DESIGN SPECIFICATIONS FOR CIVIL WORKS

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ARTICLE 1 GENERAL

1.1 OBJECTIVES OF THE DOCUMENT

1.1.1 This Document describes the specifications, on the basis of which all Civil Works related Designs shall be performed, required for the implementation of this Contract.

1.1.2 More specifically the purpose of this Document is as follows:

a. To ensure compatibility of the requirements of Regulations, Codes and Standards with the specific works included in the present Contract.

b. To specify additional requirements, wherever considered necessary, in addition to those indicated in the Regulations, Codes and Standards.

c. To specify requirements in subjects not covered by the Regulations, Standards, and Codes.

d. To specify issues relevant to the procedure of performing, checking and approval of the Design.

1.2 SCOPE

1.2.1 The Contractor is obligated to perform the Designs of the Project Civil Works according to the requirements of this Document, the requirements of articles GS0101 “PLANNING AND CODIFICATION MANUAL OF TRAMWAY WORKS” and GS0200 “DESIGN REQUIREMENTS – DESCRIPTION OF THE SCOPE OF DESIGNS/ DRAWINGS/ REPORTS”, as well as all relevant requirements set in the Technical Description, the Conditions of Contract and in the “Design, Performance, Material and Workmanship Specifications for Trackwork”, taking into consideration all commitments of the pertinent articles contained in the Document entitled “Material and Workmanship Specifications for CW”.

The content of the Document is also applicable to any Design Document or Report, which may be provided by the Contractor to support or document any technical proposal (i.e. Technical Deviations, Non-Conformance Reports, Field Changes etc.).

1.2.2 The requirements specified in this Document refer also to issues about which ATTIKO METRO S.A. (AM) sets additional or more stringent requirements as compared to the corresponding provisions of the Regulations, Standards, and Codes. The latter, however, retain their validity in subjects which either are not covered in this Document or are in agreement with its requirements.

1.3 USE OF CODES, STANDARDS AND REGULATIONS

1.3.1 The following paragraphs and sub-paragraphs of article 1, starting from this paragraph 1.3, refer to the Geotechnical Design and the Structural Design for the construction of the Depot Expansion, i.e. they relate to articles 2, 3 and 4 of this Document. As regards the remaining scopes of civil works which may be required (roadworks, flood protection designs, etc.), valid shall be the requirements referred to in detail in the respective articles of this Document.

The Geotechnical Design and the structural Design shall be prepared in accordance with the following Regulations, Codes and Standards. Individual Articles of this Document may also make reference to other Regulations, Standards and Codes for specific scopes of works.

As regards the applicable release of the standards, regulations, technical recommendations, etc., referred to in this document, kindly refer to the Conditions of Contract for this Project.

Kindly also refer to the Conditions of Contract as regards the order of precedence of the applicable standards, regulations, etc.

A List containing the most significant Regulations, Standards, Codes, etc., to be used in the preparation of the Designs of the Project is presented below:

I. Eurocodes (national standards that constitute a transposition of European standards of structural design)

- ELOT EN 1990, Eurocode: "Basis of Structural Design"
- ELOT EN 1991, Eurocode 1: "Actions on Structures''
- ELOT EN 1992, Eurocode 2: "Design of Concrete Structures''
- ELOT EN 1993, Eurocode 3: "Design of Steel Structures"
- ELOT EN 1994, Eurocode 4: "Design of Composite Steel and Concrete Structures"
- ELOT EN 1995, Eurocode 5: "Design of Timber Structures"
- ELOT EN 1996, Eurocode 6: "Design of Masonry Structures"
- ELOT EN 1997, Eurocode 7: "Geotechnical Design"
- ELOT EN 1998, Eurocode 8: "Design of Structures for Earthquake Resistance"
- ELOT EN 1999, Eurocode 9: "Design of Aluminium Structures".

The above titles constitute a brief description of the Eurocodes, whose all individual Parts - in combination with the respective National Annexes - are in effect.

II. National Standards (they constitute a transposition of European standards)

- ELOT EN 10080: Concrete steel reinforcement – Weldable steel – General requirements
- ELOT EN ISO 17660-1, Welding - Welding of reinforcing steel -- Part 1: Load-bearing welded joints
- ELOT EN ISO 17660-2, Welding - Welding of reinforcing steel -- Part 2: Non-load bearing welded joints
- ELOT EN 10025 Hot rolled products of non-alloy structural steels
- ELOT EN 1536 + A1 "Special Geotechnical Works - Bored Piles"
- ELOT EN 1537 E2 "Special Geotechnical Works - Ground Anchors"
- ELOT EN 1538 + A1 "Special Geotechnical Works – Diaphragm Walls"
- ELOT EN 12063 "Special Geotechnical Works - Sheet Pile Walls"
- ELOT EN 12699 E2 "Special Geotechnical Works - Displacement Piles"
- ELOT EN 12715 "Special Geotechnical Works - Grouting"
- ELOT EN 12716 "Special Geotechnical Works - Jet Grouting"
- ELOT EN 14199 E2 "Special Geotechnical Works – Micropiles"

III. Greek Regulations, Standards

- "Greek Concrete Reinforcing Steel Technology Standard" (K.T.X-2008), FEK 1416/B/17.07.2008 and FEK 2113/B/13.10.08.
- "Greek Concrete Technology Standard" (ΚΤΣ-2016), FEK 1561/B/02.06.16.
- ELOT 1421-02 E2: Concrete steel reinforcement – Weldable steel – Part 2: Technical class B500A
- ELOT 1421-03 E3: Concrete steel reinforcement – Weldable steel – Part 3: Technical class B500C
- (Government's Gazette 649/B/24.05.06, Government's Gazette 938/B/18.07.06, Government's Gazette 1881/B/29.12.06)

- Regulations concerning Buildings' Fire Protection (P.D. 41/2018 – FEK A'/ 80 / 07.05.18).

IV. German Standards and Recommendations

• DIN 1054:2010	Verification of the Safety of backfilling works and foundations - Supplementary Rules to DIN EN 1997 - 1
• DIN 4017:2006-03	Calculations of the Bearing Capacity of the Subsoil Mechanics under Shallow Foundations
• DIN 4017, paragraph 1:2006-11	Calculations of the Bearing Capacity of the Subsoil Mechanics under Shallow Foundations – Examples for Calculations
• DIN 4018: 1974-09	Subsoil; Calculation of the Bearing Pressure Distribution under Spread Foundations
• DIN 4019: 2015-05	Subsoil; Settlement Calculations
• DIN 4030:2008-06	Assessment of water, soil and gases for their aggressiveness to Concrete
• DIN 4084:2009-01	Subsoil; Calculations of terrain rupture & slope rupture and overall stability of retaining works
• DIN 4085:2017-08	Subsoil; Calculation of earth-pressure
• DIN 4093:2015-11	Design Of Ground Improvement - Jet Grouting, Deep Mixing Or Grouting
• DIN 4095: 1990-06	Planning, Design and Installation of drainage systems for the protection of the structures against water on ground
• DIN 4123: 2013-04	Excavations, foundations and underpinnings in the range of existing buildings
• DIN 4124:2012-01	Excavations and trenches - Slopes, planking and strutting, breadths of working spaces
• EAB	Recommendations for Excavation Works
• EAP	Recommendations for Piling Works
• DIN 4150	Vibrations in the Structures
• DIN 18218	Fresh Concrete Pressures in Vertical Formwork

1.3.2 In cases where certain types of structures or subjects relevant to their design are not covered by the Regulations, Codes and Standards, , included in this Document, then Regulations, Codes or Standards governed by the same principles and well proven in similar projects is to be proposed by the Contractor. Such a proposal shall be subject to ATTIKO METRO S.A. approval.

1.3.3 Prior to the inception of the design preparation procedure, the Contractor should submit to ATTIKO METRO S.A. a complete list of the proposed Regulations, Standards, Codes, etc.. AM shall approve this set, if it ascertains that it complies with the requirements laid down in that document. This set of Regulations, Codes and Standards that may be approved by AM together with the set stated in this document shall hereafter be referred to as the "Approved Codes".

1.4 DESIGNS - CALCULATIONS

1.4.1 As regards the content of the Structural Design, it shall include a Technical Report, Calculation Notes and Drawings. At the beginning of the Technical Report, the concept of design shall be set out and the design assumptions, loads, safety factors, notations, material properties, Regulations and references used shall be listed. Wherever the design criteria/assumptions are imposed by any requirements of the Contractual Documents, reference to the specific article(s) of the subject Contract document shall be made. The numerical values of the parameters, variables and assumptions of the design used in the calculations, they shall be presented in a precise manner in the Technical Report and the Calculations Notes

1.4.2 Calculations, tables, diagrams, etc., presented elsewhere shall be clearly cross referenced in view of facilitating the checking process.

1.4.3 Calculations shall be set out clearly and shall follow a logical sequence to be comprehensible by the engineers of the respecting discipline.

1.4.4 The proposed construction method and sequence of works taken into account in the design shall be clearly set out.

1.4.5 In cases where it is not possible to form an accurate structural model and/or to accurately assess the actions, an envelope of solutions for the extreme values of the not accurately defined data shall be carried out. That is, in case of input data uncertainty, the sensitivity of the model shall be checked against the variation of the output data as a result of the variation of the input data. Additionally to this requirement, especially as regards uncertainties concerning geotechnical data, applicable shall be the content of Article 2B herein. Unless the non necessity of performing these checks is justified by the Contractor to the satisfaction of AM, AM may instruct the Contractor to perform any necessary calculations, in order to verify that the sensitivity of the model does not affect significantly the correctness of the results.

1.4.6 References used in the design shall be listed and copies of the references used in the preparation of this design shall be provided. Copies of tables and diagrams used in the design shall be included in the Calculation Notes.

1.4.7 The structural modelling as well as the analysis methodology shall be in accordance with the most advanced and tested methods, so as the actual stress conditions is as closely approximated as possible.

1.4.8 To achieve design consistency throughout the project and to avoid any possible confusion, calculations shall be carried out using the following SI units:

- Force: kN
- Moment: kNm
- Stress: N/mm^2, MN/m^2 (MPa)
- Pressures (soil, water, wind): kN/m^2

1.4.9 The requirements and content of the Geotechnical Design are described in detail in Unit 2B of Article 2 herein, whose requirements are applicable along with the requirements of this Article.

1.5 COMPUTER AIDED DESIGN

1.5.1 In the framework of each design, where a specialized software is used for dimensioning or control purposes, the type and the theoretical basis of the applied software shall be stated clearly and the inherent assumptions, field of application and limitations of the software shall be identified.

1.5.2 It shall be ensured that the reliability of the software used are satisfactory and can, if required, be so substantiated. If requested, the user's manual and the detailed description of the software, along with any justification required, shall be submitted to AM for approval before software can be used in the design.

The employed software programs used for the analysis and dimensioning of the works (like finite element, finite difference, boundary elements, analysis of the limit balance etc.) shall include its latest commercially available version for a 2D, or a 3D analysis.

The Output Files shall necessarily be accompanied by introduction Input Files in the software.

1.5.3 The Designer/Contractor has the sole responsibility for the accuracy and correctness of the Computer Aided Design results.

1.5.4 Any type of electronic files of all documents (Technical Report and Calculations Notes) shall be submitted each time along with the relevant printed copies of documents of each design for AM use and check, in accordance with the requirements of the contractual documents mentioned in paragraph 1.6.1.

With regard to the Geotechnical Design, as well as the Structural Design which are submitted for review, the Contractor shall submit all data in digital format, wherein the following as a minimum shall be included:

- The drawings in the format "drawing number.DWG".
- The Technical Report and Calculations Notes documents in the format "documentnumber.PDF" or "documentnumber.DOC", which shall contain the complete documents, along with any diagrams, figures and analyses results. Moreover, all input data files and analysis results files in a ".PDF" form.
- All input data files for each employed software program, in a format suitable to be used by this applied software and suitable for the reproduction of the analysis.
- All files with the analyses results and the relevant diagrams, figures and graphs of the analyses for each employed software program.

1.6 DRAWINGS

1.6.1 In view of ensuring uniformity and correctness of the design standards, all drawings prepared by the Contractor/Designer shall comply with the requirements of Articles GS0101 "PLANNING AND CODIFICATION MANUAL OF TRAMWAY WORKS" and GS0200 "DESIGN REQUIREMENTS – DESCRIPTION OF THE SCOPE OF DESIGNS/ DRAWINGS/ REPORTS" of the General Specifications.

The aforesaid Documents include specifications for drawing categories as follows:

- General (plans, elevations, sections).
- Excavations and foundations (surface and deep).
- Construction phases.
- Auxiliary structures.

- Formwork.
- Reinforcement detailing.
- Insulation, waterproofing and special items.
- Joints, bearings, balustrades, etc.
- Transport and traffic studies
- Drainage
- Traffic
- Reinstatement and Landscaping
-As Built

1.6.2 The sheet sizes, scales, dimensions and material indications, cross references to other sheets and specifications etc., are specified for every drawing category.

1.6.3 For all drawing categories, a unique numbering code, indications for possible revision stages and dates and symbols of revised data shall be adopted.

1.6.4 Every sheet will have a title block column for drawing circulation with rows for register of dates, initiators and recipients at all phases of submission, check, approval, delivery to AM and Contractor, AM's correspondence etc.

1.6.5 The full name and the signature of the Engineers who designed and checked each drawing shall be shown in the title block of all drawings.

1.6.6 Any means of electronic files of the drawings shall be submitted together with the hardcopy drawings for the use and checking by AM, in accordance with the requirements of the contractual documents mentioned in paragraph 1.6.1.

1.6.7 The Design drawings to be used for the construction of Works shall be complete and clear enabling their application without uncertainties, ambiguities or misinterpretations. They shall contain all necessary information, the appropriate scales required for the proper and safe construction of the Project, e.g. geometry - dimensions of the structures, description of the method and phases of construction, construction and details of the reinforcement, joint configuration, location/dimensions of openings, description of the construction method and phases, connections, etc. Before the construction drawings are submitted, there will be the proper coordination among the various disciplines and the relevant information shall be noted on the drawing. The submission of incomplete or unclear drawings shall not be accepted.

1.7 TECHNICAL DESIGN REPORT

1.7.1 The Structural Design shall be accompanied by a detailed Design Report (Technical Report) shall accompany the design of all parts of the Works, signed by the Contractor's respective designer, in compliance with the requirements of Articles GS0101 "PLANNING AND CODIFICATION MANUAL OF TRAMWAY WORKS" and GS0200 "DESIGN REQUIREMENTS – DESCRIPTION OF THE SCOPE OF DESIGNS/ DRAWINGS/ REPORTS" of the General Specifications.

1.7.2 The Design Report shall describe in detail in a text form and, wherever necessary, in the form of tables, diagrams, sketches, etc., the method in which the designer approaches the problem, the design assumptions, the applicable Codes, Standards, etc., the modelling of the various structures, the various loads and their combinations, the safety coefficients, explanations of the symbols used in the software, reference / bibliography, interfaces with other disciplines and in general any other information required in order to fully and clearly present the structure of the design and to provide all necessary tools for its effective review.

Moreover, the results of the analyses and dimensioning shall be presented in the form of concentrated results per part of the structure (e.g. a scheduled showing the required and the actually installed reinforcement in slabs/walls, etc.). Any submittal

that includes no Technical Report or a report consisting only of printouts made by the relevant software shall not be accepted.

1.7.3 The requirements and contents of the Geotechnical Design are described in detail in Unit 2B of Article 2 herein, whose requirements are applicable together with the requirements of this Article.

ARTICLE 2 GEOTECHNICAL INVESTIGATIONS, GEOTECHNICAL DESIGNS

2A GEOTECHNICAL INVESTIGATIONS

2A.1 Scope

This specification deals with the planning, organization and execution of the *Ground Investigation* (CGI).

The Contractor shall carry out the GI –i.e. all required geological and geotechnical investigations– as per the requirements of this specification, in order to define the geotechnical design parameters that are required for the preparation of all foreseen designs of the Project.

This specification contains the following paragraphs:

2A.2 Normative references
2A.3 Terms and definitions
2A.4 Geological conditions of the Project
2A.5 Minimum CGI requirements
2A.6 Health & Safety
2A.7 Planning of the CGI Works
2A.8 Borehole worksite organizing
2A.9 Specifications for geotechnical investigations – Boreholes and sampling
2A.10 Specifications for geotechnical investigations – *In-situ* tests
2A.11 Specifications for geotechnical investigations – Lab Tests
2A.12 Specifications for geological investigations
2A.13 Photographic archive
2A.14 Submittals

as well as the following appendices:

2A.A Installation and maintenance of piezometers
2A.B Engineering geological description of borehole cores
2A.C Rock mass classification systems
2A.D Borehole log (sample)
2A.E Not applicable
2A.F Codification of points of investigation and measurements
2A.G Available data from geological and geotechnical investigations
2A.H Hellenic Soil Classification System (HSCS)

The main scope of the CGI, as described in the minimum requirements of para. 2A.5 and in other pertinent paragraphs, shall be executed by the Contractor at the beginning of the Project, so as to obtain all this information that is necessary for the preparation of the Project's designs, as per the requirements of the approved time schedule.

2A.2 Normative references

This specification has been compiled on the basis of Eurocode 7. Eurocode 7 is composed of the following documents:

NOTE 1 OGG stands for "Official Government Gazette" of Greece.

ELOT EN 1997-1, *Eurocode 7, Geotechnical Design – Part 1: General rules*

ELOT EN 1997-2, *Eurocode 7, Geotechnical Design – Part 2: Ground investigation and testing*

NOTE The two parts of Eurocode 7 are accompanied by the respective National Standards (ELOT EN 1997-1:2005/NA and ELOT EN 1997-2:2007/NA), as their integral parts.

The following documents in total or in part include provisions which by being referenced in this document constitute the document's own provisions. With regard to dated references, applicable shall be only the latest edition (with its annexes).

ELOT EN ISO 14688-1, *Geotechnical investigation and testing – Identification and classification of soil – Part 1: Identification and description*

ELOT EN ISO 14688-2, *Geotechnical investigation and testing – Identification and classification of soil – Part 2: Principles for a classification*

ELOT EN ISO 14689, *Geotechnical investigation and testing – Identification, description and classification of rock*

ELOT EN ISO/IEC 17025, *General requirements for the competence of testing and calibration laboratories*

ELOT EN ISO 17892-1, *Geotechnical investigation and testing – Laboratory testing of soil – Part 1: Determination of water content*

ELOT EN ISO 17892-2, *Geotechnical investigation and testing – Laboratory testing of soil – Part 2: Determination of bulk density*

ELOT EN ISO 17892-3, *Geotechnical investigation and testing – Laboratory testing of soil – Part 3: Determination of particle density*

ELOT EN ISO 17892-4, *Geotechnical investigation and testing – Laboratory testing of soil – Part 4: Determination of particle size distribution*

ELOT EN ISO 17892-5, *Geotechnical investigation and testing – Laboratory testing of soil – Part 5: Incremental loading oedometer test*

ELOT CEN ISO/TS 17892-7, *Geotechnical investigation and testing – Laboratory testing of soil – Part 7: Unconfined compression test*

ELOT EN ISO 17892-8, *Geotechnical investigation and testing – Laboratory testing of soil – Part 8: Unconsolidated undrained triaxial test*

ELOT EN ISO 17892-9, *Geotechnical investigation and testing – Laboratory testing of soil – Part 9: Consolidated triaxial compression tests on water-saturated soils*

ELOT CEN ISO/TS 17892-10, *Geotechnical investigation and testing – Laboratory testing of soil – Part 10: Direct shear tests*

ELOT EN ISO 17892-12, *Geotechnical investigation and testing – Laboratory testing of soil – Part 12: Determination of liquid limit and plastic limit*

ELOT EN ISO 22475-1, *Geotechnical investigation and testing – Sampling methods and groundwater measurements – Part 1: Technical principles for execution*

ELOT EN ISO 22476-1, *Geotechnical investigation and testing – Field testing – Part 1: Electrical cone and piezocone penetration test*

ELOT EN ISO 22476-2, *Geotechnical investigation and testing – Field testing – Part 2: Dynamic probing test*

ELOT EN ISO 22476-3, *Geotechnical investigation and testing – Field testing – Part 3: Standard penetration test*

ELOT EN ISO 22476-4, *Geotechnical investigation and testing – Field testing – Part 4: Ménard pressuremeter test*

ELOT EN ISO 22476-5, *Geotechnical investigation and testing – Field testing – Part 5: Flexible dilatometer test*

ELOT EN ISO 22476-6, *Geotechnical investigation and testing – Field testing – Part 6: Selfboring pressuremeter test*

ELOT EN ISO 22476-7, *Geotechnical investigation and testing – Field testing – Part 7: Borehole jack test*

ELOT EN ISO 22476-8, *Geotechnical investigation and testing. Field testing – Part 8: Full displacement pressuremeter test*

ELOT EN ISO 22476-10, *Geotechnical investigation and testing – Field testing – Part 10: Weight sounding test*

ELOT EN ISO 22476-11, *Geotechnical investigation and testing – Field testing – Part 11: Flat dilatometer test*

ELOT EN ISO 22476-12, *Geotechnical investigation and testing – Field testing – Part 12: Mechanical cone penetration test (CPTM)*

ELOT EN 196-2, *Method of testing cement – Part 2: Chemical analysis of cement*

ELOT EN 1329-1, *Plastic piping systems for soil and waste discharge (low and high temperature) within buildings – Unplasticized polyvinyl chloride (PVC-U) – Part 1: Specifications for pipes, fittings and the system*

ELOT EN 13286-2, *Unbound and hydraulically bound mixtures. Part 2: Test methods for laboratory reference density and water content. Proctor compaction*

ELOT EN 13286-47, *Unbound and hydraulically bound mixtures. Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling*

ELOT EN 13577, *Chemical attack on concrete – Determination of aggressive carbon dioxide content in water*

ELOT EN 16228-1, *Drilling and foundation equipment – Part 1: Common requirements*

ELOT EN 16228-2, *Drilling and foundation equipment – Part 2: Mobile drill rigs for civil and geotechnical engineering, quarrying and mining*

ELOT EN 16502, *Test method for the determination of the degree of soil acidity according to Baumann-Gully*

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*

ISO 3310-1, *Test sieves – Technical requirements and testing – Part 1: Test sieves of metal wire cloth*

ISO 3310-2, *Test sieves – Technical requirements and testing – Part 2: Test*

sieves of perforated metal plate

ISO 4316, *Surface active agents – Determination of pH of aqueous solutions – Potentiometric method*

ISO 7150-1, *Water quality – Determination of ammonium – Part 1: Manual spectrometric method*

ISO 7393, *Determination of free chlorine and total chlorine*

ISO 7980, *Water quality – Determination of calcium and magnesium – Atomic absorption spectrometric method*

Concrete Technology Regulation (Κ.Τ.Σ.) (ΟGG Β΄/1561/02.06.2016)

E 101-83, *Technical specifications for sampling boreholes on land* (OGG B΄/363/ 24.06.83, as supplemented by M.D. 6019, para. 2 (OGG B΄/29/ /11.02.1986))

E 102-84 and E 103-84, *Specification for In-situ Rock Mechanics Tests and Rock Mechanics Lab Tests* (OGG B΄/70/08.02.1985)

E 104-85, *Specifications for Geological Works in the framework of Designs for Technical Projects* (OGG B΄/29/11.02.1986)

E 105-86, *Specifications for Soil Engineering Lab Tests* (OGG B΄/955/ /31.12.1986)

ASTM D 2974, *Standard Test Methods for Moisture, Ash and Organic Matter of Peat and Other Organic Soils* ASTM D 3080, *Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions*

ASTM D 4373, *Standard Test Method for Rapid Determination of Carbonate Content of Soils*

ASTM D 4427, *Standard Classification of Peat Samples by Laboratory Testing*

ASTM D 4644, *Standard Test Method for Slake Durability of Shales and Other Similar Weak Rocks*

ASTM D 5607, *Standard Test Method for Performing Laboratory Direct Shear Strength Tests of Rock Specimens Under Constant Normal Force*

ASTM D 6467, *Standard Test Method for Torsional Ring Shear Test to Determine Drained Residual Shear Strength of Cohesive Soils*

ASTM D 7012, *Standard Test Methods for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures*

ASTM D 7625, *Standard Test Method for Laboratory Determination of Abrasiveness of Rock Using the CERCHAR Method*

BS 1377-3, *Methods of test for soil for civil engineering purposes – Part 3: Chemical and electrochemical tests*

BS 1377-4, *Methods of test for soil for civil engineering purposes – Part 4: Determination of maximum and minimum dry densities for granular soils*

ISRM *Suggested Method for Determining Tensile Strength of Rock Materials, Part 2: Suggested Method for Determining Indirect Tensile Strength by the Brazilian Test*

DIN 38414-4, *German standard methods for the examination of water, waste water and sludge – sludge and sediments (group S) – determination of leachability by water*

AASHTO T 194, *Standard Method of Test for Determination of Organic Matter in Soils by Wet Combustion*

Ministerial Decision ΔΝΣγ /32129/ΦΝ 466/20.07.2017 (ΟGG Β΄ 2519), *Approval of the Regulation on Pre-estimated Frees for designs and technical and other related*

scientific services provided as per the procedure foreseen in para. 8.d, article 53 of L. 4412/2016 Decision Δ14/οικ./108445 dated 16.05.2014 of the Minister of YPOMEDI, *Procedure for granting a permit to operate private laboratories, including worksite laboratories, conducting quality control tests for technical projects and supervised by the General Secretariat for Public Works of the Ministry of Infrastructures, Transports and Networks* (OGG B΄/1450/05.06.2014)

Decision 6019 dated 17.11.1985 of the Minister of PEHODE, *Approval of Specifications for Geological Works in the framework of the Designs for Technical Projects* (OGG B΄/29/11.02.1986)

Decision No. 6952 dated 14.02.2011 issued by the Ministries of Environment and Infrastructures. *Obligations and measures for the safe circulation of pedestrians during the execution of works in public areas designated for pedestrians* (OGG B΄/420/16.03.2011)

Presidential Decree 344 dated 29.12.2000, Exercising the profession of *geotechnical engineer* (OGG A΄/297/29.12.2000)

EPA method 8015, *Nonhalogenated organics using GC/FID, U.S. Environmental Protection Agency (U.S.E.P.A.)*

APHA method 5520-C, *Standard methods for the examination of water and wastewater – Oil and grease – Partition-Infrared method, American Public Health Association*

A list with all the standards the Contractor intends to use shall be submitted for approval to AM, as part of the GI Programme.

2A.3 Terms and definitions

The terminology is based on Eurocode 7 (ELOT EN 1997-1 and ELOT EN 1997-2) and its normative references, with the exception of paragraphs 2A.3.13 and 2A.3.15. The following are the key terms, as well as their definitions as used in this specification.

NOTE Terms and definitions related to soil classification are presented in paragraph 2A.H.3.

2A.3.1 anthropogenic soil
soil placed by human activity which can be divided into those composed of reworked natural soils and those composed of synthetic materials

NOTE Anthropogenic soil that can be further divided into *fill*, when deposit is is placed with engineering control, or into *made ground* or *reconstituted ground*, when the deposit is placed without engineering control.

2A.3.2 not applicable

2A.3.3 not applicable

2A.3.4 rock material, intact rock
the rock within the framework of the discontinuities

NOTE Intact rock generally presents an unconfined compressive strength higher than 600 kPa.

NOTE Intact rock may present textural characteristics which affect its isotropy (schistocity, grain and mineral orientation etc.) which should be taken into consideration for the assessment of laboratory data with regard to the final strength parameter selection.

NOTE Strength and deformation parameters of the intact rock are directly determined based on laboratory tests.

2A.3.5 not applicable

2A.3.6 rock mass
the rock together with its discontinuities and weathering / alteration profile

NOTE Rock mass generally consists of rock material blocks delimited by geological discontinuities (joints, bedding planes, faults, shear planes etc.), not excluding, however, soil geomaterial participation.

NOTE Since it is not usually possible to obtain representative rock mass samples, strength and deformation parameters of the rock mass are usually indirectly determined by correlating laboratory tests on rock material samples and use of classification systems. Rock masses with few and infrequent discontinuities are an exception to the above; the influence of the said discontinuities to the behaviour of the rock mass as to its deformation is negligible. In these cases, rock material samples are representative of the rock mass and, therefore the determination of strength and deformation parameters can be directly achieved based on laboratory tests on rock material samples.

2A.3.7 rock
a naturally occurring assemblage or aggregate of mineral grains, crystals or mineral based particles, compacted, cemented or otherwise bound together, and which cannot be disaggregated by hand in water.

2A.3.8 not applicable

2A.3.9 borehole
hole of any predetermined diameter and length formed in any geological formation or man-made material by drilling

NOTE Investigations carried out in such a hole can be to recover rock, soil or water samples from a specific depth or to carry out *in-situ* tests and measurements.

2A.3.10 sample
portion of soil or rock recovered from the ground by sampling techniques

2A.3.11 specimen
part of soil or rock sample used for a laboratory test

2A.3.12 soil
aggregate of minerals and/or organic materials, which can be disaggregated by hand in water

NOTE The term also applies to made-ground consisting of replaced natural soil or man-made materials exhibiting similar behaviour, e.g. crushed rock, blast-furnace slug, fly-ash etc.

NOTE Soil generally has unconfined compressive strength lower than 600 kPa. Strength and deformation parameters of soils are directly determined based on laboratory tests, as soil behaviour in project scale and sample scale is generally similar.

2A.3.13 trial pit
open excavation constructed to examine the ground conditions in situ, recover samples or carry out field testing

2A.3.14 not applicable

2A.3.15 pre-excavation pit
any hand excavated pit carried out for the inspection and investigation of surface layers and the existence of PUO networks

2A.3.16 not applicable

2A.3.17 not applicable

2A.3.18 ground
soil, rock and fill in place prior to the execution of the construction works

2A.3.19 not applicable

2A.4 Geological conditions of the Project

This paragraph provides information data on the geology of the area, as these derive from earlier investigations (see Information Data) and bibliographical evidence. This description is not a geological study on the prevailing conditions, while the Contractor is responsible to investigate, study and review the geological

conditions of the Project. In the area encountered are neogene formations, both soil (clay soil, sandy/ gravely soil, etc.) and rocky (marly limestone, siltstone, etc.). According to the Geological Neotectonic Map of OASP drafted in cooperation with the University of Athens (2002, GEOLOGICAL AND GEOTECTONIC STUDY OF ATTICA BASIN), the formations encounterd in the wider area of the Project are neogene formations, marine limestones of Upper Miocene, quaternary formations with lateral scree and fans, while on a smaller scale encountered are Alpine formations with thin-bedded limestones of the upper cretaceous and shales of Upper Cretaceous. In the Project area, mapped are inactive faults with NS-WS trend.

In the area of the Project there are no available piezometric measurements of the ground water level. Based on measurements conducted during boring drilling works executed in the framework of previous investigations (2002, DETAILED FINAL DESIGN FOR THE GEOTECHNICAL INVESTIGATION IN ELLINIKO DEPOT), the groundwater level was identified at 5-6m from ground surface.

2A.5 Minimum GI requirements

This paragraph lists the minimum requirements regarding the number and the location of the investigation points of the GI.Other requirements regarding the investigation works in the framework of the GI (sampling, *in-situ* tests, lab tests, geological surveys) are presented in the pertinent paragraphs of this document.

2A.5.1 General requirements

The locations and depths of the investigation points of the GI shall be defined in the GI Programme, as per the stipulations in para. 3.2.1 and 3.2.3 of ELOT EN 1997-1 and para. 2.4.1.1 and 2.4.1.3 in Appendix B of ELOT EN 1997-2, in order to obtain all necessary - on a per case basis- ground data to be used in the geotechnical designs (e.g. stratigraphy at the locations of the different foundation foots of the shed for the calculation of the differential settlements).

2A.5.2 Sampling boreholes

- Sampling at boreholes shall be continuous.
- The minimum number of sampling boreholes to be mandatorily executed by the Contractor of GI is four (4) of a depth of 20 meters. The locations of these boreholes shlal be proposed by the Contractor in the GI Programme. Piezometers shall be installed in at least three (3) sampling boreholes. If during borehole drilling no groundwater is encountered, then a piezometer shall not be installed.

2A.5.3 CPT Tests

At least six (6) CPT tests shall be executed, one out of which shall have a distance of up to 20m from the sampling borehole of para. 2A.5.2. It is pointed out that boreholes for the CPT tests shall be executed before their adjacent sampling boreholes are drilled (para. 2.4.1.3 (5) of ELOT EN 1997-2).

2A.5.4 Trial pit

At least six (6) trial pits shall be drilled in order to examine the ground at the excavation surface of the tramway. Large samples shall be recovered from these pits in view of conducting laboratory tests (granulometric analysis, plasticity, organic compounds, proctor, CBR). The locations and depths of the trial pits shall be proposed by the Contractor in the GI Programme.

2A.6 Health & Safety

The Contractor shall carry out the CGI works in full compliance with the applicable Greek legislation on H&S of Workers, the General Specification GS0750, the

relative articles of the *CC*, as well as the standards ELOT EN 16228-1 and ELOT EN 16228-2. The stipulations of the following paragraphs also apply.

2A.6.1 H&S of personnel

The Contractor shall ensure that all worksite personnel has received proper training and is properly supervised so as the safety of the personnel itself as well as of any other persons in the worksite is ensured.

The Contractor shall train its personnel to cope with fire risks and shall supply the appropriate (type and number) of fire extinguishers.

The Contractor shall equip all personnel with high visibility vests.

It is mandatory for all personnel engaged in drilling works to utilize all Personal Protection Equipment (PPE) deriving from the risk analysis (for example: safety helmet, safety boots, gloves, protective goggles, ear-plugs, etc.).

The Contractor shall supply and maintain throughout the duration of the contract all the aforementioned PPE that is necessary for the protection and safety of all persons (personnel or third parties).

Entrance to a fenced worksite area is permitted only to the Contractor's personnel and AM's supervisors, as long as they are equipped with the appropriate Personal Protection Equipment.

The Contractor shall provide employees with working uniforms. It is advisable that working uniforms should bear the Contractor's name.

The Contractor shall introduce all measures required for the supply and installation of a movable toilet unit and a first-aid kit.

2A.6.2 not applicable

2A.6.3 H&S regarding mechanical equipment

All equipment of the Contractor shall be as determined by the European Legislation and shall bear the CE marking, as stipulated in the applicable legislation, as well as all relevant documentation (e.g. manuals, maintenance books) proving the capability of the equipment to function safely. The Contractor shall ensure that all safety tests, measurements and inspections foreseen by the law are implemented on the equipment. Copies of the certificates shall be available in the drilling worksite to be reviewed by AM.

The compressed air pipework or the piping system for the pressurize oil drilling rig lubrication system (pressure > 10 atm) shall be equipped with whip checks.

The drilling rig shall be equipped with emergency buttons, as required by the manufacturer.

Rigs shall commence their drilling activities only on condition that all safety related requirements are met (fencing, appropriate signage, personnel protection equipment, pre-excavation pit, returned flushing medium closed circuit, screens for movable part, etc.).

Special attention is required when the drilling rig derrick is raised in the presence of overlaying power supply cables.

2A.7 Planning of the GI works

2A.7.1 GI organisation chart

The Contractor, within the framework of the execution of GI works, employs as a minimum the personnel described in Article 15 of the *CC*.

The GI Organisation chart is submitted to AM for approval as part of the Project's Organization Chart. The GI Organisation chart shall be included in the GI Programme as an Appendix.

2A.7.2 GI Programme

The Contractor prepares and submits to AM a GI Programme for the execution of the required GI works. The GI Programme is prepared in compliance with the requirements in para. 2A.14.2.2, as well as all other requirements herein.

2A.7.3 not applicable

2A.7.4 GI Reports

The following reports specified herein shall be submitted for approval in the framework of the Project Quality Plan (see Article GS0600 of the *General Specifications*).

Pre-excavation Pit Report (para. 2A.14.4.1)
Borehole Daily Report (para. 2A.14.4.2)
Piezometer Installation Report (para. 2A.14.4.5)
Laboratory Test Programme Table (para. 2A.11.2).
Borehole Log (para. 2A.14.5.2 and 2A.D)
Soil sample Classification per HSCS (para. 2A.H) and/or per ELOT EN 16907-2/UIC719R.

For the sake of completeness, the Contractor shall include in the GI Programme the GI Reports, as well as the reports described in the regulatory references in this document –such as the reports specified in the standards governing the *in-situ* and laboratory tests.

2A.8 Borehole worksite organizing

2A.8.1 not applicable

2A.8.2 Mechanical equipment

The drilling rigs, drilling bits and sampling equipment (drill bits, core barrels, samplers, etc.) shall be selected on the basis of paragraphs 4, 5, 6 and 7 of ELOT EN ISO 22475-1. The Contractor shall provide an adequate number of drilling rigs in order to carry out all necessary works of the GI in accordance with the present specification and within the approved time schedule.

The Contractor shall submit a detailed table describing the mechanical equipment to be used, as a part of the GI Programme which will include, as a minimum, the number and the type of the drill rigs, the pressuremeter test equipment, the pumps and the air compressors of the *in-situ* tests, the air lift devices and the Standard Penetration Test arrangements as well as the number, the type and diameters of core barrels, samplers.

The Contractor shall comply with AM requirements with regard to the provision of additional mechanical equipment, in any phase of the execution of works, as long as the requirements of the approved time schedule are not adhered to.

The Contractor shall adduce to the worksite properly maintained drilling rigs. Controls and maintenance procedures of the mechanical equipment will be conducted thoroughly by the Contractor according to the directions issued by each device manufacturer and the *in-situ* needs of the Project and there will always be an appropriate spare parts stock at the site in order to address immediately all problems related to the operation of the mechanical equipment without creating any problem or interruption to the works.

In addition, the requirements specified in para. 2A.6.3 also apply.

2A.8.3 Supervision of the works

The Contractor's Field Works Supervisor is responsible for the supervision of the GI site works, as well as for all other activities related to the operation of the drilling worksites.

2A.8.4 Environmental requirements

2A.8.4.1 Control of noise and vibrations due to the executed works

During the execution of the works, the Contractor shall check the noise and vibration levels and maintain them as low as possible. Moreover, the Contractor is obliged to adhere to the requirements relating to rest hours, especially in residential areas, unless special permit has been obtained from the responsible authorities.

2A.8.4.2 Waste handling

The Contractor is responsible to handle wastes during the execution of the drillings.

During the execution of the drilling works, the returning flushing medium shall be piped through a closed circuit in a 3-compartment settling tank, wherein the particles are set and clean water is used again in the drilling. The Contractor, on a regular basis and in compliance with the instructions of AM, shall remove from the worksite the muck deposits and shall transport and dispose the liquid waste, which remains in the special bins, to a designated disposal area, located far away from the worksite. The disposal of waste to the storm water or sewerage system is not permitted unless the Contractor has obtained the written permission of the responsible Authority for their handling.

2A.8.4.3 not applicable

2A.8.4.4 Water supply

The Contractor is responsible for ensuring the supply of the required quantity of water to be used in drilling works.

2A.8.5 Deployment and execution of works – Third party relations

2A.8.5.1 Drawings of borehole positions for execution

Prior to the commencement of the relevant works, the Contractor shall prepare a layout showing the location of the boreholes proposed by GI and the boreholes of previous investigations. This layout is submitted as part of the GI Programme.

The Contractor shall use detailed topographical drawings of the area, where he shall execute his works. The scale of the drawings will be such as to facilitate the procedure for the approval of the works and the issuance of permits by the responsible authorities and also allow the exact representation of the location of the drilling (to be shown by a sketch).

2A.8.5.2 Permits required for the execution of boreholes

The Contractor is responsible for obtaining the required permits in order to perform the drilling in the specific location, as per the GI Programme. As soon as the implementation of drilling locations are finalised, the Contractor must contact the responsible agencies (Municipal Authority, Regional Authority, Ministry of Infrastructure, Transportation and Networks, designated Archaeological Department, Traffic Police, private entity, etc.) in order to ensure the required written permit regarding the exact location of the drillings, their depths, areas of occupation and the time period required for the execution of the works. Any amount payable for deposits shall be paid by the Contractor.

In case the drilling is performed on a road surface, and especially on highways, avenues or streets, where public means of transportation circulate, the Contractor is obliged to obtain the required permits from the responsible agencies (Ministry of

Infrastructure, Transportation and Networks, Traffic Police, OASA, etc.), submit all necessary traffic signs and regulations for approval to the designated authorities and during the execution of the works he is obliged to undertake all required safety measures regarding the passing-by vehicles and pedestrians and strictly adhere to the instructions of the Traffic Police and the traffic arrangements and signs.

As per Decision no. 6952 of the Ministers of the Environment and Energy & the Transport and Networks Ministries, (article 5, para. 3) "*The permit to occupy a sidewalk, etc., in public areas of cities and communities intended for pedestrian circulation is granted only after the configuration and marking of the pedestrian circulation path is indicated on drawing. In case the road pavement is occupied, the permit is granted upon consent of the service responsible for the road maintenance. In case the traffic is diverted, a traffic regulation design must be prepared and approved in advance by the service responsible for the road maintenance*."

The Contractor shall access the area where the works are to be executed, shall install his equipment and shall execute the works, only after having obtained the required permits.

2A.8.5.3 not applicable

2A.8.5.4 Protection against damage

The Contractor is obliged to take all required protection measures against damage that may be inflicted both to his equipment and to third parties' material properties.

