International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 04 | Apr-2018 www.irjet.net p-ISSN: 2395-0072

Effect of Stone Slurry And Crumb Rubber on Phosphogypsum Treated Clay

Jildha Janardhanan[1], Nithin Joseph[2], Pournami R[3], Unnikrishnan M[4], Vidya V[5], Sankar Bose[6]

[1, 2, 3, 4, 5] B-Tech Students, Civil Engineering Department, Vijnan Institute Of Science And Technology, Kerala, India
[6] Assistant Professor, Department of Civil Engineering, Vijnan Institute Of Science And Technology, Kerala, India

---

Abstract - *In the developing countries like India, it is necessary for increasing the geotechnical properties of clayey soil. The problem of disposal of industrial wastes such as stone slurry, crumb rubber and Phosphogypsum leads to the investigation of utilization of such wastes as the stabilizing agent. The stone slurry waste is taken from the stone cutting plant and then it is mixed with water to form the stone slurry. Stone slurry is rich with calcium oxide. The crumb rubber is obtained by crushing the tyre wastes into smaller pieces. Phosphogypsum is a waste material which is produced as the by-product from processing of phosphate rock with sulphuric acid. The annual phosphogypsum(PG) production is around 5 million tonnes per year. The radiation property of PG causes the environmental problems. By using these materials as the stabilizer the strength of the clayey soil can be increased as well as the environmental problems can be reduced. The geotechnical properties of clay is improved by adding different percentages of phosphogypsum, stone slurry and crumb rubber. Laboratory tests like California Bearing Ratio (CBR)test, proctor compaction test, unconfined compressive strength test were done .From the test results, the optimum value of PG is obtained and keeping it as a constant amount , stone slurry and crumb rubber is added separately to the PG treated clay. The total thickness of the pavement can also be reduced by the use of these materials. The total thickness of pavement with the stone slurry is comparatively less than the total thickness of pavement with normal clayey soil as per CBR method recommended by California State of Highway.*

***Key Words*: StoneSlurry, Crumb Rubber,Phosphogypsum, Soil Stabilization, CBR value, Strength, Pavement thickness.**

1. INTRODUCTION

The stabilization process aims that to increase the soil strength and to decrease its permeability and compressibility. If weak soils exist, stabilization and improvement of their properties is necessary. The stabilization process may include mechanical, chemical, electrical or thermal processes. The processes used depend on the type of soils, the time available to execute the project and the stabilization cost compared to the overall cost of the project. Clayey soil possess high threat for the construction of buildings due to its less strength and high swelling property and shrinkage characteristics.

Problematic soils, especially cohesive soil deposits are considered to be a potential natural hazard, which can cause extensive damage to structures if not adequately treated. During the last few decades, damage due to swelling action has been observed in pavements, roadways, building foundations, slab-on-grade members, and channel and reservoir linings, irrigation systems, water lines, and sewer lines. In order to control this behaviour, treating the clay suitably with industrial solid waste or any other available materials, which can alter its engineering properties of clay.

Hence suitable measures are need for the improvement of properties of clay before construction work. A wide range of soil improvement methods has been used including soil replacement, lime/cement columns, stone columns, and soil reinforcements. The selection of an appropriate method depends on ground characteristics, effectiveness, and applicability of the preferred technique and installation and maintenance costs. Soil stabilization is used to reduce the permeability and compressibility of the soil mass in earth structures and to increase its shear strength and bearing capacity or load carrying capacity of soils. The main objective of soil stabilization is to increase the strength of soil and to reduce the construction cost by making best use of the locally available materials.

2. LITERATURE REVIEW

Roshni R, Divya krishnan K and P. T. Ravichandran (2014), In this study two waste materials are used. The materials are wood ash and phosphogypsum (PG) to stabilize problematic clay soil samples were evaluated. Wood ash is the residue left from burned wood and phosphogypsum is a by-product obtained from the fertilizer industry. The effect of varying percentage of ash on the strength properties of two clayey soil samples stabilized with 4% phosphogypsum is presented. The strength test such as CBR, Proctors and UCC are conducted. The test results showed maximum strength of the soil samples when treated with 4% phosphogypsum and 12% wood ash. The use of two waste by-products such as phosphogypsum and wood ash may serve as an effective and efficient way to stabilize the soil and minimize disposal problem caused by the waste materials.

