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Strengthening and Supporting Efforts to Reduce Swelling of Soil by Using Beach Sands Through CBR Test

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Abstract. Many roads are damaged due to heavy tonnage vehicles or because the road foundation is in the form of expansive clay. The rescue effort is to use beach sand (sea sand) for stabilization / repair of road sub-grade in the form of clay. This research using experimental method to carried out by repairing/stabilizing soil clay by mixing beach sand. Sand content varies from 60%, 80%, to 100%. Mixed soil was compacted at optimum water content, then tested by CBR test and Swelling test. The results of this study are CBR (strong-support) and Swelling (development) values. Mixing: 60%, 70%, 80%, 90%, 100% beach sand against clay, able to increase the CBR value by a row: 7.3%; 9.6%; 11.8%; 18.5%; 25.2% (Lendah clay, Unsoaked), and 6.2%; 9.8%; 13.4%; 19.3%; 25.2% (Lendah clay, Soaked). The Prambanan clay, the yield is slightly smaller than the Lendah clay. The Swelling value is: 0.095%; 0.055%; 0.015%; -0.107%; -0.229% (Lendah clay), almost the same as Prambanan clay. Here it can be seen that mixing beach sand will always increase the CBR value, but if the percentage of sand is too much, the soil will easily collapse (negative swelling). The conclusion is that in the clay mixture with beach sand the optimum percentage of beach sand will be 85%.

Keywords: clay, sand, CBR, swelling

1. Introduction

Today, the development of the construction industry in Indonesia is so rapid, ranging from buildings, factories, ports, and transportation infrastructure in the form of railroads, flyovers, and highways. All of these projects will require building materials such as asphalt, cement, gravel and sand. In line with the rapid physical development, environmental damage due to exploitation of natural materials (sand and gravel) is increasingly rampant. Residents dredging sand in the river are no longer manual (with manpower) but have used a suction pump engine power which results in the river running out of sand. Then people dig the ground (mine) to take sand. The result is that everywhere the earth is gaping in holes (damage to the environment) due to sand dredging.

Furthermore, the sand and gravel were transported from the quarry to the project site using heavy tonnage trucks, as a result of which roads were damaged everywhere. Then the road was repaired by the government, then destroyed again by sand trucks. This incident repeatedly and annoyed road users. Road damage will be worsened if the highway has a basic clay layer. Within a short time the road will return damaged / bumpy even though only passed by light vehicles. This is a result of poor clay properties for roads, for example: low bearing capacity when wet, large swelling / expansion properties when wet-dry. The bad nature of this clay can actually be reduced, namely by improving the soil, eg mixed with lime, cement, sand. But now sand is scarce.

Because of this case, alternative ways to use sand from the beach / sea will be tried here for road building materials (subgrade). It is expected that the clay bearing strength will rise, and the swelling of the clay



will decrease. Road conditions in the area of Wates, Prambanan, often experience cracks, bumps and bumps on the structure of the road surface layers. This damage may be caused by the soil whose base CBR value is low and the nature of large shrinkage, the plasticity index value is large. The strength of subgrade is influenced by soil type and water content. The strength value of the bearing can be measured by CBR [1].

Sand is known as a soil stabilization material, reducing the clay's shrinkage. This sand will inhibit the expansion / swelling of clay and increase the density (density) of mixed soil, increasing the CBR value, the result is that the highway will be stronger / more stable.

People have studied kitchen salt (Na Cl), it turns out it can be used to stabilize clay soil (raising the CBR value), for example [2], [3].

In this study, beach sand (as a substitute for scarce river sand) was used for the improvement of sub grade clay soil. In addition, there will be a new business, namely the use of beach sand for building materials (roads).

This research is also an attempt to conserve natural sand on land and to save land from environmental damage due to improperly dug up people.

Previous research related is as follows. Sea sand can also be used for making asphalt concrete (for example) [4], [5].

The use of table salt to improve the technical properties of clay has been investigated by: Febry Mandasari [6]; Agus Duty Sudjiyanto [2]; Alfred Anando [3]. It turns out that table salt can increase the CBR value of clay.

The use of sand for lower foundation material has been investigated by Aswar, Yudit Agus Pranowo, Reza Maulana in Medan, but this study uses sand from rivers [7]. Darma Prabudi once examined the improvement of the properties of the lower foundation soil using a mixture of sea sand mixed with mountain sand [8].

The use of beach sand to increase bearing capacity and reduce swelling of clay soils, but the optimum percentage of sand has not yet been found [9].

