

Anas Puri

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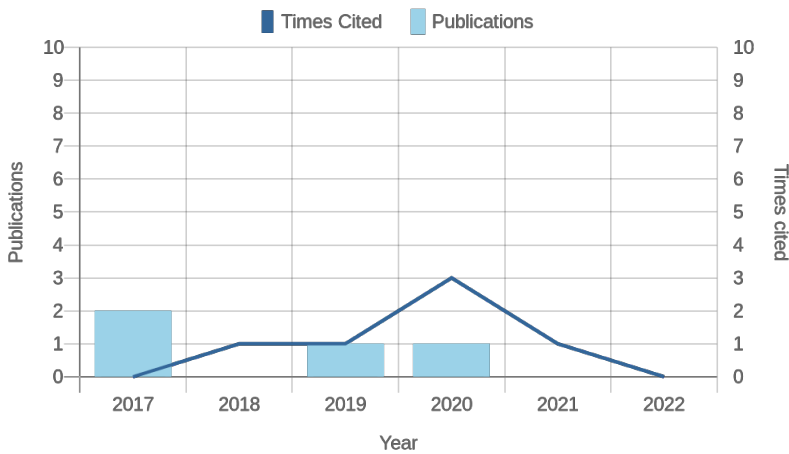
Publications

PUBLICATION METRICS

For all time

TOTAL TIMES CITED	H-INDEX	PUBLICATIONS
6	2	4
WEB OF SCIENCE DOCUMENTS		
4		

PUBLICATION IMPACT OVER TIME



PUBLISHING SUMMARY

(3) International Journal of GEOMATE **WOS** (1) International Journal of Technology **WOS**

MANUSCRIPTS PUBLISHED (4)

**TIMES CITED
(ALL TIME)**

NUMERICAL ANALYSIS OF NAILED-SLAB PAVEMENT SYSTEM BY
CONSIDERING A VOID UNDER THE END OF SLAB

0

Published: Feb 2020 in International Journal of GEOMATE
DOI: 10.21660/2020.66.9306

VALIDATING THE CURVE OF DISPLACEMENT FACTOR DUE TO FULL SCALE OF ONE PILE ROW NAILED-SLAB PAVEMENT SYSTEM 2

Published: Jul 2019 in International Journal of GEOMATE
DOI: 10.21660/2019.59.65815

EFFECTS OF VERTICAL WALL BARRIER ON THE RIGID PAVEMENT DEFLECTION OF FULL SCALE 1-PILE ROW NAILED-SLAB SYSTEM ON SOFT SUB GRADE 0

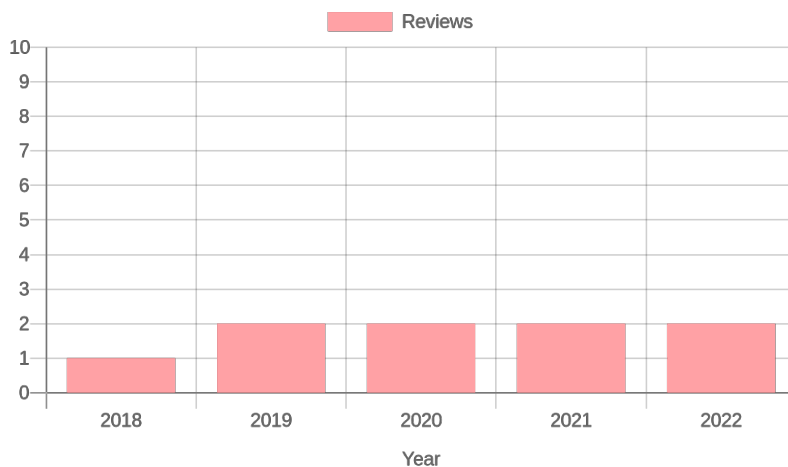
Published: Apr 2017 in International Journal of GEOMATE
DOI: 10.21660/2017.32.6577

DEVELOPING CURVE OF DISPLACEMENT FACTOR FOR DETERMINATION OF ADDITIONAL MODULUS OF SUBGRADE REACTION ON NAILED-SLAB PAVEMENT SYSTEM 4

