Civil Engineering Beyond Limits 4 (2022) 1744
Civil Engineering Beyond Limits
journal home: www.acapublishing.com/journals/1/cebel
Research Article

Shear Strength Behavior of Coal Mine Waste Stabilized by Cement, Lime and Fly Ash

Ashok Kumar[1], Chotan Chowdhury[*,2]
[1]Geotechnical Engineer, Dhaka Mass Rapid Transit Development (MRT Line-1), Dhaka, Bangladesh.
[2]Lecturer, Dept. of CE, Prime University, Dhaka, Bangladesh.

Keywords

Coal waste,
Cement,
Lime,
Fly ash,
Triaxial,
Shear strength.

Abstract

In this paper, description of the results of this study which was the determination of shear strength behaviour of coal mine waste stabilized by cement, lime and fly ash. The mine is found at Parbatipur upazila in Dinajpur, this is often the as it were dynamic mine in Bangladesh. Mining workplaces opened in Dhaka and exchange was helped by British Rail arrange in India. In 1962 the study found 1.05 million ton of coal in Jamalganj, Sunamganj Locale. The another huge revelation came in 1985 when Geographical Overview of Bangladesh found coal in Dinajpur. Bangladesh has an assessed 2 billion tonnes of coal in underground saves within the Northwest locale of the nation. Fine coal waste obtained from Barapukuria to ascertain its suitability for use as a construction material. Coal mine waste samples were tested by treating with cement, lime and fly ash. In the present investigation, laboratory test of Triaxial tests were conducted on waste samples added with various percentages of cement, lime and fly-ash by the weight of dry waste. It was observed that addition of about 1%, 3% and 5% cement, lime and fly ash to coal waste, increased the shearing strength significantly. The fine coal waste, alone or with cement, lime or fly ash admixtures, possesses acceptable strength characteristics. It appears from the test results that the fine coal waste used in this study can be properly stabilized for use in construction of highway subgrades.

1. Introduction

Coal is the world's most abundant and most widespread fossil fuel source. Coal is a very important but dirty fossil fuel. Coal is said to help ensure the country's energy security. Coal is expected to remain an important energy source for Bangladesh. Mining coal produces a large amount of coal waste. This waste is typically dumped in piles behind a holding structure such as a dam. Increased mining of thinner layers and lower-grade coal will generate even greater amounts of coal waste, which can lead to serious environmental and stability issues. Accidental disposal of coal mine tailings has resulted in the failure of several such plants in the past [1]. Burning coal also produces waste such as fly ash and bottom ash.

It is important to find alternative uses for coal mine tailings and fly ash, two important by-products of the coal industry, so that they can be disposed of in an environmentally safe manner. Physico-technical stabilized and unstabilized mixtures of waste coal and fly ash for the construction of road embankments and foundation layers and other engineering structures, taking into account the economic and environmental impact. Recently, efforts have been made to study the properties of lime that can stabilize low-bearing subbases, pavements, and soils [3]. Soil physical or mechanical properties are treated with lime, fly ash, and cement [4]. In soil strength studies, lime is mixed [5]. Effect of loading rate on undrained triaxial shear strength [6]. One of the major problems with the use of mine tailings in civil engineering is acidic leachate and other harmful constituents that can contaminate groundwater [7]. The impact of acid leachate from coal tailings can be mitigated by adding fly ash and maintaining proper drainage control. Stabilized coal waste can be used as raw material for road construction. These requirements are compressive properties, shear strength, toughness, permeability, and durability. The focus of this study was solely to investigate the shear strength properties of stabilized mine tailings. This study aimed to determine the shear strength properties of coal tailings from the Balapria coal mine and their potential applications with cement, lime, and fly ash. A laboratory test was performed to determine the shear strength. Here are the details of the tests performed and the results obtained.

2. Testing process

2.1. Test specimens and properties (ASTM D2850)

This test method is used for the determination of the strength and stress-strain relationships of a cylindrical specimen of either undisturbed or remolded cohesive soil. Specimens are subjected to a confining fluid pressure in a triaxial chamber. We performed Consolidated Drained (CD) test according to ASTM D2850. The equipment has strain-controlled system. The loading velocity was 0.0196 mm/min. and the sensitivity were 2.7367 mV/V.

Figure 1. Triaxial Experimental Setup

*Corresponding Author: chotan.ce@gmail.com
Received 10 Nov 2022; Revised 28 Nov 2022; Accepted 28 Nov 2022
https://doi.org/10.36937/cebel.2022.1744

3. Testing Result and Discussion

Plots of deviatoric stress versus axial strain for untreated and treated coal tailings samples for triaxial tests performed at effective confining pressures of 100, 200 and 400 kPa are shown in Figure 2-31. Therefore, as the cement, lime and fly ash content of the specimen initially increases, the deviatoric stress at failure and thus the shear strength increases. Cohesive force (c) and internal friction angle (φ) values were calculated from the observed deviatoric stress values at failure corresponding to the different confining pressures used in performing the triaxial tests. These results (Table 1) show that adding a mixture of cement, lime and fly ash to the coal waste significantly increases the cohesive content, but has a small effect on the value of the internal friction angle.

