[[Characterization of Landfill-Mined-Soil-Like-Fine-Fractions for use in the Geotechnical and Environmental Areas]]

Palavras-Chave: [[Landfill mining]], [[Waste characterization]], [[Fine-fractions]]

Autores/as:

Eduardo Augusto Licco [UNICAMP]

Profa. Dra. Miriam Gonçalves Miguel (orientadora) [UNICAMP]

INTRODUÇÃO:

The municipal solid waste (MSW) is a by-product of human activities, has a very varied composition and must be disposed of sanitary landfill. However, many of these materials are considered value-added secondary raw materials and can be reused. Landfill mining refers to practices of excavation of landfilled wastes with a view to its use as natural resources, materials, and energy. Landfill-Mined-Soil-Like-Fine-Fractions (LMSFF) are fine factions of mined MSW considered as soil type and reused as daily cover of landfills, construction material and fertilizers (VAN VOSSEN; PRENT, 2011; FORD; WARREN; READ, 2013). Therefore, knowledge of the characteristics and composition of these fine fractions is essential to carry out any study involving its use or improvement. This research presents physical and geotechnical characterizations of LMSFF from Delta A Sanitary Landfill located at Campinas city, southeastern Brazil, aiming its utilization as material for geotechnical constructions.

METODOLOGIA:

MSW studied in this research comes from the city of Campinas-SP, classified as Class IIA, according to NBR 10.004 (ABNT, 2004). MSW were collected in December 2019 from a cell built at the Delta A municipal landfill in 2012 with aperture of a trench with aid of a backhoe. The excavated material was placed on a canvas stretched out near the trench, successively homogenized and quartered, to reduce the material mass to obtain a final representative sample, with wet mass close to 500kg. This sample was inserted in several plastic bags, which were transported to the Prototypes Laboratory at Unicamp to be stored, prepared, and subjected to laboratory tests. The final representative sample was subjected to manual separation to select the thickest materials. After this preliminary manual separation, the remaining mass was sieved in the 19mm mesh, and the passing constituents in this mesh were defined as landfill-mined-soil-like-fine-fractions (LMSFF) of the sample (D < 19mm), that is, those that have a fraction with a size that is difficult to identify in their category, due to the already suffered biodegradation processes. The LMSFF of the sample were the object of this research.

The total mass, on a wet basis, of LMSFF was determined by a mechanical scale with a precision of 100 g. The percentage of this mass in relation to the total mass of the final representative sample of MSW (248.23 kg) was calculated. A 500g portion of the LMSFF was subjected to the moisture content test, according to NBR 6457 (ABNT, 2016a), in an oven at 60°C. The moisture content of the LMSFF on a dry and wet basis were calculated. Subsequently, the total dry mass of the LMSFF was indirectly determined by dividing their total wet mass by their moisture content on a dry basis. Thus, the ratio between the total dry mass of the LMSFF and the total dry mass of the representative sample was also calculated, which also allowed us to obtain the gravimetric percentage of these fractions on a dry basis.

Recommendations from NBR 6458 (ABNT, 2016b), adapted to the fractions of MSW with a diameter smaller than 2 mm, were followed. As the LMSFF contained organic matter, the microporosity retained more air, increasing the test time, therefore, four particle density values were obtained. The particle size distribution test of the LMSFF was carried out according to NBR 7181 (ABNT, 2016c) and consists of the determination of the diameters of the LMSFF performed by the sieving and the sedimentation methods. Textural classification of the LMSFF was according to NBR 6502 (ABNT, 1995). The tests of liquid and plasticity limits were performed according to NBR 6459 (ABNT, 2016d) and NBR7180 (ABNT, 2016e), respectively.

Compaction curves were obtained according to NBR 6457 (ABNT, 2016a) and NBR 7182 (ABNT, 2016f) and adapted for the LMSFF. Two compaction tests were carried out at Normal Proctor Energy, the first with sample reuse and the second without reuse.

The saturated permeability coefficient (k) was obtained by the permeability tests with variable load according to NBR 14545 (ABNT, 2000), with the compacted sample under the conditions of optimum moisture content and maximum dry density, obtained in the compaction test for reused sample. The permeability tests were performed on two specimens of LMSFF using two PVC permeameters, over 42 days.

Unconfined compression strength tests were performed based on ASTM D2166/D2166M-16 (ASTM, 2016). Four specimens were compacted within a split cylinder using the sample compaction data with reuse. Then, the specimen was removed from the cylinder and submitted to the unconfined compression test until its rupture.

RESULTADOS E DISCUSSÃO:

The percentages of LMSFF in relation to MSW final representative sample were 35.56% and 35.65%, respectively, on a dry and wet basis. These values are below those found in Kaartinen et al. (2013); Mönkäre et al. (2016); Wolfsberger et al. (2015), which can be explained by the different definitions of the LMSFF in relation to the passing sieve, ranging from 25mm to 10mm. In this research, LMSFF was defined as those smaller than 19mm. The moisture contents on a dry and wet basis were 49.02% and 32.90%. Climatic conditions, age of landfilled waste, waste gravimetric composition, landfill operation, moisture content among other factors, interfere in the biodegradation of MSW and, consequently, in the generation of theses fractions.

Values of the particle density ranged between 2.39 g/cm^3 and 2.48 g/cm^3 and approached the interval found in Song et al. (2003), which was between 2.44 g/cm^3 and 2.58 g/cm^3. This variability occurs due to by the differences in the contents of the organic matter, paper, plastic, and other materials with lower specific mass in the composition of the LMSFF.