2A.8.5.5 not applicable

2A.8.5.6 not applicable

2A.8.5.7 not applicable

2A.9 Specifications for geotechnical investigations – Boreholes and sampling

2A.9.1 Sampling requirements

2A.9.1.1 General

The rock, soil and water sampling works in boreholes or trial pits shall be executed in line with standard ELOT EN ISO 22475-1 and the stipulations of the subsequent paragraphs.

The sampling category of soils and rocks and quality class of soil samples will be the minimum required by case, depending on the laboratory test which is planned for each specimen according to Table 9.1 (for soil specimens) and paragraphs 3.4 and 3.5 (for soil and rock samples, respectively) of the standard ELOT EN ISO 1997-2. Acceptable types of sampling for the Project are A and B (see paragraphs 2A.9.6.2 and 2A.9.7.2).

The volume and mass of each sample will be the ones required to properly perform the necessary laboratory tests described in para. 2A.11 also according to the information in appendices L and T of Eurocode 7 (ELOT EN 1997-2).

2A.9.1.2 Sampling boreholes

The minimum percentage of sample recovery in a sampling borehole is 90 % (sampling category in line with the above para.). In case the saple recovery in a sampling borehole is less than the minimum required, AM is entitled not to accept and pay for the subject borehole, and to instruct the Contractor to repeat the borehole at an adjacent location.

The diameter of the samples will be adequate to properly perform the required laboratory tests of para. 2A.11. Additionally, the minimum diameter of the samples

will be 82 mm along the entire depth of the boreholes. The Contractor is not entitled to any compensation for any increase in diameter.

The drill run will not exceed 1,6 m and the core barrel will be removed from the drilling hole as often as required in order to obtain the best possible sample (core). When core recovery is less than 90% of the full length of the drilling, then the drill run of the subsequent drilling will be reduced to 1 m.

2A.9.1.3 not applicable

2A.9.2 Mechanical equipment selection

The stipulations of para. 2A.8.2 apply.

2A.9.3 Selection of sampling method

The choice of sampling method is as per paragraphs 5, 6 and 7 of ELOT EN ISO 22475-1.

The Contractor shall justify in the CGI Programme the choice of sampling methods in relation to the required sampling category, the required volume of the sample, and the required diameter of the sample, depending on the type of laboratory tests in accordance with the requirements herein.

2A.9.4 Requirements before the start of works

2A.9.4.1 General

The Contractor shall begin the execution of drilling operations after approval of the GI Programme and relevant Material Submission Sheets (MSS).

Applicable are also the contents of para. 5, ELOT EN ISO 22475-1.

2A.9.4.2 Pre-excavation pits

The Contractor, prior to the commencement of works, shall examine the extent to which the drilling about to be executed prevents the execution of other works or services or gives rise to problems at existing networks. In such cases, the Contractor shall timely communicate with the concerned agencies in order to inform them.

Prior to the commencement of any works, the Contractor shall obtain updated drawings from the responsible Public Utility Organizations (PUO) showing the networks and other installations, shall investigate the presence of networks on the basis of these drawings and on site evidence and finally shall communicate with the responsible PUOs in order to avert any risk to inflict damage on existing networks. The above drawings shall be submitted to AM in a digital form, once the respective field works are completed,

The Contractor, prior to the execution of any drilling, shall very carefully excavate the pre-excavation pit, opened with no mechanical means, depth of not less than 1,2 m, in order unless he has ruled out the existence of underground services or networks. At the locations where PUO Networks may be at a depth greater than 1,2m, or where the expected PUO Networks have not been encountered, the Contractor will conduct further excavation, again without using mechanical means

NOTE In order to detect underground PUO networks, the use of Cable Avoidance Tools-CAT is recommended.

NOTE If the Contractor has ruled out the possibility of encountering underground PUO networks, he may not excavate the pre-excavation pit once he has secured the consent of AM.

For the entire excavation period, the Contractor shall maintain the pit free from water through pumping or other means.

Immediately after the completion of the excavation, plastic casing of a suitable diameter shall be placed running from the ground surface to the excavation bottom,

serving as a guide to start drilling. This casing shall be secured in place using temporary or permanent backfill (see para. 2A.9.14). The drilling rig is subsequently installed at the drilling location.

The positions, depths and dimensions of all encountered PUO networks, the final depth of the pre-excavation pit, as well as all required information concerning the pre-excavation pit shall be recorded in the Pre-excavation Pit Report (see 2A.14.4.1).

2A.9.4.3 Boreholes' drilling locations

The Contractor shall install the drilling rig at the borehole location specified in the GI Programme.

2A.9.5 Trial pits

The execution of any trial pits to investigate ground conditions *in-situ*, sample recovery or execution of field tests and backfilling / compaction shall follow the stipulations in para. 2A.9.4.2 herein.

2A.9.6 Soil sampling methods

2A.9.6.1 General

Soil sampling is based on the provisions of para. 6 of ELOT EN ISO 22475-1.

There are three sampling techniques:

Continuous sampling during drilling
Sampling using samplers
Block sampling

2A.9.6.2 Sampling categories

The sampling categories according to ELOT EN 1997-2 and ELOT EN ISO 22475-1 are three: A, B and C.

These three categories of sampling are associated with five quality classes of samples that can be recovered according to Table 9.1. These classes are determined each time by soil properties that are considered unchanged during sampling, handling, transportation and storage of samples, in relation to the requirements of any laboratory tests.

Table 9.1 — Quality classes of soil samples for laboratory tests and the required sampling categories

Soil properties ↓ **quality class →**	**1**	**2**	**3**	**4**	**5**
Unchanged soil properties					
Particle size	✓	✓	✓	✓	
Water content	✓	✓	✓		
Density, density index, permeability	✓	✓			
Compressibility, shear strength	✓				
Properties that can be determined					
Stratigraphy	✓	✓	✓	✓	✓
Boundaries of strata – broad	✓	✓	✓	✓	
Boundaries of strata – fine	✓	✓			
Atterberg limits, particle density, organic content	✓	✓	✓	✓	
Water content	✓	✓	✓		
Density, density index, porosity, permeability	✓	✓			
Compressibility, shear strength	✓				
Sampling category, per ELOT EN ISO 22475-1	A				
			B		
					C

Samples of quality class 1 or 2 can only be obtained by using category A sampling methods. The intention during category A sampling is to obtain samples in which no

or only slight disturbance of the soil structure has occurred during the sampling procedure or in handling of the samples. The water content and the void ratio of the soil correspond to that *in-situ*. In addition, no change in constituents or in the chemical composition of the soil has occurred.

By using category B sampling methods, this will preclude achieving sampling quality class 1 and 2. The intention is to obtain samples containing all the constituents of the *in-situ* soil in their original proportions and the soil has retained its natural water content. The general arrangement of the different soil strata or components can be identified. The structure of the soil has been disturbed.

The Contractor shall select the appropriate method for sampling, per case, in relation to the expected geological and hydrogeological conditions, so as to ensure minimal disturbance of samples so as to be able to execute the laboratory tests of para. 2A.11 herein and to make the engineering geological description of para. 2A.B. Examples of sampling methods in relation to different categories of soil sampling are given in Table 4 of the ELOT EN ISO 22475-1.

2A.9.6.3 Sampling by drilling (continuous sampling)

The Contractor shall recover samples with rotary core drilling with a double or triple tube core barrel as per para. 6.3.2.2 of ELOT EN ISO 22475-1. Additionally, the inner sleeve shall be divisible in two along the axis (split inner tube) to avoid disturbance of the sample during removal from the core barrel. In the event that the Contractor wishes to use another method of continuous sampling, he shall submit the relevant justification to AM for approval, within the CGI Programme.

According to the above, sampling is not permitted using a rotary single tube core barrel**,** since that kind of sampling normally provides samples of quality class 4. The use of single tube core barrel is only allowed in cases of cleaning of the borehole (removal of muck e.g. following casing, when restarting of drilling after an interruption, for the removal of tested geomaterial following an SPT), or in cases of loose gravel that can be sampled by no other core barrel. After cleaning of the borehole, the material recovered with the samples shall be disposed of and shall not be taken into account in the core drilling procedure.

The flushing medium shall be clear water. Where required, and with the approval of AM, additives such as bentonite, biodegraded materials and other types of material can be used in order to improve viscosity.

Water supply during the drilling-sampling will be continuous and sufficient in order to achieve the optimum sampling according to the prescriptions described herein.

Sampling without using flushing medium or with a very low flow rate is not allowed, since such type of sampling normally falls into samples with quality class 4.

During drilling, temporary casings are used where the ground is or is expected to be unstable, contains cavities or where sampling is not satisfactory. In cases where casing is required, given the above, its advance will follow each drilling step at a short distance, not higher than 0,30 m.

The Contractor shall provide onsite all required temporary casing diameters and the required lengths for each diameter in order to achieve the minimum required sampling diameter for the entire length of the boreholes, as mentioned in para. 2A.9.1.2 herein.

2A.9.6.4 Sampling with samplers

The Contractor shall select the appropriate sampler (e.g. Shelby, Denison, Pitcher), as the case may be, in relation to the anticipated geological conditions, in order to ensure the minimum disturbance of the samples, according to the provisions of para. 6.4 of ELOT EN ISO 22475-1 standard.

The Contractor shall provide and use all the above types of samplers at all the drill sites that are required, per case.

The equipment of all types of samplers is submitted as part of the CGI Programme.

2A.9.6.5 Jar samples

Small disturbed “jar samples” are category B samples and are not less than 700 g. They are placed immediately in airtight containers.

2A.9.6.6 Block sampling from trial pits

Block sampling is executed based on the provisions of para. 6.5 of the ELOT EN ISO 22475-1 standard.

2A.9.7 Rock sampling methods

2A.9.7.1 General

Rock sampling is based on the provisions of para. 7 of the standard ELOT EN ISO 22475-1.

There are three sampling techniques:

Sampling by drilling.
Block sampling.
Integral sampling.

2A.9.7.2 Sampling categories

The sampling categories according to ELOT EN 1997-2 and ELOT EN ISO 22475-1 are three: A, B and C.

By using category A sampling methods, it is intended to obtain samples in which no or only slight disturbance of the rock structure has occurred during the sampling procedure of the samples. The strength and deformation properties, water content, density, porosity and the permeability of the rock sample correspond to the in situ values. No change in constituents or in the chemical composition of the rock mass has occurred.

By using category B sampling methods, it is intended to obtain samples that contain all the constituents of the *in-situ* rock mass in their original proportions and the rock pieces have retained their strength and deformation properties, water content, density and porosity. By using category B sampling, the general arrangement of discontinuities in the rock mass can be identified. The structure of the rock mass has been disturbed and thereby the strength and deformation properties, water content, density, porosity and permeability of the rock mass itself.

The Contractor shall select the appropriate method for sampling, per case, in relation to the expected geological and hydrogeological conditions, so as to ensure minimal disturbance of samples so as to be able to execute the laboratory tests of para. 2A.11 herein and to make the engineering geological description of 2A.B.

2A.9.7.3 Sampling by drilling

The Contractor shall recover samples by rotary core drilling with a double or triple tube core barrel as per para. 7.3.3 of the ELOT EN ISO 22475-1 standard. Additionally, the inner sleeve shall be divisible in two along the axis (split inner tube) to avoid disturbance of the sample during removal from the core barrel.

According to the above, sampling is not permitted using a rotary single tube core barrel, since that kind of sampling normally provides samples of quality class 4. The use of single tube core barrel is only allowed in cases of cleaning of the borehole (removal of muck e.g. following casing, when restarting of drilling after an interruption, for the removal of tested geomaterial).

The flushing medium shall be clear water. Where required, and with the approval of AM, other flushing medium may be used such as mud, additives or foam.

Water supply during the drilling-sampling will be continuous and adequate in order to achieve the optimum sampling according to the prescriptions described herein.

Sampling without using flushing medium or with a very low flow rate is not allowed, since such type of sampling generally disturbs the sample.

During drilling, temporary casings are used where the ground is or is expected to be unstable, contains cavities or where sampling is not satisfactory. In cases where casing is required, given the above, its advance will follow each drilling step at a short distance, not higher than 0,30 m.

The Contractor shall provide onsite all required temporary casing diameters and the required lengths for each diameter in order to achieve the minimum required sampling diameter for the entire length of the boreholes, as mentioned in para. 2A.9.1.2 herein.

2A.9.7.4 not applicable.

2A.9.8 Soil and groundwater sampling methods for conducting chemical analyses

2A.9.8.1 Soil sampling for aggressivity tests

Obtaining soil samples includes the use of vessels compatible with the controlled chemical parameters (stainless vessels or vessels coated with TEFLON material) and with appropriate safety measures, held in hermetically sealed containers of 100-500 ml volume, the maintenance in a portable refrigerator at constant temperature of 4 °C in the field and the direct transfer directly to the chemical laboratory.

The soil samples are used in the execution of chemical analyses to determine aggressivity, as described in para. 2A.11.4.3 herein.

2A.9.8.2 not applicable

2A.9.8.3 Groundwater sampling methods

Groundwater sampling follows the provisions of para. 8 of the ELOT EN ISO 22475-1.

The containers are thoroughly rinsed with demineralized water and are sealed before transportation to the sampling location. Three water samples will be taken per sampling location. Each sample will be no less than 0,5 litres. Before sampling, the container is thoroughly rinsed with groundwater for that area. The water sample is immediately transferred to the laboratory for (a) aggressivity tests according to the Concrete Technology Regulation and the provisions herein (para. 2A.11.4.3) or (b) chemical analyses to determine geochemical contamination (para. 2A.11.4.4).

At boreholes where more than one aquifer has been detected, separate samples are taken for each aquifer.

2A.9.9 Drilling and sampling programme

The Contractor shall obtain samples as follows:

2A.9.9.1 Drilling and Sampling of a Rock or a Rock Mass:

Category A continuous sampling with the use of double tube split core barrel
In cases of rock mass of very poor quality, category A samples will be obtained with the use of a triple tube split core barrel for every 3 meters of drilling or according to the AM's field instructions.

2A.9.9.2 Drilling and Sampling of Soil

In soil, the first one meter of the drilling are obtained with category A or B samples

using a double tube split core barrel. Then, the cycle of works described below will be followed:

Obtaining a small disturbed jar sample from the core of the above sampling. At each change in soil formation, a small disturbed sample (jar sample) shall be taken.
Cleaning of the borehole
Standard Penetration Test
Cleaning of the borehole
Category A or B sampling for 4 metres using a double tube split core barrel

NOTE Category A sampling with the use of a triple tube split core barrel or an appropriate sampler (e.g. Shelby, Denison, Pitcher) shall be executed in very soft and soft fine soil.

The aforementioned sampling cycle may be modified depending on the field conditions after having obtained AM's consent.

2A.9.9.3 Drilling and Sampling in Alternations of Rock or Rock Mass and Soil

When there are alternations between rock or rock mass and soil, a combination of the above will be followed. In any case, for each layer of the soil whose thickness exceeds 2 m, one Standard Penetration Test (SPT)shall be executed.

2A.9.10 Groundwater level measurements during drilling

When groundwater is encountered during the drilling procedure, it is measured and recorded in the following manner:

Water levels are recorded at the beginning and end of each shift, upon completion of the borehole to the required depth and prior to backfilling. Whenever groundwater is recorded, the depth of the boring, the length of casing inserted in the borehole and the time of measurement will also be recorded.
In addition to the level, the Contractor shall record any other observations regarding the groundwater, e.g. artesianism, sudden groundwater inflow or loss during drilling, sudden rise or fall of the groundwater level, etc.

2A.9.11 Measurement of the final length of the borehole drilling

As soon as the drilling is completed and before the installation of any type of instrument (e.g. piezometer), the Contractor shall measure the final length of the drilling in the presence of AM's representative, who shall have been notified on the previous day.

The overall length (depth) of the borehole to be measured is equal to the length deriving from the invert pre-excavation pit elevation (drilling commencement point) minus the borehole invest elevation. The final length of the borehole shall be measured along its axis with the drilling rods.

2A.9.12 Piezometer installation

The type of piezometer shall be selected as per the requirements of ELOT EN ISO 22475-1 (se para. 2A.A.1) and shall be documented in the GI Programme.

Piezometers shall be installed as per the requirements of para. 2A.A. herein. The piezometer tip shall be designed per para. 2A.9.13 herein.

2A.9.13 Backfilling of drill holes

In case piezometers are installed, the stipulation in para. 2A.A.7 herein finds application.

In the event no piezometer is installed, as well for the cases of non-sampling boreholes which must be backfilled, the hole shall be sealed with grout from the bottom to the surface by pouring through a tremie pipe the specified cement grout in compliance with para. 5.5 of ELOT EN ISO 22475-1. The grout properties shall be

proposed by the Contractor in the GI Programme.

When artesian conditions are encountered with flow of water from the borehole to the surface, the borehole is grouted to prevent the flow. This may require the use of additional casings, plugs and/or special grouts. Upon completion of works, no water leakage from the borehole should be observed.

2A.9.14 Worksite area reinstatement

Immediately following the completion of the borehole drilling and the removal of the drilling rig and all other worksite installations, the area is reinstated to its original condition clean, free of any excavation spoil and liquid / solid wastes, according to AM's directions. If a piezometer has been installed in the borehole, its protective measures will also be constructed (see para. 2A.A.7).

After the completion of the above works, the Contractor shall notify AM to inspect the area.

2A.9.15 Topographical 'as built' survey

The Contractor carries out a survey of the site and locates all boreholes, trial pits and other investigation 'as built' locations.

Initially, the Contractor shall prepare a sketch showing the location of the 'as-built' borehole or pit with the location and the distances from three fixed objects shown on the drawings. This sketch is included in the Daily Borehole Sheet.

The Contractor also submits an 'as built' layout with all the locations of the boreholes and pits which is submitted in the CGI Factual Report. The EGSA 87 coordinate system shall be used. The precision of the survey for the location of boreholes is:

Location (X & Y): ± 0.10 m.
Elevation (Z): ± 0.01 m.

The coordinates of the locations shall be submitted in a tabulated form, as part of the GI Factual Report.

2A.9.16 Handling, transport and storage of samples

2A.9.16.1 General

The handling, transport and storage of samples are carried out in compliance with the guidelines of chapter 11 of the standard ELOT EN ISO 22475-1 and the guidelines herein.

The Contractor is responsible for the packing, preservation and storing of all samples and their transport to the laboratory or places to be designated by AM. The Contractor is exclusively responsible for the safety and the good condition of the cores and samples. It is emphasised that poor management and protection of samples at all stages of work from drilling to the execution of laboratory tests, results in a significant deterioration in quality. If in its reasonable and documented opinion AM ascertains, at any stage after sampling, loss of core samples or deterioration of their quality to the extent that the proper engineering-geological description and conduct of the lab tests is not permitted, then AM reserves the right to impose the stoppage of the relevant works and demand even the repetition of the drilling.

2A.9.16.2 Recovery, field photographing and core preservation

Core barrels are held horizontally whilst cores are extruded. Core extraction is accomplished without vibration and in a manner to prevent disturbance of samples. Except where inner rigid tubes are used (e.g. Shelby, Denison, Pitcher samplers), the cores shall be extruded into rigid plastic receiving channels of approximately the same diameter as the cores.

Then, the core is placed in the middle of a wooden levelled base, with colour charts and depth indications and is photographed from a vertical position, so that the base may cover the visual field of the camera. The photos will be taken in compliance with the provisions of para. 2A.13 herein.

Once photos are taken, the channel and the core are then wrapped in transparent polyethylene foil and secured with adhesive tape and shall be placed in the core box. Cores are carefully re-wrapped with transparent polyethylene foil every time after their description and/or after sample selection.

2A.9.16.3 Core boxes

The construction of core boxes is carried out in compliance with para. 11.6 of ELOT EN ISO 22475-1 and the following guidelines.

Core boxes are soundly constructed of wood or other approved material fitted with partitions, stout carrying handles, fastenings and hinged lids. The core boxes shall be divided in three compartments each containing 1 m long core. The external dimensions of the boxes will be 1,05 m by 0,35 m by 0,12 m. The core boxes shall have smooth external surfaces (lid and base) for easy stacking. The total tare weight of each core box (full of cores) shall not exceed 50 kg and shall be subject to approval by AM.

Cores are placed in the core box with the shallowest core to the top left hand corner (the top being considered adjacent to the hinged lid). For every compartment, the shallower core is to the left. The cores are rigidly contained in the core box with rigid spacers (e.g. wood) indicating the limits of the core run. In case a void is encountered during drilling, two successive spacers shall be placed indicating the void's start and finish depths, designated with the word "void". Unused spaces within the core box are filled with appropriate material so as to secure the cores for their transportation.

At the outer and inner surface of the lid, the following shall be permanently marked:

Project name.
Borehole code.
Borehole serial number associated with the total core boxes of the borehole.
Depths (start-finish) of the cores contained in the core box.

On the three sides of the core box (front, left and right) the abovementioned information shall also be permanently marked with the exception of the Project name.

At the end of each day's work, core boxes are stored in an area secured from interference and protected against weather conditions

2A.9.16.4 Description of core samples, core photographing, selection of samples and transportation of samples to the laboratory

Following the completion of boreholes, photographs of the cores in the core boxes will be taken as well as a description of the cores and selection of samples for the execution of laboratory tests. The aforementioned works will take place in a sheltered area in compliance with para. 2A.B.1 herein.

Core photographing procedure in the boxes will take place in compliance with the provisions of para. 2A.13.3 herein.

The engineering geological description of cores will be carried out in compliance with para. 2A.B.

The selection of samples is done in accordance with para. 2A.11. After sample selection, they are packed according to the terms in para. 11.3 of the ELOT EN ISO 22475-1 and should be accompanied by an inscription, according to the

prescriptions of para. 11.4 of the ELOT EN ISO 22475-1. Samples inside the tubes of the samplers bear similar inscriptions, which will be opened directly at the laboratory.

The packed samples are then transported to the laboratory of the Contractor, in accordance with the requirements of para. 11.5 of the ELOT EN ISO 22475-1.

2A.9.16.5 Preservation and disposal of laboratory samples

All samples delivered to the Contractor's laboratory are kept for a period of at least one month after submission of the approved corresponding GI Factual Report and afterwards may be discarded only if agreed with AM.

2A.9.16.6 Transport and storage of core boxes

Following the engineering geological description of and the selection of the samples for the execution of laboratory tests, the core boxes are carefully transported and delivered to a safe and protected location and they shall also be available for inspection by AM, whenever requested.

All core boxes are protected at all times during handling, transportation and storage against precipitation, sunlight, vibrations, freezing conditions and drying.

After approval of all submissions related to GI, and at a time that AM will determine, all core boxes will be transferred from the worksite facilities of the Project, and will be placed, classified by borehole and serial box number, to a specific storage location which will be indicated by AM. The transportation and placement of core boxes shall be made by personnel and equipment which shall be provided by the Contractor, and at the Contractor's expenses, in consultation with AM.

2A.10 Specifications for geotechnical investigations – *In-situ* tests

2A.10.1 General

In-situ tests are generally the following:

Standard Penetration Test (SPT)
Cone Penetration Test (CPT): Electrical Cone Penetration Test (CPT), Electric Piezocone Penetrometer (CPTu), Mechanical Cone Penetration Test (CPTM)
Pressumeter test
Water Permeability Test: variable head (Maag), constant head (Lefranc) and packer test (Lugeon)
Measurements of Volatile Organics
Dynamic probing test
Flexible dilatometer test
Rigid dilatometer test
Flat dilatometer test
Weight sounding test

2A.10.2 Personnel to execute *in-situ* tests

All *in-situ* tests are carried out by trained personnel (see para. 2A.7.1) who have gained experience in the use of the equipment, the test methods and the recording of results. The Standard Penetration Test (SPT) will generally be carried out by rig operators under the supervision of the Borehole Geologist.

2A.10.3 *In-situ* test equipment calibration

Where equipment is used in the execution of the tests, the Contractor has such instruments calibrated at intervals consistent with their usage and in compliance with the relevant specifications.

2A.10.4 Continuous recording devices

Where pressuremeter and CPT tests are carried out, continuous recording equipment is provided to monitor the results as the test proceeds.

All the equipment is used in accordance with the manufacturer's recommendations to ensure that the readings obtained are true and accurate.

2A.10.5 *In-situ* tests specifications and requirements

In-situ tests shall be executed in line with ELOT EN ISO 22476-1 to 2246-12 or other equivalent standards.

2A.10.5.1 not applicable
2A.10.5.2 not applicable
2A.10.5.3 not applicable
2A.10.5.4 not applicable
2A.10.5.5 not applicable
2A.10.5.6 not applicable

2A.10.6 *In-situ* test programme

The Contractor shall define the required i*n-situ* test programme which is submitted as a part of the GI Programme, in terms of the type, methodology, the frequency and any other parameters of the required *in-situ* tests.

2A.10.7 Data to be submitted

The *in-situ* test results are recorded as described in the requirements of the standard governing their execution.

The data submitted by the Contractor shall include the following, as appropriate:

Calibration charts for all the instruments used.
Records of calibration checks made in the field before, during and after the test.
Copies of original field data sheets and, where continuous recording devices are used, copies of chart records or printouts from data loggers.
Calculation sheets showing the analysis of the results and the parameters obtained from each test. Where computer carries out calculations, then copies of the computer output will be accepted, as long as the computer programme has been previously approved.

All the above are submitted as part of the GI Factual Report.

2A.11 Specifications for geotechnical investigations – Laboratory tests

2A.11.1 Laboratories

Laboratory tests shall be executed in recognized laboratories that have the necessary equipment for the execution of the tests included in Table 11.1. In addition, these laboratories must be accredited to National Committee of Accreditation (or by other respective foreign agency) in accordance with ELOT EN ISO/IEC 17025 for the execution of the soil mechanics laboratory tests T1, T2, T3, T4, T5, T6, T7, T8, T15, T19 & T20 and rock mechanics tests T27, T28, T29, T30, T31 and T34 listed in Table 11.1 or laboratories approved by the Central Laboratory of Public Works for the execution of these tests.

These laboratories shall be included in the CGI Programme.

2A.11.2 Selection of samples – Laboratory Test Programme Tables

After the completion of each borehole or group of sampling boreholes, the Contractor notifies AM in order to carry out the engineering geological description of

borehole cores. It is emphasized that the time period between the completion of the borehole, the engineering geological description and selection of the samples must be the shortest possible, so as to avoid sample disturbance (e.g., drying during summer months). The Contractor shall transmit an e-mail message to AM, specifying the date of the engineering geological description and sample selection, as well as the code numbers of all boreholes. Moreover, the Contractor shall transmit an e-mail to AM with the Preliminary Laboratory Test Programme Tables for each borehole. The lab test programme shall be drafted as described in para. 2A.11.4, taking into account all data from the Borehole Daily Report.

A similar procedure shall be followed for *in-situ* engineering geological description and selection of samples from trial pits, after communication with AM.

Then follows the engineering geological description and the sample selection for the execution of laboratory tests, in the presence of AM.

The Contractor, after the completion of each borehole, prepares the Proposed Laboratory Test Programme separately for each borehole. The Tables for all boreholes shall be transmitted via e-mail to AM the latest on the day after the sample selection. If the Contractor does not receive a response until the next working day, then he can execute the tests according to his proposed programme.

The final Proposed Laboratory Test Programme Tables along with the Executed Laboratory Test Programme Tables (tables listing the executed lab tests) are submitted as part of the CGI Factual Report.

The Laboratory Test Programme Table shall be a standardized report and shall include the following information:

Code of borehole.
Sample selection date.
No. of sample.
Sample depth (from/to) (from borehole).
Sample type (from core sampling, sampler type, glass jar).
Type of proposed tests.
Name and signature of Head of Laboratory.

2A.11.3 Specifications for the execution of laboratory tests

Table 11.1 lists the foreseen laboratory tests and their respective standards governing their execution. The Contractor shall carry out the laboratory tests in accordance with one of the respective standards in Table 11.1, or other equivalent standard.

Table 11.1 — Foreseen laboratory tests and execution standards

No.	Test Type	Test execution standard
T1	Dry preparation of soil sample for laboratory tests [1]	E105-86
T2	Soil water content	ELOT EN ISO 17892-1
T3	Determination of apparent density	ELOT EN ISO 17892-2
T4	Determination of particle density	ELOT EN ISO 17892-3
T5	Determination of liquid and plastic limits (Atterberg limits)	ELOT EN ISO 17892-12
T6	Determination of particle size distribution - sieving [2]	ELOT EN ISO 17892-4
T7	Determination of particle size distribution - sieving–determination of fines [2]	ELOT EN ISO 17892-4
T8	Determination of particle size distribution - sieving - Hydrometer or pipette	ELOT EN ISO 17892-4
T9	Organic matter in soils using dry combustion	ASTM D2974
T10	Organic matter in soils using wet combustion	AASHTO T 194

No.	Test Type	Test execution standard
T11	Determination of calcium carbonate concentration	BS 1377-3 Clause 6
T12	Determination of water content – soil density relation (standard or modified PROCTOR)	ELOT EN 13286-2
T13	Laboratory determination of Californian Bearing ratio (CBR)	ELOT EN 13286-47
T14	Determination of the maximum and minimum dry densities of granular soils	BS 1377 -4
T15	Unconfined compression test	ELOT EN ISO 17892-7
T16	Unconsolidated undrained triaxial test and drainage	ELOT EN ISO 17892-8
T17	Consolidated-undrained triaxial test with pore pressure measurement (CUPP triaxial tests)	ELOT EN ISO 17892-9
T18	Consolidated-drained triaxial test with pore pressure measurement (CD triaxial tests)	ELOT EN ISO 17892-9
T19	Unconsolidated direct shear tests	ELOT CEN ISO/TS 17892-10
T20	Consolidated, undrained (fast) direct shear tests –	ELOT CEN ISO/TS 17892-10
T21	Consolided, undrained (slow) direct shear test	ELOT CEN ISO/TS 17892-10
T22	Direct shear test – Determination of residual shear strength in shear test apparatus	ELOT CEN ISO/TS 17892-10
T23	Direct shear test – Determination of residual shear strength in ring shear apparatus	ELOT CEN ISO/TS 17892-10
T24	Incremental loading oedometer test	ELOT EN ISO 17892-5
T25	Incremental loading oedometer test - controlled loading rate	ELOT EN ISO 17892-5
T26	Incremental loading oedometer test – swelling test	ELOT EN ISO 17892-5
Rock tests		
T27	Preparation of cylindrical rock sample	See NOTE 3
T28	Determination of moisture content in rock sample	E103-84
T29	Determination of porosity & density	E103-84
T30	Determination of unconfined compression strength	E103-84
T31	UCS with *E* and Poisson's ratio *v* readings	ASTM D 7012
T32	Determination of point load strength	E103-84
T33	Determination of triaxial compression strength	E103-84
T34	Determination of hardness by SCHMIDT hammer (L)	E103-84
T35	Determination of shear strength of natural and artificial discontinuities	ISRM suggested methods or ASTM D5607
T36	Slake durability index	ISRM suggested methods or ASTM D4644
T37	Indirect tensile strength (Brazilian test)	ISRM suggested methods
T38	C.E.R.CHAR. Abrassiveness Test	
Mineral composition analysis		
T39	Mineralogical analysis using XRD method	–
T40	Petrographic analysis [4]	–
Soil aggressivity tests and geochemical contamination detection tests		
T41	Recovery of soil sample for chemical analysis	See para. 6.8.1 or 6.8.2
T42	Determination of sulphates and ions concentration in soils	ELOT EN 16502
T43	Determination of chlorides concentration in soils	BS 1377-3 Subclauses 7.2, 7.3
T44	Determination of acidity degree in soil sample – pH	ELOT EN 16502
T45	Preparation of soil solution	DIN 38414-4
T46	Total petroleum hydrocarbons - TPH	EPA 8015b APHA 5520-C

No.	Test Type	Test execution standard
T47	Water sampling and transportation to the laboratory for analysis	See para. 6.8.3
T48	Water chemical analysis	See NOTE 5
T49	Trace elements in water	–

NOTE 1 Detailed information regarding soil samples preparation is found in Appendix L of ELOT EN 1997-2.

NOTE 2 The particle size distribution is performed with sieves in accordance with standards ISO 3310-1 and ISO 3310-2, as well as in accordance with para. 2A.H.

NOTE 3 Detailed information regarding rock samples preparation is found in Appendix T of ELOT EN 1997-2.

NOTE 4 Petrographic analysis shall include the requirements expressed in para. 2A.12.3.9.

NOTE 5 Water chemical analyses shall determine the following chemical properties on the basis of the respective standards (in parentheses):

SO_4^{-2} (mg/l) (ELOT EN 196-2)
pH (ISO 4316)
Corrosive CO_2 (mg/l) (ELOT EN 13577)
NH_4^+ (mg/l) (ISO 7150-1)
Mg^{+2} (mg/l) (ISO 7980)
Cl^- (mg/l) (ISO 7393)

Whenever a laboratory test is executed on the basis of a standard not included in those listed in Table 11.1, this shall be an internationally recognized standard and the Contractor shall submit in the CGI Programme the proper documentation concerning the applicability of that specific standard to the specific ground formation and the specific geotechnical conditions, as per the stipulation in para 2.1 of ELOT EN 1997-2:2007/NA.

As regards the test in Table 11.1, for which there is no reference to an execution standard (T37, T38, T56), the Contractor shall submit –as part of the GI Programme– the relevant standards or internationally accepted methods based on which these tests shall be executed.

Those laboratory tests the Contractor intends to execute but are not included in Table 11.1, shall be carried out on the basis of an internationally recognized standard which shall be submitted by the Contractor as part of the GI Programme.

2A.11.4 Laboratory Test Programme

The lab tests are scheduled according to the design requirements of the subject Project.

The general guidelines and minimum requirements with regard to the programme and the quantities of the laboratory tests for soil, rock and water samples recovered from sampling boreholes are presented below.

For each test, the numbering of the respective test of Table 11.1 is given in parentheses. The tests listed in Table 11.1 for which no guidelines are given in this paragraph shall be programmed on a per-case basis upon communication and agreement with AM. AM may request the execution of other tests beyond those specified in Table 11.1, as per its reasonable and documented judgement.

The laboratory test programme shall be included in the CGI Programme.

2A.11.4.1 Soil samples

2A.11.4.1.1 Physical properties tests

Determination of water content, apparent density, particle density, Atterberg limits and particle size distribution (T1, T2, T3, T4, T5, T6, T7 and T8): one test every 1 meter for the first 10 meters of the borehole and after that, one test every 2 meters.

Atterberg limits determination tests (T5) and Hydrometer and or pipette tests (T8) will be executed, when following particle size analysis with sieves the fine fraction is higher than 5 %.
Water content determination test (T2) will also be executed on 'jar samples'.
Organic substances test (T9 or T10) will be executed on organic soils (see para 2A.H.10.2.2).
The calcium carbonate concentration test (T11) shall be carried out in carbonate soils (see para 2A.H.10.22).
From the results of the tests, the Plasticity Index I_P, the Liquid Index I_L, the Consistency Index I_C and the Activity Index I_A will be estimated. For coarse grained soil which contain less than 10 % fines and less than 10 % gravel, the Density Index I_D can also be determined (T14). The description of consistency and density shall be based on these indices, as per para. 2A.B.3.2 herein.

2A.11.4.1.2 Mechanical properties tests

Every 1 meter for the first 10 meters of borehole and after that, one test every 2 meters. A sample shall be recovered for the execution of the mechanical properties tests as follows: tests shall eb varied out alternately from the following two groups of tests.
1st group: unconfined compression test (T15), unconsolidated undrained triaxial test and drainage (T16), unconsolidated direct shear tests (T19) with determination of residual shear strength in shear test apparatus (T22) or without determination.
2nd group: consolidated-undrained triaxial test with pore pressure measurement (CUPP triaxial tests) (T17 or T18), consolidated, undrained (fast) direct shear tests (T20 or T21) with determination of residual shear strength in shear test apparatus (T22) or without determination

Per borehole: three incremental loading oedometer tests with controlled loading rate (T24 or T25) with or without swelling test (T26). 2A.11.4.2 Rock samples

2A.11.4.2.1 Physical properties tests

One test for the determination of moisture content (T28), porosity and density (T29) every 5m of borehole.

2A.11.4.2.2 Mechanical properties determination tests

One unconfined compression strength with *E* and Poisson's ratio *v* readings (T31) and two point load strength tests (T32) (one axial and one diametral) every 1 meter for the first 10 meters of borehole and then one test every 2 meters.

2A.11.4.3 Soil aggressivity and groundwater tests

Specifically to determine basic design parameters, regarding the permanent works of reinforced concrete, sampling and testing according to the Concrete Technology Regulation (Concrete Technology Code, Appendix AB2) are required.

Aggressivity parameters that have to be checked are:

a) Soil:

Acidity degree (ml/kg) per Baumann – Gully (T44)
Sulphurous, as sulphur ions SO_4^{-2} (mg/kg) (T42)

b) Groundwater (T48):

Sulphurs SO_4^{-2} (mg/l)
pH
CO_2 (mg/l)
Cations NH_4^+ (mg/l)
Cations Mg^{+2} (mg/l)
Chlorions Cl^- (mg/l)

The number of the tests shall depend on the on site conditions (e.g. ground water level in the Project area, foundation depth, pile driving depth):

2A.11.4.4 Not applicable

2A.11.5 Submittal of laboratory test results

All the results of the laboratory tests are recorded based on the standard according to which they are executed, taking also into account the general requirements presented in chapter 5 of ELOT EN 1997-2.

The information submitted by the Contractor shall include the following, as required:

- Copies of original laboratory data sheets and, where continuous recording devices are used, copies of chart records or printouts from data loggers.
- Calculation sheets showing the analysis of the results and the parameters obtained from each test. Where computer carries out the calculations, then copies of the computer output will be acceptable together with verification of the computer program.
- Especially as far as uniaxial strength tests are concerned, the following data will always be included in the laboratory test sheet: (a) lithological type of the sample (see para 2A.B.1, phase 3), (b) report on the isotropy or anisotropy of the sample and in the case of anisotropy, record of the angle of the dominating bedding, foliation, schistocity etc., with the loading axis and (c) angle of the specimen fracturing surface with the loading axis.

All the above are submitted in printouts and soft copies as part of the GIReport.

2A.12 Specifications for geological investigations

2A.12.1 Not applicable

2A.12.2 Not applicable

2A.12.3 Geological works

2A.12.3.1 Not applicable

2A.12.3.2 Not applicable

2A.12.3.3 Not applicable

2A.12.3.4 Recording of locations of earlier ground investigations and of water occurrence points

The Contractor shall record the locations where earlier ground investigations were conducted and the location where water is present within the Project area, as per the following paragraph.

The recording of locations where earlier ground investigations were conducted (sampling boreholes, wells, pits, galleries, geophysical investigations, etc.) shall include: (a) general information (execution entity and time, coordinates, etc.), (b) engineering geological description and test results, (c) installed instruments, (d) groundwater level measurements, (e) general observations and (f) documentation with photographs.

The recording of the locations with water occurrence (springs, wells, pumping wells) shall include: (a) general information (location, coordinates, ownership status, etc.), (b) technical data (depth, diameter, casing, pump, etc.), (c) hydraulic data (level, flow rate, etc.), (d) land use details, (e) geological data and (f) documentation with photographs.

Recording of works carried out during earlier ground investigations shall be presented in the Ground Investigation Report.

2A.12.3.5 Groundwater level measurement

The Contractor shall carry out groundwater level measurements on the piezometers of the GI. Groundwater level measurements shall be carried out in line with the contents of para. 10, ELOT EN 22475-1.

Groundwater level measurements shall commence immediately –upon availability of the measurement location– shall be taken at a frequency of at least one measurement per week and shall be completed with the submission of the Ground Investigation Report.

2A.12.3.6 Not applicable

2A.12.3.7 Not applicable

2A.12.3.8 Rock mass classification

The Contractor shall perform rock mass classification GSI (para. 2A.C) on all rock cores of the sampling boreholes of the Ground Investigation, during phase 2 of the engineering geological description of the cores (para. 2A.B.1). The classification of the rock mass for borehole cores is recorded in the Borehole Log (para. 2A.14.5.2).

2A.12.3.9 Not applicable

2A.12.3.10 Chemical analyses on groundwater and soil

See paragraphs 2A.11.4.3.

2A.12.3.11 Rock quality designation – RQD

The Contractor shall determine the rock quality designation RQD (para. 2A.B.2.11) on all rock cores of the sampling boreholes, during phase 1 of the engineering geological description of the cores (para. 2A.B.1), taking into account the requirements expressed in para. 1.5 (b) of E 104-85. The RQD is recorded in the Borehole Log (para. 2A.14.5.2).

2A.12.3.12 Not applicable

2A.12.3.13 Not applicable

2A.13 Photographic archive

The Contractor will perform detailed photographing of the works. Digital pictures will be taken from the rig worksites, pre-excavation pits and trial pits, the core runs of the samplers, the core boxes, the samples for laboratory testing, the locations of geological works, etc.

2A.13.1 Photographs' specifications

All photographs will be digital, full colour, minimum resolution is 15 megapixels, ¾ height/width ratio, in JPEG format, of high quality, low compression, 32 million colours, 24 bits per pixel with camera sensor at least APS–C/H (>300mm^2).

The time and the date that the photograph was taken shall appear on each photograph, while the photograph shall also include on a per case basis the appropriate item for the length scale (tape measure, scale meter, coin, etc.). Where required, the photograph shall also include a colour control patch (colour scale). When the shooting light conditions are different, there will be white or grey and/or neutral colour correction.

