On the effectiveness of MOSTAP sampling in tailings

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ABSTRACT

The MOSTAP sampling apparatus is a popular tool in geotechnical investigation, since MOSTAP sampling can be done efficiently and cost effectively with the same rig used for CPT testing. Although few publications exist discussing the nuances and application of the MOSTAP sampler in practice, it is generally found that the MOSTAP sampler provides lower quality undisturbed samples when compared to piston tube or block samples. This paper discusses the experiences and learnings from geotechnical investigations where the MOSTAP sampler was employed in platinum and discard sand tailings in Southern Africa. A comparison between different sampler diameters at the same site showed significant improvements in sample recovery with larger diameter samplers. Ancillary equipment such as a core catcher and nylon stockings have significant effects on sample recovery and quality. The soil type and degree of saturation of samples also have a significant effect on sample recovery and sample quality. Transportation and storage of samples were identified as major contributors in moisture loss and sample disturbance. Even with the potential challenges in obtaining a representative sample at depth, MOSTAP samples are shown to be greatly beneficial in evaluating a soil profile and density determination with high confidence, especially when paired with index tests. The opportunity is identified where diligent sample measurement and tracking can provide reliable and invaluable information about a relevant soil stratum. Advanced laboratory testing (e.g., triaxial and oedometer tests) is not recommended on undisturbed MOSTAP samples, these should rather be remolded for critical state line testing, if relevant.

Keywords: MOSTAP; CPTu sampling; tailings.

1. Introduction

The use of the MOSTAP sampling apparatus has become popular in geotechnical investigations due to its efficiency, in terms of time and cost since it is driven using a cone penetration test (CPT) rig. The samples are usually taken shortly after CPT testing is performed at a desired location, where one would use the acquired data to define soil strata to target for sampling. The MOSTAP sampler provides an effective method for extracting samples at depth for further testing in laboratories.

This paper discusses the author's experience and learnings with MOSTAP sampling using different equipment configurations on various tailings facilities with different soil conditions in Southern Africa. MOSTAP samples were extracted as part of accompanying CPT investigations, where the samples were used to conduct laboratory testing. This paper considers the effect of various equipment configurations, sampling conditions, as well as the realistic opportunities for data collection and laboratory testing with samples collected using a MOSTAP sampler.

2. The MOSTAP soil sampler

The MOSTAP soil sampler is an intricate instrument with various features to be cognizant of. A retractable cone mechanism is used for the sampler to be sealed and able to penetrate into the soil before a sample is taken A sample then needs to be captured and retained inside the sampler. A core catcher and removable liner is used for this purpose. A nylon stocking is sometimes used to aid in sample collection, to reduce the friction between sample and the liner. A simplified schematic of a MOSTAP soil sampler with pertinent features is shown in Fig. 1.

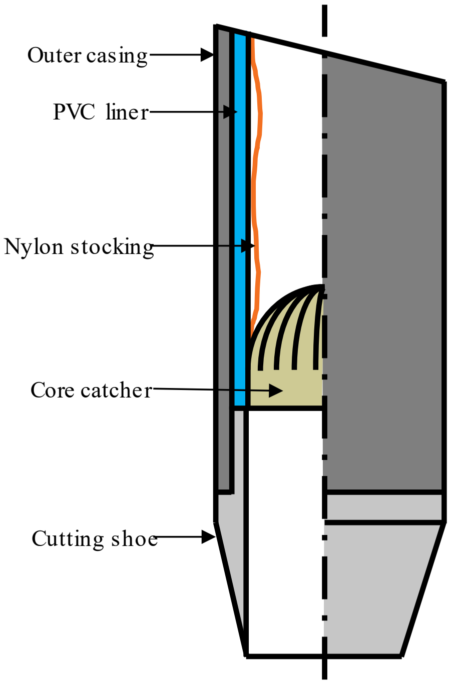

Figure 1. Schematic section of a MOSTAP soil sampler.

3. Existing literature

Very little published literature exists, documenting the nuances and application of the MOSTAP sampler. Long (2002) published a comprehensive assessment of the quality and the accompanying soil parameters derived from MOSTAP samples, among other methods. The study was mainly focussed on natural, soft soil deposits in Ireland (mainly clays and silts) with varying sensitivity. The key findings related to the MOSTAP sampler are described below.

Samples taken with the MOSTAP sampler showed a decrease in moisture content, compared to samples taken with piston tube samplers and block samples. This corresponds to an increase in bulk density for MOSTAP samples of ±50 kg/m³. It should be noted that piston tube samples have also shown a decrease in moisture content and an increase in bulk density, compared to block samples. The MOSTAP sampler is simply the worst performer in this comparison.

