SCIENTIFIC AND TECHNICAL CO-OPERATION

between

Graz University of Technology (Austria)
and
University of Zagreb (Croatia)

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The partners discussed about experimental programme which needs to be carried out in order to improve the prediction power of the hypoplastic constitutive model for MBT waste material. The experimental programme will be carried out within the Croatian Science Foundation project *Testing and modelling of mechanical behavior of biodryed waste as a Waste-to-Energy prerequisite – WtE* (wte.gfv.hr)

The following topics has been discussed:

SAMPLING

The samples are going to be taken from MBT facility near Varazdin. The samples are going to be fresh and organically rich, therefore highly degradable. Thus, I suggest that we take only the necessary amount of the sample for conducting the tests one by one.
Samples will be stored in plastic bags and transferred to the lab.

SAMPLE STORAGE

The samples is going to be storage in the laboratory in plastic bags. The amount of waste per bag is around 10-20 kg.
The sample degradation is going to be suppressed with addition of the necessary amount of acetic and propionic acids.
My idea is that we should first to examine fresh waste material with suppressed biodegradation. The sample degradation can be suppressed with addition of the necessary amount of acetic and propionic acids.
In that way we are going to obtain purely mechanical response of the samples. Afterword's we can conduct tests on samples on which the degradation is not suppressed. The difference between mechanical response of samples with suppressed and non-suppressed biodegradation is going to give us the changes in mechanical response caused by degradation.

DETERMINATION OF BASIC PARAMETERS

Determination of waste composition (organic, glass, metals, papers, etc.) - manual sorting of waste components. For assessing the average values at least three separate samples have to be examined.
The mass percentage of biodegradable portion of waste material will be established through the heating process at high temperatures (ignition loss).
The waste classification will be carried out according to the simplified version of the classification system suitable for MBT waste (*Velkusanova, 2009*).
The characterization of waste material (leaching test) will be conducted by an authorized laboratory.
The granulometric curves for waste material will also be established. The granulometric curves will be determined according to the Croatian standard HRN.U.B1.018 (sieving method). In the case that larger amount of small particles will be detected, the granulometric curve for small size particles will be determined with hydrometer.

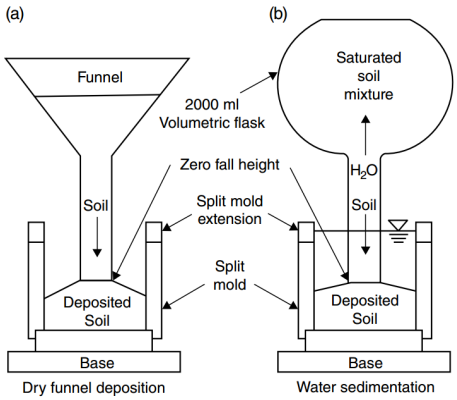
The specific gravity of MBT waste sample will be determined according to the ASTM D 854 standard and according to the procedure described by Yesiller et al. (2014).

The moisture content will be determined according to the ASTM D 2974 standard.

TRIAXIAL TESTS

SAMPLE PREPARATION

For sample preparation procedure I suggest that we use dry funnel deposition (DFD) method or water sediemtation as described in Lade (2016) – see figure below the text.
This method gives more or less satisfying results with respect to the uniform distribution of fine grained particles among the coarse grained particles through whole specimen.
The sample is going to be anisotropic in his nature.
Different densities can be achieved with rising the funnel more quickly. In addition, we can also use a vibrating table for further increase of sample density. The vibrating table which I have in my laboratory can vibrate in vertical direction only, at various frequencies.



SATURATION

For saturation of sample I suggest that we first try the percolation method as described in Lade (2016). I guess that this simple method should be sufficient since I suppose that initial permeability of this material is sufficiently high. We can also try CO_2 method and back pressure method if we conclude that percolation method does not give us a satisfying results.