Each photograph shall contain sufficient information to locate the samples (e.g. borehole number and depth shall be recorded on sample photos, while the data referred to in para. 2A.13.3 of this article shall be recorded on the borehole core photos, and on the photographs of the geological works, detailed data shall be provided for map tracing).

2A.13.2 Photographs of boreholes locations

Photographs are taken to provide a fully detailed record of all site drillings. Site photographs will be submitted only in electronic form.

2A.13.3 Photographs of borehole cores

The Contractor takes photographs to provide a fully detailed record of all borehole cores. Colour control patches (colour scale) and length scale to be included in each photo.

The cores are photographed twice:

- The first set of photographs (per drill run) is taken as soon as the cores are extracted from the core barrel. These shall be submitted only in electronic form.
- The second set of photographs (per core box) is taken later when the cores are fully unwrapped and prior their engineering geological description and samples' selection for testing (see para. 2A.B.1, phase 2).
  These shall be submitted in electronic form as well as in printed form.

When core boxes are photographed, attention shall be given to the uniform lighting of all boxes. In this case, apart from white or grey colour correction, there will also be colour balance correction/adjustment using a colour control patch and the appropriate software, so that colour and brightness rendering is the same for all photographs of this session, to the extend this is feasible.

The hard copy is presented in A4 size pages as follows: Each sheet shall successively include the photographs of five consecutive boxes (only the section including the cores with no cover). Special attention shall be paid to the following: (a) the widths of each photograph should be the same, (b) the photographs should not be distorted and (c) each photograph should also include the length scale and the colour control patches on its sides.

On the top of the sheet, the drilling code shall be recorded as well as the limits of the core depths shown on the said sheet. At the bottom of the sheet the page number will be referred as well as the total number of pages for each drilling. These A4 sheets shall be printed on photo quality paper at a minimum resolution of 300 dpi in colour, and shall be submitted as part of the GI Factual Report (para. 2A.14.5.1).

2A.13.4 Laboratory test sample photographs

The Contractor shall take sets of photographs of all samples (before and after the test) to create a full test archive. Rock samples are cleaned and lightly sprayed with water prior to photographing to reveal structure and bedding.

The photographs of the samples will be submitted only electronically as part of the Ground Investigation Factual Report (para. 2A.14.5.1).

2A.14 Submittals

2A.14.1 Not applicable

2A.14.2 Submittals before commencement of the works

2A.14.2.1 Not applicable

2A.14.2.2 Ground Investigation Programme

The Contractor shall prepare the Ground Investigation Programme according to the requirements of this document and those of Eurocode 7 (chapter 2 of ELOT EN 1997-2). The report to be delivered shall include the following chapters as a minimum and shall have the following structure:

TABLE OF CONTENTS

1 GENERAL
1.1 Introduction - Scope
1.2 Normative references (para. 2A.2, 2A.11.3)
1.3 Reference documents and drawings
2 ORGANIZING THE BOREHOLE WORKSITES (para. 2A.8)
3 INVESTIGATION WORKS
3.1 Boreholes (para. 2A.5.1, 2A.5.2, 2A.5.3, 2A.9.13)
3.2 Piezometers (2A.5.2, 2A.9.12, 2A.A)
3.3 Sampling and sampling handling methods (paragraphs 2A.9.3, 2A.9.6.3, 2A.9.6.4, 2A.9.7.3)
3.4 On site tests (2A.5.3, 2A.10.6)
3.5 Lab Tests (para. 2A.12.3, 2A.11.4)
3.6 Geological works (para. 2A.12.3)

APPENDICES
A LAYOUT PLAN WITH THE INVESTIGATION LOCATIONS (para. 2A.8.5.1)
B GI ORGANIZATION CHART (para. 2A.7.1)

C MECHANICAL EQUIPMENT LIST (para. 2A.8.2)
D GI REPORTING SHEETS (para. 2A.7.4)

2A.14.2.3 Not applicable

2A.14.3 Material Submission Sheets

The Contractor submits for AM's approval the Material Submission Sheets (MSS) for all material, instruments etc. to be incorporated in the drilling works.

2A.14.4 Submittals during the investigations

During the execution of the GI field works, the Contractor shall transmit to AM the reports / forms / files specified in paragraphs 2A.14.4.1 to 2A.14.4.7 herein.

2A.14.4.1 Pre-excavation Pit Report and Trial Pit Report

For each pre-excavation pit, the Contractor shall prepare a corresponding report which shall be submitted to AM at the beginning of the next working day further to its completion.

The Report contains the following:

1. Project name, Client, Contractor.
2. Borehole code.
3. Drilling date with reference to the depth at the end of each working day or shift.
4. Equipment which was used.
5. Data related to the quantity of water pumped from the pit.
6. Description of each formation, together with sketches of the formation encountered.
7. Details of time spent due to encountering of obstructions.
8. Details of any PUO networks located.
9. Dimensions and final depth of the pit.
10. Remarks on the stability of the excavation slopes and description of any support means used.
11. Description of the backfill (backfill material, layers etc.) and the compaction.
12. Photographs of the pit's slopes13.Borehole Geologist's Name and Signature.

The Pre-excavation Pit Reports are also submitted as part of the GI Factual Report (para. 2A.14.5.1).

2A.14.4.2 Borehole Daily Report

For each borehole (sampling or not, including the pumping shafts), the Contractor shall compile a daily sheet which shall be submitted to AM at the beginning of the next working day. The details concerning the submission shall be defined in communication with AM.

The Borehole Daily Report contains the following:

1. Project name, Client, Contractor
2. Borehole code, type of borehole
3. S/N of Report, date, weather conditions
4. Borehole data:
   - sketch indicating the location of the borehole in ilne with para. 2A.9.15 (it concerns the first Borehole Daily Report kept for each borehole)
   - Daily progress of the works
   - Total drilling time
   - Flushing medium
   - Casing data: diameter and beginning-end depths
   - Orientation of the drilling given as an angle to the horizontal
5. Drilling rig data (type, capacity, power etc.)
6. Drilling and sampler's data (with references to the beginning-end of each 'drill run'):
   - Corebarrel - sampler type
   - Cutting tools type
   - Sampler's nominal diameter
   - Drilling time (drill run)
   - TCR, SCR, RQD and If (para. 2A.B.2.11) for each rock core drilling step (on soil materials only soil sample recovery CR is measured; for the relevant definition, kindly see para. 3.3.15 of ELOT EN ISO 22475-1)
   - Casing and length diameter
   - Flushing medium returns' colour
   - Morning and evening water level
   - Water loss
7. Samples' data (with references to the beginning-end of each drill run):
   - S/N of sample
   - Type of sample
   - Diameter of sample
   - SPT
8. Jar samples
9. Engineering geological description (as per para. 2A.B.1):
   - soil and rock description
10. In situ permeability measurements:
    - Depths of the tested section
    - Type of test
11. PID measurements
12. Pocket penetrometer measurements
13. Instrument installation
14, Backfilling and sealing works
15. Comments
16. Rig operator name
17. Borehole Geologist's Name and Signature

2A.14.4.3 Macroscopic Description Borehole Report

It is compiled during the procedure of phase 2 of the engineering geological description, as described in para. 2A.B.1. The details of the submission shall be defined in communication with AM.

2A.14.4.4 Not applicable.

2A.14.4.5 Piezometer Installation Report

It is compiled in accordance with para. 12.1.7 of the standard ELOT EN ISO 22475-1. The report includes a form with the following piezometer data : (a) sketch (section) with the piezometer manufacturing components and the geological data (geological formations) encountered during the drilling, (b) the data obtained from the installation with air-lift (tables and water level recovery diagrams etc.).

The Piezometer Installation Report shall be submitted to AM on the day that follows the installation with air-lift, by means to be agreed with AM. All the reports for all the piezometers shall be submitted as an appendix to the GI Factual Report (pra. 2A.14.5.1).

2A.14.4.6 Not applicable.

2A.14.4.7 Laboratory Test Programme Tables

These Tables shall be compiled and submitted according to para. 2A.11.2 herein.

2A.14.5 Submittals after the completion of investigations

2A.14.5.1 GI Factual Report

The GI Factual Report shall be compiled according to the requirements of this document, those of article ΓΤΕ.3 of the Regulation of Ministerial Decision ΔΝΣγ/32129/ΦΝ 466/20.07.2017 (OGG B' 2519) and those of Eurocode 7 (para. 3.4 of ELOT EN 1997-1 and chapter 6 of ELOT EN 1997-2). It shall include the chapters and the general structure listed below:

VOLUME 1: TECHNICAL REPORT
TABLE OF CONTENTS
1 GENERAL
1.1 Introduction – Scope
1.2 Normative references
1.3 Relevant documents and drawings
1.4 Description of the area
1.5 Information on in-situ works and worksite organization
2 BOREHOLES
2.1 Borehole data
2.1.1 Groundwater level measurement during drilling
2.2 Data from piezometers
2.2.1 Piezometer development works (air lift)
3 IN-SITU TESTS
3.1 Standard Penetration Tests (SPT)
3.2 Cone penetration tests (CPT)
4 LABORATORY TESTS
4.1 Specifications for the execution and presentation of the soil / rock mechanics laboratory tests
4.2 Cumulative tables with results obtained from soil mechanics lab tests
4.3 Cumulative tables with results obtained from rock mechanics lab tests
4.4 Ground water level measurements
4.5 Chemical analyses
5. DIFFERENTIATIONS BETWEEN GI EXECUTED WORKS AND THE RESPECTIVE WORKS OF THE GI PROGRAMME AND JUSTIFICATION
6 BIBLIOGRAPHY
APPENDICES
A LAYOUT PLAN OF THE GROUND INVESTIGATION LOCATIONS

(paragraph 2A.9.15)

B BOREHOLE LOGS (para. 2A.14.5.2)

C PHOTOGRAPHS OF BOREHOLE CORES (para. 2A.13.3)

D PROPOSED AND EXECUTED LABORATORY TEST PROGRAMME TABLES (para. 2A.11.2)

E PIEZOMETER INSTALLATION REPORTS (para. 2A.14.4.5)

F IN-SITU TEST REPORTS (para. 2A.10.7)

G LAB TEST REPORTS (para. 2A.11.5)

H LAB & IN-SITU TEST REPORTS (unofficial records during test execution –only in a digital format (pdf file))

I TABLE WITH EARLIER GROUND INVESTIGATIONS AND OF WATER OCCURRENCE POINTS (PARA. 2A.12.3.4)

J PHOTOGRAPHIC RECORD (para. 2A.10.4)

If the Ground Investigation includes ground investigations related works which are not listed in this table, the Contractor shall complete it accordingly in agreement with AM 2A.14.5.2 Borehole Logs

2A.14.5.2 Borehole Logs

The Borehole Logs shall be standardized documents. They shall be submitted to AM for approval as part of the GI Factual Report.

The “Borehole Log” form shall be compiled as shown below (see sample in para. 2A.D), taking also into account the requirements in para. 1.5 (d) of E 104-85.

1. Project name, Client, Contractor's name
2. Borehole No. coordinates of borehole, angle from the horizontal
3. Groundwater data (with references to depths): morning and night level
4. Drilling and sampling data:
   - Type and nominal diameter of corebarrel-sampler
   - Drilling time (min)
   - Diameter of casing (if used)
   - Flushing medium returns (%)
   - TCR (%) or TC (%)
   - SCR (%)
   - RQD (%)
5. Engineering geological description (phase 4) with references to depths (as per para. 2A.B.1):
   - Symbols of units units (following ISO 710-1 to ISO 710-7 standards)
   - Engineering geological description of units
6. Rock mass classifications, GSI (structure, discontinuities’ condition, value range, as per para. 2A. C), with reference to depths
7. Rock strength (bar chart, as per 2A.B.2.2)
8. Rock mass weathering (bar chart, as per 2A.B.2.12)
9. Description of discontinuities (type and characteristics, as per para. 2A.B.2.10)
10. Strength for cohesive soils (bar chart, as per 2A.B.3.6)
11. Cohesion of fines and density of coarse-grained soils (bar charts, as per 2A.B.3.2):
12. In-situ tests, with references to depths:
    - SPT (record the depth of test commencement, the blow count per step, N_{SPT}, penetration)
    - c_U with pocket penetrometer
    - Permeability tests (test type, depth of the tested section, value)
13. Sample info (sample depths, code)

14. Laboratory tests:
    - HSCS soil group symbol, according to para. 2A.H
    - Physical properties
    - Mechanical properties
    - C.E.R.RCHAR Abrasiveness Test (CAI)
    - Petrographical analyses (only depth of the samples)
    - XRD tests (only depth of the samples)
15. Scale: the scale shall be 1:50.

2A.14.5.3 Geotechnical Investigation Results Evaluation Report

The Geotechnical Investigation Results Evaluation Report shall be submitted further to the approval of the GI Factual Report and in line with the requirements of the approved time schedule.

The Geotechnical Investigation Results Evaluation Report shall be compiled according to the requirements of this document, those of article ΓΜΕ.1, para. 1.3 of the Regulation of Ministerial Decision ΔΝΣγ/32129/ΦΝ 466/20.07.2017 (OGG B' 2519) and those of Eurocode 7 (para. 3.4.3 of ELOT EN 1997-1 and chapter 6.3 of ELOT EN 1997-2). In this Report provides the GI data are evaluated in parallel to all available data that the Contractor will gather.

The Geotechnical Investigation Results Evaluation Report shall include the following chapters and shall be structured as follows:

	TABLE OF CONTENTS
1	GENERAL
1.1	Introduction – Scope
1.2	Normative references
1.3	Relevant documents and drawings
2	GENERAL DESCRIPTION OF THE PROJECT
3	METHODOLOGY FOR EVALUATION OF THE INVESTIGATION RESULTS
4	INVESTIGATION REVIEW AND COMMENTING – COMPARISON BETWEEN CGI RESULTS AND OTHER AVAILABLE DATA
5	GEOLOGICAL CONDITIONS
6	HYDROGEOLOGICAL CONDITIONS
7	ENGINEERING GEOLOGICAL CONDITIONS
7.1	General – Basic principles
7.2	Rock mass GSI classification of engineering geological formations
7.3	Physical and mechanical properties of soil formations
7.4	Physical and mechanical properties of rock formations
7.5	Ranges of geotechnical parameters of the formations
8	CONCLUSIONS
	APPENDICES: Cross sections

Chapter 1 shall contain Contract details (Project, contract, resolutions, Service, Contractor), the scope and purpose of the Geotechnical Investigations Factual Report'. It shall also contain the regulatory reference documents, references to documents, drawings of the approved prerequisite (GI Programme, GI Results Evaluation Report) as well all other data which are co-evaluated in the framework of the specific Evaluation Report.

Chapter 2 describes the Project's location and details.

Chapter 3 describes the principles of the applied methodology of evaluation.

Chapter 4 highlights and comments upon any remarks related to the completeness, quality and reliability of the data (e.g. deficient, irrelevant, insufficient or inaccurate) that resulted from the Contractor's CGI as well as from pre-existing investigations. Sampling procedures and the procedures for sample transportation and storage

shall be taken into account in the interpretation of the test results. Any out-of-scale results shall be carefully examined in order to determine whether they are not representative or represent an actual situation that has to be taken into account in the preparation of the Project's design.

Upon completion of the above commenting, a table shall be drafted at the end of the chapter listing the test results that are excluded from the evaluation. For each excluded test result, the reason for its exclusion shall be provided, on the basis of the above comments. Chapter 4 shall also compare the results of the GI to the results of earlier investigations, as well as to any other data the Contract may have gathered in relation to the geological, hydrogeological and engineering geological conditions.

Chapter 5 briefly describes the geological conditions in the study area. Description shall be made of the properties of the geological formations encountered during drilling works and as regards the rocky formations, the lithological units included therein.

Chapter 6 describes the Hydrogeological conditions in the Study Area and the ground water level based on the measurements of the piezometers.

Chapter 7 is where all data (physical, mechanical and engineering geological properties) are analyzed per formation

Cumulative tables shall be given presenting their physical and mechanical properties, as well as the respective diagrams.

These cumulative tables shall include the results of all executed tests, and all required data per test; after the statistical processing, these tables shall present at least the following:

- Multitude of tests or length of the evaluated core (e.g. RQD, GSI) respectively.
- Range of values (min - max).
- Average value.
- Standard deviation.

It shall also include a classification of the materials to be excavated to be used as backfilling construction material, an excavation workability classification and project-wide classification of the track foundation bed based on the criterion of the necessity to construct a soil exchange layer, a drainage layer etc.

Paragraph 7.5 shall evaluate all data per formation as required, in order to extract the ranges for the necessary geotechnical parameters parameters:

Chapter 8 describes in brief the results of the evaluation.

Appendices shall provide the segregation of the encountered formations based on the physical and mechanical properties. They shall also include geotechnical sections (cross sections at the investigation locations) showing the layers segragation and the groundwater table in relatioj to the several Project sections (shed foundation, excavation trench for the tracks, piles locations).

2A.14.5.4 Not applicable

2A.14.6 Not applicable.

2A.A APPENDIX A: INSTALLATION AND MAINTENANCE OF PIEZOMETERS

2A.A.1 General

Installation and maintenance of piezometers shall be in accordance with the provisions of chapter 9 of standard ELOT EN ISO 22475-1 as well as with the following.

The following types of piezometers will be installed in boreholes:

- open systems (open standpipe or open pipe with inner hose)
- closed systems (hydraulic, pneumatic and electrical)

The choice of the type of piezometer which shall be installed depends on the permeability of the formation, the rate of change of pore water pressure and the required accuracy and duration of measurements.

Open systems are preferable for measurement of water level in soils or rocks of medium to high permeability and, generally, they should not be used for measurement of water level in soils and rocks with very low permeability or for monitoring rapid fluctuations of pore water pressure in low permeability soils and rocks.

Closed systems may be used for measurement of pore water pressure and as such the distribution of the hydraulic potential in all types of soil. More specifically, closed systems are required for the determination of pore water pressure in soils or rocks with very low permeability, for monitoring rapid fluctuations of pore water pressure and for cases of artesianism.

Installation of piezometers must not affect on a permanent basis the quality and flow of ground water, in accordance with the provisions of para. 9.3.1.1.3 of the standard ELOT EN ISO 22475-1.

Piezometer caps shall be protected and will be constructed in accordance with the provisions of para. 2A.A.7. Open system piezometers' caps will not protrude from the ground surface or sidewalk or pavement.

The Contractor, prior to the installation of the piezometer, will submit an Instrument Installation Announcement Report and after installation the Contractor will submit a Piezometer Installation Report.

2A.A.2 Materials

Pipes and filter pipes of the open system piezometers shall be heavy duty PVC-U according to the standard ELOT EN 1329 with a 50mm outer diameter. Filter pipes must bear sufficient slots to allow free water flow yet should not be in danger of breaking.
Open pipe with inner hose piezometers shall comprise at their lower end a porous ceramic or plastic element with an external diameter greater than 50 mm and length no less than 200 mm. This element will have appropriate characteristics (permeability, length, pore diameter) depending on the formation characteristics in which it is installed, in the order of 50 to 60cm. The permeability of the element will be slightly greater (up to one order of magnitude) than the one of the formation at the location of the installation.
Electrical piezometers consist of a porous ceramic element or other material approved by AM with an external diameter greater than 30mm. This element will have appropriate characteristics (permeability, length, pore diameter) depending on the formation characteristics in which it is installed. The permeability of the element will be slightly greater (up to one order of magnitude) than the one of the formation at the location of the installation. The electrical leads are protected by a PVC-U outer cover.

The filter which is placed in the perimeter of the casings is clean filter sand within grading limits of 0.2 and 1.2 mm, or clean rounded gravel of 2 mm to 5 mm, preferably of river origin and silicate composition. It is supplied on site in sealed bags. The Contractor will submit to AM for approval the grading of the filter that he intends to use.
The bentonite which will be used for sealing shall be in the form of lumps or pellets and the bentonite which will be used for the preparation of grout shall be clayey.
The sealing grout shall consist of sand and clayey bentonite in the proportion of 2:1 by weight. The quantity of the added mixing water shall allow the formation of a pumpable mix.
The concrete used in the capping arrangements shall be C10/15.

At the worksite, there will be a sufficient quantity of all materials required for the installation of piezometers.

The quantity of the materials to be used for the execution of works will be accurately measured prior to the installation and a record of the used quantities will be kept.

2A.A.3 Installation of open standpipe piezometers

1. Before the installation of piezometer, the borehole depth is checked. There must be no excavation spoil more than 20 cm thick. In case there are excavation spoil more than 20 cm thick the borehole will be cleaned.
2. The pipes are glued together with fast setting special glue for PVC and adhesive tape for better protection of the joints, in order to ensure they remain watertight and fixed before and after their installation at the borehole.
3. The perforated or slotted section of the pipes must be protected by plastic mesh in two layers. Placement of the mesh must be done carefully with overlap of 2-3 cm. The second layer follows with reverse direction.
4. Initially, bentonite lumps are placed at the bottom of the borehole in order to form a seal of at least 50 cm thickness.
5. First stage of filter installation follows: upon the bentonite seal and before the installation of the pipes, filter of 30 cm thickness is installed.
6. If the depth of the borehole is 1.5 m greater than the installation depth then, at the bottom of the borehole, grout is injected with the use of tremie pipe in a way that the upper edge of the grout is at least 0.8 m below the scheduled base of the filter. Following, stages 4 and 5 are implemented.
7. After first stage of filter installation the pipes are installed. The pipes shall be installed with the use of spacers in order to ensure their installation at the centre of the borehole.
8. Second stage of filter installation: the rest of the filter is placed continuously and in small quantities so as to avoid caving and achieve a homogenous filling of the gap between pipes and ground. The filter shall be installed up to 30 cm above the perforated pipe.
9. Then, another layer of bentonite pellets or lumps is placed in order to ensure that the length of the seal is not less than 50 cm.
10. Then, grout is placed up to the borehole cap, using a tremie pipe. The next day, the grout is filled if required.
11. The capping arrangements (paragraph 2A.A.7) are executed the soonest possible following the completion of the piezometer installation. Until the caps are complete and secure, the Contractor is responsible for the safety and security of the installation.

2A.A.4 Installation of open pipe with inner hose piezometers

1. Stage 1 of para. 2A.A.3.

2. The pipes are glued together with fast setting special glue for PVC and adhesive tape for better protection of the joints, in order to ensure they remain watertight and fixed before and after their installation at the borehole. The porous element is fitted at the lower end of the pipes.

3. Stage 4 of para. 2A.A.3.

4. Stage 5 of para. 2A.A.3.

5. Stage 6 of para. 2A.A.3.

6. The pipes and the porous element are installed.

7. Second stage of filter installation: the rest of the filter is placed in such a manner to secure a 30 cm coverage above the porous element.

8. Stage 9 of para. 2A.A.3.

9. Stage 10 of para. 2A.A.3.

10. Stage 11 of para. 2A.A.3.

2A.A.5 Installation of closed electrical piezometers

1. Stage 1 of para. 2A.A.3.

2. Stage 4 of para. 2A.A.3.

3. Stage 5 of para. 2A.A.3.

4. Stage 6 of para. 2A.A.3.

5. The electrical instrument is installed. The cables shall be protected by tubing, flexible or not, which terminate at the borehole cap.

6. Second stage of filter installation: the rest of the filter is placed in such a manner to secure a 30 cm coverage above the porous element.

7. Stage 9 of para. 2A.A.3.

8. Stage 10 of para. 2A.A.3.

9. Stage 11 of para. 2A.A.3.

10. Where required, the electric cables are taken from the borehole to a remote terminal unit. The details are agreed with AM before each installation. Where the cable tubing is laid in trenches, the depth is not less than 30 cm from the surface and surrounded with sand. The pipes are coded with marker tape every 2 m to allow their identification and such identification is permanently marked on the terminal unit.

2A.A.6 Verification of installation of piezometers

2A.A.6.1 General

Upon completion of the installation the Contractor will prove that the piezometer operates properly. The verification of installation of the various piezometer types is executed in accordance with the provisions of para. 9.3.2 of the standard ELOT EN ISO 22475-1. For open standpipe piezometers, the provisions of para. 2A.A.6.2 herein apply.

In case the piezometer is out of order, the Contractor will repeat the whole procedure related to the borehole execution and piezometer installation at a nearby location at his own expense.

2A.A.6.2 Open standpipe piezometers' development procedure

The verification of installation of open standpipe piezometers is executed using the piezometer development procedure by the air-lift method as follows:

1. Measurement of ground water level before any action.
2. Installation of the nozzle connected to the air/water pipe. The nozzle shall be made of metal, at least 2 m long and placed at the deepest point of the borehole. The nozzle outlet shall be facing upward, so as to facilitate the air/water movement without damaging the lower part of the piezometer.
3. Cleaning with fresh water of low pressure and normal flow and mixing up with slight movement of the pipe up and down.
4. Cleaning with water stops when water coming out of the borehole is relatively clear and there is no coarse-grained material.
5. Then, the procedure of pressing air into the piezometer. The air pressure increases progressively, until counterbalancing the water column and causing water to come out of the pipe with as normal flow as possible. Extraction of water with high pressure must be avoided, because the objective of this procedure is water extraction not trapping the air into the piezometer filter or around it.
6. Low pressure air compressor shall be used (up to 100 psi) and sufficient supply (> 200 ft^3/min).
7. The duration of the air-lift shall be as required so that the water coming out of the piezometer is clear.
8. In case of non-clear water, the cleaning with fresh water is repeated.
9. Then, measurements of restoration of the water level are performed and recorded, in order to determine the normal operation of the piezometer.

2A.A.7 Construction of protective measures of piezometer

As soon as installation works are completed, protective measures shall be implemented as per para. 9.1.2.5 of ELOT EN ISO 22475-1 (see also appendix E of standard ELOT EN ISO 22475-1).

The termination of the piezometer pipe shall be properly capped within a suitably configured manhole, covered with heavy duty lid. The top surface of the lid shall not protrude from the reinstated area. The design of the piezometer protection measures, the details and the required materials shall be proposed by the Contractor in the CGI Programme.

When artesian conditions are encountered with water flowing on the surface, the Contractor shall necessarily install closed type piezometer and shall seal the hole with grout.

2A.A.8 Piezometer maintenance

The Contractor shall ensure the proper operation of the piezometers throughout the Projects' duration by executing periodical maintenance inspections, as well as whenever there is evidence that piezometers are 'blocked'.

Maintenance inspections of the piezometers are carried out in accordance with the provisions of para. 9.4 of ELOT EN ISO 22475-1.

2A.B APPENDIX B: Engineering geological description of borehole cores

2A.B.1 Principles and procedure of the engineering geological description

The engineering geological description refers to engineering geological units (units in short). The procedure of the engineering geological description refers to two distinct methodologies: the description of rocks and the description of soils, in accordance with the references of the following paragraphs.

An engineering geological description is made for all sampling cores and in all trial pits, as stipulated herein and it is gradually realised in the following four distinct and successive phases:

Phase 1

Description of the cores by the Borehole Geologist during the drilling: rudimentary macroscopic description of soil and rock units (name of unit) and determination of TCR, SCR, RQD and If (for rock core drilling), or TC (for soil core drilling). These data are recorded in the Daily Borehole Report.

Phase 2

Detailed macroscopic description of soil and rock carried out by the Engineering Geological Description Geologist during the inspection of the cores of a borehole or a group of boreholes: an analytical macroscopic description of all necessary soil and rock characteristics, rock mass classification (GSI), the determination of the unit boundaries as well as the primary assignment of the geological formation are carried out at this phase. Data are recorded in the Macroscopic Description Borehole Report. At this phase, the borehole cores are photographed per core box. After the description of borehole cores, sample selection for laboratory testing takes place under the supervision of the Head of Laboratory, as well as the description of the pertographic type for each sample. The works of this phase take place at an appropriately sheltered area, to allow all core boxes of the boreholes to be described to be able to be opened simultaneously. The Contractor will provide all necessary materials for the works of this phase (geological hammer, water supply for the sprinkling of the borehole cores prior to description, hydrochloric acid, magnifying glass, soil cutting tools, colour scale, architect's scale, tape measure, sample cling film, sample collection containers, empty core boxes for the transportation of the samples to the laboratory etc.).

Phase 3

Macroscopic description of samples (or specimens) during execution of the laboratory tests. The Head of Laboratory shall examine the sample (or specimen) in relation to the description of the lithological type of the phase 2 sample (. Whenever there is difference between the description of the lithological type of the sample and the description in phase 2, the new description is recorded. The lithology type of the sample is recorded in the respective laboratory test sheet, which shall be attached to the GI Factual Report.

Phase 4

Compilation of the Borehole Log by the Engineering Geological Description Geologist, where the description of each formation is finalised after the co-evaluation of all available data (macroscopic description, laboratory and in situ test results, correlation of formations in adjacent boreholes etc.).

NOTE For the description of phase 2, the Contractor shall timely inform AM about the time and place of the opening of the core boxes in order for a representative to be present. After the end of phase 2, copies of the Macroscopic Description Borehole Sheets shall be handed to AM.

NOTE At phase 2, the group of boreholes which are to be described shall, as far as possible, consist of adjacent boreholes to allow for a better determination and correlation of the formations. The Engineering Geological Description Geologist shall bear the Daily Borehole Sheets of the group of boreholes in order to be used for the engineering geological description.

2A.B.2 Engineering geological description of rock units

2A.B.2.1 General

The description of the rock unit shall correspond to that of the rock (lithological or petrographic type) it is composed of. Whenever the unit is made of more than one rock types, the description of the unit shall result from the synthesis of the description of the described rock types. The methodology of the engineering geological description of rocks shall follow the provisions of the standard ELOT EN ISO 14689. With regard to earth works (excavation of tracks), a second description/ classification method is also required (see Article 2229 of the Material and Workmanship Specifications for Civil Works).

All rock characteristics which are examined and recorded in the succession given below:

1. Unconfined compressive strength of intact rock.
2. Rock structure.
3. Rock colour.
4. Rock texture.
5. Rock grain / mineral size.
6. Rock weathering and alteration.
7. Unit name (in uppercase).
8. Geological formation (in parentheses, in uppercase).
9. Rock mass discontinuities.
10. Core recovery and core fracture state of rock mass.
11. Rock mass weathering.
12. Additional properties.

NOTE From the above characteristics, elements 1 to 8 and 12 are reported in the unit description field of the Macroscopic Description Report and the Borehole Sheet. Elements 9 to 11 are recorded in the respective fields of the Borehole Log and may be reported in the unit description field, wholly or partially, only when deemed necessary (e.g. “discontinuities with filled with calcite”, “total core recovery 20 %” etc.).

NOTE Description of elements 1 to 8 (rock characteristics) is reported in one sentence. A sentence for elements 9 to 11 (rock mass characteristics) and 12 (additional data and information) follows, whenever deemed necessary.

NOTE In cases of alternations of rocks with different geotechnical properties, the description shall be a synthesis of the descriptions of the two types when layers are distinct, regardless whether the form a unified unit. Whenever the alternations are of such a scale that does not allow the distinct description of the individual rock types, the description will be unified.

Example Alterations of medium strong, with thick foliage, green-grey, faded META-SILTSTONE (ATHENS SCHIST, LOWER FORMATION). The unit appears slightly folded.

Guidelines are given below for the description of the individual properties which are examined.

2A.B.2.2 Unconfined compressive strength of intact rock

The unconfined compressive strength (UCS) of intact rock is reported in accordance with the provisions of para. 5.3 of the ELOT EN ISO 14689 standard. During phase 2, UCS is identified macroscopically based on Table B.1. If necessary, UCS is corrected at phase 4 based on the results of the laboratory tests.

Table B.1: Field identification of the unconfined compressive strength

Term	Identification by hand test	Unconfined compressive strength (MPa)
Extremely weak	Scratched by thumbnail, gravel size lumps can be crushed between finger and thumb	0,6 – 1
Very weak	Scratched by thumbnail, lumps can be broken by heavy hand pressure, can be peeled easily by a pocket knife, crumbles under firm blows with point of geological hammer	1 – 5
Weak	Thin slabs, corners or edges can be broken off with hand pressure, can be peeled by a pocket knife with difficulty, easily scratched by pocket knife, shallow indentations made by firm blow with point of geological hammer	5 – 12,5
Moderately weak	Thin slabs, corners or edges can be broken off with heavy hand pressure, can be scratched with difficulty by pocket knife, hand-held specimen can be broken with single firm blow of geological hammer	12,5 – 25
Medium strong	Cannot be scraped or peeled with a pocket knife, specimen on a solid surface can be fractured with single firm blow of geological hammer	25 – 50
Strong	Specimen requires more than one blow of geological hammer to fracture it	50 – 100
Very strong	Specimen requires many blows of geological hammer to fracture it	100 – 250
Extremely strong	Specimen can only be chipped with geological hammer	> 250

NOTE Some extremely weak rocks will behave as soils and should be described as soils in accordance with para. 2A.B.3 herein.

NOTE In cases of units of alternations of rocks with different strength, either a range of strength is given, form the weakest to the strongest, or a different strength for each rock.

NOTE Attribution of a strength range that exceeds an order of magnitude should be avoided (e.g. very weak to medium strong).

NOTE N.B.: this strength, which refers to the strength of the intact rock, should not be confused with the strength of the containing rock mass. The strength of the rock mass will obviously be lower and will be derived indirectly (e.g. with the utilisation of appropriate failure criteria).

2A.B.2.3 Rock structure

Rock structure is reported in accordance with the provisions of para. 6.3 of the standard ELOT EN ISO 14689. Examples referring to the rock structure are given in Table B.2:

TABLE B.2 — Examples of terms which may be used in the description of rock

Sedimentary	Metamorphic	Igneous
Term	**Term**	**Term**
Bedded (see Table B.6) Interbedded Laminated Folded Massive Graded	Cleaved Foliated Schistose Banded Lineated Gneissose Folded	Massive Flow-banded Folded Lineated

For flat structure elements, the terms in Table B.2 shall be used in conjunction with the terms in Table B.3 (e.g. very thin bedded) or of the spacing of discontinuities in Table B.6 (e.g. very dense foliage).

Table B.3 — Terms to describe bedding thickness

Term	Spacing
Very thick bedded	> 2 m
Thick bedded	0,6 m – 2 m
Medium bedded	20 cm – 60 cm

Term	Spacing
Thin bedded	6 cm – 20 cm
Very thin bedded	2 cm – 6 cm
Thickly laminated	6 mm – 20 mm
Thinly laminated	< 6 mm

NOTE It is possible for the structural elements of the rock to constitute or not constitute discontinuities. In the event the structural elements are discontinuities then these should also be described as rock mass discontinuities (para. 2A.B.2.10). As concerns this item, there is a differentiation between this document and Standard ELOT EN ISO 14689: in this document, the structure is assumed to be a characteristic of the rock and of the rock mass – in case the flat structural element is a discontinuity, while in ELOT EN ISO 14689 the structure is assumed to be a characteristic only of the rock mass.

2A.B.2.4 Rock colour

Colour is described in accordance with the provisions of para. 5.1 of the standard ELOT EN ISO 14689 as follows: one term from each column of Table B.4 is combined to identify the colour to be used .

Table B.4 — Terms for lightness, chroma and hue which may be used in combination for colour description (examples)

Lightness	Chroma – Secondary descriptor	Hue – primary descriptor
Light Dark	Reddish Pinkish Orangish Yellowish Brownish Greenish Bluish Greyish	Red Pink Orange Yellow Cream Brown Green Blue White Grey Black

If deemed necessary, the colour differences in a rock may be pointed out and be described separately with the use of terms such as spots, specks, stripes etc.

EXAMPLES Light brownish-red, dark brown, yellowish-green with greyish-white stripes.

A colour collection can be especially useful in order to ensure compatibility among descriptions coming from different persons under different lighting conditions. The best lighting conditions are those outdoor or next to window in a bright or cloudy day.

2A.B.2.5 Rock texture

Rock texture is described in accordance with the provisions of para. 44.2.4 of the standard BS 5930. Rock texture refers to the interrelation of the minerals from which it consists of, which may exhibit a preferable orientation. Common terminology for the rock texture description comprises the terms porphyritic, crystalline, crypto-crystalline, amorphous, glassy etc.

NOTE Macroscopic description of texture is only for special cases of crystalloid rocks, whose textural features are apparent on a microscopic scale.

NOTE An analytical description of rock texture may be found in the petrographic analyses which are prescribed (rock microscopic analysis, see Table G.2).

2A.B.2.6 Grain / mineral size

The grain / mineral size is described in accordance with the provisions of para. 5.2 of the standard ELOT EN ISO 14689.

The subject size refers to medium size of the main grain / mineral forming the rock and it consists in a main diagnostic criterion for the determination of the petrographic

type, e.g. sedimentary or igneous rocks (see Table A.1 of ELOT EN ISO 14689).

Usually, an estimation of the grain/mineral size by naked eye is sufficient however, a magnifying lens may be used for the identification of fine grained and amorphous rocks. It is possible that a separate description of the grain/mineral size and the rock matrix.

2A.B.2.7 Rock weathering and alteration

Rock weathering / alteration is defined in accordance with the provisions of para. 5.4 of the standard ELOT EN ISO 14689.. The result of the rock weathering / alteration shall be recorded as a primary element to identify the grade and extent of weathering / alteration of the rock and the materials left after the weathering / alteration process. The relevant information concern the following characteristics:

The grade and extent of the changes in the colour of the rock

The initial (primary) unconfined compression strength of the rock (intact rock) and any changes related to weathering / alteration.

In order to have a description of the rock weathering/alteration, it is possible to apply adjectives to the terms of Table B.5, such as: partially discoloured, completely discoloured or slightly discoloured. The three latter terms may also be used in combination such as: completely discoloured and slightly disintegrated.

Table B.5 — Terms to describe weathering/alteration of rock materials

Term	Description
Fresh	No visible sign of weathering/alteration of the rock material.
Discoloured	The colour of the original fresh rock material is changed and is evidence of weathering/alteration. The degree of change from the original colour should be indicated. If the colour change is confined to particular mineral constituents, this should be mentioned.
Disintegrated	The rock material is broken up by physical weathering, so that bonding between grains is lost and the rock is weathered/altered towards the condition of a soil in which the original material fabric is still intact. The rock material is friable but the mineral grains are not decomposed.
Decomposed	The rock material is weathered by the chemical alteration of the mineral grains to the condition of a soil in which the original material fabric is still intact; some or all of the mineral grains are decomposed.

2A.B.2.8 Unit name

The identification of the unit name derives from the characteristics of the rock (or rocks), such as origin (sedimentary (clastic, chemical or organic), igneous (plutonic, volcanic) or metamorphic), structure, texture, mineral composition, grain/mineral size, voids etc. An aid to rock identification is given in Table A.1 in Appendix A of the standard ELOT EN ISO 14689, as regards the description of basic sedimentary, igneous and metamorphic rocks.

The terminology of the lithological (petrographic) types and units is given in para. 2A.B.5.

2A.B.2.9 Geological unit

The geological unit is estimated during Phase 2 and is finalized during Phase 4, when it will be obligatorily registered in the Macroscopic Description Sheets and the Drilling Logs. The geological units in the wider area and their characteristics can be identified on the geological maps of the Institute of Geology and Mineral Exploration (IGME).

2A.B.2.10 Rock mass discontinuities

Discontinuities are described in accordance with the provisions of para. 6.4 of the standard ELOT EN ISO 14689. Discontinuity is defined as a surface in the rock material, interrupting its continuity, the tensile or shear strength of which, across or

along it, is lower than the strength of the rock material.

The following discontinuities' characteristics are described and recorded:

Discontinuity type with respect to their genesis, as such: bedding plane, foliation, schistosity, joint, fault, shear, cleavage, incipient fracture, induced fracture, etc.
Orientation: only the dip of discontinuity.
Spacing, terminology in accordance with Table B.6.
Discontinuity roughness: The terms which are used are: *planar, undulating and stepped* in conjunction with terms: *rough, smooth and striated, slickensided.*
Discontinuity aperture based on Table B.7.
Infilling: the discontinuity infill is reported, e.g. *soil*, minerals such as *calcite, quartz, epidote, chlorite, clay minerals, oxides, hydroxides, gouge* or *breccia* etc. As the case may be and wherever it is relevant, the shear strength and the swelling potential of the infill will also be described.

