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# Increasing Soaked CBR Stability Value of Mixed Soft Clay with Sodium Chloride (NaCl) and Rice Husk Ash (RHA)

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**Abstract.** The soil type that often is an obstacle in its construction is soft clay with a low bearing capacity. Generally, soft clay also has non-uniform expansion and shrinkage properties. Therefore, it is necessary to improve the stabilization of soft clay to meet the technical requirements to be used as a subgrade. Soil stabilization is usually done by applying chemicals to the soil, which will increase its bearing capacity. In this study, addition of sodium chloride (NaCl) salt and rice husk ash was used. The bearing capacity characteristics of the soil after being stabilized were checked using the CBR immersion test. In the first stage, rice husk ash powder passes filter No. 200, and the sodium chloride (NaCl) salt is dissolved. Rice husk ash was mixed with 0%, 8%, 10%, 12%, 14%, and 16%, respectively, while 15% NaCl was used in a dry soil mixture, then tested the CBR value by immersion. The results showed that the CBR value of the original soil increased from 2.84% to 7.57% after being mixed with 15% NaCl salt. In addition, the use of rice husk ash varied with 15% NaCl salt also significantly increased soil stabilization. The results of the CBR value in the overall rice husk ash mixture increased from 2.84% to 4.73%; 2.84% to 7.76%; 2.84% to 12.78%; 2.84% to 11.36%; and 2.84% to 7.1% for soils with husk ash 8%, 10%, 12%, 14% and 16% respectively without being mixed with 15% NaCl salt. In comparison, the resulting CBR value increased from 2.84% to 5.87%; 2.84% to 8.05%; 2.84% to 9.47%; 2.84% to 8.33%; and 2.84% to 6.15% for soils with 8%, 10%, 12%, 14%, 16% husk ash mixed with 15% NaCl salt, respectively. The largest increase was obtained in 12% rice husk ash, namely the CBR value of 12.78% without 15% NaCl and 9.47% CBR value with 15% NaCl.



## INTRODUCTION

Soil is the primary material in construction projects because all buildings and roads will rest on the ground. However, not all types of soil are suitable for use as the subgrade of a building. Several types of soil have problems in terms of soil bearing capacity related to soil shear strength and soil stability related to total or partial subsidence of the soil. One type of soil that is often found in the location is soft clay. Soft clay is classified as a problematic soil type because it has a relatively high Plasticity Index value (more than 17%). Thus, providing low bearing capacity. The characteristics of high-volume changes significantly affect the properties of the soil shear strength parameters, namely the internal shear angle, cohesion and weight of the soil volume. This condition requires a process of stabilization so that these properties are improved to increase the soil's bearing capacity.

One effort to enhance or improve the mechanical properties of clay is a technical way of stabilization, better known as soil stabilization. Soil stabilization is the process of mixing the soil with certain materials, which can improve the engineering properties of soil or attempt to modify or improve the properties of specific technical ground to meet certain technical requirements. Many studies have been carried out to stabilize the soil, including lime, fly ash, gypsum, palm bunch ash, silica, cement, bituminous materials, and others [1–7]. Research on a mixture of rice husk ash and lime for soil stabilization showed an increase in the carrying capacity of the soil due to the increase in soil density because the voids in the soil were filled with mixed material. From the results of soil stabilization by using a mixture of lime and rice husk ash, soaked CBR values obtained high of 23.66%. This CBR value was obtained in a mixture of soil by adding lime 6% and rice husk ash as much as 4%. In line with the

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stabilizing agent with a mixture of rice husk ash percentage of 7% + 4% lime produces a percentage value decreased to 0.032% development means rice husk ash and lime can reduce the potential for development contained in expansive soil type. The curing process was proven to increase the CBR value, and curing for 7 days showed the CBR value continued to increase with the addition of rice husk ash up to 7% compared to the CBR value of the soil without husk ash mixture [8].