Research Objectives: (1). What is the CBR value of soil in a mixture of clay and beach sand at sand content: 60%, 70%, 80%, 90%, 100% ?; (2) What is the value of swelling of soil in a mixture of clay and beach sand at the sand content: 60%, 70%, 80%, 90%, 100%?

Research Benefits: (1). Reducing environmental damage due to natural exploitation, which is digging land (to take sand). (2). Maximizing the use of beach sand that has not been maximally utilized. (3). Knowing how much influence sand has on clay in a mixture of clay and beach sand in terms of: CBR and Swelling. (3). It will be beneficial for building construction planning in areas with poor soil (clay which has high shrinkage properties) when erecting buildings, as an effort to stabilize the soil.

2. Experimental Methods

Research materials in the form of clay and sand beach (sea). Expansive clay is taken from Lendah, Wates (Kulonprogo), and Prambanan. Here a lot of road damage occurs. The beach sand used is from the beach in South Bantul. The number of test samples taken as many as (40) and (20) pieces, namely (2x2x5) x2 for CBR (Soaked & Unsoaked) and (2x2x5) for Swelling Test. The research method is experiment. Testing is done at Soil Mechanical Laboratory, Departement Civil Engineering and Planning Education, Engineering Faculty, YSU.

Test objects in the form of clay mixed with beach sand (sea) with varying percentages, ranging from 0% to 100%. These specimens were then compacted with optimum moisture content and then conducted a CBR Laboratory Test (Soaked and UnSoaked conditions) and Swelling (soil development). CBR test refers to the AASHTO T-193 standard.

The relationship between the research variables is arranged as follows.

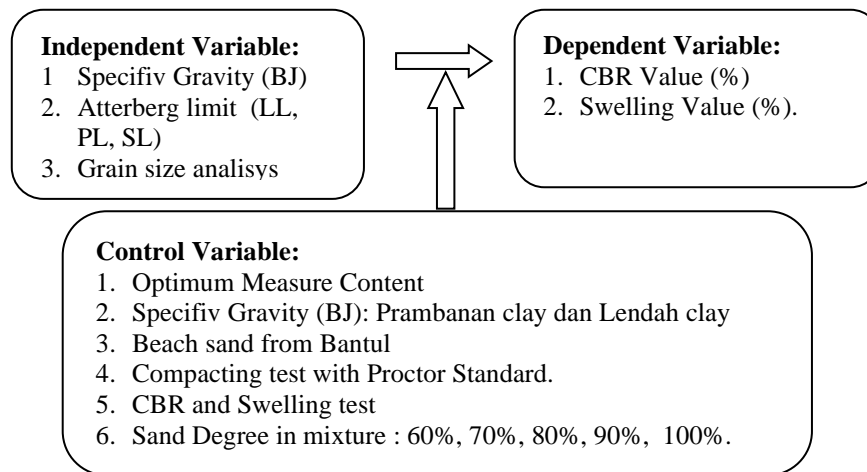


Figure 1. Experiment Variabel

Table 1. Experimental Design

1. CBR TEST in the Laboratory and Swelling Test				
Mixed composition / weight ratio Clay : Beach Sand =	The Number of Sample Test	CBR value		Swelling value (%)
		UnSoaked (%)	Soaked (%)	
Prambanan Clay				
40%L+60%P	2+2+2	CUP60	CSP60	SP60
30%L+70%P	2+2+2	CUP70	CSP70	SP70
20%L+80%P	2+2+2	CUP80	CSP80	SP80
10%L+90%P	2+2+2	CUP90	CSP90	SP90
100%P	2+2+2	CUP100	CSP100	SP100
Lendah Clay				
40%L+60%P	2+2+2	CUW60	CSW60	SW60
30%L+70%P	2+2+2	CUW70	CSW70	SW70
20%L+80%P	2+2+2	CUW80	CSW80	SW80
10%L+90%P	2+2+2	CUW90	CSW90	SW90
100%P	2+2+2	CUW100	CSW100	SW100

Information : 2+2+2 that means: two sample CBR Unsoaked test, two sample CBR Unsoaked test, two sample CBR Soaked test and two sample swelling test.

The experiment consist of 3 experimental design. The first design is native clay from Prambanan clay and Lendah clay; the second design is mixture of Prambanan clay with beach sand and the third design is mixture of Lendah clay with beach sand. The final results of the study are: CBR-Unsoaked, CBR-Soaked values, and Land Swelling (development) values.

