Journal of Engineering and Applied Sciences 13 (22): 9739-9743, 2018
ISSN: 1816-949X

Using Bypass Addition to Improve Expansive Soil Strength

[1]Noor Al- Hassnawi, [2]Rasha Jasim and [2]Mohammed Qasim
[1]Department of Roads and Transportation,
[2]Department of Civil Engineering, University of Al-Qadisiyah, Al Diwaniyah, Iraq

Abstract: Expansive soil cover most areas in the middle of Iraq and create major problems for the construction of buldings. The low bearing capacity and high compressibility of the expansive soil, preclude the support of structures on them. This study presents laboratory test for expansive soil mixing with additives, identified as by-paass which is usually brought from cement industry which is called (by-pass) to improve the expansive soil properties for possible use as a foundation bearing soil. An experminatal research including liquid limit, plastic limit, plasticity index, specific gravity and soil classification was carried out to determine the physical properties of clayey soil samples without additives. The research also included conducting unconfined compression test on soil samples without additives and samples contained several ratios of by-pass (6, 12, 18 and 24%) while keeping the misture content at 20%. Moreover, the chemical compostitions of the baypass material were obtaited through a chemical laboratory experiment. The result have shown that with the increase of the by-pass ratio the soil became more ductile and unconfined compression strength increases whereas the strain decrease. The undrained shear strength increased from 0.25 kg/cm^2 for a soil without additives to 1.6 kg/cm^2 for a soil contained 24% by-pass. The ingrediants of the by-pass were found to be as same as for those of ordinary cement.

Key words: Expansive soil, improving soil, additives, waste of cement industry, by-pass, strength

INTRODUCTION

Expansive soil is one of the most important problems faced the construction field in the world because this kind of soil is very weak and have the ability to change in volume many times whenever the water ground table changed. So, to improve the properties of expansive soil such as liquid limit, plastic limit, fluctuation or increase the strength of expansive soil many ways were used:

- Replacing expansive soil with another type of soil
- Mixing expansive soil with another material
- Using chemical production with expansive soil

To improve soil properties with many types of additives and many ways are used such as using cement, lime, aggregate, fly ash, silica, chemical additions and other materials. A cement industry produces a hundred of tons of industrial waste harmful to the environment and one of these waste material is called (bypass). The bypass is an important product materially from the cement manufacturing process. Over the past a few years the advances have been achieved in the management and use of bypass, thus, reducing its throw out on landfill disposal. From 1990-2006, the US cement industry has reduced by 47% the amount of bypass which throw away and use the waste (bypass) in landfill to obtain a hard or strong soil rather than normal untreated soil. Also, usage of bypass in landfill helps to keep the environment clean and safe because the bypass causes many problems for humans and for the environment. The bypass dust percentage varies from 0.17-10% of the clinker produced. Bypass could be used as a raw material for other construction industry for producing bricks and tiles manufacturing and it was given a different brake pressure depends on the percentage of the additions (Askar *et al*., 2010), road pavement, soil stabilization, glass production or nceramic to produce paving stone with low compressive strength and could be used again as a raw material in cement production. In other countries bypass is used in road stabilization or to produce mortar cement.

The other opportunity is to use bypass dust by 50% with glass raw material (silica and sandstone) at a temperature 1250-1450°C to produce a greenish transparent glass, resistant to chemicals. Also, by further thermal treatment in the presence of 750-900°C for 15-30 min, marble-like ceramic glass can be produced. This

Corresponding Author: Noor Al- Hassnawi, Department of Roads and Transportation, University of Al-Qadisiyah, Al Diwaniyah, Iraq

product can be used for external decoration prefabricated walls and other engineering usages, due to its high strength and chemical resistance and atmospheric durability solutions (Askar *et al*., 2010).

More than 500,000 metric tons of the bypass were used in soil stabilization. The bypass was used widely as a binder in soil stabilized base and sub-base pavement applications because of the ability to enhance and the free lime content (ASTM D-5050) (Anonymous, 1996).

McCoy and Kriner (1971) show a wide range of testing conducted on kiln dust compositions for soil stabilization. Zaman *et al*. (1992) and Sayah (1993) have proved the effectiveness of bypass in stabilizing very soft clay soils. Their study showed matches to those for lime, fly ash and Portland cement for stabilizing expansive soils. The use of bypass in the stabilization of clays has shown improvement of unconfined compressive strength and reduced the plasticity index using dust with low LOI (Bhatty *et al*., 1996).