The particle size distribution curve resulted in a soil composed of 0.82% clay, 0.13% silt, 2.10% fine sand, 4.83% medium sand, 12.12% coarse sand and 80% of gravel. The predominance of sand and gravel was also reported by Kaartinen et al. (2013), Monkare et al. (2016) and Hogland et al. (2004).

Liquid and plasticity limits had values close to each other, 39.73% and 39.47%, respectively, classifying the LMSFF as no-plastic, as well as in Vasant (2017). Under the Unified Soil Classification System (USCS), the material was classified as Well Graded Gravel with Sand (GW), while under the American Association of State Highway and Transportation Officials (AASHTO), as A-1-a Gravel and Sand, excellent material for use in paving.

The compaction curves resulted in optimum moisture contents of 29% and 33%, and maximum dry densities of 1.36 g/cm^3 and 1.25 g/cm^3, respectively, for the reused sample and the non-reused sample. Udeni et al. (2014) obtained the optimum moisture contents ranged between 17% and 24%, and the maximum dry densities ranged between 1.27 g/cm^3 and 1.67 g/cm^3.

The saturated permeability coefficient (k) was found in a scale of 10^{-8}cm/s to 10^{-7}cm/s (Figure 1). These variations can be explained due to the formation of air bubbles (gases) that were trapped in the load tube and were removed through the upper opening of this tube, before taking the hydraulic load readings. These bubbles were interpreted as the result of biological activities under anaerobic condition within the specimen during permeability tests. The formation of gases inside the specimen compromises its saturation and, consequently, reduces its permeability. As the gases were eliminated, the specimen regained its saturation and its permeability stabilized at the value corresponding to saturation. Most authors obtained the permeability coefficient between 10^{-8}cm/s and 10^{-1}cm/s depending on the particle size. Considering the particle size used in this research, the permeability coefficient ranges between 10^{-8}cm/s and 10^{-6}cm/s (GAVELYTE et al., 2016).

The normal stress versus axial strain curves (Figure 2) indicated values of unconfined compression strengths range between 48.9 kN/m^2 and 62.8 kN/m^2. The curves did not show a defined rupture peak, being considered the highest value obtained as the unconfined compression strength. The plastic and pruning fragments acted as fiber reinforcement and allowed strains of the specimens without clear rupture.

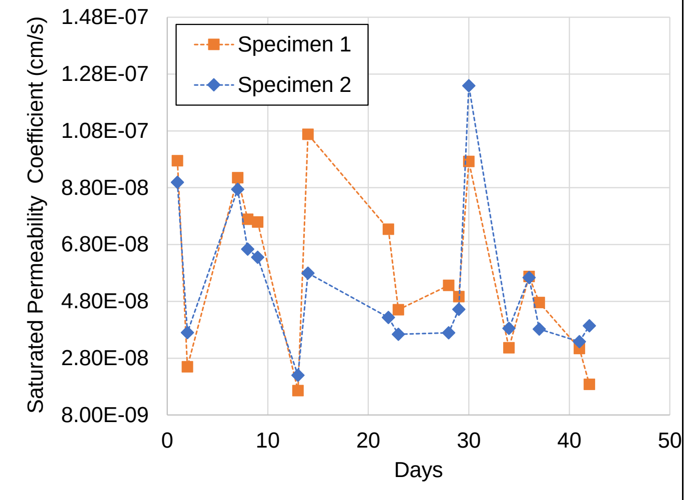

Figure 1: Saturated permeability coefficient versus time

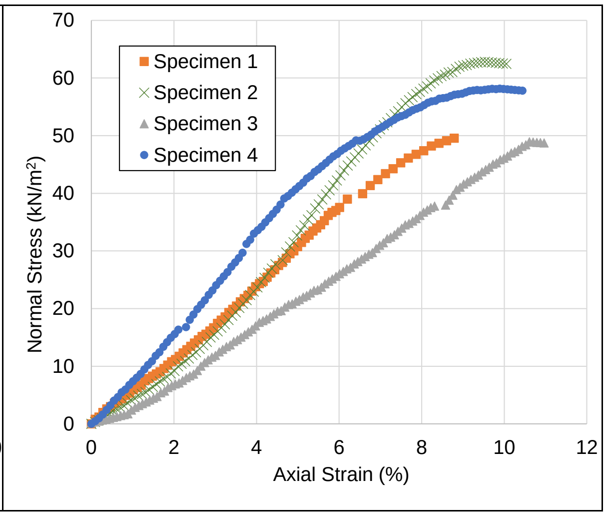

Figure 2: Unconfined Compression Strength Curves.

CONCLUSION:

Landfill-mined-soil-like-fine-fractions (LMSLF) from Delta A Sanitary Landfill located at Campinas city, southeastern Brazil, accounted for just over a third of the landfilled MSW mass, age of 8 years. The moisture contents values on dry and wet basis were 33 and 49%, respectively. They were texturally classified as sandy gravels, non-plastic and with an average particle density value of 2.44 g/cm^3. Under USCS, LMSLF was classified as GW and under AASHTO, as A-1-a. Optimal moisture content and maximum dry density values were also like fine soils (clays and silts), presented high water retention. The values of saturated permeability coefficient of the compacted LMSLF presented orders of 10^{-8} and 10^{-7}cm/s, indicating low permeability, typical of clays. The unconfined compression strength values were relatively low, between 50 and 60kN/m^2, with axial strains close to 10%. Despite LMSLF have being classified as granular material, its geotechnical behavior was typical of fine materials, most likely due to its composition with organic matter, plastics, paper/cardboard, garden waste, clay minerals, among others, which present high compressibility, high water retention, low density, and low compression strength. Thus, it is suggested that they can be better investigated for use as sanitary landfill covers and small containment landfills.

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