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ARTICLE 101 GENERAL

1. Objectives of the Document

1.1 This Document sets out the specifications, on the basis of which the Designs of the Works, included within this Contract shall be performed.

1.2 More specifically the aims of the Document are:

a. To ensure compatibility of the requirements of Codes, Standards and Regulations with the specific works included in the present Contract.
b. To specify requirements, wherever considered necessary, in addition to those indicated in the Codes, Standards and Regulations.
c. To specify requirements n subjects not covered by the Codes, Standards and Regulations.
d. To specify subjects relevant to the procedure of performing, checking and approval of the Design.

2. Scope

2.1 The Contractor is obligated to perform the Designs of the Works according to the requirements of this Document. The content of the Document is also applicable to any design note or report, which may be provided by the Contractor to support or justify any technical proposal.

2.2 The Contractor shall also prepare the Designs for Public Utility Organizations (PUO) Networks Diversions further to the corresponding Organizations' pertinent request, in line with the Design Specifications of each PUO.

3. Use of Codes, Standards and Regulations

3.1 The designs of the Project will be carried out in accordance with the relevant Regulations, Codes and Standards , as these are stated in detail in the following articles of this document and apply to the scope concerned.

3.2 For all codes, standards, regulations, specifications, technical recommendations, instructions etc referred to in this Document, applicable shall be the most recent release at the time of expiry of the deadline for the submission of offers intended for the Tender.

4. Designs - Calculations

4.1 At the beginning of the calculation notes, the concept of the design shall

be set out and the design assumptions, symbols, regulations, references used shall be listed. Wherever the design criteria/assumptions are imposed by any Contract document, reference to the specific article(s) of that Contract document shall be made. The calculations shall be presented in a manner that the correspondence of the numerical values utilized in the calculations with the variables of the design criteria/assumptions is clear and comprehensive.

4.2 Calculations, tables, diagrams, etc., carried-out elsewhere shall be clearly cross referenced in view of facilitating the checking process.

4.3 Calculations shall be set out clearly and shall follow a logical sequence to be comprehensible by engineers specialising in the relevant discipline.

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

4.5 The bibliography sources referred to in the design shall be listed, while copies of the bibliography sources used in the preparation of the design shall be made available. Copies of the tables and diagrams used in the design shall be incorporated in the calculation notes.

4.6 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/mm2, MN/m2 (MPa)
- -Pressures (soil, water, wind): kN/m2

5. Computer Aided Design

5.1 Where a computer aided analysis (software) is used during the analysis/dimensioning, the type and the theoretical basis of the software shall be stated clearly and the inherent assumptions, field of application and limitations of the software shall be identified.

5.2 It shall be ensured that the performance and reliability of the software used are satisfactory and can, if required, be so substantiated. The user's manual and the detailed description of the software, along with any justification required, shall be submitted to ATTIKO METRO for approval, if requested.
Data preparation sheets shall accompany the computer input and output printouts.

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

5.4 Any means for data saving (CDs, DVDsetc.), which include all design data and results, shall be submitted together with the design documents for the use and checking by ATTIKO METRO.

With regard to the designs which are submitted for approval, the Contractor shall submit all data in a digital disk (CD or DVD), wherein the following as a minimum shall be included:

The drawings in the format "drawing number.DWG".

The 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 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.

6. Drawings

6.1 All drawings prepared by the Contractor/Designer shall comply with the requirements of the article entitled "Design Requirements" of the General Specifications and the document entitled "Drawing Office Manual" of ATTIKO METRO for this Contract, in order to ensure uniformity and accuracy of drawing standards.

The aforesaid Documents include specifications for drawing categories as follows:

- General (plans, elevations, sections).
- Excavations, retaining structures.
- Construction phases.
- Auxiliary structures.
- Reinforcement detailing.
- Road and traffic design
- Drainage
- Traffic
- Reinstatement and Landscaping
- As Built

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

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.

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 ATTIKO METRO and Contractor, ATTIKO METRO's correspondence etc.

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.

6.6 Any means of data saving (CDs/diskettes etc.) which include the electronic files of the drawings shall be submitted together with the hardcopy drawings for the use and checking by ATTIKO METRO.

6.7 The DFD or the construction drawings 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 and dimensions of the structures, construction and details of the reinforcement, , 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.

7. Design Reports

7.1 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 this Specifications, the article entitled "Design Requirements" of the General Specifications and the document entitled "Drawing Office Manual" of ATTIKO METRO.

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, etc. 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. Any submittal that includes

no technical report or a report consisting only of printouts made by the relevant software shall not be accepted.

ARTICLE 102 ROAD AND ROAD PAVEMENT DESIGN

1. General

1.1 This section provides the principles for the preparation of the designs for roadworks and road pavements.

1.2 The basic principles and the requirements of the design shall comply with the Regulations in force. Namely:

- "Instructions for Road Projects Designs", YPEHODE (Hellenic Ministry for the Environment, Regional Planning and Public Works), 2001
- European Standard EN 1317

1.3 Road reisntatement shall be based on the pre-existing alignment and geometry, unless otherwise instructed by the Service.

1.4 Asphalt road surfaces to be dismantled due to execution of traffic diversions, worksite occupations, network diversions etc. shall be reinstated with due care without leaving any bumps along the joints. Where major disturbances take place (occupying more than one third of the road pavement), the final asphalt layering shall be implemented on the entire width of the road.

2. Roadworks

2.1 The basic geometric characteristics and the typical cross-sections of roads of various categories shall be the ones foreseen in the applicable regulations (Instructions for Road Projects Designs - OMOE) unless otherwise instructed by the Service.

2.2 The Contractor shall submit to the Service and to the pertinent Organization the Detailed Final Design for Roadworks for approval, incorporating therein any comments required for the design's final approval. The design shall be submitted in eight (8) colored copies and in digital format.

2.3 Energy absorption systems, such as safety barriers for vehicles, pedestrian guardrails etc., or a combination thereof, shall be placed where required for ensuring the completeness of the project and for compliance with the pedestrians and vehicles safety regulations.

2.4 Permanent walls or panels (e.g. for ventilation shafts) higher that the sidewalks shall be located at a minimum horizontal distance, in line with the applicable OMOE instructions.

3. Road pavements

3.1 Road pavement construction

In case of reinstatement and upgrading of existing roads, as well as construction of new roads, the road pavement shall consist of the following layers in line with the Greek Technical Specifications (ETEP) in force:

Road pavement layers:

a. sub-base layers, thickness: 0.10m each after compaction.

b. base layers, thickness: 0.10m each after compaction.

Asphalt layers:

a. asphalt base layer, thickness: 0.05m. each after compaction.

b. asphalt concrete layers, thickness: 0.05m after compaction.

c. anti-skid layer, thickness: 0.04m.

The number of the layers of the final cross-section shall be approved by the Service and the responsible Department of the Ministry of Infrastructures and Transport.

The appropriate asphalt coatings shall be applied between layers.

The composition of the asphalt concrete must be checked by a laboratory certified per ISO.

Test certificates issued by a laboratory certified per ISO must be submitted for the base and sub-base aggregates.

3.2 Temporary roads

In case of road diversions, temporary road pavements must be properly designed, so that to endure the entire period of the temporary diversion. Nevertheless, as a minimum, the road pavement shall have a 50mm thick surface layer made of hot asphalt or a bituminous mix laid on a 30cm thick base made of crushed material. The Contractor shall be fully responsible for the quality and the maintenance of this road pavement.

3.3 Asphalt

The asphalt shall be supplied by the Contractor and shall meet the terms of the relevant ETEP specifications. The quality of the asphalt shall be controlled on the basis of the control certificates issued by the asphalt

batch plants that the Contractor is required to have available. The Contractor shall be exclusively liable for the asphalt quality control.

One month prior to the commencement of the asphalt works, the Contractor must submit the designs for the bituminous mixes to be used in the subject project, having previously been controlled by a certified laboratory.

3.4 Panels, safety barriers

Panels or temporary safety barriers shall be installed as required to ensure protection at the perimeter of the temporary traffic diversions or protection against other hazards generated by vehicle circulation close to the areas where works are executed. In the event of long-term surface occupation or traffic diversion, the panels to be installed should be painted or decorated for aesthetic reasons. Light type fencing shall be installed only in the event of short-term occupations or traffic diversions (less than one week long).

ARTICLE 103 DESIGN FOR THE TEMPORARY DRAINAGE OF WORKSITES

1. General

The scope of the designs for the Temporary Drainage of Worksites is the development of a system for the collection, cleaning and discharging to the city network of the water collected within the worksite area, so that the permanent projects are constructed in dry conditions.

2. Basic design principles

- The water that has to be drained comes from ground water seepage, as well as from storm with a return period T=20 years.
- The water collection network consists of perforated pipes, pits, tanks and pumps for water discharge.
- Water cleaning takes place in a sedimentation tank, as well as in an oil trap, if required, so that water discharged to the city network meets the quality standards specified by the Service responsible for the relevant approval.
- Connection to the city's rainwater network constitutes the scope of this design and is included in the present Contract.

3. Relevant Standards

The Contractor shall adhere to the following relevant standards and specifications:

a) Applicable Greek Technical Specifications (ETEP)
b) EYDAP's or other Organization's specifications, as well as any other equivalent international standard
c) ISO certificates issued by the Manufacturing Plant.

4. Hydrological – Hydraulic calculations

The expected quantity of rainwater to be discharged is calculated on the basis of a rational method for a storm with a return period T=20 years

$$Q = ciA$$

Where:

Q = the design supply in lt/sec
C = coefficient of runoff
I = rainfall intensity in lt/sec/m^2
A = the area of the sump in thousand of m^2

The appropriate rainfall curve to be taken into account by the responsible Services (EMY, EYDAP, EYDE) shall be used in the determination of the rainfall intensity.
In any case, the estimated rainfall intensity shall not be less than the intensity resulting from the following formula:

$$i_{20} = 230\Delta t^{-0.41}$$

Where:

i = rainfall intensity in mm/h
Δt = the concentration time of the runoff sump in min.

- For the sizing of the pipes, the rain intensity shall correspond to an initial concentration time Δt=5 min.

- For the sizing of the volume of the pits-sumps, the rain intensity shall correspond to a concentration time Δt= 60 min and the rain duration shall be taken equal to 60 min.

5. Contents of the Detailed Final Design

The Hydraulic Designs for the temporary drainage of worksites shall include a Technical Report, Layout Plan of the proposed works, Typical Details – Sections.

5.1 Layout Plan of the proposed works

The following information shall be included in the drawing at a scale of 1:200:

- Worksite fencing and outline of the trenches including the respective excavation levels
- Piles, walls, slopes and other geotechnical works
- Sloping, ridges, flow lines and directions
- Layout of the drainage network (perforated pipings, pits, tanks, pumps, pressure pipes, drainage holes, DORKIN etc.)
- Sedimentation tank
- Dimensions for all materials
- Connection with the rainwater drainage network of the city.

5.2 Typical Details – Sections

The following information shall be provided in the drawing at a scale of 1:25 or 1:50:

- Transverse section of the trench and/or the tunnel at the location of the manhole with the pumps
- Typical section of the drains
- Typical section of the drainage holes

- Section of manholes – tanks.

5.3 Technical Report

The Technical Report shall include, as a minimum:

- Available data – background
- Description of the proposed works
- Hydrological calculations and assumptions
- Construction drawings.

6. Submittals

6.1 The Contractor shall submit to AM for approval a temporary drainage Detailed Final Design for each worksite, in six (6) coloured printouts and in electronic format.