This density trend is primarily attributed to the sampling process being partially drained for the silts in question. This causes the silts to contract and densify during the sampling procedure.

Soil parameters and stress path behaviour derived from these MOSTAP samples were erratic when compared to high quality block or tube samples of the same soil strata (Long 2002). Furthermore, the level of disturbance experienced in the aforementioned study, when using a MOSTAP sampler, was significantly higher than that when compared to other tube or piston type samplers. This is attributed to a steeper cutting angle, as well as a greater wall thickness of the MOSTAP sampler compared to the alternative methods.

Despite the potential drawbacks identified by Long (2002), it was noted that continuous soil samples, even with a MOSTAP sampler, provide a good visual profile of the soil strata being investigated. Furthermore, if properly handled and stored, MOSTAP samples can provide sufficient accuracy for bulk density and moisture content for a soil stratum. Lastly, transportation was identified as a significant cause of disturbance for MOSTAP samples.

4. This study

In this study, MOSTAP samples were taken during various CPT investigations conducted on tailings facility sites in Southern Africa. The focus of these investigations was the deposited tailings as well as the foundation soils underlying the tailings facilities.

The soils that were sampled mainly consisted of platinum tailings as well as discard sand deposits from heavy metal extraction processes. The platinum tailings are mainly characterised as silts with low plasticity (ML), with some clays with low plasticity (CL). The discard sands are characterized as sand to silty sand. Some thin clay lenses were also sampled on the site.

For the platinum tailings, a site was selected where MOSTAP sampling was done over two separate campaigns. The equipment setup was varied between the campaigns in an attempt to improve sample recovery and quality. The first campaign (P1-35) used a 35 mm diameter MOSTAP sampler, with the nylon stocking. A core catcher was not available for the first campaign. For the second campaign (P2-65), a 65 mm diameter MOSTAP sampler was used with a core catcher. The nylon stocking was not used during this campaign.

For the discard sand campaign (S-65), a 65 mm diameter MOSTAP sampler was employed with a core catcher and a nylon stocking was used on select samples. It was later excluded to aid sample recovery. The core catcher was damaged during this campaign and some samples were taken without it.

A total of 21 samples were taken for P1-35, 30 samples for P2-65 and 56 samples were taken for S-65.

For all MOSTAP samples taken in these campaigns, the samples were measured for length and mass on site. Since the diameter of the sample was constant (35 mm or 65 mm), the volume was known. By measuring the mass of the samples, the in-situ bulk density could be calculated. It should be noted that, by nature, masses taken on-site may include errors due to a less controlled environment.

Once the samples were transported to the laboratory, the samples were opened and visually assessed for clear and obvious disturbance. The samples were then dried and weighed for dry density determination. Particle size analyses with Atterberg limits and specific gravity tests were undertaken from prevalent layers where applicable.

A comparison between these campaigns have highlighted some significant factors and opportunities to be considered when conducting MOSTAP soil sampling.

5. Factors influencing sample recovery and quality

During the CPT campaigns where MOSTAP sampling was undertaken, multiple factors were identified that had an influence on the quality and recovery achieved. These factors are grouped between the choice of equipment and the prevailing conditions on-site for a given campaign.

5.1. Choice of equipment

5.1.1. Sampler diameter

The effect of the sampler diameter on sample recovery is shown in Table 1. Between P1-35 and P2-65 which were performed on the same site, the 65 mm sampler was able to consistently recover >95% of the sampler's capacity. At S-65, the 65 mm sampler was less consistent, although still providing significantly better sample recovery than that of the 35 mm sampler.

The 35 mm sampler showed indications of blockages occurring in the cutting shoe, preventing more soil being captured into the sampler. This is attributed to dilation of denser silt layers during sampling.

Table 1. Sample recovery statistics for all samples

	Average recovery (%)	**Standard deviation (%)**
P1-35, All samples (N=21)	36.6	14.2
P2-65, All samples (N=30)	98.1	4.3
S-65, All samples (N=56)	79.5	21.0

5.1.2. Nylon stocking

The campaigns considered in this study, provided the author with the opportunity to assess the effect of the use of a nylon stocking in the MOSTAP sampler under various conditions. A nylon stocking was used for the entire P1-35 campaign, and partially during the S-65 campaign.

During P1-35, the sample recoveries were significantly lower than that of the P2-65 campaign. Whilst this is mainly attributed to the sampler size, it was also observed that the nylon stocking used with P1-35 was prone to twisting and distortion during sampling. This meant that the sample would not be able to enter the stocking as intended and sample recovery would be inhibited.

This was corroborated during S-65 where 9 samples were taken with the nylon stocking in place and 32 samples without. The sample recoveries significantly improved when the nylon stocking was excluded from the sampler as can be seen in Table 2.

