Original Research Article

Influence of Triaxial and CBR Scrutiny on Engineering strength of Rice husk blend geopolymer, and its behavior at various proportions.

Abstract-The stabilization capability of and rice husk ash (RHA) and Ordinary Portland cement (OPC) was scrutinized using laboratory scrutiny. Three soils (Soil A, B and C) were improved with various percentages (via weight of dry soil) at 0, 2, 4, 6, 8 and 10% for all stabilizing agents and compacted via BSL (British Standard light) energy. Their impacts were assessed on the strength physiognomies such as UCS (unconfined compressive strength), OMC (optimum moisture content), and California bearing ratio (CBR), and MDD (maximum dry density tests based on ASTM (American Standard Testing Materials) codes. The result reveals the optimum values for three lateritic sample A, B and C illustrated reduction in plasticity for rice husk ash (RSA) stabilizer from 17.32%, 12.67% and 19.07% (at 6% cement) to 16.32%, 9.90% and 17.00% (at 6% cement and 6% RHA) respectively. Likewise, the optimum Triaxial test result for RHA at 6% with specified cement content of 6% are: A (Deviation stress 595.45KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 28^0 and Shear stress 175.5KN/m^2), B (Deviation stress 514.75KN/m^2, Cohesion 9KN/m^2, Angle of internal friction 28^0 and Shear stress 168.5KN/m^2), and C (Deviation stress 530.58KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 29^0 and Shear stress 162.0KN/m^2.

Keywords- *Construction engineering, material, rice hush ash, geopolymer, North-Central..*

I. INTRODUCTION

Laterites contribute to the general economy of the areas where they are found, their scope is very extensive and comprises of mining research such as (iron, aluminum as well as manganese) deposits, civil engineering and agronomic (Upshaw and Cai2021; Roychand2021; Igibah et al. 2020). There is no need to emphasize the significance of laterites for various construction purposes (Rivera 2020; Seyhan2020). In geotechnical works, a site is surveyed whether soil conditions meet the design criteria. Nevertheless, most frequently, sites designated for earthworks do not reach the minimum criterions (Adeyanju et al. 2020; Farhangi et al. 2020; Saberian2020), such as those with soft, highly compressible, or expansive soils lacking the desired strength for loading during construction or for their serviceability (Razazadeh et al. 2020; Wang et al. 2020; Zhu et al. 2020). For this reason, such soils are enhanced through soil stabilization, wherein the mechanical properties of the soil are improved by applying materials that have cementitious properties or are considered to be binder materials (Khasib and Daud2020; Ghadakpoor et al. 2020; Abdulkareem2020). Stabilization is necessary when soils at site are loose or highly compressible; when the soils have unsuitable consistency indices and are too highly permeable or any other undesirable property making them unsuitable for use in construction project (Vitale et al. 2020; Dheyab et al. 2019; Teing2019). Rapid rate of industrialization and expansion leads to high demand on quantity of cement for infrastructure works (Yaghroubi et al. 2019). The manufacturing of cement, quite it's most vital material for concrete, cement signifies a sustainability subject that should be dealt with; which in turn known to be a substantial contributor towards the greenhouse gas emissions (GHGE) signifying about 5% of global CO$_2$ discharge (Jahandan et al. 2019; Abdullah et al. 2019; Sharina et al. 2019) The cement company needs intense energy, third (3rd) largest consumer of energy after the power as well as steel sector (Amori and Emami2019; Chang and Cho 2019). An alternative to stabilizing soil is by introducing geopolymer materials and activators, a readily available proximate raw material, that release just 1 t of carbon-dioxide of energy into the climatic condition save energy beside create green environment (Wen et al 2019). Besides, is a product of the alkali activation of aluminosilicate materials present in industrial waste materials such as furnace slag, slag furnace, granulated blast-furnace slag, fly ash, kaolin clay and red mud.

II MATERIAL AND METHOD

Soil sample used in this paper was collected from three different lateritic soil borrow pit along Abuja – lokoja road in the Federal capital territory of Nigeria. It was collected at a depth below than 150mm using the disturbed sampling approach and afterward air-dried. The both cement and sodium silicate activator was purchased from the local market while rice husk was collected from a rice mill located at kwali, FCT Nigeria (Adeyanju et al. 2020). Rice husk fibre was incinerated into ash in a furnace with temperature of up to 500^{0}C for more than six (6) hours after which it was allowed to cool and absolutely grounded. Then it was sieved via 75mm sieve as prescribe BS 12 (Sharma et al. 2019; Seyhan2020). Similarly, Preliminary tests on the collected three lateritic soil sampling were done in the laboratory of the Department of Civil Engineering, Federal University of Technology, Akure, Ondo State, Nigeria.

