CERUCUK
Volume 6 No. 7 2022 (469-480)

EFFECT OF MIXING METHOD OF MIXED PERMEABILITY *CLAYSTONE* AND *BENTONITE*

Tiara Putri Rahmayanti[1], Yulian Firmana Arifin[2]
Civil Engineering Department, Faculty of Engineering, Lambung Mangkurat University
Jl. A. Yani km. 35,8 Kalimantan Selatan, Indonesia
Phone. (0511)47738568-4781730 Fax.(0511)4781730
Email: tiaraputrirahmayanti@gmail.com[1], yulianfirmana2@gmail.com[2]

ABSTRACT

In geotechnical work, soil permeability is one of the important parameters in the manufacture of landfill. Permeability is a geometrical property of the soil that shows the ability of the soil to deliver certain substances through its pores. Based on the PUPR ministerial regulation (2009), the bottom layer of the landfill must be watertight so that leachate is prevented from seeping into the ground and does not contaminate ground water. Many techniques can be used to prevent the spread of leachate into the groundwater table. One of them is the construction of a *clay liner* with regard to the permeability coefficient value of the clay barrier itself. This study aims to analyze the effect of different mixing methods on the permeability coefficient of a mixture of *claystone* and *bentonite* compacted at high density as one of the recommended materialsas *clay liners*.

There are two mixing methods, namely (CS+AIR)+BN and (BN+AIR)+CS. Meanwhile, there are four kinds of mixed combinations based on bentonite content of 5%, 10%, 15%, and 20% based on dry weight with moisture content of 10%, 15%, and 20%. The sample was compacted to have a diameter of 6.34 cm and a height of 1 m with a dry volume weight of 1.8g/cm3. Samples were tested using the Falling Head Test method toobtain the coefficient of permeability.

Based on the research, it is recommended that the most ideal mixed method usedforlayers *clay liner* in landfill is to use the mixed method (CS+AIR)+BN. In general, ata dry volume weight of 1.8 g/cm^3, samples with a moisture content of 20% more produce a permeability that meets the requirements (that is, less than 1x10^{-7}cm/s) than samples with a moisture content of 10% and 15%. .

Keywords: Claystone, Clay Liner, Bentonite, Mineral Layer, Permeability Coefficient, High Density

1. INTRODUCTION

According to Astono et al. (2015), population growth and the progress of the economic level in a city are several factors that influence the increase in the amount of waste. An increase in the amount of waste will cause problems in the environment, if it is not accompanied by efforts to improve and improve the performance of the waste management system. The final process from which waste management comes from human activities is in the TPA (Final Waste Processing Site). Leachate seeping into the ground can contaminate the surrounding water bodies (Cumar and Nagaraja, 2010; Kale at al., 2009) which in turn will affect the living organisms that are exposed. This is a crucial reason for modeling leachate seepage where the misplacement of the landfill greatly affects the movement of leachate to the surroundings (Dang et al., 2009; Tsanis, et al., 2009). 2003; Young et al., 2003).

Soil permeability is one of the important parameters in making landfill. As reported by Lestari et al (2016) soil permeability means the ability of the soil to drain water through soil pores. Where the soil consists of solid particles in which there are pores around it. In general, soil pores are interconnected, which causes water to flow through these pores. Based on the PUPR ministerial regulation (2009), the bottom layer of the landfill must be waterproof so that it can prevent leachate from seeping into the ground so asnot to pollute ground water. The permeability coefficient of the landfill base layer should be less than 10-6 cm/s. Many techniques can be used to prevent the spread of leachate to the ground water surface.

In most concepts, materials such as bentonite are usually highly considered for use as a landfill cover material (Zhang, 2014). According to Widyananda et al (2020) bentonite is a clay material which is included in the mineral montmorillonite which is produced in the weathering process. The properties of bentonite, among others, have high absorption and are natural elements that are harmless and practical, making it an environmentally friendly technology that can be applied in constructing clay barriers on leachate pollutants.

According to the French concept (Andra 2005), the use of claystone produced from excavation is a profitable alternative as a cover material for radioactive waste mineral layers. Its use has many advantages, including chemical-mineralologic compatibility with the host rock, availability in sufficient quantities, low material preparation and transport costs, and the need to occupy the surface space used as backfill for excavated claystone. Based on this description, the use of claystone (CS) can be added with additional alternative materials that may be used, such as bentonite (BN) while maintaining the economic value of claystone itself. It is hoped that later on claystone is more difficult to pass water, so that it can be used as a mineral layer for landfill.

