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Investigation on California Bearing Ratio (CBR) Value on Stabilised Peat Using Ceramic Waste

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Abstract: The peat soil is often considered problematic for the development because of its low shear strength, high water content and high compressibility. This study will concentrate on waste ceramic as addictive to improved soil strength. Therefore, the problem of ceramic waste disposal is something that should be a serious concern. Rather than disposal in landfills, ceramic waste may be used in geotechnical engineering applications, which is to increase the shear strength of the soil. During this study, a preliminary is taken to analyse the function of ceramic waste (tiles) that are used in soil improvement as a strengthening agent toward peat soil, in order to find out the potential methods of using the ceramic waste in huge practice for geotechnical applications to increase the soil properties and furthermore to decrease the area of a land for removal waste. The main objective for this study was to determine the best ceramic waste ratio for the stabilization of the peat soil. The California Bearing Ratio (CBR) test were conducted on the study. California Bearing Ratio (CBR), tests were conducted on the mixtures of the peat soil with the ceramic dust. The sample had been curing for 7 days with different percentage of ceramic dust. The 4% and 8% of ceramic dust for unsoaked obtain CBR value of 12.7% and 29% respectively. Next sample also 4% and 8% of ceramic dust for soaked obtain CBR value of 8% and 25% respectively.

Keywords: Peat Soil, California Bearing Ratio (CBR), Ceramic Waste

1. Introduction

Peat soil is framed from materials that are halfway decayed in anaerobic water immersion. This peat soil has a very high content of organic matter. The arrangement of peat is impacted by the humidity and temperature in it. The development of foundation on peat soils is unimaginably trying for the engineer because of its low shear strength, high pressure and high water content that will cause engineer to ensure that the buildings that was devolve on peat soil won't crack afterward because of the high moisture content in the peat (Hua, 2016). These features will cause issues and challenging in development in

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different viewpoints, for example, pre-development troubles, post-development disappointment, development costs, upkeep issues, yet in a present moment and future effect (Hua, 2016)

For satisfactory performance of the structural that placed on such soil, the properties of the peat soil must be improved. The principal objective of this study is to sort out the ratio of ceramic waste for stabilizing. Second is to find out the CBR value and also the last one is to investigate the applicable the ceramic waste as stabilize agent. This paper will study on the application of waste ceramic as that the agent that will use as additives to increase the characteristics of soil. Stabilization using ceramic waste as addictive agent could be used to improving the properties of peat soil.

Ceramic waste is very readily available in various manufacturing units and on construction sites due to the production to produce various stuff. In developing countries such as Malaysia, waste management may be a major concern on how waste going to be disposal as waste is produced at a rapid rate. It will need a larger area for landfills to dispose the ceramic waste. However, there is a limit on the disposal area that can use to dispose the waste, it necessary to come out with the alternative to reduce waste by using the waste i.e. using the waste as a peat stabilizer. Ceramic waste is often used for soil stabilization because ceramic waste is safer from the environment. Subsequently, the utilization of ceramic waste was not only can improve the properties of the soil yet the matter of removal issue can likewise be settled (Hua, 2016). This paper were study the ratio of ceramic dust in order to stabilize peat using the California Bearing Ratio (CBR) test when it absolutely mix with peat. The ceramic dust useful as agent to increase the soil strength of the peat. The right ratio of ceramic dust was determine using California Bearing Ratio (CBR) test.

2. Use of ceramic waste in stabilisation peat

Ameta et al. (2013) utilized of ceramic waste to settle sand ridges, produce a practical development material, and tackle the issues made by the removal of ceramic waste (tile) from previous construction project. Powdered ceramic tiles are widely used as an environmental additive to improve the properties of soft soils by increasing index and mechanical properties. It's a cost-effective method to add value to soils while being environmentally friendly. Ceramic tiles were tested in various percentages to determine their suitability in treating soft soils and to establish the ideal percentage. A comparative analysis for the optimum percentage of ceramic tiles proposed by researchers to increase the index and mechanical properties of soft soils. Ranji et al. (2014) found that tile waste could improve peat soils. For this type of soil, appropriate treatment is required before it can be used to build pavements for any infrastructure. To stabilize an expansive soil, waste ceramic was used as an additive in their study to minimize the environmental impact and the economic value. The tile waste additive could result in higher performance and strength compared to the untreated expansive soil. According to Sumayya et al. (2016), tile wastes were utilized to treat peat and create a high-quality pavement subgrade. Ceramic tiles also improve the engineering characteristics of soils used as a subgrade for pavement that contributes to the reduction in maintenance costs of untreated soils.