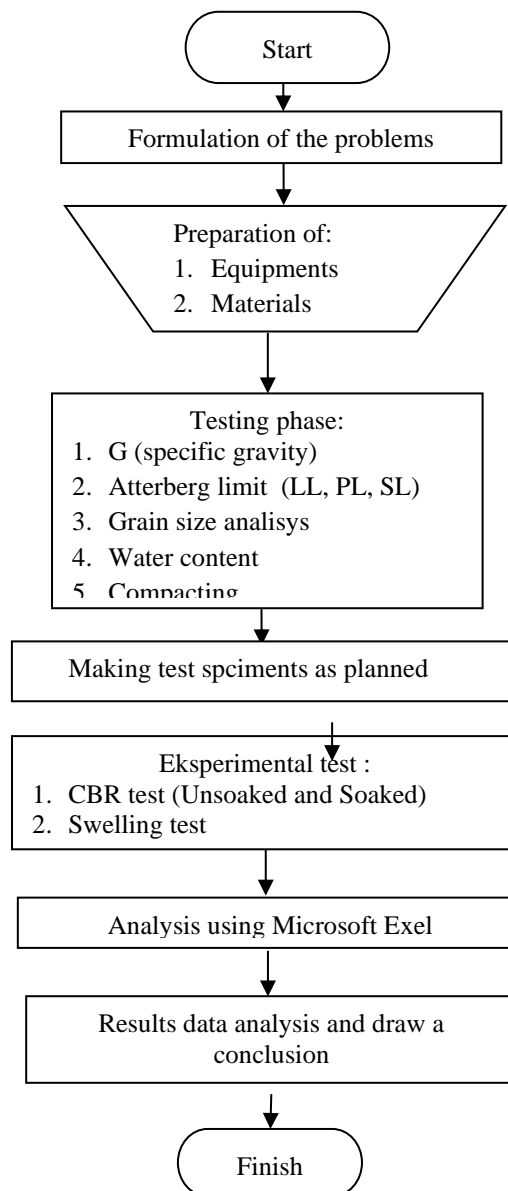


Figure 2. Testing stage flowcharts

3. Result and Discussion

3.1 Research Results

1) The results of specific gravity test of clay are as follows: the specific gravity of Lendah clay (G) is 2.60 and Plambanan clay (G) is 2.60. It means the soil clay have same value of specific gravity. The Lendah clay have liquid limit (LL) = 50%, plasticity limit (PL) = 20%; and the Prambanan clay have liquid limit (LL) = 50%, plasticity limit (PL) = 20%. While the Value of the specific gravity (G) of the beach sand from Bantul is 2.65.

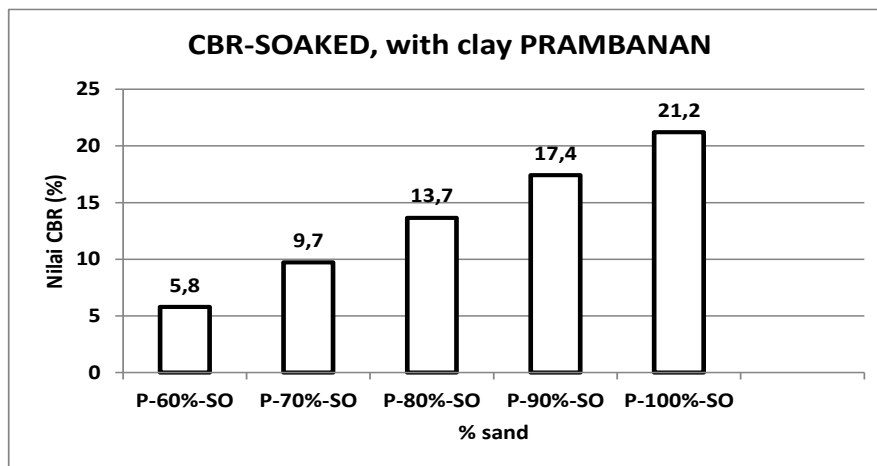
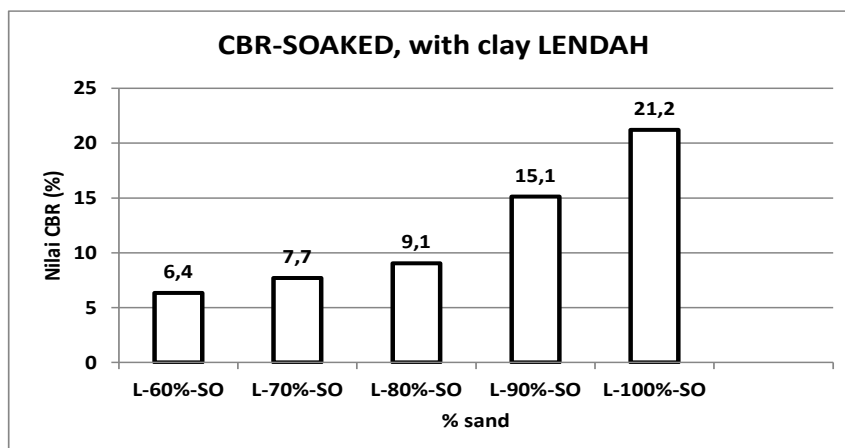
2) The results of the Optimum measure content (OMC) test and Maximum measure content (MDD) of soil clay from soil compacting test in the laboratory obtained the following data presented in Table 2.