Published: 2017 in International Journal of Technology
DOI: 10.14716/IJTECH.V8I1.1688

Verified reviews

REVIEW SUMMARY



REVIEWER SUMMARY

(3) International Journal of Technology WOS	(3) International Conference on Geotechnique, Co...
(3) Indonesian Journal of Geoscience WOS	

9 REVIEWS OF 7 MANUSCRIPTS

Stabilization of Weathered Clay Shale Using Propylene Glycol and Potassium Chloride as an Embankment Material Alternatives

3 rounds from Oct 2020 to Apr 2022 for International Journal of Technology

Determination of Uniaxial Compressive Strength (UCS) Using Point Load Test (PLT) of Setap Shale (Miri) Sarawak, Malaysia

Reviewed: Nov 2021 for Indonesian Journal of Geoscience

Sustainability of Enzyme Mediated Calcite Precipitation Method for Soil Stabilization

Reviewed: Feb 2021 for Indonesian Journal of Geoscience

A Method for Real-time Evaluation of the Properties of Compacted Soil from Acceleration Response of Compaction Roller

Reviewed: Jun 2020 for International Conference on Geotechnique, Construction Materials and Environment

The Influence of Rock Slope Scales on the Stability and Failure Mechanisms

Reviewed: Jul 2019 for International Conference on Geotechnique, Construction Materials and Environment

Analysis of Geotechnical Behavior of Rock Configurations Implementing Geological Structures in the Limit Equilibrium Method

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Dry Dust Collector and Ceramic Silica Sand Waste as Clays Stabilizer

Reviewed: Mar 2018 for Indonesian Journal of Geoscience



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International Journal of Technology

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Certificate ID: 1883-3251

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for the contribution in reviewing a submission entitled "STABILIZATION OF WEATHERED CLAY SHALE USING PROPYLENE GLYCOL AND POTASSIUM CHLORIDE AS AN EMBANKMENT MATERIAL ALTERNATIVES" which was completed at 03 October 2020.

Depok, 03 October 2020

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Invitation to Review Manuscript #CVE-1883

Dear **Dr. Anas Puri**,

You are cordially invited to review a manuscript **#CVE-1883** entitled "**STABILIZATION OF WEATHERED CLAY SHALE USING PROPYLENE GLYCOL AND POTASSIUM CHLORIDE AS AN EMBANKMENT MATERIAL ALTERNATIVES**" that was submitted to the International Journal of Technology (IJTech, pISSN: 2086-9614, eISSN: 2087-2100). IJTech is an open-access journal indexed by Scopus, EBSCO, DOAJ, and many internationally-recognized indexer. In 2019, IJTech achieved SJR score of 0.35 (Q2), SJR H-index of 9, acceptance rate of 29.5%, and average submit-to-publish duration of 162 days.

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Article to be reviewed

Title: STABILIZATION OF WEATHERED CLAY SHALE USING PROPYLENE GLYCOL AND POTASSIUM CHLORIDE AS AN EMBANKMENT MATERIAL ALTERNATIVES

Abstract: Unweathered clay shale that is stacked beneath the soil surface has a high value of strength. Due to brittleness that is related to weathering, clay shale will deform and lose its strength if it is exposed to the atmosphere. Thus, it would be dangerous if it is used as embankment material due to its sensitiveness. Propylene glycol and potassium chloride are commonly used as a drilling fluid to prevent the degradation of shale layer. They are able to increase the stability of clay shale making it more

durable when contact with water and atmosphere. This study analyses about the effect of addition of propylene glycol and potassium chloride to weathered clay shale. Propylene glycol, which is mixed to the clay shale can increase the value of soaked CBR as twice as the initial value, and decrease the swelling percentage. Potassium chloride that is mixed to the clay shale can also increase the value of soaked CBR as twice as the initial value, and decrease the swelling percentage. Yet, the combination of Propylene glycol and potassium chloride are not able to increase the value of soaked CBR, can shrink the specimen, and reduce the optimum water content.

We look forward to hearing from you.