3. Materials and methods

The main material is ceramic dust and peat soil that was collected in Parit Nipah, Batu Pahat, Johor area.

3.1 Ceramic dust

Waste ceramic tiles was collected from the different development projects and change over into powder structure utilizing a jaw smasher machine. After the powder has gone through #200 No. ASTM sieve, a material delivered call ceramic dust.

3.2 Peat soil

Peat soil that was used for this study is within the Parit Nipah, Batu Pahat, Johor.

3.3 Proctor compaction test

A Proctor compaction test was used to evaluate the properties of soil compaction, such as determined the optimal water content at which soil is able to reach its maximum dry density. Optimum moisture content and maximum dry density of expansive soil with various percentages of tile waste were determined according to I.S heavy compaction test. The process of compaction is to increasing the soil's density and removing the air. In order to improve the strength and stiffness of soil, it should be purposefully compacted.

3.4 California bearing test

The California Bearing Ratio (CBR) test is performed in order to determine the CBR index value and the performances of the samples. The test was performed according to the standard procedure stated in BS1377-4: 1990. The CBR test method was used to evaluate the strength of peat soil. A CBR is used in the study to evaluate the strength of peat mixed with varying percentages of cement dust in both unsoaked and soaked conditions.

3.4 Soil sample preparation

All the sample of soil was prepared for this study according to ASTM Standard D1997. Generally, peat samples was mixed with a certain percentage of different ceramic dust for 7 days curing periods. This sample was tested using CBR test to determine the effectiveness and performance of the soil after using ceramic waste to stabilize the soil.

Table 1: Sample preparation data

Type of sample	**Percentage addictive**	**Number of sample (soaked and unsoaked)**
Peat soil	4% of ceramic dust	2
	8% of ceramic dust	2

3.5 CBR test procedure

The soil has been divided into 4 portion. The empty mold has been weighted. For sample 1 and sample 2 the untreated peat soil was mix with 4% of ceramic dust. While for sample 2 and sample 3 was mix with 8% of ceramic dust. The water was added into the all sample and mix it well. The specimen was filled into the mold and the compaction has been done for 62 layer per blow in five layer. After the blow had been done for compaction, the collar and level the surface had been remove. Weight the mold and the compacted specimen for the next step. After that placed mold in air curing method for 7 days. The unsoaked CBR test was performed after 7 day curing period while the another sample for soaked CBR was splash for 4 days before the drench CBR test was convey.

4.0 Results and discussion

Table 2 summarizes the result from the experiment in which four samples were tested using various amounts of ceramic dust and in two conditions, soaked and unsoaked.

The wet density has been obtained for sample 1 which is contain 4% of ceramic dust in soaked condition are 696.5kg/m3 For unsoaked conditions that contain similar percentage of ceramic dust are 860kg/m3. As can be seen, the wet density of ceramic dust unsoaked is higher than soaked and at 4% of ceramic dust.

Additionally, the wet density for 8% of ceramic dust in soaked condition was obtained to be 888kg/m3, which is higher than the wet density for 8% of ceramic dust in unsoaked condition, which was 867kg/m3.

The higher dry density value are obtained for sample 2 which is 15.5 kg/m3. Sample 2 contains 8% of ceramic dust in soaked condition compared to sample 4, which contains 8% of ceramic dust in unsoaked condition and has 14.2 kg/m3 value of dry density. Samples 1 and 3 both contain 4% ceramic dust in soaked and unsoaked conditions, respectively. Their dry density values are 10.9 kg/m3 and 13.2 kg/m3. The California bearing ratio of the peat soil increases with the percentage of ceramic waste. With increasing proportions of ceramic waste dust in the peat soil, the dry density increases.

