

SOME MECHANICAL PROPERTIES OF DEWATERED AND DRIED
SEWAGE SLUDGE

QUELQUES QUALITÉS MÉCANIQUES DE BOUES DE DÉCANTATION
ÉVACUÉES D'EAU SECHÉES

EINIGE MECHANISCHE EIGENSCHAFTEN ENTWÄSSERTER UND GE-
TROCKNETER KLÄRSCHLAMME

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Summary: In recent years more and more sewage sludge has to be disposed off on waste tips. The mechanical properties that affect both the placement of the sludge and the stability of the slopes in the tips are discussed.

Zusammenfassung: In den letzten Jahren muß immer mehr Klärschlamm auf Deponien entsorgt werden. Die mechanischen Eigenschaften, die sowohl den Einbau des Schlamms als auch die Stabilität der Deponieböschungen beeinflussen, werden diskutiert.

Résumé: Dans les années passées il devient de plus en plus nécessaire de déposer des boues de décantation sur les décharges. Les qualités mécaniques qui peuvent influencer le placement des boues ainsi que la stabilité des talus des décharges sont traitées.

Key words: Sewage sludge, mechanical properties, waste tips

An increase in the feeling of responsibility for the environment, together with the advancement of analytical methods in chemistry, have led to the fact that ever increasing quantities of sewage sludge which were "used" in agriculture now have to be "disposed" of. In the majority of cases the only means of disposal open to the authorities responsible is to deposit it in waste tips. This takes place either together with household refuse or in separate tips reserved for sewage sludge. In either case the mechanical properties of the sludge are of paramount importance first of all in the placing and compacting of the sludge and secondly for the slope stability of the tips.

After the final treatment stage in the sewage works the sludge has a dry solids content of about 5 %. This consistency is liquid and in this state can neither be handled nor placed on the tips. Furthermore the large quantities of water present will percolate through the fill thus affecting the stability and later appear in the drainage system of the tip as heavily contaminated water which has to be treated. For these reasons the original sludge is generally dewatered at the sewage plant using mechanical methods with or without additives. The water extracted from the sludge is then treated in the sewage works. The dry solids contents of these mechanically dewatered sludges depend on the method and the additives used and vary generally between 20 % and 50 %. The dry solids contents and also other mechanical properties will also depend on the original composition of the sludge.

When the sludge is placed and compacted in the waste tip a minimum undrained shear strength of the sludge is needed in order to prevent the equipment from sinking in or getting bogged down. This minimum shear strength as determined with the vane test will depend on the method used to deposit the sludge which will partly depend on the percentage of sludge in the waste tip. Up to about 20 % - 30 % sludge by volume it has been shown to be advantageous for both the slope stability and permeability for gas and water, to place the sludge in mounds and to compact the house-hold waste around and over the mounds. In order that the mounds can be built up to the required height - in general about 1,5 m - and that they are not deformed when compacting the household waste around and over them it has been found that the sludge should have a vane shear strength of about 15 kN/m^2 - 20 kN/m^2 .

If the percentage of sludge is higher than about 30 % of

the total volume of the waste tip, it can be an advantage to place the sludge all together in a separate area inside the waste tip. Here the sludge is distributed and compacted in thin layers of about 30 cm as in the construction of earth dams or embankments. In this case a higher shear strength of the sludge is required and depending on the equipment used for distribution and compaction must be between $25 \text{ kN/m}^2 - 50 \text{ kN/m}^2$.

The results shown in Fig. 1 show the variation of shear strength with type of additive, origin of sewage sludge and dry solid contents.