6.2 The Contractor shall submit a Detailed Final Design for the discharge of the Temporary Drainage waters to the city network. The design shall be submitted at first to AM to incorporate any AM comments and then to the responsible Service for approval in six (6) coloured printouts and in electronic format. The submittal shall be also copied to AM with three (3) additional coloured copies and in electronic format.

ARTICLE 104 INVENTORY OF EXISTING FEATURES

1. GENERAL

1.1 Description of Works

1.1.1 Before the commencement of the construction of Works, the Contractor is obliged to submit (in digital form too) a detailed inventory of the existing features for the areas that are to be occupied for the execution of the works or for the diversions of the Public Utility Organizations (PUOs) networks. This inventory shall be conducted through drawings, descriptions, tables, quantities, photographs, etc. The drawings related to the inventory of existing features shall be compiled using accurate measurements at scale 1:200 and shall be linked with the horizontal and vertical control networks, as these are described in Article 107.

To this end, the Contractor shall conduct a detailed inventory of existing features on the appropriate topographical drawings, for example manholes, gauges and boxes of all PUO networks, trees, streets, balustrades, parapet walls, islands, curbs (gutters' elevations shall be recorded in pairs, so that the height of the curbs can derive from the subtraction of two elevations), all PUO poles, municipal poles, etc., kiosks (including their additional equipment, e.g. refrigerators, etc.), flower-beds, card-phones, cameras, bollards, bus stops, grade-separated passages, signaled intersection/junctions (traffic lights, pedestrian passageways, etc.), benches, fountains, ramps for PSNs, "guides" for visually impaired persons, all traffic signs, information sighs, advertisement signs, etc. horizontal signage of the streets, parking facilities and underground areas' ramps, etc., within the work areas and the worksites at street level. Each feature shall be indicated with a number on the drawing. Files shall be developed with these features for every area to be occupied.

All aforementioned inventories shall be conducted with the exclusive use of surface methods.

1.1.2 The aforesaid drawings shall accompany documents that shall provide description of each feature using the number that will correspond to the number given on the drawings, as well as its quantities. Trees will be described making reference to their type, height and perimeter. On an as required basis, for features such as steps, flower-beds, etc., typical details or sections shall be drawn, to include a complete description thereof.

1.1.3 The inventory is necessary for the Contractor to have recorded the existing features of the various areas where Works will be executed.

1.1.4 Before the commencement of works and beyond the inventory drawings and documents, photographic material is also required for the areas that may be affected, so that verification of their initial condition can be feasible.

1.1.5 The inventory of features shall cover the entire area where the Works are to be constructed or any other area that need to be occupied for the Works' needs. The Contractor is obliged to conduct a supplementary inventory – beyond the inventory of the initial surfaces – should it be required by AM.

2. Submittals

2.1 The Inventory of the existing features shall be submitted to AM for review and approval in digital format too. The inventory of the existing features diagrams shall be compiled at a scale of 1:200 and shall be accompanied by a technical report document to include the measurements, calculations, quantities, descriptions, photographs, etc.

If deemed necessary, AM may request that the drawings and documents be forwarded through the Service to the Organizations involved, such as OTE, PPC, EYDAP, D10, Municipalities, EPA, etc., for verification and commentary.

2.2 Any corrections or complementary data provided by the Organizations shall be made on the drawings and documents by the Contractor; the drawings and documents shall be signed by the Contractor and by the Organizations' and AM's representatives. A sufficient number of photocopies of the signed drawings and documents shall be reproduced by the Contractor; these photocopies shall be transmitted, through AM, to the various Organizations and the pertinent Municipality for future use.

2.3 A copy of drawings and documents shall be kept in files in the worksite area and shall be made available to AM's representatives upon submission of a relevant request.

ARTICLE 105 PUBLIC UTILITY ORGANIZATIONS (PUO) NETWORK DIVERSIONS

1. General

Existing networks are the underground and overhead networks of the Public Utility Organizations (PUO), irrespective of whether they are active or not. These networks are the following:

- Networks of EYDAP, of the DIRECTORATE OF HYDRAULIC WORKS – ATTICA PREFECTURE (D10) and of various Municipalities (water supply, fire extinguishing, sewage and storm water pipes)
- PPC networks (high, medium and low voltage cables)
- OTE networks (telephones) and all mobile telephony networks
- EPA networks (gas)
- DKEO networks (traffic lights)
- Municipal Lighting networks
- Municipal Water Supply networks

2. Design

Each network diversion shall be designed taking into account all available data in ATTIKO METRO S.A. (AM)'s design (layout drawings, etc.), as well as any recent available information. The exact location of the existing networks, on a general plan view and a longitudinal profile, shall be received by the PUOs, via coordination meetings, for which the Contractor is responsible, and shall be confirmed by in situ surveys and excavations of investigation trenches prior to the execution of excavation works. Iinvestigation trenches at various characteristic points assist in clarifying the location, as well as the type/number of the PUO networks to be relocated in view of preparing the relevant designs and implementing the relevant works. At this phase, the Contractor is obligated to cooperate and coordinate with the respective Organization, as well as with the other Organizations. All necessary actions should be taken, so that the routing of permanent relocations is effected in public areas.

3. Protection of the existing networks

When an existing network is located at the boundaries of the excavation, instead of being diverted, it may be supported and protected during construction, in accordance with the requirements of each Organization.

4. Network diversions

4.1 When existing networks must be diverted or relocated on a temporary or permanent basis, the design must meet the criteria and requirements of each PUO and be subject to the approval of the PUO to which the relevant network belongs.

4.2 The Detailed Final Designs (DFD) for the diversion of OTE, PPC and EPA networks are prepared by the Organizations themselves, based on the conceptual designs compiled by the Contractor, who is also responsible for the coordination of the designs, in order to satisfy the Project needs. However, the pertinent Organization can request that the design is prepared by the Contractor.

4.3 The DFDs for the diversions of EYDAP networks (sewage, water supply, Hydraulic Works Directorate (D10) for storm water, the Municipality for street lighting, DKEO for Signaling) shall be prepared by the Contractor and shall be submitted along with the coordination drawing in electronic format to AM for commentary on routing related issues in six (6) copies. The implementation of these designs, after their approval by the respective Organization, shall be supervised by AM and the relevant Organizations at the same time.

The Contractor's designer shall incorporate AM's comments and shall submit separately each DFD in six (6) color copies as well as in electronic format to the Organization concerned, by communicating two (2) additional copies to AM. All the above designs shall be stamped and signed by the designer.
In case there are comments on the designs by the responsible Organizations, the Contractor is obligated to re-submit the design, since he is fully responsible 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, as well as to promptly ensure the approvals of the designs.

In paragraph 6, the content of the design of hydraulic diversions are presented in detail.

4.4 During the implementation of traffic arrangements, temporary (or permanent) relocations of networks (especially of traffic lights and Municipal lighting) shall be required. Moreover, in case the dimensions of the sidewalks are reduced, it may be required to introduce protective measures or downgrade other PUO networks situated within the zone of these traffic arrangements.

4.5 PUO networks should not be isolated without having previously obtained the concurrent opinion of the Organization concerned either for a limited, or for an extended time period. On the contrary, either based on temporary safe solutions, or via permanent works, it must be ensured

that these networks operate smoothly causing the minimum disturbance/intervention to the area.

4.6 In case the routing of networks is effected within non-public areas, the Contractor should prepare cadastral diagrams and charts on the temporary occupations that may be required.

4.7 Upon completion of the works, the Contractor shall submit to AM and the respective PUO the "As built" drawings of the networks concerned.

5. Coordination drawing

The Contractor shall submit at GFD level the coordination drawing with all existing networks, as these have resulted from AM's preliminary design drawing, the investigation trenches and the information obtained from the PUOs. This drawing shall also show the proposed diversions of all networks after communications and the concurrent opinion of the PUOs and AM.
The coordination drawing shall be submitted for further AM's comments in six (6) color copies and in electronic format. The Contractor's designer shall incorporate AM's comments in the DFDs for all diversions. The coordination drawing shall be approved before all the remaining relevant drawings.

6. Hydraulic designs of PUO network diversions

6.1 General

The scope of the Hydraulic Design for PUO network diversions is to define the routing of the proposed diversion, to calculate its hydraulic efficiency and to select the material utilized for the construction of new pipes.

6.2 Planning principles

- Permanent diversions shall be routed in public areas, to the extent possible, and shall be sufficiently accessible for future maintenance.
- The channeling capacity of the proposed temporary or permanent by-pass duct must be at least equal or higher than the capacity of the existing duct.
- Each manhole or sump affected by temporary or permanent network diversions, temporary traffic arrangements or re-configurations of curbs shall be relocated to a new position.
- The material utilized to manufacture the pipes shall be compatible with the material utilized in the existing network and shall be selected in accordance with the Materials and Workmanship Specifications and the PUO requirements.

6.3 Specifications – Regulations

- ETEP specifications
- EYDAP specifications
- PD 696/74

6.4 Design contents

The Hydraulic Designs for the temporary and permanent PUO network diversions (water supply, sewage, storm water) consist of the Technical Report, the Coordination Drawing of the proposed diversions of all PUOs, which provides the possibility to implement the diversions under examination, a Layout, a Longitudinal Profile, Typical Details, as well as any other drawing requested by the Service or the PUOs concerned.

6.4.1 Layout

The layout presents in detail the existing routing and the proposed diversion of the networks under examination. The hydraulic and geometrical data (supply, flow speed, filling etc.) are shown on each part of the pipe. Moreover, the following are also presented:

- Manholes with elevations for sewage and storm water networks.
- Connecting points with existing pipes for water supply networks.
- Sumps and connections with pipes.
- Discharge pipes and discharge manholes connected to the network.

The sub-base of the layout should present the following:

- Temporary occupation – worksite fencing.
- Outlines of trenches and other structures.

- Configurations of sidewalks and curbs due to traffic diversions.
- Final configuration of street level in case of permanent diversions,

The drawing scale is 1:200/ 1:500.

6.4.2 Longitudinal Profile

The Longitudinal Profile presents the proposed pipe with the following information:

- Shafts and an at least 5m long part of the existing pipe (upstream and downstream).
- Intersections with sumps or secondary braches – Standard routing.
- Intersections with the remaining PUO networks.
- Hydraulic data (supply, flow speed, length, filling etc.).

As regards pipes of the water supply network with a small diameter (Φ<200), it is not required to prepare a Longitudinal Profile.

The length scale is 1:500 and the height scale is 1:50.

6.4.3 Typical Details

The typical details drawings include the following:

- Manholes, sumps, manholes for reducing water pressure, valve's manholes, etc.
- Typical pipe trenches.
- Anchoring.
- Pipe suspension layout, if it results from the Design.

The drawing scale is 1:25 / 1:20.

6.4.4 Technical Report

The Technical Report includes at least the following:

- Available PUO network data.
- Description of the proposed diversions.
- Hydraulic calculations.
- Construction data (pipe materials, trenches, suspension, etc.).

ARTICLE 106 TRAFFIC ARRANGEMENTS

1. General

The Contractor shall prepare complete traffic studies at a Detailed Final Design level and signalling designs for all the traffic diversions required during the construction works as well as for the final reinstatement. These designs shall be submitted in 15 coloured hard copies and in a digital form.

1.1 The Contractor shall be responsible for obtaining all permits and approvals required before proceeding with the implementation of any traffic diversion works.