Rice husk ash is a waste from the combustion of rice hulls containing large amounts of silica. Therefore, it is necessary to use rice husk ash for building construction. Rice husk ash contains chemicals that can be used for soil stabilization due to the nature of the chemical pozzolan. The results of further analysis of rice husk ash showed that the $SiO_2$ content reached 80-90%, even 99.9% amorphous in the form at optimized condition, which has adhesive properties and supported the presence of hydrogen-bonded siloxane groups and silinol groups in silica so that its utilization has been widely used as a filler in the manufacture of soaps and detergents, adhesives, and silica gel. Filler is used to filling the voids between the coarse aggregates on roads construction are expected to increase density and decrease the permeability of the mixture. In addition to its size should be relatively smooth, this waste also has specific properties such as cementation when exposed to water and high adhesion with other aggregates.

Sodium Chloride (NaCl) is an ingredient that is also used for soil stabilization. The structure of the salt includes an anion in the middle and a cation occupying the octahedral cavity. The salt solution is an electrolyte, which has a brown motion on the surface more significant than the brown motion in pure water to degrade the water, and this solution increases the strength of the cohesion between the particles so that the particle bonds become tight. Based on the research that has been done, it is stated that the salt reaction can increase the density between clay particles and increase the bearing capacity of the soil [9]. Studies conducted to analyze the properties of soil mixed with gypsum and NaCl with a variation of 15%, 20% and 25%, respectively which showed increasing volume maximum dry weight of the soil and reduced the optimum moisture content and unconfined compressive strength increases as the salt content increases [2,10].

The general objective of this research is to stabilize clay which is often a problem in the field because it has high swelling and shrinkage properties, and it is hoped that this research can be used as reference material for further research that can be applied and provides benefits in the field of geotechnical engineering. The specific purpose of this study was to determine how much the bearing capacity of the soil stabilized using a mixture of 15% NaCl salt and husk ash varied from 0%, 8%, 10%, 12%, 14%, 16% will increase. In addition, it can also be seen whether the addition of these two additives simultaneously can improve stability for the better compared to only mixing one additional ingredient, either with rice husk ash or with salt NaCl. The test is carried out by immersion first to meet the specifications used for building repairs, subgrade construction, and especially road construction.



## METHOD OF RESEARCH (EXPERIMENTAL)

The purpose of this study was to determine whether a mixture of rice husk ash and NaCl can be used as an alternative to improve clay soil. The CBR test observed the potential for swelling of the soil and additional stabilization without rice husk powder that passed the No. sieve. 200 then mixed with NaCl. Rice husk ash and NaCl 15% of the dry weight of the soil [11] were first dissolved according to the weight of water at the optimum water content. The variations of the rice husk ash mixture used were 0%, 8%, 10%, 12%, 14%, 16% of the dry weight of the soil, referring to previous studies where the variation of the mixture used was around 2% to 12% with a prolonged soaking for three days after mixing. Then proceed with the compaction process and CBR testing.

The soil in this study was clay soil type taken from the Karawang area, West Java. The mixed material used is rice husk ash which passes the No. 200 filter. The research was conducted in the UKI Soil Mechanics laboratory. To determine the type and classification of native soil and test to obtain CBR parameters and development potential, both on native and stabilized soil. Testing to get the potential value for development is done by doing a swelling test.

The test method refers to the SNI (Indonesian National Standard) testing standard. The research procedure includes some stages, which are (1) Liquid Limit Test (SNI 1967:2008); (2) Plastic Limit Test (SNI 1966:2008); (3) Shrinkage Limit Test (SNI 3422:2008); (4) Testing the physical properties of the soil with the Specific Gravity test (SNI 1964:2008); (5) Soil compaction test (SNI 1742:2008); and (6) Testing the value of CBR with immersion (SNI 1744: 2012). The methodology used for this experimental study can be seen in the Flowchart of Fig. 1.