Table B.6 — Terms to describe discontinuities spacing

Term	Spacing
Very wide	> 2 m
Wide	0.6 m – 2 m
Medium	20 cm – 60 cm
Close	6 cm – 20 cm
Very close	2 cm – 6 cm
Extremely close	< 2 cm

Table B.7 — Terms for the description of discontinuity aperture

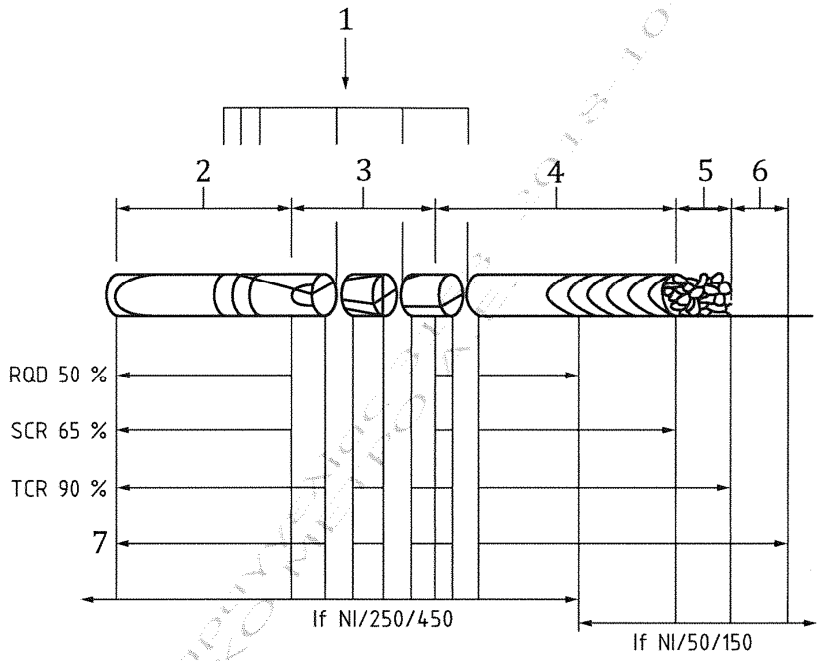
Term	Aperture
Very tight	< 0.1 mm
Tight	0.1 mm – 0.25 mm
Partly open	0.25 mm – 0.5 mm
Open	0.5 mm – 2.5 mm
Moderately wide	2.5 mm – 10 mm
Wide	1 cm – 10 cm
Very wide	10 cm – 100 cm
Extremely wide	> 1 m

The remaining characteristics of discontinuities (persistence, seepage characteristics, number of sets and rock block size, see paragraphs 6.4.4, 6.4.5, 6.4.9 and 6.4.10 of ELOT EN ISO 14689) are described only in rockmass occurrencies and cannot be possibly described in borehole cores.

2A.B.2.11 Core recovery and core fracture state of rock mass

Fracture state is described with the following terms, in accordance with the provisions of para. 7 of the standard ELOT EN ISO 14689 (Figure B.1):

Figure B.1 — Application of fracture state terms for rock cores



Legend of Figure B.1:

1. drilling-induced fractures
2. solid core (at least one full diameter)
3. no single full diameter
4. solid core (at least one full diameter)
5. non-intact
6. no recovery
7. core run

TCR (total core recovery) is the summed length of core recovered (both solid and non-intact), in the total core run, expressed as a percentage.
SCR (solid core recovery) is the summed length of solid cylinder core pieces recovered inthte core run, where solid core has at least one full diameter, expressed as a percentage.
RQD (rock quality designation) is the summed length of solid core pieces each with at least one full diameter recovered in the core run where each piece is at least 100 mm long or larger between natural fractures, expressed as a percentage.
If (fracture index) is the spacing between natural fractures along the core in zones of uniform character, not per core run. The If can usefully be given as a minimum, mode and maximum values within each zone.

NOTE Solid core has a full diameter which is not interrupted by discontinuities but not necessarily a full perimeter and its length is measured along the core axis.

NOTE Drilling induced fractures should not be considered for the calculation of the RQD and SCR.

NOTE With respect to the Alpine bedrock units, RQD should be assigned only in rocks, in rock masses which contain discontinuities which can be described and in rock masses which are described as heavily fractured. RQD assignment should be avoided for rock masses within which heavily sheared and soil-like units are dominant such as clayey schist.

NOTE As regards Neogene - Quaternary units, RQD should be assigned only on rock materials.

2A.B.2.12 Rock mass weathering

Rock mass weathering is described in accordance with the provisions of para. 6.5 of standard ELOT EN ISO 14689.

Rock mass weathering is described on the basis of the distribution and quantitative

relation between fresh rock and discoloured, disintegrated or decomposed rock in conjunction with the discontinuity weathering. The weathering process finally converts the rock in soil and as such, the rock mass weathering description is carried out in relation with the existence of three “phases” within the rock mass: rock, rock and soil, soil.

For the description of the rock mass weathering the following six-stage scale of Table B.8 is used.

Table B.8 — Scale of weathering stages of rock mass

Term	Description	Grades
Fresh	No visible sign of rock material weathering; perhaps slight discolouration on major discontinuity surfaces.	0
Slightly weathered	Discolouration indicates weathering of rock material and discontinuity surfaces.	1
Moderately weathered	Less than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as continuous framework or as core stones.	2
Highly weathered	More than half of the rock material is decomposed or disintegrated. Fresh or discoloured rock is present either as continuous framework or as core stones.	3
Completely weathered	The entire rock is decomposed or disintegrated. The original structure of the rock mass is still intact to a great extent.	4
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume. But the soil has not been significantly transported.	5

NOTE Table B.8 gives a typical weathering classification scale and may not be applicable to all rock mass types. Annex B of Standard ELOT EN ISO 14689 presents a more general weathering classification scale as concerns rock and rock mass.

NOTE Weathering/alteration description should be carried out with particular attention since, given that it is discharged on borehole cores which do not necessarily reflect the true state of the rock mass.

2A.B.2.13 Additional characteristics

They refer to all characteristics which are not included in elements 1 to 8, para. 2A.B.2.1 (e.g. rock degradation, in line with paragraph 5.6 of ELOT EN ISO 14689, carbonate content for carbonate rock, in line with paragraph 5.5 of ELOT EN ISO 14689), or to characteristics which are included in elements 9 to 11 of the same para. and it is deemed necessary to be stressed in the unit description field.

NOTE In cases of sieve analyses in soil-like zones of rock masses, these are not required to be described in the unit description field as additional characteristics and they will be reported in the respective Borehole Log column.

2A.B.3 Engineering geological description of soil units

2A.B.3.1 General

The description of the soil unit shall correspond to the description of the lithological type of which it is composed. In case of more than one lithological type, the description shall be a synthesis of the descriptions of the composing lithological types. The methodology of the engineering geological description of soils will, in principle, follow the standards ELOT EN ISO 14688-1 and 2. As regards earthworks (track troughs), another method of description/classification is also required (see Article 2229 of the “Materials and Workmanship Specifications for Civil Works”).

In the unit description field the following elements will be reported in the displayed sequence:

1. Consistency or relative density.

2. Discontinuities.
3. Bedding.
4. Colour.
5. Strength of cohesive soils.
6. Unit name (base group name in uppercase) and symbol (in parenthesis).
7. Geological formation (in parentheses, in uppercase).
8. Size, shape and mineral composition of granular fractions.
9. Shape and description of very granular fractions.
10. Maximum size of very granular fractions.
11. Additional characteristics.

NOTE Description of elements 1 to 7 is reported in one sentence, followed by elements 8 to 11 in one or more sentences. Any elements out of the above not characterizing the soil formation will be deleted.

NOTE In case of a unit with alternations of different soil layers, when the layers are distinct they should be described separately regardless of being united as a unified unit. Whenever the alternations are of such a scale that does not allow the distinction of the composing layers, the description will be unified. See also paragraph 7.3 of ELOT EN ISO 14688-1

EXAMPLE Moderate, dense, light greyish-green, slightly clayey GRAVELLY SAND, well graded, with stones (grSa-w) (QUATERNARY FLUVIO-TORRENTIAL DEPOSITS). Fine quartz sand, coarse medium-sized gravels, well rounded, of calcareous and schist origin. Well-rounded stones made of moderately strong, pinkish-grey, sound LIMESTONE. D_{max} = 120mm. C_U = 17 and C_C = 0.2 (gap-graded).

Guidelines are given below for the description of the individual characteristics which are examined.

2A.B.3.2 Consistency or relative density

Consistency is determined at phase 2, in fine grained (cohesive) soils by a field macroscopic estimation in accordance with para. 6.1.6 of the standard ELOT EN ISO 14688-1 and is corrected, if necessary, at stage 4 based on laboratory test results (determination of Consistency Index $I_C = (w_L\text{-}w)/I_p$), in accordance with para. 5.5 of the standard ELOT EN ISO 14688-2.

The terminology as regards the consistency and the respective Consistency Index IC is given in Table B.90.

Table B.9 — Consistency terms for fine grained soils

Term	Consistency description definition	Consistency index I_C
Very soft	Finger can be easily pushed In up to 25 mm. Soil exudes between the fingers when squeezed in the hand.	< 0,25
Soft	Finger can be pushed In up to 10 mm. Soil can be moulded by light finger pressure.	0,25 – 0,50
Firm	Thumb makes an impression easily. Soil cannot be moulded by fingers, but rolls in the hand to 3 mm thick threads without braking or crumbling.	0,50 – 0,75
Stiff	Soil can be indented slightly by thumb. Soil crumbles and breaks when rolling to 3 mm thick threads but is still sufficiently moist to be moulded to a lump again.	0,75 – 1,00
Very stiff	Soil can be indented by thumb nail. Soil cannot be moulded but crumbles under pressure. Many desiccated soils fall in this class.	> 1,00

NOTE The above subdivisions of consistency may be approximate, especially for low plasticity cohesive materials (e.g. silts).

Relative density is determined in coarse grained soils, by laboratory tests (determination of Density Index $I_D = (e_{max}\text{-}e) / (e_{max}\text{-}e_{min})$), in accordance with para. 5.2 of ELOT EN ISO 14688-2. Additionally, relative density may be estimated by in situ tests (e.g. Standard Penetration Test SPT). The terminology as regards the relative density of coarse grained soils is given in Table B.11.

Table B.10 — Relative density of coarse grained soils

Term	Density index I_D (%)	$(N_1)_{60}$
Very loose	0 – 15	0 - 3
Loose	15 – 35	3 - 8
Medium dense	35 – 65	8 - 25
Dense	65 – 85	25 - 42
Very dense	85 – 100	42 - 58

NOTE Normalized blow count for normally consolidated natural sand deposits. For the determination of the normalised blow count see EN ISO 22476-3.

2A.B.3.3 Discontinuities

The discontinuities' types are described as: fissure, shear plane, fault, and induced fracture. In addition to the above, the term 'fissured' states that the soil breaks along slippery discontinuities and the term 'sheared' states that the soil breaks along slickensided shear planes.

Other discontinuities related features are described in accordance with para. 2A.B.2.10 herein.

2A.B.3.4 Bedding

Bedding is described in accordance with para. 2A.B.2.3 herein. Bedding thickness is described in accordance with Table B.3 herein.

Bedding may appear as parallel surfaces (planar bedding) but may also appear in other forms as a result of sedimentation processes, e.g. cross-bedding, graded bedding etc. Bedding planes may or may not constitute discontinuities, as the case may be.

2A.B.3.5 Colour

Colour is described in accordance with para. 2A.B.2.4 herein. Colour description should be carried out on a fresh exposure of the soil as, in some cases, the soil colour changes rapidly when in contact with air. Furthermore, alterations of the original soil colour due to oxidation or drying should be recorded.

2A.B.3.6 Strength of cohesive soils

The terminology regarding the undrained shear strength is given in Table B.11.

Table B.11 — Undrained shear strength of fine soils

Strength	Undrained shear strength C_u (kPa)	Equivalent unconfined compressive strength q_u (kN/m^2)
Extremely low	< 10	< 20
Very low	10 – 20	20 – 40
Low	20 – 40	40 – 80
Medium	40 – 75	80 – 150
High	75 – 150	150 – 300
Very high	150 – 300	300 – 600
Extremely high	> 300	> 600

NOTE Materials with undrained shear strength greater than 300kPa may behave as weak rocks and may be described in accordance with para. 2A.B.2.

2A.B.3.7 Unit name

Initially, the soils shall be classified into groups according to the Hellenic Soil Classification System HSCS (AnnexH).The name of the unit shall correspond to the name of the soil group wherein the soil sample is classified and shall be recorded as follows: the name of the base group (see para. 2A.H.10.3) wherein the soil is

classified is reported in uppercase and the other characteristics (secondary fractions, tertiary constituents) are reported in lowercase are reported in lowercase. At the end of the name, the soil group symbol is given in parentheses.

EXAMPLE slightly calcareous gravely sandy, slightly organic, HIGH PLASTICITY CLAY ((or)Cl-H).

During phase 2, there is a macroscopic examination of the unit (determination and per weight estimate of the primary and secondary fractions, determination of probable tertiary constituents, plasticity of fines (if applicable) and determination of organics and/or calcium carbonate (if applicable), see ELOT EN ISO 14688-1, followed by the application of the HSCS criteria HSCS (see para. 2A.H.10). In case the unit is made up by more than one lithological type, macroscopic examination for each type is carried out, while the name of the unit shall result as a synthesis of the name of the individual lithology types.

During phase 4 and after the classification tests, the name of the units shall be corrected – if required, on the basis of the results of these tests.

2A.B.3.8 Geological unit

The references regarding the description of rock units apply (para. 2A.B.2.9).

2A.B.3.9 Size, shape and mineral composition of granular fractions.

2A.B.3.9 Particle *size* is described for gravel and sand based on Table B.12 (see also Table H.1) and is finalised for all materials after the execution of the classification laboratory tests.

Table B.12 — Terms for coarse fraction size

Term	Particle size (mm)
Coarse gravel	> 20 – ≤ 63
Medium gravel	> 6.3 – ≤ 20
Fine gravel	> 2 – ≤ 6.3
Coarse sand	> 0.63 – ≤ 2
Medium sand	> 0.2 – ≤ 0.63
Fine sand	> 0.063 – ≤ 0.2

Particle *shape* shall be described in accordance with paragraph 6.1.2 of LEOT EN ISO 14688-1. Description shall be made of the shape of gravels only. The terms *very angular, angular, sub-angular, sub-rounded, rounded* and *well-rounded* in conjunction with the terms *cubic, flat* or *tabular* and *elongated*, as well as rough and smooth are used (see also Figure 17 of BS 5930).

The mineral composition shall be described in accordance with paragraph 6.1.4 of ELOT EN ISO 14688-1. The rock of origin of gravels shall be given (*limestone gravel, gneiss gravel* etc.) whereas as regards sand, if possible, the composing minerals shall be given (*quartzitic sand, muscovite sand* etc.).

2A.B.3.10 Shape and description of very granular fractions

The shape of the very granular fractions (stones, boulders and large boulders) is described in accordance with paragraph 6.1.2 of ELOT EN ISO 14688-1 (for terminology, see paragraph 2A.B.3.9). A subsequent description is made of the rock forming the granular fractions, in accordance with the stipulations of paragraphs 2A.B.2.2 to 2A.B.2.8.

EXAMPLE Rounded stones, elongated and smooth, moderately strong, compact, pinkish-grey, crystalline, sound LIMESTONE and moderately weak, with schistocity, greyish-green, discoloured GREY SCHIST.

NOTE The case of sampling in soils with very coarse-grained fractions is not actually representative of the soil. In this case, the following statement shall be recorded: "*very coarse-grained fraction – non representative sampling*", followed by the location (depths) and the description of the very coarse-grained fractions as above.

2A.B.3.11 Maximum size of very coarse-grained fractions

In case of very coarse-grained fractions, the maximum grain size D_{max} shall be recorded.

2A.B.3.12 Additional characteristics

The additional characteristics can record any characteristics of the soil formation not included in the above paragraphs 2A.B.3.2 to 2A.B.3.11 and it is deemed advisable to include them in the description.

2A.B.4 Special cases and man-made deposits

During sampling, when voids, ducts and other structures are encountered, these will be described as units and shall be classified under the geological unit “Man-made Deposits”.

Description of other structures within the Man-Made Deposits shall be effected in line with paragraph 2A.H.5 (f) (see paragraph 6.2.4 of ELOT EN ISO 14688-1).

2A.B.5 Designation and coding of lithological types and engineering geological units

2A.B.5.1 Petrographic types and rocky engineering geological units

The purpose of the terminology referring to the petrographic types in the following Tables is to assist the geologist in the description of borehole cores by choosing, on the basis of the macroscopic description one executes, one of the petrographic types in Tables B.13 and B.14. These Tables include the pertographic types described in the framework of earlier ground investigations (see also *Geotechnical Baseline Report*). This terminology is by no means binding to the geologist which carries out the macroscopic description to choose from one of these names.

Table B.13 presents the AGS field code.

Table B.13 — Petrographic types

s/n	Term	ROCK_DESC
1	BRECCIA	BREC
2	Calcareous BRECCIA	BRECCC
3	CONGLOMERATE	CONG
4	Calcareous CONGLOMERATE	CONGCA
5	GRIT	GRIT
6	SANDSTONE	SDST
7	Calcareous SANDSTONE	SDSTCA
8	SILTSTONE	SLST
9	Calcareous SILTSTONE	SLSTCA
10	Gravelly SILTSTONE	SLSTGR
11	CLAYSTONE	CST
12	Calcareous CLAYSTONE	CSTCA
13	Gravelly CLAYSTONE	CSTGR
14	MARL	MRL
15	Calcareous MARL	MRLCA
16	MARLY LIMESTONE	MRLMST
17	Thin-bedded MARLY LIMESTONE	MRLMSTTB
18	Intraclastic MARLY LIMESTONE	MRLMSTBR
19	Karstic MARLY LIMESTONE	MRLMSTCR
20	LIMESTONE	LMST
21	Intraclastic LIMESTONE	LMSTBR
22	Karstic LIMESTONE	LMSTCR
23	DOLOMITE	DL
24	METASANDSTONE	MSDST
25	Calcareous METASANDSTONE	MSDSTCA

s/n	Term	ROCK_DESC
26	METASILTSTONE	MSLST
27	Calcareous METASILTSTONE	MSLSTCA
28	SHALE	SHALE
29	PHYLLITE	PHYL
30	Calcareous PHYLLITE	PHYLCA
31	Chlorite SCHIST	SCHCL
32	Chlorite quartzitic SCHIST	SCHCLQ
33	Chlorite epidote SCHIST	SCHCLE
34	Calcareous SCHIST	SCHCA
35	Calcareous chlorite SCHIST	SCHCACL
36	Mica quartzitic SCHIST	SCHMQ
37	SERPENTINITE	SEPITE

In the case of variable rock units, the terms is derived from the combination and participation percentages of the petrographic types listed in Table B.14. Table B.14 also presents the AGS field code.

Table B.14 — Terminology for variable rock unit

Participation (%) of the primary petrographic type (A)	Participation (%) of the secondary petrographic type (B)	Name of unit	GEOL_LEG
90	10	A with rare intercalations B [1] A with thin intercalations B [1]	A9B1
70	30	A with intercalations B	A7B3
50	50	Alteration A and B	A5B5

NOTE 1 Depending of the structure of the unit.

2A.B.5.2 Soil lithological types and rocky engineering geological units

The purpose of the terminology referring to the soil lithological types (Table B.15) is identical with the names of the basic groups of soil of the soil classification HSCS (Table H.2).

Table B.15 — Soil lithological types

s/n	Term	ROCK_DESC
1	GRAVEL	GR
2	SANDY GRAVEL	GRSA
3	GRAVELLY SAND	SAGR
4	SAND	SA
5	SILTY GRAVEL	GRSI
6	CLAYEY GRAVEL	GRCL
7	SILTY SAND	SASI
8	CLAYEY SAND	SACL
9	SILT	SIL
10	MEDIUM PLASTICITY SILT	SIM
11	HIGH PLASTICITY SILT	SIH
12	VERY HIGH PLASTICITY SILT	SIV
13	LOW PLASTICITY CLAY	CLL
14	MEDIUM PLASTICITY CLAY	CLM
15	HIGH PLASTICITY CLAY	CLH
16	VERY HIGH PLASTICITY CLAY	CLV

In the case of variable soil units, the names mentioned in Table B.14 can be used.

2A.B.6 Names for special cases of units

Table B.16 presents the names of special cases of materials and the corresponding AGS field code.

Table B.16 — Special cases of units

s/n	Term	GEOL_LEG
1	ASPHALT	ASPHALT
2	PAVEMENT	PAVE
3	CONCRETE	CONCR
4	WEATHERING MANTLE	WRMATL
5	SHEAR ZONE	SHEAR
6	CATACLASITE	CATACLASITE
7	SOIL MATERIALS (undifferentiated)	FILL
8	VOID	VOID
9	Karstic VOID	CRVOID
10	FILLED CARSTIC VOID	CRFILL
11	QUARTZ	QUARTZ
12	CALCITE	CALCITE

2A.C APPENDIX C: Rock mass classification systems

2A.C.1 General

As regards rock mass classification, the Contractor shall utilize the Geological Strength Index (GSI) system and any other (if necessary) classification system.

The Rock Mass Classification system may be correctly applied on the borehole cores requires category A sampling, according to the provisions of para. 7.2 of standard ELOT EN ISO 22475-1. It is obvious that special attention should be paid to the implementation of rock mass classification systems on disturbed cores (category B sampling) since in these cases there is inevitably increased uncertainty as to the estimation of individual parameters as to the rock mass structure (RQD, Jspacing and Jcondition for MR, rock mass structure and discontinuities condition for GSI). Therefore, the Geologist involved in the preparation of the rock mass classification will decide on the level of uncertainty introduced based on the sampling condition and will subsequently, depending on the case, implement the rock mass classification with caution, or proclaim that its implementation is not possible.

2A.C.2 Geological Strength Index – GSI

2A.C.2.1 General

The Geological Strength Index (GSI) is based on the estimation of lithology, structure and rock mass discontinuities' condition. This para. refers to the application of the GSI both during the borehole core description and the Project excavation faces (tunnel faces, excavation and pits' slopes etc.).

2A.C.2.2 Application of the Geological Strength Index

For the application of the Geological Strength Index, the following bibliography is proposed. It is pointed out that due to the continuous assessment of data and information ensuing from the application of the GSI on technical projects, the latest bibliography is updated based on the relevant experience and therefore are more important.

Marinos V, Fortsakis P, Prountzopoulos G, 2011. *Estimation of geotechnical properties and classification of geotechnical behaviour in tunnelling for flysch rock masses*. In: Anagnostopoulos A et al. (eds) *Proceedings of the 15th European conference on soil mechanics and geotechnical engineering*. Part 1, Athens, pp. 435–440.

Marinos P., Marinos V., Hoek E., 2007. *Geological Strength Index (GSI). A characterization tool for assessing engineering properties for rock masses*, In:

Proceedings of the Rock Mass Classification Workshop, publ: Department of Earth and Human Services, NIOS, Information IC9498, Information circular 2007, Vancouver.

Marinos V, Marinos P, Hoek E., 2005. *The geological Strength index: applications and limitations.* Bull. Eng. Geol. Environ., 64:55-65.

Marinos, B., Marinos, P., Hoek, E., 2004. *Geological Strength Index GSI. Implementation, recommendations, restrictions and fields of change according to rock type*. Bulletin of the Geological Society of Greece, XXXVI. Proceedings of the 10th International Conference, Thessaloniki 2004.

Marinos P, Hoek E., 2001. *Estimating the geotechnical properties of heterogeneous rock masses such as flysch*. Bull. Eng. Geol. Environ. 60:82–92.

Marinos P, Hoek E., 2000. *GSI: a geologically friendly tool for rock mass strength estimation*. In: *Proceedings of the GeoEng2000 at the international conference on geotechnical and geological engineering*, Melbourne, Technomic publishers, Lancaster, 1422–1446.

Hoek E, Marinos P, Benissi M., 1998. *Applicability of the geological strength index (GSI) classification for weak and sheared rock masses - the case of the Athens schist formation*. Bull. Eng. Geol. Environ. 57(2):151–160.

2A.C.2.3 Recommendations for the application of the Geological Strength index

Special attention should be paid during the application of the GSI to the following points, according to the provisions of the relevant bibliography presented in above:

Application of the GSI to borehole cores

During the engineering geological description of borehole cores the punctual borehole information should be protruded at the Project scale in order to assess the rock mass GSI value more properly. For this reason, a co-assessment of the adjacent boreholes should be made in order to appreciate the rock mass structure at the Project scale. Moreover, the attribution of GSI values to core sections less than 1m long should be avoided; however, the application of the GSI to lengths representative of the geomaterial at the Project scale should be preferred. In general, it is safe to attribute GSI values to distinct strata, as described. It is noted that the GSI is on its own a criterion of stratum segregation since different GSI values are obviously due to different structure or discontinuities' conditions and consequently to different mechanical characteristics. Therefore, the strata to which the GSI is attributed should generally coincide with the strata resulting from the engineering geological description.

Application of the GSI to heterogeneous rock masses

Heterogeneous rock masses are considered those on which there are alternating strata of different lithological types with significant differences to their mechanical characteristics. As to these rock masses, the application of the relative chart (GSI for heterogeneous rock masses such as flysch, V. Marinos, 2007). In any case, the application of the "classic" GSI chart (Geological Strength Index for jointed rock masses, Hoek and Marinos, 2000) is not excluded, taking into account the experience of the person who describes. In the second case, the member of the heterogeneous rock mass which is the least adequate will be considered as discontinuity infill and, therefore, the discontinuities' condition will have to range from poor to very poor or, marginally, fair depending on the layer's thickness of the least adequate member, its lithology and its degree of tectonism.

Application of the GSI to rock masses with few and infrequent discontinuities (usually rock masses of the Neogene - Quaternary age)

The use of the GSI on rock masses with few and infrequent discontinuities, whose

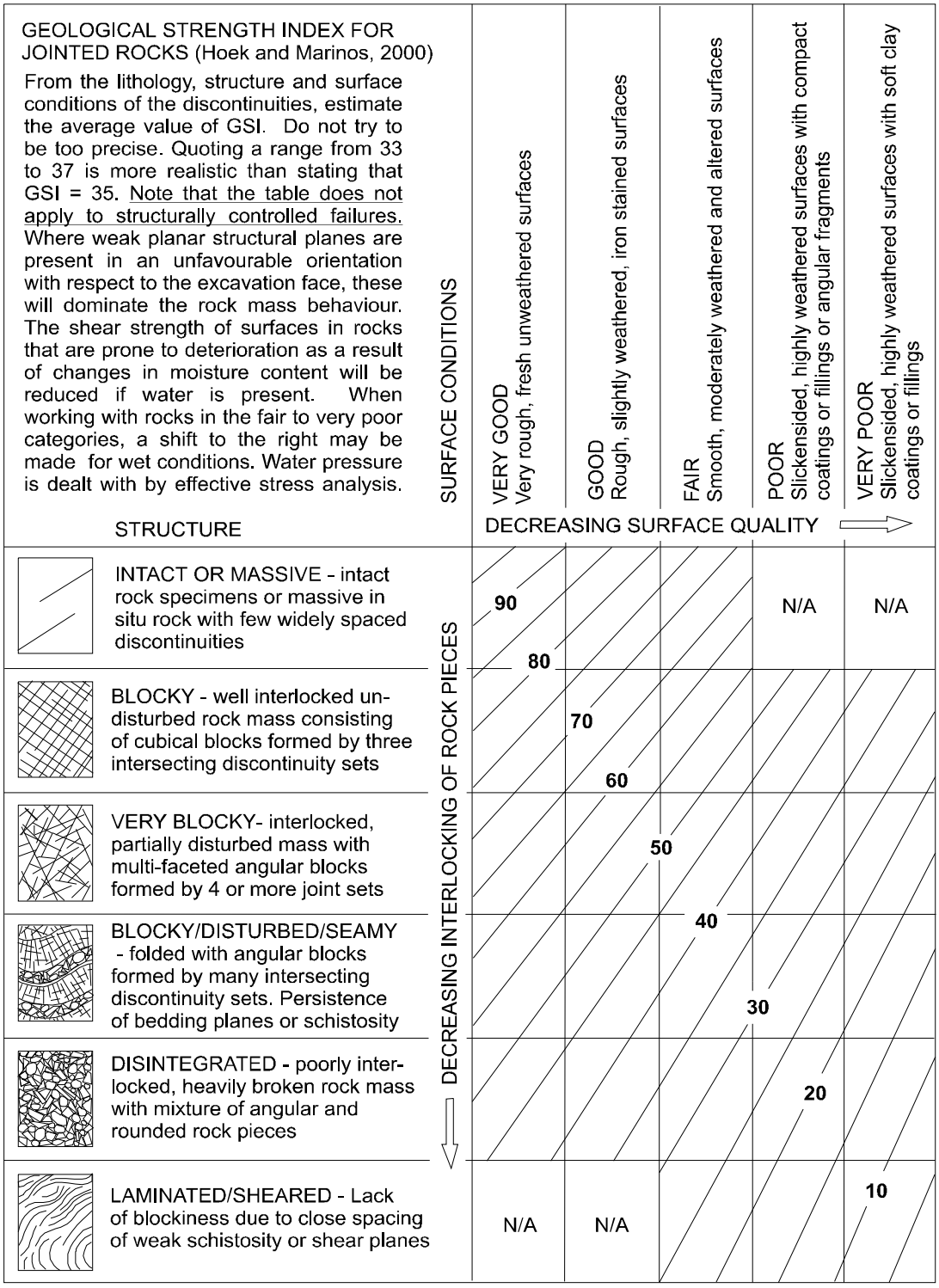
effect on their behaviour as to the deformation is negligible on a Project scale, should be avoided. In these cases, the intact rock samples are representative of the rock mass and, therefore, strength and deformation parameters can directly result from laboratory tests on intact rock samples.

Strength of intact rock

Intact rock unconfined compressed strength is not taken in consideration in the GSI classification, since it is included as an independent parameter during the application of the Hoek-Brown failure criterion. Based on the above, the geologist who proceeds with the classification should be particularly careful not to confuse the sense of the rock mass structure with the intact rock strength. Therefore, rock masses with very weak to weak intact rock (e.g. metasiltstone) are attributed GSI values throughout the entire range provided for in the respective charts, depending on the structure and the condition of their discontinuities, but not necessarily poor values.

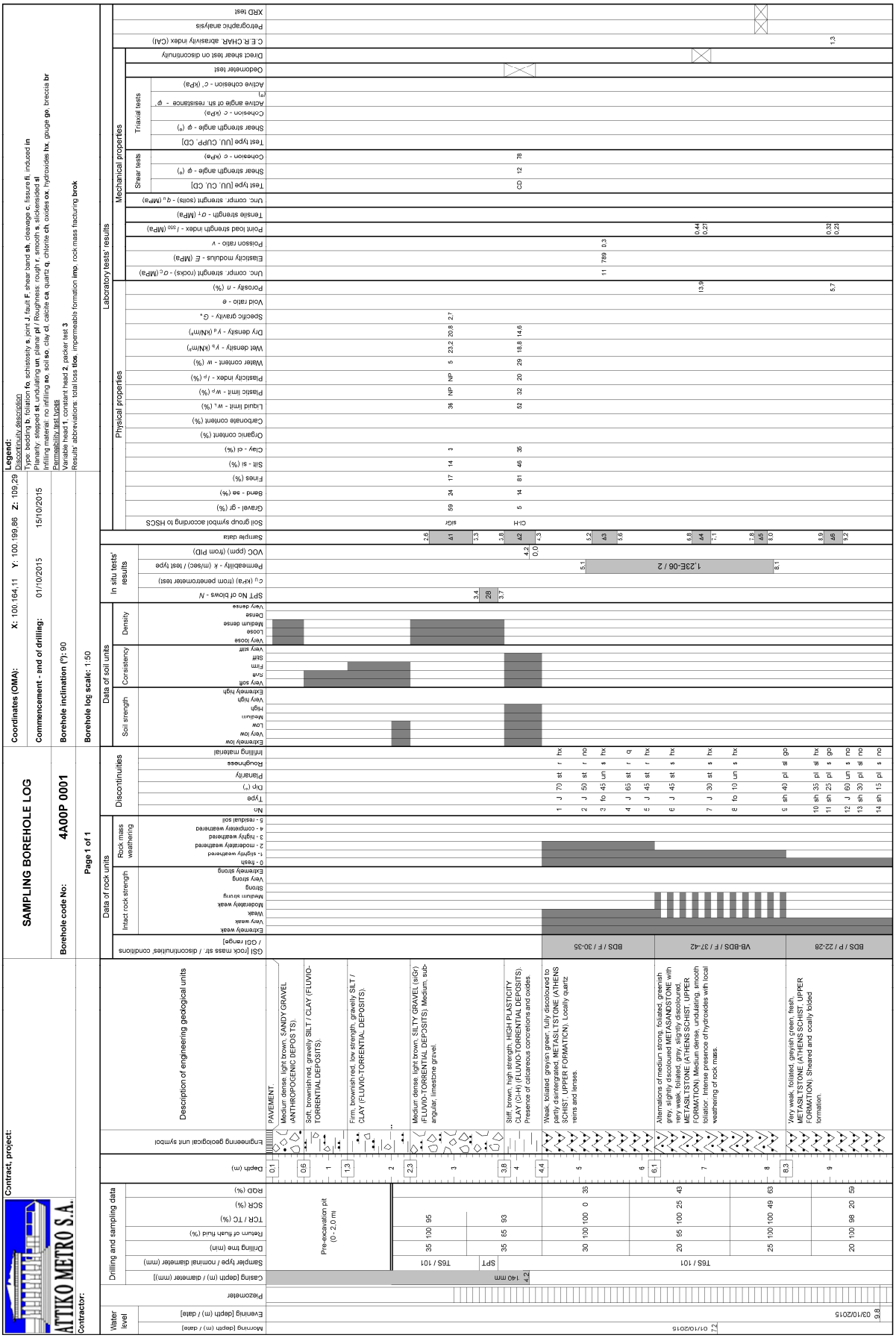
The relevant GSI charts which are applicable to the anticipated rock masses in the Project area are presented below.

2A.C.2.4 Geological strength index for jointed rock masses (Hoek and Marinos, 2000)



2A.C.2.5 Not applicable

2A.D APPENDIX D: BOREHOLE LOG (sample)



2A.E APPENDIX E: Not applicable

2A.F APPENDIX F: Codification of points of investigation and measurements

The purpose of this appendix is to provide a unified system for the codification of the ground investigation points (boreholes, trial pits, etc.) or measurements (ground water level measurements, etc.) and to render possible the identification of their details (such as location, type, etc.) by means of a code designation.

All points of investigation shall be designated by a unique code. Whenever there are earlier boreholes or trial pits executed by AM, then AM shall provide to the Contractor their pertinent codes, in order to avoid repetition of already assigned codes.

The code designation does not serve as a substitute for the correlation of the investigation point with geographical coordinates.

The total number of characters in a code shall be eight (8). The four first characters designate the location and type of the investigation or measurement point, while the last four characters are used as the sequence number. All shall be Latin characters (not the numbers).

More specifically, the first five characters are assigned with the following values:

1st and 2nd character: refers to the Athens Tramway and is assigned with the Latin letter **"TR"**.

3rd character: refers to the Tramway Line section and the Project and is assigned with the Latin letter **"H"**.

4th character: specifies the type of the investigation point or the measurement instrument and is assigned with values in accordance with Table F.1 below.

Table F.1 — Values assigned to the fifth character of the code

Value (Latin character)	Location of the investigation or measurement point
P	Sampling borehole, with piezometer
H	Sampling borehole, without piezometer
Z	Non sampling borehole, with piezometer
R	Pressuremeter borehole
C	Cone Penetration Test (CPT) borehole
Y	Trial pit
O	Investigation pumping well / Well

2A.G APPENDIX G: Available data from geological and geotechnical investigations

The available data from executed geological and geotechnical investigations are given in Table G.1.

Table G.1 — Geological and geotechnical investigations

No	Title	Code	Prepared by/Date
1	Modern Tramway corridor in the Athens greater area, Detailed Final Design, Elliniko Depot – Rails Workshop, Geotechnical survey, Document with Results	DFD CA ALN DP GEO 2073 0 G	TERNA-IMPREGILO, Geoterra / 29.03.2002
2	Modern Tramway corridor in the Athens greater area, Detailed Final Design, Elliniko Depot – Maintenance Building, Geotechnical survey, Document with Results	DFD CA ALN DP GEO 1073 0 G	TERNA-IMPREGILO, Geoterra / 03.04.2002
3	Modern Tramway corridor in the Athens greater area, Detailed Final Design, Elliniko Depot – Geotechnical survey, Investigation shafts, Document with Results	DFD CA ALN DP GEO 0 0 G	TERNA-IMPREGILO, Geoterra / 18.04.2002
4	Modern Tramway corridor in the Athens greater area, Detailed Final Design, Elliniko Depot – Shed, Geotechnical survey, Evaluation Document – Foundation related Opinion	DFD CA ALN DP GEO 1073 0 G	TERNA-IMPREGILO, Geoterra / 02.05.2002
5	Modern Tramway corridor in the Athens greater area, Detailed Final Design, Elliniko Depot – Shed, Geotechnical survey, Evaluation Document – Foundation related Opinion	DFD CA ALN DP GEO 8074 0 G	TERNA-IMPREGILO, Geoterra / 02.05.2002
6	Modern Tramway corridor in the Athens greater area, Detailed Final Design, Elliniko Depot – Geotechnical survey, Evaluation Document	DFD CA ALN DP GEO 0000 0 G	TERNA-IMPREGILO, Geoterra / 29.10.2002

2A.H APPENDIX H: Soil Classification according to the Hellenic Soil Classification System – HSCS

2A.H.1 Introduction - Scope

This appendix describes the procedure for classifying the soils into groups of soils, in the framework of the geotechnical investigations and tests. The soils shall be classified on the basis of the Hellenic Soil Classification System, HSCS. This system was developed in order to cover the need for the application of a system for classifying soils in the framework of geotechnical investigations and tests carried out in Greece which would be compliant to Eurocode 7 (ELOT EN 1997). This classification system was initially presented during the 7th Pan Hellenic Conference on Geotechnical Engineering of 2014 (Boronkay et. al., 2014). The first 2014 edition has been modified in this document for harmonization with ELOT EN ISO 14688-1:2017 and ELOT EN ISO 14688-2:2017.

NOTE: All classification principles specified in ELOT EN ISO 14688: 2-1017 have been taken into account with the following exceptions:

In HSCS, in terms of fines, the percentage of 35% is used as distinction limit between fine and coarse soils contrary to the percentage of 50% proposed in Table 1 of ELOT EN ISO 14688-2:2017.

In HSCS, the field “CIL-SiL” is not used in the proposed fines plasticity chart as per ELOT EN ISO 14688-2:2017 (compare Fig. 1 in ELOT EN ISO 14688-2:2017 with Fig. H.3 of the document).

2A.H.2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitues requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ELOT EN 1997-1, Eurocode 7: Geotechnical design – Part 1: General rules.

ELOT EN 1997-1, Eurocode 7: Geotechnical design – Part 2: Ground investigation and testing.

ELOT EN ISO 14688-1, *Geotechnical investigation and testing – Identification and classification of soil – Part 1:Identification and description*

ELOT EN ISO 14688-2, *Geotechnical investigation and testing – Identification and classification of soil – Part 2 : Classification principles*

ELOT EN ISO 14689, Geotechnical investigation and testing – Identification, description and classification of rock.

ELOT EN ISO 17892-4, *Geotechnical investigation and testing – Laboratory tests on soil – Part 4: Determination of particle size distribution*

ELOT CEN ISO/TS 17892-12, *Geotechnical investigation and testing – Laboratory tests on soil – Part 12: Determination of liquid limit and plastic limit*

ELOT EN ISO 22475-1, Geotechnical investigation and testing - Sampling methods and groundwater measurements – Part 1: Technical principles for execution.

2A.H.3 Terms and definitions

For the purposes of this document, the following terms and definitions deriving from parts 1 and 2 of ELOT EN ISO 14688 are valid.

2A.H.3.1 carbonate soil

soil containing a percentageof calcium carbonate > 1% (for more information, see para. 5.3 of ELOT EN ISO 14688-1).

2A.H.3.2 anthropogenic soil

soil placed by human activity which can be divided into those composed of reworked natural soils and those composed of synthetic materials

NOTE Anthropogenic soil that can be further divided into *fill*, when deposit is is placed with engineering control, or into *made ground* or *reconstituted ground*, when the deposit is placed without engineering control.

2A.H.3.3 loess

windblown (aeolian) sediment (for more information, see para. 5.6 of ELOT EN ISO 14688-1).

2A.H.3.4 activity index

I_A

$I_A = I_P$ / CF

the ratio of plasticity index I_P to the per weight percentage % of the clay fraction in soil *CF*.

NOTE The activity index may provide an indication of the colloidal characteristics of the clay fraction and mainly concerns the type and the percentage of clay minerals and the organic colloids in the soil, as well as the existence of electrolytes in the water inside the soil pores.

NOTE The following terms can be used in relation to the activity of the soil: if $I_A \geq 1.25$, the soil is characterized as *active*, while when $0.75 < I_A < 1.25$, the soil is characterized as *normal* and when $I_A \leq 0.75$, as *inactive*.

2A.H.3.5 plasticity index

I_P

$I_P = w_L - w_P$

the difference between the liquid limit and the plasticity limit of fine grained soil

NOTE Soil whose plasticity limit is equal to zero or whose plasticity limit cannot be determined is termed non-plastic.

2A.H.3.6 consistency index

I_C

$I_C = (w_L – w) / I_P$

the difference between the liquid limit and the water content expressed as a percentage of the plasticity index

2A.H.3.7 soil

Aggregate of minerals and/or organic materials, which can be disaggregated by hand in water.

NOTE This term also applies to made-ground materials exhibiting similar behaviour, which however hve been reworked and placed again or which are anthropogenic, e.g. backfill, crushed rock, mined materials etc.

NOTE Soil produced from weathered/altered rocks presenting rock structures and/or tissues whose strength is lower than the strength of the rocks.

2A.H.3.8 volcanic soil

unconsolidated pyroclastic sediment produced and formed by explosive volcanic eruption (for more information, see para. 5.5 of ELOT EN ISO 14688-1).

EXAMPLES bombs, blocks, lapilli, volcanic ash (see also para. 6.2.1 of ELOT EN ISO 14688-1).

2A.H.3.9 sulfide soil

Soil with high content of iron sulfide (for more information, see para. 5.4 of ELOT EN ISO 14688-1).