The optimum moisture content for 4% ceramic waste in soaked conditions 63% meanwhile for 8% ceramic waste in soaked condition the optimum moisture content is 56%. Optimum moisture content of the peat soil decreases as the percentage of ceramic waste increases and the maximum dry density obtained at certain optimum content of ceramic waste and increase beyond this optimum content of ceramic waste.

Table 2: Summary of the properties of the sample

Sample	1	2	3	4
Type of test	**soaked**	**soaked**	**unsoaked**	**unsoaked**
ceramic waste	4%	8%	4%	8%
No of blows	62/per layer	62/per layer	62/per layer	62/per layer
No of layer	5 layer	5 layer	5 layer	5 layer
Empty weigth of mould,W1 (kg)	7.6	7.06	7.18	7.12
Weigth of mould + wet sample, W2 (kg)	9.52	9.56	9.6	9.56
Volume of sample,V (m3)	0.002814	0.002814	0.002814	0.002814
Wet density y= (W2-W1)/V (kg/m3)	696.5	888	860	867
Can no (before soaked)	1	2	3	4
weigth of empty can, A	140g	140g	70g	70g
Weight of can + wet sample, B	320g	390g	530g	470g
Weight of can + dry sample, C	250g	300g	350g	320g
Water content,W%= [(B-C)/(C-A)]*100	63%	56%	64%	60%
Dry density, yd=y/(1+W) (kg/m3)	10.9	15.5	13.2	14.2

4.1 California Bearing Ratio Test

4.1.1 4% ceramic dust, soaked – top

Table 3 shows the bearing ratio results from the California bearing ratio test (CBR) for sample 1, which contains 4% ceramic dust mixed with peat soil under soaked conditions after curing for 7 days. As a result, when a piston penetrates the surface by 2.5 mm, the CBR value is 2.9%. In the meantime, when the penetration of the piston reaches 5 mm, the CBR value is 4.2%. Its can concluded, the peat soil with

4% of ceramic dust in soaked condition as an addictive is having a poor- fair rate performance of the peat soil.

The CBR value is usually base on the load ratio for penetration of 2.5 mm. However the result show the penetration of 5 mm is larger, so the test has been repeated for the bottom sample.

Table 3: CBR value for 4% in soaked (top)

Penetration (mm)	Std load kgf/cm2	read load kgf	read load kgf/cm2	corrected load kgf/cm2	CBR %
0.625		3	0.2	0.6	
1.25		6.7	0.3	1	
1.875		11.5	0.6	1.5	
2.5	70	17.8	0.9	2	2.9
3.75	88	37.1	1.9	3.2	
5	105	59.7	3.1	4.4	4.2
7.5	134	106.8	5.5	6.9	
10	162	156.7	8.1	9.5	
12.5	183				

Figure 1 shows the relationship between stress load and penetration for top sample 1 (4% ceramic dust, soaked) CBR tests. According to this graph, the CBR values increased with increasing penetration. Test result show when the penetration 2.5mm the value for stress load is 0.9kgf/cm2 and for 5mm penetration the value of stress load increase to 3.1kgf/cm2. This shows that the minimum stress load is 0.2kgf/cm2 and the maximum amount is 8.1kgf/cm2.

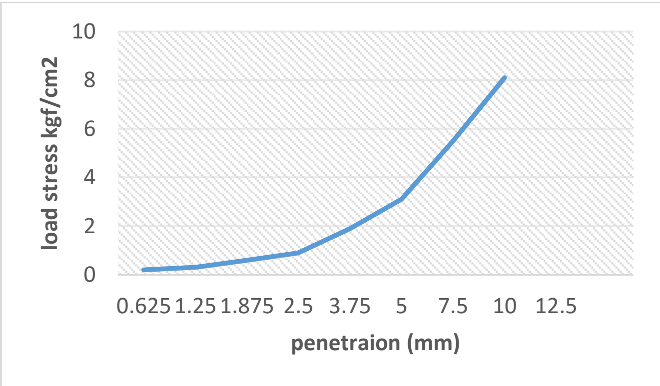

Figure 1: CBR soaked curve for 4% of ceramic dust (top)

4.1.2 4% ceramic dust, soaked bottom

Table 4 shows the result for sample 1 which is at the bottom sample of CBR test. The CBR value for penetration of the piston for 2.5 mm is 6.4% meanwhile for 5 mm penetration is 8%. An addition CBR value for 5 mm penetration is larger than 2.5 mm. In the meantime, the CBR value for 5 mm for bottom sample test higher than top sample test for 4% of ceramic dust for soaked. So the value of CBR for 4% of ceramic dust in soaked condition is 8%.

