rocks which have undergone metasomatic, pneumatolytic or hydrothermal transformation or transformation by weathering
ISO 710-7	Graphical symbols for use on detailed maps, plans and geological cross-sections -- Part 7: Tectonic symbols