III RESULTS AND DISCUSSIONS

A *Atterberg Test*

The effect of RHA, KCP, SSA and GP stabilized soils on the liquid limit (LL) and plasticity index (PI) on the different soils are showed in Table 1 and Figure 1. In this context, the optimum values for three lateritic sample A, B and C illustrated reduction in plasticity for rice husk ash (RSA) stabilizer from 17.32%, 12.67% and 19.07% (at 6% cement) to 16.32%, 9.90% and 17.00% (at 6% cement and 6% RHA) respectively. In the same way, optimum of both kaolin clay powder (KCP) and geopolymer (GP) stabilizer was at 6% cement and 8% additives, meanwhile the values also experience reduction from 17.32%, 12.67% and 19.07% (at 6% cement) to 9.95%, 4.80% and 10.8% (KCP) as well as 13.85%, 8.97% and 16.00% (GP) for samples A, B and C respectively. Also sodium silicate activator (SSA) revealed decreasing trends and Optimum at 6% cement and 4% SSA, with values of 15.05%, 10.05% and 18.02% for sample A, B and C respectively. Reduce in the PI indicate an improvement.

According to Adeyanju et al. (2020) and Igibah et al. (2020), liquid limit less than 35% indicates low plasticity, between 35% and 50% indicates intermediate plasticity, between 50% and 70% high plasticity and between 70% and 90% very high plasticity and greater than 90% extremely high plasticity. This shows that samples A, B, and C, have intermediate plasticity. The addition of Portland cement in 2, 4, 6, 8 and 10% to the samples caused changes in the liquid limits and plastic limits of all the samples, the plasticity indices of samples A, B and C decreased from 23.36 to 7.89, 16.66 to 7.78 and 25.00 to 12.78 respectively. These reductions in plasticity indices are indicators of soil improvement.

B *Effect on the compressive strength (CBR)*

Table 2 and Figure 2 showed tremendous improvement in the CBR with increase in the RHA, KCP, SSA and GP content at specified cement contents.

The peak values of 6% cement and RHA is 6%, with values of 82.60%, 87.45% and 85.64% for samples A, B and C respectively. For both KCP and GP the optimum was 6% cement content plus 8% KCP or GP contents. The KCP optimum values are A (100.95%), B (97.50%) and C (98.50%), Whereas GP values are 125.75%, 120.75% and 115.75% for all the samples (A, B and C). Meanwhile it was observed that CBR of the soil-cement-SSA content increases upon adding sodium silicate activator content up to 4% SSA content before the value experiences reduction at much higher SSA content. But, the RHA-treated residual soils decrease the CBR value from 6% upwards. This, again, alludes that RHA alone is not suitable as stabilizer. Combination between RHA and cement yields a significant enhancing of strength. This result confirms that 6% cement– 8% KCP mixtures, and 6% cement–8% -GP mixtures attain the maximum CBR value, respectively, 100% and 125.75%

C *Effect on Triaxial*

Results of triaxial test for Rice Husk Ash (RHA), sodium silicate activator (SSA) and geopolymerare shown in Table 3 and Figure 3. The result showed the impact of various percentages of RHA, SSA and geopolymer on the soil sampling stabilized. The results showed that the optimum Triaxial test result for RHA at 6% with specified cement content of 6% are: A (Deviation stress 595.45KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 28^0 and Shear stress 175.5KN/m^2), B (Deviation stress 514.75KN/m^2, Cohesion 9KN/m^2, Angle of internal friction 28^0 and Shear stress 168.5KN/m^2), and C (Deviation stress 530.58KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 29^0 and Shear stress 162.0KN/m^2).