1.2 The Contractor shall provide and install the traffic signs at the relevant locations as these arise from the traffic studies and shall ensure their maintenance throughout the execution of the works. The same applies for horizontal signage.

1.3 Where required by the traffic study, the Contractor shall cover using removable covers the existing traffic signs, or shall remove and store them in order to be used again after the completion of the works.

1.4 The Contractor shall submit a drawing at a 1:200 scale presenting the inventory of the existing situation prior to the execution of the traffic works (horizontal and vertical signage, traffic lane/sidewalk widths etc.) for all areas where traffic diversions will be implemented.

2. Relevant Standards

- "Technical Specification for the Signage of Roadworks executed inside and outside residential areas", YPEHODE (Hellenic Ministry for the Environment, Regional Planning and Public Works) and Government's Gazette Issue (FEK) 946 B, 9/7/03.
- ''Instructions for Roadworks Designs'', YPEHODE, 2001
- ''Instructions for Worksites Signage within the Urban Road Network" YPEHODE, 2002
- Road Traffic Code, Law 2696/99, FEK 57/23-3-99, as amended by Law 3542/2007 FEK 50 A.

3. Traffic diversion designs

3.1 Prior to the commencement of the relevant works, the Contractor shall submit for approval to AM and to the concerned bodies complete DFD traffic design for the traffic arrangements in all areas to be affected by the execution of the works.

3.2 Proposals for traffic diversion and arrangements shall be accompanied by a technical report and drawings (scale 1:200) to include at least the following items:

- Identification of the worksite access points, entrance/exit points for vehicles and pedestrians
- Determination of the location and surface area of the worksite
- Geometrical data of the alignment
- Horizontal and vertical signage (existing, abolished, new)
- Signalling
- Bus stops.

3.3 The routes of the Contractor's worksite (heavy-duty) vehicles to/from the worksite shall be made available.

3.4 The Contractor must maintain and reinstate in a systematic manner the horizontal and vertical signage in the areas with traffic diversions, so that this signage is maintained in an excellent condition. The Contractor is also be obliged to reinstate immediately damage and wear on street pavements and sidewalks occurring during the execution of works.

3.5 Easy access of service vehicles to roadside buildings and installations must be maintained for ensuring that the intended use of these buildings'/installations' is not disturbed, as dictated by their function, and most of all, for ensuring access in case of emergency (access of Fire Brigade vehicles, ambulances, etc.). Such access shall be ensured even if the service vehicles have to cross though the worksite areas. Appropriate parking spaces shall be provided for the service vehicles if construction activities block the use of the dedicated parking places.

4. Traffic lane and sidewalk width

As regards traffic diversions, the minimum width of the traffic lanes shall be as follows:

One (1) lane: 3.50 m
Two one-way lanes: width 6 m (2 x3)
Three one-way lanes: width 9 m (3 x3)
Two-way street with one traffic lane per direction: width 6.5 m (2 x3,25)
Two-way street with two traffic lanes per direction: width 12 m (2x3 + 2x3).

Exclusive left-turn lanes can be 2.75 m wide.

The minimum width of the sidewalks shall be 1.2 m.

4.1 Unless otherwise agreed upon by AM and OASA, the locations of the bus stops will remain as they were prior to the commencement of construction works. In the event that stops need to be relocated, the Contractor shall be responsible to coordinate with OASA.

4.2 At locations to be indicated by AM, the Contractor shall implement improvements at the local streets in the area where the worksite is located, when such works are required in view of being utilized by diverted vehicles or for access to the worksite. Works include inter alia widening, reconstruction or reconfiguration of the road pavement or the sidewalks surface, installation and re-installation of curbs, marking on the street pavement and installation of traffic lights.

4.3 Throughout the execution of works, direct access of the pedestrians shall be ensured to all properties, public areas in the area directly in contact with the worksite. At locations where works are expected to affect existing sidewalks or pedestrian passages, the Contractor shall keep and shall abolish – when no more required – separate appropriate corridors passing through the works execution area. At locations where temporary sidewalks must be constructed for maintaining access to properties or for ensuring the pedestrian circulation, these sidewalks shall be slab-paved and at least 1.20m wide.

ARTICLE 107 TOPOGRAPHIC SURVEYS, WORKS AND DEMARCATIONS

1. GENERAL

1.1 All the obligations of the Contractor related to topographical works, surveys and demarcations are described below.

Topographic works to be carried out by the Contractor during design and construction of the Works shall include the following:

a. Establishment of (trigonometric & polygonometric) horizontal and vertical control networks, where required, in OMA reference system and their correlation to the already existing networks. In case there are available polygonometric networks with elevations, it is possible to calculate the elevations of the new polygonometric networks based on the trigonometric elevation.

b. Topographic survey and updating of all areas to be temporarily occupied for the construction of the Works in all areas, and correlation to the horizontal and vertical networks to be established for the needs of the Works, where required.

c. Topographic survey of areas with archaeological excavations, prior to their commencement, after the completion of the excavation and the backfilling of these areas.

d. Establishment of the worksite installation boundaries in a manner to be agreed with ATTIKO METRO S.A. (AM).

e. Constant control of the Works demarcation (throughout all construction phases).

f. "AS BUILT" topographical survey of the Works after the completion of their construction, either completely, or up to the stage to be defined by AM in the relevant instruction, as well as "AS BUILT" topographic survey of the configuration at street level of all areas occupied for the needs of the Works.

g. All topographical calculations that will be required for the Geotechnical and Structural Monitoring.

1.2 As regards all topographic measurements, the required corrections shall be made for reasons related to pressure, temperature and refraction.

1.3 As regards all topographic works, the Contractor is obligated to ask the concurrence of the Service and communicate with the Service on a daily basis.

1.4 All topographic data (raw data, coordinates records, drawings) shall be saved in a digital format and sent to the Service immediately through e-mail at commonly pre-defined time periods.

1.5 All topographic works shall be carried out in accordance with the "Technical Specifications for Geodetic, Topographic, Cadastral and Mapping Works" of PD 696/1974 and in accordance with the specifications described in the documents of the subject Contract.

1.6 OMA reference system shall be utilized for all topographic works required for the construction of the Works.

1.7 The Service shall provide to the Contractor all available topographic data.

1.8 The Contractor shall be responsible to verify the accuracy and completeness of data provided to him about any part of the Works. Note that in areas where an adequate polygonometric network is established, the Contractor can use this network (without establishing a trigonometric network), based on AM's concurrent opinion, on condition that the Contractor would have previously checked whether the existing polygonometric network is reliable or not, concurrently updating AM accordingly. All topographic measurements, surveys, alignments, updating of drawings, preparation of new ones etc., shall be carried out using exclusively ground level methods.

1.9 All topographic measurements, calculations, results and drawings shall be submitted to the Service for approval in digital format as well and shall bear the signature of the person responsible of the Contractor's Topographic Department.

1.10 Alignments and surveys (as well as their implementation) shall be planned always based on an hierarchical scheme, starting from the general drawings which shall include the reference data and the limits shown on the details drawings, in order to avoid gaps or discrepancies on the details drawings.

1.11 The Contractor is obligated to submit for approval to the Service the organization chart of the personnel to execute the topographic works, as well as the CVs of all the aforementioned (main and auxiliary) personnel.

1.12 For all topographic works, a responsible topographer engineer must be appointed, holder of a University Degree, with ten years of experience in similar projects. The topographic work crews shall be formed by either Topographer Engineers with at least 4 years of experience in similar projects, or by Technical Institute (TEI) graduates in similar fields with at least 7 years of experience. The entire personnel of the Topographic Department shall be at all times sufficient in number and experience, so that Project needs are constantly covered.

2. Layout network

2.1 For each work area, a local layout control (trigonometric) network shall be established, consisting of points with a common sight of line per pair, to be connected with the already existing layout network. The location of the points shall be set after communication with the Service.

2.2 Measurement of this network shall be effected based on the GPS system and the relevant coordinates shall be provided to the OMA reference system of the Metro network and to the Greek Geodetic System EGSA '87, where possible. The aforementioned network shall be connected with at least two points of OMA network.

The adjustment and balancing of the network shall be effected using the appropriate software (using the method of the least squares) based on

three-sigma confidence level. The coordinates shall be provided in the Metro OMA reference system and in the Greek Geodetic System EGSA '87, where possible, along with their respective accuracies and typical divergences.

The accuracy of the network shall be ±10mm.

The Global Positioning System (GPS) to be used must be a dual band system, whose accuracy should be ±5mm+1ppm in case of static positioning and ±10mm+1ppm in case of kinematic positioning with a subsequent processing.

The GPS system and software to be used shall be submitted for approval to the Service.

Identification of the points of the base layout network shall be permanent, ensuring that this network shall be preserved throughout the construction of the Metro Project and for future use of these points, and shall be approved by AM.

The primary measurements, calculations, results, accuracies, description, ensuring of points and network diagrams shall be submitted to the Service in digital format as well.

Alternatively and upon approval by AM, in the areas where it is possible to establish and measure the layout network using ground level methods (sufficient available data, common sight of line per pair capacity), settlement shall be effected by applying once more the method of the least squares. The instruments to be utilized for the measurement of the network shall have an angular accuracy of 2" (0,6mgon) and shall be located at a distance of ±2mm+2ppm and shall be submitted for approval to AM.

These points shall be identifiable on a permanent basis, at locations safe from the construction of future works, and shall be approved by AM.

The accuracy of the network shall be ± 10mm.

2.3 The Contractor is responsible for the maintenance, periodic control, replacement and re-definition (if required) of the layout network points.

2.4 The Contractor is obligated to update and communicate at a constant basis with the Service and submit the measurements, calculations, results, diagrams, descriptions and insurance of points in digital format as well.

2.5 For the alignment and construction of the Works, a polygonometric network must be established. This network shall consist of polygonal traverses fully correlated on both ends with the points of the polygonometric network. It is noted that in the areas where a sufficient polygonometric network is available, further to AM's concurrent opinion, the network could be utilized provided that the Contractor checks its

reliability beforehand advising at the same time ATTIKO METRO S.A. accordingly.

2.6 For each polygonometric network established, the Contractor shall submit the relevant measurements, calculations, results, diagrams, specifications and the description of points that have been ensured also in a digital format.

2.7 The points of the horizontal control network shall be identifiable in a permanent manner and in a way that ensures their use throughout the construction of the project as well as their future use.

2.8 The Contractor shall be responsible to maintain the points of the aforementioned network and in the event that wear or obstacles are ascertained, he should see to their replacement or reintegration in the horizontal control network.

2.9 The aforementioned network shall be subject to periodic checks at intervals to be agreed upon with the Service. In case of discrepancy between the results, the network shall be leveled again.

3. Levelling control network

3.1 Where works are being executed, a leveling control network shall be established with elevation benchmarks at locations to be agreed upon with the Service. These locations should be set outside the construction zone of the project.

3.2 This network shall be measured using geometrical levelling transverses and shall be connected with the already existing levelling network of the Metro. Geometrical levelling transverses shall be open and fully correlated on both ends with the benchmark points of the Metro levelling network. Elevations shall be established further to the pertinent examination using the Method of the Least Squares.

3.3 The accuracy of the network measurements shall be $\pm$ 1mm/km.

3.4 The instruments to be used shall be electronic levels with a $\pm$ 1.0mm/km precision which shall be submitted to the Service for approval.

3.5 The points of the elevation control network shall be identifiable in a permanent manner and in a way that ensures their use throughout the construction of the project as well as their future use.