K. Divya Krishnan c. and Ajesh K (2016), They are made on the utilization of phosphogypsum (PG) with soil by adding various percentages of 2, 4, and 6% in soils and accessed their geotechnical behaviour. Strength improvement of compacted clayey soil due to the addition of PG are studied based on micro structural analysis and Unconfined Compression tests for different curing periods. From the UCC test they identified that addition of phosphogypsum attained high strength with the increasing percent of phosphogypsum in soils.

Purushotham G Sarvade and Prashant R Shet (2012). They explain that by the use of Crumb Rubber Powder (CRP) which is made from old automobile tyres is used as an additive to improve properties of clayey soil and study the effect of CRP on strength of problem clay after stabilization. Their investigation was evaluated optimum CRP for stabilization of the clay from the point of view of plasticity and strength characteristics. This journal describes the experimental studies with respect to geotechnical properties (particle size, specific gravity, compaction characteristics, and unconfined compression strength (UCS) of both clay and stabilized clay.

Yashdeep Saini and D.K. Soni(2017). From the paper the treatment of clayey soil using stone slurry waste and cement is pollution controlling and also solves disposal problem. Cement induces bonding between the particles. The study describes the effectiveness of stone slurry waste and cement to stabilize the clayey soils. The two materials are mixed with clayey soils in different proportion and investigate the effect of stone slurry waste and cement on strength, compaction and CBR properties of clayey soil. They shows that with the addition of stone slurry waste and cement has significant effect on the clayey soil.

Nabil Al-Joulani (2016). In this study the stabilization of stone slurry waste using particular percentages of cement and clayey soil was carried out. The stone slurry waste was dried, grinded to fine particles and then mixed with specific amounts of Portland cement and cohesive soils. Appropriate amount of water added and mixed thoroughly. The mixture was compacted in special mould under a pressure of 25 MPa. The tests carried out on the stabilized specimens included compressive strength, indirect tensile strength and natural absorption.

3. MATERIALS USED

The materials used are kuttanad clayey soil, phosphogypsum from fertilizer industry, crumb rubber powder (CRP) and Stone slurry powder from stone cutting plant.

3.1 Kuttanad Clay

Kuttanad clay is collected from the Kuttanad region, Alappuzha, Kerala.The image is shown in figure 1.The basic index and engineering properties of the soil were determined by various preliminary laboratory tests such as Moisture Content, Specific Gravity, Atterberg Limits (liquid limit and Plastic limit), Standard Proctor Compaction Test, Unconfined Compressive Strength (UCS)Test and California Bearing Ratio (CBR) Test. The result obtained is shown in Table-1.

Fig -1: Kuttanad Clay

Table -1: Properties of Kuttanad clay

Properties	**Results**
Colour	Dark Gray
Moisture Content (%)	56.34
Specific Gravity	1.463
Atterberg Limits Liquid Limit (%) Plastic Limit (%)	 98.7 43.97
Unconfined compressive strength (kg/cm^3)	0.073
Maximum Dry Density (kN/m^3)	1.06
CBR value	3.7
Degree of compressibility	Very Highly Compressible

3.2 Phosphogypsum (PG)

Phosphogypsum is collected from the FACT, Ernakulam, Kerala. It is a by-product obtained from the fertilizer industry. The PG is formed by the reaction between phosphate ore and sulphuric acid. By this reaction, phosphoric acid and phosphogypsum are formed. The chemical formula of gypsum is $CaSO_4.2H_2O$. PG have almost similar properties of gypsum.

$$Ca_5(PO_4)_3F + 5H_2SO_4 + 10H_2O \rightarrow 3H_3PO_4 + 5(CaSO_4.2H_2O) + HF$$

In India, PG production is 11 Million tonnes per year. 10 tonnes of PG is produced with the production of 1 tonne of Phosphoric acid.

In 2009, the atomic energy regulation board of India approved PG used for construction purpose. The PG is shown in figure 2. The test conducted on different percentages such as 4%,8%,12% & 14% of PG with the kuttanad clayey soil and the optimum value is find out. The obtained results are shown in the table-2.

Fig-2: Phosphogypsum

Fig-3: Crumb Rubber

Table-2: Test on PG treated clayey soil.

SL NO.	TESTS	% OF PG ADDED TO CLAYEY SOIL			
		4%	8%	12%	16%
1	Specific gravity	1.96	2.02	2.03	2.03
2	Atterberg limit a) Liquid limit (%) b) Plastic limit (%)	60 33.3	66.6 40	62.5 31.25	60 28.5
3	Unconfined compression test (Kg/cm²)	0.0963	0.1274	0.1115	0.1035
4	Proctors compaction test (KN/m³)	1.46	1.57	1.56	1.55
5	CBR test (%)	48.7	64.14	59.5	53.02

3.3 Crumb Rubber

The crumb rubber (CR) is collected from tyre company, Kottayam, Kerala which is shown in figure 3. They are composed of rubber, carbon black, textile, oxidize zinc, sulphur & additives.They are recycled rubber product from automotive and truck scrap tyres. Crumb rubber reduces swelling pressure and compression index of the mixes. They are available in different sizes. During recycling, steel and other materials are removed. The granulate is sized by passing through a screen.