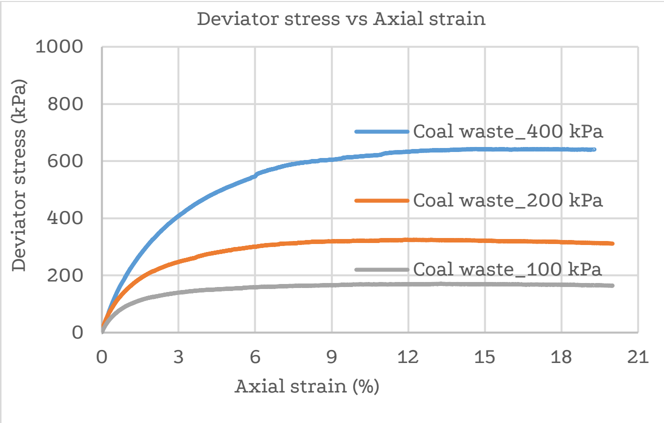

Figure 2. Deviator stress vs Axial strain

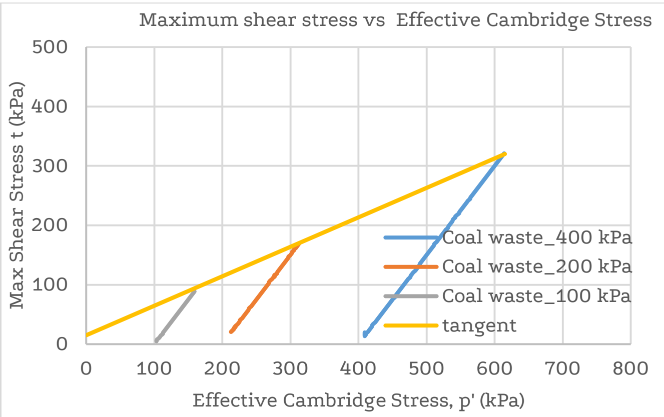

Figure 3. Maximum shear stress vs Effective Cambridge Stress

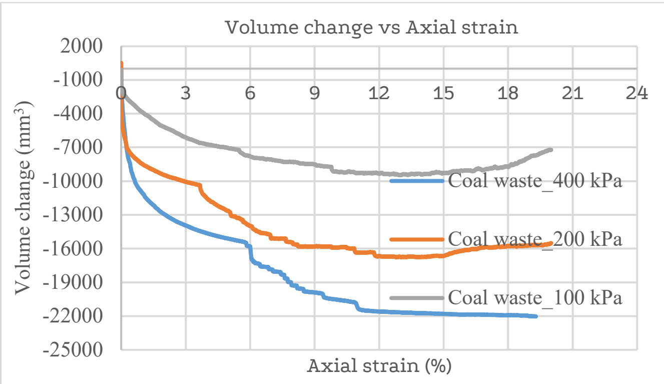

Figure 4. Volume Change Vs Axial strain

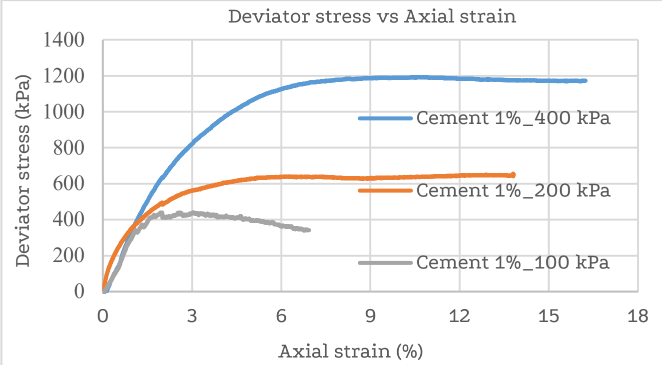

Figure 5. Deviator stress vs Axial strain

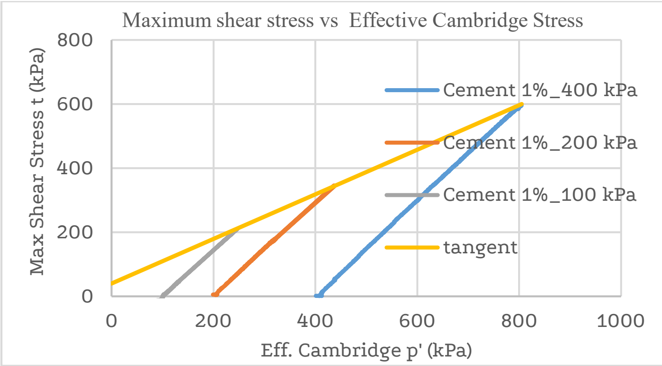

Figure 6. Maximum shear stress vs Effective Cambridge Stress

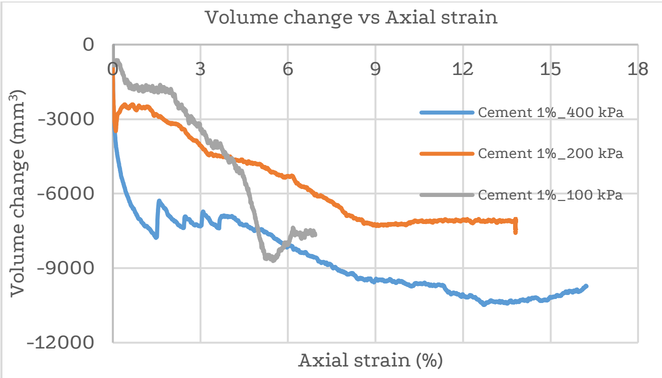