Although the nylon stocking can be detrimental for sample recovery, it has significant benefits in terms of sample quality and preservation. The author has observed the following during the various campaigns:

- The nylon stocking aids in sample extraction from the MOSTAP liner.
- The nylon stocking aids in preserving the original shape of the sample during transportation.
- The nylon stocking is beneficial to prevent sample adhesion to the liner and subsequent smearing for clayey soils.

Elaborating on the final point in terms of smearing of adhesive soils, Fig.2 presents two MOSTAP samples taken during P2-65 where the nylon stocking was excluded. The top image represents a typical silty profile where the sample did not adhere to the liner of the sampler during sampling. The bottom image shows a more clayey profile where significant sample disturbance through smearing occurred. The effect of the sample-liner adhesion on the level of sample disturbance is evident.

Table 2. Sample recovery statistics for samples taken with and without nylon stocking

	Average recovery (%)	**Standard deviation (%)**
S-65, Saturated, with nylon stocking (N=9)	59.3	27.5
S-65, Saturated without nylon stocking (N=32)	78.1	18.3

5.1.3. Core catcher

The core catcher is a metal or plastic split-dome apparatus which acts as a one-way valve for the sampler. The idea is that a soil sample will force the dome open during sampling and enter the liner, and then the weight of the sample will force the core catcher shut during extraction – thus preventing the sample from falling out.

The use of the core catcher was not directly assessed for the campaigns considered in this paper. Fortunately, the effects of the use of the core catcher can clearly be seen in the data in Table 1. The core catcher was not used for P1-35, but was employed for P2-65 and S-65, although it broke during the latter campaign, and some samples were taken without the core catcher in place.

The author notes that, with P1-35, some samples taken below the phreatic surface did enter the liner, but fell out during extraction. The nylon stocking was saturated and discoloured by the soil sample prior to being lost.

For S-65, the average percentage and variability in sample recovery was poorer than that of P2-65 where a similar equipment configuration was used. It was noted that the core catcher had broken during the S=65 campaign and some samples were taken without it in place while a replacement was being sourced. Whilst the poorer recovery for S-65 can be attributed to different site conditions as well, the intermittent use of the core catcher is also deemed to be a factor in this case.

The core catcher should be considered an essential part of the MOSTAP sampling system, and it should be used for all samples to prevent loss during extraction.

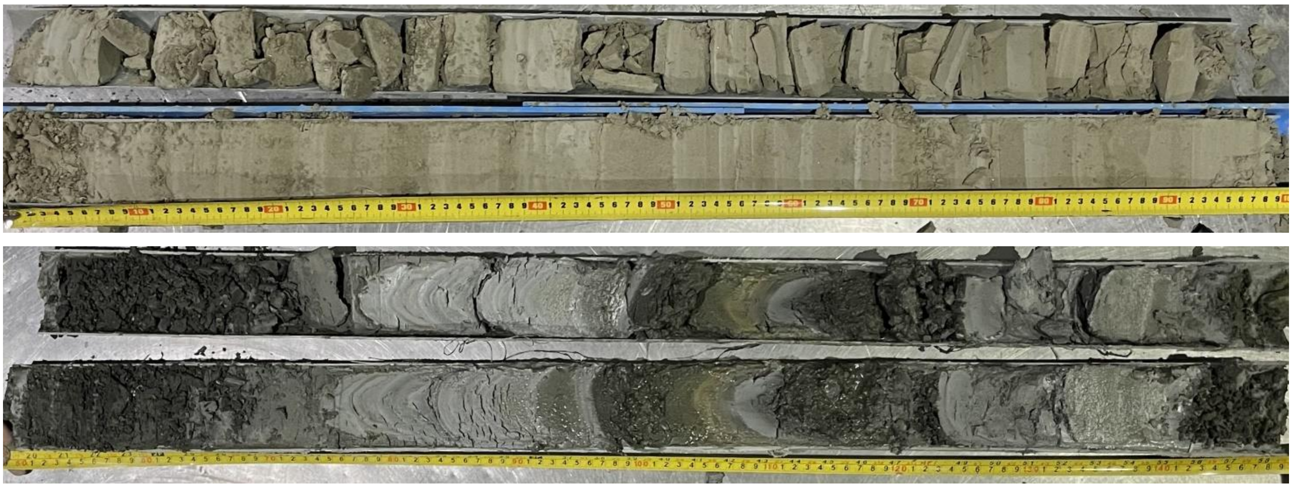

Figure 2. MOSTAP samples from P2-65 after opening showing smearing of clayey samples

5.2. Site conditions

5.2.1. Degree of saturation

The degree of saturation of a sample can also influence sample recovery during MOSTAP sampling. Table 3 shows a comparison of the recovery statistics between the MOSTAP samples each of the campaigns in this study. The samples were divided between those taken above the phreatic surface (unsaturated) and those taken below the phreatic surface (saturated).

