Strength Behavior of Poorly Graded Sand Improved by Cement and Bagasse Ash

Weeraya Chimoye
Associate Prof.
Civil Engineering Department,
Faculty of Engineering, Thammasat University
KlongLaung, Pathumthani, Thailand

***Abstract*—This research studied the behavior of strength of poorly graded sand stabilized with cement and bagasse ash by using shell waste sand. The pozzolanic contents are 5%, 7% and 9% by dry weight of sand and the replacement ratio of cement by bagasse ash are 100:0, 80:20, 60:40, 40:60, 20:80 and 0:100. The strength of specimens was tested by unconfined compression test (USC). It is found that the unconfined compressive strengths of shell waste sand mixed with cement and bagasse ash at the wet side increase with the increasing of percent of pozzolanic. On the opposite way, the unconfined compressive strengths decrease with the increasing of the replacement ratio of cement and bagasse ash. From the standard of Highway Department, it is found that if the admixed shell waste sand with cement and bagasse ash should not exceed 40 percent for pozzolanic content from 5%. But in case, if this admixed shell waste sand with cement and bagasse is used as the base, the replacement ratio of cement and bagasse ash should not exceed 40 percent for pozzolanic content from 7 percent.**

Keywords*— *Poorly Graded Sand, Soil Improvement, Cement, Bagasse Ash

I. INTRODUCTION

The embankment fill such as highway usually is lateritic soil (SW) since its engineering properties are good. But is some case, it is not possible to find such good material in the field and also the use of recycled materials in geotechnical construction has been promoted in order to reduce consumption of natural material. For such soil as poorly graded sand (SP) is an alternative for using as base or subbase material, and embankment or structural fill material. Use of poorly graded sand in embankment fill requires proper improvement of engineering properties such as compaction and strength to meet the standard. Cement-stabilized soils have been widely used for the highway construction, both to stabilize the soft soil for the foundation of the highway and to stabilize the soil used as base, subbase and/or subgrade materials due to the effectiveness in improving their engineering properties. There are many researches have been studied the sand stabilization using cement [1], [2], [3], [4]. Previous researches have reported that the dry density, water content, cement content, water to cement ratio and initial void ratio are the main controlling factors in the behavior of cement-sand. Not only the recycle material that can be used as embankment fill material, but also pozzolanic material, such as ash from industry waste, is used for cement replacement [5], [6]. This paper reports results from a laboratory testing program to evaluate the effects of replacement ratios of bagasse ash to cement, dry density and water content on cemented sand strength.

II. MATERIAL USE

A. Poorly graded sand

Poorly graded sand that used in this study is the by-product sand from shell waste sand. From the grain size distribution, it can be classified as poorly graded sand (SP) according to Unified Soil Classification System with Cu = 1.95 and Cz = 1.05. The specific gravity is 2.52. From the standard proctor test, the maximum dry density is 1.72 g/cm^3 and optimum water content is 13%.

B. Bagasse ash and cement

The bagasse ash is the by-product ash from sugar industrial. The bagasse ash was sieved and only passing sieve no. 40 is used. The specific gravity is 2.37. The cement is Portland cement type 1.

III. METHODOLOGY

The standard proctor test of poorly graded sand mixed with pozzolanic material was tests in order to find the maximum dry density and optimum water content. The percent pozzolanic materials are 5%, 7% and 9%. The replacement ratios of bagasse ash to cement are 0:100, 20:80, 40:60, 60:40, 80:20 and 100:0. During the test, sand, bagasse ash and cement were well mixed then the required water were added and well mixed again before compact in the mold. The time from adding water until finish the compaction is controlled within 15 minutes. The maximum dry densities and optimum water contents of the sand admixed with cement and bagasse ash are shown in Table. 1. The behavior of the compaction curve is shown in Fig. 1.

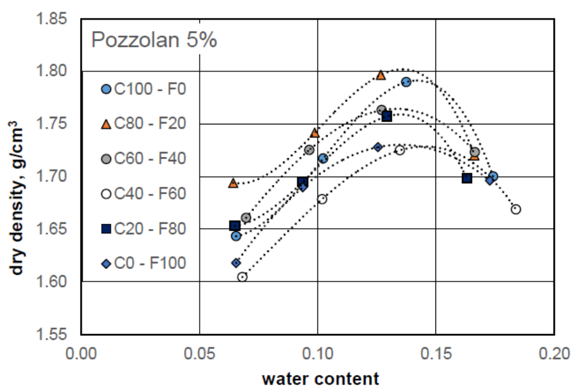

Fig. 1. Compaction curve of sand admixed with 5% pozzolanic.

