Walkway Subgrade Stabilization Using Fly Ash

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Abstract

The effectiveness of fly ash use in the stabilization of soil and the method that is used to test the strength of the subgrade soil with different amount of fly ash in order to stabilize the soil were studied. In this research project, the by-product of coal which is the fly ash was used as the subgrade stabilization material for walkway. The primary reason fly ash is used in soil stabilization applications is to improve the compressive and shearing strength of soils. The soil effectiveness was tested by using different percentages of fly ash which is 5%, 10% and 15%. Laboratory tests such as the moisture content, particle size analysis, liquid limit, plastic limit, standard proctor and California Bearing Ratio (CBR) were carried out for the soil sample in order to study the engineering properties of the soil and to determine the optimum moisture content of fly ash that give maximum CBR value for 5%, 10% and 15% soil-fly ash mixture. If the CBR value is increasing by adding the fly ash to the soil there is effectiveness in increasing the soil strength and vice versa.

KEYWORDS | *Fly ash, Optimum moisture content, California Bearing Ratio (CBR), soil stabilization*

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INTRODUCTION

Soil stabilization is the permanent physical and chemical alteration of soils to improve their physical properties. The shear strength of a soil can be increased or the shrink-swell properties of a soil can be controlled by stabilization, thus improving the load bearing capacity of a subgrade to support pavements and foundations. Soil stabilization involves the use of stabilizing agents in weak soils to improve its geotechnical properties such as compressibility, strength, permeability and durability. Soils or soil minerals and stabilizing agent or binders are the components of stabilization technology.

Fly ash is a by-product from burning pulverized coal in electric power generating plants. Two major classes of fly ash are specified based on their chemical composition resulting from the type of coal burned which are classified as Class F and Class C. Many projects have been completed successfully to improve the strength characteristics of soils by using fly ash. Fly ash can be used to stabilize bases or subgrades, to stabilize backfill to reduce lateral earth pressures and to stabilize embankments to improve slope stability. Fly ash is used in soil stabilization applications in order to improve the compressive and shearing strength of soils. Walkway is an important medium used for walking by the pedestrians and bicycle riders. Defect on walkway is caused by the improper stabilization of the subgrade and also due to lack of compaction.

This study will test the application of fly ash as the subgrade stabilization material for walkway. The effectiveness of soil is determined by using different percentages of fly ash which is 5%, 10% and 15%.The objectives of this study are to conduct the testing in order to know the engineering properties of soil and to determine the optimum moisture content of fly ash that give maximum CBR value for 5%, 10% and 15% soil-fly ash mixture.

Fly Ash

Fly ash is a by-product of coal fired electric power generation facilities. Fly ashes are easy to obtain, environmental friendly and cheaper. There are two main classes of fly ashes, class C and class F. Class C fly ash usually has pozzolanic properties due to free lime in addition to cementatious properties, whereas Class F is rarely cementitious when mixed with water alone. Fly ash by itself has little cementatious value but in the presence of moisture it reacts chemically and forms cementatious compounds and attributes to the improvement of strength and compressibility characteristics of soils.

Soil Stabilization

Soil stabilization aims at improving soil strength and increasing resistance to softening by water through water proofing the particles, bonding the soil particles together or combination of the two. The stabilized soil materials have a higher strength, lower permeability and lower compressibility than the native soil. Laboratory tests will help to assess the effectiveness of stabilized materials in the field. Successful stabilization has to depend on the proper selection of binder and amount of binder added.

METHODOLOGY

The flow chart shows the tests that were carried out for this research.

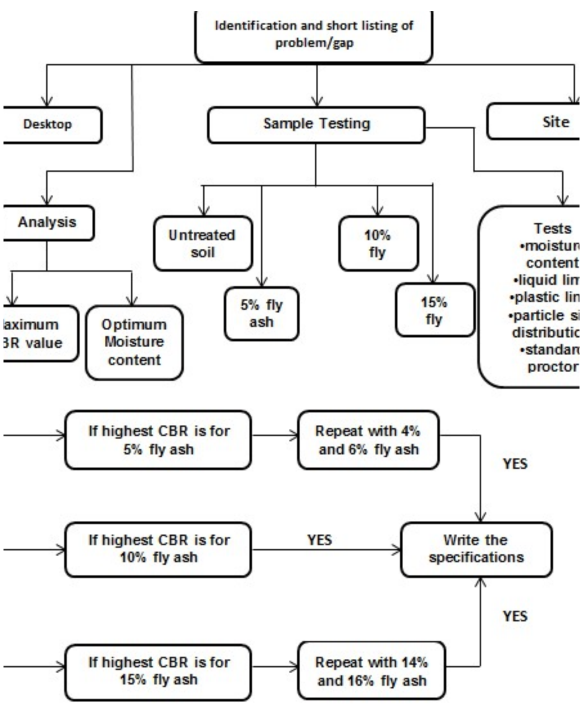

Figure 1 | Overall Process Involved

Laboratory Tests

Moisture Content

Moisture content test was performed to determine the water (moisture) content of soils. The water content is the ratio, expressed as a percentage, of the mass of "pore" or "free" water in a given mass of soil to the mass of the dry soil solids.