Based on both result for 4% ceramic dust in soaked condition. The CBR value for bottom sample shows that the bottom sample has higher CBR value then top sample test at 5mm penetration. For bottom test for 4% ceramic dust the rate performance of the soil is at fair condition. The CBR value is usually based on the load ratio for penetration of 2.5mm. However, the result show the penetration of

5mm is larger, so the test has been repeated for the bottom sample. The results show for second test which is bottom test has larger value of CBR at 5.00mm then this larger value has been adopted

Table 4 CBR value for 4% in soaked (bottom)

Penetration (mm)	Standard load kgf/cm2	Read load kgf	Read load kgf/cm2	Corrected load kgf/cm2	CBR %
0.625		32.3	2.1	2.1	
1.25		50.1	2.5	2.5	
1.875		67.3	3.8	3.8	
2.5	70	107.5	4.5	4.5	6.4
3.75	88	135.7	6.7	6.7	
5	105	195.3	8.4	8.4	8
7.5	134	206.8	13.6	13.6	
10	162	229.5	20.1	20.1	
12.5	183				

Figure 2 shows the relationship between the stress load and penetration. The graph shows the increase in load as penetration increases. The minimum value of load is 2.1kgf/cm2 at the 0.625mm of penetration. The maximum value of load is 20.1kgf/cm2 at the 10 mm of the penetration. It can be concluded that when load increases, bearing capacity increases, which will increase the strength of the soil as well.

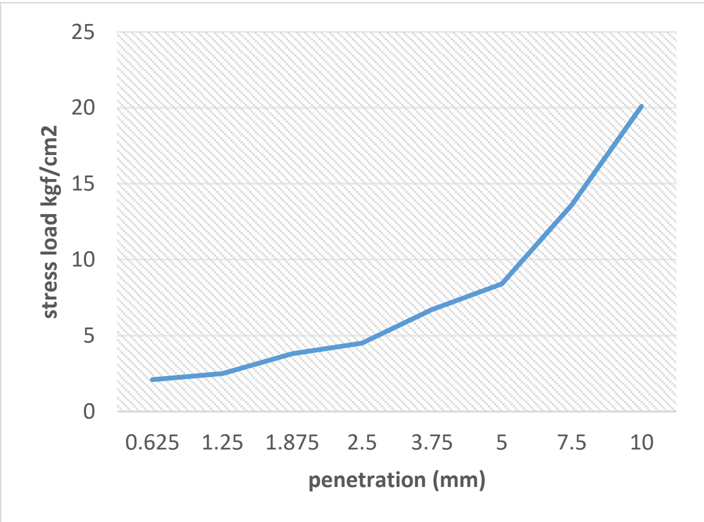

Figure 2: CBR soaked curve for 4% of ceramic dust (bottom)

4.1.3 8% ceramic dust, unsoaked-top

Table 5 shows the results of CBR for sample 4, which is at the top sample. This sample contain 8% ceramic dust and in an unsoaked condition. The CBR value for penetration of the piston for 2.5 mm is 8.3% meanwhile for 5 mm penetration is 11.4%. An additional CBR value for 5 mm penetration is larger than 2.5 mm. Since the CBR value only 8%, it is classified as a fair soil condition. The CBR value is usually base on the load ratio for penetration of 2.5mm. However the result shows the penetration of 5mm is larger, so the test has been repeated for the bottom sample.

Table 5: CBR value for 8% in unsoaked (top)

Penetration mm	Standard load kgf/cm2	Read load kgf	Read load kgf/cm2	Corrected load kgf/cm2	CBR %
0.625		8.6	0.4	1.9	
1.25		22.4	1.2	3	
1.875		42.1	2.2	4.4	
2.5	70	65.1	3.4	5.8	8.3
3.75	88	121.3	6.3	7.5	
5	105	180.1	9.3	12	11.4
7.5	134	301.9	15.6	18.2	
10	162	420.6	21.7	24.3	
12.5	183				

A relationship between stress load and penetration for sample 4 (8% ceramic dust, unsoaked) is shown in Figure 3. The figure represents the top sample test. According to this data, the CBR values increased with increasing penetration. Test results show that when penetration is increased from 0.625 mm to 10 mm, stress load also increases from 0.4kgf/cm2 to 21.7kgf/cm2. As the stress increases, the value of CBR will also increase, which in turn will increase the soil's shear strength.