FREEZING

If we use water sedimentation method, in order to keep the prepared sample intact, we can frizz him in the refrigerator. Such frizzed sample can then be shaped into the desired form and placed in the triaxial cell. Prior testing, we will allow the sample to thaw.

MEMBRANE

To reduce the puncture risk, I suggest that we use two thicker membranes (0.64 mm each). To further reduce the leakage through the membrane we can place a thin metal foil between the membranes.

H/D RATIO – BULGING (BARRELING) AND BUCKLING

In order to keep the sample strains uniformly distributed as much as possible we need to consider restraint effect due to friction on the end plates (bulging) and to find out the appropriate sample height in order to reduce the risk of buckling.

To reduce the friction on the end plate we can lubricate the end plates. Another possibility that we can try is to place a thin HDPE foil between sample and end plates. HDPE foil is a kind of material that has the tendency to reduce friction coefficient as the stresses increasing.

We can do a both type of tests and to see what is more appropriate for us to use.

If we manage to keep the sample deformation as uniform as possible we can then calculate the radial strains from vertical and volume strains.

If the sample is still going to bulge (probably it will due to a strong sample inhomogeneity and anisotropy) we can try to measure average radial deformation with laser displacement sensors. (http://www.gdsinstruments.com/gds-products/2d-laser-sample-mounting-set-and-displacement-sensor).

To reduce a risk of buckling we can reduce the sample height. We can do the tests with couple of H/D ratios to see what is best for us, although the H/D of 1/1 seems the reasonable choice. Sample preparation procedure also plays important role in reducing the risk of buckling. We should be careful and prepare the sample in such way to avoid occasional/sporadic large void spaces.

Another important issue is the alignment of the axis of the material (sample) symmetry with vertical axis of the triaxial apparatus. One possible way is to freeze the sample after preparation, then to establish the position of the material symmetry axis's and the to cut the sample in such way that one of the material symmetry axis will be aligned with the axis of the triaxial apparatus. Another possibility is to incline the principal stress direction. This may be done in equipment in which shear stress can be applied to the surface of the specimen.

MEASUREMENT OF VOLUME CHANGE OF DRY MATERIAL

To measure the volume change of dry material I suggest that we use the procedure described in Lade (2016). With this setup we can measure the volume of the air expelled from the sample. I think that this simple setup we can make ourselves.

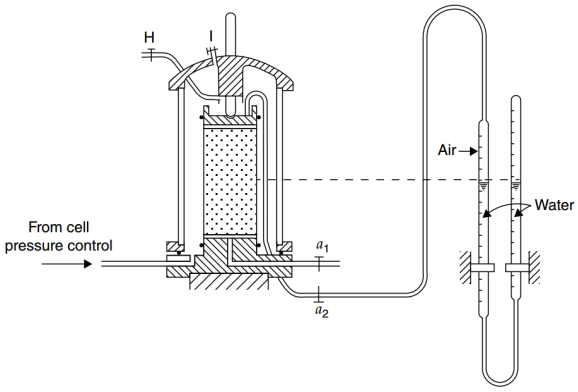


Figure 4.51 Measurement of the volumes of both air and water expelled from a partly saturated specimen (after Bishop and Henkel 1962).

DOUBLE WALL CELL
The double cell is a good solution but unfortunately it is out of our budget reach.

Literature:
Lade, P.V. (2016), “Triaxial Testing of Soils”, Wiley Blackwell, ISBN: 9781119106623

Yessiler, N., Hanson, J.L., Cox, J.T., Noce, D.E. (2014), “Detemination of specific gravity of municipal solid waste”, Waste Management, 34 (2014), 848-858

Velkushanova, K., Caicedo, D., Richards, D. and Powrie, W., 2009, "A detailed characterization of an MBT waste," Proceedings Sardinia 2009, Twelfth International Waste Management and Landfill Symposium (CD-ROM), S. Margherita di Pula, Cagliari, Italy