The bentonite mixture has an important role in increasing the density, if more than 20% the optimal water content will increase and the soil density will approach the density of pure bentonite (Arifin & Sambelum, 2018).

Claystone (claystone) based on Pettijohn (1975) is a plastic rock, composed of Hydrous Aluminum Silicate (2H2OAL2O3. 2SiO2) or clay minerals that have a fine grain size (claystone is a sedimentary rock with a grain size of less than 0.002 mm). At the Banjarbakula Regional TPA construction project site, quite a lot of claystone material was found, of which there were more than 8000 m3 of claystone (Noorsaly, 2018).

Based on previous research reported by Najmi (2021) it was found that only 37.5% of the total mixing methods met the requirements, therefore this study was conducted to analyze the effect of different mixing methods on the permeability coefficient of a mixture of claystone and bentonite compacted at a density tall.

2. THEORITICAL STUDY

Clay Stone

According to Ingram (1953) which states that claystone is a massive rock that contains clay in greater quantities than siltstone. Some experts (eg Shrock, 1948; Flawn, 1953) use the term claystone to name rocks that are less compact than shale.

Bentonite

According to Ruskandi et al (2020), bentoniteIt is a natural colloid derived from hydrated aluminum silicates. Bentonite has the ability to expand, ion exchange properties, large upper area and easily absorbs water, binders to foundry molding sand, raw material for making cement, ceramics, crayon cosmetics and become adsorbents, in the pharmaceutical field, and so on.

Mixture of Claystone and Bentonite

Zhixioang Zeng et al (2019) stated that a mixture of claystone and MX80/Callovo-Oxfordian (COx) bentonite has been proposed as a sealing or backfilling material in deep geological warehouses of radioactive waste in France. Crushed claystone resulting from excavation of repository openings has been investigated as a fill or seal material. Coarse-grained claystone can be used to fill repository openings and, in combination with bentonite, to seal boreholes, drifts and shafts. On the characterization of thethermo-hydro-mechanical properties of claystone. Compacted claystone-bentonitemixture, including mechanical compaction, gas and water permeability as a function of porosity, water retention and saturation,

Clay Liner

Clay liner is defined as a compacted layer of clay. The clay to be used as a liner must be made in such a way that it has a low permeability value. Therefore, the following things must be considered, including the percentage of clay content, grain size, plasticity, moisture content when compacted, the type of compacting tool, and the minimum thickness of the liner (EPA, 2000).

Soil Permeability

Permeability is defined as the property of a porous material that allows the circulation of seepage from a liquid in the form of water or oil flowing through the pore cavity. Soil pores are affiliated with each other, so that water can flow from points with high energy to points with lower energy (Hardiyatmo, 1992).

Properties Index Test

Properties index testing generally consists of testing water content, specific gravity, filter analysis, hydrometer analysis, and atterberg limit.

3. METHOD

This research will be carried out using primary data obtained from laboratory testing using materials, namely claystone and bentonite. The claystone material used was taken from the Pasir Mine, Cempaka, Banjarbaru using the direct extraction method and put into sacks. While the bentonite material was purchased separately. The flow of this research is as follows.`