2A.H.3.10 particle size distribution or grading

measure of the particle sizes of a soil and their distribution

2A.H.3.11 particle size fraction or size fraction

portion of soil defined by a range of particle sizes

The names of the particle size fractions, their symbols and the range of their size are shown in Table H.1 (see also Table 1 of ELOT EN ISO 14688-1).

Table H.1 — Particle sizes and symbols of particle size fractions

Categories of particle size fractions	Particle size fractions [1]	Symbols	Range of particle sizes (mm) [1]
Very coarse fractions	Large boulder	lBo	> 630
	Boulder	Bo	> 200 and ≤ 630
	Cobble	Co	> 63 and ≤ 200
Coarse fractions	Gravel	Gr	> 2 and ≤ 63
	Sand	Sa	> 0,063 and ≤ 2
Fine fractions	Silt	Si	> 0,002 and ≤ 0,063 [2]
	Clay	Cl	≤ 0,002 [2]
NOTE 1 Particle size ranges .for silt and clay are given only as a reference for the particle size of “silt particles” and “clay particles” and not for “silt” and “clay” as fine fractions.			

2A.H.3.12 fines

the total of the soil fine fraction –namely the soil fraction passing from the 0.063mm sieve - which can be classified as clay or silt.

2A.H.3.13 soil group

soils of similar composition and geotechnical properties

2A.H.3.14 organic soil

soil containing a high proportion of plant and/or animal organic materials and the conversion products of those materials.

NOTE Organic soil presents very low density and, usually, a great percentage of humidity

2A.H.3.15 plastic limit

w_P

the water content where fine soil passes from the plastic to semi-consolidated state, as defined by the plastic limit determination test

2A.H.3.16 liquid limit

w_L

the water content where fine soil passes from the liquid to the plastic sate, as defined by the liquid limit determination test

2A.H.3.17 mineral soil

soil composed largely or entirely of mineral (inorganic) constituents

2A.H.3.18 water content

w

mass of water which can be removed from the soil, usually by drying, expressed as a percentage of the dry mass

2A.H.3.19 coefficient or curvature

C_C

$C_C = (D_{30})^2 / (D_{10} \times D_{60})$,

where D_{60}, D_{30} and D_{10} are the particle diameters corresponding to 60 %, 30 % and 10 % finer on the cumulative particle size distribution curve, respectively

2A.H.3.20 uniformity coefficient

C_U

$C_U = D_{60} / D_{10}$,

where D_{60} and D_{10} are the particle diameters corresponding to 60 % and 10 % finer on the cumulative particle size distribution curve, respectively

NOTE The particle size D_{10} is stated in the bibliography as active size (e.g. Koukis G.CH. & Sampatakakis N.S. (2002): *Technical geology*, p. 516, Papasotiriou Publications, Athens, Greece, ISBN 978-960-7530-09-7).

2A.H.3.21 classification of soil

integration of a soil to a soil group on the basis of characteristics and criteria related to the soil's behaviour and formation.

2A.H.3.22 till

multi-graded, not bedded sediment of glacigenic origin (for more information, see para. 5.7 of ELOT EN ISO 14688-1).

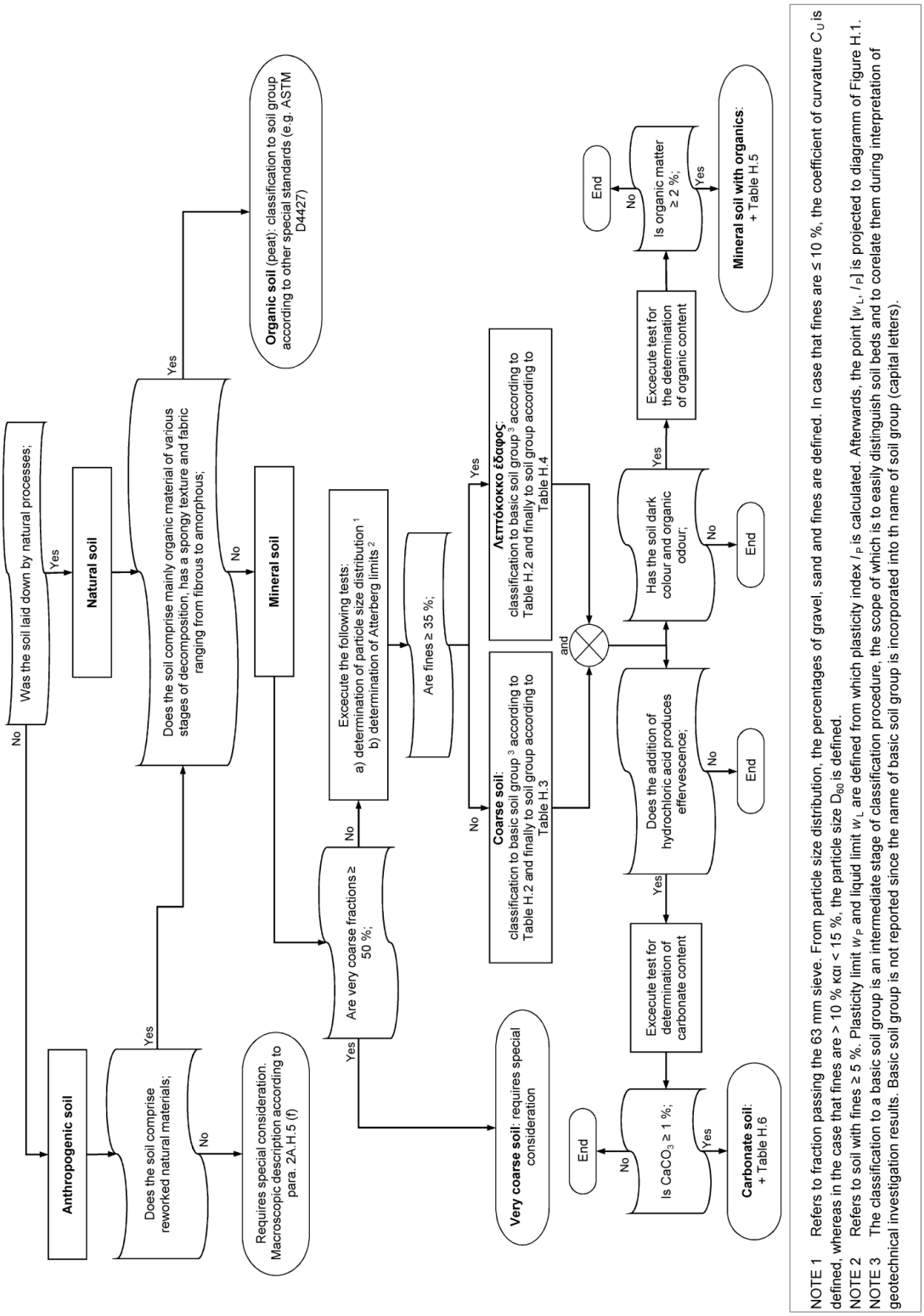
2A.H.4 Summary

Based on the flowchart in Fig. H.1, the HSCS establishes three categories of soils, namely: coarse, fine and organic soils. These three categories are further divided into 17 basic soil groups: 8 basic groups of coarse soils, 8 groups of fine soils (Table H.2) and one basic group of organic soils (peat).

In detail, based on the macroscopic characteristics of the soils and further to the execution of specific laboratory tests, soils are assigned with a symbol and a name based on the soil group into which they have been classified in line with Tables H.3 (groups of coarse soils) and H.4 (groups of fine soils) and additionally in line with Tables H.5 (mineral soils with organics) and H.6 (carbonate soils). Special attention must be given when classifying anthropogenic soils with anthropogenic components, very coarse soils and organic soils.

2A.H.5 Soil classification principles and application field

Figure H.1 — HSCS soil classification system / Flowchart



NOTE 1 Refers to fraction passing the 63 mm sieve. From particle size distribution, the percentages of gravel, sand and fines are defined. In case that fines are ≤ 10 %, the coefficient of curvature C_U is defined, whereas in the case that fines are > 10 % και < 15 %, the particle size D_{60} is defined.

NOTE 2 Refers to soil with fines ≥ 5 %. Plasticity limit w_P and liquid limit w_L are defined from which plasticity index I_P is calculated. Afterwards, the point [w_L, / $_P$] is projected to diagramm of Figure H.1.

NOTE 3 The classification to a basic soil group is an intermediate stage of classification procedure, the scope of which is to easily distinguish soil beds and to corelate them during interpretation of geotechnical investigation results. Basic soil group is not reported since the name of basic soil group is incorporated into th name of soil group (capital letters).

Before proceeding with the classification of the soil, the soil shall be identified and macroscopically described in line with ELOT EN ISO 14688-1, while soil characteristics and the soil's genetic origin shall be identified.

As regards its origin, soil is distinguished into *natural* and *anthropogenic*. Natural soils are further distinguished into *mineral* soils –including the *mineral soils with organics*, *volcanic soils, sulfide soils, carbonate soils, tills and loess– and organic soils*.

The HSCS is applicable to usual natural soils, as well as to anthropogenic soils of a similar composition encountered in Greece. Nevertheless, generally it can be applied in any other geographical location.

The soils are classified into soil groups, depending on their composition, irrespective of their water content or compactness, taking into account the particle size distribution, fine plasticity, the organics' content, calcium carbonate content and the origin of the deposit.

Mineral soils are further divided based on their particle size distribution into *very coarse soils* (very coarse fractions > 50%), *coarse soils* (fines <30%) and *fine soils* (fines >35%). The classification of the soil ends up in attributing a name and a symbol to the soil.

The procedure related to the identification and macroscopic description of the soil, together with the classification procedure, can be used for the purpose of describing the soil, while these procedures contribute to the evaluation of its significant characteristics, so thay they are used in geotechnical engineering.

HSCS is applied on all soils with the following exceptions / special cases:

- The classification of the anthropogenic soils that include anthropogenic materials, requires a special treatment, in line with the stipulations of para 2A.H.8.
- The classification of the very coarse soils (> 50 % of the soil consists of very coarse fractions) requires a special treatment.
- The classification of organic soils shall be made on the basis of other specialised standards (see para 2A.H.9).

2A.H.6 Equipment

In addition to the devices required for soil sampling, preparation of the soil sample and execution of the specified laboratory tests, a chart with the particle size distribution curve similar to the one shown in Fig. H.2 and a plasticity chart similar to the chart shown in Fig. H.3 are required.

2A.H.7 Sampling

Sampling is executed based on ELOT EN ISO22475-1 (paragraph 6.6). Soil samples of quality classes 1 to 4 are required (see para. 3.4.1 of Eurocode 7 (ELOT EN 1997-2) and para. 6.2 of ELOT EN ISO 22475-1).

2A.H.8 Classification of anthropogenic soils

Any soil which has not been placed by natural process shall be classified as *anthropogenic soil.*

If the anthropogenic soil includes only reworked natural components, it shall be classified in line with the provisions applicable for natural soil.

If anthropogenic soil also includes anthropogenic materials at a significant percentage, the macroscopic description of the soil shall include detailed recording of the following –per case- characteristics of these anthropogenic components

(paragraph 6.2.4 of ELOT EN ISO 14688-1), namely:

Origin of material

Presence of large objects, e.g. concrete, masonry, ceramics, metallic items etc.

Presence of voids or collapsible hollow objects

Chemical wastes and dangerous or toxic substances.

Organic matter, with a note on the degree of decomposition

Odorous smell

Striking colour tints

Any dates readable on buried papers

Signs of undergrounc heat or combustion, e.g. smoke emerging from borehole

Structure, variability and method of placement.

The classification of the anthropogenic soils, in case these involve anthropogenic materials, requires special handling, depending on their characteristics.

2A.H.9 Classification of organic soils

For organic soils, the sole basic group is *peat* (symbol: Pt). Peat is recognized from its macroscopic characteristics: it is composed of plant residues at various stages of decomposition, a spongy texture and a structure ranging from fibrous to amorphous.

In order to classify peat in soil groups, it is recommended to use specialized standards (e.g. ASTM D4427 or other equivalent standard).

NOTE If standard ASTM D 4427 is applied, the terminology for peat classification is provided in paragraph 2A.H.13.

2A.H.10 Classification of mineral soils

2A.H.10.1 Classification of very coarse soils

If during the macroscopic description it is ascertained that very coarse fractions are $\geq$50%, the soil shall be characterized as *very coarse*, while its classification requires special handling. Otherwise, the procedure described in paragraphs 2A.H.10.2 to 2A.H.10.6 shall apply.

2A.H.10.2 Preparation for classification

2A.H.10.2.1 Macroscopic description and identification of soil

Before classifying the soil, it is required to proceed with the macroscopic description and identification of the soil, in line with paragraph 2A.B.3. The macroscopic description shall identify –in terms of quality- very coarse fractions (cobbles, boulders and large boulders), whether the soil is natural or anthropogenic, mineral or organic, mineral with organics or carbonate soil (for the examined characteristics, see Fig. H.1).

2A.H.10.2.2 Required laboratory tests

After the macroscopic description, the following laboratory tests are performed:

a) In all soils, the *particle size analysis with sieves* must be performed for determining the soil fraction passing through a 63 mm sieve and the soil retained by the 0.063 mm sieve, in line with standard ELOT EN ISO 17892-4, using as a minimum the following series of standards on sieves (as per ISO 3310-1 and ISO 3310-2):

63 mm

20 mm

6,3 mm

2,0 mm

0,63 mm

0,20 mm

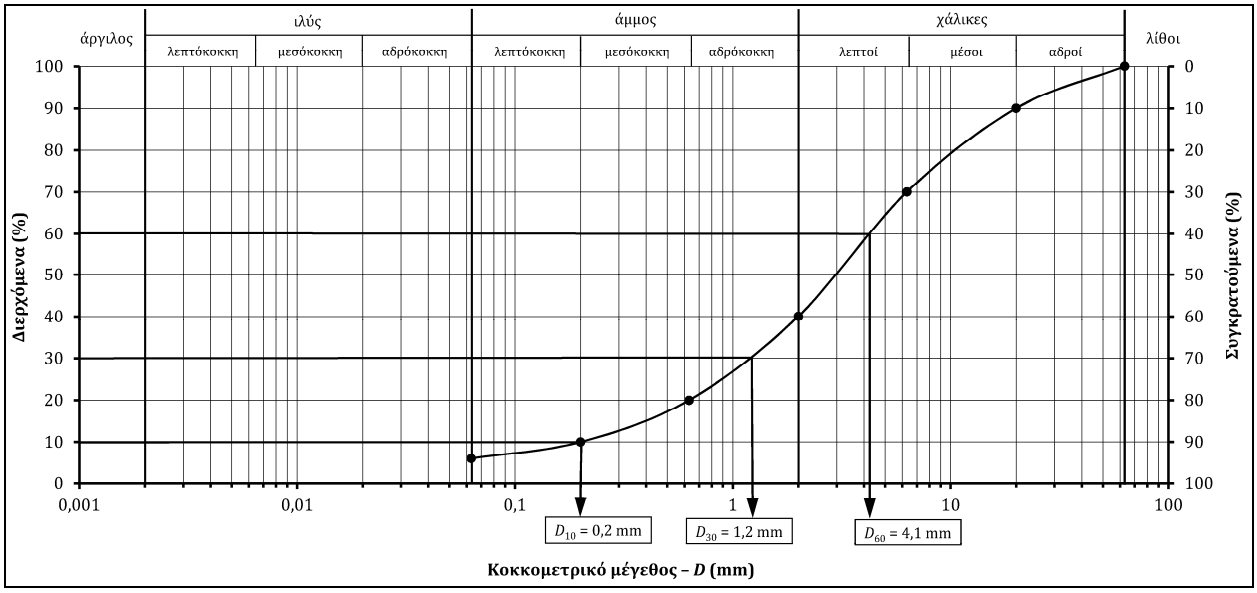
0,063 mm

NOTE The fractions retained by the 63 mm sieve are not considered in the soil sample's particle size analysis and their participation percentages do not participate in the particle size distribution curve

NOTE Even though the testing procedure for identifying the particle size grading may require an analysis using a sedimentation process, testing for identifying the particle size grading through a sedimentation process is not necessary for the classification of the soil.

The results of the particle size analysis shall be shown on a diagram similar to the semi algorithmic diagram on Fig. H.2 in the form of a particle size distribution curve. From the particle size distribution curve the proportions of the basic particle size fractions of the soil shall be determined, namely: gravel, sand and fines.

Fig H.2 — Particle size distribution curve diagram – Particle size distribution curve for coarse soil with fines < 10 %

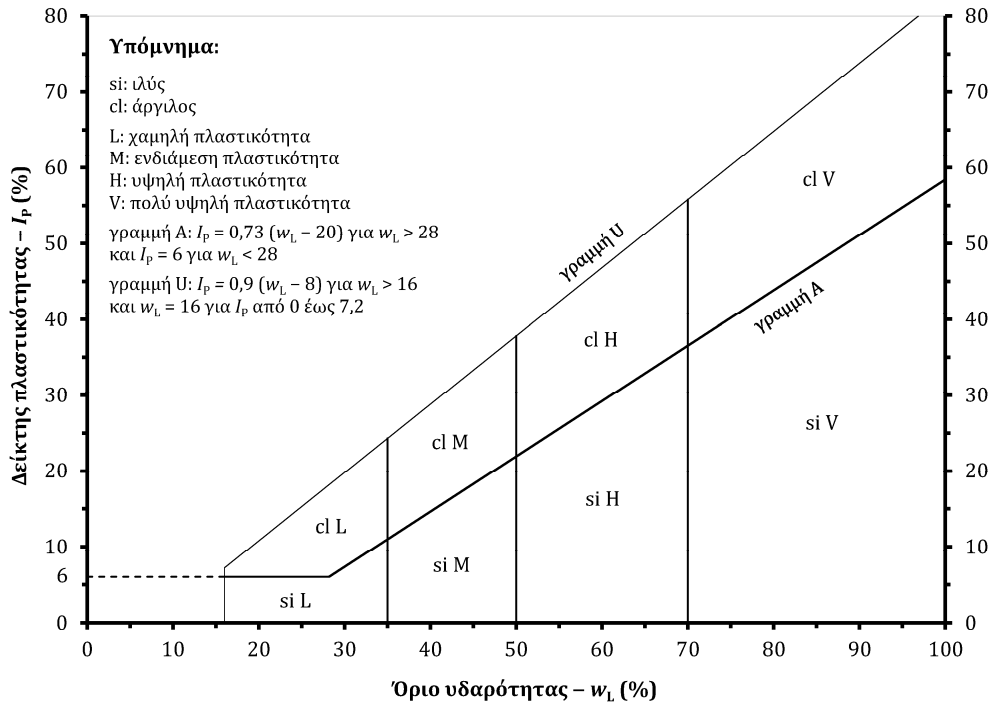


The percentage of the very coarse fractions (fraction retained by the 63 mm sieve) is recorded as an additional element. The maximum particle size of the soil D_{max} is also measured and recorded.

b) In case of soils with fines ≥ 5 %, in addition to the requirements of clause 2A.H.10.2.2(a), the execution of the test for the *determination of the liquid limit* and the test for the *determination of the plastic limit* of fines is required, in line with ELOT EN ISO 17892-12. The plasticity index (I_P) is calculated from the liquid limit and the plastic limit; then, point [w_L, I_P] is projected onto a plasticity chart similar to the one of Fig. H.3.

NOTE The tests for the determination of the liquid limit and the plasticity limit are executed on the soil fraction passing through a 0.425 mm or a 0.4 mm sieve.

Fig. H.3 — Plasticity chart of HSCS for the classification of fines (modified by ELOT EN ISO 14688-2, BS 5930 and ASTM D 2487)



NOTE The U line has been empirically determined to be the appropriate "upper limit" for natural soils. It is a good check against erroneous dat, and any test results presented that plot above or to the left of it should be verified.

c) In case of soils with fines < 10 %, additionally to the requirements specified in paragraphs 2A.H.10.2.2(a) and 2A.H.10.2.2(b), it is necessary to *determine the particle sizes D_{60}, D_{30} και D_{10}* (Fig. H.2).

d) In case of soils with fines ≥ 10 % and < 15 %, additionally to the requirements specified in paragraphs 2A.H.10.2.2(a) and 2A.H.10.2.2(b), it is necessary to *determine the particle size D_{60}* (Fig. H.2).

NOTE The differentiation in the determination of the particle sizes D_{60}, D_{30} and D_{10} between the soil with fines < 10 % and the soil with fines ≥ 10 % and < 15 % results from the fact that in the second case it is not possible to specify the particle size D_{10} from the particle size curve and, for this reason, the relevant grading criterion for these coarse soils is modified accordingly (see paragraph 2A.H.10.4).

e) In case of mineral soils with dark colour and odorous smell, in addition to the requirements of clauses 2A.H.10.2.2(a) to 2A.H.10.2.2(d), the relevant *tests for the determination of the percentage of the organics* must be executed. In soils with a very small percentage of clay fraction and/or carbonates, the percentage of organics is usually determined from the loss at ignition, under controlled temperature. The other method of determination is the loss of mass during processing with hydrogen peroxide (H_2O_2). The percentage of organics is determined according to ASTM D 2974, or AASHTO T 194, or other equivalent standard.

f) If during the addition of drops of hydrochloric acid solution (10 % HCl), the mineral soil becomes effervescent (see Table 7 ELOT EN ISO 14688-1), in addition to the requirements of clauses 18.10.2.2(a) to 18.10.2.2(e), the *execution of the test for the determination of the percentage of calcium carbonate* in line with standard ASTM D 4373 or standard 1377-3 or other equivalent standard is required.

2A.H.10.2.3 Classification of fines

Fines are classified in whole as clay or silt, depending on their plasticity and not their particle size distribution. The plasticity of the fines is determined by means of tests to determine the plastic limit (w_P) and the liquid limit (w_L), (clause 2A.H.10.2.2(b) by projecting the point [w_L, I_P] onto the plasticity chart shown in Figure H.3.

Depending on the field of the plasticity chart onto which the point [w_L, I_P] is projected, the fine fraction is classified as follows:

If the point is projected above line A, fines are characterized as *clay*, while depending on the liquid limit of the clay, they are characterized as *low plasticity clay* (w_L < 35 %), *intermediate plasticity clay* (35 % < w_L ≤ 50 %), *high plasticity clay* (50 % < w_L ≤ 70 %) and *clay of very high plasticity* (w_L > 70 %).
Similarly, if the point [w_L, I_P] is projected below line A, fines are characterised as *silt*, while depending on the liquid limit of the silt, they are characterized as *silt* (w_L < 35 %), *intermediate plasticity silt* (35 % < w_L ≤ 50 %), *high plasticity silt* (50 % < w_L ≤ 70 %) and *silt of very high plasticity* (w_L > 70 %).

NOTE The term “low plasticity silt” is not used, since it is a redundancy to characterize the silt as “low plasticity.

2A.H.10.3 Initial classification into basic soil groups

Soils with fines < 35 % are classified as *coarse soil*, while soils with fines ≥ 35 % are classified as *fine soil*. Coarse and fine soils are classified in the basic groups of soils presented in Table H.2 based on the criteria of the percentage of gravels, sand and fines and based on the classification of the fines.

Similarly, soils are classified into groups of soils in line with paragraphs 2A.H.10.4, 2A.H.10.5 and 2A.H.10.6.

NOTE The classification into a basic soil group constitutes an intermediate stage which aims at ensuring a simpler distinction of the soil layers and their correlation during the stage of the evaluation of the results of the geotechnical investigation and is not recorded, since the name of the basic group of soils is included in the name of the soil group.

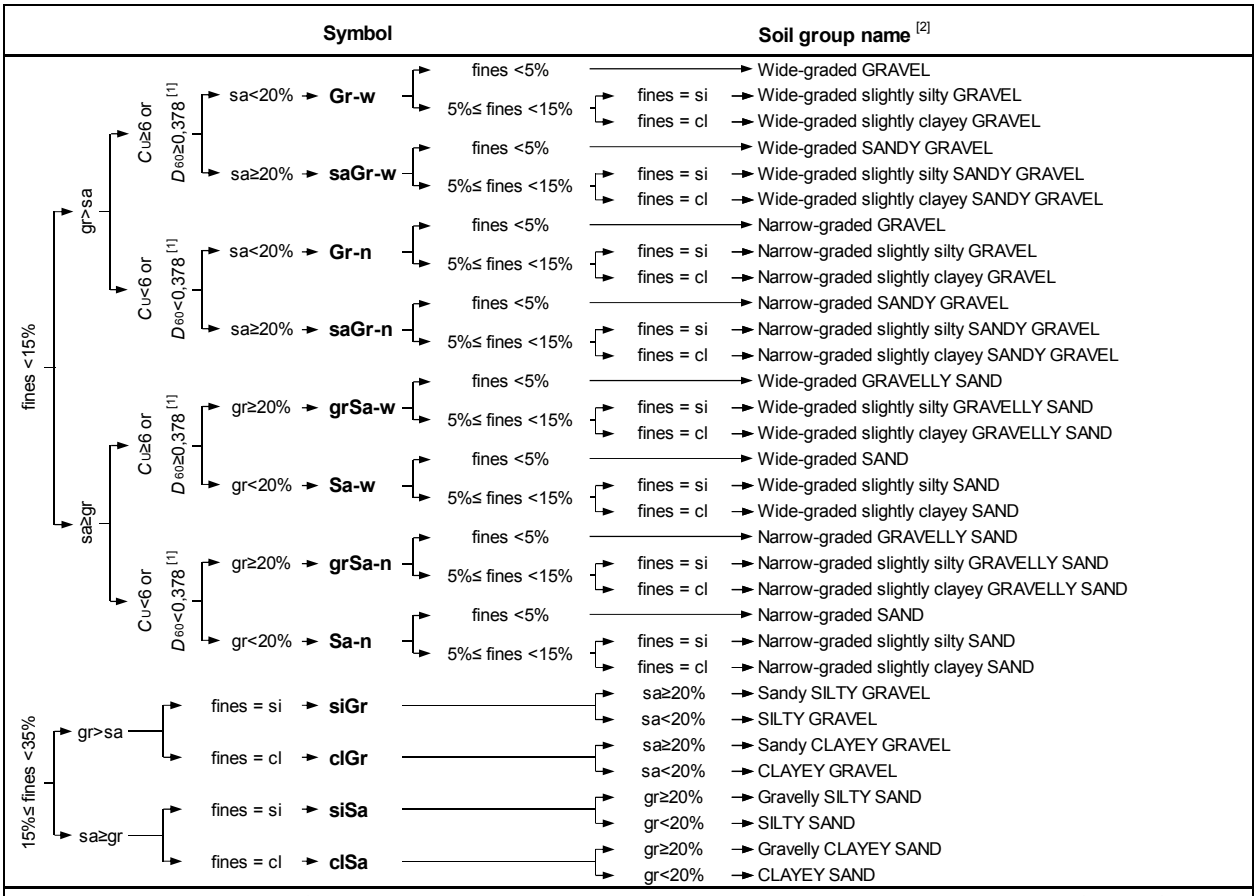
Table H.2 — Basic groups of mineral soils

	Classification criteria of mineral soils					Basic groups of mineral soils	
	Percentage of fines	Percentages of coarse fractions		Classification of fines		Symbol	Name [1]
Coarse soils	< 15 %	gr > sa	sa < 20 %	—		**Gr**	GRAVEL
			sa ≥ 20 %			**saGr**	SANDY GRAVEL
		sa ≥ gr	gr ≥ 20 %			**grSa**	GRAVELLY SAND
			gr < 20 %			**Sa**	SANDY GRAVEL
	≥ 15 % and < 35 %	gr > sa		si		**siGr**	SILTY GRAVEL
				cl		**clGr**	CLAYEY GRAVEL
		sa ≥ gr		si		**siSa**	SILTY SAND
				cl		**clSa**	CLAYEY SAND
Fine soils	≥ 35 %	—		si	L	**SiL**	SILT
					M	**SiM**	MEDIUM PLASTICITY SILT
					H	**SiH**	HIGH PLASTICITY SILT
					V	**SiV**	VERY HIGH PLASTICITY SILT
				cl	L	**ClL**	LOW PLASTICITY CLAY
					M	**ClM**	MEDIUM PLASTICITY CLAY
					H	**ClH**	HIGH PLASTICITY CLAY
					V	**ClV**	VERY HIGH PLASTICITY CLAY

2A.H.10.4 Classification of coarse soils

Coarse soils are classified based on the flow chart shown in Table H.3.

Table H.3 — Coarse soil groups – Flow chart



NOTE 1 In case that fines are ≤ 10 %, the criterion of the coefficient of curvature C_U is applied. Relatively, in the case that fines are > 10 % to < 15 %, the criterion of the particle size D_{60} is applied.

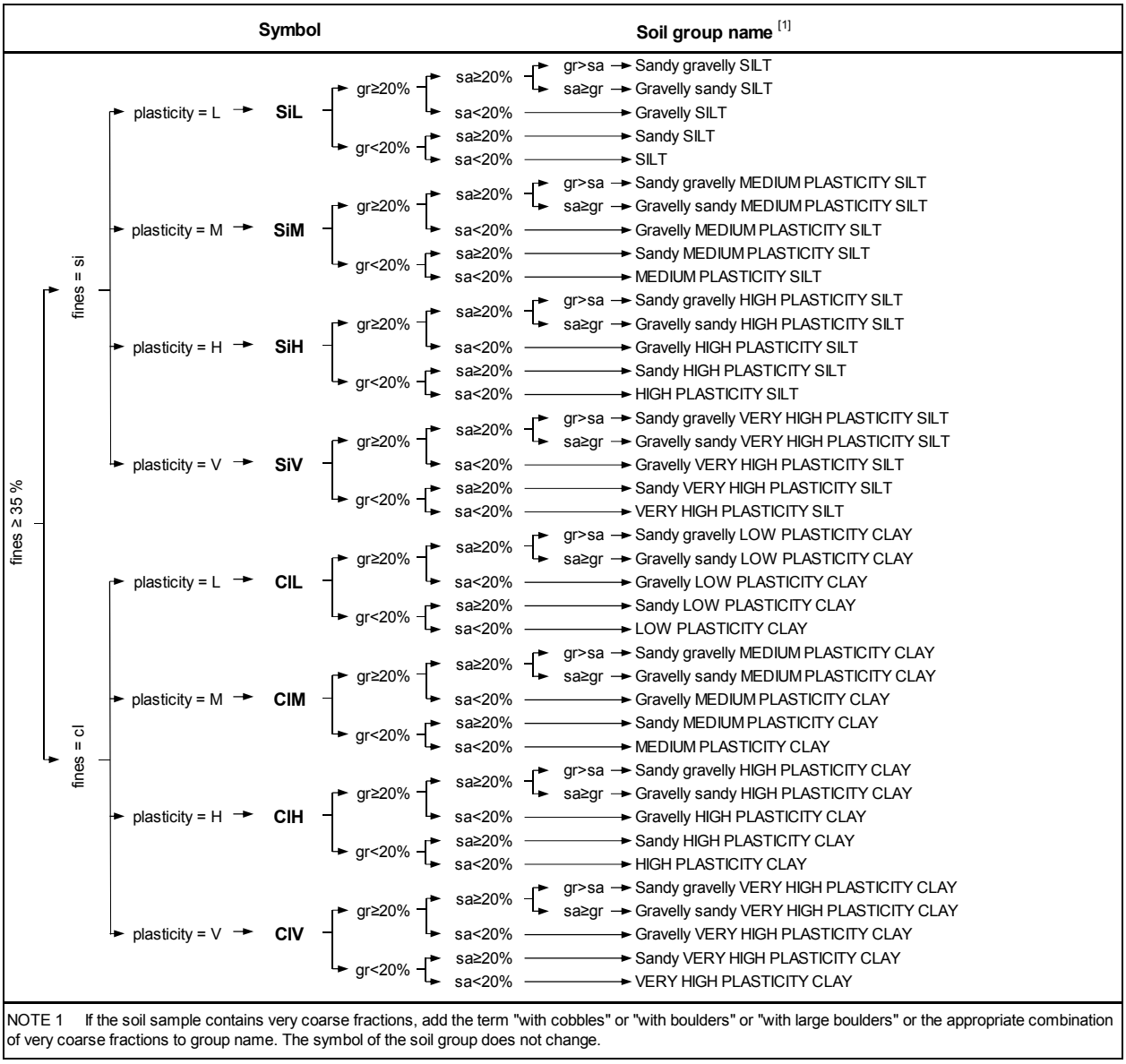
NOTE 2 If the soil sample contains very coarse fractions, add the term "with cobbles" or "with boulders" or "with large boulders" or the appropriate combination of very coarse fractions to group name. The symbol of the soil group does not change.

If fines are < 15 %, the classification criteria also include, in addition to the percentage of gravel, sand and fines and the classification of fines, the soil grading criterion. If fines are ≤ 10 % and the uniformity coefficient C_U is ≥ 6, then the soil shall be characterised as *wide-graded soil,* while if C_U is < 6, the soil shall be characterised as *narrow-graded soil.* If fines are > 10 % and < 15 %, if particle size D_{60} is ≥ 0,378, then the soil shall be characterized as *wide-graded soil*, while if D_{60} < 0,378, the soil shall be characterized as *narrow-graded soil.*

If fines are ≥ 15 % and < 30 %, classification criteria include the percentages of gravel and sand and the classification of fines to silt or clay.

2A.H.10.5: Fine soils classification

Table H.4 — Fine soils groups – Flow chart



NOTE 1 If the soil sample contains very coarse fractions, add the term "with cobbles" or "with boulders" or "with large boulders" or the appropriate combination of very coarse fractions to group name. The symbol of the soil group does not change.

Fine soils are classified based on the flow chart of Table H.4. Classification criteria include classification of fines into silt or clay, their plasticity (low L, intermediate M, high H or very high V) and the percentages of gravel and sand.

2A.H.10.6 Classification of mineral soils with organics and calcareous soils

2A.H.10.6.1 Classification of mineral soils with organics

Mineral soils with organics are classified into soil groups as follows: once the soil is classified into the relevant group of coarse or fine mineral soil and provided that the soil is dark coloured and has odorous smell, the percentage of the organics shall be examined: depending on the percentage of the organics and if the percentage is ≥ 2 %, the respective term shall be added to the end of the soil group name, while the symbol of the soil group shall be modified accordingly, in line with Table H.5 (see also Table 3 of ELOT EN ISO 14688-2).

Table H.5 — Additional terms and symbols used for groups of mineral soils with organics

Organic content of dry mass	Additional symbol	Terms to be added to the name of the soil group
≥ 2 % to < 6 %	(or)...	… low-organic

≥ 6 % to < 20 %	or…	… medium-organic
≥ 20 %	Or…	… high -organic

EXAMPLE sandy gravely MEDIUM PLASTICITY CLAY high-organic (or CIM)

2A.H.10.6.2 Classification of carbonate soils

Similarly to mineral soils with organics, the classification of the carbonate soils is made taking into account the calcium carbonate percentage in soil as follows: once the soil is classified to the group of mineral soils and provided that there is soil effervescence once drops of hydrochloric acid solution (10 % HCl) are dripped to it, the percentage of calcium carbonate is examined. Depending on the calcium carbonate percentage and provided that the percentage is ≥ 1%, the respective adjective shall be added at the beginning of the soil group name in line with Table H.6 (see also Table 4 of ELOT EN ISO 14688-2), while the symbol of the soil group is not modified.

Table H.6 — Additional terms used for the groups of carbonate soils

Carbonate content	Terms to be added to the name of the soil group
< 1 %	–
≥ 1 % to < 5 %	slightly calcareous …
≥ 5 % to < 25 %	calcareous …
≥ 25 % to < 50 %	highly calcareous …
≥ 50 %	very highly calcareous …

EXAMPLE Highly carbonate sandy gravely HIGH PLASTICITY CLAY (CIH)

2A.H.10.6.3 Classification of carbonate soils with organics

Mineral soils may be carbonate soils and may contain organics. In this case, both classification procedures shall apply, namely the procedure related to the classification of mineral soil with organics (para. 2A.H.10.6.1) and the procedure related to the classification of carbonate soil (para. 2A.H.10.6.2). Thus, with regard to the name of the soil, Tables H.5 and H.6 shall apply.

EXAMPLE carbonate CLAYEY SAND low-organic ((or)clSa)

2A.H.10.7 Additional classification principles

Onsite conditions and/or geotechnical design requirements may lead to additional soil classification principles than the ones presented in para. 2A.H.5. These may include on a per case basis the parameters of para. 5 of ELOT EN ISO 14688-2 or of Table 2, para. 4.3 of the same standard (figure showing the particle size distribution curve) which are not used in the HSCS.

2A.H.11 Reporting

The data required for the classification of the soil samples shall be recorded in a data sheet and shall include the following info (see also Figure H.4):

a) the details of the lab, the name and the signature of the certified laboratory employee who conducted the tests described in para. 2A.H.10.2.2 and the classification date,
b) the project's data,
c) the details of the soil sample, i.e. the borehole code and the borehole coordinates X, Y, Z, as well as the sample code for samples obtained from sampling boreholes or borehole coordinates X, Y, Z and the sample code for samples obtained from natural exposure.

d) the results (applicable each time) of:
   - the particle size analysis with sieves (percentage of particles passing through each sieve), including the percentages of gravels, sand and fines D_{60}, D_{30} and D_{10}, uniformity coefficient C_U, the curvature coefficient C_C and the percentage of very coarse fractions and of the maximum particle size D_{max} of the sample,
   - the hydrometer or pipette analysis for fines,
   - the determination of the liquid limit w_L, plastic limit w_P and plasticity index I_P,
   - the soil sample organics determination results,
   - the results of the tests for determining the calcium carbonate in the soil sample

e) references to the sheets with the results of the above tests executed for the classification of the soil sample,

f) the chart with the particle size distribution of the soil sample (particle size distribution curve),

g) the plasticity chart presenting the classification of the fine of the soil sample and

h) the symbol and name of the soil in line with HSCS classification.