Although the magnitude of the differences between saturated and unsaturated samples varies between the campaigns, it is evident that the samples extracted from below the phreatic surface, showed lower recovery percentages that those taken above the phreatic surface. The standard deviations also indicate higher variability in sample recoveries for samples from below the phreatic surface versus that of samples from an unsaturated stratum.

Table 3. Sample recovery statistics for saturated and unsaturated samples

	Average recovery (%)	**Standard deviation (%)**
P1-35, Unsaturated samples (N=15)	38.9	13.3
P1-35, Saturated samples (N=6)	30.7	15.7
P2-65, Unsaturated samples (N=11)	98.5	2.9
P2-65, Saturated samples (N=19)	97.9	5.0
S-65, Unsaturated samples (N=15)	94.5	7.3
S-65, Saturated samples (N=32)*	78.1	18.3

*Samples taken without nylon stocking only

Once the samples were transported to the laboratory for further assessment, the samples were opened and assessed for indicators of disturbance as well as to provide a photographic profile of the samples. Fig. 3 shows photos of a MOSTAP sample that was taken above the phreatic surface (top) and one of a sample taken from below the phreatic surface (bottom)

The quality of the sample taken above the phreatic surface is significantly higher than that of the sample taken below the phreatic surface. Furthermore, the saturated sample showed clear signs of disturbance with transportation. The orange-shaded area in Fig. 3 highlights a cavity that formed as the water and soil segregated inside the tube. The soil layers also experienced significant distortion for these samples.

The samples taken above the phreatic surface also showed signs of disturbance – crumbling and cracking of some layers, but they remained largely intact and in a usable condition for soil profiling.

5.2.2. Soil type

The consistency and soil type that is being sampled may also influence the recovery and quality of samples taken with MOSTAP samples. Long (2002) mentioned that sample disturbance effects reduced as soil sensitivity reduced for their study. Likewise, the samples taken in softer clays did show more disturbance and smearing than those taken in firmer clays for the campaigns in this study.

The densities of the soils are also important. Contractive soils reduce in volume upon shear such as the cutting shoe advancing during sampling. This would improve the potential sample recovery as the sample can enter the mouth of the sample and advance into the liner. Dilative soils increase in volume during shear. If this is significant, the soil may dilate and kick against the mouth of the cutting shoe, this blocking the sampler and no further sample would be recovered. An increase in sampler size would mitigate this problem as discussed in Section 5.1.1.

The finer soils in P2-65 showed improved sample recoveries, compared to the coarser sands in S-65, whereas the sands were more variable. A potential factor in this instance may also be the particle shapes, although this was not assessed.

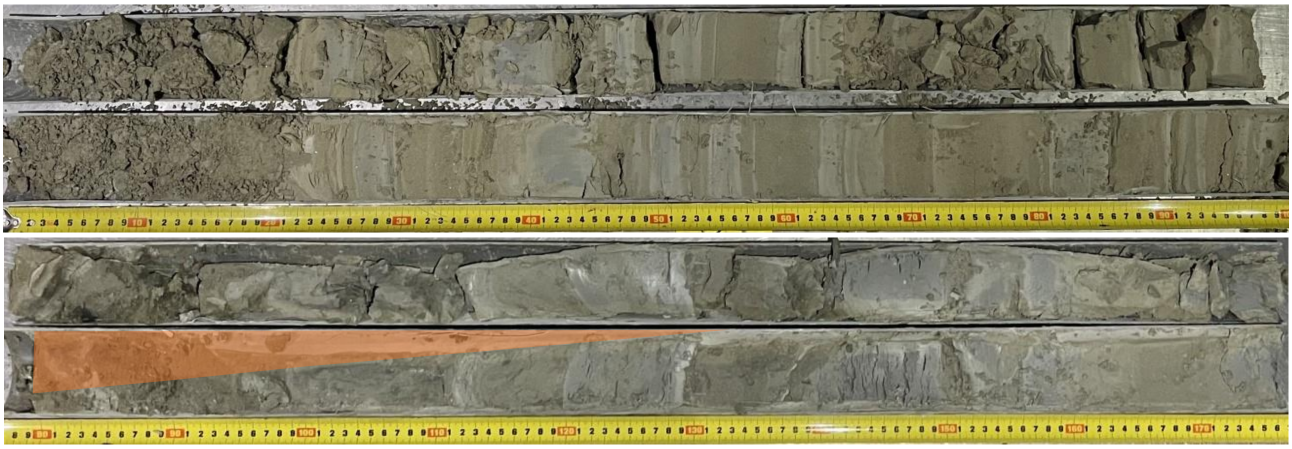

Figure 3. MOSTAP samples taken from above(top) and below (bottom) the phreatic surface.