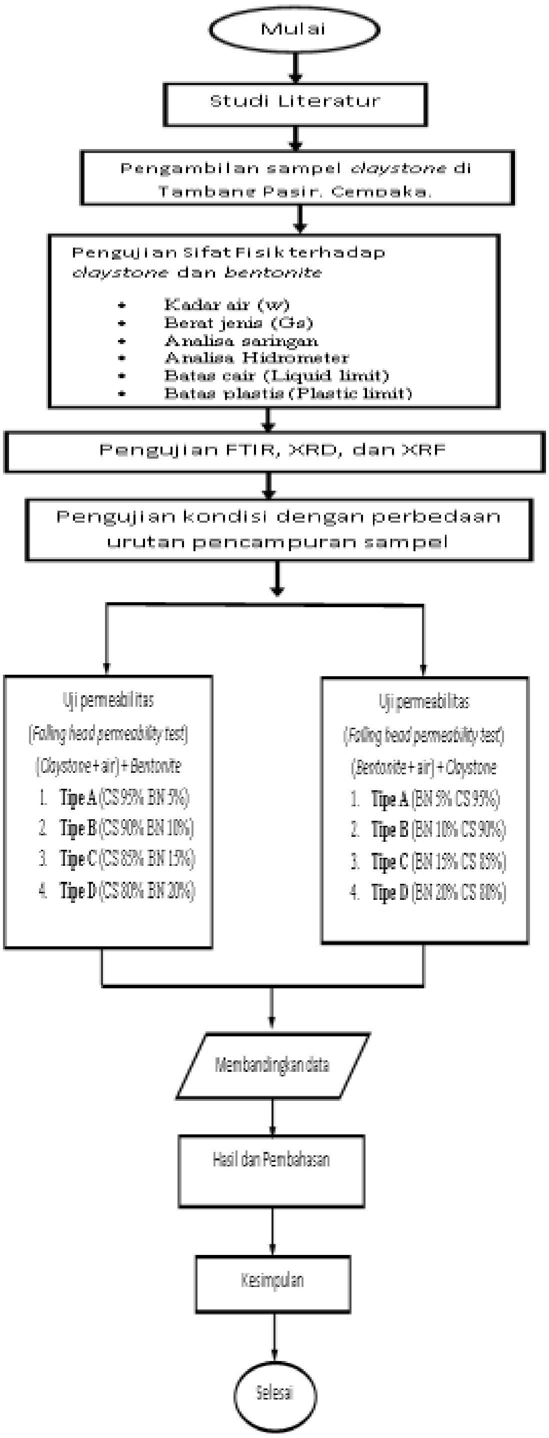

Figure 1. Research Flowchart

4. RESULT AND DISCUSSION

This chapter discusses the results of research conducted at the Soil Mechanics Laboratory, Faculty of Engineering, University of Lambung Mangkurat.

Comparison of 10% Water Content Permeability Coefficient Value

Based on the test with hourly decrease readings at 10% moisture content with variations in bentonite levels of 5%, 10%, 15%, and 20% for 5 hours, the permeability coefficient values were obtained as follows.

Table 1. Comparison of Permeability Coefficient Values with 10% Water Content at 5% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	8.890E-06	2.810E-06	2.010E-06	1.803E-06	1.689E-06
2	(BN+AIR)+CS	7.782E-07	1.160E-07	1.754E-07	1.335E-08	8.110E-08

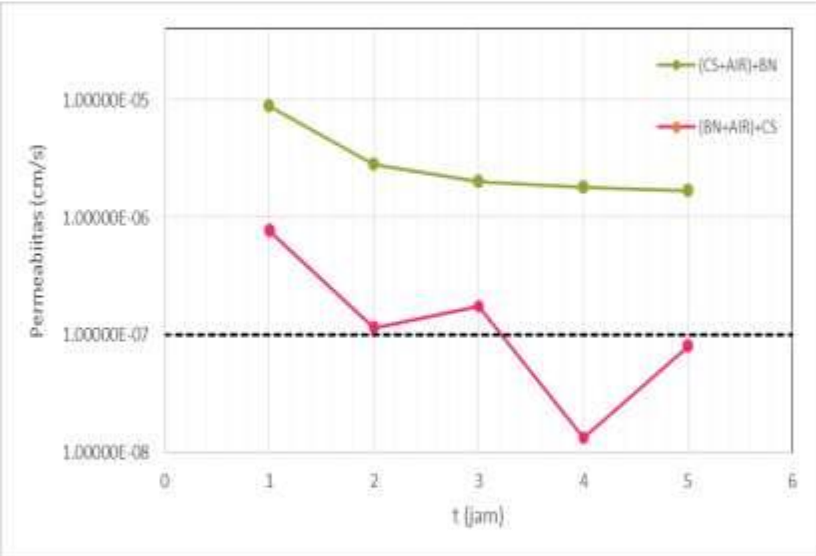

Figure 2. Graph of Comparison of Permeability Coefficient Values with 10% Moisture Content at 5% Bentonite Content

Table 2. Comparison of Permeability Coefficient Values with 10% Water Content at 10% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.842E-07	5.304E-08	3.556E-08	2.682E-08	2.158E-08
2	(BN+AIR)+CS	1.762E-07	5.070E-08	4.251E-08	1.281E-08	1.543E-08