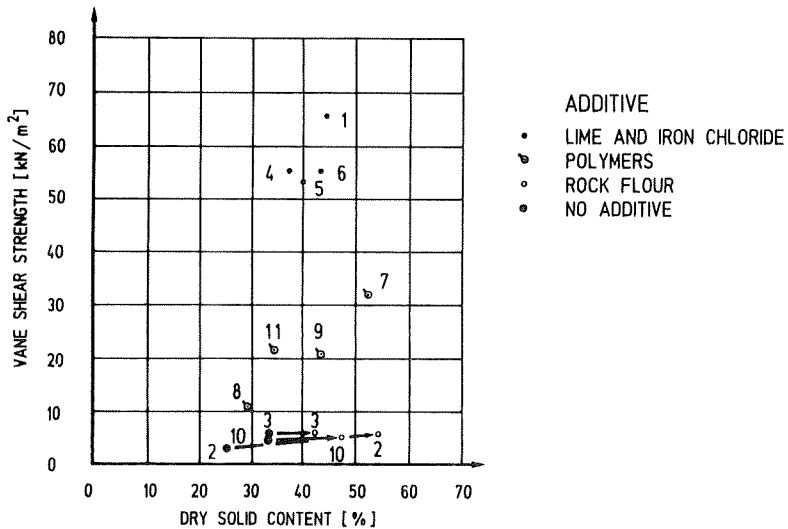


Fig. 1 Dependence of vane shear strength on dry solids content

Mechanically dewatered sludges even with additives contain large amounts of water (50 % - 70 %) which as a result of loading due to increasing height of the tip will be pressed

out of the sludge. The rate at which the water will be pressed out depends on the permeability of the sludge and the length of the drainage path. The permeability of sewage sludge will depend on the origin of the sludge but in general it is very low with values often between $1 \cdot 10^{-9}$ m/s and $1 \cdot 10^{-11}$ m/s. Soils with such low values are often considered to be "impermeable". If in addition a long drainage path is present then pore water pressure will develop which will prevent the full mobilisation of the frictional part of the shear strength and the strength of the sludge will remain low no matter what the loading. This is particularly detrimental for the slope stability. The results of a typical unconsolidated-undrained triaxial test on a sewage sludge are shown in fig. 2.

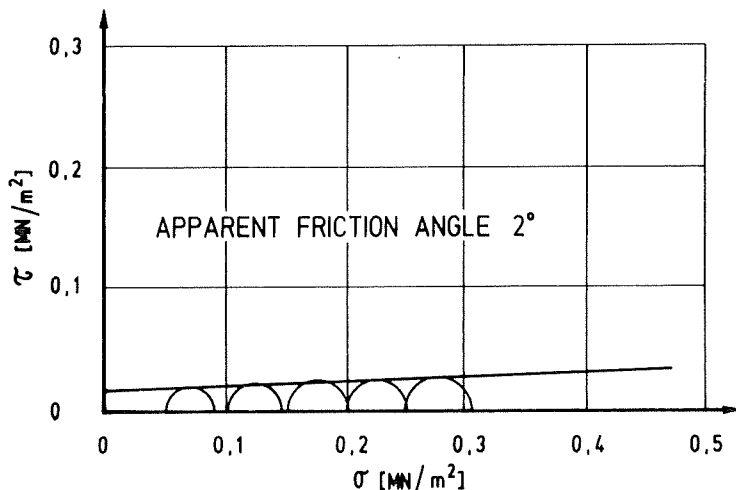


Fig. 2 Unconsolidated-undrained triaxial test on sewage sludge

If the sludge is allowed to drain during the increasing vertical load (consolidation) then the same sludge has en-

tirely different shear properties due to the mobilisation of the frictional properties, see fig. 3.

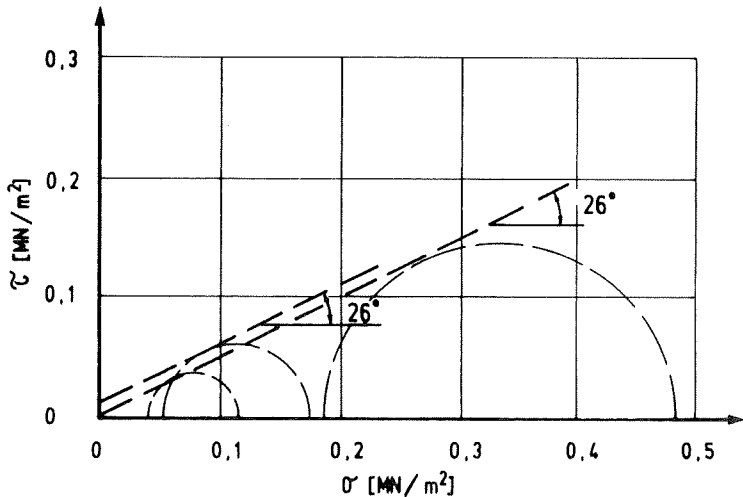


Fig. 3 Consolidated-undrained triaxial test on sewage sludge

The shear properties of consolidated undrained sewage sludge will vary according to the sludge origin and additives used. An example of another sludge is shown in fig. 4.

