International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 10 Issue: 04 | Apr 2023 www.irjet.net p-ISSN: 2395-0072

Effect of Phosphoric Acid Stabilization And Fiber Reinforcement In Dredged Soil

Nimisha G Prasannan[1], Ms Arya K S [2]

[1]PG Student, Dept. of Civil Engineering, Sarabhai institute of Science and Technology, Kerala, India
[2]Assistant Professor, Dept. of Civil Engineering, Sarabhai institute of Science and Technology, Kerala, India

---

Abstract - *Disposal of dredged sediment is a environmental burden. To improve the mechanical properties of sediment treatment techniques are required. Phosphoric acid can be effectively used as a stabilizing agent. dredged sediments stabilized with mixing varying % of phosphoric acid by 2,4,6,8,%. Optimum % of acid is obtained by standard proctor test and UCS test. Natural fiber reinforcement in soil helps to improve the tensile and compressive strength of soil Sisal fiber reinforcement in soil improve the ductile behavior of soil. In this project, reinforcement with sisal fiber is completed by randomly mixing with varying % of fiber. In this study various laboratory test such as standard proctor test and UCS test were performed to evaluate the use of varying % (0.25, 0.5, 0.75 &1) of sisal fiber - soil composite.*

Keywords— unconfined compressive strength (UCS), dredged sediment, phosphoric acid, sisal fiber.

1.INTRODUCTION

The disposal of contaminated sediment is a environmental burden. To improve the mechanical properties of the sediment soil stabilization and soil reinforcement are effective. Different methods are used for soil stabilization. The phosphoric acid can be used as a stabilizing agent. Fiber reinforcement in soil helps to improve the ductile property. Stabilized soil – fiber composite has several applications. Natural flexible fiber application in soil improve compressive and tensile strength. Sisal fiber in soil have many more advantages because it's have excellent resistance to fungi and better insulation against temperature and sound.

2. LITERATURE REVIEW

- **A.S. Michaels et.al.(2017) :** Acidic phosphorous Compounds as Soil Stabilizers. Tests are conducted on a soil having Specific gravity 2.69, Liquid limit 20 %, and Plastic limit 14%. Soil at its natural water content was blended with additional water in a small Baker-Perkins sigma-mixer until visibly homogeneous. phosphoric acid dissolved with other additives and mixed. Samples tested in UCS test. Provided phosphoric acid concentration is 1 to 10.

- **A.Chandel et.al.(2018) :** Conducted a study based on the application of coir and fly ash in clayey soil. The obtained soil having a Specific gravity 2.72, Gravel – sand content 13.78 % ,Silt content 41.62 %, Clay content 44.60 % ,Liquid limit 37 %, and Plastic limit 26%. The specific gravity changes from 2.727 to 2.649 and then decreases with increase in % addition of fly ash from 0% to 16%.

- **J. Wei et.al.(2018) :** Conducted a study on Sisal Fiber and Polyurethane Admixture on the Strength and Mechanical Behavior of Sand. In this investigation, sisal fiber (SF) and water-based polyurethane (PU) were used to reinforce sand. A series of unconfined compression tests were carried out on sand specimens at different percentages of fiber contents (0.2%, 0.4%, 0.6%, and 0.8%) and polymer contents (1%, 2%, 3%, and 4%). Max UCS value occurs at 3% addition.

- **K. Balaji et.al.(2019) :** Conducted a study based on Soil Stabilization using Phosphorus Pentoxide.. The test is conducted on a clayey soil having specific gravity 2.5 , liquid limit 58% and plastic limit 37.6%.standard proctor compaction test is done on the soil to determine the OMC and MDD values. UCS test is done to determine the compressive strength values.the strength increased at 5 to 10 % addition then decreased at 15% addition.

- **Sandyarani et.al.(2018) :** Conducted a study on Stabilization of black cotton soil by using Sisal fiber. The test is conducted on black cotton soil having Moisture content (%) 22.33 specific gravity 2.683, liquid limit 66.6% and plastic limit 27.20%. soil samples were prepared with adding varying % of sisal fiber (0.2,0.4,0.6 and0.8%) with varying length. Max MDD occurs at 0.4% addition and max UCS value obtained at 0.4% addition.