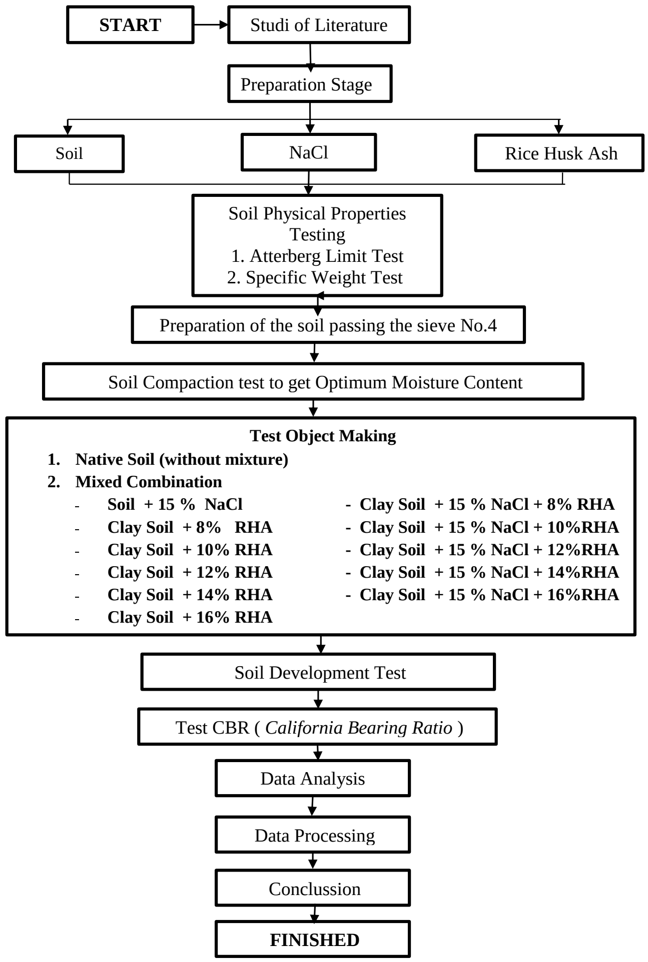


**FIGURE 1.** Research flowchart

## RESULT AND DISCUSSION

At the initial stage, the physical properties of the soil were tested (Table 1) to identify the type of soil to be mixed with rice husk ash and NaCl to improve soil stability.

**TABLE 1.** Physical properties of soil

| Physical parameter | Specific Gravity (Gs) |
|---|---|
| Liquid Limit (LL) | 67.25% |
| Plastic Limit (PL) | 35.48% |
| Plasticity Index (PI) | 31.77% |
| Shrinkage Limit (SL) | 4.92% |
| Soil Density (Gs) | 2.63 gr/cm$^3$ |

From Fig. 2, the type of soil tested included in soil type groups MH, where MH soil is inorganic silt or fine sand, elastic silt.

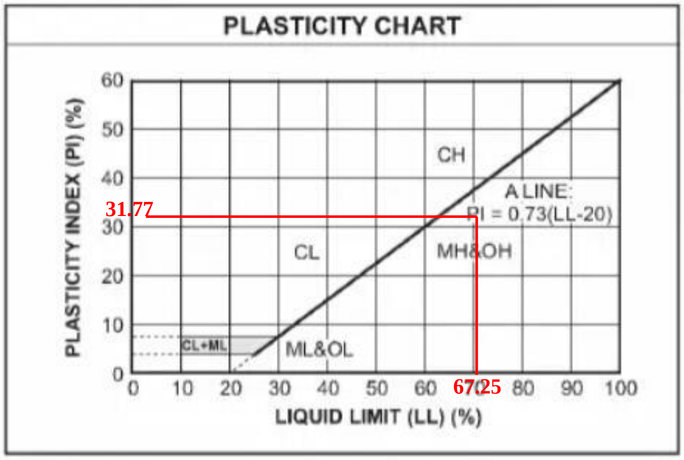


**FIGURE 2.** USCS classification of soil

As shown in Table 2, the soil is classified as inorganic clay, but further research needs to be done for organic content. In addition, Table 3 shows that the soil used is silty clay with high plasticity. It can be concluded that the clay used as a sample can expand to a critical degree due to rapid soil changes such as augmenting and shrinking. As shown in Table 4, it can be seen that the clay has the potential to expand at a critical stage. Thus, it can be concluded that the type of soil used is inorganic soil containing high plasticity clay with moderate development potential.