Yours sincerely,

Dr. Nyoman Suwartha
nsuwartha@eng.ui.ac.id Managing Editor

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Review assignment for manuscript #CVE-1883

Dear **Dr. Anas Puri**

Thank you for your willingness to review manuscript **#CVE-1883**, entitled [**STABILIZATION OF WEATHERED CLAY SHALE USING PROPYLENE GLYCOL AND POTASSIUM CHLORIDE AS AN EMBANKMENT MATERIAL ALTERNATIVES**]

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Thank you for your review on manuscript #CVE-1883

Dear **Dr. Anas Puri**

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03 Sep 2018 - 16:40

Title:

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Abstract:

Unweathered clay shale that is stacked beneath the soil surface has a high value of strength. Due to brittleness that is related to weathering, clay shale will deform and lose its strength if it is exposed to the atmosphere. Thus, it would be dangerous if it is used as embankment material due to its sensitiveness. Propylene glycol and potassium chloride are commonly used as a drilling fluid to prevent the degradation of shale layer. They are able to increase the stability of clay shale making it more durable when contact with water and atmosphere. This study analyses about the effect of addition of propylene glycol and potassium chloride to weathered clay shale. Propylene glycol, which is mixed to the clay shale can increase the value of soaked CBR as twice as the initial value, and decrease the swelling percentage. Potassium chloride that is mixed to the clay shale can also increase the value of soaked CBR as twice as the initial value, and decrease the swelling percentage. Yet, the combination of Propylene glycol and potassium chloride are not able to increase the value of soaked CBR, can shrink the specimen, and reduce the optimum water content.

Reviews and Comments

Done, Revisions Required

Review completed at:

03 Oct 2020 - 16:32

Comments for Introduction section:

Some very closed of related research were neglected such as Wiwik Rahayu (2019) and Lesmana (2017). Figure 1 is not belong to Alatas, et.al. (2015) which typed in the paragraph. It might be better to also refer Oktaviani, Rahrdo & Sadisun (2018) about Jati Luhur clay shale formation. Little bit uncomplete state of the art.

Comments for Methodology:

Please complete with some photographs of stabilized samples. Give briefly description about method of data analysis.

Comments for Results and Discussion:

Optimum water content or optimum moisture content? It is better that all properties are compared also with previuos researchers. Where the XRD results of stabilised clay shale? It should be discussed with Table 5. All figures are not good for eyes. Table 3 is not good presented. Need the advanced proof reading.

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STABILIZATION OF WEATHERED CLAY SHALE USING PROPYLENE GLYCOL AND POTASSIUM CHLORIDE AS AN EMBANKMENT MATERIAL ALTERNATIVES

ABSTRACT

Unweathered clay shale that is stacked beneath the soil surface has a high value of strength. Due to brittleness that is related to weathering, clay shale will deform and lose its strength if it is exposed to the atmosphere. Thus, it would be dangerous if it is used as embankment material due to its sensitiveness. This study analyses about the effect of addition of propylene glycol and potassium chloride to weathered clay shale. Propylene glycol and potassium chloride are commonly used as a drilling fluid to prevent the degradation of shale layer. They are able to increase the stability of clay shale by making it more durable when contact with water and atmosphere. The results from this study show that Propylene glycol which is added to clay shale can increase the value of soaked CBR as twice as the initial value, and decrease the swelling percentage. The addition of potassium chloride to the clay shale can also increase the value of soaked CBR as twice as the initial value, and decrease the swelling percentage. Yet, the combination of Propylene glycol and potassium chloride are not able to increase the value of soaked CBR, can shrink the sample, and reduce the optimum water content.

Keywords: Clay shale, Potassium Chloride, Propylene Glycol, Stabilization, CBR Value

1 INTRODUCTION

Some very closed of related research were neglected such as Wiwik Rahayu (2019) and Lesmana (2017). Figure 1 is not belong to Alatas, et.al. (2015) which typed in the paragraph. It might be better to also refer Oktaviani, Rahrdo & Sadisun (2018) about Jati Luhur clay shale formation. Little bit uncomplete state of the art.

Engineering behaviour of shale is a very complicated subject. In undisturbed condition, or stacked below the ground surface, clay shale is firm and stable thus shows high undrained shear strength. If it is exposed to the open air, sunlight, and water, it will be weathered in quite short time and transform from a hard rock into soft clay (Alatas, et al., 2015) as shown in Figure 1. It can be caused by the brittleness of shale and its low durability that is the primary characteristics of shale (Widjaja, 2008) especially when it has contact with water or exposed to the atmosphere (Sadisun, et al., 2010).