- **M. E Kumar et.al (2019) :** This study is based on Influence of Sisal Fibers on the Properties of Rammed Earth . in this study red soil mixed with different % of (5,10,15 and 20 %) of OPC and sisal fiber with varying % (0.2,0.4,0.6,0.8 and 1%). The bamboo splits were treated with chemical solution. After 28days of curing

period the cubes were tested for compressive strength, pull-out test is done. The compressive strength is more for 20% mixture addition.

- **R.Marcal et.al.(2020) :** This study evaluated the strength characteristics of lateritic soil reinforced with waste strips. 15mmwidth pp strips of different length used in the soil. This combination is added in clayey sand and clayey soil. 0.25 to 2% of pp strips with varying length is mixed in soil. UCS and CBR test is conducted to determine the compressive strength and bearing capacity of soil. And result showed that CBR value increased to 133%.

- **Marques A et.al.(2021) :** This research uses stabilization method by using lime and phosphoric acid. In this project different % of lime content with 55 opf phosphoric acid is used. Varying % of lime content are 6,8,10,and12%. UCS test is done to determine the compressive strength value of soil. Max UCS value obtained at 12% of lime and 5% of phosphoric acid addition.

3. OBJECTIVES

The objectives of this study are:

- To determine maximum dry density, optimum moisture content and unconfined compressive strength of soil with different percentage of phosphoric acid.

- To determine maximum dry density, optimum moisture content and unconfined compressive strength of phosphoric acid stabilized soil with different percentages of sisal fiber.

4. MATERIALS USED

The materials used in the project collected from various regions

4.1 Dredged sediment

The soil used in the project dredged from Neyyattinkara . dredged soil was air dried in laboratory. The soil gradation curve is given in Fig.1. The soil is classified as silt of intermediate plasticity (MI). The compaction tests were carried out on the soil, and the optimum water content (OMC) and maximum dry density (MDD) are 18 % and 14.51 kN/m^3, respectively. The soil properties are shown in Table 1

Table-1: Properties of soil

properties	values
Moisture content, w (%)	14.28
Liquid limit, w_L (%)	40.66
Plastic limit, w_P (%)	27.98
Plasticity index, PI (%)	12.62
Shrinkage limit, w_s (%)	11.17
Specific gravity, G	2.16
% clay	17
% silt	83
Soil classification	MI
Optimum moisture content (%)	18%
Maximum Dry density (kN/m^2)	14.51
Unconfined Compressive Strength (kN/m^3)	24.52

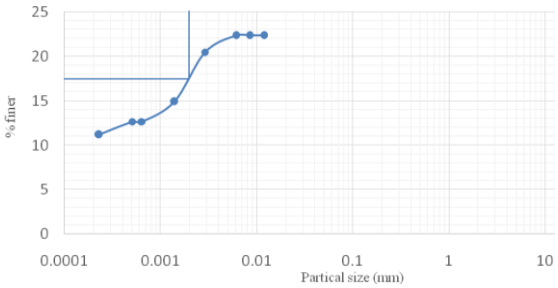

Chart - 1: Gradation curve

4.2 Phosphoric acid

Phosphoric acid is a colorless, and odorless substance. It is used in soft drinks for acidic properties.

Table – 2 : properties of phosphoric acid

properties	values
color	white
odor	odorless
Density (kN/m^3)	19.91
Melting point (°C)	42.4

4.3 sisal fiber

The sisal fiber obtained from leaves of sisal plant. It have higher strength and durability it have better resistant to salt water.