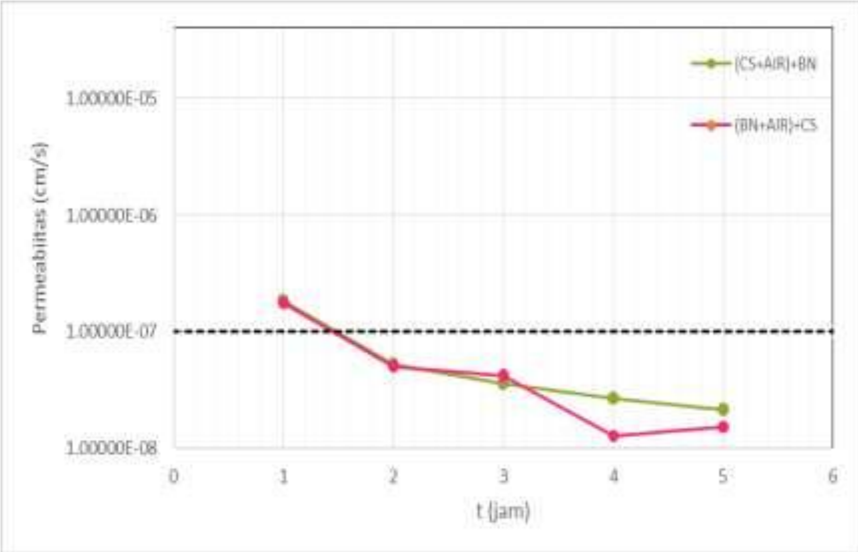

Figure 3. Graph of Comparison of Permeability Coefficient Values with 10% Moisture Content at 10% Bentonite Content

Table 3. Comparison of Permeability Coefficient Values with 10% Water Content at 15% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.887E-07	1.090E-07	6.427E-08	4.171E-08	4.495E-08
2	(BN+AIR)+CS	3.022E-07	1.297E-07	6.645E-08	8.546E-08	2.806E-08

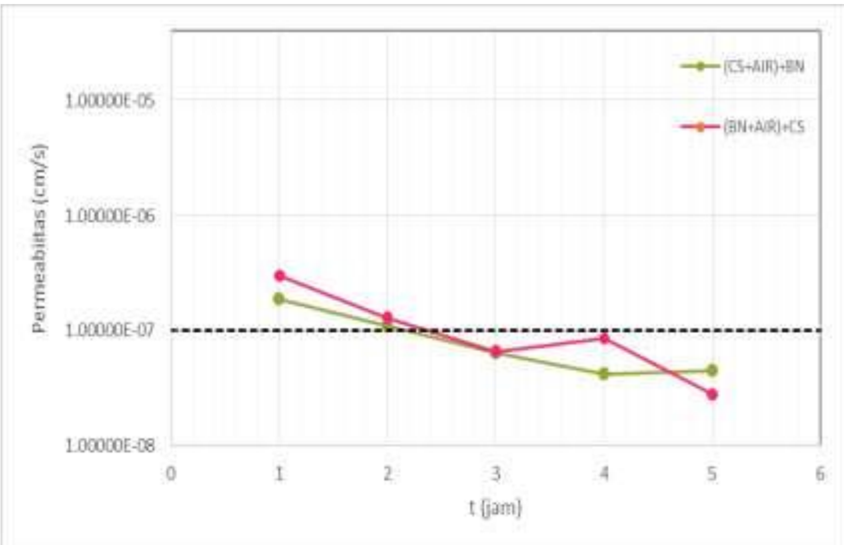

Figure 4. Comparison Graph of Permeability Coefficient Value with 10% Moisture Content at 15% Bentonite Content

Table 4. Comparison of Permeability Coefficient Values with 10% Water Content at 20% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.329E-07	2.671E-08	2.680E-08	2.019E-08	1.081E-08
2	(BN+AIR)+CS	4.816E-07	1.181E-07	7.114E-08	6.196E-08	4.787E-08