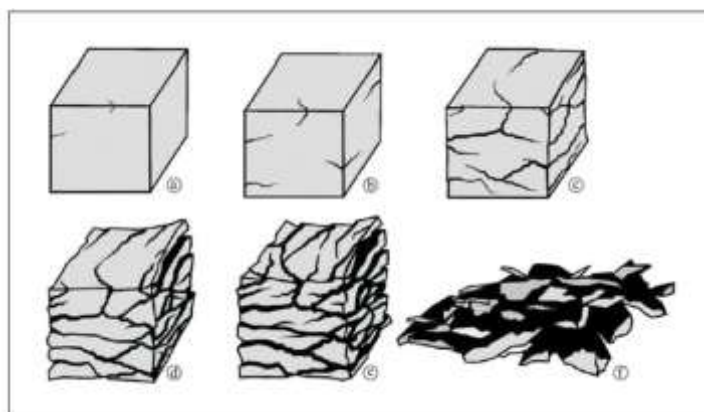


Figure 1 Illustration of physical disintegration of clay shale (Sadisun, et al. (2015))

In sever part of the world including United States of America, shale is sometimes used as the embankment material due to limitation of the source of material around the embankment location. Yet the usage of shale as embankment material usually leads to high cost of maintenance and repair due to the condition of the shale that can deteriorate following with the degradation of

Stabilization Of Weathered Clay Shale Using Propylene Glycol And Potassium Chloride As An Embankment Material Alternatives

physical and mechanical properties due to the characteristic of the shale itself. Therefore, the problem that is usually faced in using shale as embankment material are excessive settlement and stability since the material of embankment will degrade due to weathering. The more serious problem will occur especially in wet areas where the embankment is subjected to the repeated wetting and drying condition. This condition will lead the degradation of shale faster and the problems of stability of the embankment occurs (Gomez-Gutierrez, 2013).

Based on the geological map of Indonesia, there is a quite large clay shale formation in Sentul, West Java, and some of them are exposed to the surface. The formation is called as Jatiluhur formation as shown in Figure 2. Some construction problems are recorded related to the clay shale deposits near Sentul area, e.g., landslide on the construction of Wisma Atlet Hambalang (Alatas, et al., 2015), and some local problems that give disadvantage for the surroundings. It is assumed that those problems are related to the degradation of the clay shale layer.



Figure 2 Jatiluhur clay shale formation in Sentul, West Java

From the previous research (Widjaja, 2008), clay shale from Sentul, West Java has significant reduction of durability when it is exposed to open space. The reduction has value of 50% from unweathered condition within a month. The difference of depth from the sample taken shows that the deeper of the sample taken, the value of the durability would be increased as it has the tendency that the clay content is reduced.

Most shale layers are also stacked underneath the ground surface, and some are surfaced during oil and gas drilling process. When the drilling process find the shale layer, it usually causes the instability of the bored well due to the shale's water-sensitive characteristic. Therefore, an important consideration in the drilling process is to protect the water-sensitive shale and reduce problems caused by water absorption (Patel, 2009). Using drilling fluid is one of the solution that can be used to prevent the degradation of shale formation during the drilling process. Water based drilling fluid, e.g., inorganic salts and organic polymer is widely used for that purpose because the less negative environmental effect (Lee, et al., 2001).

