Recommendations for High Quality Field Sampling using the Gel-Push Type TR sampler

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DISCLAIMER:

This document has been prepared to provide guidance on achieving the best quality samples using the GP-TR sampler. Following these guidelines does not guarantee that sampling campaigns will be successful, or that any subsequent laboratory testing will be of high quality.

These guidelines do not cover every scenario which may arise during field sampling, and in some cases the supervising engineer will need to deviate from some of the guidelines in this document. Any deviations should be carried out with the goal of maintaining the quality of the sampling procedure. Vibrations and impacts should be avoided.

GENERAL NOTES

Gel-push sampling is a developing technique for obtaining high-quality soil samples suitable for advanced testing in the laboratory (Mori & Sakai, 2016). The GP-TR sampler is a rotary triple tube device similar to the Mazier core barrel sampler. A sketch of the sampler with photos of key components is shown in Figure 1, while diagrams of the sampler during operation are shown in Figure 2. A key difference is the incorporation of a polymer gel which coats the soil sample and significantly reduces friction as the soil sample is captured in the liner barrel. Drilling mud is pumped through a rotating reaming shoe to help remove soil in the bottom of the borehole, and allow the sampler to advance. Protruding slightly ahead of the reaming shoe is a spring-loaded non-rotating cutting shoe. Soil passing through the cutting shoe is captured within a PVC core-liner barrel (length = 100 cm, outer/inner diameter = 89/83.5 mm). The floating piston moves upwards on the top of the captured soil column, and forces polymer gel to travel down the annulus between core-liner barrel and middle barrel, exiting above the cutting shoe and coating the soil sample. Excess gel is vented through the top of the tube directly into the borehole.

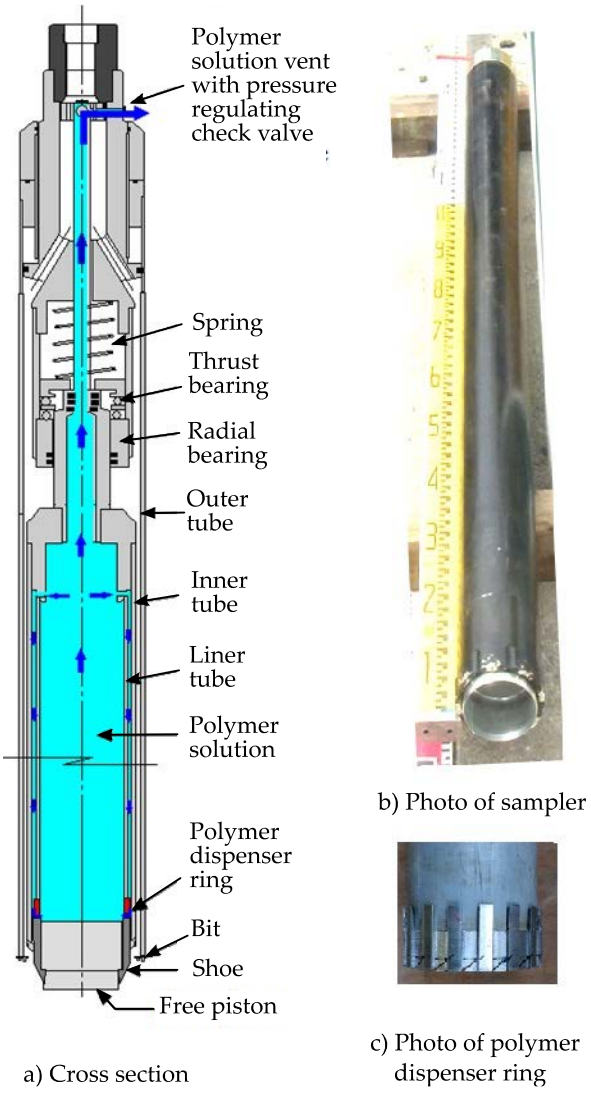

Figure 1: GP-TR sampler (Mori & Sakai, 2016)

