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# THE EFFECT OF COMPRESSION TECHNIQUE IN SOLID WASTE LANDFILL SYSTEMS

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**Abstract :** One of the biggest problem of the last century in the world is the elimination of solid wastes resulted from the unconscious consumption of the increasing population. Maintaining imperviousness in prepared storage area is a condition in order that waste leachate isn't mixed up with ground water and surface waters and can't harm the human health, animal health and vegetation in Solid Waste Landfill areas.

**Key Words :** Solid Waste, Solid Waste Landfill Area, Clay, İmperviousness.

# KATI ATIK DÜZENLİ DEPOLAMA SİSTEMLERİNDE SIKIŞTIRMA TEKNİĞİNİN ETKİSİ

**Özet:** Dünyada son yüzyılın en büyük sorunlarından biri hızla artan nüfüsun biliçsiz tüketiminin nihai sonucunda oluşan katı atıkların bertaraf olmuştur. Katı Atık Düzenli Depolama alanlarında, çöp sızıntı suyunun yeraltı ve yüzey sularına karışmaması ve insan sağlığı, hayvan sağlığı ve bitki örtüsüne zarar vermemesi için, hazırlanan depolama alanında geçirimsizliğin iyi sağlanması şarttır.

**Anahtar kelimeler:** Kat atık, Katı atık düzenli depolama alanı, Kil, Geçirimsizlik.

## 1. INTRODUCTION

**Objective:** Developed countries increased the standards of waste storage in parallel with environmental conscious in contrast with used methods for maintaining imperviousness in Turkey and some other countries that transferred to solid waste landfill system lately. In the study, the clay which is the most important material used in maintaining imperviousness in regular solid waste landfill system is discussed.

**Tools and method:** 60 cm clay composing of two 30 cm layers was laid down and compressed after finding available clay in order to maintain imperviousness while making solid waste space in Turkey.

Some experiments were carried out on clays having different thickness by being constituted artificial landfill spaces and the most appropriate thickness was tried to be found.

The earth is continuously changing as a result of human activities for thousands of years. Humanity producing continuously, heading for new horizons, new geographies consume constantly and give form to niche which they are in interaction with.

Wastes that are the results of production and consumption chain come into prominence as a problem and an important part of our interaction with the environment. Millions of tons of wastes are left to environment and natural life is jeopardized.

The aim of building landfill spaces is to protect the quality of ground water and surface waters, to protect the air quality, to gain energy with systems intended for gas collecting, to use the landfill space effectively and long term, to evaluate the space after storage.

### 1.1. CLAY MINERALS

Clays which draw great interest with their physicochemical features are of great importance agriculturally and they constitute the foundation stone of agriculture sector (Işık, 1996).

Clay is a material which formed naturally, consisting of fine-grained minerals principally, being plastic when enough water is added and hardening with drying and firing.

The features of clay minerals are related to mineralogical, chemical and physical features such as surface area, surface load, cation exchange capacity, interaction with water, interaction with organic compounds directly or indirectly. Clay minerals direct many reactions in which they are involved in.

Clay minerals rank among the most complicated industry minerals in composition and classification terms.

Clay minerals are classified as below (Işık, 1996);

1. Types of layer
2. Kinds of intermediate material
3. Layer load
4. Cation contents in Oktahedral layer

They were composed of decomposition and low degree hot water operations as a result of change of clay minerals' aluminum silicate. This information was gained from geological relations but the details of changing operations are indefinite. Clay minerals develop with slowly developing reactions, oxides of elements constituting clays or solutions of these elements only under the condition of high temperature.

Clay minerals are generally composed in 5 environments.

- Decomposition environment
- Sedimentation environment
- Embedding environment
- Digenesis environment
- Hydrothermal alteration environment

The clays used in solid waste storages have high plasticity due to the low permeability features. When the study results of Yılmaz and colleagues and studies in literature are analyzed (Petrov et al., 1997; Jo et al., 2001; Ruhl et al., 1997) it is seen that these clays are affected from (class CH) chemicals substantially and some great changes in permeability coefficients occur as a result of this exposure.