The test conducted on different percentages such as 15%, 18%, 21% & 24% of crumb rubber with clayey soil and optimum dosage of PG were calculated. The obtained results are shown in table 3. The chemical composition of crumb rubber is following.

Ash Content (%) - 5.11
Carbon Black Content (%) - 28.43
Acetone Extract (%) - 9.85
Volatile Matter (%) - 0.56
Hydrocarbon Content (%) - 56.05

Table-3: Test on PG treated clayey soil with Crumb Rubber.

SL. NO.	TESTS	% OF CRUMB RUBBER ADDED TO 8% OF PG			
		15%	18%	21%	24%
1	Specific gravity	1.45	1.22	1.15	1.11
2	Atterberg limit a) Plastic limit (%) b) Liquid limit (%)	45 47.67	33.3 60	34.05 58.3	35 42
3	Unconfined compression test(Kg/cm²)	0.375	0.557	0.403 9	0.363 6
4	Proctors compaction test (KN/m³)	1.84	1.87	1.84	1.83
5	CBR test (%)	71.94	74.97	74.51	71.94

3.4 Stone Slurry

Stone slurry is obtained from stone cutting plant, Ernakulum, Kerala. In quarrying and stone cutting industry which produce large quantity of stone slurry(SS) waste during extraction, cutting and processing of rocks. These slurry is dried and grinded to small particles which shown in figure 4.

The stone slurry powder particles are rough, sharp and angular in nature which possess strength. The main constituent in the stone slurry is calcium carbonate ($CaCO_3$). The stone slurry waste is usually disposed in open areas which causing various health and environmental problems. The chemical composition of stone slurry powder may vary, depending on the origin of parent rocks. Basically, the stone slurry powder is composed of calcite as denoted by high content of CaO and loss of ignition. By using stone slurry waste as a stabilizing material of cohesive soil, dry density and strength can be increased and the optimum water content can be decreased.

Fig-3: Stone Slurry Powder

The study aims to improve the properties of clayey soil. Different percentages of stone slurry is added to PG treated clayey soil. The corresponding percentages of stone slurry added into the phosphogypsum treated clayey soil are 4%, 8%, 12% and 16%. The obtained test results are shown in table-4.

Table-4: Test on PG treated clayey soil with Stone Slurry.

SL. NO.	TESTS	% OF STONE SLURRY ADDED TO 8% OF PG			
		4%	8%	12%	16%
1	Specific gravity	2.105	2.22	2.35	2.29
2	Atterberg limit a) Plastic limit (%) b) Liquid limit (%)	40 41.75	33.3 40.8	25 20.13	27.27 15.4
3	Unconfined compression test(kg/cm^2)	0.201	0.489	0.522	0.303
4	Proctors compaction test (kN/m^3)	1.85	1.883	1.903	1.896
5	CBR value (%)	75.44	81.5	83.15	81.5

4. EXPERIMENTAL INVESTIGATIONS

4.1 Test On Normal Clayey Soil

There are different tests conducted on normal clayey soil. Clay is an expansive soil. The clay possesses swelling property. The swelling of clay is due to the presence of montmorillo nite mineral. The index properties and engineering properties of clayey soil is determined by conducting preliminary tests as well as strength tests. Preliminary tests like moisture content, specific gravity, Atterberg limits are find out. The unconfined compressive strength test is carried out to determine the strength of clay. Proctors compaction test is carried out to determine the maximum dry density of clayey soil. Also the California bearing ratio (CBR) Test is conducted to find the CBR value. Thus the thickness of the pavement can be calculated and can compare the construction cost about the pavement construction.

4.2 Test On Normal Clay With Phosphogypsum

In this study the strength characteristics on normal clayey soil is determined when the clay is added with the different percentages of phosphogypsum. Here, different percentages of phosphogypsum is added with the clay and the strength test such as UCS, proctors compaction test and CBR are conducted. The clay is treated with 4%, 8%, 12% and 16% of phosphogypsum and the optimum value is obtained. From the tests the optimum value is obtained at addition of 8% of phosphogypsum into the normal clayey soil. The unconfined compressive strength is obtained as 0.1274 kg/cm^2 .the maximum dry density is obtained as 1.57 and the obtained CBR value is 64.14%.