Miller and Zaman (2000) found the bypass could be used in highway construction in state of quick lime for sub-grade stabilization. The laboratory and field experimental data show the bypass was effective more than quicklime for stabilizing soil.

According to Ramchairitar *et al*. addition of bypass with different ratios of the expansive soil in state of Portland cement, the compressive strength increased with increasing the ratio of bypass while the slump and bleeding decreased with increasing bypass content. He found that replacing the 25 kg/m^3 of cement in the control mix with 50 kg/m^3 of bypass gave the most optimum results. Katz and Kovler (2004) studied the effects of the bypass on self compacting material. And found that mixtures contain 3% fly ash showed bleeding.

This study aims to evaluate the improvement of undrained shear strength of weak expansive clayey soil by adding different ratios of by-pass additives to the soil.

MATERIALS AND METHODS

Soil and additive material: A sample of expansive clayey soil is used in this study. it was brought from a site located in Al-Qadiseyah University, Al-Dewaniyah Province, Iraq. The properties of the soil sample are shown in Table 1. The bypass which was used as additives in stabilizing soil obtained from Al-Kufa factory in Al-Najaf Province. The chemical properties of bypass are shown in Table 2.

Experimental research: The testing program included soil classification test, specific gravity, unconfined compression test and a determination of Atterberg's limits

Table 1: Physical properties of the tested soil

Variables	Values (%)
Specific Gravity (Gs)	2.70
Liquid Limit (LL)	47
Plastic Limit (PL)	29
Grain size (sieving) distribution	
Gravel	0
Sand	8
Silt and clay	92

Table 2: Chemical compositions for by-pass dust

Content	Ratio
S_iO_2	20.83
Fe_2O_3	03.50
Al_2O_3	04.75
CaO	63.04
MgO	02.30
K_2O	00.54
SO_3	02.47
T_iO_2	00.24
Na_2O	00.23
Mn_2O_3	00.04
LOI (Loss-on-Ignition)	01.73

on soil samples without additives. The program also included conducting index properties tests and unconfined compression tests on samples with additives. Gasagranda equipment is used to determine the liquid limit according to Atterberg's limits (ASTM standard test method D 4318) (Anonymous, 2010).

The unconfined compression strength is done by applying a vertical load on a horizontal circular cross section of a cylindrical specimen and this load is increased until failure. The unconfined compression strength is given by the Eq. 1:

$$q_u = P/A \quad (1)$$

Where:

q_u = Unconfined compressive strength of the soil
P = The applying load
A = The cross sectional area

The unconfined compression strength test has been done with a untreated soil (soil without additives) by using a cylinder of 3.6 cm diameter and 7.2 cm high. The soil was put in a three layer in the cylinder with a compacting by a plastic hammer with 10 bowls for each layer and the samples were put in a plastic bag to be put in a water bath to be cured for a 7 and 28 days to keep the moisture level in the soil. Then unconfined compression test has been done for soil with several ratios of bypass (6, 12, 18 and 24%) of dry weight by keeping the ratio of water constant bout 20% of the dry weight and returns back all the steps above, all the reading should be recorded for each sample.

A chemical laboratory experiment was carried out to find out the chemical composition of the added bypass.

RESULTS AND DISCUSSION

Index properties: The index properties of soil without additives are shown in Table 1. From the results the soil is classified as silty clayey soil as can be seen in Fig. 1. The soil type falls in the A-7-6 group. This soil usually includes materials of high plasticity and extreme volume changes.

Liquid and plastic test: Figure 2 show the effect of adding bypass on the consistency of the studied soil which is represented as liquid limit, plastic limit and plasticity index. The data show that whenever the amount of bypass increased, the liquid limit decreased slowly. And the plastic limit decreased when the amount of bypass increased and as a result the plasticity index increase when the amount of bypass increased too. These changes in soil consistency after the addition of by-pass showed that there was an improvement in the properties of the soil in terms of consistency as the additive worked as a granular material that reduced the liquidity limit, the plasticity and increase the plasticity index of the soil of the study.