**TABLE 2.** Specific Gravity of Soil

| Soil Type | Specific Gravity (Gs) |
|---|---|
| Gravel | 2,65 – 2,58 |
| Sand | 2,65 – 2,68 |
| Inorganic silt | 2,62 – 2,68 |
| Organic Clay | 2,58 – 2,67 |
| Clay | 2,68 – 2,72 |

**TABLE 3.** Classification of soil based on plasticity index

| Plasticity Index | Characteristic | Soil Type | Classification |
|---|---|---|---|
| 0 | Non-Plastic | Sand | Non Cohesive |
| < 7 | Low Plasticity | Silt | Partially Cohesive |
| 7- 17 | Medium Plasticity | silty clay | Partially Cohesive |
| > 17 | High Plasticity | silty clay | Cohesive |

The relationship between the plasticity index with the specific gravity of the samples soil and the relationship between the shrinkage limit and the degree of swelling potential can be seen in Table 4 and Table 5.

**TABLE 4.** Classification of the Swelling Potential of Clay

| Shrinkage Limit (%) | Linear shrinkage (%) | Potential Swelling |
|---|---|---|
| <10 | >8 | Critical |
| 10 – 12 | 5 – 8 | Medium |
| >12 | 0 – 8 | Not Critical |

Thus, it can be seen from Table 4 that the clay used has a low shrinkage limit and high linear shrinkage. Meanwhile, soil plasticity index between 10-35% classified the soils medium or moderate level of swelling potential (Table 5).

**TABLE 5.** Identification swelling potential in clay soil

| Swelling Potential | Plasticity Index (%) |
|---|---|
| Low | 0 – 15 |
| Medium | 10 – 35 |
| Height | 20 – 55 |
| Very high | >35 |

Based on the compaction test results, the optimum water content was obtained to be used for the sample by immersion to be tested for CBR. The results of the soil compaction test are shown in Fig. 3. It can be seen that the optimum moisture content of the compaction test results in the soil is 22.1%, and the dry volume weight of the soil is 2,395 kg/cm$^3$. The optimum water content was mixed into the soil for swelling testing by obtaining the CBR value, either for the original soil or soil with a 15% NaCl salt mixture and variations of rice husk ash.

