Classification of Municipal Solid Waste in the City of Rio de Janeiro Using the German Regulation E1-7 GDA

Cláudio Mahler, Ronaldo Luis dos Santos Izzo, André Vinicius Azevedo Borgatto

Abstract. The subject of this paper is the application of a morphological classification of MSW in the city of Rio de Janeiro based on the German recommendation DGGT (1994) – E 1-7 GDA. This recommendation deals with the identification and description of waste according to aspects of waste mechanics. This will give the environmental control agency and companies responsible for final waste disposal more comprehensive information about the geotechnical characteristics of the materials. First, the waste is described in relation to type, identification and its condition. After determining the type of waste, indications for analysis in groups of substances are obtained in a second step. The results have shown that in the Brazilian sample the percentage of waste with dimension 1 and dimension 2 is higher than 30% in weight, which is a favourable indicator in the MSW landfill analyses in view of stability. The results found using this classification furnish information for a better analysis of slope stability of MSW landfill by including the fibre reinforcement effects. It is also important for projects concerning waste recycling.

Key words: MSW, morphological classification, sanitary landfill, German regulation.

1. Introduction

In the past few years the world is becoming increasingly concerned with the Municipal Solid Waste (MSW) issue. In large metropolitan centers where there is a shortage of available space, the situation is even more of a problem. Accordingly, many attempts have been made to extend the lifespan of existing waste disposal areas. Common to these attempts is that due to the lack of knowledge of MSW characteristics and behaviour, harmful and unexpected consequences often arise. Slope stability problems in MSW landfills have occurred throughout world, including Brazil, such as, for example, a landslide in the Bandeirantes sanitary landfill in São Paulo city (Borgatto, 2006), in 1991. The purpose of this paper therefore is to adopt a morphologic classification of Brazilian MSW based on the German technical recommendation DGGT (1994) – E 1-7 GDA. The results found using this classification provide information for a better analysis of slope stability of MSW landfill by including the fibre reinforcement effects (Mahler & Neto, 2006). It is also important for projects for waste recycling.

2. Test Procedures

The first activity carried out was to identify the waste from the location where samples have been collected. In this identification, a characteristic of the waste is defined, which is not possible during collection. At this stage the following criteria have been considered:

- Amount of waste received (t/day);
- Class of waste;
- Origin of waste;
- Supply type;
- Estimate of waste homogeneity.

2.1. Sampling

For this research a fresh waste was chosen, before being sent to the landfill. The samples were collected in the MSW storage and redistribution shed of Comlurb (Rio de Janeiro City Urban Waste Collection Company) at Jacarepaguá, Rio de Janeiro, Brazil.

Once the samples were collected, they were taken to an external area where they were displayed on a plastic blanket inside a square formed by wooden rulers 2.00 x 2.00 m in dimension, in order to undertake the homogenisation and quartering process.

The sampling procedure was repeated until a sample was obtained with approximately the volume of a Comlurb standard container, namely, approximately 50 kg of MSW.

2.2. Physical characterisation

At the Comlurb field laboratory the following physical analyses were done:

- Determination of water content;
- Distribution of the substance groups according to the regulation established by the German DGGT (1994);
- Analysis of the piece sizes that comprise the groups of substances established by the German regulation DGGT (1994);
- Morphological classification by groups of substances established by the German regulation DGGT (1994).

Claudio Fernando Mahler, Professor, DSc., Laboratório de Geotecnia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil. e-mails: mahler@coc.ufrj.br and cfmahler@yahoo.com.br.
Ronaldo Luis dos Santos Izzo, D.Sc., Laboratório de Geotecnia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil. e-mail: ronaldoizzo@gmail.com..
André Vinicius Azevedo Borgatto, M.Sc., PhD. Student, Laboratório de Geotecnia, Universidade Federal do Rio de Janeiro, Rio de Janeiro, RJ, Brazil. e-mail: aborgatto@gmail.com.
Submitted on December 13, 2007; Final Acceptance on July 2, 2008; Discussion open until April 30, 2009.

2.2.1. Water content

Upon collection, the buckets were weighed and then taken to the selection table for separation. After that the waste was placed in trays that were taken to the oven, staying there at a temperature of 70 ºC for a period of time varying between 48 h and 72 h.

The water content of the samples was determined using this procedure. The water content was determined for each group of substance.