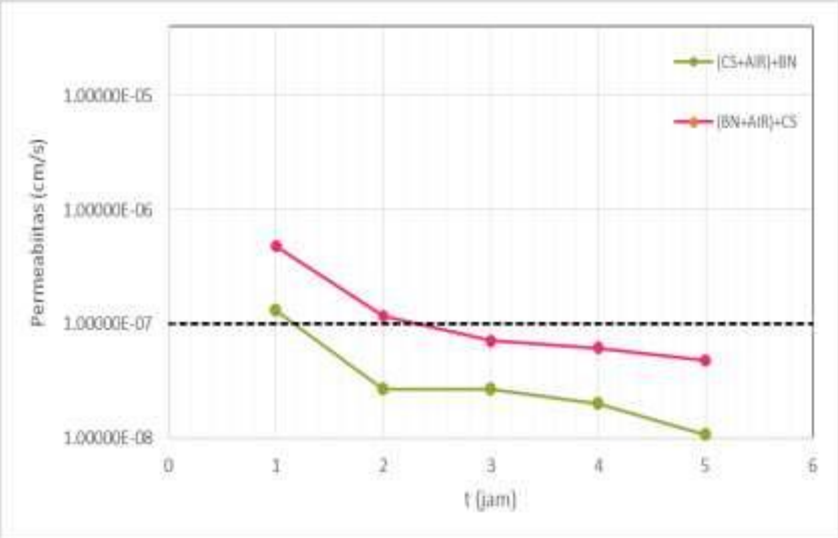

Figure 5. Graph of Comparison of Permeability Coefficient Values with 10% Moisture Content at 20% Bentonite Content

Table 1- 4 shows the comparison of 2 variations of mixing methods on the value of the permeability coefficient with dry volume weight 1.8 g/cm3 and using 10% moisture content and 5%, 10%, 15%, and 10% bentonite respectively, which are then plotted in the form of a graph shown in Figure 2-5.

Based on Figure 2-5, it can be seen that the permeability coefficient in the mixing method (CS+Air)+BN decreases with increasing time, except for the bentonite content of 20% when the 3 hour reading the permeability coefficient increases slightly. While inthe mixing method (BN+Air)+CS the permeability coefficient decreases consistently only at 20% bentonite content.

Comparison of Water Content Permeability Coefficient Value 15%

Based on the test with hourly decrease readings at 15% moisture content with variations in bentonite levels of 5%, 10%, 15%, and 20% for 5 hours, the permeability coefficient values were obtained as follows.

Table 5. Comparison of Permeability Coefficient Values with 15% Moisture Content at 5% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.064E-07	6.692E-08	4.493E-08	2.713E-08	3.279E-08
2	(BN+AIR)+CS	4.649E-07	2.241E-07	1.241E-07	1.097E-07	1.185E-08

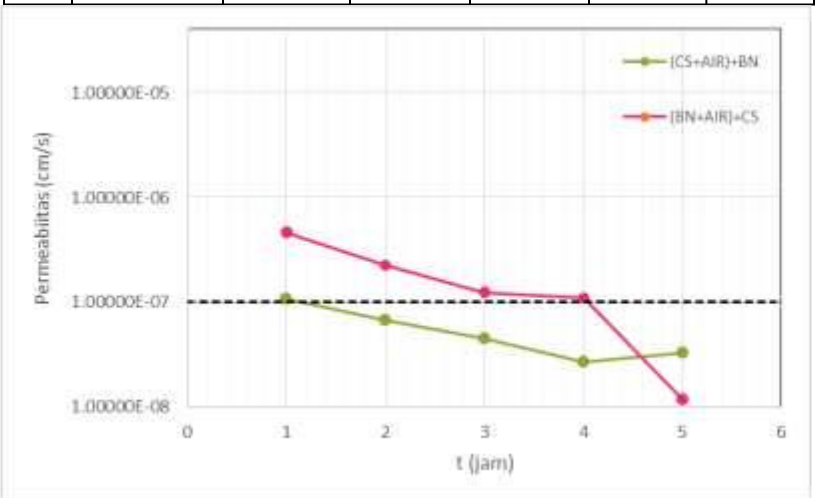

Figure 6. Graph of Comparison of Permeability Coefficient Values with 15% Moisture Content at 5% Bentonite Content

Table 6. Comparison of Permeability Coefficient Values with 15% Moisture Content at 10% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.842E-07	5.304E-08	3.556E-08	2.682E-08	2.158E-08
2	(BN+AIR)+CS	1.293E-07	6.508E-08	3.492E-08	3.295E-08	1.059E-08

