# NEW FINNISH NATIONAL GUIDELINE: SAMPLING FOR GEOTECHNICAL INVESTIGATION

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## KEYWORDS

Guideline, Standards, Soil Sampling, Rock Sampling, Sampling category

## ABSTRACT

With the new standard EN ISO 22475-1:2021 for soil, rock and groundwater sampling, new requirements for the sampling equipment and sample quality classes were defined. As the soil conditions and state-of-the-practice sampling equipment vary country by country, there was a clear need to create a new national guideline about geotechnical sampling in Finland. In a work funded by the Finnish Transport Infrastructure Agency, a new sampling guideline was created and subsequently published by the Finnish Geotechnical Society. The guideline presents practical guidance on the sampling process from choosing a suitable sampler to storing the samples in a laboratory. This paper presents the most significant observations made during the creation and the main national recommendations regarding the sampling equipment and procedure. With the new guideline, the quality of samples is expected to become higher in the future, thus ensuring reliable and accurate geotechnical investigations.

## 1. INTRODUCTION

Finnish Geotechnical Society SGY has published a series of national guidelines for various ground investigations, including soil sampling. With the renewal of European standard EN ISO 22475-1:2021 for geotechnical sampling [4], there was a clear need to revise the corresponding SGY guideline to align with the latest standard and state-of-the-practice sampling equipment used in Finland. In a work funded by the Finnish Transport Infrastructure Agency, new guidance was created and subsequently Ground investigation guideline III: Sampling for geotechnical investigation was published (in Finnish) by the SGY [3].

This paper presents the most significant observations made during the creation of the SGY guideline and the main national recommendations regarding the geotechnical

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sampling equipment and procedure. Besides soil sampling, the guideline also describes sampling from rock and groundwater. Substantial work was done to define sampling categories (A/B/C/D/E) for specific equipment while considering varying soil conditions (soil type, depth of groundwater, etc.). All five sampling categories are considered in the guideline, even though the Finnish practice has considered only three sampling categories so far: undisturbed, disturbed, and unperfect sample. Sampling categories were discussed together with the ground investigation practitioners in a workshop, and comments were collected from a wider group of professionals, including geotechnical designers.

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## 2. SOIL SAMPLING

According to the standard 22475-1 [4], "the aim of category A sampling is to obtain samples in which structure, texture, consistency and in-situ stresses are intact." Hence, category A soil samples correspond to the "undisturbed" samples. Meanwhile, "category E sampling only obtains samples where all the initial soil properties have changed is wholly or partially separated due to the drilling process".

The sampling categories A/B/C/D/E are connected to the quality classes in the standard's Table H.1 [4]. The Finnish national guideline presents a revised version of this table: attempt was made to further clarify the classification and to modify it to better apply to Finnish geology and typical testing programmes (see Table 1). The classification itself was not modified, but some additional definitions were added; For example, testing for geochemical properties is not covered by the standard and was thus added to the national guideline. Required quality class was assessed based on literature and interviews with environmental professionals. For instance, pH testing is relevant for sulphate bearing clays [1].

The guideline presents which sampling category (A/B/C/D/E) can be achieved with certain samplers in different soil conditions. The guideline also describes the most common equipment (which follow the standards' requirements) with photos or diagrams. Detailed guidance for category A sampling with piston samplers is provided as an appendix to the guideline.

Table 2 shows an example of the guidance provided for the selection of a suitable sampler (it should be noted that a shortened version of the table is shown in this paper for the sake of brevity.). The parentheses mean that such sampler is suitable in some specific conditions, referring to the properties listed for each soil type (e.g., relative density, depth of groundwater).

Based on the previous sampling experiences in Finland, silts without clay fraction are very challenging: the consensus among professionals was that thin-walled piston samplers (e.g., STII or Norwegian piston sampler Geonor), which usually corresponds to

category A sampling, are suitable for category C sampling from silts. Category A or B sampling from silts requires block samplers or large-diameter special piston samplers described in Di Buò [2].

Table 1. Quality classes of soil samples and the sampling categories [3].

| **Soil properties that can be determined in the laboratory** | **Quality classes of soil samples in laboratory testing** | | | | |
|---|---|---|---|---|---|
| **Soil layer classification** | **1** | **2** | **3** | **4** | **5** |
| Soil type (based on visual inspection) | x | x | x | x | x |
| Layering order of soil types (approximate) | x | x | x | x | x |
| Boundaries of soil layers in rough accuracy | x | x | x | x | |
| Accurate soil layer boundaries (e.g., varved clay) | x | x | | | |
| **Classification properties** | | | | | |
| Grain size distribution | x | x | x | x | |
| Organic content, density of solid particles, Atterberg limits | x | x | x | x | |
| Proctor maximum dry unit weight | x | x | x | x | |
| Water content | x | x | x | | |
| **Geochemical testing** [b)] | x | x | x | | |
| **Permeability properties and porosity** | | | | | |
| Water permeability and capillarity [a)] | x | x | | | |
| Unit weight, bulk density, porosity, relative density | x | x | | | |
| **Strength and deformation properties** | | | | | |
| Undrained shear strength and sensitivity | x | | | | |
| Shear strength (cohesion and friction angle) [a)] | x | | | | |
| Stiffness and compressibility properties [a)] | x | | | | |
| **Sampling categories** | **A** | | | | |
| | | **B** | | | |
| | | | **C** | | |
| | | | | **D** | |
| | | | | | **E** |