Figure 7. Volume Change Vs Axial strain

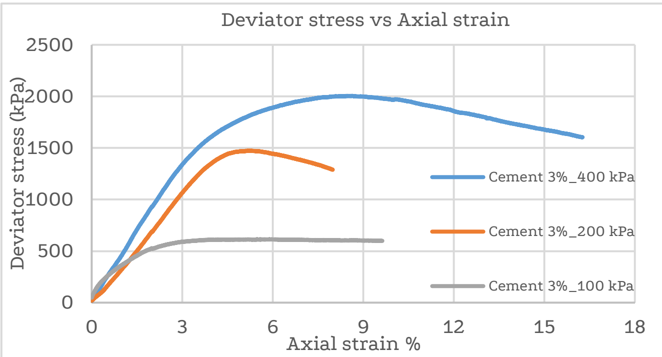

Figure 8. Deviator stress Vs Axial strain

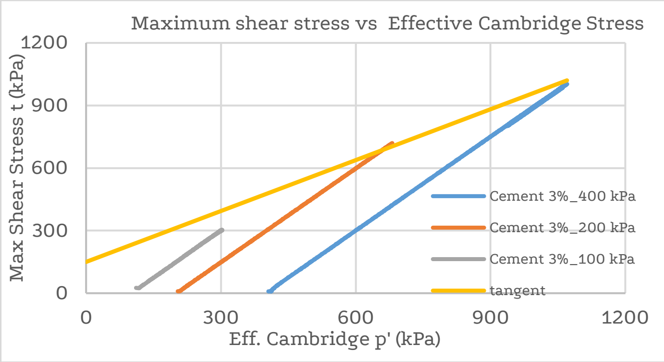

Figure 9. Maximum shear stress vs Effective Cambridge Stress

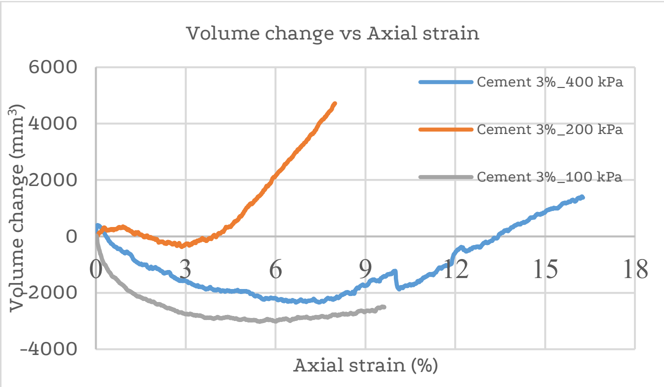

Figure 10. Volume Change Vs Axial strain

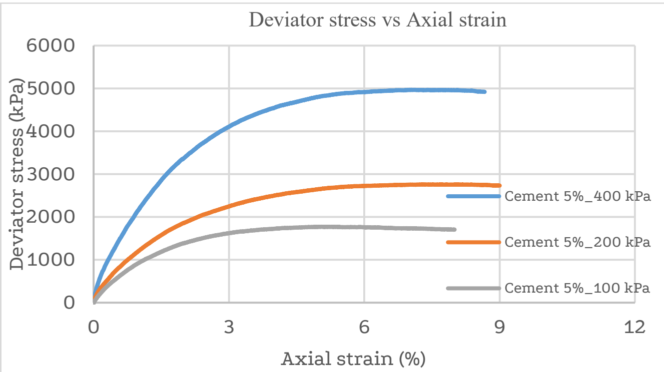

Figure 11. Deviator stress Vs Axial strain

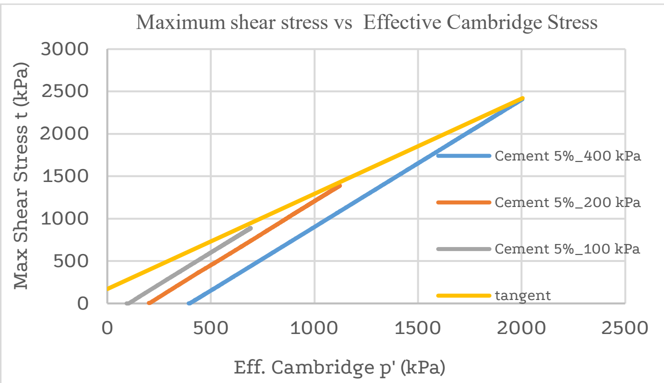

Figure 12. Maximum shear stress vs Effective Cambridge Stress