3.6 The Contractor shall be responsible to maintain the points of the aforementioned network and in the event that wear or obstacles are ascertained, he should see to their replacement or reintegration in the leveling control network.

3.7 The network shall be subject to periodic checks at intervals to be agreed upon with the Service.

3.8 Measurements, calculations, the results, the relevant description and the points that have been ensured shall be submitted to the Service in a digital form as well.

4. Topographical survey of the Works areas

4.1 An older topographical survey is available for the areas of the Works. The survey is performed at a 1:500 scale and has been compiled in the OMA reference system utilized by AM.

4.2 Using topographical methods, the Contractor shall update the existing topographical survey of the areas to be temporarily occupied for the needs of the individual works and throughout their entire surface.

4.3 Upon the completion of the works, the Contractor shall be required to proceed with the survey using topographical methods of all the corresponding areas that have been occupied for the needs of the works.

4.4 In case of PUO networks relocations, the Contractor shall be required to proceed with the survey of the new locations of the shafts, the columns, etc, at street level.

4.5 In case of archaeological excavations, the Contractor, using topographical methods, shall be required to proceed with the survey of the archeological excavations areas prior to the commencement of the works, after the completion of the excavation depth and after backfilling thereof.

4.6 The topographical survey of the above shall be performed in the OMA reference system of the Metro using the horizontal and vertical control networks, as these are described under paragraphs 2 and 3 herein.

4.7 The instruments to be used shall have the same accuracy with the one of the instruments described under Article 2.

4.8 Topographical diagrams shall be submitted at a 1:500 scale and in digital format.

5. Works alignment and checking

5.1 The Contractor shall perform all topographical works necessary for the alignment and the execution of all the Works, while he shall also process the field data, he shall execute all the necessary calculations and shall submit any drawings required for the completion of the works.

5.2 The aforementioned Works in their entirety shall depend on the horizontal and vertical control networks which shall be increased and checked in line with the content of paragraphs 2 and 3 herein.

5.3 The Contactor shall be responsible for the correct and accurate implementation of all theoretical lines, dimensions and inclinations required for the construction of the Works. If the Contractor fails to satisfy this requirement, any defective construction or part thereof shall be repaired or reconstructed by the Contractor himself.

5.4 The instruments of the Contractor and the entire topographical equipment shall provide precision services, shall be appropriate for the required topographical works, compliant with the recognized technical standards, in good condition, capable of being properly set and calibrated at any given time and shall be submitted for approval to the Service before the commencement of any phase of work. Topographical works shall be performed by topographical instruments, as these are specified in para. 1.11 herein.

5.5 A university graduate Survey Engineer, as specified under paragraph 1.11 herein, shall have overall responsibility for the coordination of the aforementioned groups and the reliability of the networks and shall be in constant contact with the Service.

5.6 All original data and files shall be stored and filed by the Contractor in such a way so that they are easily accessible and understandable by the Service. The Service or its appointed representatives have at all times the right to utilize and review the aforementioned data. The Contractor is required to supply the Service with equipment and personnel and facilitate the Service or its representatives when and where requested to do so. The results of the measurements and the calculations and the calculations per se shall be made at all times available to the Service and shall be also available in digital format.

5.7 The software to be used by the Contractor for the execution of all the topographical designs and works must be made available to the Service.

5.8 At all times throughout the execution of the Project, the Service shall have the option to check any part of or all the topographical works (such as field data, measurements, lines, inclinations, points, indicators and drawings). Regardless of whether or not the Service will make use of this option, the Contractor is not released from his responsibility with regard to the accuracy and the correctness of the topographical works. The Contractor shall be responsible for all lines, dimensions, inclinations, points or measurements and for any deficiencies in the works to arise. The Contractor shall execute all additional topographical works required for correcting any mistakes that might arise during construction works and/or any items that will be pointed out further to the review of the Service applicable to the entire or part of the topographical works.

5.9 All topographical works, measurements and calculations and all the required alignments shall be executed with the precision that the Contract dictates.

5.10 If the Contractor uses trigonometric points, control points and benchmark points that have either been installed by the Contractor himself or by earlier Contractors, he shall have to verify the accuracy and the correctness of the topographical data provided to him and assume the responsibility for the measurements in relation to the above.

6. "As-built" topographical surveys

6.1 The Contractor shall prepare with due precision the topographical survey of any structure in any construction phase of the Project.

6.2 All the aforementioned Works shall include the "as built" survey of all areas using topographical methods.

6.3 These data shall be in the appropriate form (to be agreed upon with the Service), namely in the form of drawings, technical reports/ recommendations including all the details on dimensions, materials etc. and in digital format.

6.4 After the completion of the Works, the topographical survey shall include, where required, structures and facilities, reflecting the actual status.

6.5 The Contractor shall also submit topographical survey drawings of all the occupied areas compiled based on precision measurements at a 1:500 scale.

6.6 The "as-built" drawings should, when required, meet the requirements of the authorities concerned and should be submitted to the authorities and to the Service also in digital format for information purposes and/or for approval.

6.7 For all the aforementioned topographical works the OMA reference system shall be used. Measurements shall be performed in correlation with the horizontal and vertical control leveling networks.

ARTICLE 108 DESIGN FOR THE TEMPORARY FLOOD PROTECTION OF WORKSITES

1. General

The purpose of the designs for the temporary flood protection of the worksites is to define the required layouts and configurations, so that flood water discharge in the wider area does not flow into the worksite area. Concurrently, the necessary means for the rapid and safe discharge of collected water, clean and foul, within the worksite are defined.

2. Basic Design Principles

- All project construction phases shall be taken into account and, if required, the corresponding protection schemes shall be designed per main traffic phase.
- 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 axes 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, machine wash water, water from damaged pipes etc. shall be collected and channeled, after cleaning, by the temporary drainage system.

3. Usual protection measures

- Raising the pile guiding walls or installing 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 standing water.

4. Standards

- PD 696/74
- Law 4258/2014

- Law 3010/2002 (concerning the hydraulic model)
- Specifications issued by EYDAP.

5. Hydrological – Hydraulic Calculations

The Contractor shall prepare a non-uniform flow model for all main axes of the wider area flood water discharge, which affect the worksite and shall calculate the Maximum Water Level (MWL) at typical cross sections around and inside the worksite area. The final required protection elevation shall result by increasing the MWL by a freeboard at least equal to 20cm. For design flows smaller than 0.5m^3/sec, it is sufficient to resolve only point cross sections.

The design flow shall be calculated for a storm with a return period of T=20 years, on the basis of the following rational method:

$$\mathbf{Q = c\ i\ A}$$

where:

Q = design inflow in lit/sec

c = discharge factor

i = intensity of rainfall in lit/sec/m^2

A = the area of the discharge basin in m^2

For the calculation of surface A, the discharge basins shall be outlined and the average combined coefficient of the surface discharge c shall be calculated. In any case, the factor c shall not be <0.75.

For the calculation of the rainfall intensity, a suitable and recent rainfall curve obtained from the Services concerned (EMY, EYDAP, etc.), dully documented in terms of its applicability, shall be utilized. In all cases, the calculated rainfall curve to be used shall not be less than the one resulting from the following formula:

$$\mathbf{i_{20} = 230\ \Delta t^{-0.41}}$$

where: **i** intensity of rainfall in mm/hr

Δt influx time of the discharge basin in min

The calculation of the influx time can be performed per Giandotti, Kirpich, FAA etc. In any event, the resulting average water flow speed (V = L/Δt) shall not be less than 1.5m/sec at minor slopes and 2.5m/sec at steeper surfaces.

If required in the calculations, the minimum inflow time $t_{\varepsilon\iota\sigma}$ shall be assumed to be equal to 5min.

If a rainwater network is present in the wider area, then and having documented its functionality, the design assumption can be decreased by 70% of the network's discharging capacity, or by the 5-year inflow that would have been calculated using the rational method ($i_5 = 165\ \Delta t^{-0.41}$).

6. Contents of the Detailed Final Design

The Hydraulic Designs for the temporary flood protection of worksites shall include a Technical Report, a Layout Plan of the discharge basins, a Layout Plan of the proposed works, Typical Details – Hydraulic Sections, as well as any other drawing requested by the Service.

7. Layout Plan of the discharge basins

The scope of the drawing at a 1:5000 scale is the outlining and area measurement of the discharge basins affecting the worksite area, as well as the determination of the main flow axes.

In detail, the above drawing shall present:

- Outline of the discharge 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 or lateral routes for the relief of the adjacent basins, proving, thus, that these basins do not affect the discharge procedure.

In addition, the following should be presented:

- Calibrated curved contours
- Road network
- Significant flood protection works in the area (e.g. Peripheral Trench)
- Outline of the worksite areas.

8. Layout Plan of the proposed works

The following information shall be included in the drawing to be prepared at a scale of 1:200:

- Flow axes and directions, control cross-sections, hydraulic elements
- Proposed protection measures (walls, sandbags, watertight fencing etc.) with the respective elevation
- Configurations (sloping, ramps, trenches etc.) within the worksite area
- The proposed locations of the new manholes and connecting pipes of the city's rainwater network
- Temporary flood protection measures in public areas.

Moreover, the following should be presented:

- Complete topographical plan with elevations within the worksite and the wider area (streets, curbs, buildings, public areas etc.)
- Calibrated curved contours
- Fencing and entrances to worksite areas, trench outlines
- Temporary drainage scheme
- Existing rain water network and manhole locations.

9. Typical Details

Construction details shall be provided for every proposed flood protection measure at a scale of 1:25 or 1:50.

10. Technical Report

The Technical Report shall include, as a minimum:

- Available data – background
- Description of the proposed works
- Hydrological calculations and assumptions
- Construction data (materials, pumps' manometers, etc.)

11. Submittals

The Contractor shall submit to AM for approval a Temporary Flood Protection Design for each worksite and for every eventual main traffic phase, in six (6) coloured printouts and in electronic format.

ARTICLE 109 DESIGNS FOR RETAINING WORKS

1. Retaining works field of implementation

1.1 PUO Networks

During the submission phase of the coordinating drawing regarding the PUO network diversions at any location of the Project, and upon assessment of the information related to the sub-soil, the ground water level and the routing/depth of the slope (trench), as well as the proximity to buildings/structures and/or traffic loading, the Contractor shall make his proposal about the necessity for implementing works for slopes' retaining purposes, along with the type of these works, by estimation. Once the coordinating drawing for the commencement of the preparation of the individual designs for the PUO network diversions is approved, AM shall provide its concurrence and/or instruction for the preparation of the designs for retaining works.

1.2 Archaeological Works

Retaining works shall be performed in case the archaeological excavation activities (either, as foreseen right from the beginning, or as the works progress) are extended at an adequate depth (in relation to the assessment of the information related to the sub-soil, the ground water level and the proximity to buildings/structures and/or traffic loading). The necessity of the retaining activities and its type shall be agreed upon between AM and the Contractor and the relevant instruction for the preparation of the designs for retaining works shall be given.

2. Available Geological/Geotechnical Data

APPENDIX I shall present the sample boreholes data obtained from earlier geotechnical surveys, including also a brief description of the geological conditions and the annual maximum ground water level at the open slopes of Line 4A', as measured until the present date.

Wherever the execution of retaining works is required, AM shall provide the borehole logs, laboratory tests and ground water level measurements, etc., so that the relevant designs can be prepared.

3. Design Documents and Drawings

The coordination drawing for the diversion of PUO networks at any location of the Project shall be accompanied by a Brief Technical Report on the necessity (or not) for the construction of retaining works at the slopes of the subject location and the preparation of the corresponding design.