When the sludge is placed in mounds, the length of the drainage paths are generally short and the sludge will consolidate sufficiently under the increasing vertical loads. If the sludge is placed altogether in a separate area of the waste tip or if a separate tip for sludge alone is made then the lengths of drainage paths can be considerable and it is often necessary, to provide artificial drainage paths. These drainage paths will not only allow the pore water to escape but also allow gas pressures which can occur in some sludges to dissipate. These gas pressures can

also have detrimental effects on the slope stability.

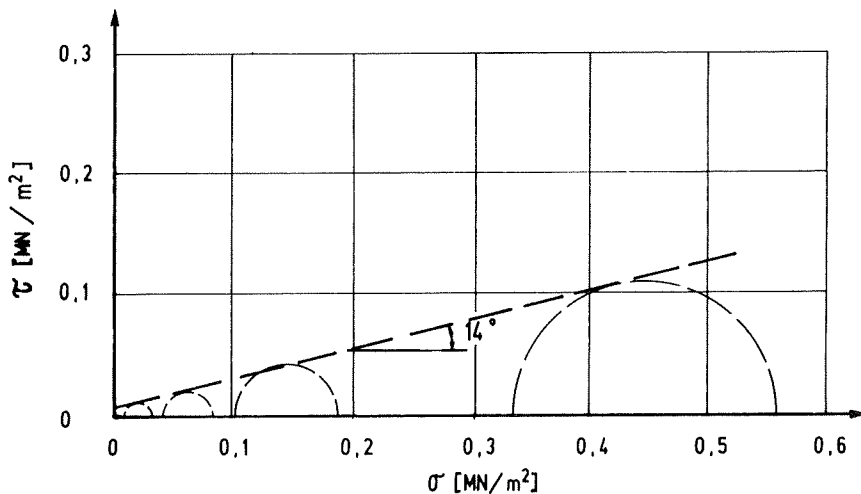


Fig. 4 Consolidated-undrained triaxial test on sewage sludge

When the water is pressed out of the sludge a reduction in volume takes place. This reduction in volume manifests itself in the form of settlements in the waste tip which should be taken into account when considering the use of impermeable coverings for such tips. The compressibility of dewatered sewage sludges lies between 0,2 and 1 MN/m².

In order to reduce the amount of water being deposited, which will later appear as seepage water, several authorities have started to dry sewage sludge using thermal methods. The dried sewage sludge has dry solids contents generally between 90 % - 96 % and looks like a fine to coarse grained sand. The problem with this material is that it is very dusty and because of the granular structure is difficult to compact. One solution to these problems is to rewet

it using dewatered sludge. This not only binds the dust but also creates a mixture which is easier to compact. The amount of dewatered sludge necessary to obtain an optimum mixture can be determined using the Proctor test which is well known in the compaction of soils. The amount of dewatered sludge necessary generally lies between 30 % - 50 % depending on the properties of the dried and dewatered sludge. Such mixtures can be compacted fairly easily using normal earth compaction equipment and dry densities between 0,9 and 1,1 t/m³ are obtained compared with 0,5-0,7 t/m³ with dewatered sludge. The vane shear strength varies at optimum mixture between 100-170 kN/m². It is important to realize that the structure of these rewetted mixtures are not the same as a sewage sludge only dried to the equivalent dry solids content. In the consolidated undrained state angles of friction between 28-40° have been measured. These values which are important for the slope stability are higher than for dewatered sludge alone which means the slopes are more stable or that for the same factor of safety steeper slopes are possible. Because of the higher dry densities the compressibility of the mixtures are much lower and the compressibility coefficients are between 1 and 4 MN/m². This means that settlements due to vertical loadings are greatly reduced.