Table H.4 — Data sheet for soil classification per HSCS

Classification of soil sample according to HSCS

Sample data		Company name:
Sample from borehole ☐	Sample from natural exposure ☐	Clinet's name:
Borehole:	X:	Project / contract:
Sample depth:	Y:	Name of certified laboratory personnel:
Sample No:	Z:	Signature of of certified laboratory personnel:

Particle size distribution (diagramm 1)

Sieve (mm)	Passing fraction (%) [1]	Particle size (mm) [2]	Passing fraction (%) [2]	Coefficients of uniformity (C_U) and carvature (C_C)
63	100			D_{60} =
20				D_{30} =
6,3				D_{10} =
2,0				
0,63				C_U =
0,20				C_C =
0,063				

Plasticity of fines (diagramm 2) [3]

w_L =
w_P =
I_P =

Organic content (%) [4]

organic matter

Carbonate content (%) [5]

$CaCO_3$

Basic fractions	NOTE 1 Particle size distribution with sieving report:
gravel (%) =	NOTE 2 Particle size distribution with sedimentation report:
sand (%) =	NOTE 3 Determintion of Atterberg limits report:
fines (%) =	NOTE 4 Determination of organics report / type of test:
	NOTE 5 Determination of carbonate content report:

Diagramm 1 — Particle size distribution of soil sample

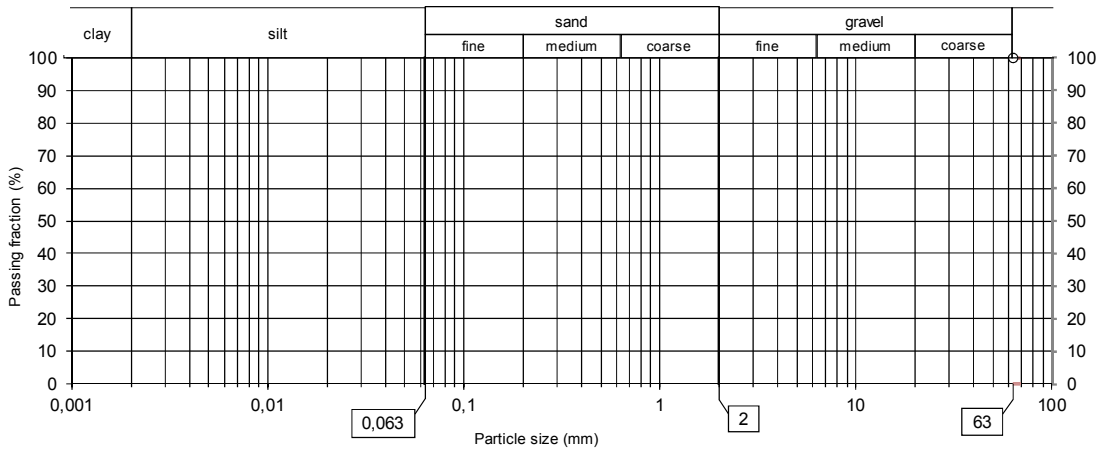
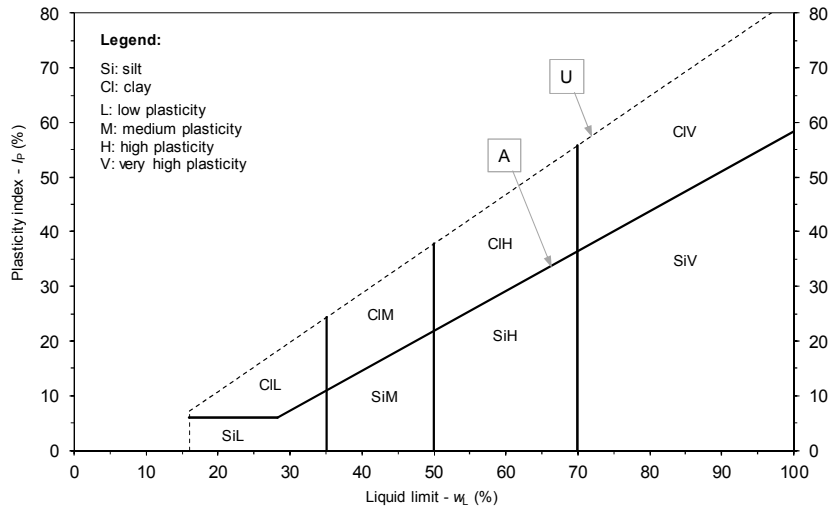


Diagramm 2 — Plasticity of fines of soil sample



Classification according to HSCS	Soil group symbol:
	Soil group name:

Classification of soil sample according to HSCS

Sample data				Company name:
Sample from natural exposure ☐			Coordinates of borehole or of natural exposure	Clinet's name:
Sample from borehole ☐				Project / Contract
Borehole:			X:	Name of certified laboratory personnel:
Sample depth:			Y:	Signature of certified laboratory personnel:
Sample No:			Z:	Date:

Particle size distribution (diagramm 1)					**Classification of fines (diagramm 2)**	**Organic content (%)**
Sieve (mm)	Passing fraction (%)	Particle size (mm)	Passing fraction (%)	Coefficients of uniformity (C_U) and curvature (C_C)		
63	100			D_{60} =	w_L =	organic matter
20				D_{30} =	w_P =	
6,3				D_{10} =	I_P =	
2,0						
0,63				C_U =		**Carbonate content (%)**
0,20				C_C =		
0,063						$CaCO_3$
Fraction retained on sieve 63 mm:						
Maximum particle size (D_{max}):						

Basic fractions	
	Particle size distribution with sieving report:
	Particle size distribution with sedimntation report:
gravel (%) =	Determination of liquid limit and plastic limit reports:
sand (%) =	Determination of organics report / Type of test:
fines (%) =	Determination of carbonate content report:

Diagramm 1 – Particle size distribution curve

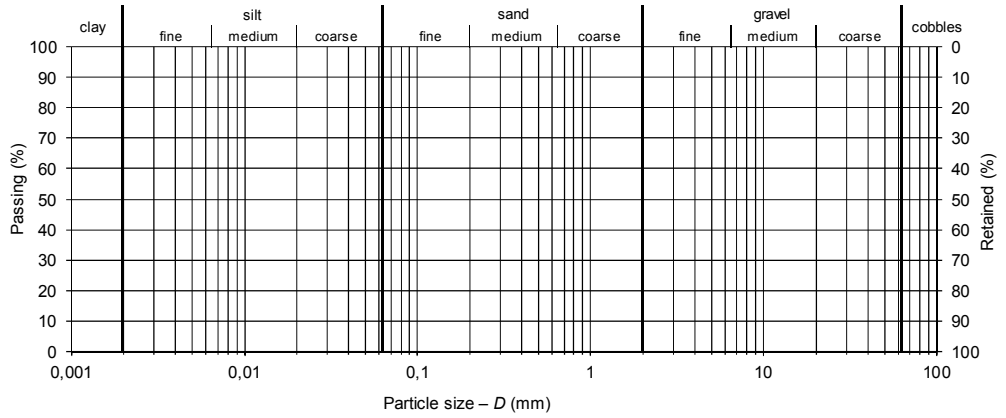
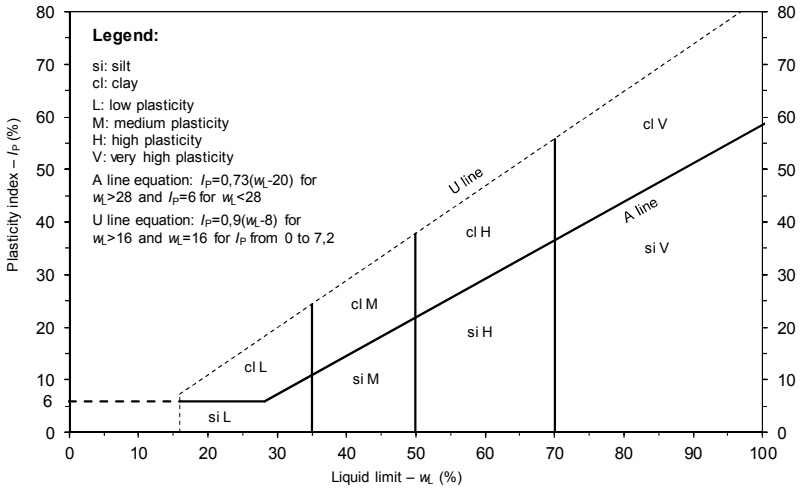


Diagramm 2 – Classification of fines



Classification according to HSCS	Soil symbol:
	Soil name:

2A.H.12 Abbreviation symbols for soil classification per HSCS

In many instances, due to lack of space, an abbreviations system that specifies the name and symbol of the soil classification per HSCS can be of great use. Examples of such instances are borehole logs, databases, tables with records of geotechnical investigation records, etc.

These abbreviations do not substitute for the name and symbol of the soil classification per HSCS and the soil description, but may be used in supplementary presentations of data, when reference is made to the full description.

In this system of abbreviations the following symbols are used:

lbo = large boulders
bo = boulders
co = cobbles
gr = gravel
sa = sand
si = silt, silty, slightly silty
sil = (low plasticity) silt
sim = medium plasticity silt
sih = high plasticity silt
siv = very high plasticity silt
cl = clay, clayey, slightly clayey
cll = low plasticity clay
clm = medium plasticity clay
clh = high plasticity clay
clv = very high plasticity clay

w = wide graded
n = narrow graded
o1 = few organics
o2 = moderately organic
o3 = highly organic
c1 = slightly calcareous
c2 = calcareous
c3 = very calcareous
c4 = highly calcareous

The rules for soil abbreviations are as follows:

a) The soil symbol abbreviation –as shown in Tables H.2 and H.3– goes first, followed by a dot.

NOTE The abbreviation for the additional symbol concerning the organics (Table H.5) follows after the dot (see section (c)).

The correspondence between the abbreviations and the soil symbols per HSCS is presented in Table H.7.

Table H.7 — Correspondence between the abbreviations and the soil symbols per HSCS

Soil Symbol per HSCS	Abbreviation
Gr-w	grw.
Gr-n	grn.
saGr-w	grsaw.
saGr-n	grsan.
siGr	grsi.
clGr	grcl.
Sa-w	saw.
Sa-n	san.
grSa-w	sagrw.
grSa-n	sagrn.
siSa	sasi.
clSa	sacl.

Soil Symbol per HSCS	Abbreviation
SiL	sil.
SiM	sim.
SiH	sih.
SiV	siv.
ClL	cll.
ClM	clm.
ClH	clh.
ClV	clv.

b) Next comes the abbreviation of the secondary fractions corresponding to the terms e.g. "slightly silty", "sandy", "sandy gravel", "with stones", "with boulders and stones". In case of two or more secondary fractions, the order of the fractions in the abbreviation corresponds to the rate of their presence in the soil (from the highest to the lowest).

c) The next is the abbreviation of the terms referring to the organics (in Table H.5), and lastly the abbreviations of the terms referring to the calcium carbonate content.

Based on the above rules, here are some examples of abbreviations for certain soils in Table H.8.

Table H.8 — Soil abbreviations examples

Soil name and symbol per HSCS	Abbreviation
Calcareous, slightly silty, widely-graded SANDY GRAVEL with cobbles (saGr-w)	grsaw.sicoc2
Narrow-graded GRAVELY SAND with cobbles and boulders (grSa-n)	sagrn.cobo
Slightly silty GRAVELY SAND (grSa)	sagr.si
Slightly calcareous sandy CLAYEY GRAVELS (clGr)	grcl.sac1
CLAYEY SAND with few organics and cobbles ((or)clSa)	sacl.coo1
Very calcareous sandy gravely SILT (SiL)	sil.grsac3
Gravely sandy HIGH PLASTICITY CLAY moderately organic (orClH)	clh.sagro2
Very highly calcareous sandy VERY HIGH PLASTICITY CLAY high-organic (OrClV)	clv.sao3c4

2A.H.13 Peat classification terminology as per ASTM D 4427

This appendix provides the terms in standard ASTM D 4427, if this standard is selected to classify peat.

Terms related to fibre content:

Fibric (fibres > 67 %)
Hemic (fibres 33 % – 67 %)
Sapric (fibres < 33 %)

Terms related to ash content:

Low ash (ash < 5 %)
Medium ash (ash 5 % – 15 %)
High ash (ash > 15 %)

pH-related terms (acidity):

Highly acidic (pH < 4,5)
Moderately acidic (pH 4,5 – 5,5)
Slightly acidic (pH 5,5 – 7)
Basic (pH > 7)

Terms related to absorbency:

Extremely absorbent (absorbency 800% >1500%)
Highly absorbent (absorbency > 1500 %)
Moderately absorbent (absorbency 300 % – 800 %)
Slightly absorbent (absorbency < 300 %)

The terms concerning the botanical composition remain in Latin.

Example of terms for the classification of peat according to standard ASTM D 4427:

Peat, fibre content 55 %, ash content 8 %, pH = 4,7, absorbency 1200 %, with 70 % of its fibres originating from *Sphagnum* and 20 % of the fibers from *Carex* is classified as follows:

Hemic, medium-ash, moderately acidic, highly absorbent *Carex-Sphagnum* peat (Pt).

ARTICLE 2B GEOTECHNICAL DESIGN

2B.1 GENERAL

The scope of this Article concerns the Geotechnical Design related issues; it includes full dimensioning of the required surface foundations of the foreseen metal shed and the deep excavations of the power supply poles of the Tramway corridor within the limits of the subject Project, in order to ensure the safety of the Project construction itself and of all structures and buildings adjacent to the Project. In addition to the above, the scope of the Geotechnical Design also includes the design –in geotechnical terms- of excavations of the perimeter roadworks to be required for the complete and workmanlike construction of the Project.

As concerns the Geotechnical Design issues pertaining to the structures of the Project, applicable shall be the requirements of this Article 2, as well as the requirements of Articles 1 and 3 of this Document entitled “Design Specifications of Civil Works”, along with the requirements of Article GS200 of the document entitled “General Specifications”. As regards the issues covered by EN 1997 (Eurocode 7), applicable shall necessarily be all Principles of ELOT EN 1997-1 (as these may be specified in the National Appendix) and the Standardized Annex A ELOT EN 1997-1.

Within the framework of the Geotechnical Design, the Contractor shall initially submit a Geotechnical Evaluation Report for Design Parameters, and, subsequently, the Geotechnical Design, which shall include the design of the surface and deep foundations of the Project and the design of any other geotechnical design related issue in the framework of the subject Project.

2B.2 GEOTECHNICAL EVALUATION REPORT FOR DESIGN PARAMETERS

2B.2.1 GENERAL

The Geotechnical Evaluation Report for Design Parameters (EGAPS), shall be submitted for the entire Project (i.e. for surface and deep foundations to be required, the Tramway corridor foundation and the roadworks related excavations), following the approval by AM of the respective Geotechnical Investigation Results Evaluation Report, in accordance with article 2A of the Design and Performance Specifications for Civil Works.

The Geotechnical Evaluation Report for Design Parameters (EGAPS) for the Project shall be prepared by the Contractor and shall be promptly submitted for AM’s review and approval, and, in any case, before it is used in the Geotechnical Design.

The Geotechnical Evaluation Report for Design Parameters (EGAPS) shall determine, based on the respective approved Evaluation Report of the Geotechnical Investigation Results, the ideal Geotechnical Design Models (GDM) of the sub-soil, which are based on the approved geotechnical cross-sections compiled in the framework of the Geotechnical Investigation Results Evaluation Report, and which shall present (further to the data and information of the geotechnical cross-sections of the Geotechnical Investigation Results Evaluation Report) the required design geotechnical parameters for all formations, as well as the necessary Ground Water Levels (GWL) for the Project. The aforesaid ideal Geotechnical Design Models (GDM) shall indicate the stratigraphy, the design values for various geotechnical parameters (natural and mechanical properties) of the geotechnical formations that

appear, the design levels of the ground water level and the foundation levels for the works and the adjacent structures under design etc..

2B.2.2 CONTENT OF THE GEOTECHNICAL EVALUATION REPORT FOR DESIGN PARAMETERS

The Geotechnical Evaluation Report for Design Parameters (EGAPS) shall be based on the approved Geotechnical Investigation Results Evaluation Report of the Project, as specified in Article 2A of the Design Specifications for CW, and shall include as a minimum the following:

1. Abstract
2. Introduction
3. Description of the Project in question
4. Summary of the executed geological – geotechnical surveys
5. Description of the soil and of the soil conditions
6. Interpretation of the soil conditions for use in the design of the foreseen surface and deep foundations
7. Determination of ideal Geotechnical Design Models, as these are described in the previous unit 2B.2.1, Article 2B
8. Determination of the design values of the geotechnical parameters for the surface and deep foundations under design
9. Determination of the design level of the aquifer for all surface and deep foundations under design
10. Determination of water and subsoil activity (sulphates, chlorides, etc.) in surface and deep foundations
11. Conclusions

The EGAPS shall necessarily be accompanied by a Geotechnical Longitudinal Profile Drawing compiled in an appropriate and legible scale; the profile drawing shall be based on the approved Geotechnical Cross-Sections compiled in the framework of the Geotechnical Investigation Results Evaluation Report, as specified in Article 2A of this document, together with the proposed values of the geotechnical design parameters and of the aquifer design level, as also described in para.2B.2.1 of Article 2B herein.

2B.2.3 GEOTECHNICAL PARAMETERS AND GROUND WATER – DESIGN VALUES

The results of the onsite and laboratory tests concerning the soil materials and the rock masses encountered in the Project shall be quantified for use in the Geotechnical Design of the surface and deep foundations of the Project, in line with the requirements of para. 2.4.3 of Eurocode 7 (ELOT EN 1997-1). The design values of the geotechnical parameters shall ensue from the procedure described in paragraphs 2.4.5 and 2.4.6 of Eurocode 7 (ELOT EN 1997-1) using the characteristic values of the geotechnical parameters. As per ELOT EN 1997-1, the characteristic value of a geotechnical parameter must be selected as the conservative evaluation of a value, which has an impact on the onset of an examined limit state. A justification shall be provided for all the characteristic values of the geotechnical parameters selected providing a detailed presentation of the method for the selection of each parameter. Depending on the failure limit state under examination, the individual coefficients of soil parameters, as presented in the corresponding tables of annex A of ELOT EN 1997-1 shall be utilized, as per the

requirements of para. 2.1, ELOT EN 1997-1:2005/NA.

The types and the selected values of the design geotechnical parameters shall include proposals about the parameters for the various depths under the surface of the ground and at various invesrtigation points, taking into consideration the kind, the extent and the geometry of the structures (surface and deep foundations), the requirements of the proposed analysis method concerning the design assumptions etc. In the Geotechnical Evaluation Report for Design Parameters, the design assumptions of the geotechnical conditions should correspond to the actual conditions, as far as it concerns, as required on a per case basis:

1. The types of soil and their natural properties (specific weight, densities, particle size, Atterberg limits, natural water content etc.).
2. Changes and alterations of soil properties.
3. Types of rockmass (classification based on the Geological Strength Indexes RQD and GSI), natural properties (wet and dry apparent weight, etc.) and mechanical properties (results of unconfined compression tests, results of shear tests, elasticity modulus, etc.)
4. Succession and geotechnical layers thickness, presence of discontinuities.
5. Ground water level and hydrogeological conditions, piezometric pressures that shall be used in the permanent structures of the Project (maximum and minimum level for the foreseen life time of permanent structures), permeability.
6. Loading rate and analysis method (total or active pressures).
7. Shear strength parameters in terms of total and active stresses.
8. Soil pressure coefficients (active, at-rest, passive) and any proposed modifications of the theoretical values.
9. Strength and compressibility parameters, including consolidation properties, strain measurement in loading and un-loading conditions, Poisson ratio, non linear stress and deformation parameters (if applicable), dynamic shear modulus etc.

To calculate the regime of the initial geostatic stress field (coefficient of earth pressure at-rest $K_0=\sigma'_h/\sigma'_v$), design values shall be proposed for the Project. These values should be based, as a minimum, on one of the following data categories:

1. on the results of the appropriate laboratory strength tests (e.g. triaxial tests, consolidation tests etc.), as well as on in situ tests (e.g. pressure meters etc.) and
2. on well documented empirical correlations taken from the bibliography according to the situation, the soil type, loading history (e.g. pre-consolidation stress, over-consolidation ratio, active friction angle etc.).

In order to determine the characteristic values of the ground water table level and of the unconfined aquifer, as well as the design water pressures, the related paragraphs of Eurocode 7 (ELOT EN 1997-1) 2.4.5.3, 2.4.4 (1)A, and 2.4.6.1 (6)A (up to 2.4.6.1 (11) shall be taken into account.

2B.3 GEOTECHNICAL DESIGN

2B.3.1 GENERAL

This paragraph mainly concerns the Geotechnical Design, whose contents are also presented in Article GS0200 of the General Specifications.

Upon approval of the Geotechnical Evaluation Report for Design Parameters,the Contractor shall submit (in line also with the requirements of para. 2B.4, article 2B herein) the corresponding Geotechnical Design.

The Scope of the Geotechnical Design is the full dimensioning of the surface and deep foundations, as well as of any other issue related to the geotechnical design which is required in the framework of this Project, in order to ensure the safety and operability of the structure itself and of the buildings and structures of third parties adjacent to the Project, as well as the confinement of deformations within permissible limits. The limit Design values of the deformations applied in the framework of this Project are specified as follows:

- 30mm for maximum total subsidence and 1/500 for maximum twisting as regards the surface and deep foundations;

- 30mm for maximum vertical surface displacement (settlement or heave) as regards the free field in case of excavations.

The term “structures of third parties” means buildings, monument, public utility pipe lines, etc. adjacent to the works and also existing structures of the Tramway Depot in the area of Elliniko.

2B.3.2 GEOTECHNICAL DESIGN REPORT

The Geotechnical Design Report (as specified in Article GS0200 of the General Specifications), shall cover the following subjects:

1. Structures description (surface and deep foundations, as well as any other structure required by the geotechnical design)
2. General concept of the design
3. Names of the design authors and reviewers
4. Regulations, Contract Documents, Drawings etc. on the basis of which the design is compiled
5. Brief description of the geotechnical – geological conditions with reference to the approved Geotechnical Evaluation Report for Design Parameters
6. Geotechnical design simulation models with reference to the approved Geotechnical Evaluation Report for Design Parameters
7. Description of the simulation model to be used in the analyses
8. Construction method
9. Construction phases, where required
10. Prerequisites for the commencement of every construction phase, where required
11. Construction materials
12. Structure protection measures against water ingress and chemical actions, where required
13. Correlation of the Project construction works with other parallel works, such as relocation of PUO networks, electromechanical installations, drainage and sewage works, etc.
14. Interfaces with other trades
15. All other technical information necessary for the safe and sound construction, not included in the drawings
16. Calculations
17. Conclusions.

2B.3.3 CALCULATIONS REQUIREMENTS – LIMIT STATE

The calculations should include the exploration of the impact of the use of less favourable combinations of geotechnical parameters and loading conditions on the estimated stresses and deformations of the foundation systems. The calculations should demonstrate that attention has been given to the likely mutability of the

geotechnical parameters (range of values, typical divergence etc.) and to the use of different analysis methods. The effects of such alterations in the design and dimensioning of the structures should be indicated, whilst explanations and justification should be given for the parameters selected in the Geotechnical Design.

According to Eurocode 7 (ELOT EN 1997-1), two distinct checkings of the structures are required, i.e. at an Ultimate Limit State (ULS) and at a Service Limit State (SLS). At the ULS state, the strength (bearing capacity and other ULSs, as described in Eurocode 7) of a certain structural member or the entire Project has been exceeded with potential impact on the safety of persons or of the Project, since they are associated with collapse or similar types of structural failure, while at SLS state the Project's functional requirements have been exceeded, as for example excessive (i.e. beyond the acceptable limits) subsidence, shifting, twisting, deformation or cracking with potential impact on the operability of a structural member under normal use, on the comfort of persons and on the appearance of the structures.

When the Ultimate Limit State (ULS) is checked, what is checked among others is whether structural strength (STR) and soil strength (GEO) have been exceeded, whether structural equilibrium (EQU) and equilibrium due to uplift (UPL) has been lost, and whether there is a soil failure due to hydraulic gradient (HYD).

According to National Appendix of Eurocode 7 (ELOT EN 1997-1), with regard to the designs concerning the geotechnical planning of the Project, the analysis methods DA-3 and DA-2 shall be applied in the analysis of the Ultimate Limit States of the geotechnical (GEO) and structural (STR) type. The **DA-3** method **pertains only to** the **checking of the overall stability of the geotechnical projects**, while the **DA-2** method shall be applied when the **checking** is related to **geotechnical (GEO) or structural (STR)** Ultimate Limit States, shallow foundations, deep foundations and various other geotechnical projects.

The Ultimate Limit State checking shall be carried out by utilizing the appropriate individual coefficients for load and strength. The relevant values shall be obtained based on the type of the works (temporary or permanent), the loading case (normal or accidental) and the subsoil.

2B.3.4 ANALYTICAL METHODS OF GEOTECHNICAL DESIGN

Regarding the analysis methods that are to be used in the geotechnical design, the Contractor shall provide evidence that he has experience in the use of his proposed methods. The information about the personal computer programs that are to be used shall include the identity, the number of release and the details of the supplier and shall concern their most recent and commercially available two-dimensional and three-dimensional release. The proposed methods described shall include analyses regarding:

1. Vertical displacements (settlement and heave) at the surface foundations.
2. Stability of excavations, total stability against sliding, and stability of the excavation bottom against heave or liquefaction, where required.
3. Slope stability for different loading conditions, if required.

2B.3.5 DESIGN AND ANALYSIS METHODS

The modelling of the Project's bearing structures for the surface and deep foundations, as well as the analysis methodology shall come up to the most advanced and proven methods, in order to achieve the maximum possible approximation of the actual stress condition. In order to achieve the above, the Geotechnical Design shall be properly documented, taking into account and including at least the following, by applying the above in accordance with the

respective requirements of Eurocode 7 (ELOT EN 1997-1):

1. Determination of the vertical and horizontal ground index
2. Examination of the surface and deep foundation structures-soil interaction using 2-D analysis (plain strain or plain deformation of the structure and of the surrounding soil)
3. Calculations of the bearing capacity of the surface and deep foundations and comparison of the value that occurs each time with the exerted load that results from the structural analysis of the overlaying structure.
4. Calculations of settlements (immediate and long-term) and their evolution in time, as well as estimation of the differential settlements and their comparison with the respective limit values specified in the framework of Eurocode 7 (ELOT EN 1997-1)
5. Calculation of thrusts in line with the soil parameters
6. Check whether the pile drive depth is sufficient or not
7. Eventually assuming the seismic action, where required
8. Analysis, where required, based on the finite or boundary elements method, or finite differences method

It is also pointed out that the modelling shall take into account the actual conditions (geometry and rigidity of structures, type of soil, loads and time sequence of their application, thickness of overburden etc.).

2B.3.6 GROUND WATER CONDITIONS

Regarding the conditions of the ground water, a careful assessment of its presence and pressures must be made, as well as of any likely impact on the structures.

Given that the presence and the nature of the regime of ground water affect the design of surface and deep foundations in the framework of the Geotechnical Design, the following minimum factors have to be examined:

1. Impact on third parties (e.g. impact on building foundations, subsidence, or on the operating Tramway network etc.): due to the changed ground water level during the construction and operation of the Project etc.
2. Impact of water on “soil”: assessment of the variation of the properties of the material being excavated due to the water effects, such as looseness, disintegration, expansion etc.
3. Drainage: design of the appropriate drainage system for the works regarding short-term and long-term inflows.
4. Changes of the water table and the impact on the soil parameters.

The ground water regime expected to be encountered during the construction period and the local drainage characteristics of the subsoil shall be taken into account in the determination of the most appropriate method for excavation and control of the ground water, so that any change to the water table is minimized.

Care shall be taken for the amendment of the pore pressure limits and the drainage characteristics, during the progress of the excavation and construction.

2B.3.7 LOADING CASES – LIMIT STATE (FAILURE)

The loads and the loading combinations that are to be selected shall cover all the possible loading cases from the initial construction phase to the Project operation phase. These combinations shall cover the design envelopes for the internal stresses with the use of the upper and lower limit load values.

The limit state method analysis shall be carried out with the use of certain safety coefficients for the loads and strength. The values of the individual safety coefficients shall be taken from Eurocode 7 (ELOT EN 1997-1) based on the Project type, the loading case (normal or accidental) and the subsoil type.

For the design and construction of the surface and deep foundations of the entire project, the Regulations/Standards/Codes mentioned in Article 1 of this document apply.

2B.3.8 SLOPE STABILITY

The geotechnical design of the slope stability shall be carried out in line with the requirements of Eurocode 7 (ELOT EN 1997-1), as well as based on the other related regulations-standards of Article 1 herein.

The slope stability according to the requirements of the relevant regulations – standards of article 1 of this document shall be controlled (where required based on the height and geometry of the slope under examination) via the appropriate recognized software and the methodology which is advisable for the sliding surfaces that can be possibly developed within the material of the slope, e.g. Bishop in case of development of a circular sliding surface, Janbu in case of development of a polygonal sliding surface, "combinations" of circular and polygonal surfaces and/or wedges for rocky material. The selection of the testing methodology shall be fully documented on the basis of the given materials' properties.

Excavations and backfills, including backfills from excavation spoils, shall be designed to be safe and stable under all loading conditions that could possibly occur during the construction phase and the permanent operation phase. The safety requirements of the critical phases of construction of retaining systems, backfills or trenches and excavation spoil backfills should be satisfied on the basis of Eurocode 7 – Geotechnical Designs (ELOT EN 1997-1).

In excavation spoil deposits, the natural surface drainage of the surrounding areas shall be kept unobstructed. The planning of the excavation spoil deposits shall also ensure that the slope surface is safe from weathering due to discharge.

2B.3.9 SURFACE FOUNDATIONS

The geotechnical design of surface foundations shall be prepared in accordance with the requirements of Eurocode 7 (ELOT EN 1997-1), as well as the remaining relevant regulations / standards of Article 1 of this document.

2B.3.10 PILE FOUNDATION

The geotechnical design of pile foundation shall be in accordance with the requirements of Eurocode 7 (ELOT EN 1997-1), as well as based on the remaining relevant regulations / standards of Article 1 of this document.

2B.4 GEOTECHNICAL DESIGN SUBMISSIONS – PREREQUISITES

The Contractor shall submit the following distinct geotechnical design submissions which shall be compiled in accordance with the provisions of the respective units of the Article herein:

1. Geotechnical Evaluation Report for Design Parameters
2. Geotechnical Design.

The Contractor shall submit to AM for approval Geotechnical Evaluation Report for Design Parameters in accordance with the stipulations of para. 2B.2 herein. Only after the approval of the Geotechnical Evaluation Report for Design Parameters by AM could the geotechnical parameters and their assumptions be used in the Geotechnical Design to be submitted in accordance with para. 2B.3 herein.

ARTICLE 3 DESIGN LOADS

3.1 GENERAL

3.1.1 Design Loads are considered to be:

a. The self weight of load carrying structures and the imposed loads, both permanent and live.

b. Stresses due to hindered or imposed deformations of the structure resulting from temperature variations, concrete shrinkage cracking and creep, differential displacements of supports, stresses due to assembly of prefabricated members, geometrical inaccuracies in statically indeterminate structures etc.

c. Inertial forces loading caused by seismic activities, impact loading (due to impact or blasts) oscillation due to the operation of machinery, etc..

3.1.2 The values of loads used in the Detailed Final Designs shall derive from the following sources:

a. The “Approved Codes” as defined in Article 1.3 of this Document.

b. Chapter 2B of Article 3 of this Document (loads from ground and groundwater).

c. The manufacturer’s technical specifications for electromechanical equipment. The nominal values of loads included in these specifications shall be substantiated analytically.

d. The minimum loads included in the present Article.

3.1.3 For each load, the most unfavourable value of those derived from the above sources shall be used in the Design.

3.2 DEAD LOADS

3.2.1 Self weight of structure

For assessment of self weights the following specific weights shall be considered:

Reinforced or prestressed concrete	: 25 kN/m^3
Plain concrete	: 23 kN/m^3
Fresh Reinforced Concrete	: 24 kN/m^3
Steel	: 78 kN/m^3
Water	: 10 kN/m^3
Other materials	: Specific weights derived from “Approved Codes” or other valid sources.

3.2.2 Superimposed dead loads

These include the weight of all essential and permanent of the structure, beyond the bearing elements such finishes and insulation, cables, trackwork etc., taken with the dimensions foreseen in the design.

Their specific weight of these elements shall be assessed according to the “Approved Codes” or other valid sources, or from substantiated and controllable manufacturer’s information, or by experimental measurements.

In addition to the requirements of the previous paragraph. Consideration must be also made of the load from the traction system, as this shall result from the E/M designs.

3.3 LIVE LOADS

Live loads shall be taken from Table 3.1. The slabs shall also be checked, in critical locations, using the concentrated loads.

TABLE 3.1

LIVE LOADING

Location	Distributed Load (kN/m^2)	**Concentrated Load on square of 300 Mm side (Kn)**
1. Platforms	5.0	2.0 (square 0.2m)
2. Flat roofs, canopies of above-ground structures, sheds Non accessible	0.75	1.0
3. Maintenance, Storage and other areas for Tramway vehicles	Estimate based on actual data for Tramway vehicles, facilities, etc.	Estimate based on actual data for Tramway vehicles, facilities, etc.

3.4 PLANT / EQUIPMENT LOADING

3.4.1 In addition to the requirements of Table 3.1, the floors and supporting structural members in places containing switch gear or machinery shall be designed to resist the following live loads:

- The total net static load of the assembled items of equipment at any reasonable position on the structure likely to be experienced during or after the installation
- The total net static load of assembled equipment units at the designated installation locations according to the design, plus the dynamic action due to their operation. This action shall be specified in the particular manufacturer's specifications.

3.4.2 Units of equipment with dynamic load characteristics contained in the same part of the structure shall be assumed to exert their dynamic loads simultaneously, unless the number of units exceeds four where in this case, the dynamic load from one unit need not be considered as acting simultaneously with the other ones.

3.4.3 Lifting points for plant and machinery shall be provided and adequate allowance shall be made in the design for the respective live loads.

3.4.4 In stabling and maintenance areas for Tramway vehicles etc., where gantry cranes, equipment, machineries or installation are foreseen, the design shall take into consideration the live loads determined by the respective manufacturers or the live

loads given in the design drawings.

3.5 TRAMWAY VEHICLES LIVE LOADS

3.5.1 Several information (loads, distances, coefficients, etc.) to be taken into consideration in structural calculations are mentioned below. This information must be verified once the actual data of the rolling stock are made available.

3.5.2 Tramway vehicle loads

The typical Tramway vehicle is shown on the following Figure. Each vehicle has 3 pairs of axes (bogies), each spaced at 11m. The distance between the axes of a bogie is 1.7m.

The load of each bogie axle is equal to 120kN (12 tn), i.e. 60kN per wheel multiplied by the increase coefficient due to dynamic phenomena Φ3, as per ELOT EN 1991-2, para. 6.4.5.2 and the respective National Annex, para. 2.54. Based on equation 6.5 of ELOT EN 1991-2, it results that for value Lφ=9m, Φ3=1.50. Therefore, the load per wheel is 1.5*60=90.0 kN and is exerted as point load on the rail rods.

3.5.3 Tramway vehicle derailment load

Four 120kN wheel loads, each spaced at 1.70m, at 34 successive points along the slabs, every 0.30m, are taken to act on the slab as point loads on the surface elements.

3.5.4 Tramway vehicle loads due to eccentricity (lurching)

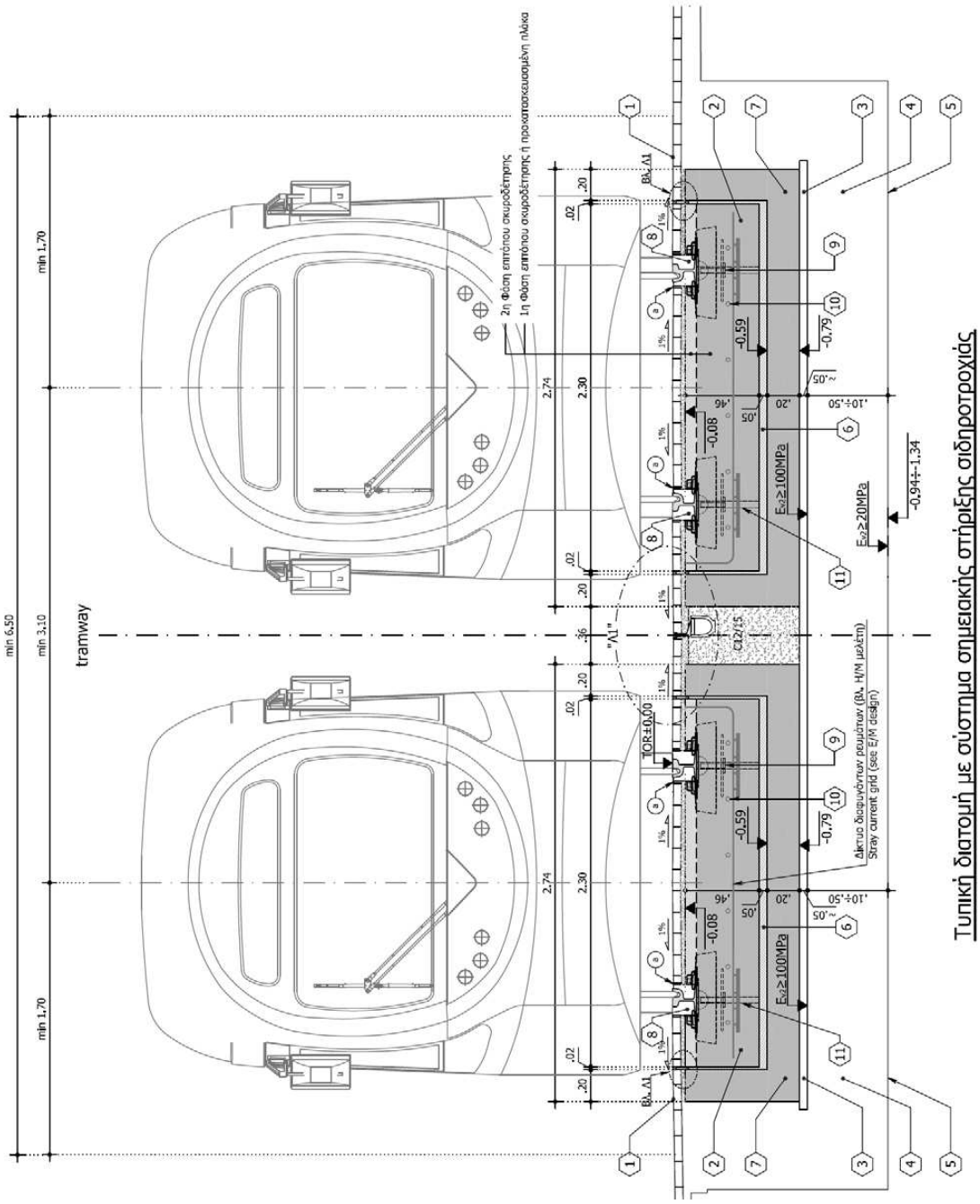
Due to the Tramway vehicle nosing effect, there is eccentricity in the distribution of the axial load on the two wheels. According to ELOT EN 1991-2, para. 6.3.5, the final ratio between the two wheels cannot be higher than 1.25. Based on this, the maximum load re-distribution is $\pm$11%.

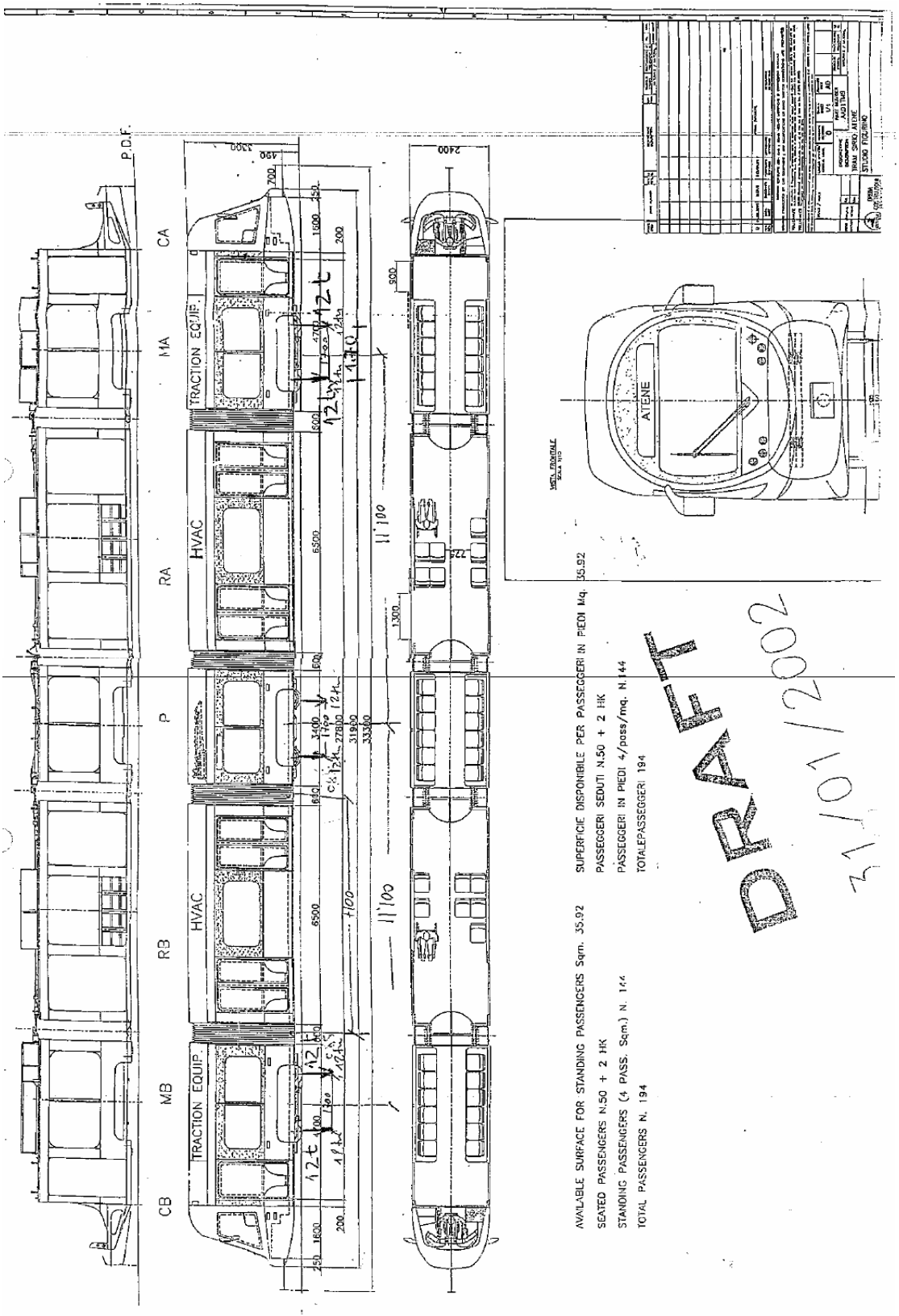
A pair of opposite forces is finally taken to act, while the vertical load shall be +0.11*60*1.5 kN on the one wheel and -0.11*60*1.5 kN on the other wheel.

3.5.5 Lateral impact loads or nosing force loads

According to ELOT EN 1991-2, para. 6.5.2, the nosing effect of the Tramway vehicle leads to a horizontal load exerted on the first wheel of the bogie, equal to 0.5*100.0 kN.

The value of 100.0 kN is applicable as per the aforementioned Regulation for UIC71 loads, but the proportion between the axial load UIC71 and the respective load of the Tramway vehicle is calculated to 0.50 ≈ 120 kN/250 kN.


tramway
min 6,50
min 3,10
min 1,70
min 1,70
2η Φάση επιπόνου σκυροδέτησης
1η Φάση επιπόνου σκυροδέτησης η προκατασκευασμένη πλάκα
2,74
2,30
-0,59
-0,79
-0,08
-0,94÷-1,34
Ea≥100MPa
Ea≥20MPa
C12/15
TOR±0,00
Δίκτυο διαρρύσεων ρευμάτων (βλ. Η/Μ μελέτη)
Stray current grid (see E/M design)
Τυπική διατομή με σύστημα σημειακής στήριξης σιδηροτροχιάς


P.D.F.
CA
MA
RA
P
RB
MB
CB
TRACTION EQUIP.
HVAC
HVAC
TRACTION EQUIP.
ATENE
AVAILABLE SURFACE FOR STANDING PASSENGERS Sqm. 35.92
SEATED PASSENGERS N.50 + 2 HK
STANDING PASSENGERS (4 PASS. Sqm.) N. 144
TOTAL PASSENGERS N. 194
SUPERFICIE DISPONIBILE PER PASSEGGERI IN PIEDI Mq. 35.92
PASSEGGERI SEDUTI N.50 + 2 HK
PASSEGGERI IN PIEDI 4/poss/mq. N.144
TOTALEPASSEGGERI 194
DRAFT
31/01/2002

3.6 LATERAL LOADS FROM GROUND AND GROUNDWATER

For earth and hydrostatic pressures on retaining walls etc., use shall be made of the relevant data concerning the design of permanent structures and given in the respective Evaluation Reports on Design Parameters, as configured based on the requirements described in detail in Unit 2B.2 of Article 2 of this Volume.

