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EXTENDED ABSTRACT

Improvement of the Soil Clay at The Liner of The Landfill to Reduce Cracking Using Composite and Nano Materials

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1. Introduction

Increasing waste production due to population growth, improper waste disposal in landfills and spread of pollution caused is one of the most important environmental problems in urban areas. By special layers and coatings in the body and bottom liner, the penetration of toxic and dangerous leachate of waste into the surroundings is prevented. The cracks in the bottom layers of the landfill and expansion over time increases the permeability of the liner and accelerates the entry of the leachate of waste into the soil and groundwater. Hence, it is very important to adopt appropriate measures to prevent the creation of a network of cracks and the expansion in the liner of the landfill.

2. Methodology

In this study, focusing on the properties of Mashhad landfill and using laboratory methods, it has been attempted to improve the liners by adding polypropylene composite materials, micro-silica and nano silica. The soil clay type 1 is related to the soil around 9km from the main landfill of Mashhad, which is used as a clay depot for the Mashhad landfill. The soil clay type 2 is related to the soil of the main landfill of Mashhad. The soil clay type 3 as the selected soil is a combination of Montmorillonite (MMT) and kaolinite at a weight ratio of 3:1, respectively. First, the soil clay, water and composite materials mentioned were prepared for making the sample. These values were determined based on the results of the compaction test, the maximum dry weight, the optimal moisture content and the volume of the test box. The composite materials used in this study were prepared by dry mixing method and placed in the test box for compaction. To make reinforced samples, composite materials were added to the soil clay step by step and mixed. After preparing the samples, the test box was made for testing and photographing the samples. The test box should be such that the camera can be placed above the surface in order to take photos of the surface. The dimensions of the test box bed were 1m×60cm with a thickness of 30cm as shown in Fig. 1.

In order to evaluate the behavior of cracks and determine the properties of cracks such as crack width, photography and image processing methods have been used to measure and analyze changes in crack dimensions. The objective of this method is to provide an applicable method based on image processing, in order to identify and analyze the cracks in the clay in vitro.

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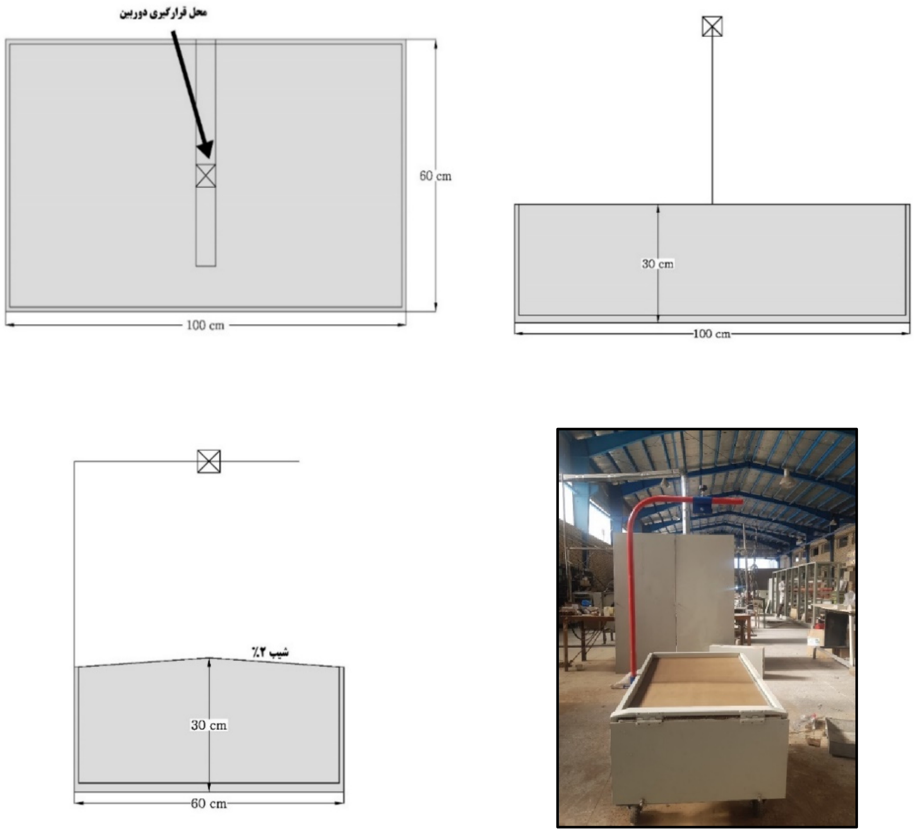

Fig. 1. The test box for evaluate of desiccation cracks by imaging processing method

LabView was used to identify the crack and determine the crack severity factor. This program is a graphical programming language that is used in many branches of engineering. The camera used to record images in this study is a canon camera with 18 megapixels accuracy, which is very fast and accurate. The camera is placed on the surface and immediately after preparation, the samples are photographed. After 24 hours, photography was done again to evaluate desiccation cracking.