4.3 Test On Phosphogypsum Treated Clay With Crumb Rubber.

In this study the strength characteristics of phosphogypsum treated clay with crumb rubber is determined. In the PG treated clay different percentages of crumb rubber is added and preliminary tests and strength tests are carried out. The chosen percentages of crumb rubber are 15%, 18%, 21% and 24%. The preliminary tests such as specific gravity, liquid limit, plastic limits are done. The obtained values of liquid limits for 15%, 18%, 21% and 24% are 47.67%, 60%, 58.3% and 42% are respectively. The liquid limit is decreased from that of untreated clay. The obtained values of plastic limits are 45%, 33.3%, 34.05% and 35% for the corresponding percentages of addition of crumb rubber. The strength tests such as UCS, CBR and proctors compaction test are carried out. The CBR value is obtained as 74.97 for 18% addition of crumb rubber which is the maximum crumb rubber value. The proctor's compaction test results are 1.84 kN/m^3, 1.87 kN/m^3, 1.84 kN/m^3 and 1.83 kN/m^3 for 15%, 18%, 21% and 24% respectively. The maximum strength obtained at the addition of 18% of crumb rubber to the PG treated clayey soil.

4.4 Test On PG Treated Clay With Stone Slurry Waste

In this study the test conducted on stone slurry waste and PG treated clay are carried out. From the experiments the strength characteristics of samples are calculated. Here, different percentages of stone slurry powder are added to the PG treated clay and the maximum value is determined. The stone slurry is taken in 4%, 8%, 12% and 16%. The tests conducted on the sample are specific gravity, liquid limit, plastic limit, proctors compaction test, unconfined compressive strength and California bearing ratio. The obtained UCS values are 0.201 kg/cm^2, 0.489 kg/cm^2, 0.522 kg/cm^2 and 0.303 kg/cm^2 for 4%, 8%, 12% and 16% of addition of stone slurry powder respectively. The obtained dry density by proctors compaction tests for 4%, 8%, 12% and 16% are 1.85 kN/m³, 1.883 kN/m³, 1.903 kN/m³ and 1.896 kN/m³ respectively. The maximum CBR value is 83.15%. The maximum strength is occurring at the addition of 12% of stone slurry to the phosphogypsum treated clayey soil.

5. RESULTS AND DISCUSSIONS

5.1 Influence Of Phosphogypsum On Clay Based On UCS Test, Proctor Compaction Test and CBR Test.

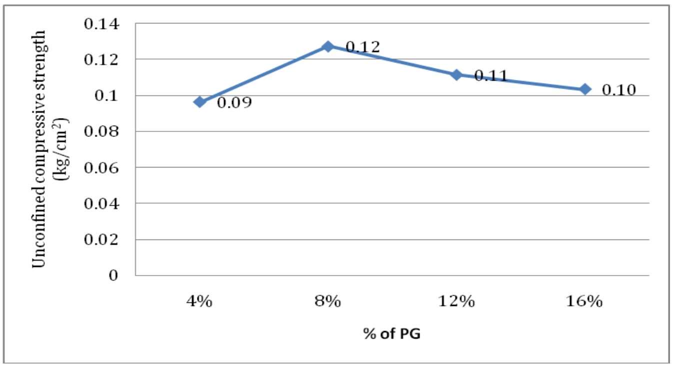

Chart -1: Effect of PG treated clay based on UCS test

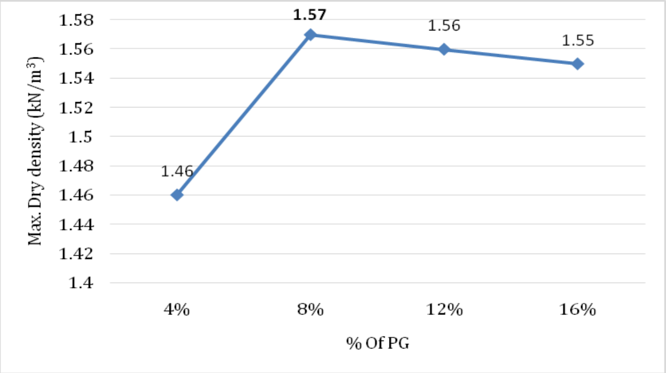

Chart -2: Effect of PG treated clay based on Proctor Compaction Test.