3.7 HIGHWAY LOADING

Highway loading shall derive from EN 1991-2, in line with which the following three standard loadings apply: Standard Loading 1 (LM1) Standard Loading 2 (LM2) and Standard Loading 4 (LM4).

3.8 WIND AND SNOW LOADS

Wind and snow loads shall be taken into account in the design of structures affected by this kind of load such as steel structures above ground, falsework etc. The applied loads will be determined on the basis of Standard EN 1991.

3.9 LIVE LOADS DUE TO THE CONSTRUCTION OF PROJECTS

3.9.1 The worksite loads exerted on the temporary retaining during the construction of the projects, e.g. movement of machinery, deposit of materials (reinforcement, excavation spoil etc.), construction cranes, etc., shall be taken into account in the design assuming the most adverse case with regard to the size, location and layout. The stipulations of the German Directives EAB shall be assumed as the minimum surcharge from worksite loads.

3.9.2 The live loads due to construction shall be taken into consideration, if it is ascertained, after appropriate checking, that they are more onerous than the normal loadings of the structure. These loads shall be multiplied by the appropriate impact factor to allow for the dynamic effects of transportation and handling.

3.9.3 All areas of floor slabs which should not be subject to construction live loads more onerous than the design live load. The necessity for confining the maximum permissible construction load imposed and for the various construction phases until the final strength of the structural elements and the completion of the entire bearing structure is achieved shall be identified, while any restrictions deriving from the design shall be clearly indicated in the appropriate drawings.

3.9.4 During construction, any loading likely to cause cracking and deflection that could affect the robustness, strength and/or appearance of the permanent structures must be avoided.

3.10 TEMPERATURE VARIATION, CREEP AND SHRINKAGE

The temperature variation related loads shall be taken into account in the design of various permanent structures, as required, depending on the type of the bearing structure, in line with ELOT EN 1991-01-05 and the pertinent National Annex.

Creep and concrete shrinkage shall be taken into account in line with ELOT EN 1992-01-01 and the pertinent National Annex.

Especially in case of installation of precast slabs for rail bedding, due to the bond created by the dowels among slabs perpendicularly and transversely, actions due to temperature must be implemented on the structure and the stresses that they cause must be estimated, to the extent possible. Three types of temperature loads shall be assumed: the concrete shrinkage, the uniform seasonal temperature variation

during summer-winter and the differential seasonal temperature variation (at the sides), also during summer-winter.

3.11 SEISMIC LOADING

3.11.1 General Conditions

In general, the seismic loading shall be calculated in accordance with the Approved Regulations and the methods stipulated in this article considering the typology, the specifications and the importance of the structure. ELOT EN 1998 along with the National Annex shall apply.

The Project area belongs to seismic zone Z1, per the National Annex of ELOT EN 1998-1 with maximum soil base line acceleration a_{gR}/g 0.16 (in soil – category A). As a minimum, assumption shall be made of soil category C (soil coefficient S=1.15 as per ELOT EN 1998-1 and the respective National Annex). The soil category shall result from the Geotechnical Survey in the Geotechnical Evaluation Report for Design Parameters.

The structures of the Project are integrated in significance category III per ELOT EN 1998 with coefficient equal to 1.20.

3.11.2 Especially as regards the design of the rail base plates, the following shall be taken into account:

a) Spectral enhancement coefficient βo is equal to 2.50 for Tramway loads, while this coefficient is equal to 1.00 for the dead weight of the slab, since it is rigid and embedded

b) seismic forces shall be as follows:

i) earthquake at dead weight per +X. Dead weight is multiplied by 0.16*1.15*1.20.

ii) earthquake at dead weight per +Z. Dead weight is multiplied by 0.7*0.16*1.15*1.20.

iii) Tramway vehicle seismic loads per X. The entire horizontal load is applied only on one of the rails, due to the wheels - rails entanglement. Thus, the horizontal load on one rail shall be 0.7*0.16*2.50*1.15*1.20*120kN, where 0.7 is the participation coefficient ψ2 of the live loads of the Tramway vehicle in the seismic combination.

Moreover, due to the overturning moment created from the horizontal diversion of the Tramway vehicle, a vertical pair of opposite forces are taken to act on the rails equal to Fseis x h /1.50, where Fseis is the horizontal seismic force equal to: 0.3*0.16*2.50*1.15*1.20*120, h being the distance of the Tramway vehicles' centre of gravity from the TOR and is equal to 1.80m, in line with ELOT EN 1991-2, para. 6.5.1(2), while 1.50 being the theoretical distance among rails.

Based on the equation, it results that a pair of opposite forces is finally taken to act, with a vertical load equal to +23.85 kN on the one wheel and -23.85 kN on the other wheel.

iv) seismic loads of the Tramway vehicle per +Z. Similarly with the static loads of the Tramway vehicle, these are taken to act only in the vertical direction, equal to 0.3*0.7*0.16*1.15*1.20*60*2.50=6,96 KN.

3.12 BALUSTRADES, HANDRAILS AND PARAPETS

Balustrades, handrails and parapets that may be used shall be designed to

withstand, without suffering any damage and deformation, the loads foreseen in the Approved Regulations.

3.12.1 Handrails shall be designed to withstand, without suffering any damage or deformation, a minimum load of 1.0 kN/m for public areas and 0.5 kN/m for technical equipment areas, to be applied at the top rail in any direction.

3.12.2 Parapets and balustrades shall be designed to withstand, without suffering any damage or deformation, a minimum load of 1.0 KN/m to be applied in any direction and at any spot.

Intermediate horizontal rails shall withstand, without suffering any damage or deformation, a uniform load of 1 kN/m applied in any direction.

For top and intermediate rails, concentrated loads of 250 N shall be applied in any direction.

3.12.3 Temperature variations and thermal movements for exterior handrails and balustrades shall be taken into account in the design.

3.12.4 In the design of parapet members exposed to wind pressure (e.g. glass panels), the respective loading according to the Approved Codes shall be taken into account.

3.13 LOADING COMBINATIONS

3.13.1 Loading combinations will be those stipulated in the relevant regulations. Load combinations that give the most critical results shall be the basis for the design of all structural elements of the Project.

3.13.2 Specifically for the accidental load combinations, the factor ψ_2 for live loads shall be taken equal to 0.70 for the design of Tramway permanent or temporary structures.

3.13.3 The structural design of the rail foundation slabs shall take into account all possible - per case- loads, i.e. dead, live from the Tramway vehicles and the road traffic, as well as seismic loads.

Moreover, whenever (i.e. at any loading) a pair of opposite vertical forces is taken to act on both rails, this pair has the same direction during every loading, finally resulting in a combined disfavour on the same side of the slab.

ARTICLE 4 BASIC DESIGN PRINCIPLES

4.1 General

4.1.1 TYPES OF PERMANENT STRUCTURES

The permanent structures of the Project shall include the metal shed of the Depot along with its foundation, the retaining walls, etc.

The following paragraphs present AM requirements concerning the design of the various structures.

4.1.2 DESIGN OBJECTIVES

4.1.2.1 The bearing structures of the permanent structures of the Project (metal shed, etc.) shall be designed and constructed in a manner ensuring that the movements and deformations, as well as stresses, which may result from the most unfavourable combinations of loading and actions likely to be sustained by the structures do not exceed in any way the limit beyond which the structures lose their capacity to fulfil their objectives either during construction or throughout the prescribed life of the Project.

Consistent with their technical soundness, the design and construction solutions must be efficient in economic and operational terms.

4.1.2.2 In the Metro works design, clear determination shall be made of the sequence of the construction phases. In the design consideration shall be taken of the construction method and the bearing structure's safety shall be checked during all stages (phases). The construction phases shall be determined in such a manner so as to cause the minimum effects possible on safety and functionality as to the existing adjacent (Tramway or third party) structures.

4.1.2.3 With regard to the content of the Design submittals concerning all types of Project structures, the requirements stated in paragraph 4.1.3 of the Document are applicable.

4.1.2.4 All points of conflict emerging from the interference of the Tramway structures with existing or under construction works or from interference of future developments with the complete Tramway Project Works shall be resolved in a manner acceptable to all parties concerned. The proposed design and construction solutions shall be subject to approval by AM. The design shall ensure that existing structures affected by the Tramway Works do not lose in any way the capacity to fulfil their objectives.

4.1.2.5 The final inner dimensions of the permanent structures shall satisfy the strength related requirements, as well as those regarding efficient operation and running of the subject installations.

4.1.2.6 Provisions shall be made in the bearing elements of the structures for fixing of cables, E/M facilities, pumping ducts and any other item of equipment that needs fixation.

4.1.3 CONTENT OF DESIGNS' SUBMITTALS

4.1.3.1 The Detailed Final Design (DFD) of each permanent structure of the Project shall consist in: the Design Report (Technical Report), the Calculations Notes, the documents for any additional checks or Appendices of calculations, the drawings and any other supporting material needed for the documentation of the design. All

aforementioned documents shall have the layout and numbering system described in article GS0101 “OFFICE DRAWING AND CODIFICATION MANUAL FOR TRAMWAY PROJECTS” and GS0200 “DESIGN REQUIREMENTS – DESCRIPTION OF THE SCOPE OF DESIGNS/DRAWNGS/REPORTS” of the General Specifications. All the aforesaid documents shall be signed by the Contactor’s responsible engineer, according to the contractual documents.

4.1.3.2 Depending on the type and the level of the design, and further to the general requirements of paragraph 1.7 of this Specification, the Design Report shall include as a minimum:

- Table presenting the basic assumptions of the design,
- Relevant information provided by the Geotechnical Base Line Report (GBR), as this is determined in Article 2B of the DSCW,
- A separate chapter describing in detail the construction process and construction sequence for each phase, along with the respective influence of each phase on the design and the calculations
- A separate chapter describing in detail and documenting the simulation of the structure. This chapter shall make a detailed presentation of the individual components of the various models, such as the geometry with sketches of their nodes and members which shall show the respective numbering, as well as presentation of the support and coupling conditions of the inertia and elastoplastic properties of all members, as well as of any support springs of the bearing structure, including their calculations of their numerical values.
- A separate chapter presenting and justifying in detail all loads exerted onto the model, including the calculations and numerical values of each load, as well as all loading combinations, are specified in the relevant Regulations. Subsequently, the loadings shall be presented in a tabulated form along with the serial number (in full correspondence with the LC number of the input-output files), the name and the numerical value or the equation to the coefficients for each case of loading or each combination of loading, respectively. The description of the loads shall included sketches showing the load influence surfaces, as well as their influence diagrams showing the name, the numerical value and the respective geometrical dimensions and elevations,
- Separate chapter describing, justifying, evaluating and presenting in detail the results of the analysis and the dimensioning. This chapter shall include a) sketches of the static model properly scaled for the various parts, the equal stress curves or the diagrams of the stress figures (M, Q, N) to enable surveillance and effective control, b) the sketches of the deformed bearing structures with typical values of deformations, c) the sketches of the static model at an appropriate and legible scale, separately for the various parts of the structure, the equal reinforcement curves for the various locations (X, Y, top, bottom, shear reinforcement) to enable surveillance and effective control of the installed reinforcement, d) sketches of the static model with the required reinforcement indicating also the installed or alternatively in tables showing the required and installed reinforcement at each location, facilitating and enabling, thus, the meaningful controlled of the installed reinforcement.

4.1.4 PROJECT DESIGN LIFETIME

All bearing structures shall be designed to ensure the following project lifetime as follows (see ELOT EN 1990, paragraph 2.3):

Building structures	50 years

(design lifetime category 4)

4.1.5 STRUCTURAL INTEGRITY OF STRUCTURES

All permanent structures of the Project shall correspond to structural integrity category RC3 and a high category of consequences due to failure or bad operation of the structure (CC3), in the sense of paragraph 2.2 and Annex B of ELOT EN 1990.

4.1.6 RESILIENCE OF STRUCTURES

The bearing structures of the permanent projects must be designed in a way so that the reduction of their initial properties due to wear throughout their lifetime does not lead to a reduction of the required performance of the structure under an acceptable limit, taking into account its environment and its maintenance level. As regards this issue, please refer to the general principles mentioned in paragraph 2.4 of ELOT EN 1990, as well as to the specific requirements of the relevant articles of the remaining Eurocodes, depending on the construction material (e.g. section 4 of ELOT EN 1992-1-1 concerning the “Resilience and Coverage of Reinforcement”).

4.1.7 FIRE PROTECTION – FIRE RATING

4.1.7.1 The effects of fire on structures either as a whole or in part shall be considered in the design of the Project and the required fire protection of structures shall be assessed by methods specified in EUROCODES ELOT EN 1991-01-02, ELOT EN 1992-01-02, ELOT EN 1993-01-02 and the relevant National Appendices, as well as in the New (Greek) Regulation for Fire Protection of Buildings (Presidential Decree No. 41/2018 – FEK/A’/80/07.05.2018).

4.1.7.2 The fire rating of a structure, expressed as the duration of fire which it is capable of resisting, shall be assessed depending on the fire attack grade.

Grade of fire attack shall be a function of the required fire rating time and the temperature developed for every particular structure.

The developed temperature for every structure shall be estimated in the design taking into account the kind and the material of the structure and shall be subject to approval by AM.

4.1.7.3 The fire rating for the bearing structures is specified according to the following fire resistance indices:

- Metal shed 90 minutes

The aforementioned fire rating time periods are, in general, applicable in the various Project structures; however, for specific individual areas therein, different values may be valid, as specified in other contractual documents (e.g. E/M specifications).

4.1.7.4 The bearing structure of the Project structures, in case of fire, should be capable of bearing the loads for which it is destined, for a time period specified by the fire rating index. This requirement is applied in the entire bearing structure and on partial structural elements that form this structure.

In order to design the bearing structural elements against fire, Eurocodes (a series of ELOT EN 1990 to 1999 standards) shall be used, in combination with the respective National Annexes, taking into account the foreseen minimum required fire rating indices, as well as other applicable relevant requirements. The design shall be based on the calculation methods mentioned in the respective Eurocodes, or based on the relevant Tables of Eurocodes, if the pre-conditions pertaining to

their use are met, as specified in the respective Eurocodes. In exceptional cases, if required and if the necessary pre-conditions are met, advanced methods and models of calculation and general principles of fire mechanics can be used.

In order to identify the required fire rating index of each structural element, irrespective of the type of material of which it is made, the certificates foreseen in the Standards must be provided, on a per case basis. In special cases or if the necessary certificates are not available, the fire rating index and/or other fire protection properties shall be identified based on the respective standard tests executed by accredited Laboratories.

The above can also apply for non-bearing structural elements and materials.

4.2 PERMANENT STRUCTURES – DESIGN REQUIREMENTS

4.2.1 The permanent structures of the Project shall be those described in detail in the Technical Description and the Contractual Drawings and in brief in paragraph 4.1.1. Their bearing structure shall be made of reinforced concrete or structural steel.

4.2.2 As regards the design of the permanent structures of the Project, applicable shall be the requirements of the approved regulations and those presented in this document, which prevail, in case of disagreement.

4.2.3 In case certain design loads – depending on the use of specific parts of the structures - are covered neither by the approved regulations nor by this document, these shall be proposed by the designer for review and approval by AM based either on actual data (weights of items of equipment) or on internationally reliable sources (e.g. similar project, bibliography).

4.2.4 The computational models shall be, preferably, 3D with finite elements. For their relevant analysis and dimensioning, appropriate state-of-the-art software programs shall be used. All required checks shall be carried out based on the applicable Regulations and the current specification.

4.2.5 The content of the following paragraph abput several construction materials of the permanent structures is also valid for building structures (e.g. concrete class, check against cracking, etc.).

4.3 REINFORCED CONCRETE STRUCTURES

4.3.1 GENERAL

For permanent reinforced concrete structures design minimum concrete class C30/37 shall be used, per ELOT EN 1992 and the Greek Concrete Technology Code (2016), unless there is a higher concrete class, based on the requirements of the applicable regulations and standards, due to the category of the environmental impact assessment study of the specific structure.

For concrete elements with large volume, special precautions must be taken during design and construction to take account of the high temperatures during concreting. The Design must clearly show that it covers the requirements of the Approved Codes.

The joints of the structure shall be shown on the construction drawings and shall be arranged so as not to create any problems in the normal continuation of construction, or in the structural integrity of the final structure, or in the normal operation of the facility in any way.

4.3.2 CHECKING OF REINFORCED CONCRETE ITEMS

All checks specified by the Codes shall be carried out, the following checks being performed in all cases:

Limit state failure by axial forces and bending moments

Limit state failure by shear forces

Limit state failure by torsion moments, if stability is ensured from torsion

Limit state failure by a combination of the above forces

Limit state failure by puncture

Limit state failure by buckling (second order deformations), if necessary according to the relevant Code

Limit state failure of Serviceability by local stress concentrations at anchoring and lapping points of reinforcing steel bars

Limit state failure of serviceability by cracking

Limit state failure of serviceability by deformations

Moreover, all members of concrete bearing structures shall be designed and constructed so as to be adequately protected against fire, per ELOT EN 1992-1-2 and the fire protection requirements sited in the Project Specifications.

Especially as regards the foundation slab of the rails, which is strained by repeated Tramway vehicle loads, a concrete strength test against fatigue shall be conducted, in accordance with the provisions of the Approved Codes.

4.3.3 PRECAST CONCRETE

Whenever precast concrete segments are used, apart from the requirements on cast in site concrete, these shall also meet the specific requirements of the Approved Codes concerning such segments. The following issues must be considered in the design of precast concrete:

- The layout of the structure and the interaction between the structural members shall be such as to ensure a robust and stable behaviour. Adequate jointing between precast elements or between precast members and cast in-situ items must be obtained using appropriate reinforcement and/or special ties in order to ensure their stability even when subjected to accidental stresses (such as excessive impact, fire, etc.) and possible differential pressures of the supports.
- Ease of assembly and maintenance should be considered in the design of precast members. In precast construction, it is necessary to check the concrete strength at all stages of construction (e.g. de-moulding, transport, erection, etc.). Where required, due consideration must be given in the design to effects of dynamic actions during transport. In absence of a more rigorous analysis, this may be allowed for by multiplying the relevant static effects by an appropriate factor.
- In addition to satisfying the requirements of the Code, the analysis of precast concrete structures shall take into account the behaviour of structural members at all stages of construction and their interaction with other members, as well as the behaviour of the joints between members. An analysis for each relevant stage of construction shall be performed using the appropriate geometry and properties for that stage, the actual deformations and strength of the connections and the uncertainties from deviations in geometry and positioning.

- The requirements and precautions which are required to be satisfied during all stages of construction must be clearly described on the Detailed Design drawings (construction drawings).

4.3.4 REQUIREMENTS CONCERNING REINFORCED CONCRETE ITEMS

4.3.4.1 The design of the reinforced concrete structural elements shall comply with the following requirements unless the “Approved Codes” are more strict.

4.3.4.2 The minimum reinforcement percentages per bearing element shall comply with the requirements of the Approved Regulations. More specifically, the minimum required percentage of reinforcement 0.16% shall be placed at the foundations towards every direction and at each reinforcement layer.

4.3.4.3 Maximum centre to centre distance of reinforcement bars in no case shall it be more than 200mm to every direction and every side of the structural element.

4.3.4.4 The minimum diameter of the reinforcement bars in main bearing elements shall be Φ12.

As regards the use of bars of different diameters in the same bearing element, it is strongly recommended not to use many different diameters, so that the structure be implemented in a more standardised, simple and quick mannerIt is suggested to use two different diameters – at the most – per direction, Φmin $\geq$ 2/3 Φmax.

4.3.4.5 As regards the (S-shaped) transverse couplers arranged as shear reinforcement on walls or structure slabs, it is imperative to make at least one end curved by 135^{o} and hold these couplers at the point of connection between the vertical and horizontal beams.

4.3.5 CRACK CHECKING

As regards cracks checking, the minimum percentages of the reinforcement of the permanent structures shall be calculated on the basis of paragraph 7.3 of ELOT EN 1992-1-1.

As concerns the bearing elements of the structures, permissible crack width of 0.30mm can be assumed, in line with paragraph 7.3.1 of ELOT 1992-1-1.

Note that the permissible crack widths mentioned above concern only the calculation of the crack and of the required reinforcement and are not related to the crack limits referred to in Article 3311 of the Materials and Workmanship Specifications for Civil Works.

4.3.6 REINFORCEMENT COVERS

The nominal cover for reinforcement assumed in the design and mentioned in the documents and drawings shall be calculated based on paragraph 4.4.1 of ELOT EN 1992-1-1 and the National Annex, paragraph 2.5. Moreover, the reinforcement covers shall be taken into consideration based on the fire protection needs (see paragraph 4.1.7 herein). However, for all structures of the Project, in no case shall its value be less than the following values:

a. External faces exposed to soil or concrete blinding — 60mm

   If a waterproofing membrane is present, the minimum concrete cover on reinforcing bars

on the membrane side shall be

b. External faces exposed to weather

b1. Primary reinforcement	50mm
b2. Stirrups, ties and spirals	40mm

Wherever possible, reinforcement shall be rationally configured by restricting to a minimum the changes and dissimilarities in the size and spacing of bars.

Detailing shall be simple to permit an easy and efficient fixing of the reinforcement on site, and shall follow the principles of good practice as recommended by the section concerning details of the "Approved Regulations".

The Detailed Final Design of the permanent structures shall provide for construction joints (working joints) to be configured in line with the requirements of the regulations. These joints shall be presented in the Detailed Final Design drawings, where the maximum spacing between such joints are referred to; the subject spacing shall be in compliance with the regulations and shall be adhered to during construction,

4.3.7 PERMANENT STRUCTURES JOINTS

Suitable joints shall be selected, in compliance with the construction method and procedure.

Joints and connections related detail and their exact construction method shall be in compliance with the assumptions of the design.

4.4 SCAFFOLDINGS – DESIGN REQUIREMENTS

4.4.1 Scaffoldings and formworks shall be designed according to the applicable legislation concerning safety of structures and safety at work, the article 03110 "Formwork for in situ cast concrete" of the Material and Workmanship Specifications for Civil Works and the "Approved Regulations" (e.g. Concrete Technology Code, paragraph D1) and the following requirements.

4.4.2 The design of the scaffolding shall take into account, apart from the loading imposed by the fresh concrete (e.g. according to DIN 18218) and the other surcharges, the live loading from the installation, the personnel and the accumulated materials that can be exercised either directly on the scaffolding or on the completed structure before the latter acquires its bearing capacity. This loading shall be assessed on a per case basis, but in no case shall it be less than the equivalent of a uniform load of 1.5kN/m^2.

4.4.3 In addition to the pressures exercised by the wind and the horizontal seismic loadings, the scaffolding shall be designed in such a way so as to withstand the following minimum values of horizontal forces, which can be exercised at any direction individually or simultaneously, namely:

a. Horizontal forces developed by unintentional offsets (deviations) from the vertical axis of the members that bear vertical loads:

These forces shall be calculated for each of the following cases as a percentage of the vertical load and shall be exercised as a horizontal force on the upper level of the permanent structure, which is to be supported:

- Supports or pipes up to 10 pieces	2.5% of the vertical load
- Supports or pipes more than 10 pieces	1.0% of the vertical load

- Self-standing scaffolding systems 1.0% of the vertical load
- Supports and tripods made of structural steel 0.5% of the vertical load

b. Horizontal forces deriving from thrusts and impacts, asymmetric horizontal forces deriving from vertical loads exercised on non-vertical surfaces, shifting of the scaffolding due to temperature alteration, creepage, shrinkage, settlements, pre-stressing / de-stressing work, external tractors and anchoring works.

4.4.4 The designer must ensure that the scaffolding shall be able to bear and retain at the required position the loads from items of the permanent structure until these items acquire their own bearing capacity. The appropriate means shall be provided for eliminating the scaffolding deformations.

As regards the time for removing scaffoldings and formworks, applicable shall be the requirements of the “Approved Codes”.

4.4.5 Any scaffolding, to be erected at a direct (close) proximity to the vehicular traffic, shall be protected against collisions, through protective safety durable balustrades of a minimum bearing capacity of 7.5 kN/m, which shall further not allow any contact of the vehicles or the protective balustrade to any section of the scaffolding.

4.4.6 The foundations of the scaffoldings shall be designed in such a way so as the maximum calculated loadings not to create failures or unacceptable settlements. By utilizing the soil related data or though the pertinent tests, the designer shall prove the grounds of his assumptions relating to the allowable settlements and earth pressures on the foundations of the scaffoldings.

4. 4.7 All materials to be used as bearing elements of the scaffoldings shall meet the requirements of the relevant standards as regards their quality and properties. In cases non-standardized materials are used, their characteristic strength figures shall be assessed on an experimental basis (yield strength, tensile strength, modulus of elasticity) and the safety coefficients referred to in the relevant codes shall be taken into consideration.

4.5 PERMANENT STEEL STRUCTURES

4.5.1 General

All the requirements stipulated in para. 1.4 related to steel structures are mandatory (calculations), as well as the special requirements of the “Approved Codes”. (para. 1.3)

Steel structures, their members, joints and supports shall be planned and checked based on ELOT EN 1993 (Eurocode 3) and the corresponding National Annex.

The requirements of ELOT EN 1998 and the corresponding National Annex related to the design of steel structures shall also be adhered to.

As to the design of steel structures, use shall be made of the adequate simulations, depending on the type of the bearings.

4.5.2 Checks

- In the planning and the design, consideration shall be made of all possible actions and action combinations as stipulated in the relevant applicable Codes.
- All general and special tests provided for in ELOT EN 1993 and in the corresponding National Annex shall be performed to the total of the structure, its sections and members (limit state failures, limit state failure of serviceability, b class phenomena, removability, deficiencies, etc.).
- All special tests related to the general and local stability of the members, elements of the steel section of the structure shall be performed, depending on

the type and the stress of each member stipulated in ELOT EN 1993 and in the corresponding National Annex.

- Steel structures and their members shall be subject to fatigue tests, when they are also subject to circular loads.

4.5.3 Connections, supports and fixing check:

- All the foreseen connections, supports checks shall be executed, as well as all individual parts of the elements thereof (electro-welding, belts, plates, anchors, base-plates, screed, etc.) depending on the type of the connection, support and according to the requirements of ELOT EN 1993 and in the corresponding National Annex.

4.5.4 Serviceability checks

Serviceability checks shall concern the following:

- Check of the whole structure for serviceability against movements.
- Check of the individual sections, sub loading structures and individual members for serviceability against deformations.

4.5.5 Corrosion Protection

For corrosion protection of steel members and their connections, the design shall provide for all the appropriate measures. The most appropriate method is hot-dip galvanization, wherever this is practicable, as per the stipulations of ELOT EN ISO 1461.

4.5.6 Fire protection

All steel members and their connections shall be designed and constructed so as to be adequately protected against fire, as per ELOT EN 1993-1-2 and the fire protection requirements of the Project specifications.

4.6 STRUCTURES MADE OF OTHER MATERIALS

The design of structures made of other materials not listed in this Volume shall conform to the “Approved Codes” requirements.

ARTICLE 5 ROADWORKS AND ROAD PAVING DESIGNS

5.1 GENERAL

5.1.1 This Article provides the principles for the roadworks and road paving designs.

5.1.2 The basic principles and requirements of the design shall be in accordance with the Regulations applicable each time, namely:

- "Directions for Roadworks Designs", YPEHODE 2001
- European Standard EN 1317.

5.1.3 The reinstatement of roads shall be based on the pre-existing layout and geometry, unless otherwise directed by the Service.

5.1.4 Paved surfaces to be damaged due to traffic diversions, site occupations, PUO network diversions etc., shall be reinstated carefully and shall not present any irregularities along their connection joints. At locations where damage is severe (in excess of one third of the road surface), final asphalt layers shall be placed across the width of the road.

5.2 ROADWORKS

5.2.1 The basic geometric characteristics and typical road cross section shall be taken from the applicable regulations (OMOE), unless otherwise instructed by the Service.

5.2.2 The Contractor shall submit for approval to the Service and the Organization concerned the roadworks detailed design and shall incorporate any comments required for the final approval of the design. The design shall be submitted in eight (8) copies in colour and in electronic format as well.

5.2.3 Energy absorption elements, such as safety parapets for vehicles, balustrades for pedestrians, etc., or a combination thereof shall be installed as required by the Project completeness and the compliance with the pedestrian and vehicular safety rules.

5.2.4 Permanent walls or parapets (e.g. for ventilation shafts) above the sidewalk level shall be at a minimum horizontal distance, in accordance with the applicable OMOE.

5.3 ROAD PAVEMENTS

5.3.1 Construction of Road Pavements

In cases such as reinstatement and improvement of existing roads, as well as in case of construction of new access roads, the pavement will be constructed with the following layers, according to the applicable Greek Technical Specifications (ETEP):

Pavement layers:

a. Sub-base layers of 0.10 m thickness, after the compaction, each.
b. Base layers of 0.10 m thickness, after the compaction, each.

Asphalt layers:

a. Asphalt layers of 0.05 m thickness, after the compaction, each.
b. Asphalt concrete layers of 0.05 m thickness, after the compaction, each.

The Service concerned shall approve the number of layers of the final cross section.

The appropriate asphalt coatings shall be applied between layers.

The composition of the asphalt concrete shall have to be checked by a laboratory certified per ISO.

Regarding the aggregate materials of the base and sub-base, test certificates shall be submitted from an ISO certified laboratory.

5.3.2 Temporary Roads

For temporary road pavements where relevant diversions exist, their construction shall be properly planned for the temporary diversion period, but, as a minimum requirement, the road pavement shall have a 50mm thick wearing coat of hot rolled asphalt or asphalt mixture resting on a 30 cm thick bed of crushed material. The Contractor shall be fully responsible for the quality and maintenance of this road pavement.

5.3.3 Asphalt

The asphalt shall be procured by the Contractor and shall fulfil the requirements of the relevant Greek Technical Specifications (ETEP). Its quality shall be checked through the certificates issued by asphalt batch plants, to be available by the Contractor. The Contractor is solely responsible for the quality control of the asphalt.

A month prior to the commencement of asphalt works, the Contractor ought to submit asphalt mix designs, which are to be used in the subject Project and shall be checked by a certified laboratory.

5.3.4 Parapets and Traffic Barriers

Parapets or temporary traffic barriers shall be installed where necessary to provide protection at the perimeter of temporary traffic diversions or other potential traffic hazard areas near the work execution areas. For long-term site occupations and traffic diversions, the parapets to be installed should be painted or decorated for aesthetic reasons. Light fences shall be installed only for short-term site occupations or traffic diversions (less than one week duration).

ARTICLE 6 INVENTORY OF EXISTING FEATURES

6.1 DESCRIPTION OF WORKS

6.1.1 In the framework of the contract price, before commencement of the construction works of all works specified in the contract, the Contractor ought to submit (in an electronic form as well) a detailed inventory of the existing features in the areas to be occupied for the execution of all works, or PUO network diversions, including redeveloped areas, areas with road works interventions and areas to be occupied as worksites. This inventory shall be carried out through drawings, descriptions, tables, quantities, photographs, etc.. The drawings for the inventory of existing features shall be prepared by means of accurate measurements at a scale 1:200 in EGSA 87 reference system and shall be correlated with the main and the secondary horizontal and vertical network, as described in Article 9 of the Design Specifications for Civil Works. In view of the above, the Contractor shall proceed to a detailed survey on appropriate topographical drawings of the existing features within the work areas and site areas at street level. Each feature shall be given a specific number on the drawing. Based on these features, records shall be created for the area to be occupied.

The following minimum features must be recorded:

- Existing tramway tracks, existing Dept buildings and floors, existing poles, etc.
- Trees or plants with reference made to their type, age, height, trunk diameter
- Flower beds
- Curbs: curb type (marble, prefabricated), height and condition
- Sidewalks slabs: type, color, condition, size
- Balustrades
- Valves, fire hydrants, fountains (any lighting and cleaning system)
- Bust, statues
- PUO poles, e.g.lighting poles (type, condition), PPC poles (substations), OTE poles etc.
- Benches
- Play ground (swings, slides etc.)
- All PUO networks with installation features
- Kiosks
- Traffic lights
- Traffic signs
- Traffic information signs
- STASY, ETHEL, etc. stop sheds
- STASY poles and power cables, etc.
- Walkways for pedestrians, sight impaired, etc.

If the above features must be demolished for the needs of the Project, the

Contractor shall store or deliver them once demolished to their owners upon request. Otherwise, the Contractor shall remove and place them at approved material disposal areas. In both cases, the cost shall burden the Contractor and the Contractor shall not receive any fee whatsoever, since all relevant expenses are considered as included in a converted form in the Contractor's offer.

All the above surveying works shall be executed using exclusively ground level methods.

6.1.2 The above drawings shall accompany documents describing each feature with the use of the numbers that will correspond to the numbers that have been given in the drawings and the relevant quantities. The trees shall be described with reference to the species, height and perimeter of each tree. Where required, e.g. in cases of steps, flower-stands etc., typical details or sections shall be drawn including full description of every feature.

6.1.3. The above recording is necessary for the Contractor to be in the position to complete and adjust the Area Reinstatement design to the adjacent area, obtaining at the same time the approval of AM and various organizations involved.

6.1.4. Apart from the drawings and inventory documents, photographs should be taken before the inception of works in the areas bound to be affected, ensuring verification of the previous condition.

6.1.5 The inventory of features shall cover the entire area where Project works are to be constructed and which will be occupied for the respective worksites, or any other areas to be also occupied for the works needs, as well as the inventory of existing features of the existing Depot at the range specified in the relevant contract documents. The Contactor is obliged to proceed with the inventory in addition to that of the initial surfaces, should it be required by AM.

6.1.6 Prior to the commencement of the works, the Contractor shall also check, verify, correct, complement or prepare anew, if and where required, the topographical surveys delivered to him by AM for the areas foreseen in the Contract throughout the works occupation front, as well as for the extension of Elliniko Depot, the perimeter road, including sections to be reconstructed and for the areas to be occupied as worksites.

6.2 SUBMITTALS

6.2.1 The inventory of existing features shall be submitted for review and approval to AM also in digital format. The inventory of existing features diagrams shall be drafted on a 1:200 scale and shall be accompanied by the technical report to include measurements, calculations, quantities, descriptions, photographs etc.

Wherever AM deems it necessary, the drawings and documents shall be forwarded via the Service to the Organizations and bodies involved for verification and comments.

6.2.2 Any corrections or completions made on the part of these Organizations shall be entered into the drawings and documents by the Contractor; the subject drawings and documents shall be signed by the Contractor and the Organizations' and/or bodies' and AM's representatives. The Contractor shall reproduce sufficient number of copies of the signed documents and drawings, which shall be transmitted via AM to the various Organizations and the Municipality for future use during the Reinstatement of Areas phase (see Article 01560 of the Materials and Workmanship Specifications).

6.2.3 A copy of the drawings and documents shall be kept as a record at the worksite and shall be made available to the representatives of AM upon relevant request.

ARTICLE 7 DIVERSIONS OF PUBLIC UTILITY ORGANIZATION (PUO) NETWORKS

7.1 GENERAL

Existing networks are the underground and overhead networks of Public Utility Organizations (PUO) regardless of whether these are active or not. Namely:

- EYDAP networks, DEPARTMENT OF HYDRAULIC WORKS OF ATTICA REGION (D10) and municipal networks (water supply/ fire-fighting/ foul water and storm water pipes)
- PPC networks (high, medium and low voltage cables)
- OTE (telephony) networks and all mobile telephony networks
- EPA (gas) networks
- Street Lighting networks (DKEO)
- Municipal Street Lighting networks
- Municipal Water Supply networks.

7.2 PLANNING

The planning for each network diversion shall take into consideration all the data given in AM's Design (layout drawings, etc.), as well as any recent information available. The exact location of the existing networks, in a general plan view, as well as in a longitudinal section, shall be obtained from the PUOs during coordination meetings and shall be confirmed by field inspections and excavation of investigation trenches, prior to the execution of excavation works. The investigation trenches at various typical points shall assist in the clear identification and determination of the type / number of PUO networks to be diverted, both in the framework of the preparation of the relevant designs, as well as for the execution of the relevant works. At this stage and with the Contractor's initiative, the cooperation and coordination among the relevant and the remaining organizations is deemed imperative. Arrangements should be made so that permanent diversion routings pass through public areas.

7.3 PROTECTION OF EXISTING NETWORKS

Whenever an existing utility network is in the boundary of an excavation, instead of being diverted, provisions can be made for supporting and protecting this existing network, during construction works, according to the requirements of the PUO concerned.

7.4 NETWORK DIVERSIONS

7.4.1 When existing networks have to be diverted or relocated, temporarily or permanently, the planning should meet the criteria and requirements of the PUO concerned at each time and shall be subject to the approval of the PUO to which the network belongs.

7.4.2 Detailed Final Designs for the diversion of OTE, PPC and EPA networks are prepared by the organizations themselves, based on the conceptual designs elaborated by the Contractor, also responsible for the coordination of the designs, so as to meet the needs of the project. However, the Organization itself may require that the design is prepared by the Contractor.

7.4.3 The Detailed Final Designs for the diversion of EYDAP networks for foul water, water supply, Department of Hydraulic Works (D10) for rainwater, the networks of the Municipality for city lighting, the networks of DKEO for Signalling shall be prepared by the Contractor and shall be submitted, together with the coordination drawing, to AM for commenting in relation to the routing in electronic format in six (6) copies. The implementation of these designs, following approval by the PUO

concerned, shall be supervised concurrently by AM and the PUOs.

The Contractor's designer shall incorporate AM comments and shall submit separately each detailed final design in six (6) coloured hard copies and in electronic form to the PU Organization concerned, communicating two (2) additional copies to AM. All the above designs shall be stamped and signed by the designer.

In the event that remarks on the designs are formulated by the Organizations in charge, the Contractor shall be obliged to re-submit the design, since he bears full responsibility for the final approvals of the subject designs.

In any case, the Contractor shall be responsible for the coordination of the diversions of all PUO networks and for ensuring on time approval of the designs.

Paragraph 9.6 includes in detail the content of the design on the diversions of hydraulic networks.

7.4.4 During traffic arrangements, temporary (or permanent) network relocations will be required (mainly traffic lights and city lights). Also, in cases of reduction in the sidewalk dimensions, there may be a requirement for preventive measures or for the lowering of other PUO networks, which are found within the zone of those traffic arrangements.

7.4.5 PUO network isolations, for a short or a longer period of time, should not be carried out without the concurrence of the Organization involved. On the contrary, the undisturbed operation of those networks should be ensured with temporary safe solutions or permanent works with minimal disturbance (intervention) to the surrounding area.

7.4.6 In cases of networks passing through non-public areas, the Contractor should prepare cadastral diagrams and tables for any temporary occupations to be eventually required.

7.4.7 At the end of the works, the Contractor shall submit to AM and the PUOs concerned the drawings of their "As Built" networks.

7.5 COORDINATION DRAWING

The Contractor shall submit the coordination drawing along with all existing networks, as these have arisen based on AM's general final design drawing, the investigation trenches and the information collected by the PUOs. This drawing shall also present the proposed diversions of all networks, having made the relevant communications and having ensured AM and the PUO's concurrence.

The coordination drawing shall be submitted to AM for commenting in six (6) copies in colour and in electronic format. The Contractor's designer shall incorporate AM's comments in the detailed final designs of all diversions. The approval of the coordination drawing shall precede the approval of all the remaining drawings.

7.6 HYDRAULIC DESIGNS FOR PUO NETWORK DIVERSIONS

7.6.1 General

The scope of the hydraulic design for PUO network diversions is to determine the routing of the proposed diversion, the calculation of the hydraulic adequacy and the selection of the construction materials for the new pipes.

7.6.2 Design Principles

- The routing of the permanent diversions shall be placed to the extent feasible within public areas and shall be sufficiently accessible for future maintenance.
- The proposed temporary or permanent diverting pipe must have a discharge capacity at least equal or larger than the capacity of the existing pipe.
- Each manhole or sump affected by the temporary or permanent network diversions, temporary traffic arrangements or re-construction of curbs shall be placed to a new location.
- The construction material of the pipes shall be compatible with the material of the existing network and shall be selected on the basis of the Materials and Workmanship Specifications and the requirements of the concerned PUO.

7.6.3 Specifications – Regulations

Diversions shall be designed and constructed in line with the Greek Technical Specifications and more precisely, in line with the following relevant standards and specifications:

a) ELOT TS 1501-08-01-03-01:2009
Underground utilities trench backfilling

b) ELOT TS 1501-08-01-03-02:2009
Underground utilities trench backfilling

c) ELOT TS 1501-08-06-02-02:2009
Pressurized u-PVC pipe networks for sewage

d) ELOT TS 1501-08-06-08-03:2009
Retrofitting of concrete paving slabs along constructed underground utility

e) ELOT TS 1501-08-06-08-04:2009
Retrofitting of kerbs and gutters along constructed underground utility

f) ELOT TS 1501-08-06-08-06:2009
Prefabricated concrete manholes

g) ELOT TS 1501-08-07-01-04:2009
Ductile iron gully tops

h) ELOT TS 1501-08-07-01-05:2009
Manhole steps

i) ELOT TS 1501-02-02-01-00:2009
General excavations for Road and Hydraulic works

j) ELOT TS 1501-12-05-02-00
Geotextiles for the protection or drainage of tunnel lining waterproofing membranes

- Specifications issued by EYDAP and Directorate D10 of Attica Region
- PD 696/74.