From Table 2, it can be seen that the MDD value on mixing sand with clay of 60% and 70% has the same value, for Lendah clay and Prambanan clay. While the highest value for the MDD value is mixing sand with clay by 80% in Prambanan clay. And for the OMC value, the highest value is found in unmixed clay both for the Lendah clay and Prambanan clay, which are respectively 32.0% and 36.0%.

Table 2. The results of Soil Compacting Test

Description	MDD (gram/cm ³)	OMC (%)
Lendah Clay	1.38	32.0
L+60% sand	1.75	18,5
L+70% sand	1.75	17,5
L+80% sand	1.75	16,5
L+90% sand	1.70	14.4
100% sand	1.63	13,1
Prambanan clay	1.27	36
L+60% sand	1.75	18,7
L+70% sand	1.75	17,2
L+80% sand	1.76	16,0
L+90% sand	1.70	14,5
100% sand	1.63	13,1

3) The CBR Laboratory Test Results for UnSoaked and Soaked conditions on native clay (Prambanan and Lendah) and clay samples with Bantul beach sand, are presented in the following Figure 3, Figure 4, Figure 5 and Fugure 6.

**Figure 3.** CBR Soaked Charts with Prambanan Clay.**Figure 4.** CBR Soaked Charts with Lendah Clay.

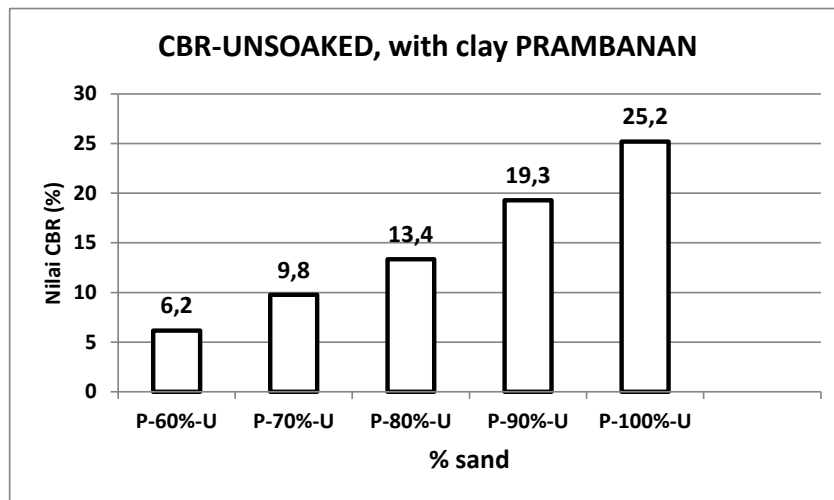


Figure 5. CBR UnSoaked Charts with Prambanan Clay.

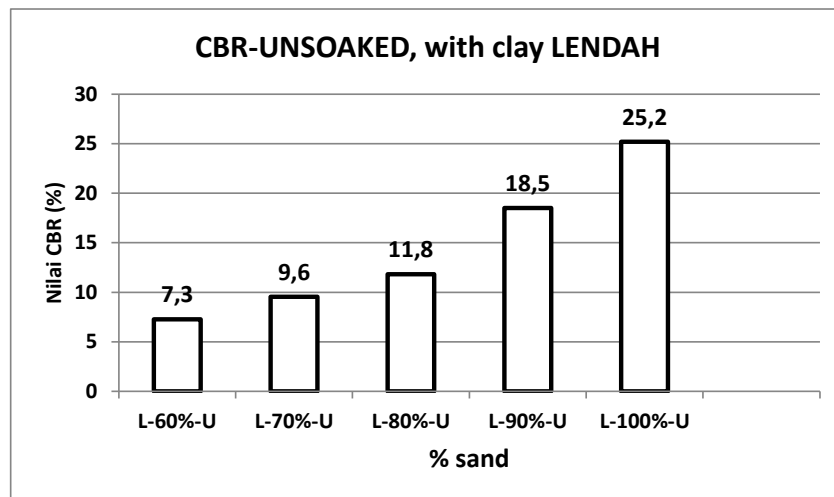


Figure 6. CBR UnSoaked Charts with Lendah Clay.