3. Results and discussion

By performing tests and adding different percentages of the composite materials, the effect on the width of the cracks has been investigated. The crack width is shown by CW. The value of the average crack width on the surface is obtained from the sum of all the crack widths in the given area divided by the number of surface cracks, which is presented by Equation 1. Where W_{avg} shows the average crack width, W_{sum} shows the sum of all crack widths in the given area, and N_{seg} shows the number of surface cracks. The number of surface cracks is as the distance between two adjacent points or nodes which is defined in the software coding and the width of the crack is calculated.

$$W_{avg} = W_{sum} / N_{seg} \quad (1)$$

As shown in Fig. 2, for soil clay types 1 and 2 used in the landfill, by adding 20% micro-silica, the crack width reduced from 12 and 10mm to 2.02 and 3.26mm, respectively. For soil clay type 3, by adding 20% of micro-silica, the crack width reduced from 17mm to 12.6mm. Also, the results have been compared with the study results of Kalkan which are consistent with these results as shown in Fig. 2. According to the results, adding micro-silica or silica foam improved the soil clay and reduced desiccation cracking on the surface. The reason for the reduction in desiccation cracking when using micro-silica is that the non-plastic properties and pozzolanic nature of micro-silica improve the properties of the clay so that it reduces the dry-bulk density and increases the optimum moisture content of the clay.

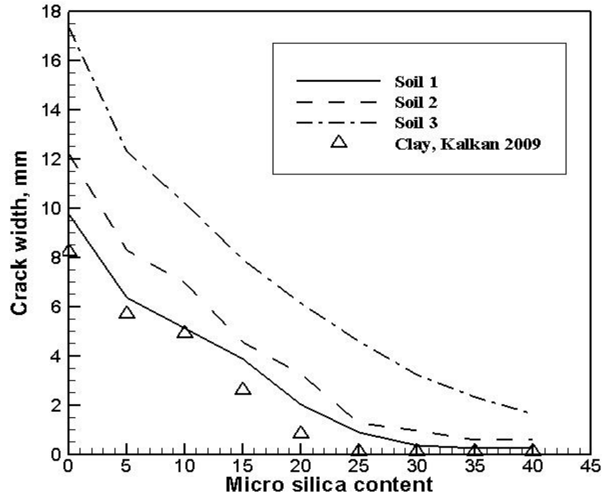

Fig. 2. The result of crack width vs micro silica content

As shown in Fig. 3, the changes in crack reduction in soil clay types 1, 2, and 3 and studies by Tang et al and Miller et al are presented in terms of different percentages and lengths of polypropylene fibers. As shown by increasing fibers the cracks on the surface of the sample are significantly reduced.

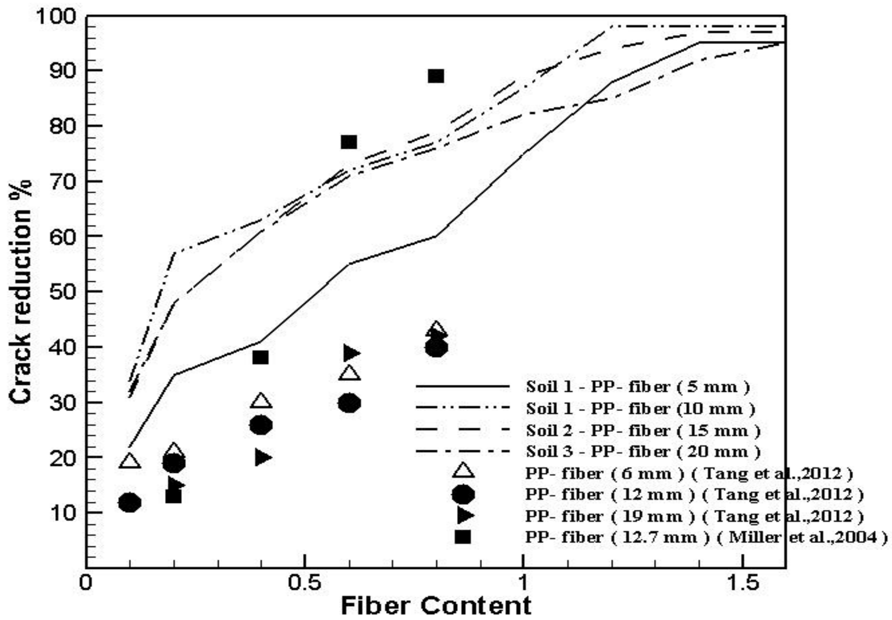

Fig. 3. The result of crack reduction vs fiber content

4. Conclusions

The results showed that by adding 0.8% of polypropylene, cracks in soil clay type 2 reduced by 81%, cracks in soil clay type 1 reduced by 71% and selected clay cracks reduced by 72%. Also, according to the results, by adding 20% micro-silica, cracks in in soil clay type 2 reduced by 83%, cracks in in soil clay type 1 reduced by 67%, and cracks in in soil clay type 3 reduced by 64%. Also, by adding about 10% of micro-silica the changes in crack width are significantly reduced by about 50%. According to the study results, it was found that adding the optimal amount of nano materials and the combination of polypropylene fiber and micro-silica had a significant effect on reducing the crack width of clay types 1 and 2 related to the clay of the landfill in Mashhad. Hence, it is necessary to improve the clay at the liner of this landfill.