7.6.4 Content of the Design

The Hydraulic Designs for temporary and permanent diversions of PUO networks (water supply, sewage and rain water) shall include a Technical Report, a Layout Plan, a Longitudinal Profile, Typical Details - Sections, as well as any other drawing requested by the Service or the PUO concerned.

7.6.4.1 Layout Plan

The layout plan shall present in detail the existing routing and the proposed diversion of the subject networks. The hydraulic and geometric data (capacity, flow rate, overflow etc.) are indicated on each section of the pipe. The following information is also presented:

- Manholes with the elevations for the sewage and rainwater networks.
- Points of connection of the water supply networks with existing pipes.
- Rainwater sumps and connections with the pipes.
- Discharge pipes and associated manholes connected to the network.

The layout plan shall present:

- Temporary occupation - worksite fencing.
- Outline of the trenches and other structures.
- Configuration of sidewalks and curbs due to traffic diversions.
- Final configuration at street level, in case of permanent diversions.

The scale of the drawing shall be 1:200 - 1:500.

7.6.4.2 Longitudinal Profile

The longitudinal profile depicts the proposed pipe with the following information:

- Manholes and lengths of at least 5m upstream and downstream the pipe.
- Contributions from sumps or secondary branches – common routing.
- Intersections with other PUO networks.
- Hydraulic data (capacity, flow rate, length, fullness etc.).

When the diameter of a water supply network pipe is less than Φ200, no longitudinal profile needs to be prepared.

The scale for the lengths is 1:500 and for heights 1:50.

7.6.4.3 Typical Details

The drawings of the typical details include:

- Manholes, sumps, pressure relief manholes etc.
- Typical trenches for pipes.
- Anchoring.
- Pipes suspension scheme, if required by the design.

The scale of the drawings is 1:25.

7.6.4.4 Technical Report

The Technical Report shall include, as a minimum:

- Available data for PUO networks
- Description of the proposed diversions
- Hydraulic calculations
- Construction data (materials of pipes, excavation pits, suspension scheme etc.).

ARTICLE 8 TRAFFIC REGULATIONS

8.1 GENERAL

The Contractor shall prepare comprehensive traffic detailed designs pertaining to all required diversions of the traffic during construction as well as to the final reinstatement. The designs shall be submitted in fifteen (15) copies in colour, as well as in electronic form.

8.1.1 The Contractor shall be responsible for all permits and approvals required prior to the implementation of each traffic diversion.

8.1.2 The Contractor shall provide and install the traffic signs at the locations deriving from the traffic designs; moreover, he shall maintain the said signs throughout the duration of the works. The same apply for the horizontal signage.

8.1.3 As required by the traffic design, the Contractor shall cover existing traffic signs using removable covers or he shall remove and store the existing traffic signs, which shall be used again after the completion of the works.

8.1.4 The Contractor shall submit a drawing at scale 1:200 with the inventory of the existing traffic features prior to the commencement of works (Traffic signs and road markings, traffic lane - sidewalk widths etc.) for all areas in which traffic diversions will be carried out.

8.2 REFERENCED STANDARDS

- "Technical Specification for the Signage of Roadworks Under Execution in and outside built-up areas", YPEHODE, FEK 946B, 09/07/03;
- "Directives for Roadwork Designs", YPEHODE, 2001;
- Directives for Worksite Signage in the Urban Road Network", YPEHODE, 2002;
- Road Traffic Code, Law 2696/99, FEK 57/23-3-99, as amended by Law 3542/2007 FEK 50A;

8.3 TRAFFIC DIVERSION DESIGNS

8.3.1 Prior to the commencement of the relevant works, the Contractor shall submit to AM and the agencies concerned for approval comprehensive Detailed Final Designs for the regulation of the traffic in all areas to be effected by the execution of the works.

8.3.2 The proposed designs for the diversion and regulation of the traffic shall be accompanied by a technical report and drawings (at scale 1:200) including at least the following:

- Identification of the access points to the worksite, entrance and exit of pedestrians and vehicles
- Determination of the location and area of the worksite
- Geometrical data of the alignment
- Traffic signs and road markings (current, abolished and new signage)
- Bus Stops.

8.3.3 The Contractor's heavy vehicle routes to/from the worksite area shall be provided.

8.4 The Contractor ought to carry out maintenance and systematic repair of the traffic signs and road markings in the areas where traffic diversions are implemented, so that signs and markings remain in a perfect condition; he shall also repair the damage and wear in the streets and sidewalks caused during the execution of the works.

8.5 Easy vehicular access to adjacent buildings and installations shall be secured obligatorily in view of serving their needs or as required by their operation, and especially in case of emergencies (Fire Brigade, Ambulance, etc. access). Such an access shall be secured even via the passage of these vehicles through worksite areas.

8.6 TRAFFIC LANES AND SIDEWALK WIDTHS

As far as traffic diversions are concerned, the minimum width of the traffic lanes shall be as follows:

One (1) Lane: 3.50 m.

Two (2) one-way Lanes: 6 m. (2 x 3)

Two-way street with one traffic lane per direction: 6.5m (2 x 3.25)

Two-way street with two traffic lanes per direction: 12 m (2 x 3 + 2 x 3)

The width of the exclusive left turn lane may be 2.75m.

The minimum width of the sidewalks shall be 1.2m.

8.7 Unless otherwise agreed upon by AM and OASA, bus stops shall be maintained at the locations where they were prior to the commencement of construction activities. In case any stops need to be relocated, the Contractor is responsible to co-ordinate with OASA.

8.8 At locations indicated by AM, the Contractor shall carry out improvements to local streets in the vicinity of the Site, which are required to be used by the diverted traffic or for access to the site, including widening, re-construction or re-surfacing of road pavement and sidewalks, installation and re-installation of curbs and road markings.

8.9 Throughout the duration of the works, direct access of pedestrians to all properties and public areas in the direct vicinity of the worksite shall be maintained. At locations where works are anticipated to intervene into current sidewalks or pedestrian passages, the Contractor shall maintain and abolish - when they are no longer needed - separate appropriate corridors through the works. At locations where it is deemed necessary to construct temporary sidewalks in order to maintain access to properties etc. or in view of securing the passage of pedestrians, these sidewalks shall be paved and their width shall be at least 1.20 meters.

ARTICLE 9 TOPOGRAPHICAL SURVEYS, WORKS AND ALIGNMENTS

9.1 GENERAL

9.1.1 All the obligations of the Contractor related to the topographical surveys, works and alignments are described herein as follows.

The survey works to be carried out by Contractor during the design and construction of all works of the Contract shall include the following:

a. Establishment of a unified basic horizontal network and a unified levelling control network within the EGSA 87 reference system and connection with the already existing reference system of the Metro and/or the Tramway , definitely in a manner to ensure compatibility (in terms of layout and as to the height) with the existing Tramway structures.

b. Establishment of secondary horizontal and levelling control networks connected with the basic networks.

c. Updating of the topographical diagram and compilation of new one, to be connected with the basic horizontal and levelling network to be established for the needs of the works.

d. Constant geometrical control of all structures for the expansion of the Depot in the area of Elliniko and of the future perimeter road for all construction phases.

e. “As Built” topographical survey of the future expansion of the Tramway Depot in the area of Elliniko and of the future perimeter road of the Depot upon completion of their construction, as well as “As Built” topographical survey of the reinstatement of all areas occupied for the needs of the works of the Contract.

9.1.2 All topographic measurements shall be accompanied by the required corrections due to pressure, temperature and refraction.

9.1.3 For all survey works, the Contractor is obliged to obtain the approval of AM and to be in close contact with it on a daily basis.

All topographical data (primary data, coordinates files, drawings) shall be stored in digital form and shall be transmitted to AM immediately attached to submittals respectively and/or through e-mail provided it is requested by AM and at a frequency that would have been mutually determined.

9.1.4 All survey works shall be carried out according to the provisions of the “Technical Specification for Geodetic, Topographical, Cadastral and Mapping Works” of PD 696/1974, as well as in accordance with the specifications described in all documents of this contract.

9.1.5 For all topographic works required for the design and construction of the projects, EGSA 87 State reference system shall be used.

9.1.6 AM shall supply the Contractor with topographical information available to AM for the Project.

9.1.7 The Contractor is responsible for verifying the adequacy and completeness of any information provided to him, related to every aspect of the Tramway Project and other structures. Moreover, the Contractor is responsible to update and supplement all diagrams.

All topographical measurements, survey works, alignments, updating of drawings,

compilation of new drawings, etc., shall be performed with the exclusive use of terrestrial methods.

9.1.8 All survey measurements, as well as the calculations, the results and the drawings for all the survey works herein shall be submitted for approval to AM in digital form too and shall be signed by the Chief of the Contractor's Survey Department.

9.1.9 Design of alignments and surveys (as well as their implementation) shall always be carried out on the basis of hierarchy, starting from the general drawings which shall contain the reference data and the boundaries of the detailed drawings, in order to avoid any omissions and discrepancies on the detailed drawings.

9.1.10 The Contractor is obligated to submit for approval to the Department the organization chart of the personnel to be employed by the Survey Department, as well as the CVs and certificates of previous experience for the entire main and auxiliary personnel mentioned above.

The Survey Department shall consist of the Person Responsible of the Department, who shall be a Licensed Topographer Engineer, holder of University Degree, with ten (10) years of experience in similar Projects of the same scale and requirements.

The Survey Department shall include experienced topographical work crews and the Head of each work crew shall be a Licensed Topographer Engineer who shall carry out measurements; he shall be holder of University Degree and shall possess four (4) years of experience in similar works of the same scale and requirements.

Alternatively, the Head for the work crew could be a Licensed Engineer, graduate of Technological Educational Institutes, of a similar specialty, with seven (7) years of experience.

The entire personnel of this Service shall be at all times efficient – in terms of number - and effective – in terms of experience - to satisfy the Project needs.

9.1.11 For all the above and before the commencement of the construction of the works, the Contractor is obliged to submit to AM for approval the Methodology for the execution of all Survey Works. This methodology shall include the following references:

A. GENERAL PART - INTRODUCTION

A1. SUMMARY DESCRIPTION OF THE PROJECT

A2. CONTRACTUAL OBLIGATIONS

A3. STAFFING OF THE SURVEY DEPARTMENT

A4. GENERAL DESCRIPTION OF THE METHODOLOGY

B. REFERENCE NETWORKS

B1. ESTABLISHMENT & INCREASE OF NETWORKS

B2. CONNECTION WITH EXISTING NETWORKS

B3. SUBMITTALS

B4. EQUIPMENT

B5. SOLUTION METHODS, ACCURACY

B6. SOFTWARE

B7. MAINTENANCE

C. GEOMETRICAL CONTROL OF STRUCTURES – SURVEYS

C1. GENERAL

C2. GEOMETRICAL CONTROL PHASES

C3. METHODS

C4. EQUIPMENT

C5 RECORDS – FORMS

C6. FILES

C7. SUBMITTALS

D. "AS BUILT" DATA

D1 GENERAL

D2. REQUIREMENTS

D3. METHODS

D4. FORMS

D5. SUBMITTALS

D6. APPROVALS

D7 FILES

The submitted Methodology must be approved by AM, and any eventual comments must be taken into account by the Contractor.

The recording of the results and the filing is performed on the basis of the project's segmentation into portions, as specified in advance.

It is evident that the structure of the documents' filing system must be accompanied by the appropriate digital data format for the purpose of the correct and immediate data exchange with AM.

9.2 Basic horizontal network

9.2.1 A basic horizontal control network shall be established for the needs of construction of the works of the Contract. The positioning of these points shall be defined in cooperation with AM. The horizontal control network (triangular) shall consist of mutually visible pairs of points, while each one of the subject points shall necessarily be mutually visible with its immediate previous and subsequent point along the alignment. The network shall be connected to at least two (2) points of the existing basic horizontal network along the Metro alignment and/or at least two (2) existing triangular points of the Tramway network, definitely ensuring compatibility with the existing Tramway project, performing all necessary controls for this purpose. Measurements in this network shall be based on the GPS system, while the coordinates shall be given on the basis of the EGSA 87 State reference system.

9.2.2 The solution and the adjustment of the network shall be carried out with the use of the appropriate software (using the method of the least squares), at a three-sigma confidence level. The coordinates shall be given based on the EGSA 87 State reference system, with the respective accuracy and standard deviations.

9.2.3 The GPS system to be used must be a dual-frequency system and must have at least 9 channels. Its accuracy in static tracing shall be $\pm$5mm +1ppm, and in kinematic tracing with post processing $\pm$10mm +1ppm.

9.2.4 The software for the processing of the GPS measurements shall be capable to:

- be used in Windows environment and to trace the location using all tracing

techniques

- import / export Rinex files, as well as to produce reports for each executed work,
- transfer data, process data bases, automatically selecting the bases for solution and controls
- control the closing of triangles / polygons
- to resolve networks, change the reference systems (datum) and programming of measurements
- select a local reference system that has been entered by a user
- automatic conversion of coordinates to any reference system
- select the geoeid model
- output results in various formats such as .dxf, ascii and other, in order to be compatible with all CAD and GIS systems
- to perform automatic hierarchy of unified solution of data concerning the static and kinematic tracing (post processing kinematic & RTK) and conventional ground level observations
- to perform automatic conversion of kinematic measurements after the solution of statistics using MET
- The network accuracy shall be ±10mm.

9.2.5 The GPS system and the software to be used shall be submitted to AM for approval.

9.2.6 The identification of the points of the basic horizontal network shall be permanent and in a way ensuring its preservation during the construction of the Projects, as well as for their future use.

9.2.7 The methodology for the above works shall be submitted to AM for approval, prior to the commencement of works.

9.2.8 The Contractor is responsible to maintain the points of the above network, and in case wear or obstacles is observed, the Contractor shall proceed to the replacement of the affected points and their incorporation into the basic horizontal network upon its re-measurement and re-calculation.

9.2.9 The above network shall be checked periodically, in time intervals to be agreed with AM.

9.2.10 The primary measurements, the calculations, the results, their accuracy, the description, the securing of the points and the network diagrams shall be submitted each time to AM in a digital form as well.

9.3 Basic elevation network

9.3.1 For the needs of construction of the works of the Contract, a basic elevation control network shall be established, with elevation benchmarks, at locations to be agreed with AM.

9.3.2 This network shall be measured by means of geometrical levelling traverses allez-retour and shall depend on the Metro elevation benchmarks, definitely ensuring compatibility with the existing Depot related Project; moreover it shall consist of an adequate number of loops, so as to ensure the maximum possible accuracy at its adjustment phase. The geometric levelling traverses shall be open, fully depending on both ends to the levelling benchmarks of the existing Metro elevation network.

9.3.3 The elevation points shall be calculated using the least squares adjustment method.

The accuracy of measurements of the network shall be in the order of ±2mm/Km.

9.3.4 The instruments to be used shall be high precision electronic levels, with an accuracy of ±1mm/Km, along with their corresponding stuffs to achieve the accuracy required, and shall be submitted to AM for approval.

9.3.5 The identification of the points of the elevation network shall be permanent and in a way ensuring their preservation during the construction of the works, as well as for their future use.

9.3.6 The Contractor is responsible to maintain the points of the above network, and in case he observes any damages or obstacles, he shall proceed to the replacement of the affected points and their re-integration into the basic elevation network through its re-measuring and re-calculation.

9.3.7 The above network shall be checked periodically, in time intervals to be agreed with AM.

9.3.8 The measurements, the calculations, the results, the description, the securing of the points and the network diagrams shall be submitted to AM in a digital form as well.

9.4 Secondary networks for horizontal and vertical control

9.4.1 The secondary horizontal control network shall be implemented following the densification of the basic horizontal control network at locations mutually visible. The positioning of these points shall be defined in cooperation with AM. It shall depend on at least three points of the basic horizontal network.

9.4.2 The measurement of the secondary horizontal network shall be carried out using open polygonometric routings fully dependant at both ends from points of the basic horizontal network. The identification of the points shall be permanent, at locations which are secured against any possible influence of the works.

9.4.3 The Contractor is responsible for the maintenance, the periodic checking and the replacement and re-definition (if necessary) of the points of the secondary horizontal network. The angular accuracy of the instruments to be used in the measurement of the network shall be 2” (6mgon) and at the distance of ±2mm+2ppm; the instruments shall be submitted to AM for approval.

9.4.4 The Contractor ought to update, be in constant communication with AM and submit the measurements, the calculations, the results, the diagrams, the descriptions and the securing of the points in a digital form as well.

9.4.5 The secondary horizontal network must be checked regularly (depending on the progress of construction of the works).

9.4.6 The elevations of the secondary horizontal network points shall be calculated through geometrical levelling traverses allez-retour fully correlated on both ends with the benchmark points of the basic elevation network and shall be checked regularly (depending on the progress of construction of the works).

9.5 Updating, supplementing the topographic diagrams and preparing new ones

9.5.1 There is a previous topographic survey in the EGSA 87 reference system for the wider area of the Project.

The Contractor must update (in terms of layout and as to the height) the topographic diagrams to be provided to him, which should include the aforementioned survey, while he must prepare a new survey and connect the above with the basic horizontal and levelling network to be established for the needs for the works.

The instruments to be used shall have the same accuracy as those described in Article 9.4.

In detail, the topographic works shall include the following:

Updating of the topographic diagram and preparation of a new one to be connected with the basic horizontal and levelling network to be established for the needs of the works of the contract, as well as topographic survey of the following areas:

Areas to be temporarily occupied as worksites

The future expansion of the Tramway Depot in the area of Elliniko and the future perimeter road to the Tramway Depot in the area of Elliniko, for a width of 10m, from the existing limit of the Tramway Depot in the area of Elliniko towards its inner area and for a width of 70m from the existing limit of the Tramway Depot in the area of Elliniko towards its outer area, as well as to the west and the east of this limit up to the areas where the future expansion of the Tramway Depot is adjusted to the existing Tramway Depot, and along the area of the new perimeter road and the existing access road to Aghia Paraskevi church and towards the former ETHEL Depot, while the survey limit shall be the limit of the area where it is foreseen to construct any roadwork.

The zone of the survey area shall be 20m wide on either side of the axis of the future perimeter road to be constructed, and 20m-wide on either side of the existing road to Aghia Paraskevi church and to the former ETHEL Depot, including the former access of ETHEL Depot and any other roadwork that may be constructed in the framework of the works of the contract.

9.5.2 The topographic surveys shall include the creation of a Digital Terrrain Model (DTM). They shall also include, with a similar indication, the survey of buildings, galleries and landplots of the Building Blocks with all overlaying structures, shafts, meters and boxes of all PUOs, trees, roads, balustrades, parapet walls, traffic islands, curbs (the elevations at the curbs shall be surveyed in pairs, so that the height of the curbs shall result from the deduction of two elevations), poles related to all PUOs, Municipal poles etc., kiosks (including their additional equipment, e.g. refrigerators, etc.), flower beds, cardphones, cameras, bollards, bus stops, grade-separated passages, signalled intersection (traffic lights, pedestrian crossings etc.), benches, fountains, PSN ramps, guidance paths for visually impaired, information and advertising signs etc. as well as the horizontal signage of streets, ramps of basements and parking areas. The building surveys shall include the building facades and the separating lines between them.

The round sections of the curbs (e.g. corners of sidewalks, traffic islands etc.), consideration shall be given to the points (on the top and the foot of the curb) required for the implementation of the 3D lines indicating the change of curvature based on their actual geometric shape (rounded or polygonal).

In addition, the following shall be surveyed: points at the top surface and/or axis of the road pavement, the building entrances, shops, as well as points required for the presentation of the grade variation lines, to fully survey the sidewalk surfaces between the sidewalk and the road pavement.

It is evident that the tilt lines should not intersect, otherwise the DTM.shall be incorrect.

For the DTM to be implemented, it shall be supported by 3D polyhedral surfaces of triangular shape, specified by the closest groups-of-three points on the survey.

All levelling points forming the DTM shall be depicted as distinct 3D points (point x, y, z).

The topographic diagrams shall be submitted at scale 1:500 and in digital format.

9.5.3 The Contractor has the obligation and responsibility to constantly update the topographic diagrams with data from all networks and structures, as these are modified until works are completed and, upon their completion, to prepare new diagrams, where required. All topographic measurements and drawings shall use as a reference system the EGSA 87 State reference system and all topographic works shall be connected with the basic and/or secondary horizontal and elevation network of the Project.

9.6 Delimiting of the expansion of the Tramway Depot in the area of Elliniko, the future perimeter road of the Depot and control of the above

9.6.1 The Contractor shall use all topographic works for delimiting the expansion of the Tramway Depot in the area of Elliniko and the future perimeter road of the Depot, shall process the field data, shall carry out all necessary calculations and shall submit any drawing required for the completion of the Project.

9.6.2 All the aforementioned works to be based on the Methodology of Topographic Works in para. 1.11 herein shall depend on the basic and/or secondary horizontal and leveling control network.

9.6.3 The Contractor shall be responsible for the correct and proper implementation of all theoretical lines, dimensions and gradients required for the construction of the project, in accordance with the construction and/or contractual documents. Should the Contractor fail to satisfy this requirement, any defective structure or part thereof shall be rectified or reconstructed as part of the lump sum price.

9.6.4 The accuracy of the instrumentation to be used shall be the same with the accuracy of the instrumentation mentioned in Article 9.4. The Contractor's instrumentation and the entire survey equipment shall be accurate, suitable for the surveys required, in compliance with the recognized technical standards and in proper condition, properly adjusted and calibrated at all times, while it shall be submitted to AM for approval through Material Submittal sheets (MSSs) before the commencement of each phase of the works. The surveying works shall be executed by survey crews, as these are defined in paragraph 9.1.10 of this Article who staff the Survey Department. In addition, the Contractor shall inform AM – through a pertinent submittal – whenever a calibration of any survey instrument is performed.

9.6.5 The Head of the Survey Department, who will be in constant communication with AM, shall have the overall responsibility for the co-ordination of the above work crews, as well as for the reliability of the networks and the accuracy of the data related to the alignment (as defined in paragraph 9.1.10 of this Article.

9.6.6 All original data and records shall be stored and filed by the Contractor on the basis of the projects segmentation and in such a way to be easily accessible and comprehensible by AM. AM or its designated representatives shall be entitled to make use and to check the above data at all times. The Contractor shall provide AM with the required equipment and personnel and facilitate AM or its representatives whenever and wherever so requested. The results of the measurements and calculations, as well as the calculations themselves shall be at AM's disposal at all times, in a digital form as well.

9.6.7 The software to be used by the Contractor for the execution of all topographic designs and works should be at AM's disposal whenever AM requires it.

9.6.8 At any time during the execution of the Project, AM reserves the option to check the overall surveying work (such as field data, measurements, lines, grades, points, markers and drawings) or any part thereof. Regardless of whether AM proceeds on this option or not, the Contractor shall not be released from his responsibility for the accuracy and the correctness of the surveying work. The Contractor shall be

responsible for any lines, dimensions, grades, points or measurements not complying with the applicable construction tolerances as well as for any resultant defect in the performance of Work. The Contractor shall perform all additional surveys required in view of correcting errors resulting during the construction works and/or identified by AM's review in relation to the overall topographical surveying work or any part thereof.

9.6.9 All topographic surveys, measurements and calculations, as well as all the required alignments shall be performed at the accuracy degree required by the Contract.

9.6.10 If the Contractor makes use of trigonometric points, control points and levelling benchmarks, which have been established either by himself or by any Contractor before him, he shall be obliged to verify the accuracy and correctness of the surveying data provided to him and accept the responsibility for all measurements in relation to the above.

9.7 Geometrical controls and "As-Built" Surveys

9.7.1 The Contractor shall conduct with the required accuracy both the geometrical controls upon the completion of each individual section of the structures executed throughout all construction phases of the works, the delimitation of the expansion of the Tramway Depot in the area of Elliniko, the future perimeter road of the Depot and their control, as well as the "as built" topographic survey (using surveying methods) of any construction of the aforementioned works, including all sections to be re-constructed due to the works. The accuracy of the instrumentation to be used shall be the accuracy of the instrumentation described in Article 9.4.

9.7.2 During the construction of the Tramway lines, the geometrical control shall be conducted approximately every 2m. lengthwise. This control shall include the horizontal and elevation survey of the Tramway lines prior to their final embedment (concreting, grouting etc.).
Moreover, during the construction phase of the future perimeter road of the Depot, a geometric control shall be performed approximately every 5m lengthwise. This control shall include the horizontal survey and elevation of the road. Moreover, during the construction phase, a geometric control shall be performed of the expansion of the Tramway Depot in the area of Elliniko. This control shall include a horizontal survey and elevation of the Tramway lines and structures of the Depot.
The aforementioned geometrical controls shall be submitted to AM based on the method to be agreed upon, immediately after the completion of each individual part of the structure.

9.7.3 After the completion of the construction of all works, the Contractor shall conduct the accurate topographic survey of the entire range of the areas occupied for the execution of the works (i.e. roads, sidewalks, shafts etc.) every 10m at points to be agreed upon with AM. Moreover, upon completion of the construction of the expansion of the Tramway Depot in the area of Elliniko, the Contractor shall accurately survey buildings and/or sheds, the Tramway vehicles parking lines, etc.

9.7.4 All the above works (geometrical controls and "as built" survey works) shall include the surveyof all points measured based on coordinates X, Y, h, as well as the calculation of the horizontal and vertical offsets of each point from the theoretical position.

Based on these results, the Contractor shall submit drawings and documents. Moreover, the drawings reference numbers which are used for the theoretical base map (e.g. Layout Plan, Longitudinal Profile) shall be also provided.

9.7.5 All the aforementioned data shall be submitted to AM progressively depending on the completion of each of the above phases or part thereof.

9.7.6 The above data shall be presented in the form (to be agreed with AM) of appropriate drawings, technical reports, containing all details related to the dimensions, the materials, etc., in a digital form as well.

9.7.7 Moreover, the Contractor is obliged to submit Detailed Final Designs for the reinstatement of all occupied areas, as well as AS BUILT drawings for the reinstatement of all occupied areas, with accurate measurements at 1:500 scale.

9.7.8 For all the above topographical survey works, EGSA 87 reference system shall be used as reference system and the measurements shall be executed in co-relation to the basic and secondary horizontal and elevation control network.

9.8 Construction Tolerances

9.8.1 The methods to be adopted by the Contractor for checking the alignment - implementation of the Works and tolerances shall be subject to AM's approval. No tolerances beyond those specified in the Contract documents or/and construction drawings shall be permitted.

9.8.2 During the construction, the Contractor may be required to remove and replace in a correct manner any section of the Project includingwhich has been constructed outside the specified tolerances. In this case, the Contractor shall propose eventual remedial measures for AM's review.

AM is solely responsible for deciding whether these measures are acceptable or whether full re-construction is required, according to the specification. In case AM accepts works of lower quality or whose dimensions are smaller than the ones specified, all appropriate reductions should be implemented.

ARTICLE 10 WORKSITE DRAINAGE

10.1 TEMPORARY DRAINAGE - GENERAL

The scope of the design concerning the Temporary Drainage is the design of the required provisions, in order to deal with the anticipated water ingress (storm water, Ground Waterl Level) at the Depot worksite and wherever required. The Contractor is obligated to prepare the respective designs for AM's approval at Detailed Final Design level as well as to provide, install, control and set into operation the necessary systems and the E/M equipment.

10.1.1 WORKS

The Contractor shall submit the required Hydraulic and Mechanical DFDs for the temporary drainage of the Depot worksite and wherever required, which shall include the following:

- water collection items,
- the networks, the piping materials, the manholes and any pumps,
- tanks and any other structural or mechanical item, required, for reasons of performing smoothly works at the worksite during construction.

10.1.2 CONTENTS OF THE DESIGN

The Hydraulic Detailed Final Designs for the Temporary Drainage of the Worksite shall include:

- Technical Report,
- Layout Plan of the proposed works,
- Longitudinal Profile of Pipes
- Typical Details – Typical Cross Sections,

as well as any other drawing requested by AM.

10.1.3 SUBMITTALS

The Contractor shall submit a Detailed Final Design for temporary drainage of Storm Water from the Depot. This design shall be submitted to AM for approval in seven (7) hard copies in colour and in electronic form.

Following the incorporation of AM comments, if any, if it is required to have a connection with the city network, and the relevant design shall be submitted for approval to the responsible Service in five (5) colored hard copies and in electronic format, with two (2) additional coloured copies to AM.

10.2 PERMANENT DRAINAGE – GENERAL

The scope of the Depot Permanent Drainage is the design of the required drainage facilities, to deal with the anticipated water inflow in the Depot (storm and/or underground water) and wherever required. The Contractor is obligated to prepare the respective designs for approval by AM at DFD level, as well as to provide, install, control and set into operation the necessary systems and the E/M equipment.

10.2.1 WORKS

The storm water sewage network in the Depot shall be designed so that it can deal with:

- The drainage of the Tramway corridor lines, whose typical cross section construction facilitates the storm water seepage (line sections on grout). At the points of connection of the perforated pipes with the main sewage pipes, there will be shafts.
- Storm water collection through gutters and discharge from impermeable surfaces (shed)
- Final connection with the existing storm water network in the Depot and, in case this is considered insufficient, connection to the city's network.

The drainage network shall include manholes, as follows:

- At every change of direction
- At every change of pipe cross section
- At every change of elevation
- In all connections where one pipe is channelled into another
- In straight sections longer than 50m.

10.2.2 CONTENTS OF THE DESIGN

The Hydraulic Detailed Designsfor the Permanent Drainage of Storom Water from the Depot shall include:

- a Technical Report,
- Layout Plan of the proposed works
- Hydraulic Sections
- Longitudinal sections of pipes
- Typical Details – Typical Cross Sections,

as well as any other drawing requested by AM.

10.2.2.1 Layout Plan of the drainage basins

The scope of the drawing compiled in a scale 1:200 is the outlining and area measurement of the drainage basins affecting the Project, which have to be drained.

In detail, the above drawing shall present:

- Outline of the drainage basins, total area and numbering
- Surface drainage coefficients
- Buildings – Road network
- Outline of the Depot area.

10.2.2.2 Layout Plan of the proposed works

The following information shall be included in the drawing at a scale of 1:200:

- Complete topographical plan of the wider area (streets, curbs, buildings, public areas etc.)
- Existing storm water network and locations of shafts

- Configuration of the Depot area according to the architectural design for the reinstatement of the surrounding area
- Level configuration of the surrounding area with point elevations and complete curved contours
- The proposed drainage network of the Depot.

10.2.2.3 Longitudinal profiles

The following information shall be included in the drawing at a scale of 1:100 / 1:1000:

- Longitudinal profiles of the proposed pipes
- Hydraulic characteristics of the proposed pipes.

10.2.2.4 Typical details – Typical cross sections

The following information shall be included in the drawing at a scale of 1:25 / 1:50, namely:

- Typical cross section of the pipe trench
- Typical cross section of the drain
- Typical sump
- Typical manhole – junction manhole

10.2.2.5 Technical Report

The Technical Report shall include, as a minimum:

- Available data – existing condition
- Existing networks
- Description of the proposed works
- Hydrological calculations and assumptions
- Hydraulic calculations
- Construction data.

10.2.3 SUBMITTALS

The Contractor shall submit:

A Detailed Final Design for the Permanent Drainage of Storm Water at the Depot, as well as its connection with the existing shaft or city network. This design shall be submitted to AM for approval in seven (7) hard copies in colour and in electronic form.

10.3 REGULATIONS

The drainage installations shall be designed and manufactured in accordance with the Greek Technical Specifications (ETEP) and, more specifically, with the following relevant Standards and specifications as follows:

a) ELOT TP 1501-08-01-03-01: 2009

Trench excavations for utility networks

b) ELOT TP 1501-08-01-03-02: 2009

Underground utilities trench backfilling

c) ELOT TP 1501-08-06-02-02: 2009

Pressurized u-PVC pipe networks for sewage

d) ELOT TP 1501-08-06-08-03: 2009

Retrofitting of concrete paving slabs along constructed underground utility

e) ELOT TP 1501-08-06-08-04: 2009

Retrofitting of curbs and gutters along constructed underground utility

f) ELOT TP 1501-08-06-08-06: 2009

Prefabricated concrete manholes

g) ELOT TP 1501-08-07-01-04: 2009

Ductile iron gully tops

h) ELOT TP 1501-08-07-01-05: 2009

Co Manhole steps

i) ELOT TP 1501-08-07-01-05: 2009

General excavations for Road and Hydraulic works

j) ELOT TP 1501-12-05-02-00

Geotextiles and related products for the protection or drainage of tunnel lining membranes

- PD 696/74
- Specifications of EYDAP and Directorate D10 of Attica Prefecture

10.4 HYDROLOGICAL – HYDRAULIC CALCULATIONS

As regards the dimensioning of the free-flow pipes, the Manning-Strickler formula is applied:

$$Q = V \times A \text{ whereas } V = Ks \times Ry^{2/3} \times J^{1/2}$$

Whereas:

Q	discharge (flow rate) in m^3/sec
A	wetted flow surface of the pipe in m^2
V	flow velocity in m/sec
Ks	roughness coefficient per Manning
Ry	hydraulic radius of the pipe in m
J	longitudinal inclination of the pipe in m/m

The designed provision shall be calculated on the basis of a rational method for rainfall with a return period of T=5 years (based on the design and operation of the drainage network at the existing Depot in the area of Elliniko):

$$\mathbf{Q= c\ i\ A}$$

Where

Q = the design supply in lt/sec

c = runoff coefficient **i =** rainfall intensity in lt/sec/m^2

A = the area of the drainage basin in m^2

In order to calculate the area A, the discharge basins must be outlined.

The c coefficient shall be assumed to be equal to 1.00 for the shed and 0.70 for surfaces with gravel.

The rainfall curve to be used for the determination of the rainfall intensity for the aforementioned return period is:

$$\mathbf{I_5 = 165\ \Delta t^{-0.41}}$$

Where

i = rainfall intensity in mm/h

Δt = the concentration time of the runoff sump in min.

The influx time can be calculated per Giandotti, Kirpich, FAA etc. The influx time at the top of the network shall be assumed to be equal to 5min.

ARTICLE 11 DEPOT FLOOD PROTECTION

11.1 TEMPORARY FLOOD PROTECTION - GENERAL

The scope of the Detailed Final Design for the Temporary Flood Protection of the Depot is to define the final height of the structures (e.g. fencing), so that flood run-off in the wider area resulting from storm rainfall with a T=50 year-return period does not flow into the worksite area. Concurrently, the level configuration of the area shall be also studied, in order to ensure smooth run-off and so that Depot construction works are not obstructed.

11.1.1 BASIC DESIGN PRINCIPLES

- The flood run-off of the wider area should be limited within the area of the Depot.
- The proposed schemes should not affect the adjacent properties with regard to flooding risk.
- The worksite entrances must be positioned as far as possible from the main access of flood water flow and their orientation shall be downstream this flow.
- The proposed measures, e.g. steps, shall not be permanently positioned within public areas. However, temporary measures addressing the cases of severe storms shall be examined.
- The worksite area outside the excavation pit must be equally protected as the pit itself.
- Ground water, car wash water, water from damaged pipes etc. shall be collected and channeled after cleaning by the temporary drainage system.

11.1.2 USUAL PROTECTION MEASURES

- Raising the temporary fencing by 20cm above the Maximum Water Level resulting from a storm rainfall with a T=50 year-return period.
- Raising the pile guiding walls or installation of concrete parapets for pit protection.
- Sandbags to divert water flow.
- Sealing the holes in precast concrete fencing blocks
- Portable pumps and pipework for the removal of ponding water.

11.1.3 SUBMITTALS

The Contractor shall submit to AM for approval a Design for the Temporary Flood Protection of the Depot in seven (7) hard copies in colour and in electronic form.

11.2 PERMANENT FLOOD PROTECTION - GENERAL

The scope of the Detailed Final Design for the Permanent Flood Protection of the Depot is to define the final height of the structures (e.g. fencing), so that flood run off in the wider area resulting from a storm rainfall with a return period T=50 years does not flow into the area of the Depots. Concurrently, the level configuration of the area is also described in order to ensure smooth run-off and so that Depot construction works are not obstructed.

11.2.1 BASIC DESIGN PRINCIPLES

- The flood run-off of the wider area should be limited within the area of the Depot.
- The proposed schemes should not affect the adjacent properties with regard to flooding risk.

11.2.2 USUAL PROTECTION MEASURES

- The protection of the Depot shall be ensured by raising the fencing by 20cm above the Maximum Water Level resulting from a storm rainfall with a T=50 year-return period.

11.2.3 SUBMITTALS

The Contractor shall submit to AM for approval a Design for the Permanent Flood Protection of the Depot in seven (7) hard copies in colour and in electronic form.

11.3 REGULATIONS

Flood protection facilities shall be designed and constructed in line with the Greek Technical Specifications and more precisely, in line with the following relevant standards and specifications:

a) ELOT TS 1501-08-01-03-01:2009
Underground utilities trench backfilling

b) ELOT TS 1501-08-01-03-02:2009
Underground utilities trench backfilling

c) ELOT TS 1501-08-06-02-02:2009
Pressurized u-PVC pipe networks for sewage

d) ELOT TS 1501-08-06-08-03:2009
Retrofitting of concrete paving slabs along constructed underground utility

e) ELOT TS 1501-08-06-08-04:2009
Retrofitting of kerbs and gutters along constructed underground utility

f) ELOT TS 1501-08-06-08-06:2009
Prefabricated concrete manholes

g) ELOT TS 1501-08-07-01-04:2009
Ductile iron gully tops

h) ELOT TS 1501-08-07-01-05:2009
Manhole steps

i) ELOT TS 1501-02-02-01-00:2009
General excavations for Road and Hydraulic works

j) ELOT TS 1501-12-05-02-00 Geotextiles for the protection or drainage of tunnel lining waterproofing membranes

- PD 696/74
- Law 4258/2014 (concerning the hydraulic model)
- Joint Ministerial Decision 140055/2017 (OGG 428B)
- Specifications issued by EYDAP and Directorate D10 of Attica Region

11.4 HYDROLOGICAL – HYDRAULIC CALCULATIONS

An uneven flow model shall be prepared for all flood run-off axes in the wider area affecting the Depot area. The Maximum Water Level in continuous cross-sections shall be calculated every 40 meters, based on which the flood line shall derive. For minor flood design flows, the calculation of point cross-sections only is necessary.

The design flow shall be calculated for a storm with a T=50 year-return period based on the rational method:

$$Q = C\,i\,A$$

where:

Q: the design flow expressed in lt/sec

C: the run-off coefficient

i: the intensity of the rainfall expressed in lt/sec/m^2

A: the area of the drainage basin expressed in m^2.

In order to calculate surface A, drainage basins shall be outlined and the average combined run-off coefficient C shall be calculated. In any case, given the intensity of the phenomenon, the coefficient shall not be less than 0.90 for urban (built) surfaces and 0.65 for suburban surfaces.In order to calculate the rainfall intensity, the rainfall curve to be utilized for the specific return period shall be:

$$I_{50} = 285\ \Delta t^{-0.41}$$

Where

i = rainfall intensity in mm/h

Δt = the concentration time of the runoff sump in min.

The time of concentration may be estimated using the Giandotti, Kirpich, FAA, etc. formula. In any case, the average water flow velocity to derive (V=L/Δt) shall not be less than 1.5 m/sec in mild slopes and 2.5m/sec on steep slopes.

The minimum concentration time Δt shall be assumed equal to 5min.

11.5 DESIGN CONTENT

The Hydraulic Designs for the Temporary and Permanent Flood Protection of the Depot shall include a Technical Report, a Layout Plan of the drainage basins, a Layout Plan of the proposed works, Standard Details – hydraulic sections and any other drawing to be required by AM.

11.5.1 Drainage Basins Layout Plan

The scope of the drawing on a 1:2000 to 1:5000 scale is the outlining and area measurement of the drainage basins affecting the Depot, as well as the determination of the main flow axes.

In detail, the above drawing shall present:

- Outline of the drainage basins, total area and numbering
- Main flow axes, street or thalweg length etc.
- Measurement of the area per elevation zones, provided that Giandotti relation is applied

- High points (ridges) or lateral routes for the relief of the adjacent basins which prove that they do not affect drainage..

In addition, the following should be presented:

- Calibrated curved contours
- Land uses – road network
- Outline of the Depot area and the Tramway track.

11.5.2 Layout Plan of the proposed works

The following information shall be included in the drawing on a scale of 1:200:

- Flow axes and directions, control sections, hydraulic elements, flood lines, as these are provided for in the hydraulic model
- The configuration of the surrounding area – height wise – with point elevations and complete curved contours
- The proposed drainage network of the Depot

Moreover, the following should be presented:

- Configuration of the area of the Depot, in line with the architectural design for the reinstatement of the surrounding area.
- A full survey diagram of the wider area (streets, curbs, buildings, public areas, etc.)
- Existing stormwater network and manhole locations.

11.5.3 Standard details – Hydraulic Sections

The 1:50 or 1:100 scale drawing shall include the following:

- Hydraulic check sections at critical locations
- A comprehensive table containing final height of structures
- Details for any other proposed flood protection measure.

11.5.4 Technical Report

The Technical Report shall include, as a minimum:

- Available data – background
- Description of the proposed works
- Hydrological calculations and assumptions
- Hydraulic calculations
- Printout of hydraulic sections in distorted scale
- Construction features.

ARTICLE 12 ALIGNMENT OF TRAMWAY CORRIDOR