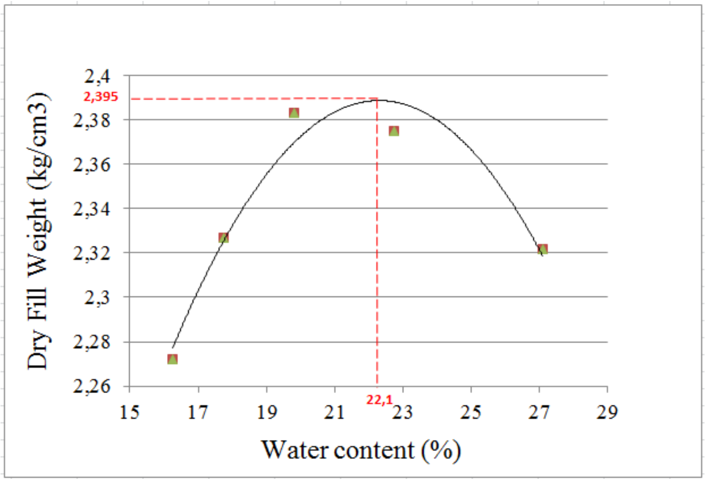


**FIGURE 3.** Optimum water content

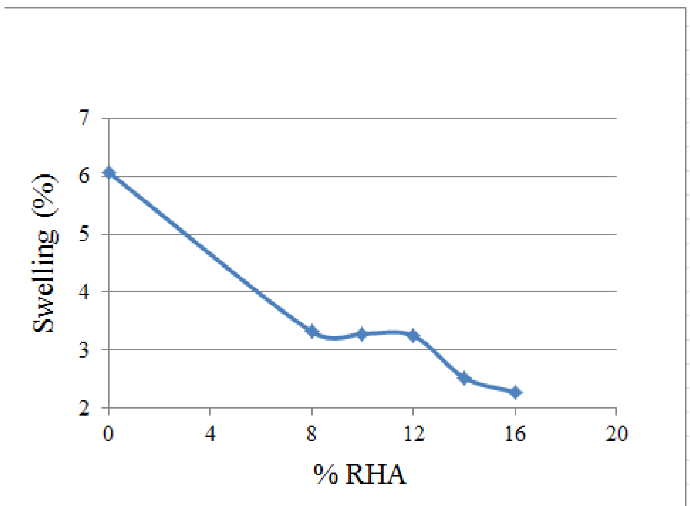


**FIGURE 4.** Relationship between swelling potential and percentage of RHA

From Fig. 4, the swelling potential of soil significantly reduces in line with the addition of RHA. The most significant expansion occurred in which the original soil is 6.06%, and a minor expansion occurred in the original soil using 16% RHA, which is 2.28%. In the original soil + 8% RHA there is a significant decrease in expansion.

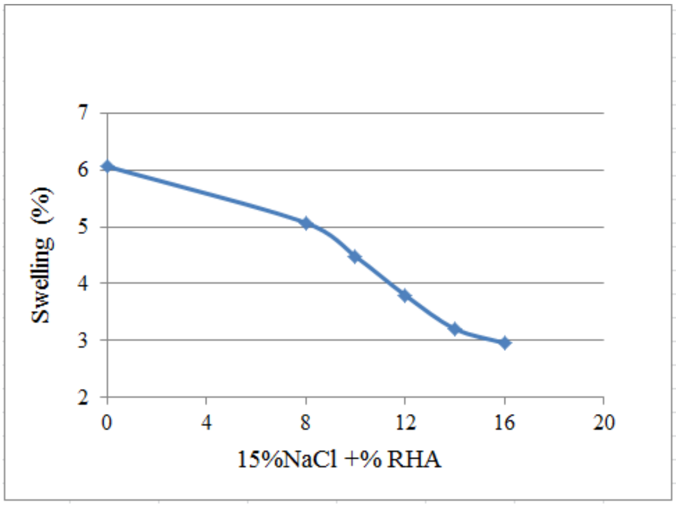


**FIGURE 5.** Swelling Potential of Soil Mixed with 15% NaCl+ RHA

Furthermore, in Fig. 5, the graph of the expansion potential of the soil with a mixture of 15% NaCl + RHA shows that the expansion potential begins to decrease with the addition of RHA. The expansion potential of the soil continued to decrease until it reached 2.96% in the 16% RHA mixture. Thus, it can be concluded that the more soil that is replaced by mixed materials, the smaller the potential for soil development that occurs.