Table 1 | Moisture Content Data

Container No	A1	A2	A3	B1	B2	B3	C1	C2	[illegible]
Moisture Content (%)	19.63	21.87	21.20	22.35	18.31	20.02	22.56	21.50	[illegible]
Average Moisture		20.90			20.23			21.50	

Liquid Limit

The liquid limit was determined based on the number of blows required to cause a groove to close in a sample. The liquid limit is expressed in terms of water content as a percentage. It is essentially a measure of a constant value of a lower strength limit of viscous shearing resistance as the soil approaches the liquid state.

Table 2 | Liquid Limit Data

ne penetration	mm	13.8	15.0	19.3	20.2	24.8	[illegible]
verage penetration	mm	14.4		19.8		25.7	
verage moisture content		[illegible]		[illegible]		[illegible]	

Plastic Limit

The plastic limit is determined as the water content at which a thread of soil of size about 2-3mm begins to crumble when rolled. The moisture content at which soil changes from plastic to brittle state represents the plastic limit. It is the upper strength limit of consistency.

Table 3 | Plastic Limit Data

Container no.	27C	34C
verage moisture content		

Particle Size Analysis

The particle size distribution of the soil sample is determined by carrying out the sieve analysis method. The particle size distribution of the soil sample was segregated using different sizes of sieves by using a sieve shaker in accordance to the AASHTO specification.

Table 4 | AASHTO Classification

General Classification	Granular Materials (35 Percent or Less Passing 75 mm)							Silt-Clay Materials (More Than 35 Percent Passing 75 mm)			
	A-1			A-2							A-7
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7-5, A-7-6
Sieve analysis, percent passing:											
2.00 mm (No. 10)	50 max	--------	--------	--------	--------	--------	--------	--------	--------	--------	--------
0.425 mm (No. 40)	30 max	50 max	51 min	--------	--------	--------	--------	--------	--------	--------	--------
75 mm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid limit	--------		--------	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[a]
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine Sand	Silty or clayey gravel and sand				Silty soils		Clayey soils	
General rating as subgrade	Excellent to Good							Fair to Poor			

Standard Proctor

The Standard Proctor Test is a laboratory test used to determine the optimum water content for a given compaction energy, for a given soil.

Table 5 | Standard Proctor Data

Average moisture content (%)	6.42	9.91	18.52	22.09	26.
Dry density, ρ_d	1.603	1.658	1.833	1.683	1.5

California Bearing Ratio (CBR)

The California bearing ratio (CBR) is a penetration test for evaluation of the mechanical strength of road subgrades and base courses. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area.

Table 6 | CBR Data

Penetration (mm)	Load (kN)	STD Load (kN)	CBR (%)	Average CBR (
2.50	0.141	13.40	1.05	1.12

RESULTS AND DISCUSSIONS

The particle size analysis showed that the soil sample is a silt and clayey gravel soil based on AASHTO classification. The group classification for the soil sample is A 2-7 where the soil is considered to be granular material.

Moisture Content

The moisture content testing was carried out for original soil sample and also for 5%, 10% and 15% soil-fly ash mixture. The testing showed that the original sample had the highest average moisture content value which is 21.50%.

Standard Proctor

The standard proctor test was carried out for the original soil sample and for the soil sample with 5%, 10% and 15% fly-ash mixture. Optimum moisture content (OMC) then is referred to the moisture content at which the maximum dry unit weight (MDD) was attained for each soil mixture. The relationship between the optimum water content and the amount of fly ash used is shown in figures below.

