GEOLOGICAL – GEOTECHNICAL CRITERIA FOR THE SELECTION OF WASTE DISPOSAL SITES

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INTRODUCTION

- Waste disposal sites must be designed and managed in such a way that no harmful substances reach the biosphere and hydrosphere in unacceptable quantities
- The design concept for a disposal site also depends on the structure and behavior of the subsoil.
- Particular attention must be paid to the protection of groundwater and the mechanical stability of the waste material

Planning –Development- management of disposal sites

- must be suited to the geological and hydrogeological conditions.
- for proposed new sites, **a detailed geological, hydrogeological and geotechnical investigation is essential.**

The type and size of the site investigation

It depends on the following factors:

- the topography and structure of the area,
- the type and behavior of the waste,
- the geological/hydrogeological setting.
- At the same time the following must be considered:
  - the design requirements,
  - the overall safety plan.

Assessment of the suitability (1/2)

To assess the suitability of a disposal site it is essential to have accurate knowledge

- of the distribution of groundwater flow paths and barriers,
- their hydraulic properties,
- the deformation behaviour of the subsoil and
- the potential for improving the sealing effect of the subsoil.

Consideration must also be given to the need for setting up adequate controls and undertaking subsequent remedial works if appropriate.

Assessment of the suitability (2/2)

To assess and evaluate the behavior of the subsoil as a foundation for a disposal site it is essential to have knowledge of the local general geological setting, including the following principal aspects:

- the characteristics of the morphology,
- the structure, extent and geological age of the outcropping strata,
- the tectonic structures,
- the deeper subsoil, if it comprises cavities or soluble rocks,
- the aquifers and groundwater flow, and
- the risk of earthquakes and other natural hazards.

The Geological – Geotechnical criteria (1/4)

1. Composition and distribution of Superficial Deposits:

In order to assess the subsoil for a disposal site it is necessary to know:-

- the composition, the physical and the chemical properties as well as the sequence of strata,
- the lateral and vertical continuity and the distribution of the strata (facies changes),
- the porosity,
- the permeability (to water and leachate),
- the resistance to erosion and washing away of the particles, and
- the stress deformation behaviour.

The Geological – Geotechnical criteria (2/4)

2. Structure and Sequence of Solid Strata

Due to regional geological factors and morphological characteristics, superficial deposits are often relatively thin and therefore the underlying solid (rock-) strata may have to be included in the survey.

The following factors need to be considered:

- the type of rock, mineralogical composition and stratigraphy,
- the state of weathering and weathering resistance,
- the solubility in water and leachate or other aggressive solutions,
- the type and position of geological boundaries,
- the extent, degree of separation and widths of individual joints,
- the tectonic and petrographical anisostropies in the rock mass,
- karstification and risk of subsidence,
- the deformation behaviour of the rock mass, and
- the permeability to water, leachate, gases and other aggressive solutions.

The Geological – Geotechnical criteria (3/4)

3 Determination of Hydrogeological Data

Disposal sites must be prevented from having unacceptable impacts on groundwater, surface water, and particularly water abstraction sources.

Comprehensive knowledge of the groundwater regime is therefore required, including the following detailed information:

- the groundwater regime, direction of flow, gradient and rate of flow, including long-term and seasonal fluctuations,
- the permeability (horizontal and vertical) or transmissivity of the outcropping strata, with maximum and minimum values,
- the distribution, thickness and depth of aquifers, aquicluedes and aquitards, including the locations of any spring,
- the groundwater levels, indicating hydraulic gradients and effective flow velocity in the individual strata components if appropriate,
- the groundwater chemistry, including determination of naturally occurring aggressive substances and groundwater quality,
- the groundwater regime, direction of flow, gradient and rate of flow, including long-term and seasonal fluctuations,
- the permeability (horizontal and vertical) or transmissivity of the outcropping strata, with maximum and minimum values …….

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The Geological – Geotechnical criteria (3/4)

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- the groundwater levels, indicating hydraulic gradients and effective flow velocity in the individual strata components if appropriate,
- the groundwater chemistry, including determination of naturally occurring aggressive substances and groundwater quality,
- the groundwater protection zones,
- the groundwater abstraction and its effects,
- the groundwater abstraction rights,
- the influence of short-term or long term lowering of the water table, restoration and extraction or augmentation of groundwater in the future,
- the influence of nearby open waters and their relationship with the groundwater system,
- the situation in respect to receiving streams, influence of flooding and tides, if appropriate, and
- the effective rainfall, surface runoff, percolation rate, evaporation and groundwater recharge.