The following items shall be submitted for review and approval, depending on the case in which the execution of retaining works and the preparation of the pertinent design are required (see paras. 1.1 and 1.2 above). Namely:

3.1 Geotechnical Evaluation Report for Design Parameters

3.1.1 General

The Contractor shall initially submit for approval to AM a Geotechnical Evaluation Report for Design Parameters for every location of the Project – separately - where retaining activities are required, taking into consideration the overall geological and geotechnical data that are available as per para. 2 above.

The Geotechnical Evaluation Reports for Design Parameters shall be prepared by the Contractor and shall be promptly submitted for AM's review and approval, and, in any case, before they are used in the respective Retaining Works Designs.

The Geotechnical Evaluation Report for Design Parameters shall determine, based on the available geological and geotechnical data, the ideal geotechnical sections of the sub-soil indicating the required design geotechnical parameters for an adequate retaining depth and for every location, where retaining works are necessary. These sections shall indicate the stratigraphy, the design values for various parameters (natural and mechanical properties) of the layers, the ground water levels, the foundation levels for the works and the adjacent structures etc. for the depth required.

3.1.2 Contents of the Geotechnical Evaluation Report for Design Parameters

Each Geotechnical Evaluation Report for Design Parameters shall be based on the available geological and geotechnical data, specifying for each location all the necessary details and shall include at least the following aspects:

- Abstract
- Introduction
- Outline of the Project
- Description of the soil and the soil conditions

- Interpretation of the soil conditions, as related to the design and construction of the works
- Definition of geotechnical longitudinal profile, along the axis of the slope
- Determination of ideal geotechnical cross sections for the design work
- Determination of geotechnical parameters for design work and construction
- Determination of the ground water level for the design work
- Conclusions.

3.1.3 Design Geotechnical Parameters

The *design values of the geotechnical parameters* shall result on the basis of the procedure described in paragraphs 2.4.5.2 and 2.4.6.2 of Eurocode 7 (ELOT EN 1997-1), using the *characteristic values of geotechnical parameters*, having also co-evaluated the test data, including a statistical analysis of the corrected test results and a correlation of the various data with the results of the field tests and the results derived from experience or other correlations and, subsequently, applying the individual coefficients shown in Appendix A of Eurocode 7 (ELOT EN 1997-1) – Part 1. The design parameters that will ensue from the above procedure should be compared to those which have been used in similar geotechnical conditions and similar projects in the wider area of the works or anywhere else, if related.

The types and the selected values of the design geotechnical parameters shall include proposals about the design soil parameters for the various depths under the surface of the ground, within the boundaries of the slope to be retained, according to the formations and the proposed stratigraphy of the soil in the area where the works are performed, taking into consideration the kind, the extent and the geometry of the retaining structure, the requirements of the proposed analysis method, with the design assumptions etc. In the Geotechnical Evaluation Reports for Design Parameters, the design assumptions of the geotechnical conditions should correspond to the actual conditions, as far as it concerns:

- The types of soil and their natural properties (specific weight, densities, particle size, Atterberg limits, natural water content etc.)
- Changes and alterations of soil properties
- Succession and geotechnical layers thickness, presence of discontinuities
- Ground water level and hydrogeological conditions, piezometric pressures that shall be used for the retaining works and long term conditions, permeability
- Loading rate and analysis method (total or active stresses)
- Shear strength parameters in terms of total and active stresses

- Soil pressure coefficients (active, at-rest, passive) and any proposed modifications of the theoretical values
- Strength and compressibility parameters, including consolidation properties, deformability module, when loading and un-loading, Poisson ratio, non-linear stress and deformation parameters (if applicable), dynamic shear module etc.
- If anchoring is to be used, values of ultimate bond strength and working bond strength between anchor or anchoring and environment medium (soil or rock).

To calculate the regime of the initial geostatic stress field (coefficient of earth pressure at-rest $\mathbf{K_0=\sigma'_h/\sigma'_v}$), design values shall be proposed for each design of retaining works. These values should be based:

- on the available results of appropriate laboratory strength tests (e.g. triaxial tests, consolidation tests etc.), as well as on the results of in situ tests (e.g. pressure meters etc.), and
- 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 design ground water level and the water pressures for the retaining works, Eurocode 7 (ELOT EN 1997-1) and more specifically paragraphs 2.4.5.3, 2.4.4 (1), 2.4.5.3 and 2.4.6.1 (8)-(11) shall be taken into consideration.

Where required, according to AM's judgment, a sensitivity analysis of the geotechnical parameter values shall be carried out.

3.2 Design for Retaining Works

3.2.1 General

Following the approval of the Geotechnical Evaluation Report for Design Parameters, the Contractor shall submit the respective retaining works design for the slope to be excavated.

The Scope of the Design for Retaining Works is the complete dimensioning of the required works for the retaining, in order to ensure the safety of the structure itself, as well as of structures adjacent to the Project and the confinement of deformations within the limitation of the Restrictive Values.

3.2.2 Design Report

The Retaining Works Design Report shall be complete and individual, as

specified in the following paragraphs of this article and shall include the following scopes as a minimum, namely:

- Structure description
- General concept of the design
- Names of the design's authors/designers
- Design regulations
- Brief description of the geological–geotechnical conditions, based on the approved Geotechnical Evaluation Report for Design Parameters
- Geotechnical design simulation models
- Retaining works for every phase (if more than one phases are required)
- Loading assumptions
- Structural model
- Construction method and phases
- Structure protection measures against water and chemical actions
- Deformations and influence zone
- Tables containing inspection data (type of structure, number of storeys/basements, estimated foundation level, any existing wear / damage condition, etc.) and classification of buildings/structures within the influence zone for determining the restrictive values of the deformations (see also paragraph 5.8)
- Contingency measures
- Any other technical information necessary for the safe and sound construction, not included in the drawings
- Calculations

In addition, in the framework of the retaining works design, the individual documents of the Technical Report for the Geomechanical and Structural Monitoring Program (GSM) and the Technical Report for the GSM Topographical Monitoring (see also paras. 6.4.2.1 and 6.4.2.2) shall be submitted at the same time.

3.2.3 Calculations Note

The Calculation Note shall be complete and individual, as specified in the following paragraphs of this article.

The calculations should include the exploration of the impact of the use of less favourable combinations of parameters and loading conditions on the estimated stresses and deformations of the proposed retaining systems.

The calculations should demonstrate that attention has been given to the likely alteration of the geotechnical parameters (range of values, typical divergence etc.) and to the use of different analysis methods. The effect 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 Design for Retaining Works.

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) of a certain part or of the entire project has been exceeded, while at SLS state the project functional requirements have been exceeded, as for example excessive (i.e. beyond the acceptable limits) subsidence, shifting, twisting, deformation or cracking.

When the Ultimate Limit State (ULS) is checked, what is checked among others is whether structural strength (STR) and soil strength (GEO) has 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), the analysis methods DA-3 and DA-2 shall be applied in the analysis of the Ultimate Limit States (ULS) 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, anchoring and retaining projects, tunnels and various other underground projects.

3.2.4 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:

- Stability of excavations, including the design of the retaining system, total stability against sliding, and stability of the excavation bottom against heave or liquefaction
- Slope stability under different loading conditions
- Vertical displacements (settlement and heave) and horizontal displacements, on the one hand, of the excavation retaining system and, on the other hand, of the soil within the Project influence zone.
- Vertical displacements (settlements and heaves), angular deformation and horizontal displacements of the buildings – structures within the Project influence zone .

3.2.5 Drawings

The Contractor shall submit drawings describing in due accuracy and detail data, methods and the retaining materials, as well as the successive excavation / retaining phases for each section. More specifically, he shall submit:

- Horizontal layout of the retaining works with a topographical base-map in the OMA reference system at a 1:100 scale (or at a more appropriate one), presenting all features at the dimensions shown on the calculation note;
- Two-directional geotechnical sections at a 1:100 scale (or at a more appropriate one), on the basis of the Geotechnical Evaluation Report for Design Parameters;
- Plan views (at a 1:100 scale or at a more appropriate one) showing piles' coordinates (taking into consideration any tolerances), piles and pile cap-beams' dimensions and spacing, etc.
- Characteristic sections and views, showing the construction phases, retaining measures, dimensions, depths and elevations (at a 1:100 scale or at a more appropriate one);
- Reinforcement drawings for piles, pile cap-beams, shotcrete, etc. (at a 1:50 scale);
- "GSM Instruments Locations" related drawing, in line with para. 6.5.2.3, showing also the categorization of each individual building (Type 1 or 2) within the influence zone;
- Bar bending Schedules for the above items;
- Pre-stressing Anchors Tables;
- Details (e.g. of struts, anchors, etc.) at the appropriate scale for application in the worksite areas;
- Reference to the relevant Material Submission Sheets (MSS)s.

4. Regulations and Design Loads

4.1 Regulations, Standards and Codes

The retaining designs shall be prepared in line with the following Regulations, Codes and Standards. The individual paragraphs of this article may also refer to other Regulations, Standards and Codes for specific scope of works.

For all Regulations, Standards, Specifications, Codes, Technical Recommendations, Provisions, etc., applicable shall be the most recent release at the time of expiry of the deadline for the submission of offers intended for the Tender.

In the following paragraph, a list is given with the main regulations, standards, codes etc. that shall be used in the elaboration of the Project designs.

I. Eurocodes

- Eurocode 0 "Basis of Structural Design"
- Eurocode 1 "Actions on Structures''
- Eurocode 2 "Design of Concrete Structures''
- Eurocode 3 "Design of Steel Structures"
- Eurocode 4 "Design of Composite Steel and Concrete Structures"
- Eurocode 5 "Design of Timber Structures"
- Eurocode 6 "Design of Masonry Structures"
- Eurocode 7 "Geotechnical Design"
- Eurocode 8 ''Design of Structures for Earthquake Resistance"
- Eurocode 9 "Design of Aluminium Structures"

Note: The above Eurocodes shall be in effect in conjunction with the existing (Greek) "National Annexes".

II. Greek Codes, Standards

- ELOT EN 1536 "Special Geotechnical Works - Bored Piles"
- ELOT EN 1537 "Special Geotechnical Works - Ground Anchors"
- ELOT EN 12063 "Special Geotechnical Works - Sheet Pile Walls"
- ELOT EN 12699 "Special Geotechnical Works - Displacement Piles"
- ELOT EN 12715 "Special Geotechnical Works - Grouting"
- ELOT EN 12716 "Special Geotechnical Works - Jet Grouting"
- ELOT EN 14199 "Special Geotechnical Works – Micropiles"

III. German Codes, Standards

• DIN 4084	Subsoil; Calculations of terrain rupture & slope rupture and overall stability of retaining works
• DIN 4085	Subsoil; Calculation of earth-pressure
• DIN 4085, Annex 1	Subsoil; Analysis of earth-pressure; Comments
• DIN 4085, Annex 2	Analysis of earth-pressure; Calculation examples
• DIN 4093	Ground treatment by grouting; planning, grouting procedure and testing
• DIN 4107	Subsoil; Settlement observations during and after construction of technical works
• DIN 4123	Excavations, foundations and underpinnings in the range of existing buildings
DIN 4124	Excavations and trenches - Slopes, planking and strutting breadths of working spaces
• EAB	Recommendations for Excavation Works

- EAP Recommendations for Piling Works

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 article, 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 approval.