6. Data derived from MOSTAP samples

Data collection from the MOSTAP samples started immediately after extraction from the ground. A simple process was followed to track the initial states of the samples as well as changes due to disturbances such as densification during transportation:

1. Before sampling, the sample container is weighed with all peripherals such as end caps to obtain the empty weights.
2. Post extraction, the samples are measured and weighed on-site to obtain initial bulk density.
3. The samples are clearly marked, indicating their name, sampled date, sample length, empty and full masses, and the top and bottom orientation (See Fig. 4 below)
4. Upon arrival at the laboratory, the samples are weighed again before opening to track moisture loss.
5. The samples are carefully opened, free water is decanted into an appropriate contained for later use.
6. The samples are visually assessed and carefully cut open to be able to better see the soil profile.
7. Photographs are taken of the samples, and any variations in the samples such as if different soil strata are present and need to be tested separately.
8. The complete samples (including decanted water) are then dried and weighed again to obtain the dry mass. This is used for dry density calculation.
9. The samples from prevalent layers undergo particle size analysis, Atterberg limit and specific gravity determination.
10. From this point, the samples are repackaged and stored for further tests as required.

Following the above procedure, this study was able to compare the results when using data collected on-site as well as if the same data was only collected at the laboratory. P2-65 is discussed in this section as the most complete dataset was derived during this campaign.

6.1. Sample masses and moisture loss

The samples were weighed directly after extraction and upon arrival at the laboratory to track mass differences and potential moisture loss during transportation. The distribution of the mass differences is shown in Fig. 5. For all the samples considered, 60% showed a ±1% mass difference between the site and the laboratory. This is considered within an acceptable margin. ±40% showed significant mass loss between the site and the laboratory. Upon further investigation, this mainly occurred with saturated samples – taken from below the phreatic surface. This mass loss is therefore attributed to moisture loss during transportation and storage.

One sample did show a significant mass increase between the site and the laboratory. This also highlights that measurements on-site may be inaccurate since the conditions on site may not favour consistent readings. This was an isolated occurrence in this instance. Therefore, by tracking mass changes, one is in a position to analyse adjust data points accordingly, if required.

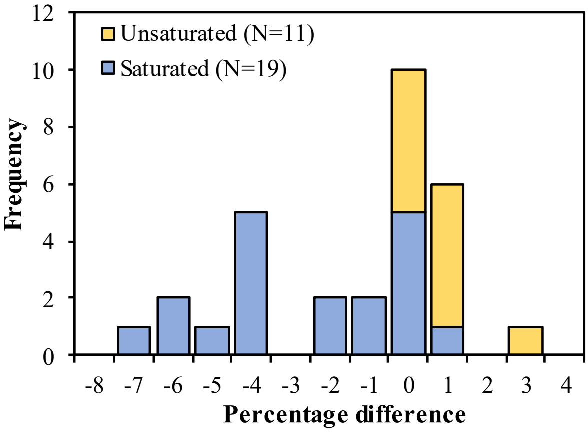

Figure 5. Mass differences between post-extraction and laboratory measurements.

6.2. Densities and moisture content

The MOSTAP samples were measured and weighed immediately after sample extraction to minimise any transportation and storage effects on the sample densities. The bulk densities were determined using the measurements taken on-site. The dry densities were determined using the on-site volume measurement, with the dry mass of the samples as determined by the laboratory.

Since the same site was considered for P1-35 as well as P2-65, the bulk densities from both campaigns could be directly compared. Table 4 shows the comparison in bulk densities derived from MOSTAP samples from the same site between the 35 mm and 65 mm MOSTAP sampler. The standard deviation for the 35 mm sampler is larger than that of the 65 mm sampler. This is partially attributed to the lower recoveries of the 35 mm sampler, somewhat reducing the resolution of the data. The average densities for both samples align very well, with the largest difference of ±50 kg/m³ seen in the unsaturated samples.

The datasets are also presented in Fig. 6 and Fig 7 for the unsaturated and saturated samples, respectively. The sample frequencies are normalised to percentages to account for the sample size differences. In these figures, it can be seen that the 65 mm MOSTAP sampler provides more consistent results for the in-situ bulk density.

Although the spread and consistency of the MOSTAP samplers varied by sample diameter, both samplers provided reasonable bulk density values for the site.

Figure 4. MOSTAP sample marked up after extraction.