TABLE 1 MAXIMUM DRY DENSITY AND OPTIMUM WATER CONTENT OF SAND MIXED WITH CEMENT AND BAGASSE ASH

Pozzolan, %	Cement : Ash	Maximum dry density, g/cm^3	Optimum water content, %
5%	100 : 0	1.79	13.2
	80 : 20	1.80	12.1
	60 : 40	1.76	12.4
	40 : 60	1.72	12.8
	20 : 80	1.76	12.2
	0 : 100	1.73	12.4
7%	100 : 0	1.80	13.2
	80 : 20	1.79	13.8
	60 : 40	1.80	12.1
	40 : 60	1.74	13.4
	20 : 80	1.75	12.9
	0 : 100	1.72	13.2
9%	100 : 0	1.81	12.4
	80 : 20	1.81	11.4
	60 : 40	1.78	12.3
	40 : 60	1.74	12.4
	20 : 80	1.71	12.2
	0 : 100	1.75	13.4

The samples for unconfined compressive strength (USC) test were prepared at wet side of the compaction, i.e. water contents were optimum water content + 2%. The curing times are 7 and 28 days. Three samples were prepared for each mix. Fig. 2 shows the sample after curing for 24 hours and after unconfined compression test.

(a) after 24 hours (b) after failure

Fig. 2 Prepared sample before and after unconfined compression test.

IV. RESULTS

A. Compaction tests

Fig. 3 shows the maximum dry density and cement replacement ratio of the sample for unconfined compression test. It is found that the maximum dry densities decreased when the replacement ratio higher than 40 : 60, i.e. bagasse ash more than cement. The maximum dry densities are in the range of 1.71 – 1.81 g/cm^3. For optimum water content, it is almost constant about 12.50% as shown in Fig. 4.

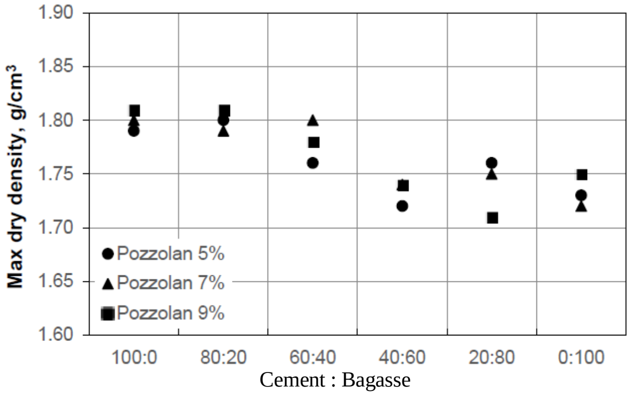

Fig. 3 Maximum dry density and replacement ratio.

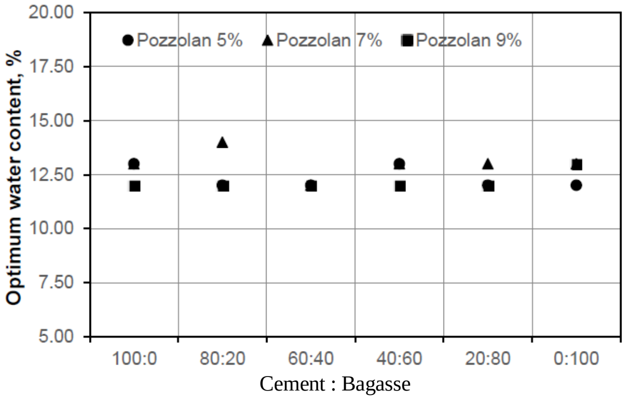

Fig. 4 Optimum water content and replacement ratio.

B. Unconfined Compression Test

After curing for 7 and 28 days, the dry densities of the compacted samples for USC were checked in order to verify that the dry densities of samples are higher than 95% of the maximum dry density as specified. Fig. 5 shows the dry density of the compacted samples for USC after 7 days curing and replacement ratio.

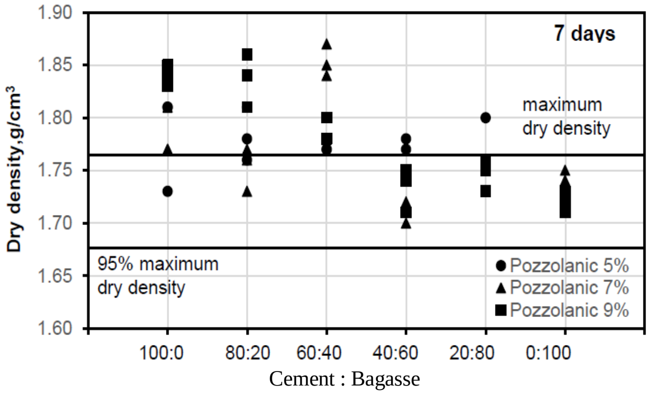

Fig. 5 Dry density of samples with replacement ratio.