4) The results of measurements of soil swelling, namely swelling of native clay (Prambanan and Lendah) and a mixture of clay + sand in Bantul beach, obtained the following results.

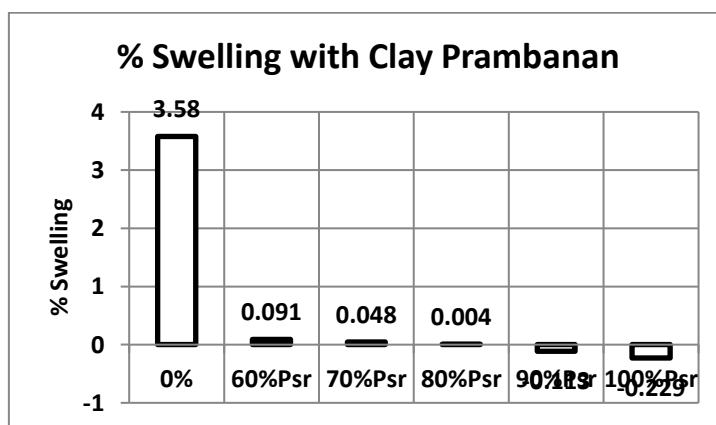


Figure 7. Swelling Charts with Clay Prambanan

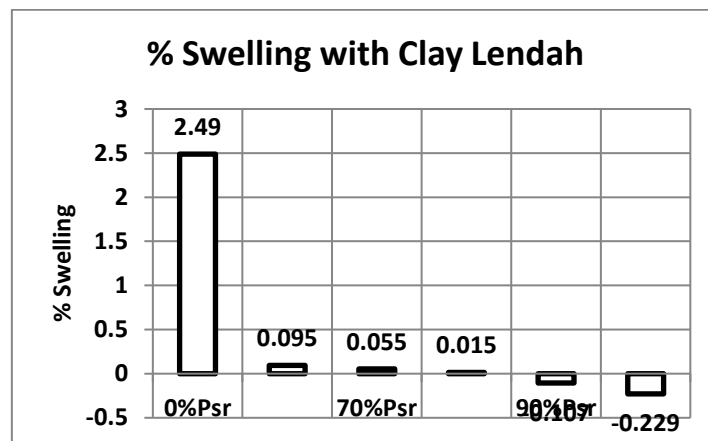


Figure 8. Swelling Charts with Clay Lendah.

3.2 Discussion

Based on the Unsoaked and Soaked CBR-Laboratory tests on a mixture of beach sand with Lendah or Prambanan clays, the following results were obtained:

1) If using Lendah clay, there will be an increase in the CBR value in Unsoaked & Soaked conditions. For the Un-soaked condition, the CBR-un value rose from 7.2% to 25.2% (up 18%). For the Soaked condition, the CBR value will increase from 6.40% to 21.2% (up 14.8%). The increase in CBR value due to the addition of sand-beach is due to the fact that sand has begun to play a role in increasing the shear strength of the soil which also means increasing the carrying capacity of the soil in supporting the load.

2) If using Prambanan, Unsoaked or Soaked clays, the CBR value increases. For unsoaked conditions the CBR-un value rose from 6.2% to 25.2% (up 19%). For the Soaked condition, Prambanan clay was proven to increase the CBR-un value from 1% to 21.2% (up 20.2%). The greater the sand content, the higher the CBR value (soaked & unsoaked). This shows that the sand began to take part in the carrying capacity of the soil. However, it's also worth noting the swelling.

Based on the Swelling Test the condition is soaked on a mixture of beach sand with Lendah or Prambanan clays, the following results are obtained:

1) If using Low Clay, there is a decrease in the value of swelling (development) of the soil by 2.475% (from 2.49% to 0.015%) at 80% sand content. If the sand content exceeds 80%, the soil will easily collapse (then a settlement occurs).