2.2.2. Segregation into substance groups

Segregation into groups of substances consists of separating the MSW samples as defined in German recommendation DGGT (1994). These are separated so that each group of substances has characteristics of similar materials with regard to mechanical behaviour and biochemistry stability. The groups of substances are:

• Large pieces: large waste substances, consisting of miscellaneous components, such as mobiles, mattress, etc;

• Paper/cardboard: waste substances basically consisting of paper or paper-like fibres, such as cardboard, paper packing, carpets, diapers, etc;

• Soft plastics: waste consisting basically of soft synthetic substances or with similar characteristics, such as soft plastic packing, plastic film, textiles, soft rubber, soft leather, etc.;

• Hard plastics: waste comprising basically hard synthetic substances, such as rigid plastic packing, PET bottles, rigid plastics, rigid leather, hard rubber, etc;

• Metals: ferrous metal and non-ferrous metal;

• Minerals: waste basically consisting of mineral substances or that has similar mechanical or biological behaviour (inert), such as glass, ceramic, soil, etc;

• Wood;

• Organic: waste that has natural origin, organic, *e.g.* vegetables, grass cuttings, plants, dry leaves, etc.

2.2.3. Morphological classification of the MSW

The morphological classification of MSW was based on the German recommendation DGGT (1994), intending to classify the waste with regard to its shape and size, according to relevant mechanical characteristics. Each group of substances was submitted to this geometric description considering the parameters observed in Fig. 1.

The MSW was also classified according to piece size. The fraction over 120 mm was visually separated and again visually separated into 500 mm and 1000 mm sizes. The remaining fraction was sieved according to the proceeding adopted for soils in accordance with the Brazilian technical regulation NBR-7181. Two sieves - 40 and 8 mm mesh - for large dimensions were used first. The fraction that passed was sieved into seven different diameter sizes in mm (38.1, 25.4, 19.05, 9.52, 4.75, 2.36 and 2).

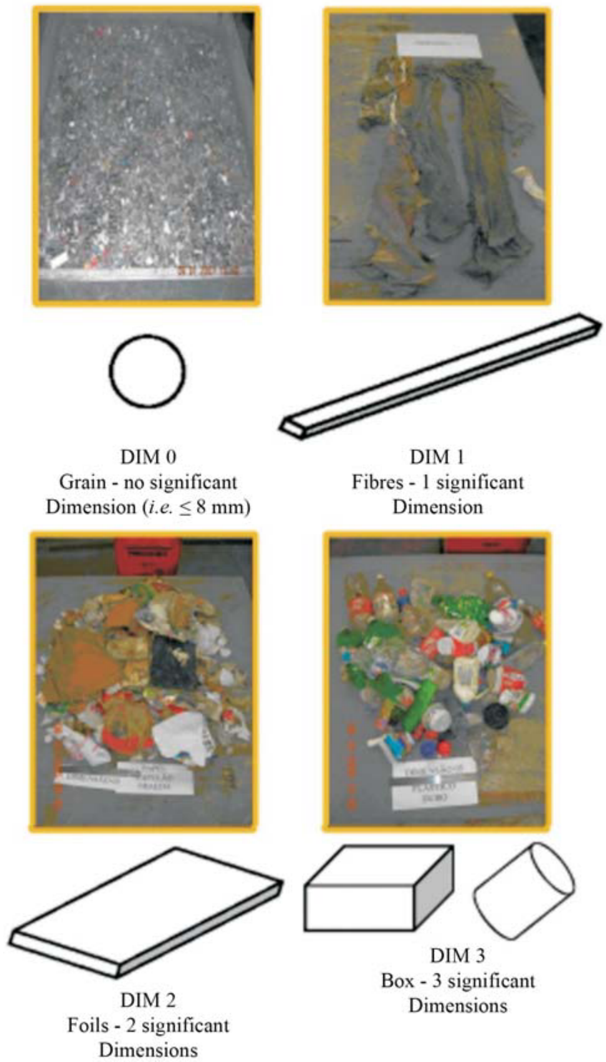

Figure 1 - Parameters considered in the morphological classification of the MSW.

3. Results

3.1. Classification into groups of substances

The values of the Classification into groups of substances are given in percentages of the total mass related to dry weight. The results are presented in Fig. 2.

3.2. Classification according to morphology

As described earlier, the classification according to the morphology is a combination of sieving and description of geometrical dimensions. The morphological classification of the substance groups is shown in Fig. 3. The results are also given in relation to the total dry mass of the sample.