While the highest triaxial values for the KCP and GP stabilized soil was A (Deviation stress 608.25KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 29^0 and Shear stress 175.5KN/m^2), B (Deviation stress 578.20KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 28^0 and Shear stress 173.5KN/m^2), and C (Deviation stress 556.50KN/m^2, Cohesion 15KN/m^2, Angle of internal friction 20^0 and Shear stress 176.5KN/m^2), as well as (A (Deviation stress 638.05KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 29^0 and Shear stress 195.5KN/m^2), B (Deviation stress 628.30KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 28^0 and Shear stress 193.5KN/m^2), and C (Deviation stress 615.40KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 29^0 and Shear stress 188.40KN/m^2), at 8% stabilization respectively, using cement, (59.05, 58.05 and 58.85) N/mm^2 at 6% content. The trends of SSA was at 4% with specified cement value at 6% and the values are: A (Deviation stress 588.40KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 28^0 and Shear stress 162.2KN/m^2), B (Deviation stress 542.05KN/m^2, Cohesion 11KN/m^2, Angle of internal friction 28^0 and Shear stress 160.8KN/m^2), and C (Deviation stress 545.40KN/m^2, Cohesion 10KN/m^2, Angle of internal friction 28^0 and Shear stress 165.7KN/m^2).

Furthermore, Figure 4 shows author visit to study location for collection of materials and Atterberg test in progress in the laboratory.

Conclusions

The investigations on KCP-SSA stabilized soils revealed that the lateritic soils were A-7-6 soil and the addition of RHA and silicate at 6% contents above, the OMC is increased abruptly. It also revealed that geopolymer material used will effectively improve cement stabilized lateritic soil at cement 6% plus, RHA 6%, KCP 8%, SSA 4% and GP 8%. The Optimum RHA and cement content was found at 6% for CBR and Triaxial tests for which indicate an improvement in the treated soil compared with the CBR of the natural The UCS values were at their peak at 6% RHA. Thus, KCP, OPC, RHA and sodium silicate activator are confirmed to be a good admixture in lateritic soil stabilization using 6% as their control.