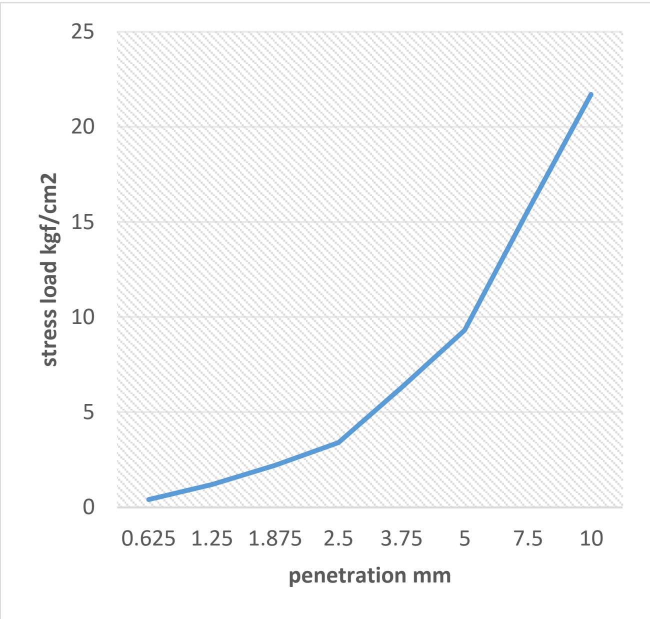

Figure 3: CBR unsoaked curve for 8% of ceramic dust (top)

4.1.2 8% ceramic dust, unsoaked-bottom

Table 6 shows the results of the second test which is bottom sample 4 containing 8% ceramic dust in an unsoaked condition. The CBR value for penetration of the piston for 2.5 mm is 29% and for 5 mm penetration is also 29%. However, the value for stress load is increasing along with the penetration pistons. A penetration of 2.5 mm and a penetration of 5 mm produce the same CBR value. However, for 8% ceramic dust in unsoaked condition, the CBR value is 29% since the top sample demonstrates a CBR of only 11.4%. The larger value is adopted for this sample since the bottom test exhibits a higher CBR, which is 29%. This sample also is belonging to good soil condition.

Table 6: CBR value for 8% in unsoaked (bottom)

Penetration mm	Standard load kgf/cm2	Read load kgf	Read load kgf/cm2	Corrected load kgf/cm2	CBR %
0.625		168.6	8.7	8.7	
1.25		253.7	13.1	13.1	
1.875		326.6	16.9	16.9	
2.5	70	392.1	20.3	20.3	29
3.75	88	496.1	25.6	25.6	
5	105	581.7	30.1	30.1	29
7.5	134	705.9	36.5	36.5	
10	162	803.2	41.5	41.5	
12.5	183				

Figure 3 illustrates the relationship between stress load and penetration of piston for sample 4 which contains 8% ceramic dust and in unsoaked condition. The figure represents the second test, which is the bottom sample test. With an increase of penetration of the piston, the stress load will increase as well, resulting in an increase in CBR value. According to this data, the CBR values increased with increasing penetration. Testing shows when penetration increases from 0.625 mm to 10 mm the stress load also increase from 8.7kN to 41.5kN. As the stress increases, the CBR value also increases, which in turn will increase the shear strength of the soil.