Table 4. Bulk densities from MOSTAP samples in platinum tailings

	Average bulk density (kg/m³)	Standard deviation (kg/m³)
P1-35, Unsaturated samples (N=15)	1 854	154
P1-35, Saturated samples (N=6)	2 184	181
P2-65, Unsaturated samples (N=11)	1 906	110
P2-65, Saturated samples (N=19)	2 180	129

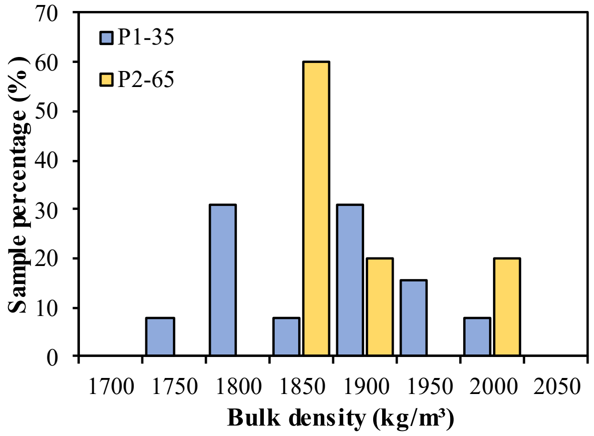

Figure 6. Bulk density comparison between 35 mm and 65 mm MOSTAP samplers in unsaturated tailings.

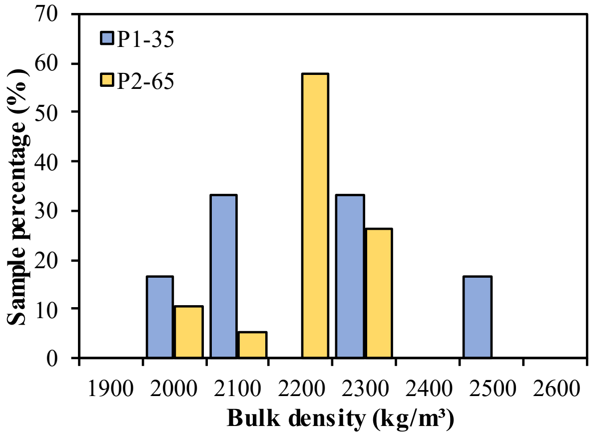

Figure 7. Bulk density comparison between 35 mm and 65 mm MOSTAP samplers in saturated tailings.

The dry densities derived from MOSTAP- and block samples taken during the two platinum campaigns are presented in Table 5 and Fig. 8. The data shows a narrow spread for the 65 mm MOSTAP and block samples. The 35 mm sampler has a large spread with clear outliers at higher densities. The average dry densities for both samplers are well aligned with the block samples' dry densities.

This study shows that the MOSTAP samples can provide reasonable dry densities in comparison to block samples. This contrasts with Long (2002), who found that the MOSTAP sampler produced denser specimens than that compared to block or piston tube samples. He only mentioned bulk density, though, which varies significantly with moisture content. This is especially true in the unsaturated zone of a soil profile.

It should also be noted that the block samples only represent the state of the unsaturated tailings at the surface of the facility, and that MOSTAP samples were taken at various, and greater, depths and under varying saturation conditions.

Table 5. Dry densities from MOSTAP and block samples in platinum tailings

	Average dry density (kg/m³)	Standard deviation (kg/m³)
P1-35, All samples (N=21)	1 677	134
P2-65, All samples (N=30)	1 650	67
P2-65, Block samples (N=12)	1 676	49

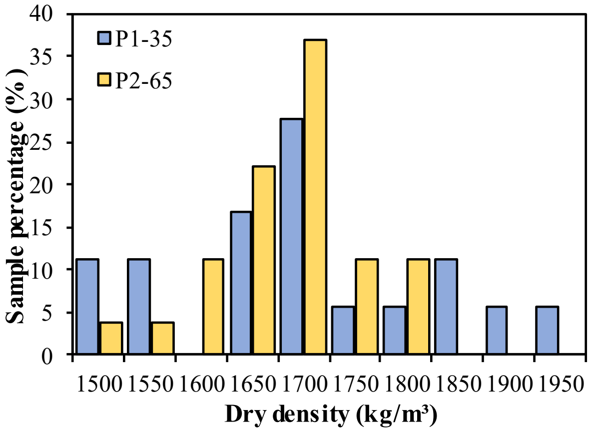

Figure 8. Dry density of platinum tailings from 65 mm MOSTAP sampler.

The degree of saturation (S_r) for each of the MOSTAP samples was calculated using the above dry- and bulk densities, along with the specific gravity determined from index tests (Section 6.3). The combined data from P1-35 and P2-65 are presented in Table 6 and Fig. 9 for the purpose of this discussion.