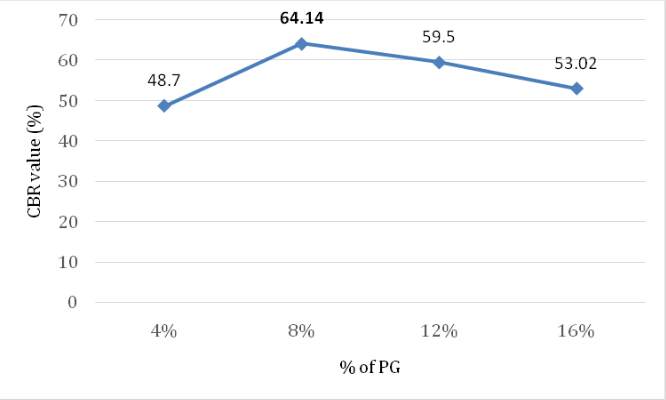

Chart -3: Effect of PG treated clay on CBR test.

5.2 Influence Of Crumb Rubber on Phosphogypsum Treated Clay Based On UCS Test, Proctor Compaction Test And CBR Test.

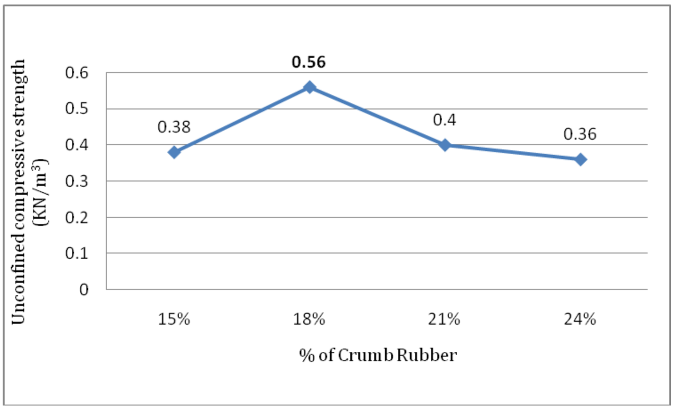

Chart -4: Effect of Crumb Rubber on PG treated clay based on UCS test.

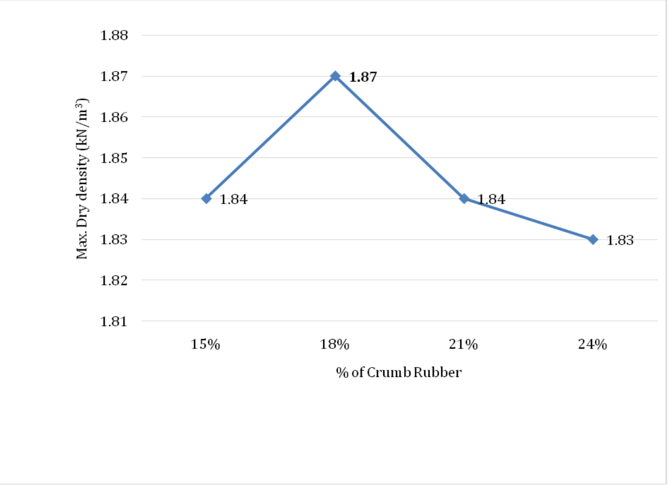

Chart -5: Effect of Crumb Rubber on PG treated clay based on Proctor Compaction Test.

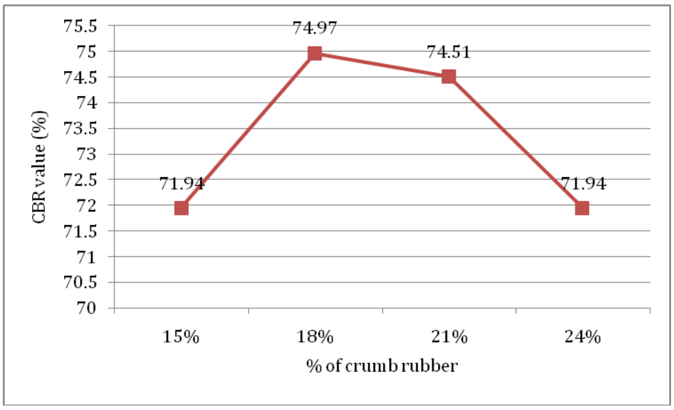

Chart -6: Effect of Crumb Rubber on PG treated clay based on CBR test.