Chemical composition of bypass test: The chemical compostion of bypass material were obtaited through a chemical laboratory experiment as shown in Table 2.

Unconfined comression n test: The unconfined compression strength tests were performed in accordance withASTM-D2166 is done by applying a vertical load P, on a horizontal circular cross section of a cylindrical specimen and this load is increased until failure. The unconfined compression strength is given by the Eq. 2:

$$q_u = \frac{P}{A} \quad (2)$$

Where:

q_u = Unconfined compression strength of the soil
P = The applying load
A = The cross sectional area

The results of unconfined compression test for varios percent of addives experiment at 7 and 28 days, represented as stress-strain curves are shown in the Fig. 3- 6 results obtained for untreated soil are also shown in these figures for comparison purposes. It is clear that as the percentage of by pass increases, the value of stress increases. In general, the data show that as the percentage of additives increases, the unconfined compressive strength increases clearly compared with the untreated soil and that's because of the adding bypass powder has the same composition of cement but in small value. So that's, lead to make the treated soil more stiff and hard. Figure 1-3 also show that as the curing

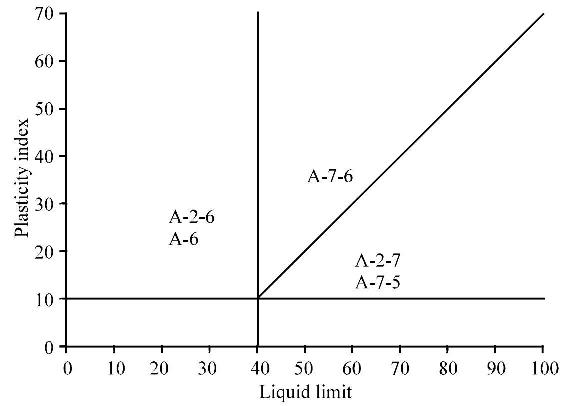

Fig. 1: The ranges of the LL and PI for groups A-2, A-4, A-5, A-6 and A-7. AASHTO soil classification system

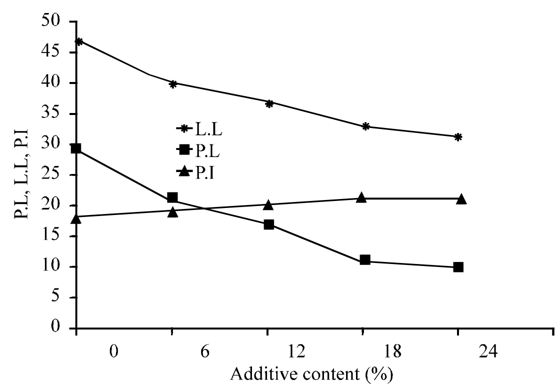

Fig. 2: Effect of adding bypass on soil consistency

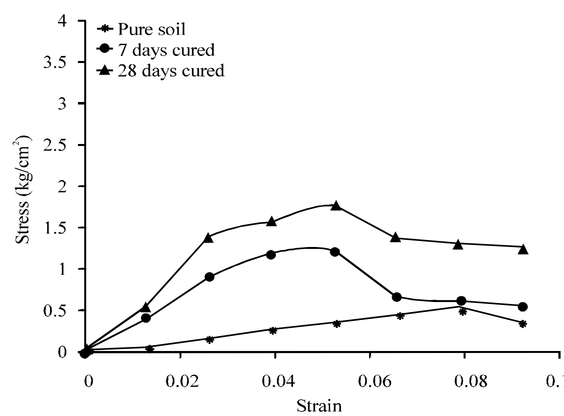

Fig. 3: Stress-strain curves for untreated soil and treated soil with 6% bypass at 7 and 28 days

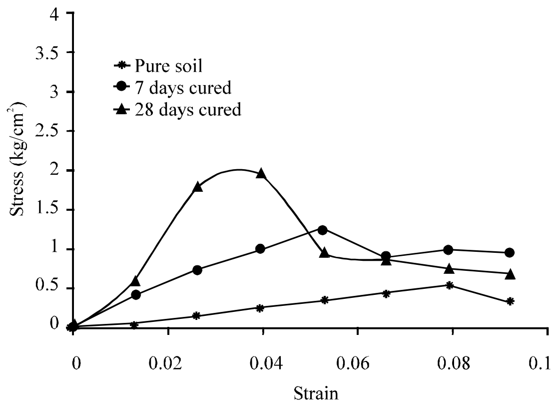

Fig. 4: Stress-strain curves for untreated soil and treated soil with 12% bypass at 7 and 28 days