For waste mechanics, in relation to the increases of shear strength, the percentage of fibre materials with dimension 1 and 2 (see Fig. 1) are more interesting because of the generated reinforcement. In analogy with reinforced

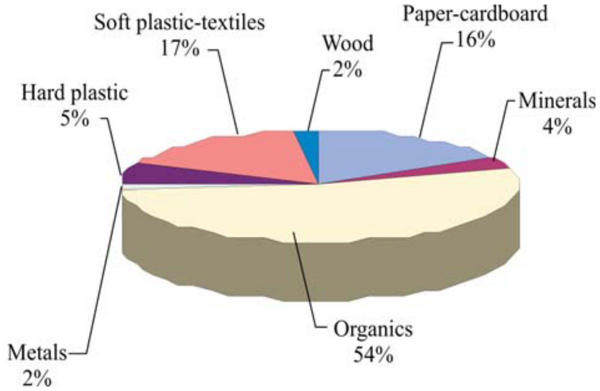

Figure 2 - Groups of MSW substances analysed.

soils, fibre concentration in the mass influences the gain in reinforcement.

In the soft plastics group it was found that the material with dimension 2 consists mostly (~76%) of plastic bags, plastic packing, textiles, and so on.

In the paper and cardboard group, dimension 2 comprises sheets of paper, cardboard, newspaper, crushed Tetra Pak type cartons, etc. (~65%). Dimension 3 consists of cardboard boxes, packing and other materials. One important point to be noted is that materials comprising the "dimension 3" group can, inside the landfill body, become dimension 2 materials because of crushing due to loading.

In the hard plastics group, the high percentage of dimension 3 is explained by materials such as PET bottles, different types of plastic packings, etc.

Again, as in the hard plastics group, the metal group shows a high percentage of dimension 3 materials, which is explained by the presence of food cans, vegetal oil cans, drink cans, etc.

The mineral group presented materials with dimension 0, such as small pieces of pottery and glass. The percentage of dimension 3 is represented in its majority by glass recipients.

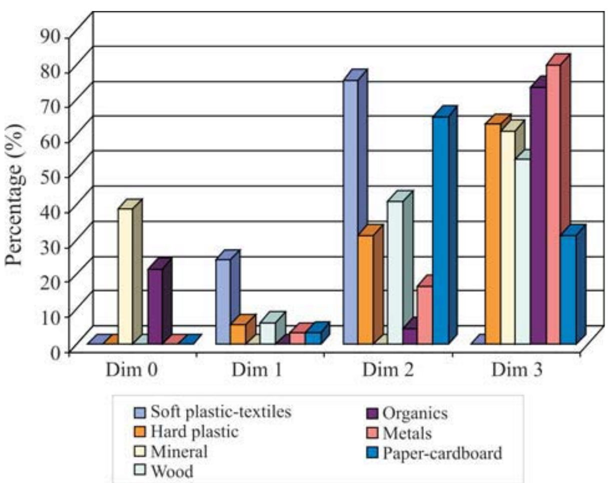

Figure 3 - Morphological classification of the MSW substances groups under study.

The wood group included materials such as wood veneers (dimension 2), boxes and crates (dimension 3).

The organic group includes remains of food and organics in general that, depending on their shape and size, were placed in group 0 and 3. The high percentage of dimension 3 is explained by the presence of bulky materials such as coconuts, oranges, and so on. Fig. 4 shows the sum of the obtained results for all the groups of substances.

By visually analysing the sample, the fraction of more than 120 mm was separated into 120, 550 and 1000 mm sizes. The waste was then passed through the 40 and 8 mm sieves. The passing fraction was sieved using small diameter mesh sieves to complete the process. The fraction of each sieving process of the substance groups is indicated in Table 1.

The total percentage of each group of substances was calculated as a percentage of each size divided by the percentage of each group of substance present in the MSW sample.

4. Conclusions

Important information was obtained through the MSW morphological classification. This information is very valuable for waste mechanics as it depends on the dimension and size of the waste particles. These MSW characteristics can be incorporated in slope stability analyses in order to take into account the effect of fibre reinforcement. The concentration and sizes of the fibres are compatible with those in fibre-reinforced soil, in spite of the different mechanical behaviour between soil and MSW.

The fibre materials responsible for the reinforcement effect on the MSW shear strength (materials with dimensions 1 and 2) presented a value (33.84%) at the concentration level for fresh waste (>30%), inducing the viability of potential fibre reinforcement effects.