5.3 Influence Of Stone Slurry On Phosphogypsum Treated Clay Based On UCS Test, Proctor Compaction Test And CBR Test.

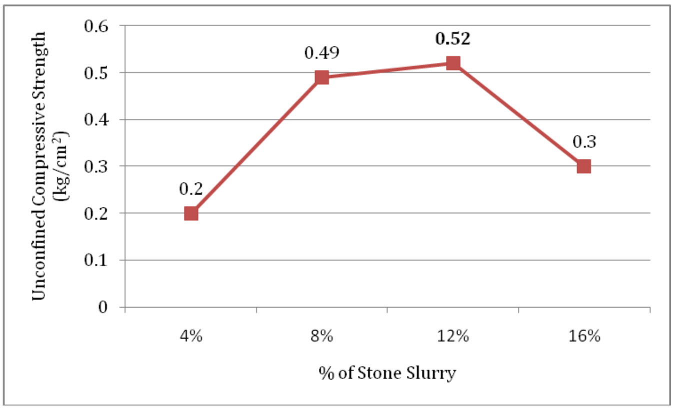

Chart -7: Effect of Stone Slurry on PG treated clay based on UCS test.

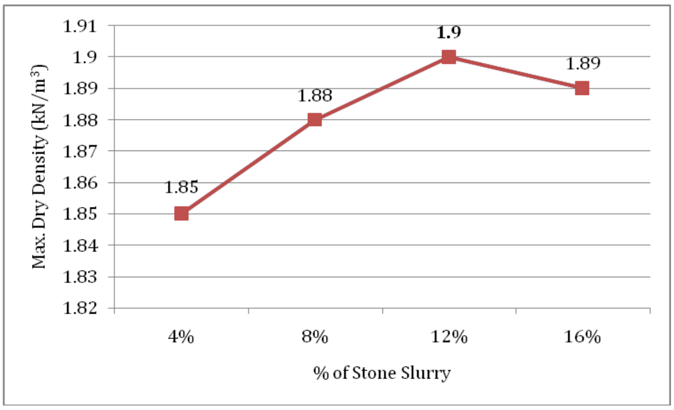

Chart -8: Effect of Stone Slurry on PG treated clay based on Proctor Compaction Test.

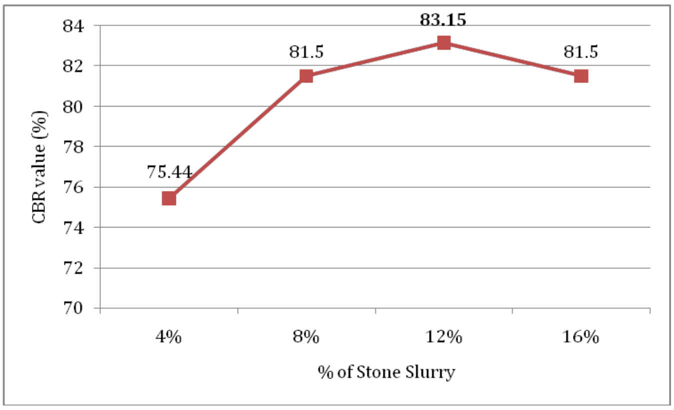

Chart -9: Effect of Stone Slurry on PG treated clay based on CBR test.

5.4 Comparison Chart On UCS, Proctor Compaction Test And CBR.

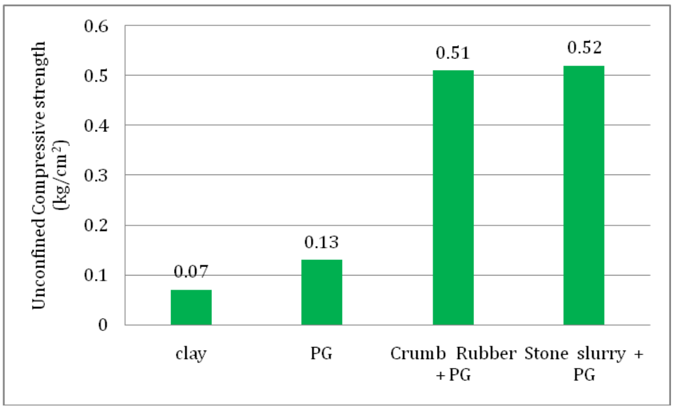

Chart-10: Comparison between untreated clay, Phosphogypsum, Crumb Rubber and Stone Slurry added clay based on UCS.