Fig. 6 and 7 show typical stress-strain relationship of compacted sand improved with cement and bagasse ash 5% and 9% at 7 and 28 days. It can be seen that the relationships are in the same pattern with practically the higher strength with the less replacement ratio. With 9% pozzolanic material, the strengths of the compacted sand cement are higher than the compacted sand cement with 5% pozzolanic material. These results show that the pozzolanic content is the prime parameter for the strength of compacted sand cement. At a

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

particular pozzolanic content, the strength development increase with time due to the pozzolanic reaction [1] and [2]. Table 2 shows the average unconfined compressive strength of compacted sand cement.

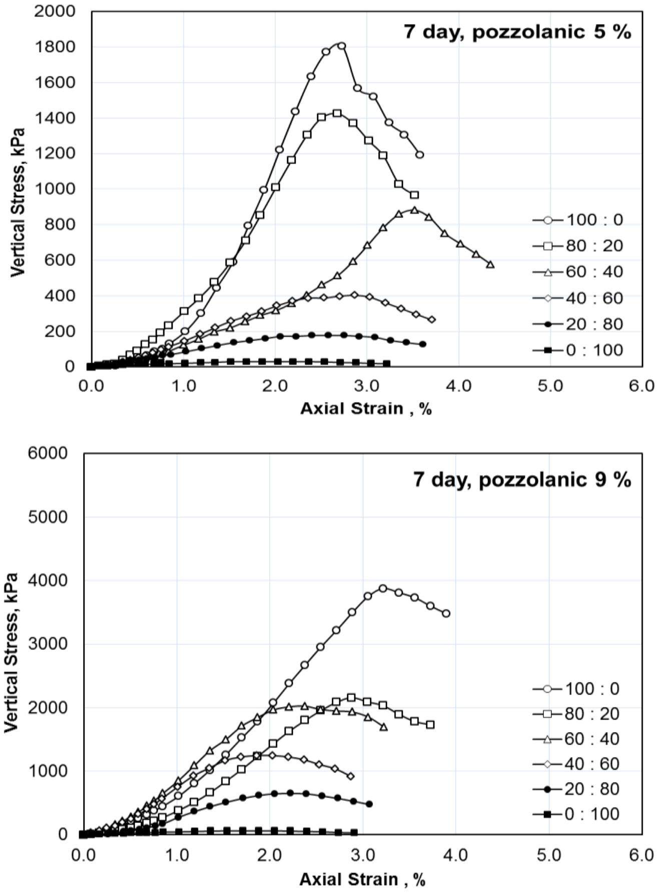

Fig. 6 Stress-strain relationship of compacted sand cement and bagasse ash 5% and 9% at 7 days

TABLE 2 UNCONFINED COMPRESSIVE STRENGTH OF COMPACTED SAND CEMENT.

% Pozzolanic	Replacement Ratio	Unconfined compressive strength, kPa	
		Curing 7 days	Curing 28 days
5 %	100 : 0	1,420.88	2,346.26
	80 : 20	1011.19	1,856.66
	60 : 40	858.14	1,650.61
	40 : 60	538.38	674.79
	20 : 80	173.29	206.57
	0 : 100	28.41	42.19
7%	100 : 0	1,763.58	2,726.95
	80 : 20	1,153.18	2,397.30
	60 : 40	1,173.78	2,288.40
	40 : 60	922.56	1,164.87
	20 : 80	427.83	476.18
	0 : 100	51.33	60.20
9%	100 : 0	3,242.97	4,930.06
	80 : 20	2,278.62	4,143.16
	60 : 40	2,278.89	2,356.93
	40 : 60	1,243.19	1,324.76
	20 : 80	479.70	619.17
	0 : 100	130.46	168.26