## 1.2. FACTORS AFFECTING THE IMPERMEABILITY

Permeability (K)

Permeability is the ability of a fluid to get through the hollow environment.

$$K = \frac{Q}{(i * A)}$$

Factors affecting the impermeability;

- Harmful and chemical materials of leachate waters
- The feature of clay
- The feature of compression
- Humidity
- Porosity

Permeability is the feature of grounds which changes in wide ranges, there are many factors in question which may affect reliability during the laboratory measurements.

## 1.3. EXPERIMENTAL STUDY

It was concluded that all packings (clay etc.) whose permeability is $1.10^{-7}$ cm/sec or having less hydraulic conductivity can be used as impermeable layer material in formation of regular storage area in all implementations and in all scientific studies which were carried out until today (Sarıkayaklı, 2003; Mollamahmutoğlu, 2004; Köseoğlu, 1998; Cope et al., 1984; Bouzza, 2002). 60 cm clay composing of two 30 cm layers are used in solid waste landfill areas, but it isn't said that why this thickness is 60 cm or how much clay thickness must be exactly.

The objective of this study is carrying out experiments on clays having different thickness by creating artificial landfill spaces and determining the clay thickness which must be used in solid waste landfill areas.

The permeability of clay which will be used in the study must be $1x10^{-7}$ or less hydraulic conductivity is necessary and foreign substance (plant root etc.) shouldn't be included in it.

### 1.1.1. Methods of the Study

Clay material whose permeability is $1.10^{-7}$ cm/sec or less was put on an apparatus which was prepared and brought to laboratory in different level of thickness (20 cm, 40 cm, 60 cm, 80 cm) and it was compressed by carrying out the necessary experiments in the laboratory within the scope of this study. Clay material in the sacks provided by İSTAÇ INC. was firstly dried under the pipes of combustion plants at 1200 $^{o}$C degree and then big and hard coagulated parts of material was grounded by caterpillars. Floccules were pulverized by being hammered with the help of wooden planks. Solid waste leachate which will be poured on the clay was provided from the solid waste leachate pool of İstanbul Metropolitan Municipality İSTAÇ INC. Provided leachate was brought into the laboratory in a closed plastic can without being changed the features and the changes which may occur was observed by pouring them on the apparatuses.

The miniature area apparatus which will be used is made from glass if possible and its dimensions were 80x120 cm and its depth was kept at 1 meter. It was decided that the areas must be made from the glass with the purpose of observing the changes in miniature areas. The length of miniature glass areas were adjusted as 40-60-80-100 cm respectively because the clay thickness was at the level of 20-40-60-80 cm and water level was 20 cm in the experiments carried out. But base measures of all areas were adjusted as 40x60 cm equally. Besides, holes were made which can drain the water that may occur in the bases of all areas.

Compression was made with wooden hammers in every 10 cm with the purpose of doing compression well. 20 cm clay material was put into first tube, 40 cm into second tube, 60 cm into third tube and 80 cm into fourth tube and they were well compressed.

Storage base impermeability is the most important phase geotechnically to control the leachate arising from the storage systematically. Finding the clay soils easily makes the implementation of impermeability layer widespread. The most important factor which affects the permeability of clay soils is compression technique.

### 1.3.2. Permeability Tests

Because one of the most important features of clays in solid waste landfill areas is compression, these clays having different features were experimented by changing the density of compression. In other words, different permeability values of less compressed, medium-range compressed and well compressed clays were determined. Samples were subjected to both distilled water and waste leachate, permeability variability of distilled water and waste leachate on clay was ascertained during these tests.

9 tests were carried out at this phase; the tests in question consist of 3 phases. First 2 phases were carried out on high plasticity clays, distilled water was used in the first phase, and waste leachate was used in the second phase.

**First phase:** 3 tests were carried out on high plasticity clay by using distilled water with the purpose of showing the relation between compression and permeability. Tests were carried out on;

1. Less compressed clay ( compressed with 5 blows in standard proctor)
2. Medium-range compressed clay (compressed with 15 blows)
3. Well compressed clay (compressed with 25 blows). Permeability values as a result of these 3 tests were transmitted to table. After then, it was mentioned about the second phase to be able to see whether the same results could be obtained by being used the waste leachate on the same clay.