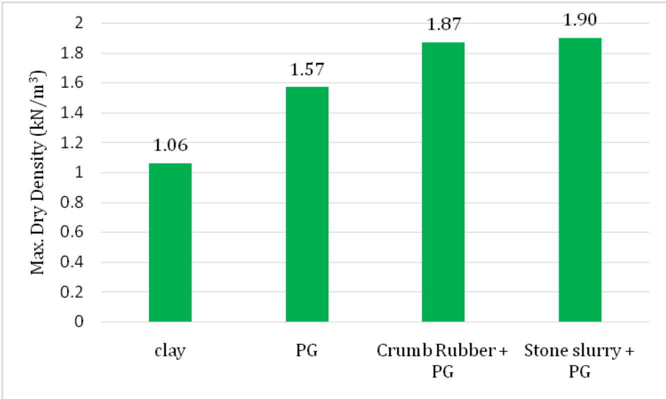

Chart -11: Comparison of Dry density between untreated clay, Phosphogypsum, Crumb Rubber and Stone Slurry added clay based on Proctor Compaction Test.

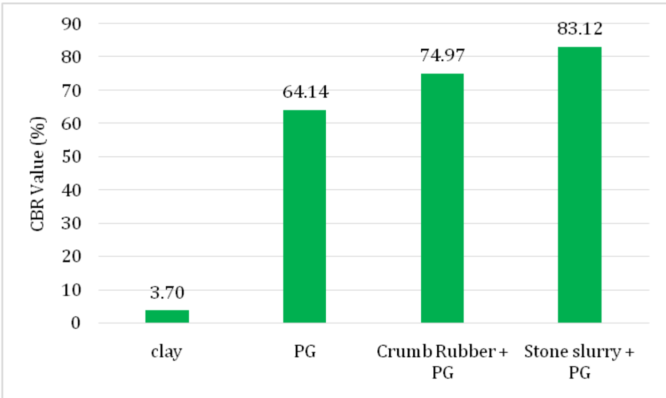

Chart -12: Comparison of CBR value between untreated clay, Phosphogypsum, Crumb Rubber and Stone Slurry added clay on CBR.

5.5 Combined Chart on UCS, Proctor Compaction Test And CBR Test.

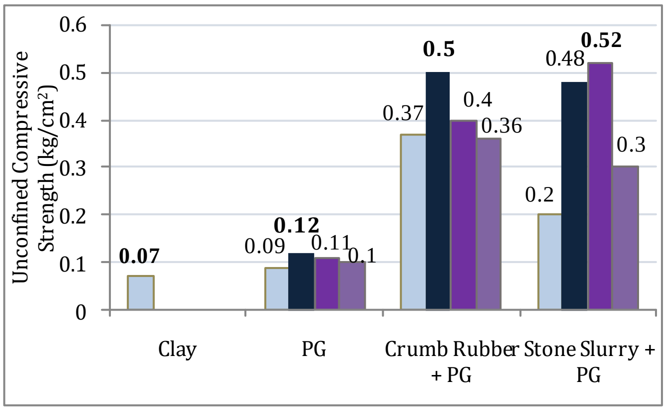

Chart -12: Comparison between UCS values of untreated clay, PG, Crumb Rubber and Stone Slurry treated clay.

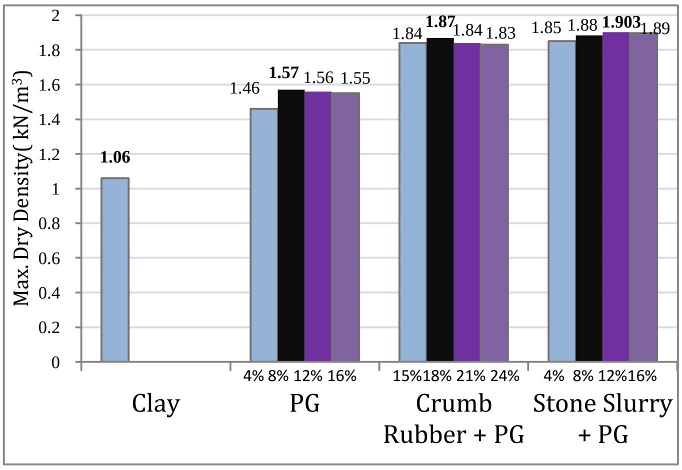

Chart -13: Comparison between Dry density values of untreated clay, PG, Crumb Rubber and Stone Slurry treated clay.