[a)] Strength and deformation properties, water permeability and capillarity may be determined for coarse-grained soils and moraines using category C or D samples, which have been compacted into the desired dry unit weight with specific compaction energy.
[b)] Depending on the exact chemical properties, also soil quality class 4 (category D) may be sufficient. Note that the determination of pH should be performed as soon as possible after sampling (if needed, in-situ measurements should be performed to verify the results.)

Table 2. Guide for selecting a sampler for some soil conditions (modified after [3]).

| **Soil types** | **Conditions that affect the sampling** | **A** | **B** | **C** | **D** |
|---|---|---|---|---|---|
| Dry crust | Stiffness<br>Strength | Block sample[a)] | Block sample[a)] | Auger,<br>Trial pit[b)], | Auger,<br>Trial pit[b)], |
| Clay (and clayey silt) | Stiffness<br>Strenght<br>Sensitivity<br>Plasticity | Piston sampler (STI/STII/ Geonor),<br><br>Block sample[a)] | Piston sampler (STI/STII/ Geonor),<br><br>Block sample[a)] | Peat sampler,<br>Open-tube sampler (double tube)<br>Small piston sampler,<br>Trial pit[b)],<br>Piston sampler with side intake,<br>(Auger)<br>(Open-tube sampler)<br>(Flow-through sampler) | Peat sampler,<br>Open-tube sampler,<br>Auger,<br>Flow-through sampler |
| Silt (without clay fraction) | Stiffness<br>Strenght<br>Sensitivity<br>Plasticity<br>GW level | Block sample[a)] | Block sample[a)] | Piston sampler (STI/STII/ Geonor),<br>Peat sampler,<br>Open-tube sampler (double tube),<br>Trial pit[b)],<br>(Auger)<br>(Small piston sampler,)<br>(Open-tube sampler)<br>(Flow-through sampler) | Peat sampler,<br>Open-tube sampler,<br>Small piston sampler,<br>Piston sampler with side intake,<br>Auger,<br>Flow-through sampler,<br>Window sampler |
| Peat | Level of decomposition | (Block sample[a)]) | (Block sample[a)]) | Trial pit[b)],<br>(Peat sampler)<br>(Auger) | Trial pit[b)],<br>Peat sampler<br>(Auger) |

(Table 2. continues)

| Soil types | Conditions that affect the sampling | A | B | C | D |
|---|---|---|---|---|---|
| Sand | Grain size<br>Relative density<br>GW level | [c] | Block sample[a] | Open-tube sampler (double tube),<br>Peat sampler,<br>Trial pit[b],<br>(Auger) | Peat sampler,<br>Open-tube sampler,<br>Piston sampler with side intake,<br>Small piston sampler,<br>Trial pit[b],<br>Window sampler,<br>(Auger) |
| Gravel | Grain size<br>Relative density<br>GW level | [c] | [c] | (Trial pit[b])<br>(Peat sampler) | Open-tube sampler (double tube),<br>Test pit[b],<br>(Peat sampler)<br>(Open-tube sampler)<br>(Window sampler) |
| Moraine | Grain size<br>Relative density<br>GW level | [c] | (Block sample[a]) | Trial pit[b] | Open-tube sampler,<br>Window sampler,<br>Test pit[b] |
| Fill | Grain size<br>Relative density<br>GW level | [c] | [c] | Trial pit[b] | Window sampler |

[a] Block sample refers to block sample taken from test pit, or a sample taken with block sampler or large-diameter piston sampler.
[b] Trial pit refers to bulk disturbed samples taken from trial pit.
[c] Category A and B sampling is rarely performed in coarse-grained soils and moraines.

According to Table 2, the peat sampler may be used in various soil conditions. It was observed that besides peat and clay, this sampler can also be used in silts and sands. In Finland, a peat sampler with 60 mm diameter (developed by Ramboll Finland) has

been used for sands and even some gravels. Meanwhile, the 40 mm version (see Figure 1) is used mainly for fine-grained soils.

For the most common samplers, the guideline presents a detailed description of the sampling category for different soil types and conditions (relative density and groundwater (GW) level). Table 3 presents such classification for two peat samplers: 40 mm and 60 mm models.