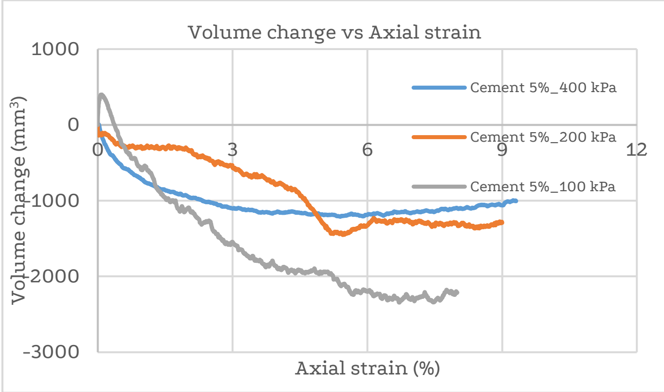

Figure 13. Volume Change Vs Axial strain

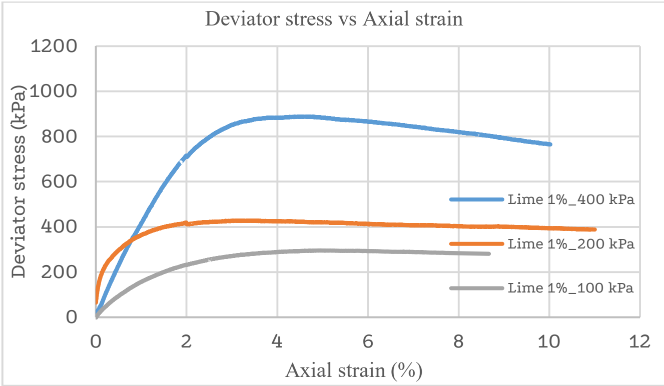

Figure 14. Deviator stress Vs Axial strain

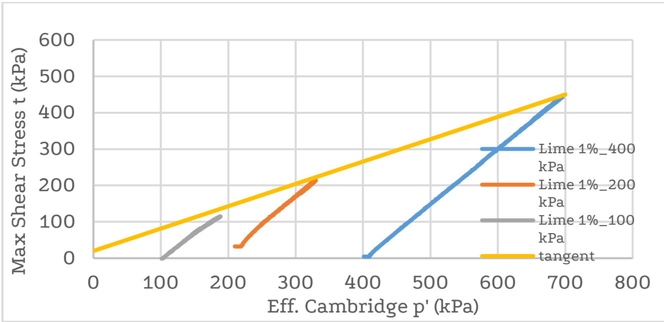

Figure 15. Maximum shear stress vs Effective Cambridge Stress

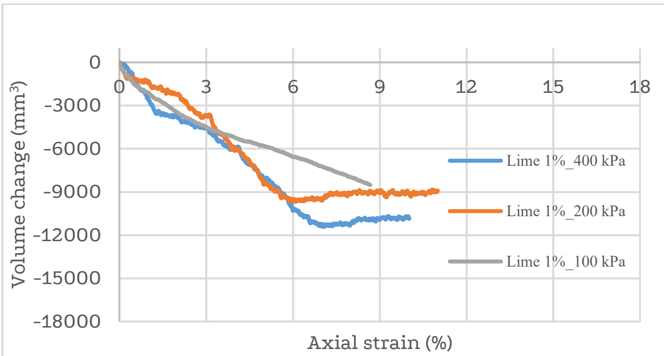

Figure 16. Volume Change Vs Axial strain

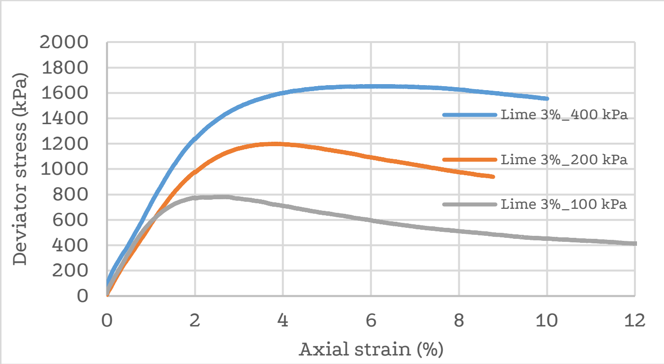

Figure 17. Deviator stress vs Axial strain

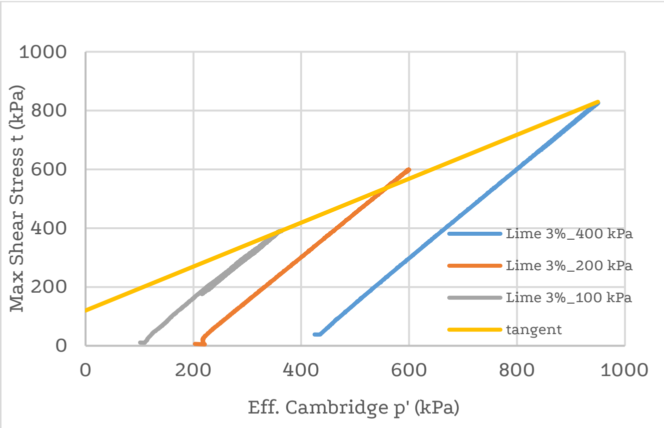

Figure 18. Maximum shear stress vs Effective Cambridge Stress

