STUDY OF MATERIALS FOR USE IN THE BACKFILL OF REPOSITORIES

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ABSTRACT

Deposition is to put radioactive waste, without the intention of removing it, in a place built for this purpose, the repository. In its construction it is adopted the concept of multiple barriers, used to isolate the waste and prevent the migration of radionuclides to the environment. The backfill acts as a waterproof and radionuclide sorbing barrier. Clays are used on this layer due to having low hydraulic conductivity, and their capacity of sorbing radionuclides. The objectives of this research are to characterize Brazilian clays and to implement a database with information of suppliers and the results obtained in the tests that were done. Among these are: identification of mineral components, determination of the compaction curves, hydraulic conductivity, moisture and organic matter content, ion exchange capacity, specific surface, etc. Such information will allow the selection of the best among these materials for use in the backfill.

Key-words: Materials, Backfill, Repository.

INTRODUCTION

Deposition is to put radioactive waste, without the intention of removing it, in a place built for this purpose, the repository. In its construction it is adopted the concept of multiple barriers, used to isolate the waste and prevent the migration of radionuclides to the environment. The backfill acts mainly as a waterproof and radionuclide sorbing barrier [(1)].

The backfill must have a series of chemical and engineering properties so that it's use is effective [(2)]. Among the engineering characteristics are: ability to prevent the waste container from settling and moving, ability to conduct heat of decay away from the container, to provide a low permeability, to retain a high swelling potential and provide a high compaction efficiency. Among the chemical one's are: ability to delay the transport of nuclides and ability to keep the intruding water in a reduced condition (by not reacting with it).

Clays are materials which have been used in backfills. Such material fulfills well the requirement of the set of properties enounced above because it has got as its main components, sand and clay minerals. While sand is responsible for high thermal conductivity and mechanical resistance, the swelling properties, low permeability and the ability to sorb radionuclides are conferred by the clay minerals.

METHODS AND MATERIALS

This work was done in six steps: research of clays' characteristics and properties, the search for national clay suppliers, acquisition of samples from suppliers, the study of methods of characterization of samples, the characterization of samples and the development of a chart containing the obtained results.

Clays and other similar materials were obtained from several national suppliers, among producers, industrial and/or technological centers. On Table 1 are the names of the suppliers and the products, besides the identification code which they were given. Some of these materials do not have a code because this process was only adopted from a certain point at which, the material (without a code) was not to be tested anymore. To some others, their code was inferred from the most likely possibility, since the records were not precise.

Table 1. Clays and national suppliers

Clays	Suppliers
EPB 1 clay (ALI-E0005/06)	Aligra Ind. e Com. de Argila Ltda.
EPB 2 clay (ALI-E0006/06)	
Argel CN40 bentonite (BNT-E0007/06)	Bentonit União Nordeste Ind. e Com. Ltda.
Brasgel NT25 bentonite (BNT-E0008/06)	
Brasgel FF bentonite (BNT-E0009/06)	
Argel CN10 bentonite (BNT-E0010/06)	
Vermifloc 4B vermiculite (VFL-E0001)	Brasil Minérios Ltda.
Vermifloc vermiculite (VFL-E0002)	
Dolomil's calcic bentonite (DOL-E0001/06)	Dolomil Industrial Ltda.
Dolomil's sodic bentonite (DOL-E0002/06)	
Eucatex's average vermiculite (EUC-E0001)	Eucatex Química e Mineral Ltda.
Fundipol bentonite	Mineração Antônio Mendes
Inducal's brown clay (IND-E0001/06)	Inducal - Indústria de Calcários Caçapava
Inducal's gray clay (IND-E0002/06)	
Inducal's black clay (IND-E0003/06)	
Nigri's mesh 40 clay (NIG-E0001)	Joseph Nigri
Nigri's mesh 60 clay (NIG-E0002)*	
Paolo Comini's clay (PAC-E0001)	Paolo Comini
M.200 sodic bentonite (RBR-E0001/98)*	Refratários Brasil
M. 200 white bentonite (RBR-E0002/98)	
Pasek's dark clay (new) (PSK-E0001)	Refratários Pasek Ltda.
Pasek's bright clay (new) (PSK-E0002)*	
Pasek's Argiflex 100 clay (old)	
UBM's sodic bentonite (UBM-E0001/98)	União Brasileira de Mineração (Mineração Pedra Lavada)
Fine vermiculite (UBM-E0003/06)	
Superfine vermiculite (UBM-E0004/06)	
Raw vermiculite (MPL-E0005/07)	
Expanded vermiculite (MPL-E0006/07)	
Izo-Flok vermiculite	Vermiculita Isolantes Termo-Acústicos Ltda. (Mineração Phoenix Ltda.)