References

1. Upshaw M and Cai C. S (2021). Feasibility study of MK-based geopolymer binder for RAC applications: Effects of silica fume and added CaO on compressive strength of mortar samples. Case Studies in Construction MaterialsVolume 14, e00500
2. Roychand R. Development of zero cement composite for the protection of concrete sewage pipes from corrosion and fatbergs. ResourConservRecycl 2021; 164:105166.
3. Igibah C, Agashua L and Sadiq A (2020). Influence of hydrated lime and bitumen on different lateritic soil samples: Case study of Sheda-Abuja, Nigeria. IJET, 1-7.
4. Rivera J. Fly ash-based geopolymer as A4 type soil stabiliser. TranspGeotech2020;25:100409.
5. Seyhan F, Sedef D, Gülgün Y and Jamal M. (2020). Characteristics of Engineered Waste Materials Used for Road Subbase Layers. KSCE.
6. Adeyanju Emmanuel, OkekeChukwueloka Austin, Akinwumi Isaac and BusariAyobami (2020). Subgrade stabilization using Rice Husk Ash-Geopolymer (GPHA) and Cement Klin Dust (CKD).
7. Farhangi V, Karakouzian M, Geertsema M. Effect of micropiles on clean sand liquefaction risk based on CPT and SPT. ApplSci 2020;10(9):3111.
8. Saberian M, et al. Application of demolition wastes mixed with crushed glass and crumb rubber in pavement base/subbase. ResourConservRecycl 2020;156: 104722.
9. RezazadehEidgahee D, Rafiean AH, Haddad A. A novel formulation for the compressive strength of IBP-based geopolymer stabilized clayey soils using ANN and GMDH-NN approaches. Iranian J SciTechnol, Trans Civil Eng 2020;44(1): 219–29. MolaAbasi H, et al. Evaluation of the long-term performance of stabilized sandy soil using binary mixtures: A micro-and macro-level approach. J Cleaner Prod 2020:122209.
10. Wang, S.; Xue, Q.; Zhu, Y.; Li, G.; Wu, Z.; Zhao, K. Experimental study on material ratio and strength performance of geopolymer improved soil. Constr. Build. Mater. **2020**, 267, 120469. [CrossRef]
11. Zhu, Y.; Chen, R.; Lai, H. Stabilizing Soft Ground Using Geopolymer: An Experimental Study. In Proceedings of the CICTP 2020,
12. Khasib, I.A.; Daud, N.N.N. Physical and Mechanical Study of Palm Oil Fuel Ash (POFA) based Geopolymer as a Stabilizer for Soft Soil. Pertanika J. Sci. Technol. **2020**, 28, 149–160. [CrossRef]
13. Ghadakpour M, Choobbasti AJ, Kutanaei SS. Experimental study of impact of cement treatment on the shear behavior of loess and clay. Arabian J Geosci 2020; 13(4):184.
14. Abdulkareem M. Environmental and economic perspective of waste-derived activators on alkali-activated mortars. J Cleaner Prod 2020;280:124651.
15. Vitale, E.; Russo, G.; Deneele, D. Use of Alkali-Activated Fly Ashes for Soil Treatment. In Geotechnical Research for Land Protection and Development; Calvetti, F., Cotecchia, F., Galli, A., Jommi, C., Eds.; Lecture Notes in Civil Engineering; Springer Inter-national Publishing: Cham, Switzerland, 2020; Volume 40, pp. 723–733. ISBN 978-3-030-21358-9.
16. Dheyab, W.; Ismael, Z.T.; Hussein, M.A.; Huat, B.B.K. Soil Stabilization with geopolymers for low cost and environmentally friendly construction. Int. J. Geomate**2019**, 17, 271–280. [CrossRef]
17. Teing, T.T. Effects of Alkali-Activated Waste Binder in Soil Stabilization. Int. J. Geomate**2019**, 17, 82–89. [CrossRef]
18. Yaghoubi M, Arulrajah A, Disfani MM, Horpibulsuk S, Darmawan S, Wang J. Impact of field conditions on the strength development of a geopolymer stabilized marine clay. Appl Clay Sci2019;167:33–42.
19. Jahandari S, Saberian M, Zivari F, Li J, Ghasemi M, Vali R. Experimental study of the effects of curing time on geotechnical properties of stabilized clay with lime and geogrid. Int J GeotechEng 2019;13(2):172–83.
20. Abdullah, H.H.; Shahin, M.A.; Walske, M.L. Geo-mechanical behavior of clay soils stabilized at ambient temperature with fly-ash geopolymer-incorporated granulated slag. Soils Found. **2019**, 59, 1906–1920.
21. Sharma, P.K.; Singh, J.P.; Kumar, A. Effect of Particle Size on Physical and Mechanical Properties of Fly Ash Based Geopolymers. Trans. Indian Inst. Met. **2019**, 72, 1323–1337.
22. Tan, T.; Huat, B.B.K.; Anggraini, V.; Shukla, S.K.; Nahazanan, H. Strength Behavior of Fly Ash-Stabilized Soil Reinforced with Coir Fibers in Alkaline Environment. J. Nat. Fibers **2019**, 1–14. [CrossRef]
23. Amiri E, Emami H. Shear strength of an unsaturated loam soil as affected by vetiver and polyacrylamide. Soil Tillage Res 2019;194:104331.

24. Chang Ilhan, Cho Gye-Chun. Shear strength behavior and parameters of microbial gellan gum-treated soils: from sand to clay. ActaGeotech 2019;14(2):361–75.

N. Wen, Y. Zhao, Z. Yu, M. Liu, A sludge and modified rice husk ash-based geopolymer: synthesis and characterization analysis, J. Clean. Prod. 226 (2019) 805–814. https://doi.org/10.1016/j.jclepro.2019.04.045

Table 1: Atterberg limit test for RHA, Kaolin clay powder and geopolymer mix

Percentages	Plasticity Index								
	RHA (%)			**Kaolin (%)**			**Geopolymer mix (%)**		
	Ka	***Sa***	***Da***	***Ka***	***Sa***	***Da***	***Ka***	***Sa***	***Da***
6% cement +2% Additives	17.06	10.67	18.94	13.60	11.10	16.05	14.62	11.80	16.72
6% cement +4% Additives	16.60	10.40	17.65	11.37	8.62	15.80	14.07	9.67	16.45
6% cement +6% Additives	16.32	9.90	17.00	11.09	6.60	13.6	14.59	9.22	16.00
6% cement +8% Additives	15.70	9.10	16.05	9.95	4.80	10.8	13.85	8.97	16.00
6% cement +10% Additives	15.30	7.97	15.30	9.10	3.72	8.05	13.72	6.72	13.55

Table 2: CBR for RHA, Kaolin clay powder and geopolymer mix.