4.2 Design Loads

4.2.1 General

Design Loads are considered to be the self weight of retaining structures, the remaining dead loads, ground and ground water loads, several live loads and the inertial forces due to seismic action. The values of loads used in the Detail Designs shall be derived from the following sources:

a) Eurocode 1 "Actions on Structures"
b) The minimum values of the loads stipulated in this article.

For each load, the most unfavourable value of those derived from the above sources shall be used in the Design.

4.2.2 Dead Loads

For assessment of self weights the following specific weights shall be considered, namely:

Reinforced or pre-stressed concrete : 25 kN/m^3
Plain concrete : 23 kN/m^3
Steel : 78 kN/m3

4.2.3 Live Loads

As live load on a structure, depending on the use of the area at surface level (square, park, worksite, roads, etc.), the following loads shall be assumed with the most adverse combination.

Worksite Loads: Worksite loads exerted on the retaining works during the construction phase, e.g. circulation of machinery, disposal of materials (reinforcement, excavation spoil, etc.), building cranes, etc., shall be taken into account in the design considering the most adverse assumption in terms of their size, location and layout.

The provisions of the German Standards EAB, shall be assumed as the minimum loading as far as worksite load is concerned.

Highway Loading: Highway loading shall derive from EN 1991-2, on the basis of which the following loadings apply: Standard Loading 1 (LM1) and Standard Loading 2 (LM2).
Loads given in the regulations shall apply for worst-case combinations and shall be multiplied by the specified impact coefficients. No dynamic allowance shall be added for underground structures with an overburden greater than 1m.
For underground structures beneath existing or planned public roads and with a minimum cover thickness equal to or greater than 2.0 m, as live load shall be taken a uniform load of 15 kN/m^2 applied at any position and configuration to give the worst-case loading. Whenever the minimum cover thickness is less than 2.0 m, the live load shall be accurately determined.

4.2.4 Ground and Ground Water Loads
These loads are described in detail in paragraph 5 below.

4.2.5 Loads deriving from existing buildings and structures
During the preparation of the design, consideration shall be given to surcharge loads from existing buildings or other structures of third parties existing near to the Project, which shall be assessed separately for each building or structure. For common building structures, a uniform load of 10 kN/m^2 per storey shall be assumed as an estimate of the dead and of the live loads of the building.

4.2.6 Seismic Loads
Seismic actions shall be calculated in line with Eurocode 8 (EN 1998) and the National Appendix, taking into consideration the type, specifications and the importance of the structure. The design shall be prepared on the basis of the Mononobe-Okabe method, as described in Annex E of EN 1998-5. The reduced ground acceleration coefficient α shall not be taken into account.

4.2.7 Loading combinations
Loading combinations shall be those foreseen in the Eurocodes. Loading combinations producing the most critical results shall constitute the basis of the design for all structural elements of the Project. More specifically, as regards accidental forces combinations, the ψ_2 coefficient for live loads shall be assumed equal to 0.70 for the design of the retaining structures.

5. Design and Analysis Methods

5.1 Geotechnical Analysis and Dimensioning of Retailing Structures

The retaining structures shall be geotechnically designed in accordance with the requirements of Eurocode 7 (ELOT EN 1997-1), chapters 8, 9 10 and 11, as well as the remaining relevant regulations / standards of paragraph 4.

In order to achieve an acceptable design of the retaining system also in terms of the ultimate limit state point, the "Design of Retaining Structures" shall present the suggested earth pressure diagram acting upon the retaining system, as well as the suggested range of earth pressure values, from active K_a to at-rest K_o on the basis of the permissible limits of displacements of the structures around the Project of this Contract, which shall be approved by AM before being used in the calculations. In case of non-concurrence, an increased earth pressure coefficient K = $(K_a + K_o)/2$ shall be utilized in the design of the retaining system.

Whenever excavation is likely to put existing adjacent structures in hazard, temporary struts shall be provided, preferably preloaded, to minimize movements. The magnitude of pre-loading shall be clearly stated on the construction drawings. The struts shall be designed according to the relevant Codes and shall be installed in such a manner so as to minimize the risk of accidental displacement.

The interaction between soil and structure shall be taken into account and the calculations for the prediction of the stress magnitudes and for the assessment of the deformations of the retaining structure – soil system and the structures around the project should be carried out using advanced methods, such as finite element methods or finite difference, while consideration shall be given to the influence of the construction process on the behaviour of the retaining system, in relation to deformations.

Soil and retaining system displacements shall be estimated also on the basis of semi-empirical methods, internationally accepted methodologies etc., such as the Clough and O' Rourke method (1990). The displacements caused by the "installation" of the retaining wall, as well as those due to the "excavation" in front of the wall, shall be examined separately.

The retaining systems can be distinguished into systems of high, medium and low rigidity, and the Clough et al (1989) equation is indicatively proposed as the module of their rigidity:

$$\rho_s = EI/(\gamma_w h^4)$$

where EI: the flexural stiffness of the wall, γ_w: the specific weight of water and h: the average value of the vertical distance of the struts or anchors of the retaining system.

5.2 Specific Issues of Retaining Structures with Anchors

Where temporary ground anchors are used to support the retaining walls during the period of construction, they shall be distributed along the supported length of the wall, taking into account the eventual presence of other supports to the wall, in such a manner that the transfer of shear at the joint between any discrete panels is kept to a minimum and adverse interaction of neighbouring anchors is avoided.

Moreover, the retaining wall reinforcement shall be placed in such a way as to facilitate the drilling of anchors and avoid the cutting off of reinforcement bars and, thus, the reduction of the retaining system's strength.

The distribution of pre-stressed anchors along the height of the wall and the required variation of their depth, length and inclination shall be such as to avoid adverse effects, e.g.:

- damage to neighbouring anchors, PUO networks, adjacent structures, etc.
- overlap of stressed areas of neighbouring anchors
- large compression of the ground between wall and anchoring bond bulbs, leading to settlements of existing structures
- high pre-tensioning loads for the anticipated geotechnical conditions in the project area.

The total area of the pre-stressed anchor tendons, as well as the area of single bars or pre-stressing cables shall not be less than the minimum values specified in the Approved Regulations. The cover to the bars and tendons over the anchored length shall be at least the minimum required.

The analyses for the dimensioning of the pre-stressed anchors shall cover at least:

- individual anchors
- a group of anchors (wherever required by the approved regulations)
- overall stability of the "wall – ground - anchor" system
- deformation of the anchored wall and displacement of the supported adjacent areas.

The percentage of tensioning of anchors shall be in accordance with the Approved Regulations, depending on the type of earth pressure and the permissible displacement thresholds stated in the contract (range of earth pressure values, from active to neutral) acting on the wall.

If anchors become loose (distressed), it shall be ascertained if this is caused by displacement of the anchoring bulb, or by compression of the soil between the wall and the anchoring bulbs. Changes shall be made to the design and construction of the anchors in order to address this problem.

5.3 Modifications of the design parameters

If, as a result of new information made available by the excavations and/or by the in situ monitoring, there are indications that the design parameters need to be modified in any way, such modification and any resulting alterations in the design and the construction and technical details, shall be implemented upon AM's approval.

5.4 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 based on the Project type (temporary or permanent), the loading case (normal or accidental) and the soil type.

For the design and construction of the retaining works, underground works, foundations etc., of the entire Project, the Codes mentioned in paragraph 4. 1 shall apply.

5.5 Soil and ground water loads

The retaining structures shall be designed to bear all the forces that may act thereon during the construction of the retaining system, as well as during life time of the permanent work.

The design forces shall be drawn with the use of well-documented theoretical and/or semi-empirical methods and shall take into consideration the construction method proposed, the relevant stiffness of the structure and the influence from the soil/structure interaction.

The retaining works, including struts and any type of anchoring, for the construction stages, shall be suitably designed for the upper and lower limits of the forces and the relevant deformations corresponding to the soil pressures and the water pressures in active and passive failure.

Any limitations in the methods and the sequence of the construction works, taken into consideration in the design and requiring appropriate

actions during construction, shall be demonstrated in a clear manner in the drawings. The construction stages, they should be clearly determined.

For the calculation of the pressures from the retaining structures, consideration shall be given to the backfilling compaction method (loads exerted by the compaction machinery), in addition to the increased resilient pressures after compaction.

The increase in pressures due to surcharge loading shall be done with the use of the conventional elastic theory and taking into consideration the stiffness of the retained structure. Where in the design use of analytical simulations is made, such as the codes of finite elements or finite differences, the actual locations and magnitudes of the anticipated loads shall be included in the model.

To estimate the value and the direction of friction between soil and wall, care shall be taken for the relevant movement of wall and soil and for the likely decrease in friction due to the smearing of the wall surface or due to membrane installation or due to vibrations.

The overall side stresses, arising from the calculations with negative warning shall be ignored in the stability calculations.

Prism type analysis for the retaining wall stability shall be carried out where deemed necessary.

5.6 Stability of Slopes' Excavation

In the framework of the geotechnical design of the retaining structures, as per the requirements of Eurocode 7, as well as of the construction, care shall be taken so that the safety requirements against:

- total failure of the excavation and the support/retaining system,
- failure of the excavation bottom due to heave or internal leak,
- failure due hydraulic fracturing or explosion,
- failure due to heave caused by uplift
- failure due to heave caused by hydraulic gradient
- failure due to internal corrosion
- failure due to hydraulic piping

are satisfied for all construction stages.

5.7 Slope Stability

The slope stability according to the requirements of the relevant regulations – standards of paragraph 4.1 shall be controlled 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 calculation 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.

In excavation spoil deposits, the natural surface drainage of the surrounding areas shall be kept unobstructed. The design of the excavation spoil deposits shall also ensure that the slope surface is safe against weathering due to discharge.

5.8 Deformations - Restrictive values

The Retaining Structures Designs require the imposition of Restrictive Values with regard to displacements, deformations, angular deformations, etc. for the ground and the buildings/structures within the influence zone. These Restrictive Values, which shall be strictly adhered to by the Contractor during the design, are presented in Tables 5.1 and 5.2 below.

Hereunder are the definitions of the parameters used in this paragraph:

- Vertical displacement (mm): settlement or heave
- Settlement (mm): the downward vertical absolute displacement of soil or structure point.
- Heave (absolute) (mm): the upward vertical absolute displacement of soil or structure point
- Total vertical displacement (mm): the total (cumulative) settlement or heave value occurrence at a point from the moment a settlement appears
- Differential settlement (mm): the difference between absolute settlement values of two points.
- Angular deformation (net number): the ratio of differential settlement of two points as to the horizontal distance between each other. The angular distortion is given as a fraction, with numerator of 1.
- Horizontal deformation (net number, %): the ratio of the change of a horizontal distance as to the initial value of the same distance
- Horizontal displacement (mm): the horizontal displacement of the retaining structure as a percentage of the height of the supported cut & cover excavation of Stations and Shafts.

Table 5.1: Restrictive Values for Deformations / Displacements

No.	Parameter	Free Field, Streets, Sidewalks, PUO networks etc.
1	Total settlement, (mm)	10
2	Angular deformation	1:800
3	Horizontal deformation (%)	0.15

Table 5.2: Restrictive Values for Deformations / Displacements of Buildings

No.	Parameter	Standard Buildings (Type 1)	Sensitive Buildings and Masonry Wall Buildings (Type 2)
1	Total settlement, (mm) (1)	10	7
2	Angular deformation (1)	1:800	1:1000
3	Horizontal displacement, (mm)	4	3

(1) Values refer to the buildings foundation level.

It is stressed that the classification of the buildings in Type 1 or 2 shall be based on data further to the inspections that the Contractor will perform during the preparation of the design. See also paragraph 3.2.2 above.