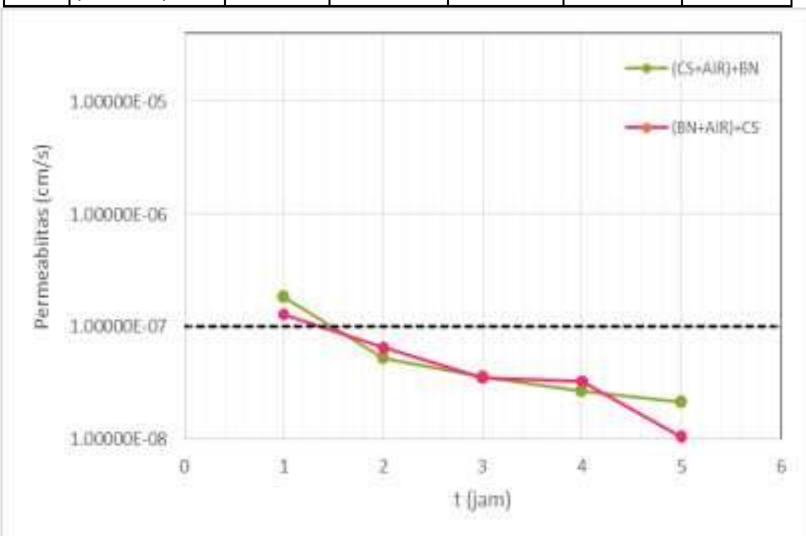

Figure 7. Graph of Comparison of Permeability Coefficient Values with 15% Moisture Content at 10% Bentonite Content

Table 7. Comparison of Permeability Coefficient Values with 15% Moisture Content at 15% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	2.957E-07	5.434E-08	2.731E-08	1.370E-08	1.099E-08
2	(BN+AIR)+CS	3.718E-07	1.896E-07	1.570E-07	1.064E-07	5.782E-08

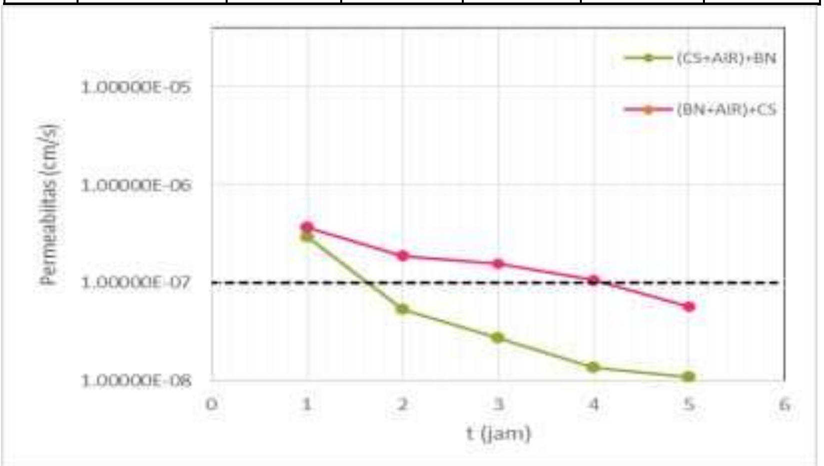

Figure 8. Graph of Comparison of Permeability Coefficient Values with 15% Moisture Content at 15% Bentonite Content

Table 8. Comparison of Permeability Coefficient Values with 15% Moisture Content at 20% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	5.224E-08	1.309E-08	1.749E-08	6.571E-09	1.054E-08
2	(BN+AIR)+CS	5.489E-07	4.187E-08	1.868E-08	3.520E-08	1.132E-08

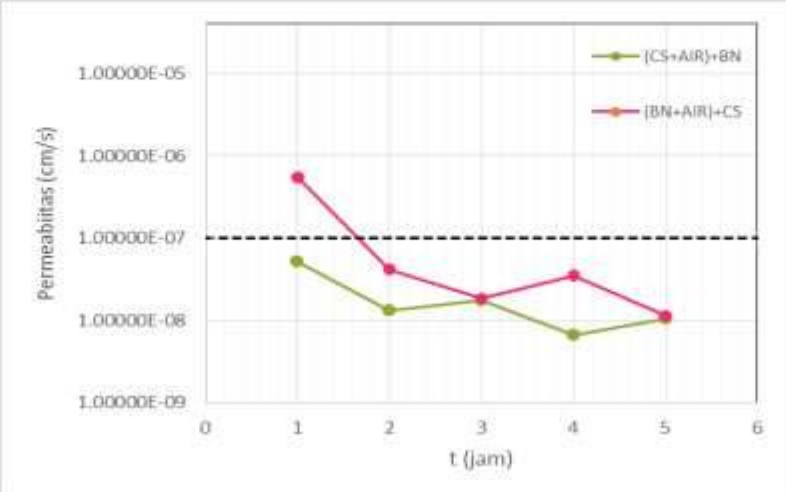

Figure 9. Graph of Comparison of Permeability Coefficient Values with 15% Moisture Content at 20% Bentonite Content

Table 5-8 shows a comparison of 2 variations of mixing methods on the value of the permeability coefficient with dry volume weight 1.8 g/cm3 and using a moisture content of 15% and bentonite content of 5%, 10%, 15%, and 10% respectively, which is then plotted in the form of a graph shown in Figure 6-9.