Percentages	CBR values								
	RHA (%)			**Kaolin (%)**			**Geopolymer mix (%)**		
	Ka	***Sa***	***Da***	***Ka***	***Sa***	***Da***	***Ka***	***Sa***	***Da***
6% cement +0% Additives	10.88	9.85	9.25	10.88	9.85	9.25	10.88	9.85	9.25
6% cement +2% Additives	60.45	65.45	63.89	60.45	65.45	63.89	60.45	65.45	63.89
6% cement +4% Additives	70.56	74.45	72.54	70.56	74.45	72.54	70.56	74.45	72.54
6% cement +6% Additives	82.60	87.45	85.64	82.60	87.45	85.64	82.60	87.45	85.64
6% cement +8% Additives	90.05	93.50	91.45	90.05	93.50	91.45	90.05	93.50	91.45
6% cement +10% Additives	98.65	100.25	98.90	98.65	100.25	98.90	98.65	100.25	98.90

Table 3: Triaxial for RHA, Kaolin clay and geopolymer mix

%	Angle of internal friction (Ɵ)^0								
	RHA			**Kaolin**			**Geopolymer mix**		
	Ka	***Sa***	***Da***	***Ka***	***Sa***	***Da***	***Ka***	***Sa***	***Da***
6% cement +0% Additives	19	23	18	107.45	105.54	106.95	107.45	105.54	106.95
6% cement +2% Additives	11	26	11	320.26	300.12	300.46	399.54	387.44	398.42
6% cement +4% Additives	10	28	11	365.65	342.25	345.45	445.20	435.80	442.40
6% cement +6% Additives	16	21	16	370.45	359.25	369.35	460.32	440.42	458.72
6% cement +8% Additives	10	29	10	445.35	426.95	435.35	560.98	550.78	556.75
6% cement +10% Additives	19	27	18	540.05	519.65	520.75	678.35	658.45	675.35

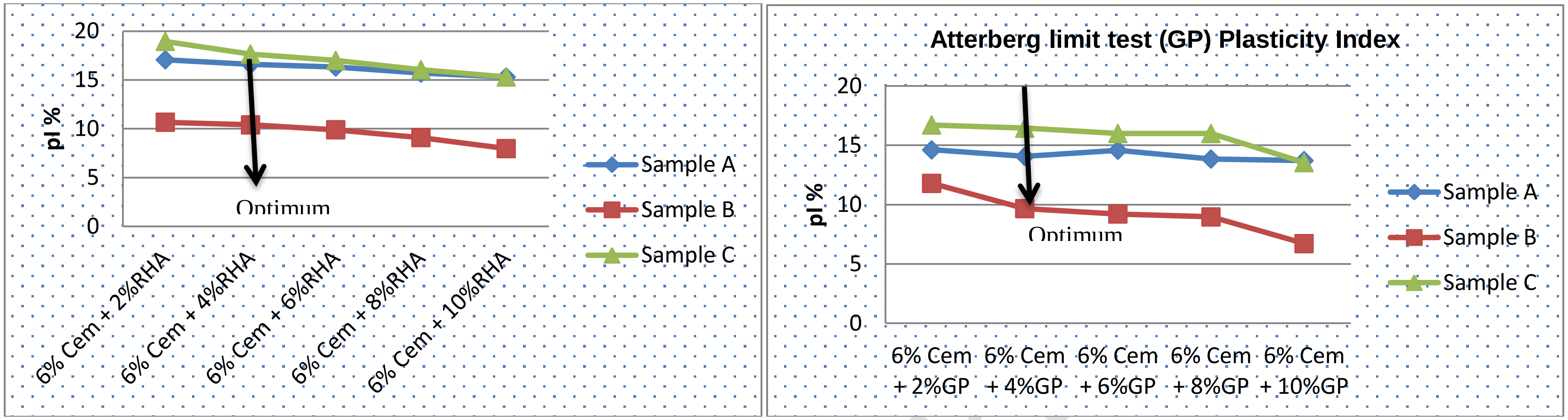

Figure 1: Variation of Atterberg at optimum cement with percentages of geopolymer.

