Effect of Curing Time and Repeated Drying-Wetting on Properties of Clay Stabilized With Calcium Carbide Residue, Trass and Fiber Plastic Waste

by Ngudiyono Ngudiyono

Effect of Curing Time and Repeated Drying-Wetting on Properties of Clay Stabilized With Calcium Carbide Residue, Trass and Fiber Plastic Waste

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***Abstract*— Waste issue becomes complicated problems in urban areas, especially plastic waste and Calcium Carbide Residue (CCR). Clay without stabilization are unsuitable for earth structure and pavement. One of the clay stabilizing agent utilizing the waste material is CCR, trass and plastic waste fiber. To study the properties of clay stabilized do experimental tests in the laboratory, ie an initial test to see soil physical properties, soaked and un-soaked CBR test with variations curing 0 day, 7 days, 14 days and 28 days, SEM and XRD test to see mineralogy of pozzolanic reactions, repeated wetting and drying treatment for see the durability of the soil to the weather. The results showed that both the CBR value un-soaked and soaked increases with increasing curing time, the highest CBR value at 28 days curing for samples tested. From the SEM and XRD test states with increasing curing time then there is agglomeration of the wide sheet into smaller sheets, but the reaction has been running mineral pozzolanic CSH and CAH has not been formed. CBR and durability index values decrease with increasing drying-wetting cycles.**

***Index Term*— clay, calcium carbide residue, trass, plastic waste fibers, curing, repeated drying-wetting**.

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I. INTRODUCTION

Waste problem becomes complicated problems in urban areas, especially plastic waste. Plastic garbage lately dominates, because almost all of the packaging of food products, beverages, electronics, clothing etc. derived from a plastic material. One way of utilizing polypropylene plastic waste with PP code to recycle waste plastics into a fiber that can be used for clay soil reinforcement materials.

Increased strength of clay subgrade is an important thing in innovation in civil engineering in particular road construction. Clay is one kind of soil is not good for the structure so replacing it with better material, or soil improvement for example compaction and stabilization method. Clay is formed from the sedimentation process, composed of particles that are very small, particles size is less than 0,002mm [1] and has the plasticity when mixed with water [2]. In clay with content expansive mineral have a high capacity ion exchange resulted in expansive clays in the event of a change in water content will have a high swelling-shrinkage potential [3], which cause structural damage, but it also relatively low bearing capacity. Therefore, it needs to be stabilized subgrade clay before it is built on top of the structure.

Stabilization of clay is generally done chemically with other substances that cause chemical reactions or mechanically by adding other materials with better mechanical properties. Chemical soil stabilization methods commonly used by mixing pozzolan material, for example minerals trass. However, the relatively low CaO content so it in a state of their own without the addition of CaO from other materials, will not harden, therefore trass need to mix calcium carbide residue.

Research conducted by [4] showed improving soil with chemical method, use by 10% trass 3-day treatment period was able to improve shear parameters on Tanon clay. Utilization of calcium carbide residue for clay stabilization in the village of Cot Seunong (Aceh) conducted by [5], the results show CBR value increase until rises to 12% in the amount of calcium carbide residue as 18.69 (CBR Un-soaked) and 11.78 (CBR Soaked) as well as the swelling value was reduced by 47%.

Utilization of plastic fibers are mixed randomly on soil will increase the strength and stability of the soil [6], improve the ductility of the soil [7], more strongly receive tensile load and resulting composite material has the mechanical behavior much better [8].

In this research, CCR, fiber plastic waste and trass used as a stabilizing agent, and then to study at the properties of clay stabilized do experimental tests in the laboratory, that is CBR test (soaked and un-soaked) with variations curing 0 day, 7 days, 14 days and 28 days, SEM and XRD test to know particle mineralogy of pozzolanic reactions, repeatedly wetting and drying treatment to study soil durability to the weather.

II. MATERIALS AND METHODS

A. *Materials*

a. The clay used in this research was obtained from Pujut, Central Lombok district, West Nusa Tenggara Province, location as shown in Fig 1. The soil samples were taken at 1m to 2m from ground surface. The natural water content was about 70.56%. The specific gravity was 2.7. The liquid and plastic limits were 76.5% and 21.16% respectively. The soil sample was classified as high plasticity clay (CH) according to the Unified Soil Classification System, as high plasticity Index has swelling-shrinkage (A-7-6) according to the American Association State Highway

Transportation Officials. Soil sample was passed through sieve No.4 (16mm) before mixing with CCR and trass to remove the coarse particles. The maximum dry density and optimum moisture content (OMC) of the clay under Standard Proctor energy were 12 kN/m^3 and 29.5% respectively. The CBR value (un-soaked) 6.5%. The chemical compositions are summarized in Table 1.