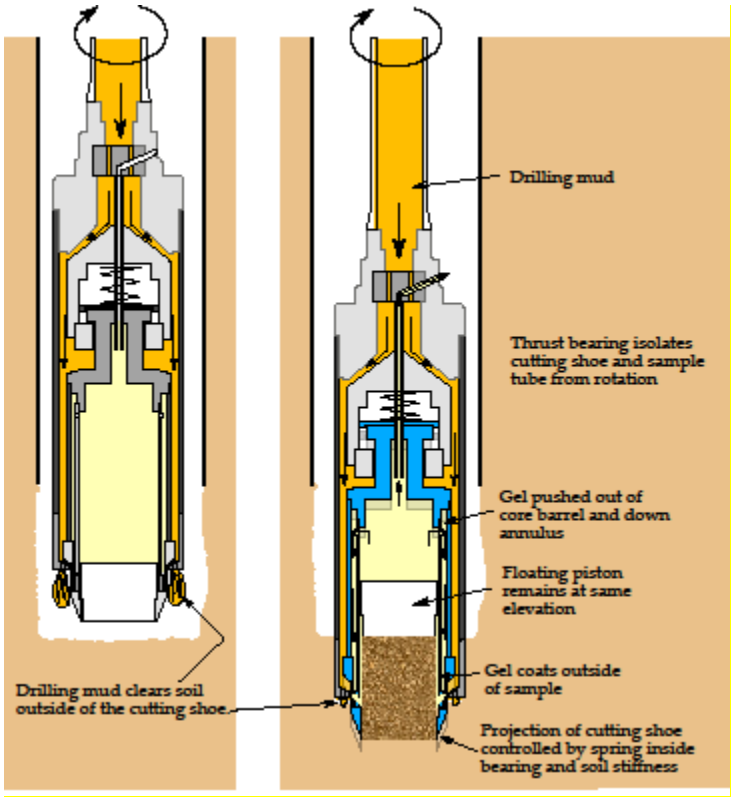

Figure 2: Schematic illustration of GP-TR sampler in operation

Full recovery with this device yields soil samples which are nominally 81 mm in diameter and 100 cm in length. With good recovery, it is possible to extract up to 5 soil specimens for triaxial testing, assuming that the triaxial specimens are 100mm in length.

Further details concerning the mechanics of the sampler during operation can be found in Mori & Sakai (2016)

In New Zealand, the GP-TR tool has been used to recover samples of sands in Christchurch, as well as the pumice-rich soils of the North Island (Taylor, 2014, Stringer et al. 2015). The latest attempts to recover pumice rich sands appear to have produced good quality samples (Stringer et al. 2018) Internationally, this sampler has been used to obtain samples of stiff clayey silts to silty sands (Jamiolkowski et al., 2015), gravelly sands (De Silva et al. 2010) and medium-dense to dense sands (Matsuo, 2004).

The notes which follow have been prepared for use by engineers and are intended to provide information and guidance at key points to help improve the quality of the sampling operation. These procedures do not explain the detailed assembly or disassembly of the tool. It should be noted that disturbance to soil samples can occur at any point between the start of drilling and the start of testing in the laboratory, and engineers are advised to consider the evaluation of sample quality as an essential part of any testing campaign. This is most commonly assessed as a combination of the visual appearance of the samples and the comparison of in-situ and laboratory estimates of shear wave velocity.

It is important to recognize the significant influence of the post-sampling procedures on the quality of recovered samples, and be aware that high quality samples can be ruined by poor handling. If high quality

samples are required, then it is essential that drilling crews are given sufficient time to handle the tool and samples carefully.

PREPARATION FOR SAMPLING

- Prior to first sampling, the tool should be disassembled to check that o-ring seals are in good condition and that the radial bearing can be turned by hand. Fully assemble the tool (prior to filling with gel), and ensure that the sampler shoe can be rotated independently of the reaming bit.
- Identifying information and the tube orientation (top/bottom) should be written on the sample liner tube prior to loading inside the sampler.
- The polymer gel should typically be mixed to a concentration of 2% by mass. Note that for most applications, a gel concentration of 1-3% by mass is suitable. Lower gel concentrations result in a less viscous solution which is appropriate for finer grained materials.
- After loading the sampler with gel, the plastic sample liner tube should inserted into the tool. During the insertion, the sample liner tube should be lifted up and down several times with rotation to fully coat both inner and outer surfaces with the polymer gel.
- The sampler shoe should be in good condition – free of dents and with smooth surfaces. If different sizes of sampler shoe are available, then it is recommended to use the shoe with the largest internal diameter (i.e. leaving the smallest possible clearance between the soil sample and the sample liner tube). If poor results are obtained, a sampler shoe with a smaller inner diameter may be used (i.e. increasing the clearance between soil sample and liner tube).
- Sampling should be carried out from within a cased borehole, with the final casing point set a minimum of two casing diameters and a maximum of 1 m above the intended sampling interval. The section of borehole between the bottom of the casing and the sampling interval should be drilled using a side discharge tri-cone bit after setting the casing. Sufficient mud should be circulated to clear excess cuttings from the hole.
- The depth of the borehole prior to sampling should be checked with a weighted tape.
- The drilling rods should be measured and marked to show the point where the sampler is expected to reach the bottom of the borehole as well as two further marks corresponding to the sampler advancing 1m and 1.1 m. It is helpful to add intermediary marks to track the progress of the sampling attempt.
- Stabilisers should be used to prevent lateral movement of the drill string during sampling.