5.9 Assessment of Deformations – Establishment of the Influence Zone

During the preparation of the Retaining Works Design, the Contractor shall assess the deformations/displacements of the ground, buildings, structures, etc. for all stages of the construction and shall estimate the dimensions of the Project's influence zone.

The assessment of the deformations/settlements shall take place through the appropriate method taking into account all types of possible deformations, e.g. initial ("elastic") deformation, primary and secondary consolidation, as well as settlement due to the lowering of the ground water level, due to vibrations, due to the excavation and due to other construction works. The history relating to the loading and settlement of the ground layers (previous loading – geological and due to drainage – and loading due to older structures, excavation spoils deposits etc.) shall also be taken into account.

In assessing the settlements from consolidation, consideration should be given to all the dead loads and part of the live loads, which shall represent the average of the loads applied at the current moment. The assessment of the initial settlements for the clays and total settlements for sands shall be based on the maximum load applied.

The Contractor shall provide prognostics and reliable estimates of the expected soil displacements and stress magnitudes caused to the structural elements and buildings-structures in the Retaining Works Design that will be prepared for the construction method intended to be used and for all the Project locations and construction phases.

In the Retaining Works Design, the Contractor shall determine, apart from the alert and alarm limits stated in Table 6.1 of paragraph 6, the alert and alarm limits regarding any critical, in his opinion, design value (e.g. strain and loads on anchors/struts of retaining systems, displacements, deformations etc.

In addition, the Retaining Works Design shall also describe in detail the additional retaining measures, or any changes to the construction procedure which will be required in case the alert and alarm limits are exceeded.

The influence zone of the Project shall be determined in the Retaining Works Design for each project section**.** The influence zone of the Project shall be the joint of:

(1) the minimum contractual influence zone, as this is defined below, and

(2) the zone in which a settlement higher than 5mm is expected with the use of advanced numerical models.

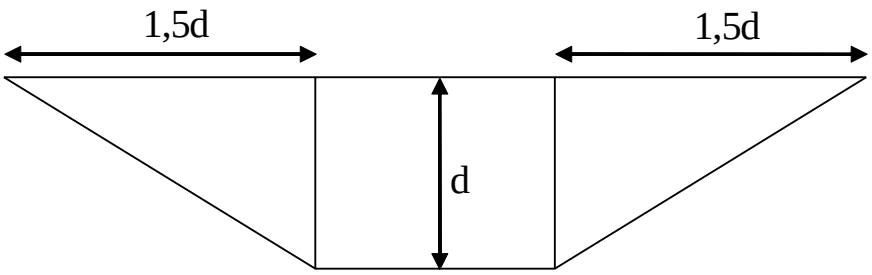

Figure 5.1: Minimum Contractual Influence Zone (surface excavation)

In line with Figure 5.1, the Minimum Contractual Influence Zone is a trapezium defined from the following points:

(1) On ground surface, from the points at a distance of 1.5 times the final depth of the excavation (d) from the walls of the trench.
(2) In case of projects with overlapping influence zones (as specified in para. 1), the Minimum Contractual Influence Zone shall be the joint of the individual influence zones.
(3) The Minimum Contractual Influence Zone is extended and encompasses all those buildings and structures which are even partly located within the geometrical boundaries described in the above paras. 1 and 2.
(4) Beyond the above, and if immediately out of the Minimum Contractual Influence Zone or if in contact and interaction with buildings located within the Minimum Contractual Influence Zone, sensitive buildings or buildings of special interest, monuments etc. are located, then the influence zone shall be expanded at AM's judgment, so that the monitoring system can also include these structures.
(5) In case auxiliary projects are constructed in the framework of this project, outside the project's influence zone (e.g. construction of well points, boring of water jet drills, etc), then the Contractor shall calculate the influence zone of these auxiliary projects, shall determine their impact, the GSM, etc.

6. Geomechanical and Structural Monitoring

6.1 General

The design of the GSM (type, number, characteristics and locations of the GSM instruments, frequency of measurements, etc.) constitutes the scope of the GSM Program for each excavation; the subject program shall be submitted by the Contractor along with the Retaining Works Design and shall be subject to AM's approval.

The GSM Program shall be prepared in line with the minimum requirements as these are stipulated in the entire article and in particular in paragraph 6.4.2.

The GSM elements that have to be measured and recorded are the following:

- Displacement of buildings and structures found within the influence zone of the excavation, including total and differential settlement;
- Ground surface displacements found within the influence zone of the excavation;
- Changes in cracks' aperture on buildings and structures located within the excavation's influence zone.

GSM instruments shall be installed in:

- Buildings, structures (either externally or internally), as well as buildings of special interest, such as churches, monuments, antiquities etc., found within the influence zone of the excavation;
- Free, not built, areas within the influence zone of the excavation, e.g. on streets, sidewalks, squares, building plots, sites, yards, forecourts etc. – green field conditions.

The duties of the Head of the Topographical Service in cooperation with the Designer shall be the following:

- organization of GSM measurements
- design of the GSM
- compilation of GSM Programs
- installation the GSM instruments and all necessary contacts/communication and actions with private entities and agencies to this end
- performance of measurements
- collection of measurements and relevant data
- calculations based on measurements
- presentation of the GSM measurements
- communication and cooperation with the AM, the Construction Engineers, the remaining Designers of the project, other agencies and individuals on issues related to the GSM
- monitoring of the activities and the progress of the project construction works.

6.2 Alert and Alarm Limits

The alert and alarm limits are related to specific measured values concerning Limit values of buildings/structures located within the influence zone, as stipulated in paragraph 5.8, and are presented in table 6.1, namely:

Measured parameter	Alert Limit			Alarm Limit		
	Free field, etc.	Ordinary Buildings (Type 1)	Sensitive and other buildings (Type 2)	Free field, etc.	Ordinary Buildings (Type 1)	Sensitive and other buildings (Type 2)
Total Settlement (mm)	7mm	7mm	5mm	10mm	10mm	7mm
Angular Deformation	1:1000	1:1000	1:1200	1:800	1:800	1:1000

Table 6.1: Alert and Alarm Limits

6.3 GSM Instruments

The requirements of ELOT EN ISO 18674-1 shall apply. More specific references to this Standard are made in the following paragraphs of this article.

Each GSM instrument shall be named on the basis of a specific name and shall be topographically surveyed on the basis of the OMA system.

At the Contractor's care and responsibility, the installation of any required instruments (levelling pins, crackmeters) on buildings and structures shall be approved by the owners and users of the structures. The Contractor is solely and exclusively responsible to repair in full any related damage or wear induced to the buildings / structures during the instruments' installation, operation or removal.

The instruments shall be properly protected against damage, minor accidents, vandalism etc.

Accessibility and integrity of all instruments throughout the duration of the GSM is the responsibility of the Contractor, who is to introduce all measures necessary for the continuous and unobstructed operation of the GSM system, including immediate replacement of any instruments that might incur damage or destruction for any reason whatsoever.

During all measurements, consideration shall be given to the environmental conditions affecting the instrument and/or the structural element being monitored (e.g. temperature variations, humidity etc.) every time that the measurements present major variations from the normal ones.

In addition to the instruments specified in the approved GSM program, it might be required after the program's approval to install more instruments and/or different types of instruments depending on the isolated incidents or other significant grounds, at the Contractor's request or AM's requirement.

6.3.2 Reference measurements

All the instruments shall be installed and operated for adequate time period before the commencement of the works in order to verify their reliability, to identify any different readings obtained for reasons not related to the construction and in order to determine the reference (zero) measurements of the instruments.

A minimum number of four successive measuring cycles shall be carried out for each instrument, within the specified accuracy, in order for the reference measurements to be defined. In case the measurement readings of such cycles diverge more than the allowable limits, then additional measurements shall be carried out in order to identify and eliminate probable errors.

In the event of complete/partial damage/destruction of a GSM instrument, a new zero measurement shall be taken according to the above. In case an instrument is repairable or replaced by a similar instrument at the exact same location (namely the same OMA coordinates), the measurement data after each new zero measurement shall continue the series of results of the replaced GSM instrument (integration of new measurements in the measurement history). The result which will correspond to the new zero measurement shall be defined by the recent measurement trend of the instrument prior to its damage/destruction and will, in any case, be agreed in print with AM. In case the GSM instrument is replaced at an adjacent position by a similar instrument (namely different OMA coordinates), the aforementioned apply in terms of new zero measurements and the result which will correspond to the new zero measurement shall be defined by the recent measurement trend of the closest instruments and will, in any case, be agreed in print with AM.

When a new GSM instrument is installed, at a location positioned in an area where measurements are ongoing, the result which will correspond to the new zero measurement shall be defined by the recent measurement trend of the closest instruments and will, in any case, be agreed with AM.

6.3.3 Levelling measurements

The levelling measurements shall be taken on levelling pins. The Contractor shall develop a network with levelling points on structural elements as to cover fully the monitoring of the vertical displacements on the surface and on all the buildings and structures within the influence zone of the entire excavation.

All topographical measurements prepared in the framework of the GSM shall be conducted using exclusively terrestrial topographical methods, based on the OMA reference system and in accordance with the requirements of this article and article 107 herein. It is the Contractor's responsibility to immediately update and complete all topographical diagrams, as well as to compile new ones, if necessary.

The levelling pins shall be of the embedment screw type of galvanized steel, its rod having a 10-cm length and 1-cm diameter, whilst its head shall be a 3cm diameter globe section. The section of the rod that will be embedded shall be threaded to ensure maximum embedment cohesion. The embedment shall be made with two-compound epoxy glue (resin and hardener) or other special glue.

The installation of the pins should be as deep as necessary ensuring that they do not cause any injury to pedestrians and that they themselves do not get crooked or damaged easily. The pins installed on the ground surface should not protrude beyond their heads.

Alternatively, where drilling and embedment of the above pins is impossible, levelling contact pins shall be used with an aluminium plate

or corner and a steel ball suitably adhered to a hemispherical hole of same diameter. The size of the plate shall be at least 2cm by 2cm, while the horizontal stem of the corner 5cm by 2cm, and the vertical stem 7cm by 2cm. The aluminium plate or the angle shall be at least 8mm thick.

The levelling pins are installed directly on the surface of the structural element at the ground surface (e.g. road pavement, sidewalk, curb etc.) on structural elements of buildings (e.g. vertical elements, columns and walls) or on other suitable elements.

The levelling pins on buildings and structures shall be installed in elements of the bearing structure, e.g. columns or walls, foundations, supporting walls etc. For each building and structure, the number of pins shall be such as to enable the calculation of the differential settlement and angular deformation in two directions, parallel and perpendicular to the axis of the works for each section of the building or the structure that may be deformed.

The Contractor may submit an alternative proposal for other elements, which shall be subject to AM's approval.

In natural soil up to the surface and specifically in a rocky soil, the levelling pins are installed in the same way as those installed on structural elements (see above).

Whenever a grid of pins is developed on road pavements, the layout varies depending on the actual conditions.

Digital levelling instruments with a precision of $\pm$ 1mm/km shall be used for the measurements. The measurements of the levelling points for the vertical displacements shall be carried out with a precision of at least $\pm$1mm per kilometre and always with open levelling routings, completely dependent from their two ends on the levelling starting points (repers) of the reference networks of the GSM levelling measurements.

During the measurements, the Head of each GSM topographical crew shall be equipped with sections of the topographical diagrams, depending on the area where measurements are carried out. In those topographical diagrams, the codes of the measurements points shall be shown in order to avoid mistakes in their recognition.