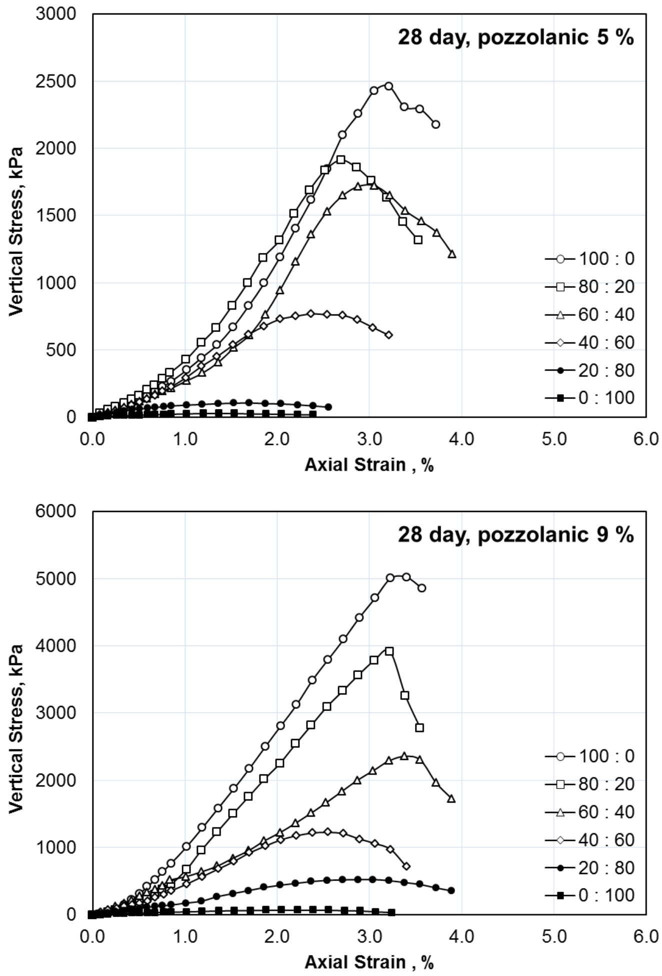

Fig. 7 Stress-strain relationship of compacted sand cement and bagasse ash 5% and 9% at 28 days

C. *Effect of pozzolanic content*

Fig. 8 and 9 show the unconfined compressive strength with % pozzolanic material at 7 and 28 days curing, respectively. It can be seen that the unconfined compressive strength increases with the increasing of the % pozzolanic material especially when the % pozzolanic material increases from 7% to 9%.

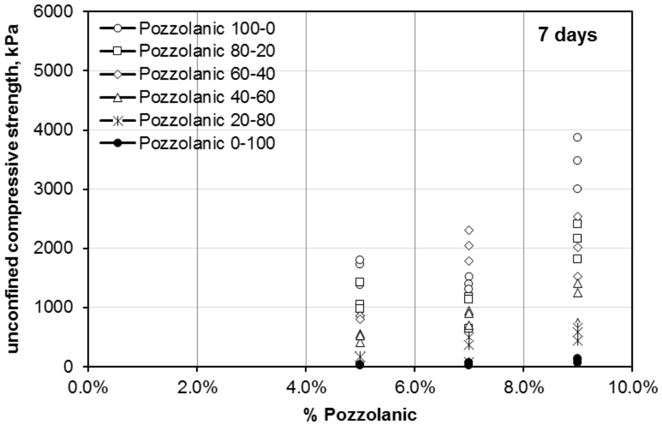

Fig. 8 Unconfined compressive strength with % pozzolanic material at 7 days curing.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 6 Issue 06, June - 2017

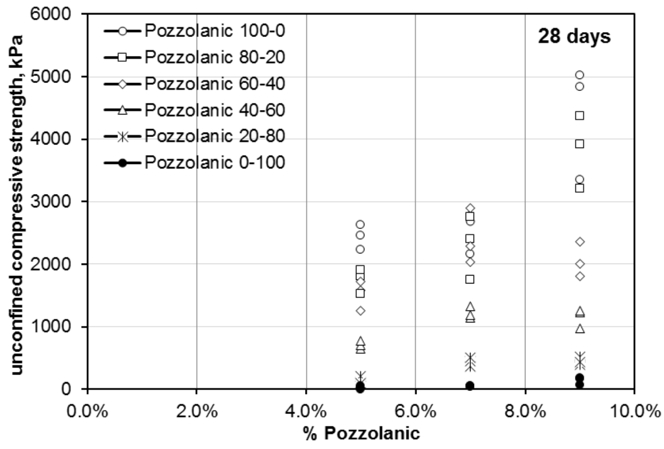

Fig. 9 Unconfined compressive strength with % pozzolanic material at 28 days curing.

D. *Effect of Replacement Ratio*

Fig. 10 and 11 shows the unconfined compressive strength at 7 and 28 days curing with cement replacement ratio. It can be seen that the unconfined compressive strength decreases with the increasing of the replacement ratio that mean the bagasse ash has a lower pozzolanic content than cement therefor the strength development is lower than cement. At 7 days curing, the unconfined compressive strengths of the replacement ratio 20% and 40% are almost the same but at 28 days the unconfined compressive strengths of replacement ratio 20% is rapidly increase.