SAMPLING OPERATION

- The borehole should be cleared of any cuttings when the sampler has reached a depth approximately 1m above the bottom using the rig pumps to circulate mud in the hole. The final lowering of the sampler to the bottom of the borehole should take place with drilling mud pumped at around 30-50l/minute.
- When capturing the soil, the sampler should be advanced at a constant rate of around 5-10cm/minute, while maintaining the flow setting of 30-50 l/minute (use lower rate for looser sands) and rotating the drill string at 50-60RPM.
- When the sampler has advanced 1m, the rate of advance is increased to descend a further 10 cm at higher speed. This tends to lock the soil in the cutting shoe.

AFTER SAMPLING

- Leave the sampler for at least 10 minutes prior to pulling the sampler to the ground surface to allow any excess pore pressures to dissipate. The rig pumps should be turned off and drill string rotation halted during this period.
- The rig pumps should be set to a low rate and the drill string rotated as the sampler is lifted the first 1.5 meters out of the hole.
- Maintain the fluid level in the borehole and avoid any shocks or sudden accelerations as the sampler is lifted. This is particularly the case when breaking down the drill rods.
- Remove as much of the drill string as possible prior to lifting the sampler clear of the hole.
- The end of the sampler should be covered as the sampler is lifted out of the drilling fluid to prevent the sample dropping out.
- The tool should be laid out horizontally as gently as possible so that the sample can be released from the tool.
- When removing the sample barrel from the fixed piston sampler, the soil within the tube should be held in a fixed location using a cylindrical block (which can fit inside the sample barrel) and the sample barrel slid back off the piston (Figure 5).

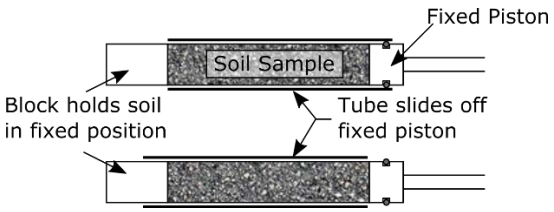

Figure 3: Removing sample barrel

- Measure the length of the sample retained in the barrel.
- The sample should be allowed to drain in the vertical position and with the bottom of the soil sample in contact with a cloth for a minimum of 2 hours prior to transportation.
- After sampling is completed, the tool should be completely broken down (disassembled) and cleaned with fresh water. O-rings should be inspected for any signs of deterioration. Pipe dope should be applied to threaded sections.

SAMPLING RECORDS

It is recommended that as a minimum, the following items are recorded by the supervising engineer:

- Date and time of sampling.
- Location, borehole ID and sampling interval.
- Depth of the top of the sample relative to ground surface.
- Depth of the bottom of the casing string relative to the ground surface.
- Maximum pressure during sampling and total volume of water pumped.
- Time required to advance sampler.
- Whether the core catcher was properly activated at the end of sampling.
- Length and appearance of sample, including whether the sample slides freely in the tube at the surface.
- Any abnormalities during sampling.

TRANSPORTATION

- Engineers should attempt to reduce the vibrations and shocks experienced by the samples during transport. This may include placing the samples on a car seat, and wrapping the samples in foam or rags.
- Where possible, unfrozen samples should be transported in a vertical orientation.
- If transporting clean sands (<10% Fines Content) it may be preferable to freeze the samples prior to transportation. The freezing process should be carried out in a uniaxial manner, freezing from the top down, while allowing the soil samples to continue to drain. Samples should remain in a frozen state until the time of testing. Additional handling procedures will be required to prepare frozen sampling for testing.

LABORATORY TESTING

- Any laboratory testing on the soil samples should take place as soon as possible after sampling.
- In preparation for testing, soil samples should be extruded vertically and cut into shorter specimens using a wire saw. Engineers should note that both the drilling operation immediately prior to sampling and the final closure of the core catcher are likely to disturb the soil at the extreme ends of the sample. It is recommended that the top 10cm and bottom 5cm (in addition to any material retained in the core catcher) of the soil sample are not used for advanced testing. Samples which are transported in a frozen state will need to be prepared differently.
- Soil specimens should be trimmed in a soil lathe using a sharp knife to remove soil which has become impregnated with the polymer gel (usually 2-3mm). In coarser soil specimens (i.e. sands), polymer gel can impregnate the entire specimen and these specimens must therefore be tested with some gel remaining in the soil. It is expected that research will be carried out in the coming years to investigate the effect which polymer gel may have on test results.

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