**Table 1. Finding the Permeability Values of High Plasticity Clays by Using Distilled Water (First Phase)**

| | 25 beats | (Fresh Water) | 15 beats | (Fresh Water) | 5 beats |
|---|---|---|---|---|---|
| Tool Number | 1 | | 2 | | 1 |
| Water Level in the beginning of the experiment (h1)cm | 100 | | 98 | | 100 |
| Cross-section of hardened glass tube (a) $cm^3$ | 0.5024 | | 0,5024 | | 0,5024 |
| Length of base which the water passes (L)cm | 11,1 | | 11,1 | | 11,1 |
| Floor area of base which the water passes (A)$cm^2$ | 80,67 | | 80,67 | | 80,67 |
| Date and time of adjustment | 15,1 | | 16 | | 16 |
| Date and time of First experiment | 15,1 | | 14 | | 10 |
| Duration of First experiment (t)sec | 86400 | | 79200 | | 64800 |
| Water level at the end of the First Experiment (h2)cm | 93 | | 83 | | 77 |
| Air temperature $C^0$ | 23 | | 23 | | 23 |
| Permeability coefficient for First Experiment (K) cm/sec | 2,52E-08 | | 6,30E-08 | | 1,21E-07 |
| Date and Time for final readout | 15,1 | | 14 | | 10 |
| Elapsed time for final readout sec | 86400 | | 79200 | | 64800 |
| Final readout fall cm | 11,1 | | 11,1 | | 11,1 |
| Air Temperature $C^0$ | 23 | | 23 | | 23 |
| Permeability coefficient of final readout (K) cm/sec | 9,08E-09 | | 9,91E-08 | | 1,21E-08 |
| Average permeability coefficient (K) cm/sec | 1,72E-08 | | 3,64E-08 | | 6,66E-08 |

**Second phase:** 3 tests were carried out on waste leachate and high plasticity clay.

1. Less compressed clay ( compressed with 5 blows in standard proctor)
2. Medium-range compressed clay (compressed with 15 blows)
3. Well compressed clay (compressed with 25 blows). Permeability values as a result of these 3 tests were transmitted to table. These were shown with graphics with the purpose of evaluating the results of first and second phase better.

**Table 2. Finding the Permeability Values of High Plasticity Clays by Using Waste Leachate (Second Phase)**

| | 25 beats | (Fresh Water) | 15 beats | (Fresh Water) | 5 beats |
|---|---|---|---|---|---|
| Tool number | 1 | | 2 | | 1 |
| Water Level in the beginning of the experiment (h1) cm | 99 | | 100 | | 100 |
| Cross-section of hardened glass tube (a) $cm^3$ | 0,5024 | | 0,5024 | | 0,5024 |
| Length of base which the water passes (L)cm | 11,1 | | 11,1 | | 11,1 |
| Floor area of base which the water passes (A)$cm^2$ | 80,67 | | 80,67 | | 80,67 |
| Date and time of adjustment | 9 | | 10 | | 15 |
| Date and time of First experiment | 20 | | 16 | | 19 |
| Duration of First experiment (t)sn | 126000 | | 115200 | | 100800 |
| Water level at the end of the First Experiment ($h^2$)cm | 90 | | 89 | | 80 |
| Air temperature $C^0$ | 23 | | 23 | | 23 |
| Permeability coefficient for First Experiment (K) cm/sn | 2,27E-08 | | 3,04E-08 | | 6,65E-08 |
| Date and Time for final readout | 20 | | 18 | | 19 |
| Elapsed time for final readout sn | 126000 | | 115200 | | 100800 |
| Final readout fall cm | 11,1 | | 11,1 | | 11,1 |
| Air Temperature $C^0$ | 23 | | 23 | | 23 |
| Permeability coefficient of final readout (K) cm/sn | 6,23E-09 | | 6,81E-09 | | 7,79E-09 |
| Average permeability coefficient (K) cm/sn | 1,45E-08 | | 1,86E-08 | | 3,71E-08 |

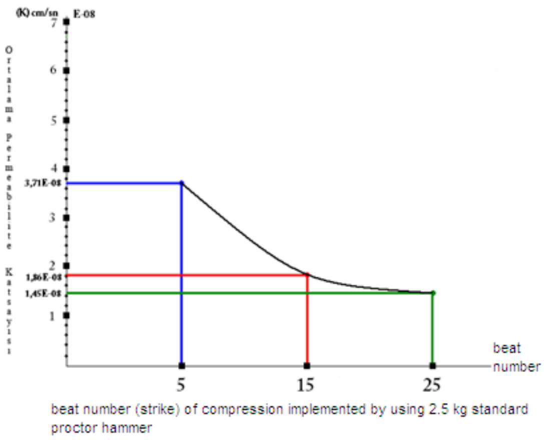


**Figure 1.** Permeability Experiment Graphic Carried out on Waste Leachate and High Plasticity Clay

**Third Phase:** 3 tests were carried out on clay samples that are low plasticity and including the coarse grained such as hoggin and permeability results were shown in the table. Here the aim is to determine that what kind of a permeability value we can reach in case of clays' not having the appropriate features.