Fig. 1. Location of Tanak Awu, Pujut, Central Lombok [9]

b. Calcium Carbide Residue (CCR), a greyish white coloured solid, was collected from welding central in Getap, Mataram City, West Nusa Tenggara Province, location as shown in Fig 1. The specific gravity was 2.39. It was oven dried at 100^{o}C and passed through sieve No.200 (0.075mm) before mixing with clay and trass. The chemical compositions are summarized in Table 1. The chemical compositions are summarized in Table 1.

c. Trass is a mineral or rock material weathering results derived from volcano which contains silica. It is a light brown coloured, was collected from Punikan West Lombok district, West Nusa Tenggara Province, location as shown in Fig 1. The specific gravity was 2.39. It was oven dried at 100^{o}C than was passed through sieve No.200 (0.075mm) before mixing with clay and CCR. The chemical compositions are summarized in Table 1.

TABLE I
CHEMICAL COMPOSITIONS OF RAW MATERIALS

	Chemical composition (%)		
	Clay	Trass	CCR
SiO_2	42,65%	45,57%	-
Al_2O_3	28,71%	31,63%	-
CaO	2,77%	4,32%	60,26%.
MgO	0,92%	1,83%	-
Fe_2O_3	-	9,52%	-

The CCR contained 62.26% CaO as greater than quicklime has a CaO content of 51.64% [10]. The trass mainly consisted of SiO_2 but contained low CaO.

d. Waste plastic Plastic derived from discarded packaging of mineral water with polypropylene types (code: PP). Test results show Tensile strength maximum as average 16.5 MPa. Tensile strain maximum as average 15.65%. Preliminary test results the optimum dimensions of 20mm length and 5mm wide and optimum percentage of 1% by dry weight.

B. Methods

The test mixtures were prepared to observe the strength from CBR test in stabilized clay for different curing time and repeated drying-wetting on condition of maximum dry density from standard proctor compaction test. Proportion of CCR and trass determined from the lowest of Index Plasticity (IP) value is 0-15% from Atterberg limits test referred on [11]. In this research the optimum mixture proportion Clay + 15%CCR + 30% trass has IP 7.36%. The determination of the optimum proportion of plastic fibers refer on preliminary research is 1% of the dry weight with dimensions of 5mm x 20mm. The test specimen was made with variations such as in Table 2.

TABEL II
DESIGN TEST SPECIMENS

No.	**Mix design**	**Curing time**	**Drying-wetting cycles**
1	Clay (C)	-	-
2	C+15%CCR+30%T +1%FP	0 day	-
3	C+15%CCR+30%T +1%FP	7 days	-
4	C+15%CCR+30%T +1%FP	14 days	-
5	C+15%CCR+30%T +1%FP	28 days	-
6	C+15%CCR+30%T +1%FP+Curing time 28 days	-	0 cycle
7	C+15%CCR+30%T +1%FP+Curing time 28 days	-	1 cycle
8	C+15%CCR+30%T +1%FP+Curing time 28 days	-	2 cycles
9	C+15%CCR+30%T +1%FP+Curing time 28 days	-	3 cycles
10	C+15%CCR+30%T +1%FP+Curing time 28days	-	4 cycles

Note: C = Clay ; CCR = Calcium Carbide Residue ; FP = Fiber Plastic

III. RESULTS AND DISCUSSION

A. Effect of Curing Time on CBR

Relationship between variations in the specimen with curing time and the value of CBR Soaked and Un-soaked as shown in Fig. 2.

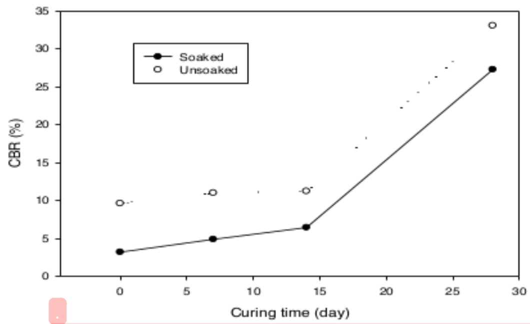

Fig. 2. Relationship between variations in the specimen with curing time and the value of CBR Soaked and Un-soaked

From Fig. 2 show that CBR value increased with increasing treatment curing time both soaked and un-soaked conditions. This is according to research conducted by [11] is to stabilize clays (CH or OH classification system and USCS systems AASTHO A.7.5) 36.38% IP native soil mixed with 15% fly Ash stabilization obtained optimum curing time 28 days with a value of 16,948% CBR (un-soaked). The SEM image of clay stabilized with the CCR and the trass are demonstrated in Fig. 3 a, b, c, d.