Potassium chloride, as one example of inorganic salt, is known as one of the inhibitors to prevent degradation of shale layer. High concentration of potassium salts, such as potassium chloride are mostly used due to the effective inhibition level among solution (Zhong, et al., 2015). The concentration of such additives between 2% to as high as 37% are frequently recommended in treating drilling fluids to minimize swelling of the sensitive clay. Salt will prevent the swelling through various mechanisms, the cation exchange reaction between shale ions and salts ions reduces the amount of water that can be absorbed by hydratable cations on the surface of swelling clay or shale (Patel, 2009). The Potassium Chloride is also chosen as an inhibitive agent to prevent the shale from swelling. It is caused by the Potassium that has greater bonding energy when it

Stabilization Of Weathered Clay Shale Using Propylene Glycol And Potassium Chloride As An Embankment Material Alternatives

interacts with clay mineral that will prevent water to inhibit to clay mineral more than other cation. It also needs only slight heat making a non-expandable compound (O'Brien & Chenevert, 1973). The one other effect of inorganic salts as Potassium Chloride (KCl) to clay mineral or clay type soil is KCl with high concentration can increase the consistency in clay soils and tend to change the clay class from clay with low plasticity to Silt with low plasticity, and clay with high plasticity according to Unified Soil Classification System (USCS) (Arasan & Yetimoglu, 2007). Beside inorganic salts, polymer additives is common used to reduce the hydration of shale. In addition to inorganic cations, polymer additives and water-soluble organic polar compounds such as glycerol, glycol, and sorbitol can also provide shale stabilization and swelling inhibition. Glycols with a molecular weight of less than about 200, e.g., ethylene glycol, propylene glycol, butylene glycol are suitable for this purpose due to their slightly to moderately viscosity, hygroscopic, colourless, and odourless (Lee, et al., 2001). The process that allows the organic polymer compound inhibits to clay mineral is called intercalation process. This intercalation process will prevent the hydration of clay minerals when it comes to water that may cause the disintegration and reduction of durability. The insertion of molecule of polymer to host molecule (the clay molecules in this case) will enlarge the space between the molecules of the host (Whittingham & Jacobson, 1982).

In this study, the potassium chloride and propylene glycol are used as additives for stabilizing the clay shale to prevent the degradation of this material when is used as embankment material. The aim of the experiment is to observe the change of characteristic of clay shale.

2 METHODS

Please complete with some photographs of stabilized samples. Give briefly description about method of data analysis.

This study used 4 sets of samples that were tested to know the significant effect of additives for stabilizing compacted clay shale and for preventing degradation of strength when the clay shale has contacts with water. The test that was conducted related to the strength of clay shale sample is California Bearing Ratio (CBR). The other tests related to physical properties and mineralogy of clay shale sample are hydrometer test, Atterberg's limit test, X-Ray Diffraction (XRD) test, and swelling measurement. The following sections explain the detail of the experiment.

2.1 Clay Shale Sample

The clay shale sample that was used in this study is weathered clay shale taken from Sentul, West Java (Jatiluhur formation) as shown in Figure 3. The purpose of using weathered material is subjected that it is more representative to the objective of the research that using weathered clay shale and to the field implementation where the shale is crushed into smaller size, moisturized, and compacted to be used as embankment material. The weathered clay shale were obtained from the surface area and shallow depth of clay shale layer. This method was used to have a natural weathered clay shale, instead of using the unweathered sample and using wetting and drying method.

Stabilization Of Weathered Clay Shale Using Propylene Glycol And Potassium Chloride As An Embankment Material Alternatives



Figure 3 Weathered Clay Shale Sample of Sentul, West Java

2.2 Sets of Sample

In this study, propylene glycol and potassium chloride are used as additives for clay shale to maintain the strength of compacted clay shale, hence the stability of clay shale as embankment can be increased.

There are 4 set of samples that were prepared as in Table 1. The first set of sample is clay shale with a water content 14,45%, which is the optimum water content (the optimum water content was obtained in advance from standard proctor test as in ASTM D698) and without any applied additive. The optimum water content that was obtained from the test, will be also considered as the optimum water content for all the set of sample, and will be the benchmark of the proportion of the additive that will be applied in the set of sample.

For the second set of sample, the propylene glycol was added to the sample as much as 75% of the optimum water content. On the third set of sample, potassium chloride was added to clay shale sample with optimum water content that was obtained using only water. The amount of potassium chloride is 3% from the dry weight of shale sample. On the fourth set of sample, the shale sample with 3% of potassium chloride (as the third set of sample) was mixed with the same amount of propylene glycol as in the second set of sample. In this study, water content for all the set of samples is assumed to be as same as the original water content (the first set of samples).