In Figure 6-9 it can be seen that the permeability coefficient with the mixing method (CS+Air)+BN and (BN+Air)+CS decreases with increasing time except when the mixing method (CS+Air)+BN with bentonite content of 5% and 20 %, as well as during the mixing method (BN+Air)+CS with 20% bentonite content

Comparison of 20% Water Content Permeability Coefficient Value

Based on the test with hourly decrease readings at 20% moisture content with variations in bentonite content of 5%, 10%, 15%, and 20% for 5 hours, the permeability coefficient values were obtained as follows.

Table 9. Comparison of Permeability Coefficient Values with 20% Moisture Content at 5% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	7.985E-08	6.692E-08	4.493E-08	2.713E-08	3.279E-08
2	(BN+AIR)+CS	5.418E-08	4.078E-08	4.558E-08	2.063E-08	1.104E-08

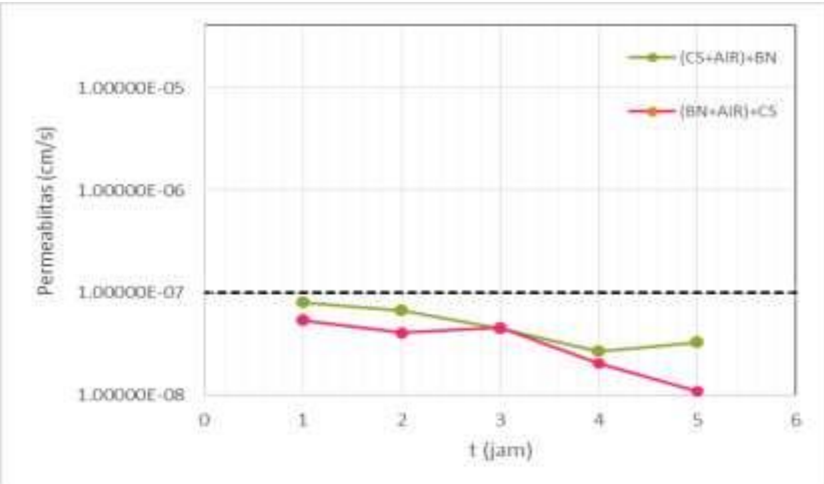

Figure 10. Graph of Comparison of Permeability Coefficient Values with 20% Moisture Content at 5% Bentonite Content

Table 10. Comparison of Permeability Coefficient Values with 20% Moisture Content at 10% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	2.349E-07	2.934E-07	2.019E-07	2.219E-07	2.048E-07
2	(BN+AIR)+CS	5.418E-08	4.078E-08	4.558E-08	2.063E-08	1.104E-08

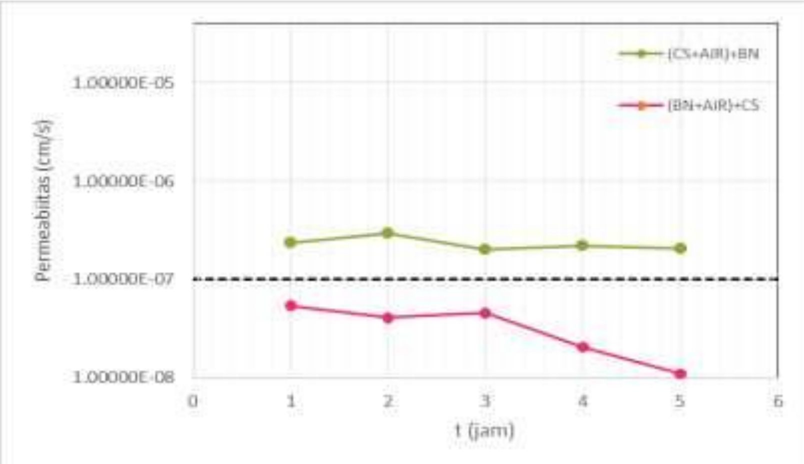

Figure 11. Graph of Comparison of Permeability Coefficient Values with 20% Moisture Content at 10% Bentonite Content