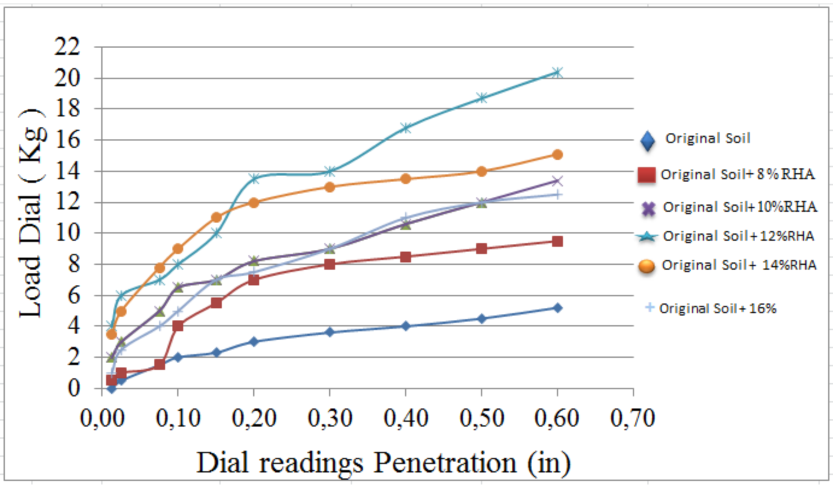


**FIGURE 6**. Graph of Penetration Dial Reading with Load on RHA Percentage

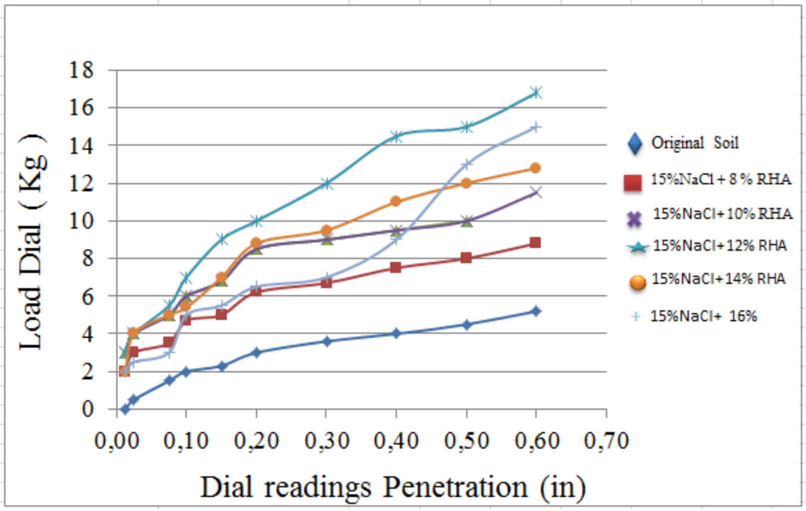


**FIGURE 7**. Graph of Penetration Dial Reading with Load at a Percentage of 15%NaCl + %RHA

The results showed that the CBR value of the original soil increased from 2.84% to 7.57% after being mixed with 15% NaCl salt. In addition, the use of rice husk ash varied with 15% NaCl salt also significantly increased soil stabilization. The results of the overall CBR value increased from 2.84% to 4.73%; 2.84% to 12.78%; and 2.84% to 7.1% respectively for soils with 8%, 10%, 12%, 14%, 16% husk ash without being mixed with 15% NaCl salt (Fig. 6). In comparison, the resulting CBR value increased from 2.84% to 5.87%; 2.84% to 9.47%; and 2.84% to 6.15% respectively for soils with 8%, 10%, 12%, 14% and 16% husk ash mixed with 15% NaCl salt. The largest increase was obtained in 12% rice husk ash, namely CBR value of 12.78% without NaCl 15% and CBR value 9.47% with NaCl 15% (Fig. 7).

According to SNI 03-1732 - 1989, it is stated that the CBR value for subgrade immersion of highway construction is at least 3% of its CBR value. This study used clay type, where the CBR value of clay is 2.84% which is unstable because the CBR value is less than 3%. Stabilization with a mixture of NaCl and Rice Husk Ash increased the CBR value of the soil from 2.84% to 12.78% (Fig. 8).