The Geological – Geotechnical criteria (4/4)

.4. Consideration of Special Factors

Artificial interference with the subsoil may have significantly altered the natural conditions. The existence of natural deposits worthy of protection or archaeological factors, may preclude use of the site as a landfill.

The following points should be included in the survey:

- the stability of existing slopes if trenches are used,
- the potential for subsidence or uncontrolled emission of gas and leachate caused by abandoned or existing mine workings and/or gas/groundwater extraction wells (underground and surface workings),
- the presence of workable natural materials in the subsoil,
- the presence of geological features or archaeological monuments worthy of protection, and
- the background contamination of the subsoil and/or groundwater.

Site Investigation: Superficial Deposits

- boreholes with continuous sampling,
- exploratory boreholes with Standard Penetrations Tests,
- cone penetrometer testing,
- trial pitting,
- micro-seismology to determine strata thicknesses and general identification of the boundary between solid rock and superficial deposits,
- surface and borehole geophysics for the determination of strata distribution and thickness and assessment of permeability, if appropriate.

Site Investigation: Solid Rock

- cored boreholes,
- trial pitting,
- water pressure tests (Lugeon tests etc.),
- borehole geophysics and geo-electrical profile measurements for the general assessment of the structure and permeability of the rock mass (correlated by reference to exploratory boreholes), and
- shafts and tunnels in special cases.

Site Investigation: Groundwater

- Boreholes can be used for monitoring groundwater levels and quality with the vicinity of the site.
- The location and depth of piezometers should be chosen in such a way that different groundwater levels or discrete aquifers can be clearly defined.
- The measurement of groundwater levels, together with groundwater chemistry where appropriate, provides the necessary data for defining a groundwater model.
- The measurement of groundwater levels should be undertaken at sufficiently frequent intervals so that fluctuations may be identified and evaluated,
- The potential effect of the landfill on the groundwater regime should also be considered.
- Piezometers should be installed in such a way that groundwater samples can be taken.
- The piezometer tube must be adequately sealed at the surface and between the measurement horizons to prevent water percolating in.

Site Investigation: Groundwater

Field tests may be necessary in some cases to confirm flow conditions. These may include:

- **groundwater tracing tests,**
- **trial pumping,**
- **infiltration tests, and**
- **flow measurement.**

Laboratory Tests

1. Petrographical and Soils Testing

- Laboratory tests on samples from boreholes or trial pits serve to classify the soil and rock material and to determine stress deformation behaviour and permeability.
- In the case of solid rock additional testing may be appropriate, and include:
  - **particle size distribution, swelling capacity and water intake of the interface,**
  - **permeability of porous rock,**
  - **state of weathering, and**
  - **solubility and resistance to weathering.**

Laboratory Tests

2. Geochemical Testing

- to assess the quality of the relevant groundwater limits and the composition of the strata.
- The scope of testing should be laid down by the qualified expert taking account of relevant national regulations and in agreement with an experienced chemical investigation laboratory

Presentation of the investigation results

The following should be included:

- site plans indicating:
  - **location of boreholes, trial pits etc,**
  - **geological and groundwater level/contour plots,**
  - **groundwater flow direction and effective flow velocity,**
  - **groundwater abstraction (including water resource catchment areas and water protection areas,**
  - **surface water and other hydrological features,**
  - **geochemical zones for groundwater and soil/rock, and**
  - **tectonic structures.**
- geological sections (indicating borehole records used),
- spatial profile (geological overlays and block models),
- representation of the groundwater system (rainfall distribution, fluctuations in groundwater level, flood and tidal influence

OVERALL ASSESSMENT

The geotechnical report must address the following aspects as a minimum:-

- description and representation of the geological structure;
- presence of high permeability strata and connections between them;
- presence and suitability of natural low permeability strata thickness, depth, horizontal continuity, permeability, adsorption capacity);
- groundwater regime and permeabilities within the area to be landfilled and its environs; a groundwater model may be appropriate;
- stability of natural or artificial slopes;
- bearing capacity and deformation behaviour of the subsoil;
- faults, possible subsidence, risk of collapse, earthquake risk and other hazard situations;
- overall evaluation of the subsoil as a natural barrier for the site;
- assessment of site soils regarding their possible use as mineral sealing materials (reworked or improved, if appropriate);
- notes on geotechnical measures required to improve the properties of the subsoil as a natural safety barrier.

Thanks for your kind attention!

Σας Ευχαριστώ
για την προσοχή σας