*. Most likely code that could be inferred.

After the determination of the mineral composition, only the minerals considered clays were selected for being tested, since it became clear that some of them were not. Furthermore, due to the fluctuation of the availability of several materials in the marked, it was decided to give a greater focus to the development of tests than to the elaboration of the database. Once the tests are set, the assembling of the database should be relatively fast.

Having as a reference the necessary feats for the backfill material the tests were elaborated so that one could quantify parameters which would place a sample as more qualified for such use than another. Besides the mineral composition determination are also: visual inspection, the particle size distribution determination, moisture content, compaction curve, organic matter content, cation exchange capacity, specific surface and specific mass determination. In the future, new tests will be implemented and old ones shall be modified, thus allowing the evaluation of the performance of such materials in different conditions.

Afterwards, the 'Overall Acceptable Zone' method shall be used to determine the compaction criteria of the chosen material in the backfill.

Visual inspection

The visual inspection should classify how rough the material is, its aspect and color. Is important for localizing or recognizing the material between others, saving effort and expenses.

Mineral composition

The mineral composition test returns an average of the principal components of the sample. It should be done before other tests, so that no tests are done on a material that cannot be used in the backfill. X ray diffraction was used for this test, which was done according to the 'powder method'.

Compaction curve

The compaction curve is determined for a soil under standard effort (standard proctor test), and at a variable moisture content. The result is the standard effort compaction curve, which is later used in the process of determining the backfill's compaction parameters by means of the 'Overall Acceptable Zone' method. Yet so, to relate the effort used and the results obtained (both from the compaction test) to the permeability values, one would need to dispose of some kind of molding press so that the dry density values could be achieved in the desired water content. This test was done according to a specific procedure [3].

Cation exchange capacity (CEC)

This parameter relates the amount of electrical charges a specific mass of the sample can retain adsorbed in its surface. This test was done according to a specific procedure [4].

Particle size

The particle size test returns the distribution of sizes of the soil sample. It is important to quantify the amount of fine particles in a sample, for this amount is directly connected to other soil properties, such as mechanical resistance, permeability, specific surface and cation exchange capacity. This test was done according to a specific procedure [5].

Moisture content

The moisture content of a soil is a parameter which shall always be used while comparing results in another test, for its direct influence in those (the compaction test, for example). This parameter is determined by means of a digital equipment, Mettler Toledo's Halogen Moisture Analyzer HG53.

Organic matter

The organic matter content is a parameter which affects others such as the mechanical resistance and thermal conductivity with the replacement of minerals by a softer, less heat conducting material (organic matter).

Specific surface

This parameter is also related to the amount of electrical charges a specific mass of the sample can retain adsorbed in its surface (it is therefore related to the CEC). Quantachrome's Autosorb Nova, model 1200, which uses the BET equation, was used.

Specific mass

The specific mass is a parameter needed to measure the degree of saturation of a soil which, in turn, is necessary to apply the 'Overall Acceptable Zone' method. This test was done based on the procedures by ASTM [6] and ABNT [7].