The Contractor shall submit to AM for approval the GSM Topographical Measurements Protocols according to the contents of paragraph 6.4.5 herein.

The readings shall be entered electronically and shall be automatically transferred into a processing software.

The processing software shall be submitted to AM for approval by an MSS and the Contractor shall secure for AM as well all relevant user and access license for this software.

The measurement instruments and their accessories (remote distance measurement devices, tripods etc) shall be serviced, checked according to the instructions of the Manufacturer and shall be replaced when thought necessary at the Contractor's care and cost. All the formal

calibration certificates shall be submitted to the AM, as attachments to the relevant MSS, according to the provisions of this article.

Reference measurements shall be taken from four successive measurement cycles and shall be calculated with the least squares method. A new reference measurement shall be taken in case the reference system is changed. The last valid measurement taken from the previous reference system shall be added to each new reference measurement further to the relevant communication with AM. The reference measurements from GSM Topographical instruments shall be submitted to AM for review (see 6.4.4. below).

The reference networks, to be utilized for the levelling measurements of the GSM, shall be established separately for the GSM needs; they shall be connected with points of the elevation network to be established for the needs of the project (article 107 herein) and shall consist of an adequate number of loops, so as to ensure the maximum possible accuracy during network adjustment. The way of establishment, measurement, calculation and the accuracy of the measurements shall be the same as those specified in this article. All calculations of elevations shall be carried out based on the least squares method.

The repers of the reference networks of the GSM levelling measurements of the levelling points shall be installed with a permanent sign in areas outside the influence zone of the works, having first been approved by AM.

The reference network to be used in the levelling measurements at levelling pins shall be submitted to AM in the framework of the GSM Program.

The control of the reference elevation network, which will be established to meet the GSM requirements, shall be conducted as per AM's requirements and all its data shall be submitted to AM.

6.3.3.1 Quantities and installation locations of instruments

- Buildings – structures within the influence zone
  Levelling pins will be installed on every building free facet within the zone of influence as follows: for facets up to 10m length, two levelling pins are installed, whilst for longer facets, the number of the levelling pins to be installed increases relatively with the length of the facet, the existence of construction joints etc.
- Ground surface around the excavations

  Pins shall be developed on a grid with a minimum density of 10mX10m covering the entire influence zone.

  Pins shall be developed at all available final locations of PUO manholes around the excavation.

In addition, in the framework of the development of pins, the Contractor shall take into account the worksite occupation plan in order to favour locations which shall be accessible as long as possible to the measurement crews.

6.3.3.2 Commencement and frequency of measurements

The minimum requirements pertaining to the commencement and frequency of the measurements are the following:

- The installation of a network and taking of reference measurements is required at least 10 days prior to the commencement of each type of excavation affecting the buildings being monitored.
- In general, three measurements per week shall be conducted over the entire excavation period, and this frequency shall be modified according to the evolution of the settlements.
- In case substantially different readings are obtained, the frequency shall be increased. In these cases, the measurements at an increased frequency shall continue throughout the duration of the excavation and until readings are stabilized, in order to fully monitor the phenomenon causing this change.
- Measurements shall be discontinued upon the Contractor's request approved by AM.

At its justified opinion, AM may request the Contractor to change the frequency of the measurements, to commence measurements in an influence zone not covered by GSM measurements or to resume measurements in areas where they have been discontinued.

6.3.4 Crack meters

The crack meters are installed in order to measure the crack aperture variation in one or two dimensions (parallel and vertically to the crack direction). The term "crack" includes not only those appearing on elements of the building itself (e.g. frame elements or masonry), but also the detachment cracks (e.g. between the frame and other members), as well as the cracks at internal joints of the building or at joints between buildings.

The crack meter type and characteristics shall be suitable to measure the crack aperture, the detachments and shifting in structural elements (e.g. masonry, walls, shotcreted etc.).

The crack meters shall measure the crack aperture in one or two dimensions (parallel and vertically to the crack direction) or shall be of a special type to monitor shifting and rotation.

6.3.4.1 Quantities and installation locations of instruments

Crack meters shall be installed where necessary on all buildings and

structures in the influence zone with cracks, as identified during the inspection of the buildings/structures, see also paragraphs 3.2.2 and 5.8 herein.

Whenever a new crack appears during the Project's construction, either on buildings and structures in the influence zone or on the excavation retaining system, AM shall be immediately notified and the appropriate crack meter shall be installed.

6.3.4.2 Commencement and frequency of measurements

The frequency of the measurements, the decreasing of their number and the end of the measurements depend on the rate at which the crack aperture changes; in any event, the measurements frequency shall be at least the same as the frequency of the levelling measurements. The measurement data shall be presented together with a recording of the environmental conditions that may affect the measurement at the specific location.

6.4. Submittals

6.4.1 Material Submittal Sheets

The Contractor shall submit Material Submission Sheets (MSS) which will be accompanied with the necessary certifications for each GSM instrument as well as all other relevant materials required for their installation and measurement. The Contractor will care for these MSSs to be submitted in due time so that they are approved by AM prior to the installation of the respective GSM instruments.

6.4.2 GSM Program

Together with the Retaining Design, the Contractor shall submit to AM for review and approval a GSM Program, which, as foreseen by Eurocode 7 (volume 1, paragraph 2.8.(4)), shall form part of the Geotechnical Design for each Project section. The GSM Program for each Project section shall be prepared by the Designer and jointly signed by the Head of the Topographical Service.

The GSM Program shall consist of at least the following items:

6.4.2.1 Technical Report – GSM Program

The Technical Report is a separate document that contains:

- References to the documents, issues, drawings of the approved prerequisite and relevant submissions
- Brief description of the section of the Project with the construction methods
- Brief description of the geological, hydrogeological and geotechnical conditions of the Project section.
- Brief description of buildings and structures in the influence zone according to the inspection of Buildings and Structures, see also paragraphs 3.2.2 and 5.8 herein.

- Detailed description of the GSM programme (measured parameters, GSM instruments) with the programme planning details and the technical details of all instruments.
- The programme for the start-up and frequency of the monitoring and the end of the measurements, as well as the changes in the foreseen measurement frequency for each instrument type, as related to the construction methodology. Within this programme, the time of installation and the time of reference measurement from each instrument is also included.
- The alert and alarm limits.
- Cumulative tables with the types and quantities of the GSM instruments.

6.4.2.2 GSM Topographical Monitoring – Technical Report

The Technical Report forms a separate document that contains:

- The elevation reference networks of the topographical measurements established for the needs of the GSM shall be correlated to the elevation network to be established for the needs of the Project. The method of establishment, measurement, calculation and the accuracy of the measurements shall be the same as those described in Article 107 of the CW Specifications and in this article.
- The primary measurements, calculations, results along with the accuracies of all elevation reference networks, which are established for the GSM needs, shall be submitted to AM, in digital form too. The calculations of the networks shall be effected based on the least squares method.
- The name, the description, the photographic documentation as well as the coordinates (X, Z, Y) of all the above reference points established for the GSM needs shall be submitted to AM in digital form too.
- In addition the submittal shall describe in detail the vertical displacement measurement method, i.e. method of measurements, the code number of the monitoring points, method of calculation etc.

6.4.2.3 "GSM Instruments Location" Drawing

The drawing shall be plan view in scale 1:500 or any other agreed with AM, presenting in detail the following information:

- The respective project section with the necessary construction details.
- The zone of influence of the works.
- The exact and updated topographical background in OMA reference system.
- The buildings and structures with their main characteristics, e.g. number of floors and basements, use etc..
- The GSM instruments with their codes.
- The control points of levelling measurements.
- Data concerning the location and the level of installation of each instrument.

- All the information collected by the Contractor concerning the GSM, such as locations, use and condition of the shafts and networks, etc. that may affect the GSM measurements.

6.4.3 Installation of GSM Instruments Report

This report is submitted immediately after the installation of the instruments foreseen in the GSM program, as well as complementarily after the installation of any additional/subsequent instruments at the same section of the Project, according to the requirements of paragraph 9.1, ELOT EN ISO 18674-1. The report shall include, as a minimum, all the items required in paragraph 9.1.2 of ELOT EN ISO 18674-1, as well as the following items:

- List of the varied instrument types installed according to their general position along the project, including their code numbers and the actual coordinates of their ultimate installation positions in the OMA Reference System.
- Precise installation drawings of all instruments in layout and profile as required, with the absolute coordinates in the OMA Reference System and the measurement reference points.
- Detailed locations of all the fixed reference points used for the performance of instrument measurements, with the coordinates and elevations of the fixed reference points according to the OMA Reference System.

6.4.4 Reference Measurements from GSM Instruments

The Reference Measurements of GSM Topographical Instruments shall be submitted to AM on a separate submission for review, signed by the Head of the Topographical Service of the Project. The primary measurements, the solutions, the adjustments, the results and their accuracies shall be included in a digital form in the abovementioned submission.

Each time new levelling pins are established, they shall be submitted to AM for approval through an additional submittal (GSM Topographic Instruments Reference Measurements) accompanied by the respective layout plan, indicating the measured points, the levelling starting points (repers) and the proposed measurement routes. In these cases, the zero measurements shall be correlated with the recorded vertical displacements of the existing network (equal settlement curve). The diagrams of the vertical displacements in time shall present an initial value of vertical displacement which shall result from the vertical displacement at the location of the new pin as resulting from the equal settlement curves.

6.4.5 GSM Topographical Measurements Protocols

The Contractor shall submit to AM for approval the GSM Topographical Measurements Protocols with the primary measurements, the

calculations and the results of the measurements in a printed and a digital form.

6.4.6 Report on Checking and Presenting the GSM Results

The Report for Checking and Presenting the GSM Results is prepared separately for each section of the Project and contains the daily measurement results as per the approved frequency program. This Report is submitted signed by the Designer and Head of the Topographical Service on the day following the reception of the GSM data it presents. During the periods when more than one Project sections are monitored, the respective reports per Project section are submitted with a single cover letter.

The Report on Checking and Presenting the GSM Results shall include at least all data required in paragraph 9.2.2 of ELOT EN ISO 18674-1, as well as the following items:

a) Reference to the GSM Program for the specific Project section,

b) a comprehensive table to include:

- The maximum values deriving from the GSM measurements;
- The respective GSM measurements;
- The codes of the respective GSM instruments;
- The respective alert and alarm limits of each parameter, as well as;
- A special note for those values that exceed the alert limits;
- A special note for those values that exceed the alarm limits and information about the course of action.

As per its justified opinion, AM may request additional data depending on the case.

6.4.7 Project Log

In the framework of the Project Log submittal (as per the stipulations in the CC), the Contractor shall submit the following items concerning the GSM:

6.4.7.1 Supply and Installation of GSM Instruments Report

The Contractor shall submit all Supply and Installation of GSM Instruments Reports.

6.4.7.2 Final GSM Report

This report, in combination with the preceding requirements under this article, shall include the following items:

- Final ("As Built") diagrams, plan views, layouts
- A final assessment of the monitoring results in relation to the alert and alarm limits, etc.
- Report on the current state of all instruments included in the "as built" drawings.

6.5 GSM Meetings

The GSM issues shall be discussed during the scheduled construction meetings. Whenever the alert and alarm limits are exceeded, the Contractor shall immediately inform AM on the calling of a meeting between AM and the Contractor's responsible personnel in order to implement the required measures each time.

GSM meetings can also be convened in other instances at the Contractor's or AM's request.