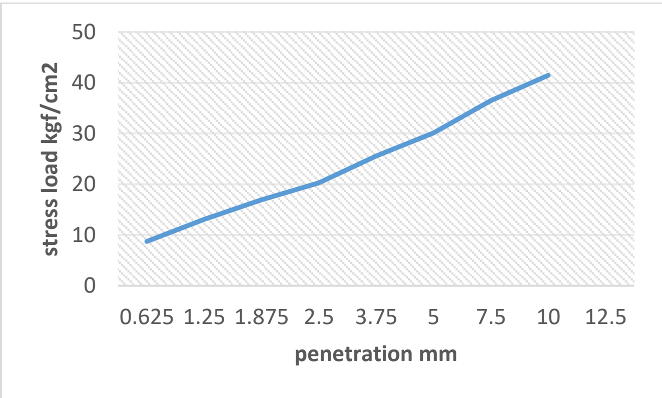

Figure 3: CBR unsoaked curve for 8% of ceramic dust (bottom)

Table 7: Comparison between 4% and 8% of ceramic dust in soaked and unsoaked condition

No of sample	1 (soaked, 4% ceramic dust)		2 (soaked,8% ceramic dust)		3(unsoaked, 4% ceramic dust)		4(unsoaked,8% ceramic dust)	
Type	Top	Bottom	Top	Bottom	Top	Bottom	Top	Bottom
CBR value for 2.5mm	2.9%	6.4%	8%	25.6%	4.1%	12.7%	8.3%	29%
CBR value for 5mm	4.2%	8%	10.7%	23.3%	5.5%	12.7%	11.4%	29%