For the S_r for samples taken below the phreatic surface, one would expect nearly 100% saturation. The results show that the S_r for samples below the phreatic surface is around 100%. Many samples had calculated S_r values slightly greater than 100%. This is possibly due to a loss of resolution when the layering in the samples is ignored when samples are weighed and dried as a unit.

For the samples taken above the phreatic surface, $S_r < 100\%$ is expected. They showed higher variability in S_r, mainly between 30-60%.

Samples taken from the capillary fringe, above the phreatic surface, showed S_r values of 70% to 95%. This shows higher saturation inside the capillary fringe, as expected. The S_r is lower than 100% because parts of the samples intersected the capillary fringe, and the remainder was above the capillary fringe.

Table 6. Degree of saturation calculated for MOSTAP samples

	Average Degree of saturation (S_r %)	Standard deviation (S_r %)
Samples above phreatic surface	50.5	17.2
Samples below phreatic surface	104.0	8.9

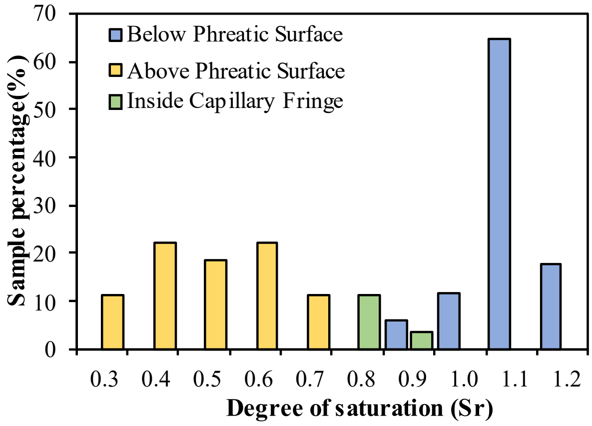

Figure 9. Degree of saturation calculated from MOSTAP samples.

6.3. Additional testing

The MOSTAP samples, once dried, were each recombined and thoroughly blended for further testing. The specific gravity of each sample was determined in triplicate as well as the particle size distribution and the Atterberg limits (index testing). This presented the study with a representative classification of the MOSTAP sample as a whole.

Using the specific gravity and the dry density, one is able to calculate the in-situ void ratio of the sample. This is a vital component in assessing the state of tailings facilities. Like with dry density, the void ratio determined from MOSTAP samples can provide a reasonable value of the in-situ conditions and variability.

The opportunity is then present for more advanced tests to be performed on the MOSTAP samples, such as triaxial or simple shear testing for critical state line determination. The samples were treated as high quality samples at depth for profiling and density determination only, and remoulded for advanced testing as the soil fabric is compromised.

As Long (2002) stated, triaxial tests on MOSTAP samples have shown erratic soil behaviour and inconsistent results when compared to undisturbed block samples. Although the opportunity may exist to obtain an intact section from a 65 mm MOSTAP sample that can be trimmed and placed into a triaxial cell, the sample will likely be disturbed by virtue of transportation and moisture migration. Furthermore, in the context of tailings, which is shown to be highly layered in profile, one is unlikely to extract sufficient sample quantities that would behave in a similar manner.

7. Additional considerations

7.1. Sampler geometry

The geometry of the MOSTAP sampler apparatus is a key consideration when planning for the depths that will be sampled. The cutting shoe of the sampler is ±110 mm in length and that needs to be added to the sampling depth that is required, i.e., a push length of ±1.1 m is required to capture 1.0 m of sample into the liner. Furthermore, the cone that is fixed to the sampler when advancing the sampler to the target depth, disturbs the soil immediately ahead of the sampler. This is also visible in Fig. 1 and Fig.2 where the greatest disturbance was noted in the top ±100 mm of the unsaturated samples.

7.2. System limitations

Since the MOSTAP sampler is significantly larger in diameter than a CPTu cone, the MOSTAP sampler is unlikely to achieve similar depths of penetration to extract a sample from. The force required to advance the sampler may well exceed the available kentledge that a given CPT rig can provide. It is also the experience of the author that the MOSTAP sampler may struggle to advance through soil layers where the CPT cone resistance exceeds 20 MPa. If early refusal is encountered with the MOSTAP sampler, one can choose to retract the cone and take the sample at the achieved depth. The reduced resistance allows for a sample to be taken successfully.

7.3. Sample disturbance

As the previous sections alluded to, the degree of sample disturbance with MOSTAP samples depends on various factors. Additional to these factors is disturbance through analysis – how the samples are handled, opened, examined, etc. It is also important to prioritise the data that is important to a specific investigation. Therefore, some compromises may need to be made when conceptualising a testing regime for a project.