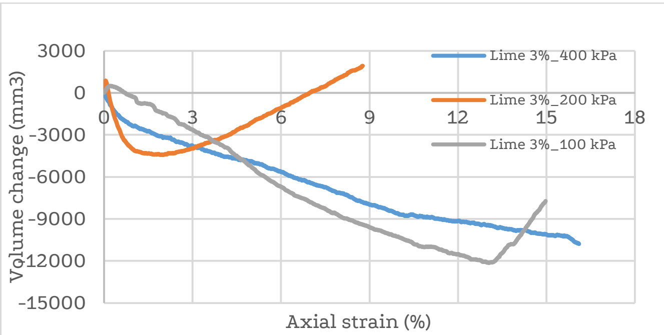

Figure 19. Volume Change Vs Axial strain

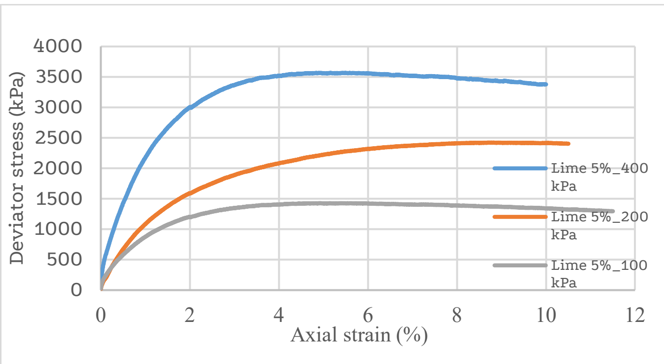

Figure 20. Deviator stress Vs Axial strain

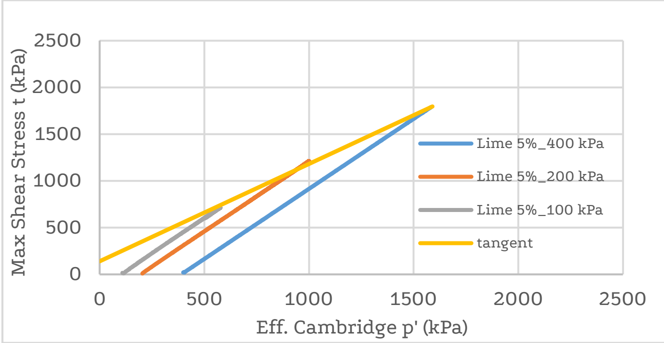

Figure 21. Maximum shear stress vs Effective Cambridge Stress

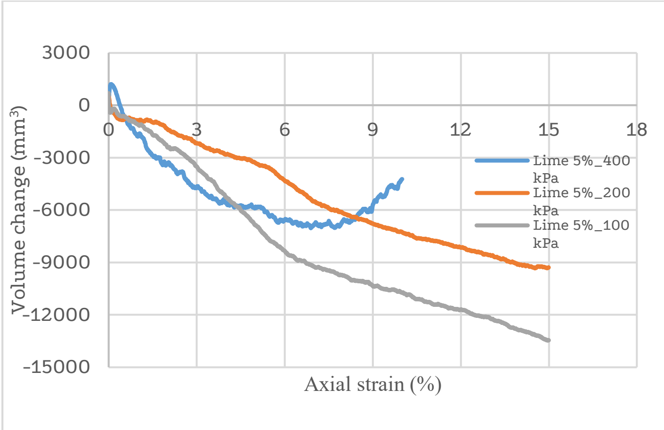

Figure 22. Volume Change Vs Axial strain

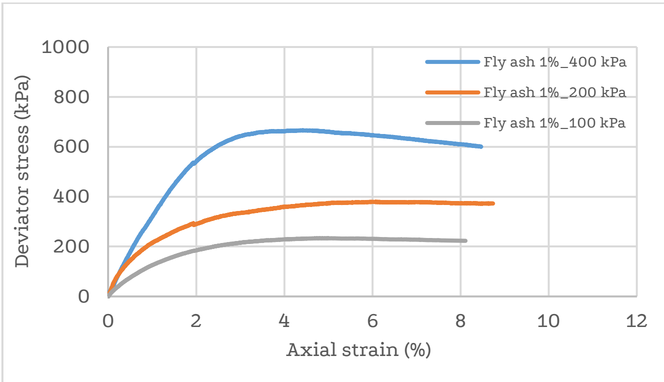

Figure 23. Deviator stress Vs Axial strain

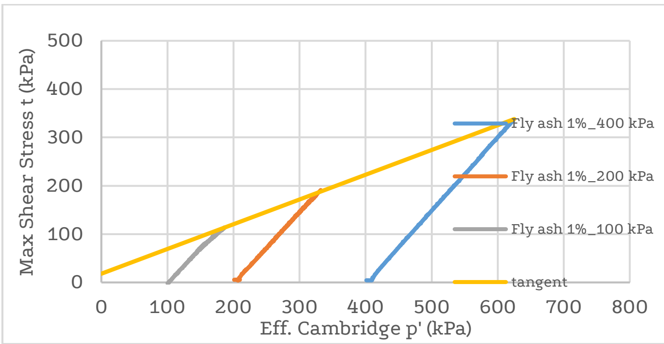