Table - 3 : properties of sisal fiber

properties	values
Colour	white
Length(mm)	20
Density (KN/m^3)	13.04 – 14.72
Tensile strength (N/mm^2)	400-700
Young's modulus (N/mm^2	38000

Table - 4 : chemical composition of sisal

Chemical composition	percentage
Cellulose (%)	65
Hemicelluloses (%)	12
Lignin (%)	9.90
Waxes (%)	2

5. RESULT AND DISCUSSIONS

5.1 Stabilization with phosphoric acid

The results of standard proctor test in table 5 shown that , OMC decreased with respect to the increase of stabilizing agent. Similarly, MDD value increased with respect to the increase in phosphoric acid. Because the increase in dry volume weight of stabilizing material. Variation optimum moisture content & maximum Dry Density for varying % of phosphoric acid is shown in chart 2.

Table – 5 : variation optimum moisture content, maximum dry density and UCS value for varying % of phosphoric acid.

% of phosphoric acid	2%	4%	6%	8%
Optimum Moisture Content (%)	18	16	14	12
Maximum Dry Density (kN/m^3)	14.55	17.06	15.7	16.77
Unconfined Compressive Strength (kN/m^2)	38.01	62.12	53.13	51.12

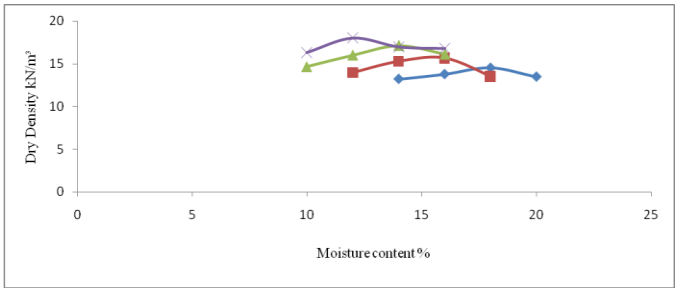

Chart - 2 : Variation optimum moisture content & maximum Dry Density for varying % of phosphoric acid.

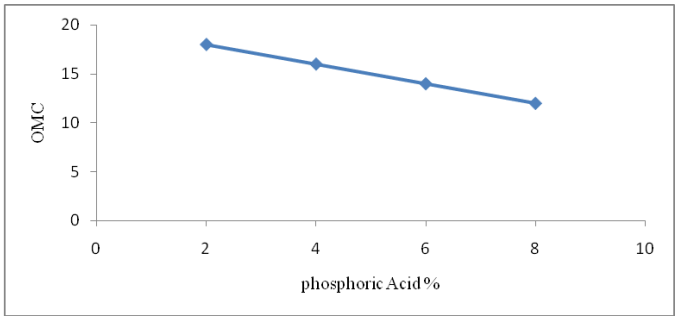

Chart - 3 : Variation optimum moisture content for varying % of phosphoric acid.

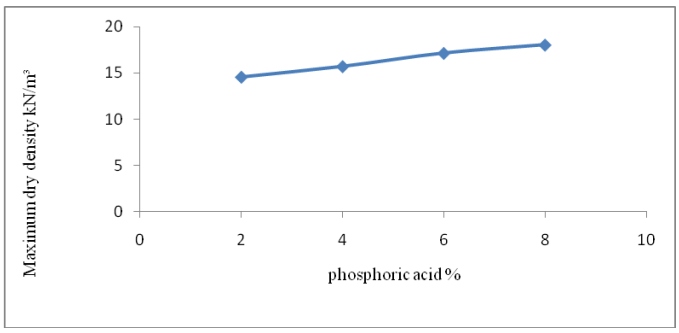

Chart - 4 : Variation maximum Dry Density for varying % of phosphoric acid.

Table – 6 : variation optimum moisture content, maximum dry density and UCS value of stabilized soil with varying % of sisal fiber.

Soil variant	0.25 % SF & 4% PA	0.5 % SF & 4% PA	0.75%SF & 4% PA	1% SF & 4% PA
Optimum Moisture Content (%)	20	22	24	26
Maximum Dry Density (kN/m^3)	15.10	14.73	14.40	13.94
Unconfined Compressive Strength (kN/m^2)	58.85	70.29	63.92	60.49

The result of the UCS test shown in chart 5. From this result, the addition of phosphoric acid in soil increase compressive strength values Maximum UCS value obtained at 4% phosphoric acid addition. UCS value of soil increased from 24.52 KN/m² to 62.12KN/m² at 4% phosphoric acid addition. Addition of phosphoric acid proved to be a good stabilizing agent.