Table 1 Set of sample of Experiment

Set of Sample	Water (%)	Propylene Glycol (%)	Potassium Chloride (KCl) (%)
1	100*	-	-
2	25*	75*	-
3	100*	-	3**
4	25*	75*	3**

*Percentage in respect of optimum water content of clay shale sample; **Percentage in respect of dry weight of clay shale sample

2.3 Physical Properties Tests

Some tests were conducted to original sample of weathered clay shale to find the physical properties of clay shale sample that was used in the research. The first test was particle distribution test as the ASTM D422 standard, and the other test that was conducted to sample was Atterberg Limit as the ASTM D 4318.

2.4 Method of Mixing

The clay shale that was used in this study are prepared to pass the 4,76 mm sieve. For the first sample, water was added to the sample in certain value to reach the optimum water content. The

sample was left for a day so that the water would evenly distributed. This method was also applied for the second set of sample with the mixture of propylene glycol and water. For the third set of sample, Potassium Chloride was mixed with the shale sample before adding the water and left for few hours (2-4 hours). After mixed with potassium chloride, water was added to the sample to reach the optimum water content. For the fourth set of sample, the original shale sample was mixed with potassium chloride before it was mixed with propylene glycol and water.

2.5 California Bearing Ratio Test

California Bearing Ratio (CBR) test as in ASTM D1883 was conducted to the sample that was compacted using standard proctor method as in ASTM D1557.

The CBR test was conducted to the dry (unsoaked) and soaked samples. The CBR value is described as:

$$CBR = \frac{\text{test unit load (psi)}}{\text{standard unit load (psi)}} \times 100\% \tag{1}$$

2.6 Swelling Test

The swelling test in this research was done using two methods. The first method to measure the swelling was conducted on the soaked samples after the CBR test. The swelling of the sample was measured at the fourth day of soaking using the swelling dial set. The second method was using oedometer test which the procedure was adopted as the procedure suggested in ASTM D 4546.

3 RESULTS AND DISCUSSION

Optimum water content or optimum moisture content?
 It is better that all properties are compared also with previous researchers.
 Where the XRD results of stabilised clay shale? It should be discussed with Table 5.
 All figures are not good for eyes. Table 3 is not good presented.
 Need the advanced proof readin

3.1 Particle Size Distribution

From the hydrometer test it is obtained the particle size distribution of Sentul clay shale as follow: 15% clay, 75% silt, and 10% sand, as in Figure 4. There is a different result with previous study by Widjaja (2008) of Sentul clay shale that shows the presentation of particle size as follows : 50-59% clay, 40-50% silt, and less than 10% sand.

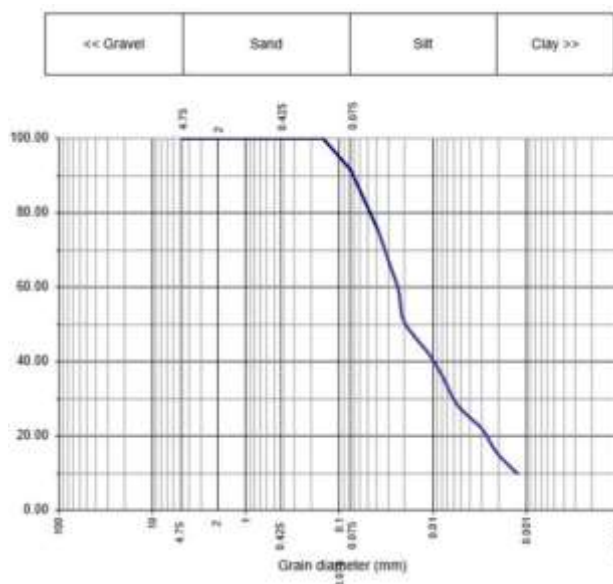


Figure 4 Particle size distribution of clay shale sample (pass the sieve no.200)

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The difference might be caused by the difficulties of clay shale particle to unravel to the smaller size. This clay shale from Sentul took quite long time to ravel or deteriorate in natural way. The particles that had not been unravelled, will be considered as the bigger particles in hydrometer test and will affect the result. The difference may be also caused by the different depth of sample taken in this study with the one in the previous study. However, the main portion in both cases is still the fine grain materials (i.e., clay and silt).