2) If using Prambanan clay, there is a decrease in the value of swelling (development) of the soil by 3.576% (from 3.58% to 0.004%) at 80% sand content. If the sand content exceeds 80%, the soil will easily collapse (then a settlement occurs).

From this research it is proven that beach sand is able to increase soil bearing strength and can reduce swelling of clay soil if given a mixture of beach sand provided that the sand content does not exceed 85%.

Follow-up from the results of this study is that the community can utilize beach sand in the construction of roads, harbor areas, airport areas because it is proven that beach sand can increase the strength of the soil as long as the sand content does not exceed 85%.

It should be noted that the collection of beach sand should not be arbitrary, that is, it must be from a beach area that is not restricted. An example of a forbidden beach area is in the Sand Dune area on Bantul beach.

4. Conclusion

Repairing clay soils by mixing clay with beach sand (clay samples from Lendah or Prambanan and sand from the Bantul beach area) using the CBR and Swelling tests, obtained the following conclusions.

1) CBR-unsoaked values on clay mixed with beach sand at sand content: 60%, 70%, 80%, 90%, 100%, are:

- a. If using a Lendah Clay, the CBR-unsoaked value in a row: 7.3%; 9.6%; 11.8%; 18.5%; 25.2%. A maximum CBR increase of 17.9% occurred at 100% sand content.
 - b. If using Prambanan Clays, CBR values are successively: 6.2%; 9.8%; 13.4%; 19.3%; 25.2%. A maximum CBR increase of 19% occurred at 100% sand content.
- 2) CBR-soaked values in clay mixed with beach sand at 60%, 70%, 80%, 90%, 100% sand content are:
- a. If using Lendah Clay, the CBR-soaked value in a row: 6.4%; 7.7%; 9.1%; 15.1%; 21.2%. A maximum CBR increase of 14.8% occurred at 100% sand content.
 - b. If using Prambanan Clays, the CBR-soaked values are: 5.8%; 9.7%; 13.7%; 17.4%; 21.2%. A maximum CBR increase of 15.4% occurred at 100% sand content.
- 3) Swelling value (development) of mixed soil of clay and beach sand at 0%, 60%, 70%, 80%, 90%, 100% sand content is:
- a. If using the Lendah Clay, the value of Swelling in a row: 2.49%; 0.095%; 0.055%; 0.015%; 0.107%; -0.292%. The greater the sand content, the reduction of swelling is also greater, but if the sand content exceeds 85%, the soil actually collapses (negative swelling).
 - b. If using Prambanan Clay, successive Swelling values: 3.58%; 0.091%; 0.048%; 0.004%; -0.113%; -0.292%. The greater the sand content, the reduction of swelling is also greater, but if the sand content exceeds 85%, the soil actually collapses (negative swelling).

5. References

- [1] Silvia S, 1999 *Highway Pavement Pavement* (Bandung: Nova Publisher)
- [2] Agus D S 2007 Expansive Clay Soil Stabilization with Kitchen Salt (Na Cl) *Journal of Civil Engineering* **8** 53-63
- [3] Alfred A 2013 *Clay Soil Stabilization Using Kitchen Salt (NaCl) dg through CBR Test in the Laboratory (Case Study: Land Clay ... Univ. Andalas)* (Padang: Andalas University)
- [4] Ratnasari R and Novita P 2008 *Study on the Utilization of Sea Sand as Fine Aggregates on Asphalt Concrete Mixture* (Scientific magazine 'MekTek')
- [5] Ahmat R 2015 Effects Use of Sea Sand As Fine Aggregate in Hot Asphalt Mixtures (AC-BC) with Marshal Testing *Journal of Civil Engineering ITP* **2** 1 5-12
- [6] Febry M 2016 *Study of the Effect of Mixture of Salt and Lime on Stabilization of Silty Clay* (Jakarta: Universitas GunaDarma)
- [7] Aswar, Yudit A P and Reza M 2012 CBR Improvement Study Lower Base Layer Material due to Sand Addition *Journal of Civil Design* **1** 1 41-49
- [8] Darma P 2003 *The Performance of the Lapis Foundation and Lower Foundation Laboratory with Sea Sand as Substitute Material for Some of Its Fine Aggregates* (Bandung: Bandung Institute of Technology)
- [9] Endaryanta, Dian E W and Pusoko P 2018 *Utilization of Beach Sand for Reducing Expansiveness and increasing Clay Support Strength Through CBR Test* (Yogyakarta: UNY Research)