Tests were carried out on;

1. Less compressed clay (compressed with 5 blows in standard proctor)
2. Medium-range compressed clay (compressed with 15 blows)
3. Well compressed clay (compressed with 25 blows). Permeability values as a result of these 3 tests were shown in the table below.

**Table 3. Finding the Permeability Values of Low Plasticity (with hoggin) Clays by Using Distilled Water**

| | 25 beats | (Fresh Water) | 15 beats | (Fresh Water) | 5 beats |
|---|---|---|---|---|---|
| Tool Number | 1 | | 2 | | 1 |
| Water Level in the beginning of the experiment (h1) cm | 100 | | 98 | | 100 |
| Cross-section of hardened glass tube (a) $cm^3$ | 0,5024 | | 0,5024 | | 0,5024 |
| Length of base which the water passes (L)cm | 11,1 | | 11,1 | | 11,1 |
| Floor area of base which the water passes (A)$cm^2$ | 80,67 | | 80,67 | | 80,67 |
| Date and time of adjustment | 14 | | 15 | | 16 |
| Date and time of First experiment | 14,3 | | 15,2 | | 16,17 |
| Duration of First experiment (t)sec | 1800 | | 1200 | | 1020 |
| Water level at the end of the First Experiment ($h^2$)cm | 77 | | 73 | | 70 |
| Air temperature $C^0$ | 23 | | 23 | | 23 |
| Permeability coefficient for First Experiment (K) cm/sn | 4,36E-06 | | 7,37E-06 | | 1,05E-05 |
| Date and Time for final readout | 14,3 | | 15,2 | | 16,27 |
| Elapsed time for final readout sec | 1800 | | 1200 | | 1020 |
| Final readout fall cm | 11,1 | | 11,1 | | 11,1 |
| Air temperature $C^0$ | 23 | | 23 | | 23 |
| Permeability coefficient of final readout (K) cm/sec | 4,36E-07 | | 6,54E-07 | | 7,70E-07 |
| Average permeability coefficient (K) cm/sec | 2,40E-06 | | 4,01E-06 | | 5,63E-06 |

### 1.4. INTERPRETATION OF PERMEABILITY TESTS

The results from the 3 phased 9 falling head permeability tests carried out by using distilled water and waste leachate on high plasticity clays and low plasticity clays are like below:

1. The permeability of clay which was compressed with 25 beats in standard proctor is 5 and in a better condition than the clays which were compressed with 15 beats. Accordingly, the compression should be made most properly in order to maintain permeability in solid waste landfill areas.
2. It was determined that high plasticity clays provided better permeability than the low plasticity clays consisting of coarse-grained material such as sand.
3. It was determined that waste leachate provided better permeability in clays than distilled water. The reason for this is foreign and harmful matters and chemicals. These materials close the pores and they increase impermeability.

## CONCLUSION

Clay thickness which should be used in solid waste landfill areas was determined by carrying out the necessary tests on clays having different thicknesses with creating artificial landfill areas.

It was ascertained that one of the most important features of clay is compression in solid waste landfill areas and compression should be made most properly to maintain permeability.

High plasticity clays provided much better permeability than low plasticity clays which includes grits in it.

It was decided that waste leachate provided better permeability in clays than the distilled water.

Maintaining imperviousness in prepared storage area is a condition in order that waste leachate isn't mixed up with ground water and surface waters and can't harm the human health, animal health and vegetation in Solid Waste Landfill areas.

Scientific researches, studies and applications which were carried out about the usage of clay in prepared landfill areas showed that all packings whose permeability was $1.10^{-7}$ cm/sec or having less hydraulic conductivity could be used as impermeability material.

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