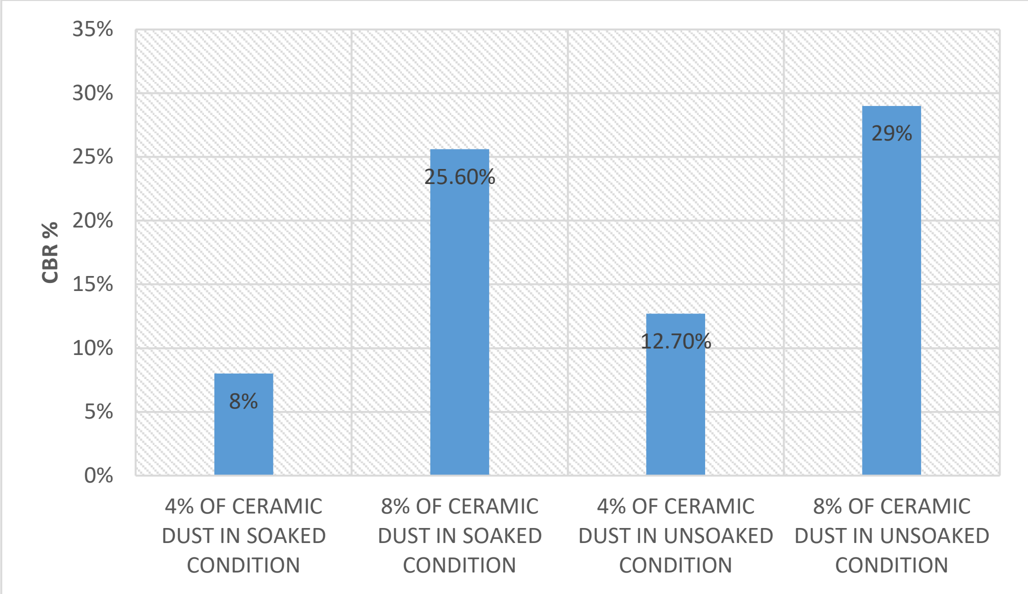

Figure 4: comparison of the CBR value in different percentage of ceramic dust

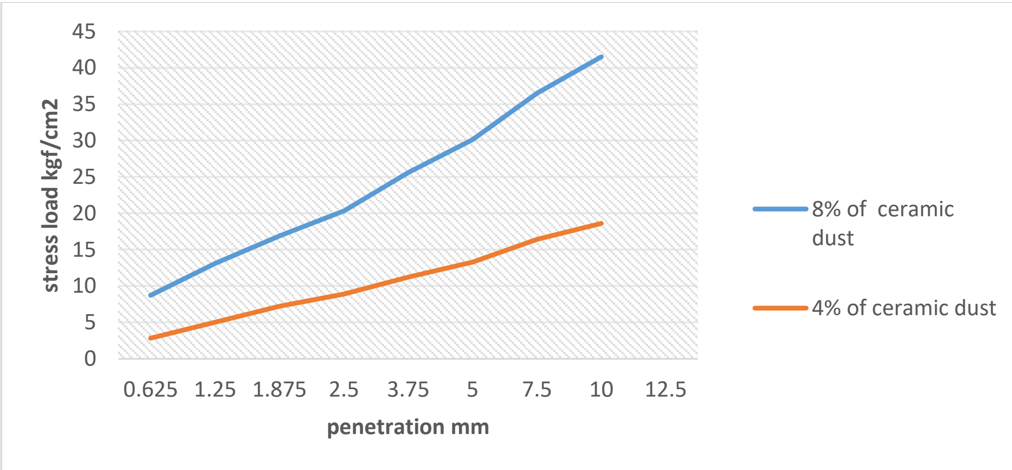

Figure 5: CBR unsoaked curve for 8% and 4% of ceramic dust

Figure 5 shows the different of the CBR curve at 4% ceramic dust and 8% of ceramic dust. The 8% of ceramic dust gained the higher value compared to the 4% of ceramic dust. The value was increased from penetration at 0.625 until 10 mm. however the higher value is 41.5 kgf/cm2 for 8% of ceramic dust.

CBR test was performed on the untreated peat soil sample with different percentages of stabilizer which are 4%, and 8% ceramic dust and were cured for 7 days curing period at unsoaked and soaked condition. All the mixtures were compacted at optimum water content.

From the result at Figure 4 the value of the CBR for bottom is higher that top for every sample. For soaked sample at 4% of ceramic dust, the value for CBR is 8%. Meanwhile for unsoaked at the 4% of ceramic dust is 12.7%. For soaked sample at 8% of ceramic dust the value of CBR is 25.6%. Meanwhile for unsoaked at 8% of ceramic dust 29%. Based on the result the CBR value for unsoaked sample is higher than soaked sample.

From the result, it can be concluded, the CBR strength increase if the dry density of the soil increase. This is because the higher the dry density of the soil the denser the soil thus more strength.

The effect of mixing ceramic dust on peat to its strength can be seen from the results of CBR testing, with curing time 7 days. The result shows the effect on adding ceramic to peat as addictive increase the

CBR value. It can be seen that the stabilized test specimen with an 8% ceramic dust (unsoaked) and peat positively increased the soil bearing capacity. It is seen that the increase of percentage of ceramic dust causes the increase in CBR value. Thus the amount of load for penetration increase, the strengthened the stabilized soil also increase which resulted in the CBR increase, which resulted in the CBR increase. The mixing of peat and ceramic dust increase the value of CBR so it’s causing the peat strength to increase as well.

CBR values ranging from 20 to 30% are considered as a good consistency. This means that the untreated peat mix with 8% of ceramic dust belong to good consistency resulting from the compaction process at the optimum water content and with the additives ceramic dust because the CBR value for that sample is 29%. The process used in this research to strengthen peat soil caused the stabilized peat soil to gain considerable strength, and therefore its load bearing capacity improved.

The stabilised soil by using ceramic dust which is 8% was suitable for the subgrade as the CBR value for this stabilised soil is 25.6% for soaked and 29% for unsoaked. A clayey soil generally has a low CBR value (less than 8). The best CBR values, generally 25 and up. The sub-base material should have minimum CBR of 20% for cumulative traffic up to 2 msa and 30% for traffic exceeding 2 msa. That is why it is suggested to use ceramic dust as stabiliser in order to use this soil as subgrade. The higher the CBR of foundation soils you have, the less pavement structure is needed, the more economical the design.

During the test certain precautions should be followed such as aligning the surcharged weight with the plunger so that the plunger penetrates into the soil freely and ensuring that the compaction is performed with 62 blows every layer so that any possible errors are prevented.

4. Conclusion

In conclusion, peat soil work well with ceramic dust as stabilized agent as the result shows the CBR values is much higher when added more amount of ceramic dust compared to unstabilized soil (without ceramic dust) . As can be seen from the above experimental results, the ceramic dust can react as addictive to stabilized peat soil it can developed high shear strength, low water content and low compressibility moisture content. It has been found that stabilized peat's curing period has an impact on its CBR value. The shear strength of the stabilized peat increases significantly with a 7-day curing period. The result shows that ceramic waste can applied in order to increase geotechnical properties so that we can reduce any addictive to stabilize soil to increase soil strength such as lime and others that can cost much money compared to the ceramic waste. The huge global environmental crisis can be solved while promoting sustainable development of society and economy at the same time.