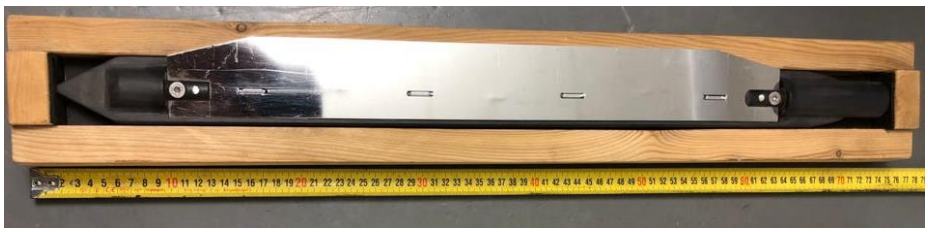

*Figure 1 Peat Sampler with 40 mm diameter (also known as "Russian Corer").*

Table 3. Sampling categories for peat sampler in different conditions [3].

| | **Peat sampler 60 mm** | | **Peat sampler 40 mm** | |
|---|---|---|---|---|
| **Soil types and conditions** | **Category** | **Notes** | **Category** | **Notes** |
| Clay [a)] | C | | C | |
| Silt [b)] | C | | C | |
| Sand – over GW | C | | C | |
| Sand – under GW | D (C) | C, if dense, fine to medium fine sand | D (C) | C, if dense, fine to medium fine sand |
| Gravel – loose, over GW | C | Only fine gravel | – | Not suitable |
| Gravel – dense, over GW | C | Only fine gravel | – | Not suitable |
| Gravel – under GW | D | Only fine gravel | – | Not suitable |
| Moraine – loose | – | Not suitable | – | Not suitable |
| Moraine – dense | – | Not suitable | – | Not suitable |
| Clayey gyttja, silty gyttja | C | | C | |
| Peat | D (C) | C, if sapric peat | D (C) | C, if sapric peat |
| Mixed man-made fill | – | Not suitable | – | Not suitable |

[a)] Fat clay, lean clay, organic clay and clayey silt, with clay-like consistency.
[b)] Silt without clay fraction.

## 3. ROCK SAMPLING

Regarding rock sampling, the definitions of quality classes of rock samples for laboratory testing were adopted in their standard form [4], and thus nor repeated here. One clarification was added to the national guideline: it was noted that the rough determination of rock quality boundaries based on drilling mud is not possible in quality class 5.

Table 3. Examples of rock sampling methods and equipment [3].

| **Sampling method** | **Equipment** | **Sample diameter [mm]** | **Hole diameter [mm]** | **Category** | **Notes** |
|---|---|---|---|---|---|
| Wireline, triple-tube | NQ3 | 45.1 | 75.7 | A (B) | Especially for rock mass with faults. B, if water flushing causes sample disturbance. |
| Wireline, triple-tube | WL-66 triple-tube | 46 | 67.1 | A (B) | Especially for rock mass with faults. B, if water flushing causes sample disturbance. |
| Wireline, double-tube | NQ2 | 50.5 | 75.7 | B (C) | Especially for rock mass with faults. C, if the structure of the sample is changed due to fracturing. |
| Double-tube core barrel | T2-46 | 32 | 46 | B (C) | By default not recommended due to small diameter. |
| Double-tube core barrel | T2-56 | 42 | 56 | B (C) | Commonly used to study the rock mass quality in projects with tunnels or drilled piles installed to bedrock. C, if the structure of the sample is changed due to fracturing. |
| Double-tube core barrel | T2-76 | 62 | 76 | B (C) | May be used to study the properties of rock material (quality of aggregate materials for road structure and pavement layers). C, if the structure of the sample is changed due to fracturing. |
| Blasting/Hydraulic splitting | – | – | – | D | Boulder samplers, e.g. to define quality of aggregate materials. |
| Drilling mud / Cuttings by rotary open hole drilling | – | – | – | E | Sample retrieved with flushing medium (water/air) |

Rock sampling categories were assigned for the most common equipment used Finland, while considering the properties of the rock (see Table 3). Special attention was given to the typical Finnish conditions characterized by hard rock types such as granite. The listed equipment refer to the most common sampler models in Finland. The most common sampler type in Finland is the double-tube core barrel, in which the sample quality is affected by the flushing medium. Possible fault fillings may be removed the water flushing, which leads to the sampling category to drop from B to C. Sampling category A can be reached by using triple-tube samplers, which include a third inner split sample tube.

## 4. CONCLUSIONS

With the new standard EN ISO 22475-1 for soil, rock and groundwater sampling, new requirements for the sampling equipment and sample quality classes were defined. As the soil conditions and state-of-the-practice sampling equipment vary country by country, there was a clear need to create a new national guideline about geotechnical sampling in Finland. The new sampling guideline presents practical guidance on the sampling process from choosing a suitable sampler to storing the samples in a laboratory. With the new guideline, the quality of samples is expected to become higher in the future, thus ensuring reliable and accurate geotechnical investigations.

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