Sorption distribution coefficient (SDC)

This coefficient is another important parameter to estimate how a contamination plume migrates in soils (or how fast). It was determined for Cesium and Strontium cations, through the batch method in laboratory [8].

'Overall Acceptable Zone' method [9]

This method will provide guidance in choosing the best compaction criteria for the chosen material, so that the backfill has a low permeability, low shrinkage potential and a high mechanical resistance. Figure 1 presents a representation of the method. In a dry unit weight versus water content graph the acceptable zones for these three criteria are drawn. With the superposition of these zones the overall acceptable zone is then found. Depending on the system, other 'zones' may be drawn (to meet other criteria).

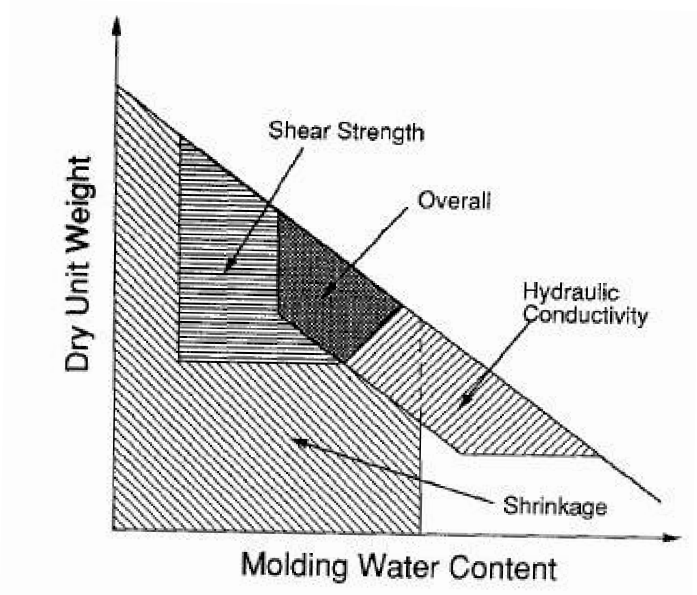

Figure 1. Acceptable zone based on the above specified criteria [9].

Permeability

The permeability test reveals how quickly fluids would percolate the sample material. A low value of permeability indicates a soil that can delay the transport of nuclides (which could happen through the permeation of water). This test is still to be implemented. It shall be done based on the procedure by ASTM [10].

Shrinkage due to drying

This test reveals how moist can the material be, for a specific dry density, so that it will not crack after drying. Its application is limited to clayey, plastic soils, in which the appearance of cracks after being dried (that can elevate the permeability considerably) is common. This test is still to be implemented.

Thermal conductivity

This parameter relates how effective the material can be in dissipating the heat of decay, keeping low temperatures around the waste container and avoiding the formation of convection profiles. This test is still to be implemented.

Mechanical resistance

This parameter displays how good a soil can be in resisting settlement and movement of its layers due to external forces, therefore keeping the waste container in place. This test is still to be implemented.

RESULTS AND DISCUSSION

In Table 2 are presented the results for some of the tests mentioned earlier for one clay, among other data which are also available in the bigger database from which the table was created. It was decided that the complete database should not be presented but instead only a sample of it, for the main focus of this research is, for now, to determine and implement the tests that will compose the basis for choosing the best material among the ones available in the national market.

Table 2. Available info on Brasgel FF Bentonite

Clay	Brasgel FF bentonite (BNT-E0009/06)	Brasgel bentonite (hangar)
Supplier	Bentonit União Nordeste Ind. e Com. Ltda.	
Place where it is stored	LABCIM	SEGRE's hangar
Amount (kg)	1.3	~200
Color	Pale-brown	
Particle Size (µm)	100% < 212 / 55% < 38	
Predominant Mineral	Bentonite (>40%)	
Moisture (w/w %)	12.0±0.1	
Specific Mass (g/cm^3)	2.79±0.05	
Organic Matter Content (w/w %)	2.2±0.1	
CEC (meq/100 g)	80	
Specific Surface (m^2/g)	75.7	
pH	10.4	
Observations	Old 'Brasgel bentonite' (BRG-E0001)	Same as 'Brasgel FF bentonite' (BNT-E0009/06)