Figure 24. Maximum shear stress Vs Effective Cambridge Stress

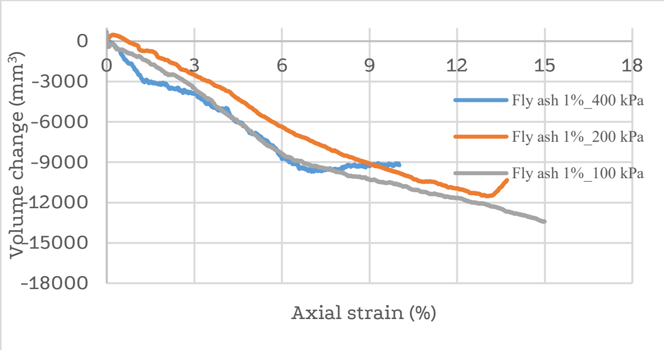

Figure 25. Volume Change Vs Axial strain

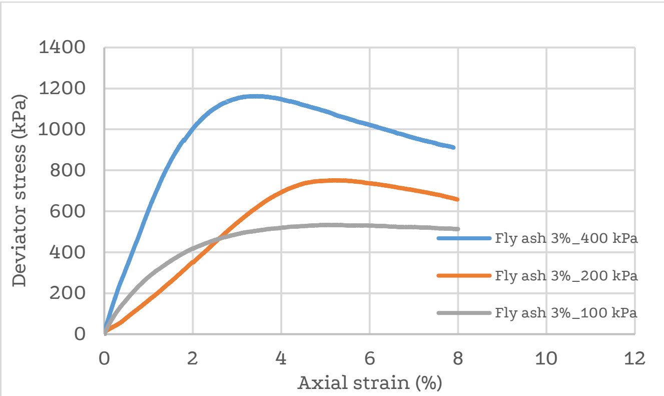

Figure 26. Deviator stress Vs Axial strain

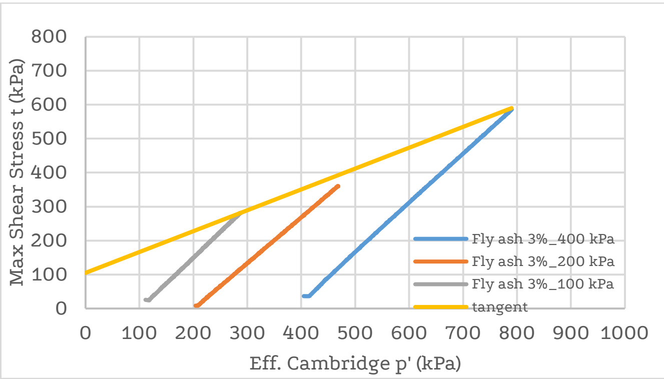

Figure 27. Maximum shear stress Vs Effective Cambridge Stress

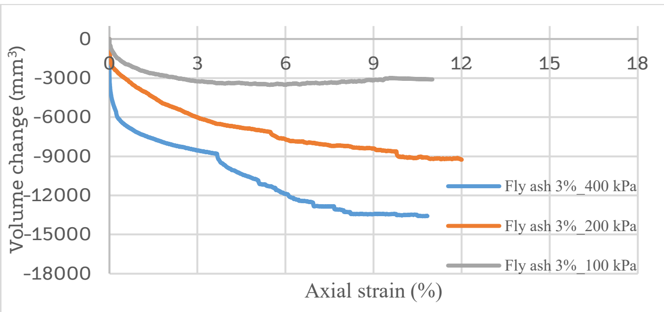

Figure 28. Volume Change Vs Axial strain

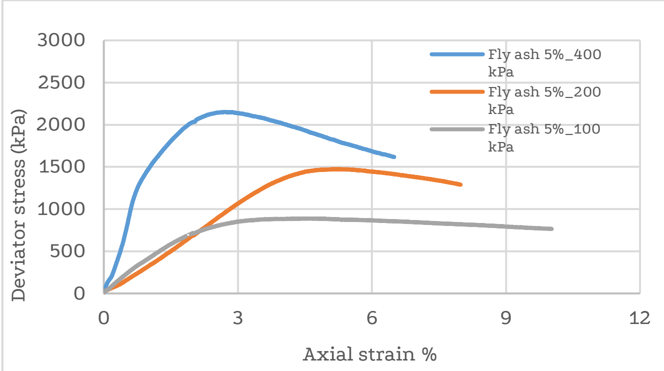

Figure 29. Deviator stress Vs Axial strain