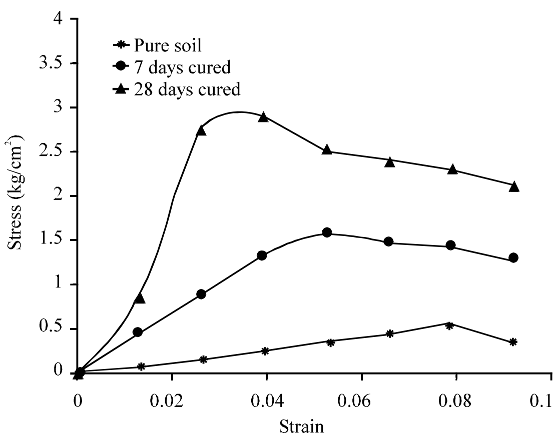

Fig. 5: Stress-strain curves for untreated soil and treated soil with 18% bypass at 7 and 28 days

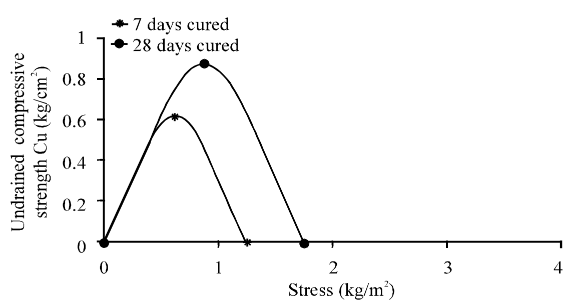

Fig. 6: Unconfined compressive streangth for treated soil with 6% bypass

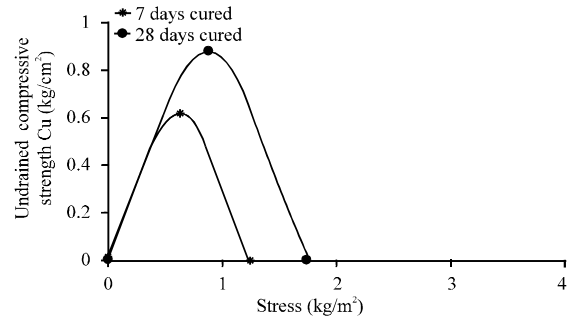

Fig. 7: Unconfined compressive streangth for treated soil with 12% bypass

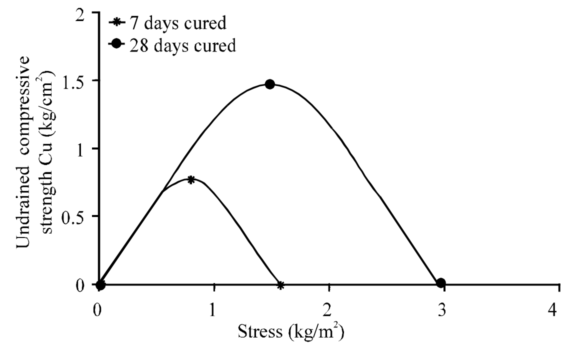

Fig. 8: Unconfined compressive streangth for treated soil with 18% bypass

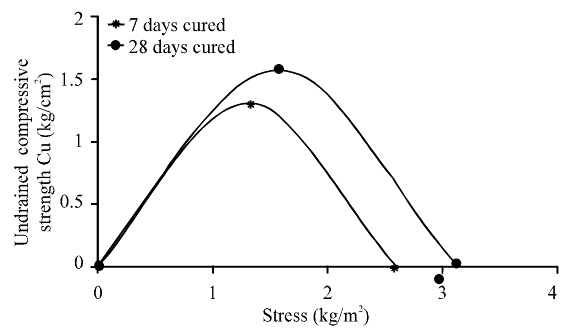

Fig. 9: Unconfined compressive streangth for treated soil with 24% bypass

time increases, the unconfined compressive strength increases and the effect of curing is more pronounced for higher additives contents. This is expected, since, the soil-additive mixture requires time to gain strength.