Table 11. Comparison of Permeability Coefficient Values with 20% Moisture Content at 15% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.879E-07	5.411E-08	2.719E-08	1.364E-08	1.095E-08
2	(BN+AIR)+CS	5.452E-07	2.266E-07	1.801E-08	6.768E-09	4.908E-08

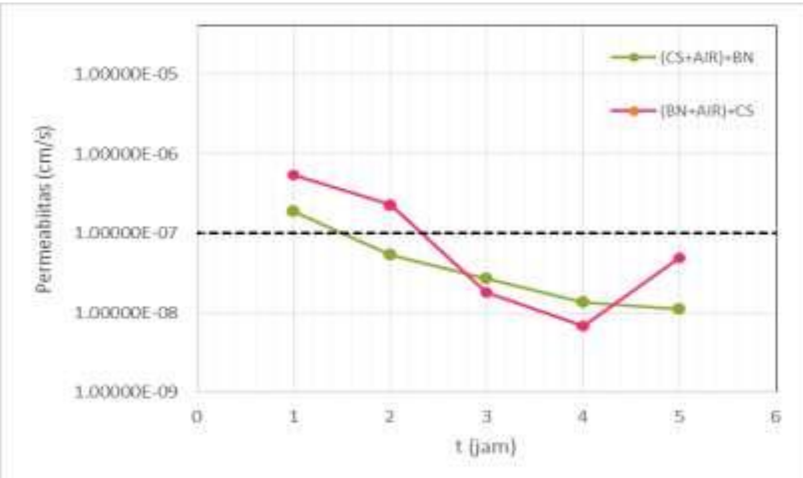

Figure 12. Graph of Comparison of Permeability Coefficient Values with 20% Moisture Content at 15% Bentonite Content

Table 12. Comparison of Permeability Coefficient Value with 20% Moisture Content at 20% Bentonite Content

No	Sampel	Koefisien Permeabilitas (cm/s)				
		1 JAM	2 JAM	3 JAM	4 JAM	5 JAM
1	(CS+AIR)+BN	1.303E-07	7.879E-08	1.761E-08	2.652E-08	1.065E-08
2	(BN+AIR)+CS	1.030E-06	4.421E-08	1.973E-08	7.415E-09	5.941E-09

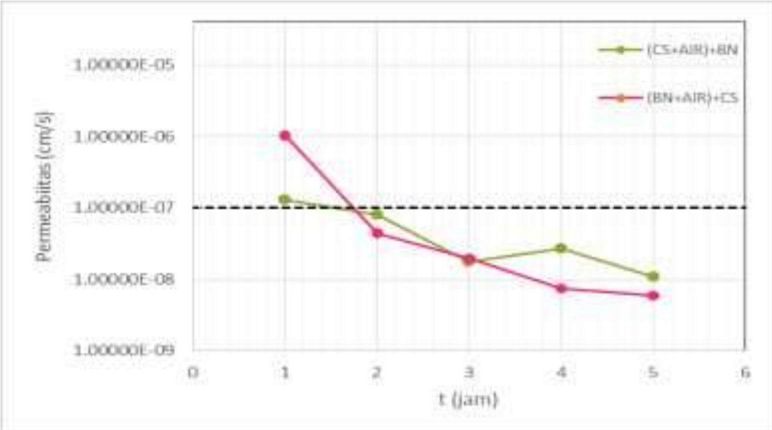

Figure 13. Graph of Comparison of Permeability Coefficient Values with 20% Moisture Content at 20% Bentonite Content

It can be seen in Figure 10-13 that the permeability coefficient decreased consistently only in the mixing method (CS+Air)+BN with 15% bentonite content and the mixing method (BN+Air)+CS at 20% bentonite content.

5. CLOSING

Conclusion

1. The effect of adding bentonite to claystone is better after adding water to the claystone. In the mixed method (CS+AIR)+BN the resulting permeability coefficient decreases with increasing the percentage of bentonite content and water content, compared to the mixed method (BN+AIR)+CS and (CS+BN+AIR). So from the results of the research above, it is recommended that the most ideal mixed method used for clay liner layers in landfill is using the mixed method (CS+AIR)+BN.
2. Generally on dry volume weight 1.8 g/cm3, samples with 20% more water content produced a permeability that met the requirements (ie smaller than 1x10-7cm/s) than samples with 10% and 15% water content.

Suggestions

Further research regarding the effect of time on changes in sample permeability is needed. This is due to the possibility of an equilibrium position of water in the mixture even though it is compacted in different methods.