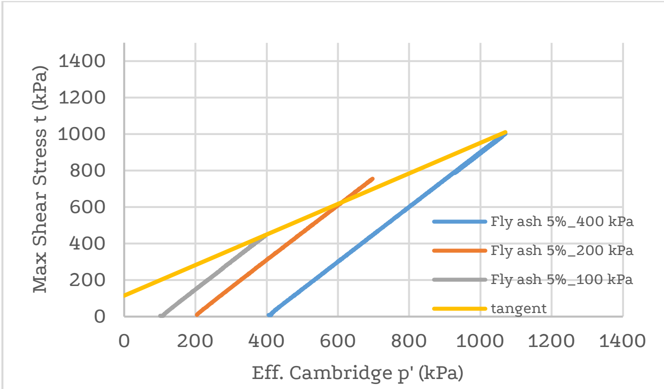

Figure 30. Maximum shear stress Vs Effective Cambridge Stress

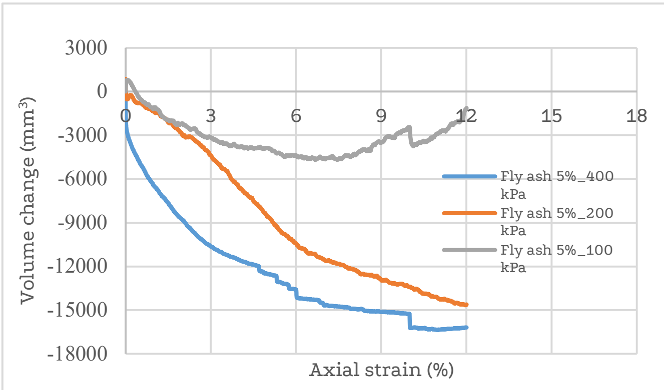

Figure 31. Volume Change Vs Axial strain

Table 1. Result of Triaxial Tests of Coal mine waste with admixtures

SL. No.	Name of Sample	Effective Pressure (kPa)	Modulus of Elasticity E (kPa)	Cohesion C (kPa)	Angle of Friction ε (%)
1	Coal waste only	400	21.20	15	26.38
2	Coal waste only	200	10.09		
3	Coal waste only	100	8.75		
1	Coal Waste + 1% Fly Ash	400	34.48	18	27.11