Figure 7-9 show the change in the amount of the unconfined compressive strength as the curing time increases for the added ratios 6, 12, 18 and 24%, respectively. The 28 days unconfined compressive strength for treated soil with 24% of bypass is about 1.56 kg/cm^2 which is hieger than for untreated soil.

The results of all compressive strength tests are shown in Fig. 10. In general, the data show that as the curing time increases, the unconfined compressive strength increases and the effect of curing is more pronounced for higher additive contents.

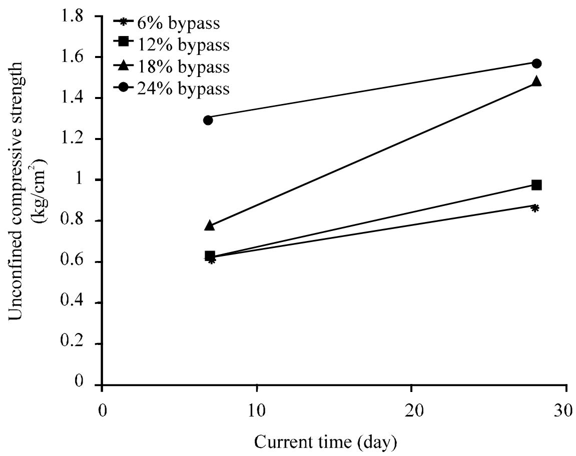

Fig. 10: Unconfined compressive steangth for treated soil with different percent of bypass

CONCLUSION

The engineering properties of expansive soil can be significantly enhanced by used the bypass dust as additive. The results of laboratory tests indicated significant decreases in the liquid limit, plastic limit and increase plastic index which is refer to that the added worked as a granular material that reduced the liquid limit, the plastic limit and increase the plasticity index of the soil.

When the percent of bypass increase,the stress increase and that's what we are looking for improving the bearing capacity of the soil, the unconfined compressive strength increase also if properly mixed and allowed to cure for a certain period of time (28 days). The value of unconfined compressive strength equal to 1.56 kg/cm^2 at 24% of additives while the unconfined compressive strength for untreated soil equal to 0.25 kg/cm^2 and thus, mention to the increase in soil capacity by adding this percent of bypass.

RECOMMENDATIONS

As a recommendation it should be there is more studied on bypass application and usage with different type of soil to find the effect of bypass on soil behavior and how could that lead to improve the soil strength and help to protect the environment.

REFERENCES

Anonymous, 1996. Standard gude for the commirical used of lime kiln dust and Portland kiln dust. ASTM International, West Conshohocken, Pennsylvania, USA.

Anonymous, 2010. Standard test methods for liquid limit, plastic limit and plasticity index of soils. ASTM International, West Conshohocken, Pennsylvania, USA.

Askar, Y., P. Jago, M.M. Mourad and D. Huisingh, 2010. The cement industry in Egypt: Challenges and innovative cleaner production solutions. Proceedings of the International Conference on Knowledge Collaboration and Learning for Sustainable Innovation ERSCP-EMSU, October 25-29, 2010, Delft University of Technology, Delft, Netherlands, pp: 1-34.

Bhatty, J.I., S. Bhattacharja and H.A. Tordes, 1996. Use of cement kiln dust instabilizingclay soils. Master Thesis, Portland Cement Association, Skokie, Illinois, USA.

Katz, A. and K. Kovler, 2004. Utilization of industrial by-products for the production of Controlled Low Strength Materials (CLSM). Waste Manage., 24: 501-512.

McCoy, W.J. and R.W. Kriner, 1971. Use of waste kiln dust for soil consolidation. Lehigh Hanson Cement Company, Allentown, Pennsylvania, USA.

Miller, G. and M. Zaman, 2000. Field and laboratory evaluation of cement kiln dust as a soil stabilizer. Transp. Res. Record J. Transp. Res. Board, 1714: 25-32.

Sayah, A.I., 1993. Stabilization of a highly expansive clay using cement kiln dust. Ph.D Thesis, University of Oklahoma, Norman, Oklahoma.

Zaman, M., J.G. Laguros and A. Sayah, 1992. Soil stabilization using cement kiln dust. Proceedings of the 7th International Conference on Expansive Soils, Dallas, August 3-5, 1992, Texas Tech Univerity Press, Lubbock, USA., pp: 347-351.