For the campaigns in this study, it was important to assess the in-situ soil profiles, densities, and composition. The samples needed to be cut open to obtain a clear visual distribution of layering in the profiles. Therefore, samples could not be maintained in a sufficiently “undisturbed” state to be directly inserted into a triaxial cell for example. The samples were still sufficient to reconstitute for critical state line testing, where sample homogeneity is important.

Clayton and Siddique (1999), using analytical techniques, found that sampler geometry and size has a significant impact on sample quality. Since the MOSTAP sampler is a constant for this study, the effect of the sampler size is clear from the findings in this study.

Whilst MOSTAP samples can be used for index characterisation, densities and simple classification, it does not provide good quality specimens for mechanical testing (triaxial- or oedometer testing) aimed at estimating soil parameters to be used in design. The specimens can be remoulded for CSL-type testing only.

8. Conclusions

Many learnings have been made throughout this study regarding the applicability of the MOSTAP sampler in geotechnical investigations:

1. The MOSTAP sampler provides both a cost- and time effective sampling method during CPT campaigns since the CPT rig is already established on-site.
2. The choice of equipment has a significant impact on the sample quality and recovery:
- Sampler diameter is the single largest factor in sample recovery and quality. In this regard the 65 mm sampler is superior to the 35 mm variant.
- The core catcher is an essential component to prevent sample loss – especially when sampling below the phreatic surface.
- The nylon stocking has proven beneficial to prevent sample adhesion to the liner, which causes disturbance. This is more significant when sampling in clayey soils. The advantage is less pronounced for coarse grained material.
- The nylon stocking had a detrimental effect on sample recovery for the campaigns in this study.
3. The prevailing site conditions also have an impact on sample recovery and quality:
- Samples from above the phreatic surface showed greater recoveries, lower apparent disturbance, and higher retention of layer composition than those from below the phreatic surface.
- Samples with a higher clay content experienced more disturbance during sampling due to smearing and distortion from the PVC liner.
4. The MOSTAP sampler is able to provide sufficient quality samples to be used for soil profiling, characterisation, and index tests.
5. Transportation, storage, and handling is the largest contributor to sample disturbance. This is more apparent for saturated samples where significant moisture migration and settling occurred.
6. Saturated samples showed the most significant mass (moisture) loss between the site and the laboratory.
7. Diligent tracking of sample volumes and weights, starting on-site, immediately when the sample is extracted, through to the laboratory mitigate transportation disturbances and ensure that the data in this regard as accurate as possible. All sample masses should be verified at the laboratory upon reception, before testing to identify losses and site inaccuracies.
8. The bulk- and dry densities from MOSTAP samples were consistent between the sampler diameters, although the 35 mm sampler showed a wider spread than the 65 mm sampler. The dry densities agreed with the those from block samples taken at the same facility. The densities were deemed to be reasonable for this site.
9. Valuable information can be gained from MOSTAP samples by doing index tests in conjunction with the above density determinations. For example, the void ratio can be calculated using the dry density and specific gravity determined above.
10. MOSTAP samplers do not provide a reasonable quality and quantity of undisturbed sample to allow for in-situ fabric to be retained for advanced soil testing (triaxial and oedometer tests).
11. There are various considerations to be cognizant of when performing MOSTAP sampling. These include the equipment geometry, limitations of the CPT rig, harder soil layers and various sources of sample disturbance on the subsequent test work to be done.

9. Recommendations

The following recommendations can be made considering the above learnings:

The 65 mm MOSTAP sampler (or larger) is recommended for use in geotechnical investigations. It provides higher recoveries, better sample quality and more consistent results than smaller diameter versions.

A core catcher should always be used with MOSTAP sampling. However, the nylon stocking should be used with discretion since the sample quality, in clays, may improve, but the recovery may suffer.

It is highly recommended that a strict mass and volume tracking program be followed for MOSTAP samples to quantify potential sources of disturbance. Measurement of mass and volume on site, post recovery is essential in ensuring that density determinations are accurate and representative for a site.

Considering the laboratory testing, a suite of index tests pair well with MOSTAP samples to provide more information on the soil stratum.

The MOSTAP sampler has an important drawback with its very thick tube walls, increasing sample disturbance. It does not provide a high-quality sample for use in undisturbed testing as the soil fabric is likely compromised. Triaxial and other advanced tests on MOSTAP samples should be done on reconstituted samples only to obtain the critical state line and associated soil parameters, where relevant.

Whilst more effective sampling techniques exist to better preserve the sample fabric and state at depth, the MOSTAP sampler remains a viable and efficient sampling technique. It provides the opportunity to derive reliable in-situ density parameters as well as a physical soil sample to be used in more advanced tests.

References

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