3.2 Plasticity Index of Samples

Table 2 shows the result of Atterberg's limit tests, which are also plotted on plasticity chart as in Figure 5. According to those results it can be said that the clay shale from Sentul has low plasticity. Clay with low plasticity has tendency to be more stable and has a low potential of swelling. The results were also plotted above the A-line in Figure 5, which means that these shale samples are composed mainly by clay minerals.

Table 2 Atterberg Limit Result of the Clay Shale Samples

Number of test	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	43,12	23,91	19,21
2	41,62	21,32	20,30
3	41,02	21,72	19,30

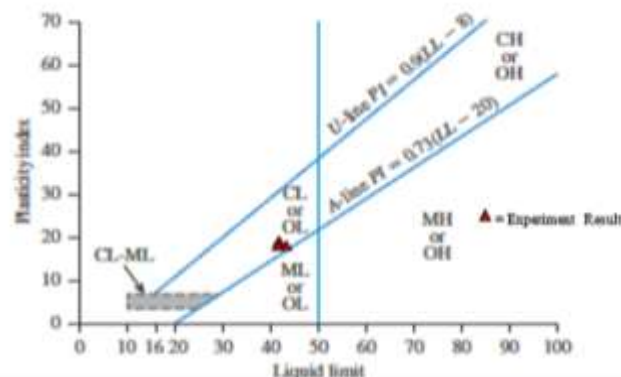


Figure 5 Soil Type Based on USCS Graph with Atterberg Limit Result

3.3 XRD Result

X-Ray Diffraction (XRD) test was conducted to obtain the information on mineral composition of Sentul clay shale. The results showed that it is mostly composed by Quartz (34,5%). Quartz is known as a stable clay mineral that is difficult to be dissolved in water. Yet the Clay shale sample in this study is also composed by kaolinite and montmorillonite, as shown in Table 3 and Figure 6. These minerals are known to be related to the swelling potential of clay shale.

Table 3 Minerals Composition of Sentul Clay Shale

No	Mineral	Percentage (%)
1	Quartz	34,5
2	Calcite	19,9
3	Be F ₂	12,5
4	Kaolinite	11,6
5	Montmorillonites	8,7

No	Mineral	Percentage (%)
6	Bementite	5,4
7	Pyrite	1,6
8	Mn Fe ₂ O ₄	1,6
9	Siderite	1,5
10	Periclase	1,3

Stabilization Of Weathered Clay Shale Using Propylene Glycol And Potassium Chloride As An Embankment Material Alternatives

condition increase because of the intercalation process that prevent water to contact with clay shale molecule (Lee, et al., 2001).

For the third set of sample, the CBR value in unsoaked condition has lower value than the first and the second sets of sample. This condition can be caused by the interaction between potassium chloride and clay shale molecule. Inorganic salt can increase the plasticity of the clay that will lead to the decreasing strength of the clay shale sample. Yet in soaked condition, it has the same CBR value as the second set of sample. The cation of inorganic salts (in this study, K^+) can make a reaction with anion from clay shale so that the molecule of water cannot interact with the anion of clay shale when it is being submerged (Zhong, et al., 2015).

The fourth set of sample has the lowest value of CBR either in unsoaked or soaked condition. The result that is shown in table 4 indicates the combination in fourth sample with the water content of 14,45% cannot be used as embankment. This result might be caused by the combination of propylene glycol and potassium chloride.

In addition to know whether there is a change in optimum water content condition from the sample, compaction test was done to the fourth sample that has the lowest result among all of set of samples. From the result that is got, the fourth set of sample also has a different optimum water content from the first set of sample as shown in Figure 7. This alteration of water content shows that the water content that was made for the fourth set of sample in CBR test is not in the optimum state of water content so that the result could be low.