On Figures 3.a and 3.b are the results for the compaction and the specific mass tests. One can see that the amount of energy used in the standard effort compaction test is insufficient to produce soils with high dry density, for the great distance of the compaction curve produced in such test to the curve that represents the saturated soil (Figure 3.b, yellow triangles).

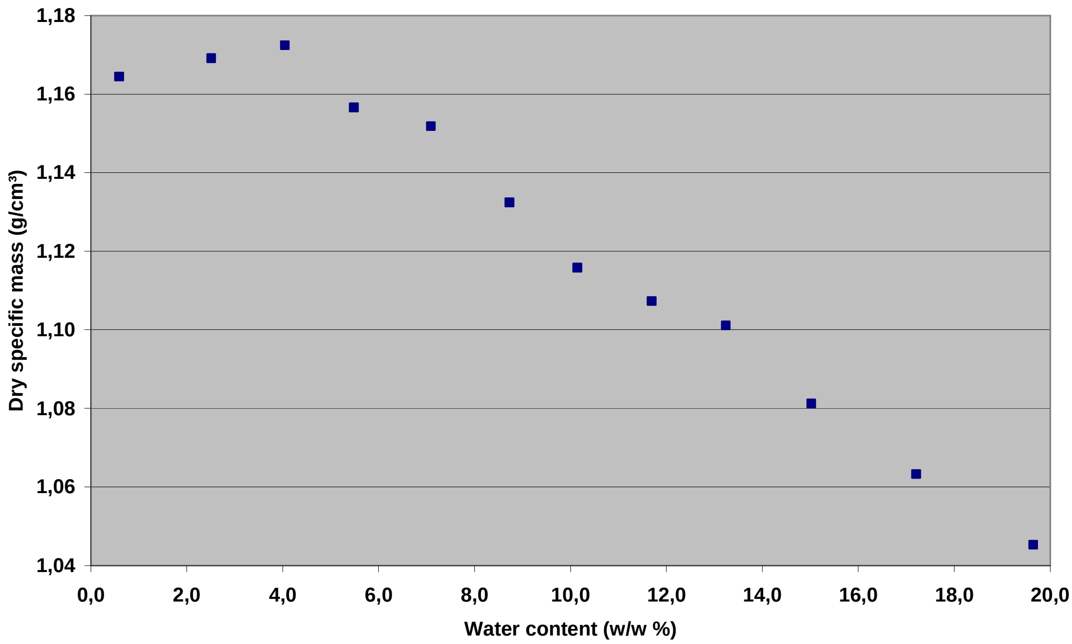

Figure 3.a. Brasgel FF bentonite compaction curve (standard effort).