Practice shows that a landfill can collapse because of many reasons such as, for example, high pore pressures inside the mass, poor compaction, fire, or a new building operation in the landfill. This is why fibre reinforcement should be considered only for back calculations of existing slopes and rupture back analyses. The fibre effect, such as

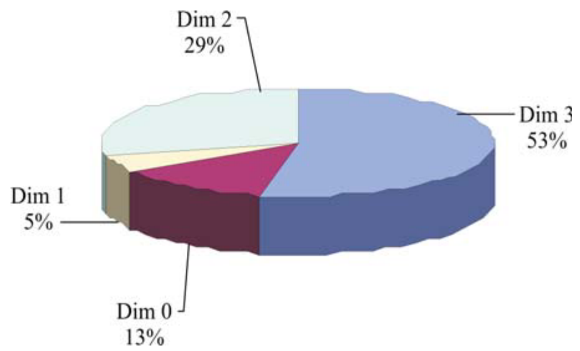

Figure 4 - Sum of results obtained from morphological classification of the studied MSW substance groups.

Table 1 - Results from the sieving process.

Group of subst.	Visual analysis			Sieves (% in retained weigh)							
	1000-500 mm	500-120 mm	120-40 mm	40 mm	8 mm	25.4 mm	19.05 mm	9.52 mm	4.75 mm	2.36 mm	2 mm
Paper cardboard	-	26.47	68.3	5.2	-	-	-	-	-	-	-
Soft plastic	23.57	41.43	34.13	0.9	-	-	-	-	-	-	-
Hard plastic	-	12.43	84.62	3	-	-	-	-	-	-	-
Metal	-	-	97.82	2.2	-	-	-	-	-	-	-
Mineral	-	24.56	31.78	10	6.9	4.8	3.6	5.7	3	5.8	3.5
Wood	-	10.12	76.34	14	-	-	-	-	-	-	-
Organic mater	0	0	21.45	17	12	6.9	9.4	7.7	8.3	8.5	8
Total (%)	4.12	13.09	36.66	11	7	4	5.3	4.4	4.7	4.9	4.5

suction in unsaturated soils, is an important characteristic of the waste. To plan new landfill areas and to use the maximum possible final slope this information should be used very carefully. For instance, in the event of internal combustion the fibre effect could be eliminated and the slope safety factor could decrease very quickly. Also, materials such as plastic, packing and textiles lose their tensile strength as time goes by at different velocities. At the same time they settle and have a higher specific weight leading to greater stability. This must be considered in the stability analysis. Therefore, the study of these phenomena can help in the near future towards a better understanding of the behaviour of the waste and to designing landfills with steeper slopes

Acknowledgments

The authors would like to thank Comlurb (Rio de Janeiro Urban Garbage Collection Company), CAPES, CNPq and DAAD for their continuous support. All authors would also like to thank Dr. Kai Munnich, Dr. Florian Kölsch and Prof. K. Fricke from TU Braunschweig for their help during this research.

References

Borgatto, A.V.A (2006) Study of the Fibre Effect and Morphology in the Stability of MSW Landfills. M.Sc. Dissertation, COPPE, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 157 pp. (in Portuguese).

DGGT, Deutsche Gesellschaft für Geotechnik (1994) Workgroup Recommendation of Waste and Landfill Geotechniques (Identification and Description of Waste) "Empfehlu ngen des Arbeittskreises "Geotechnik der Deponien und Altlasten". E 1-7: (Identifizierung und Beschreibung von Abfällen (Entwurf))." Bautechnik 71, Helf 9, Berlin. Wilhelm Ernst & Sohn.

DGGT, Deutsche Gesellschaft für Geotechnik (1994) Workgroup Recommendation of Waste and Landfill Geotechniques, Geotechnical Values for Solid Waste "Empfehlungen des Arbeittskreises, Geotechnik der Deponien und Altlasten - E 2-35: Geotechnische Kennwerte für Siedlungsabfälle", Bautechnik 71, Helf 9, Berlin. Wilhelm Ernst & Sohn.

Mahler, C.F. & Neto, A.L. (2006) Effect of fibres on shear strength on residue from mechanical-biological pretreatment of waste. International Journal of Environment and Waste, v. 1:1, p. 85-93.

ABNT (1984) Solo - Análise Granulométrica - Método de Ensaio, NBR 7181, 13 pp.