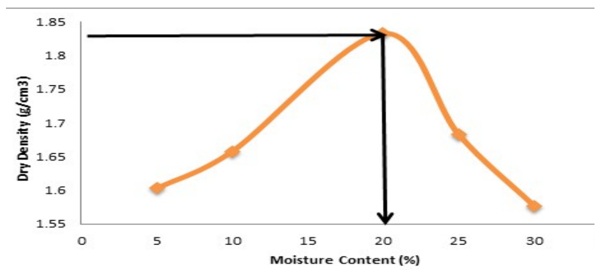

Figure 2 | Original Sample

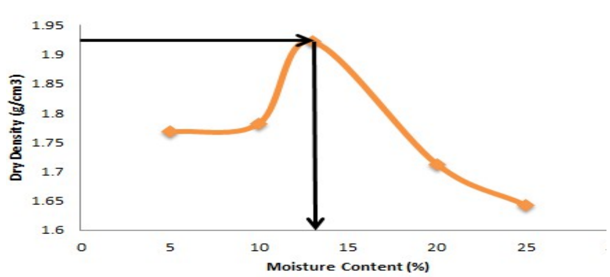

Figure 3 | 5% Fly Ash and Soil Sample

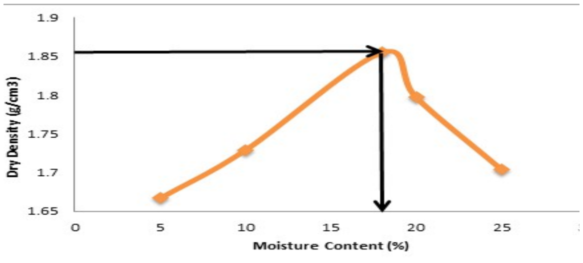

Figure 4 | 10% Fly Ash and Soil Sample

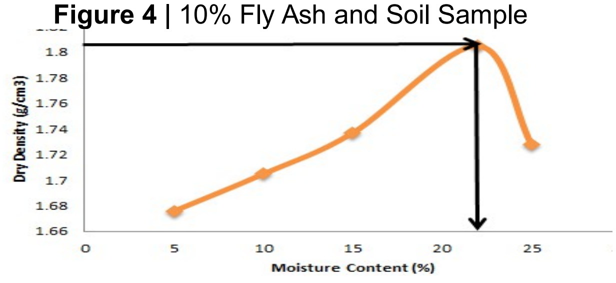

Figure 5 | 15% Fly Ash and Soil Sample

The optimum moisture content for original soil sample was 20%, for 5%, 10% and 15% soil-fly ash mixture was 13%, 18% and 22%. The dry density was 1.833 g/cm^3 for original soil sample and 1.922, 1.855 and 1.805 g/cm^3 for soil with 5% 10% and 15% fly ash.This showed that the optimum moisture content increased with the amount of fly ash and the dry density decreased with increased amount of fly ash.

California Bearing Ratio (CBR)

The CBR testing was carried out for original soil sample and also for soil sample with 5%,10% and 15% fly ash. The penetration value at 2.50 mm and 5.00 mm was considered in order to obtain the CBR value.

Table 7 | Original Sample

Penetration (mm)	Load (KN)	Std Load (KN)	CBR (%)	Average CBR (%
2.50	0.141	13.40	1.05	1.12

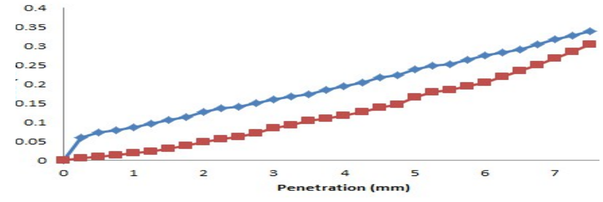

Figure 6 | Original Sample

Table 8 | 5% Fly Ash and Soil Sample

Penetration (mm)	Load (KN)	Std Load (KN)	CBR (%)	Average CBR (
2.50	0.158	13.40	1.18	1.22

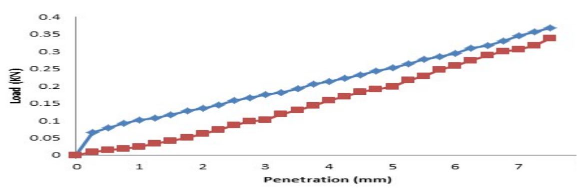

Figure 7 | 5% Fly Ash and Soil Sample

Table 9 | 10% Fly Ash and Soil Sample

Penetration (mm)	Load (KN)	Std Load (KN)	CBR (%)	Average CBR (
2.50	0.194	13.40	1.45	1.46

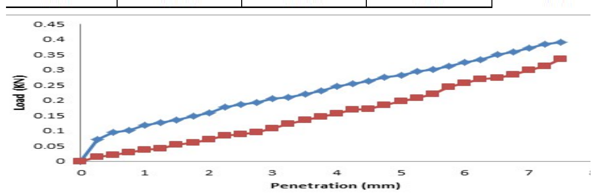

Figure 8 | 10% Fly Ash and Soil Sample

Table 10 | 15% Fly Ash and Soil Sample

Penetration (mm)	Load (KN)	Std Load (KN)	CBR (%)	Average CBR (
2.50	0.245	13.40	1.83	1.80

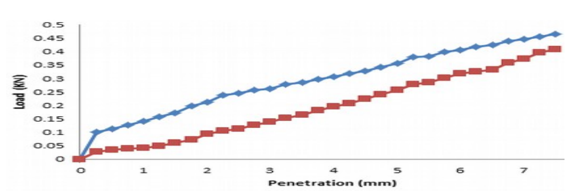

Figure 9 | 15% Fly Ash and Soil Sample

CONCLUSIONS

The testing for the engineering properties of soil showed that the soil was a A 2-7 group according to AASHTO clasification.The CBR testing showed that the CBR value increased as the fly ash amount increased.

REFERENCES

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[2] Amin Esmaeil Ramaji. (2012). A review on the soil stabilization using low-cost methods. Journal of Applied Sciences Research, 8(4) (ISSN 1819-544X), 2193-2196