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References

[1] Ameta, N. K., Wayal, A. S., and Hiranandani, P. (2013). “Stabilization of dune sand with ceramic tile waste as admixture.” American Journal of Engineering Research (AJER), Vol. 2, No. 9, pp. 133-139.

[2] Amiralian, S., Chegenizadeh, A., and Nikraz, H. (2012). “A review on the lime and fly ash application in soil stabilization.” International Journal of Biological, Ecological and Environmental Sciences (IJBEES), Vol. 1, No. 3, pp. 124-126

[3] Adon, R., Bakar, I., Wijeyesekera, D., Zainorabidin, A., Tun, U., Onn Malaysia, H., Pahat, B. (2012). Overview of the Sustainable Uses of Peat Soil in Malaysia with Some Relevant

Geotechnical Assessments. International Journal of Integrated Engineering -Special Issue on ICONCEES, 4(3), 38–46

[4] Akhtar Hossain, Md. (2019). Improvement of Strength and Consolidation Properties of Clayey Soil Using Ceramic Dust. American Journal of Civil Engineering, 7(2), 41. https://doi.org/10.11648/j.ajce.20190702.11

[5] Al-Bared, M. A. M., Marto, A., & Latifi, N. (2018). Utilization of Recycled Tiles and Tyres in Stabilization of Soils and Production of Construction Materials – A Stateof-the-Art Review. KSCE Journal of Civil Engineering, 22(10), 3860–3874. https://doi.org/10.1007/s12205-018-1532-2

[6] Balegh, B., Sellaf, H., & Hadjmostefa, A. (2020). Effect of ceramic waste on mechanical and geotechnical properties of tuff treated by cement. Case Studies in Construction Materials, 13, e00368. https://doi.org/10.1016/j.cscm.2020.e00368

[7] Chang, I., Im, J., and Cho, G. (2016). “Introduction of microbial biopolymers in soil treatment for future environmentally-friendly and sustainable geotechnical engineering.” Sustainability Review, Vol. 8, No. 250, pp. 1-23.

[8] Chen, J., & Idusuyi, F. (2015). Effect of Waste Ceramic Dust (WCD) on Index and Engineering Properties of Shrink-Swell Soils. International Journal of Engineering and Modern Technology, 1(8).

[9] Fattah, M. Y., Al-Neami, M. A., and Al-Suhaily, A. S. (2015). “Strength improvement of soft soil treated using stone columns.” Engineering & Technology Journal, Vol. 33, No. 8, pp. 1740-1756

[10] Fauzi, A., Djauhari, Z., and Fauzi, U. J. (2016) “Soil engineering properties improvement by utilization of cut waste plastic and crushed waste glass as additive.” IACSIT International Journal of Engineering and Technology, Vol. 8, No. 1, pp. 15-18, DOI: 10.7763/IJET.2016.V8.851.

[11] Hamad, A. J., Sldozian, R. J. A., & A. Mikhaleva, Z. (2020). Effect of ceramic waste powder as partial fine aggregate replacement on properties of fiber-reinforced aerated concrete. Engineering Reports, 2(3). https://doi.org/10.1002/eng2.12134

[12] Hua, L. J., Mohd, S., Ahmad Tajudin, S. A., Ali Mohamad, S. N., Bakar, I., Mohd Masirin, M. I., Mahmood, A. A.-W. (2016). Construction of Infrastructure on Peat: Case Studies and Lessons Learned. MATEC Web of Conferences, 47, 03014. https://doi.org/10.1051/matecconf/20164703014

[13] Huat, B. B. K., Maail, S., & Mohamed, T. A. (2005). Effect of Chemical Admixtures on the Engineering Properties of Tropical Peat Soils. American Journal of Applied Sciences, 2(7), 1113–1120. https://doi.org/10.3844/ajassp.2005.1113.1120

[14] Wijeyesekera, D. C., Numbikannu, L., Ismail, T. N. H. T., & Bakar, I. (2016). Mitigating Settlement of Structures founded on Peat. IOP Conference Series: Materials Science and Engineering, 136, 012042. https://doi.org/10.1088/1757- 899x/136/1/012042