Compared to the Department of Highways standard, the unconfined compressive strength of the subbase is not less than 690 kPa. It is found that if the replacement ratio is not exceeds 40%, the percent of pozzolanic material can be used from 5%. In the case of base material, the standard unconfined compressive strength is not less than 1750 kPa, so that the percent of pozzolanic material can be used only 7% and 9% with the replacement ratio not over than 40%.

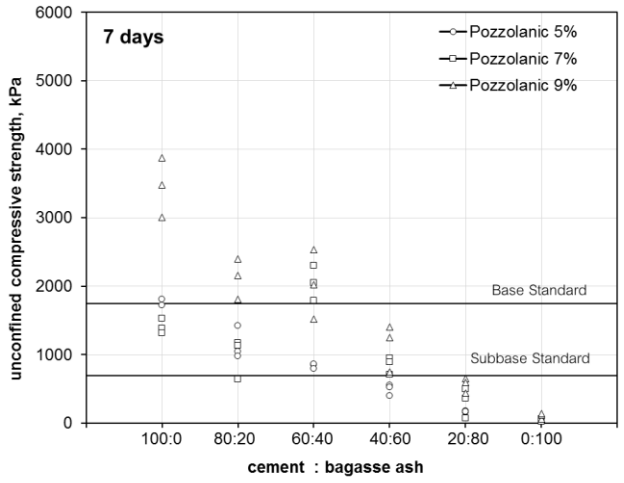

Fig. 10 Unconfined compressive strength with cement replacement ratio at 7 days curing.

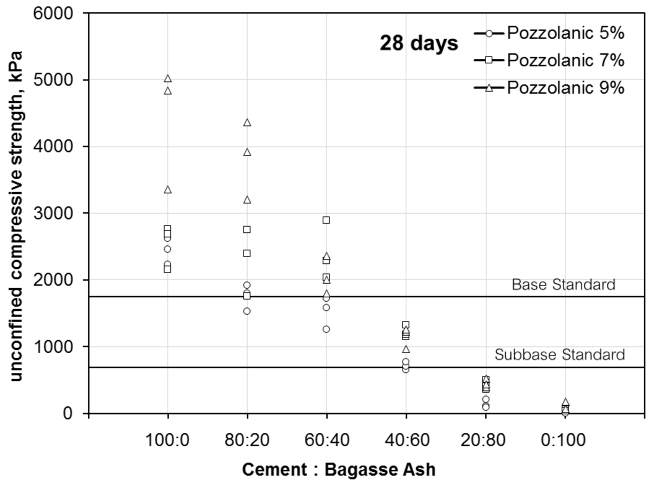

Fig. 11 Unconfined compressive strength with cement replacement ratio at 28 days curing.

CONCLUSION

Form the result, it can be concluded that

1. The unconfined compressive strengths of compacted sand mixed with cement and bagasse ash increase with the increasing of percent of pozzolanic.
2. The unconfined compressive strengths decrease with the increasing of the replacement ratio of cement and bagasse ash.
3. From the standard of Highway Department, it is found that if the admixed shell waste sand with cement and bagasse ash should not exceed 40 percent for pozzolanic content from 5%. But in case, if this admixed shell waste sand with cement and bagasse is used as the base, the replacement ratio of cement and bagasse ash should not exceed 40 percent for pozzolanic content from 7 percent.

REFERENCES

[1] S. Yoon and M.A. Farsakh, Laboratory investigation on the strength characteristics of cement-sand as base material, KSCE, 13(1), 2009, pp. 15-22.

[2] E. Stavridakis, Evaluation of engineering and cement stabiliztion parameters of clayey-sand mixtures under soaked conditions, Geotechnical and Geological Engineering, 23, 2005, pp. 635-655.

[3] L. Mohammad, A.Raghavandra and B. Huang, Laboratory performance evaluation of cement-stabilized soil base mixtures, Transportation Research Record, No. 1721, National Research Council, Washingto, D.C., 2000, pp. 19-28.

[4] S.Y. Wang and C. Vipulanandan, Foundry sand for highway applications, Department of Civil and Engineering, University of Houston, Houston, Texax, 1995.

[5] S. Mahvash, S. Lopez-Wuerol, A.B. Jahromi, Effect of class F fly ash on fine sand compaction through soil stabilization, http://dx.doi.org/10.1016/j.heliyon.2017.e00274, 2017.

[6] O.N. Spears, Shear strength parameters of sand fly ash cement mixture, Master thesis of Civil Engineering, University of North Forida, 2014.