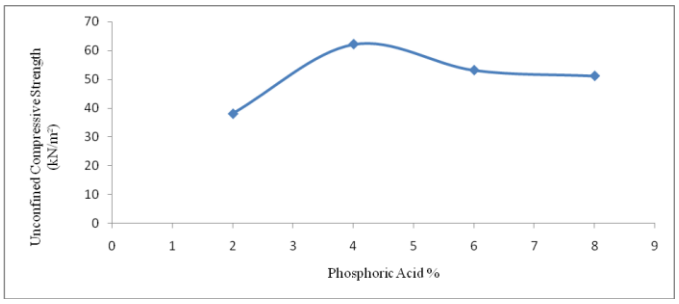

Chart - 5 : Variation UCS value for varying % of phosphoric acid

5.2 combination of sisal fiber with phosphoric acid stabilized soil

The results of standard proctor test and UCS test is given in table 6. The variation of MDD and OMC with respect different % of sisal fiber and optimum % of phosphoric acid is plotted in chart 8. Result showed that there is a increase in OMC occurs at increase in fiber addition. And there is decrease in MDD occurs due to the replacement of heavy soil mass into light weight fiber.

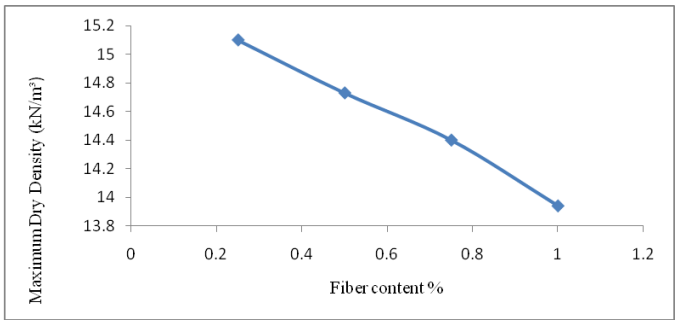

Chart - 6 : Variation of maximum Dry Density value for varying % of Sisal fiber of stabilized soil.

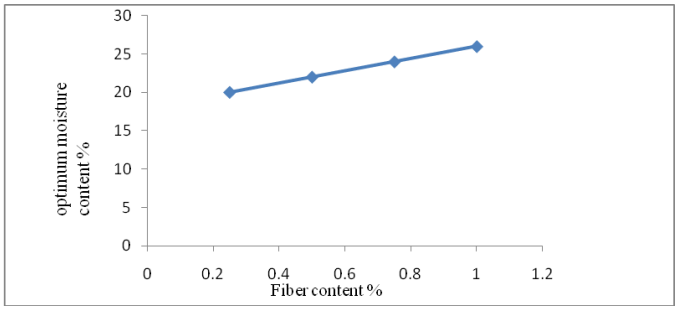

Chart - 7 : Variation of optimum moisture content value for varying % of Sisal fiber of stabilized soil.

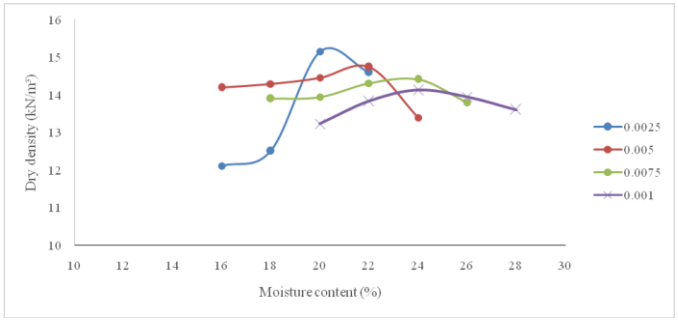

Chart - 8: Variation optimum moisture content & maximum Dry Density for varying % of of Sisal fiber of stabilized soil.