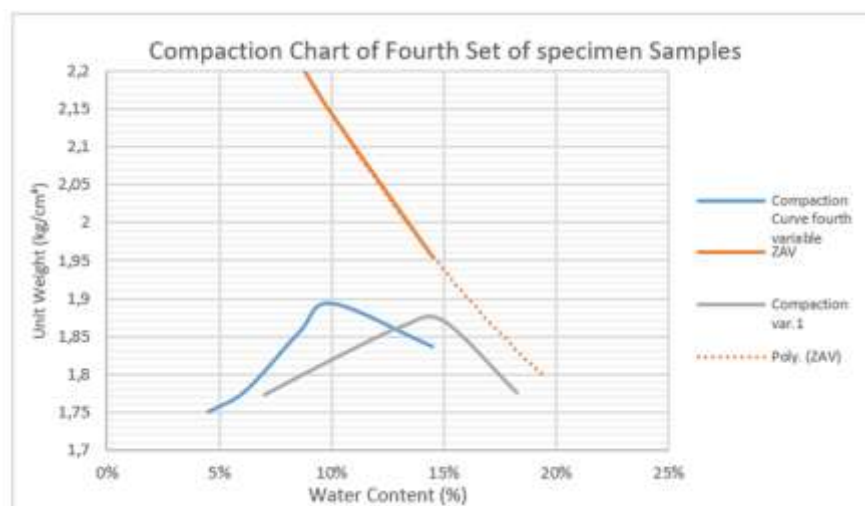


Figure 7 Compaction Result for the Fourth Set of sample

3.5 Swelling Test

The swelling test results of the clay shale sample show that Sentul clay shale has a low to medium swelling potential. It might be related to the mineral composition of Sentul Clay shale that is composed by stable clay mineral as obtained in X Ray Diffraction result. The low plasticity also indicates that the swelling of this weathered clay shale has the low potential of swelling.

From the result of experiments, both propylene glycol and potassium chloride gives the advantage in reducing the swelling potential of the soil sample as seen in table 5. The mixture of additives and soil mineral prevent the water to have reaction with soil mineral. From the difference result of swelling that is obtained from CBR sample and oedometer tests, show that the size of sample

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also affects the swelling percentage as it is shown from Table 5, that swelling percentage measured from samples for CBR are higher than the one measured in oedometer test. The combination of propylene glycol and potassium chloride gives a significant result that makes the soil sample shrunk and the swelling value became negative.

Table 5 Swelling Percentage of Sets of sample

Set of Sample	Swelling Percentage (CBR Sample)	Set of Sample	Swelling Percentage (Oedometer Test)
1	2,5%	1	1,3%
2	0,28%	2	0,11%
3	0,08%	3	0,03%
4	-0,3%	4	-0,3%

The effect of Potassium Chloride gave more significance number of swelling reduction to clay shale sample than Propylene glycol. The organic polymer still gave a vertical displacement to the sample through intercalation process, giving the clay shale sample have bigger number of swelling than using Potassium Chloride as additives. In the third set of sample, K^+ (positive charged ions) from potassium chloride had electrochemical attraction with negative charge ion from clay that will flocculate and causing the more shorter distance to each elements. The shorter distance made smaller void that might cause the smaller swelling number (Carter & Bentley, 2016).

4 CONCLUSION [Give briefly recommendation for practical purposes and further research.](#)

Sentul Clay shale is composed mainly from clay minerals which has low plasticity and low swelling potential. Yet the degradation of clay shale is still occurred due to primary characteristic of shale that will degrade when contacts with water of exposed to the atmosphere.

The initial CBR result of the unsoaked condition of compacted clay shale is 15%, but the CBR result for soaked sample has significant difference with the unsoaked condition which is 2,5%.

Propylene glycol and potassium chloride have the ability to stabilize the clay shale mineral by preventing the shale to contact with water that will also the degradation of clay shale. Propylene glycol, which is mixed with the clay shale can increase the value of soaked CBR as high as twice the first set of soaked sample, and decrease the swelling percentage from 2,5% to 0,3%. The addition of potassium chloride to clay shale may also increase the value of soaked CBR as twice the first set of soaked sample, and decrease the swelling potential from 2,5% to 0,08%. The mixture of propylene glycol and potassium chloride will cause the change of optimum water content from sample. The mixture of these additives may not be also effective in increasing the value of unsoaked and soaked CBR of clay shale sample. The effect of these additives when it is mixed will cause the negative swelling number to the clay shale sample making the sample shrink.

5 REFERENCES [please refer to author guideline.](#)

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