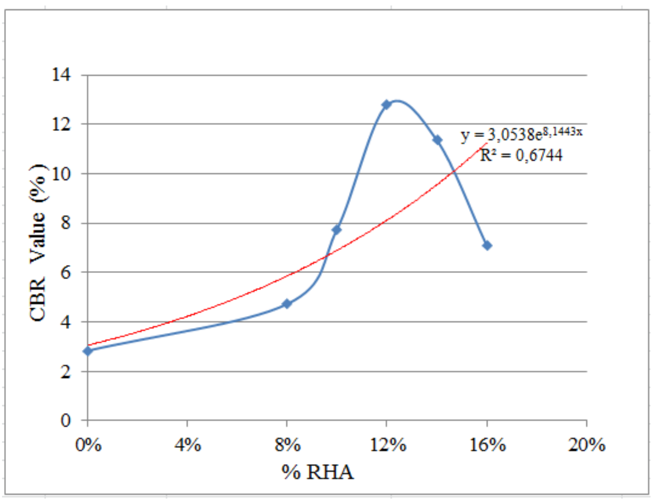


**FIGURE 8**. Relationship between CBR value and variation in the percentage of Rice Husk Ash Content

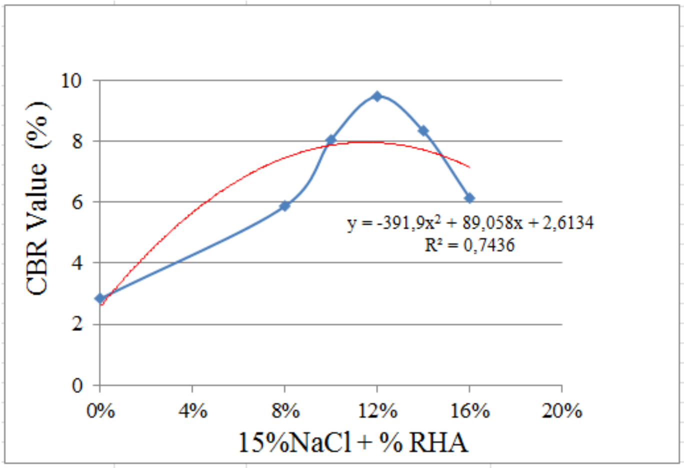


**FIGURE 9.** Relationship between CBR Value and the percentage variation of 15%NaCl + %RHA

Based on the graph in Fig. 8 can be seen that the soil with a mixture of Rice Husk Ash as much as 0%, 8%, 10%, 12%, 14%, 16% can increase the carrying capacity of the soil as well as CBR value of the original soil. In the CBR value of the original soil of 2.84%, when the mixture of Rice Husk Ash was 8%, the value of CBR increased to 4.73%, when the mixture of Rice Husk Ash was 10%, the value of CBR increased to 7,76%, in the mixture of 12% Rice Husk Ash occurred again increasing the CBR value to 12.78%, when the mixture of Rice Husk Ash was 14% the value of CBR increased to 11,36%, at that time the mixing of rice husk ash as much as 16% of the CBR value to 7.10%. The test results show that the optimal level of disturbance occurs when the original soil is stabilized with husk ash as much as 12% of immersion in the optimal CBR value. The original soil CBR value increases 2.84% with a CBR value of 9.94% to 12.78%.

Furthermore, it can be seen from Figure 9 that the original soil has a CBR value of 2.84%. When stabilized with a mixture of 15% NaCl + 8% RHA, it produces a CBR value of 5.87%, an increase from the CBR value of the original soil. In the original soil mixture + 15% NaCl + 10% RHA resulted in a CBR value of 8.05%. In the original soil mixture + 15% NaCl + 12% RHA resulted in a CBR value of 9.47%. In the original soil mixture +15% NaCl + 14% RHA resulted in a CBR value of 8.33% and in the original soil mixture 15% NaCl + 16% RHA resulted in a CBR value of 6.15%.

The test results show that the highest CBR value is when the variation of the original soil mixture+15% NaCl+12% RHA produces a CBR value of 9.47%, an increase from the original soil CBR value of 2.84%, an increase of 6.63% so that the CBR value becomes 12.78%.

## CONCLUSION AND RECOMMENDATION

From the research results, the liquid limit (LL) is 67.25%, the plastic limit (PL) is 35.48%, the shrinkage limit (SL) is 4.92%, and the plasticity index (PI) is 31.77%. Based on the plastic index obtained, the soil can be classified into silty clay with high plasticity. The shrinkage limit value (SL) is 4.92%, less than 10%, so it can be concluded that the tested clay has a critical swelling level, namely clay that can expand and shrink quickly. The specific gravity of the soil (Gs) is 2.63 gr/cm$^3$, so it is included in the type of organic clay. Clay without a salt mixture and Rice Husk Ash (RHA) has high development potential and low bearing capacity. The expansion potential reached 6.06% in the original soil, but after stabilization with mixed materials, the expansion potential decreased to 2.28%.

The CBR value on the original soil is 2.84%. The highest CBR value occurs when the original soil is stabilized with 12% RHA having a CBR value of 12.78% in the RHA mixture. When the soil was stabilized with 15% NaCl + rice husk ash, the highest CBR value increased, namely when the original soil mixture with 15% NaCl + 12% RHA had a CBR value of 9.47%, an increase of 6.63% where the CBR value on original soil by 2.84% increased to 9.47%.

Further studies should be done with a mixture of salt and RHA different on the same soil type. It is advisable to conduct further research with a seven-day curing duration before immersion CBR test to make a comparison. The use of clean water from faucets in the laboratory should not be used directly but must be left for a while so that the ions contained in the water settle.

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