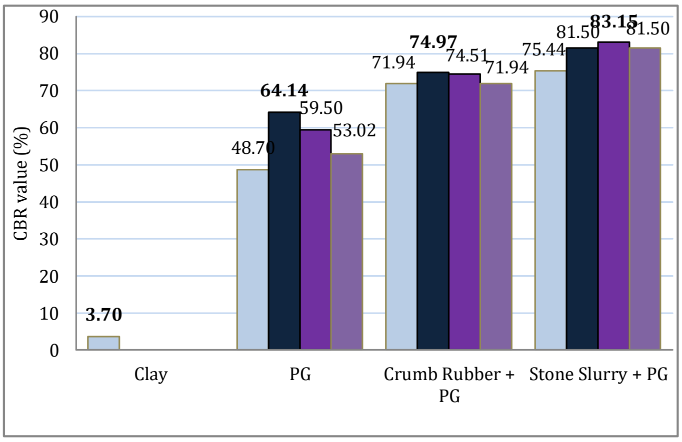

Chart -14: Comparison between CBR values of untreated clay, PG, Crumb Rubber and Stone Slurry treated clay.

6. CONCLUSION

1. Clay soil have higher moisture content and Atterberg limits and possesses lower strength. For PG added clay, unconfined compressive strength is 2 times greater than the strength of untreated clay and the obtained value is 0.13 kg/cm².

2. The CBR value for PG added clay is 17.3 times greater than normal clay and the CBR value for PG treated clay obtained at 8% is 64.14%.

3. From Proctor compaction test, the dry density of PG treated clay is increased by 1.5 times that of normal clay and the obtained value of maximum dry density of PG treated clayey soil is 1.57 kN/m³.

4. When crumb rubber is added to PG treated clay, then the dry density of it is increased by 1.76 times of the normal clay & 1.2 times of the PG treated clay. For crumb rubber added PG treated clay, the maximum dry density is obtained as 1.87 kN/m³.

5. UCS for crumb rubber added clay is 0.507 kg/cm² & for normal clay it is 0.073 kg/cm². CBR value is 20.3 times greater than that of normal clay due to the addition of crumb rubber.

6. From proctor's compaction test dry density of stone slurry added PG treated clay is 1.903 kN/m³ & for normal clay it is 1.06 kN/m³. Unconfined compressive strength is increased by 7.2 times that of clay when stone slurry added to PG treated clay.

7. When stone slurry added to PG treated clay, CBR value is 22.5 times greater than that of normal clay.

8. Optimum value of strength is obtained at 8% of PG, 18% of Crumb Rubber & 12% of Stone slurry. Liquid limit & plastic limit get decreased.

9. As per the study and by CBR method recommended by California State of highway the total thickness of pavement for normal clay is obtained as 410mm. The total thickness of pavement for PG treated clay is 98mm it is less than normal clay. The total thickness of pavement for PG treated clay with crumb rubber is 86mm and it is less than that of normal clay. The thickness of pavement for PG treated clay with stone slurry is 80mm which is less than the thickness of normal clay. Thus the total thickness of pavement is small when using the stabilizers. Cost effective on the view point of pavement construction.

7. FUTURE SCOPE OF THE STUDY

The study can be extended by conducting an experimental investigation by any other similar materials like Metakaoline instead of PG and utilize the stabilizers for the pavement construction and make cost effective.

ACKNOWLEDGEMENT

We thank our teachers and friends from Vijnan Institute of Science And Technology who provided insight and competence that greatly assisted this research.

REFERENCES

[1] Jijo James and P. Kasinatha Pandian(2014), "Effect of phosphogypsum on strength of lime stabilized expansive soil" , Gradevinar Vol.66 , 1109-1116.

[2] K. Divya Krishnan, Mani Deepika, P. T. Ravichandran, C. Sudha and Ajesh K.Kottuppillil, "Study on Behaviour of Soil with Phosphogypsum as Stabilizer", Vol. 9(23), 2016.

[3] Praveen Kumar and Dr. Rajesh Goel Vishal Yadav, "Stabilization of Soil using Crumb Rubber", International Conference on Emerging Trends in Engineering , Technology , Science and Management, 2017.

[4] P. T. Ravichandran, A. Shiva Prasad, and P. R. Kannan Rajkumar, "Effect of Addition of Waste Tyre Crumb Rubber on Weak Soil Stabilization", Vol. 9(5), 2016.

[5] Yashdeep Saini and D.K. Soni, "Stabilization Of Clayey Soil By Using Stone Slurry Waste And Cement: Review", International Conference on Emerging Trends in Engineering, Technology, Science and Management, 2017.

[6] Roshni R, Divya Krishnan K and P. T. Ravichandran , "Experimental Study on Strength Behaviour of Expansive Soil Treated with Phosphogypsum and Wood Ash", International Journal of Science and Research, 2013.

[7] Nabil Al-Joulani , "Stabilization Of Stone Slurry Waste With Cement And Cohesive Soils", International Journal of Applied Engineering Research, 2016.