2	Coal Waste + 1% Fly Ash	200	25.00		
3	Coal Waste + 1% Fly Ash	100	10.53		
4	Coal Waste + 3% Fly Ash	400	45.45		
5	Coal Waste + 3% Fly Ash	200	36.81	105	31.55
6	Coal Waste + 3% Fly Ash	100	26.38		
7	Coal Waste + 5% Fly Ash	400	200		
8	Coal Waste + 5% Fly Ash	200	85.10	115	39.91
9	Coal Waste + 5% Fly Ash	100	72.73		
1	Coal Waste + 1% Lime	400	42.61		
2	Coal Waste + 1% Lime	200	18.26	20	31.56
3	Coal Waste + 1% Lime	100	12.22		
4	Coal Waste + 3% Lime	400	62.31		
5	Coal Waste + 3% Lime	200	55.69	120	36.77
6	Coal Waste + 3% Lime	100	43.11		
7	Coal Waste + 5% Lime	400	174.78		
8	Coal Waste + 5% Lime	200	105.12	140	46.15
9	Coal Waste + 5% Lime	100	78.84		
1	Coal Waste + 1% Cement	400	24.84		
2	Coal Waste + 1% Cement	200	11.30	40	34.82
3	Coal Waste + 1% Cement	100	9.11		
4	Coal Waste + 3% Cement	400	44.12		
5	Coal Waste + 3% Cement	200	21.43	150	39.11
6	Coal Waste + 3% Cement	100	17.73		
7	Coal Waste + 5% Cement	400	110.12		
8	Coal Waste + 5% Cement	200	42.76	170	48.29
9	Coal Waste + 5% Cement	100	34.48		

4. Conclusion

Based on the results of triaxial tests performed on untreated and treated samples of coal waste, the shear strength parameters obtained from the tests on treated samples show that the addition of admixture affects the shear strength of coal waste. We can conclude that it shows a beneficial effect. Significant improvements in shear strength were observed using scrap at blend levels of 1%, 3%, and 5% compared to untreated samples.

Acknowledgments

It is my great pleasure to thank Dr. Md. Kamruzzaman, Professor, Department of Civil Engineering, Rajshahi University of Engineering & Technology (RUET), for his scientific support, constant guidance, and precise suggestions, and for his tireless patience during the thesis work. I appreciate his wide range of expertise and attention, as well as the encouragement that has given me over the entire work.

Appreciations are also expressed to the laboratory assistant of the Department of Civil Engineering for their helpful co-operations.

Declaration of Conflict of Interests

The authors declare that there is no conflict of interest. They have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1.] V. Kumar, A Comprehensive Model for Fly Ash Handling and Transportation for Mining Sector, Fly ash an opportunity for Mining Sector, New Delhi,India,2010.

[2.] B. R. Phanikumar, "Effect of lime and fly ash on swell, consolidation and shear strength characteristics of expansive clays: a comparative study," Geomechanics and Geoengineering, vol. 4, no.2,pp.175–181,2009.

[3.] R.K. Goswami and C. Mahanta, leaching characteristics of residual lateritic soils stabilised with fly ash and lime for geotechnical applications, Waste Manage. 27 (2007), pp. 466–481.

[4.] A. Sridharan and K. Prakash, Geotechnical Engineering Characterization of Coal Ashes, S.K. Jain, New Delhi, India, 2007.

[5.] R. K. Goswami, and C. Mahanta, "Leaching characteristics of residual lateritic soils stabilised with fly ash and lime for geotechnical applications," Journal of Waste Management, vol. 27, no. 4, pp. 466-481, July 2007.

[6.] B. Behera, and M. K. Mishra, "California Bearing Ratio and Brazilian Tensile Strength of Mine Overburden–Fly Ash–Lime Mixtures for Mine Haul Road Construction," Journal of Geotechnical and Geological Engineering, vol. 30, no. 2, pp. 449-459,April2012.

[7.] G. A. Ahmed, " Fly Ash Utilization in Soil Stabilization," International Conference on Civil, Biological and Environmental Engineering (CBEE-2014), Istanbul, pp. 76-78, May 27-28, 2014.

[8.] S. Dhakar, and S.K. Jain, " Stabilization of Soil: A Review," International Journal of Science and Research, vol. 5, no. 6, pp. 545-549, June2016.

[9.] Jayanthu S., Das Sarat K and Sk. Md. Equeenuddin. 2012. Stability of Fly Ash and Overburden Material in Opencast Mines-A Case Study. Proceedings of International Conference on Chemical Civil and Environmental Engineering (ICCEE'2012).pp.276-278.

[10.] Ministry of Power, Central Electricity Authority (CEA), (August 2014), Annual Report. pp.01-12.

[11.] Standard Test Method for Unconsolidated-Undrained Triaxial Compression Test on Cohesive Soils1.

[12.] J.-M. Bian, L. Jiang, and B.-T. Wang, "Subgrade construction control parameters for lime-treated expansive soils," Journal of Chang'an University, vol. 34, no. 2, pp. 51–58, 2014.

How to Cite This Article

Kumar, A., Chowdhury, C., Shear Strength Behavior of Coal Mine Waste Stabilized by Cement, Lime and Fly Ash, Civil Engineering Beyond Limits, 4(2022), 1744.
https://doi.org/10.36937/cebel.2022.1744.