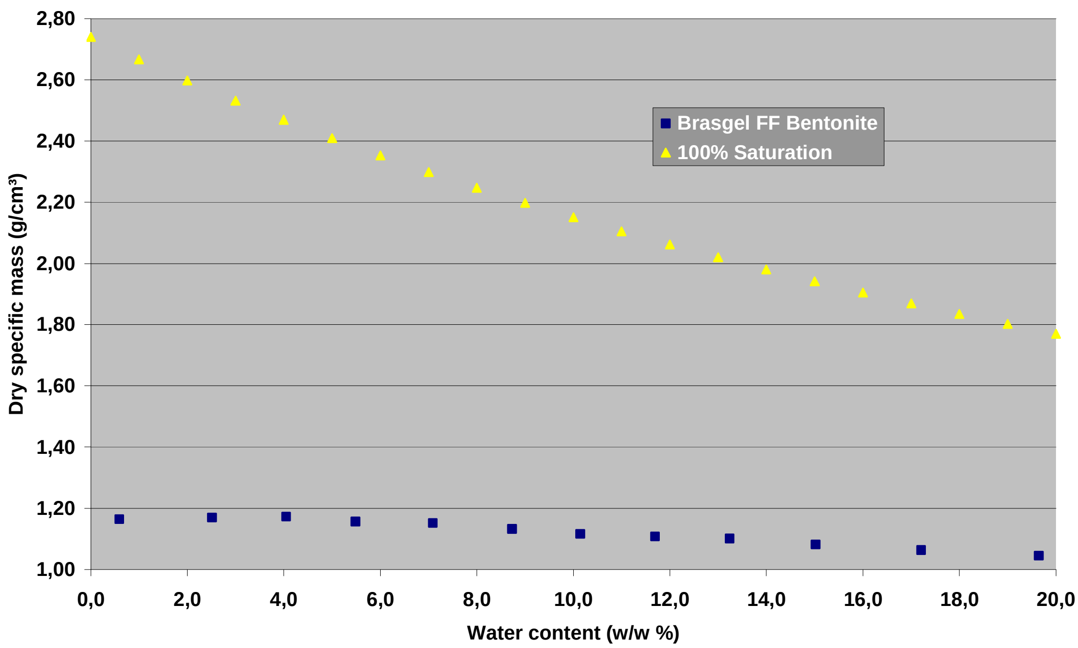

Figure 3.b. Brasgel FF bentonite compaction and 100% saturation curves.

Because the results of the permeability tests can be predicted based on the specimen saturation, it is likely that the specimens produced under such circumstances (standard effort) will not have a sufficiently low permeability value. It is necessary to implement compaction tests with efforts bigger than standard, so that one would achieve such requirement. By doing so it will also be possible to estimate how much energy would be necessary to make a soil as compacted as desired (depending on its water content).

CONCLUSION

The objective of this project is to assemble a database with complete information on Brazilian clays, presenting their physical and chemical properties, along with their suppliers. For the moment, emphasis will be given to the tests for characterization of the backfill's candidate material, for the lack of work force to assist in the realization of tests other than the ones that were considered necessary. Another reason is that there has also been a problem with the availability of materials and suppliers in the market.

Up to now, ten tests have been established: visual inspection, mineral composition determination, compaction curve determination, CEC, particle size, moisture content, organic matter content, specific surface, specific mass and SDC. Five more are to be implemented soon: permeability, shrinkage due to drying, thermal conductivity, mechanical resistance and greater effort compaction tests, with one of them having already been under development (permeability test). In the future, the data returned by these tests will allow the choice of the best material for use in the repository's backfill and in other many applications as well.

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ESTUDO DE MATERIAIS PARA USO EM CAMADA DE RECHEIO EM REPOSITÓRIOS

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RESUMO

Deposição é a colocação de rejeito radioativo, sem a intenção de removê-lo, em local construído para este fim, o repositório. Na sua construção adota-se o conceito de múltiplas barreiras, utilizadas para isolar o rejeito e prevenir a migração dos radionuclídeos para o meio ambiente. A camada de recheio age como uma barreira impermeável e sorvedora de radionuclídeos. As argilas são utilizadas nesta camada, devido a sua capacidade de sorção de radionuclídeos e baixa condutividade hidráulica. Os objetivos desta pesquisa são caracterizar argilas nacionais e implantar um banco de dados com informações dos fornecedores de argilas e resultados obtidos nos testes realizados. Dentre eles citam-se: identificação dos constituintes minerais, determinação da curva compactação em função da umidade, condutividade hidráulica, teor de umidade, teor de matéria orgânica, capacidade de troca catiônica, superfície específica, etc. Tais informações possibilitarão selecionar entre estes materiais o melhor para utilização na camada de recheio.

Palavras-chave: Materiais, Camada, Recheio, Repositório.