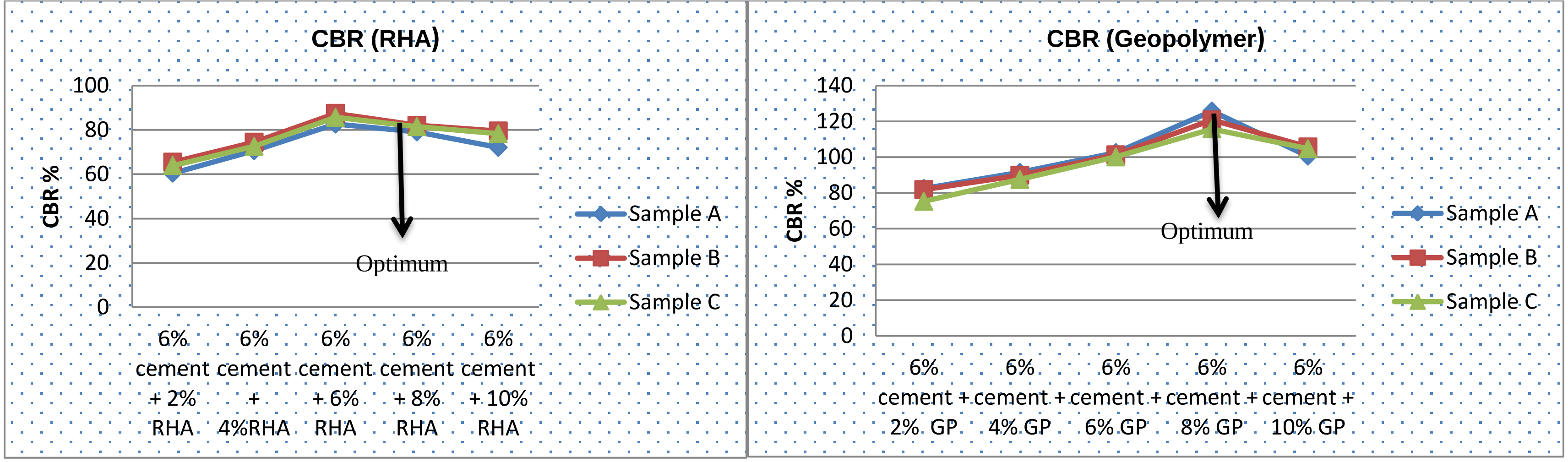

Figure 2: Variation of CBR at optimum cement with percentages of Rice husk ash and geopolymer.

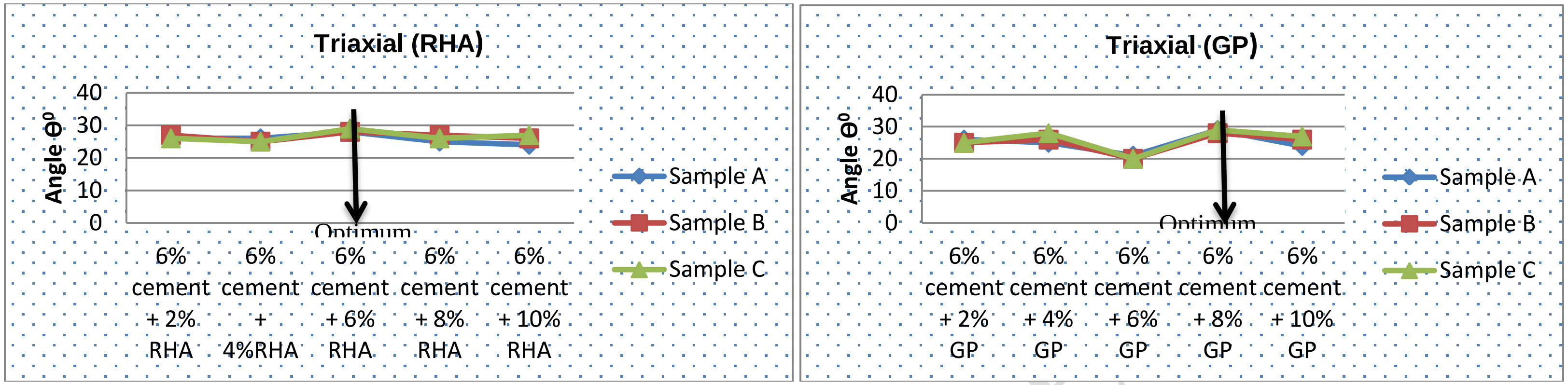

Figure 3: Variation of Triaxial at optimum cement with percentages of Rice husk ash and geopolymer.

Figure 4: Field visit, material collection and laboratory test.