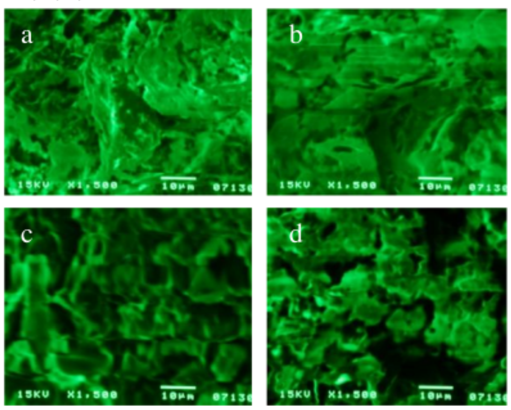

Fig. 3. SEM images of stabilized clay with 15%CCR+30%trass at different curing times: (a) 0 day, (b) 7 days, (c) 14 days and (d) 28 days

From Fig. 3 expressed with increasing curing time occur the agglomeration of soil. Based on the XRD test pozzolanic bond proceeds but has not yet formed minerals calcium silicate hydrate (CSH) and calcium aluminate hydrate (CAH). Not to the formation of two important minerals due to the bonding pozzolanic on material is running slow or require long-term time. Its consistent who studied by [13] who examined soil stabilization using Calcium Carbide Residue and Biomass Ash (CCR-BA in the ratio of 60:40) by 30% stated that based on the results of SEM aluminate Calcium Silicate crystals Hydrate (CASH) at age 90 days and more significantly formed at the age of 150 days are marked with the agglomerate aggregate.

Based on SEM and XRD test explains that increasing CBR value along with the addition of the curing time due to the bonding process pozzolanic that goes along with the time that is characterized by clotting of stabilized soil particles thereby increasing the strength of the soil.

CBR test results can be used to predict the value subgrade reaction (kv) with determining the value of the secant modulus (Es). Es or kv value is the ratio between stress in the settlement 1 inch to the constant 0.0025. Relationship between variations in the specimen with curing time and the value of kv as shown in Fig. 4.

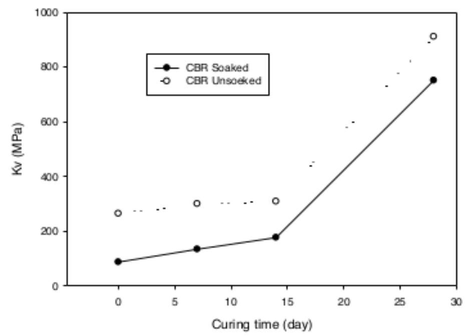

Fig. 4. Relationship between variations in the specimen with curing time and the value of kv

From Fig. 4 show that kv value increased with increasing treatment curing time both soaked and un-soaked as same as CBR value conditions.

B. *Effect of curing time on samples swelling*

The samples swelling were measured during 96 hours of CBR samples soaking. There were showed the swelling rate were decreased with increasing curing time that reverse of strength. Without curing soil the swelling was 0.13mm, but curing time 7 days and 14 days the swelling was 0.03 mm and 0 mm.

C. *Effect of repeated drying-wetting on the CBR*

Relationship between the values of CBR with repeated wetting drying as shown in Fig. 5.

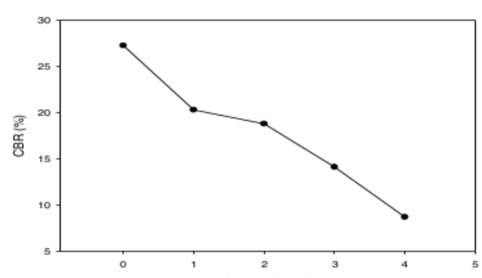

Fig. 5. Relationship between the values of CBR with repeated wetting-drying

From Fig. 5 show that CBR value decreased with increasing drying-wetting cycles. Durability index is expressed by the value of the CBR with drying-wetting cycle (CBRc) compared with the value of the CBR without drying-wetting cycle (CBRnc). Durability index analysis results expressed in Fig. 6.

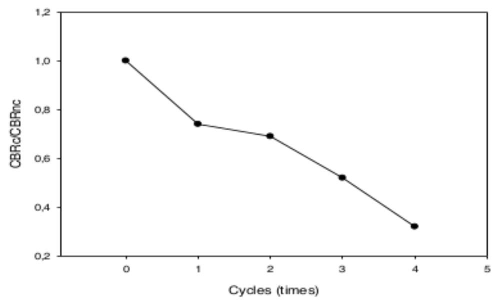

Fig. 6. Relationship between the values of CBRc/CBRnc with repeated wetting-drying

From Fig. 6 states that with increasing wetting drying cycles, decreasing the durability index, this was due to a 24-hours drying after wetting 24 hours is not enough moisture to the soil strength pozzolanic so tends to fall

IV. CONCLUSION

1. CBR value increased with increase the curing time. Curing time of 28 days resulted in CBR value and soaked un-soaked highest of the tested samples, for 27.253% and 33.047% respectively.
2. CBR value decreased along with increasing drying- wetting cycles. Reduction of CBR value due to repeated wetting drying between 6% - 20% per cycles.
3. Index durability stabilized soil decreased along with increasing the wetting-drying cycle.
4. Based on the test results of SEM along with increasing curing time it happened agglomeration. Sheet width stabilized soil particles into smaller sheets.
5. Based on the test XRD pozzolanic bond proceeds but has not yet formed minerals calcium silicate hydrate (CSH) and calcium aluminate hydrate (CAH).

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