The result of the UCS test shown in chart 9. From this result, max UCS value obtained at 0.5% fiber addition. UCS value of stabilized soil increased from 24.52 KN/m² to 70.29 KN/m² at 0.5% fiber addition. Increase in UCS value observed due to the interaction between fiber and soil and it confines the soil particles. A decrease in UCS value observed after 0.5% fiber addition due to the interaction between fiber. Due to this decrease in strength is observed.

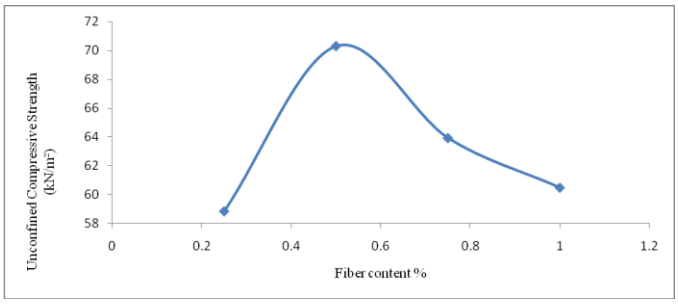

Chart - 9 : Variation of UCS value for varying % of Sisal fiber & 4% of phosphoric acid

6. CONCLUSIONS

It is found that application phosphoric acid as chemical stabilizer proved to be a better performance in soil. And combination of sisal fiber and phosphoric acid in soil helps to improve the mechanical properties such as

compressive strength and tensile strength. In case of phosphoric acid stabilization UCS value of stabilized soil with respect to control samples was in the range of 24.52 KN/m^2 to 62.12KN/m^2. Similarly in case of soil-fiber composite UCS value of fiber reinforced soil with respect to control samples was in the range of 24.52 KN/m^2 to 70.29KN/m^2.Addition of phosphoric acid as a stabilization material can increase the value of compressive strength up to 116%.Sisal fiber reinforcement in stabilized soil can increase the value of compressive strength up to 186%.The use of natural fibers in soil improves the compressive strength as compared to the synthetic fibers.

ACKNOWLEDGEMENT

This project would not have been successful without the kind support and valuable help of many individuals and organizations. I would like to express my deepest gratitude to all of them. I thank lord almighty for providing me with everything that I required in successful completion of this project. I am highly indebted to my guide in charge Ms.Arya K S. Without her help, guidance and patience the thesis would not have been successful. And I express my deepest thanks to the Head of the Department, Prof. R. Jayachandran Nair for their guidance and support in this thesis. My sincere thanks to my parents, friends and all those who have been instrumental in the successful completion of the thesis.

REFERENCES

[1] A. Dahal & M. Lal (2021) 'Performance enhancement of subgrade soil with marble dust and sisal fibers comparative Study' *Journal of emerging technologies and innovative research(JETIR)* .

[2] A .K Sharma, P. Swetha & S. kolathyar (2019) 'comparitive study of sisal and PVA fiber for soil improvement ' R*esearchgate.*

[3] A. Singh & R Sharma (2018) 'A Study of Black Cotton Soil by Using Sisal Fibre and Coconut Fibre' *International Research Journal of Engineering and Technology (IRJET).*

[4] Debtanu Seth , Suresh Prasad Singh & Shubham Singh (2019) 'Strength and Permeability Characteristics of Fibre Reinforced Liner Material' *Elsevier Ltd.*

[5] J.wei, F.Kong, J.Liu &C.Jiang (2018) 'Effect of Sisal Fiber and Polyurethane Admixture on the Strength and Mechanical Behavior of Sand' *Elsevier Ltd.*

[6] Jili Qu and Hao Zhu (2020) 'Function of Palm Fiber in Stabilization of Alluvial Clayey Soil in Yangtze River Estuary' *Journal of Renewable Materials.*

[7] J.Francisco, M.Arteaga, S.Gluhar, A.Kaurin, & D.Lestan, (2021) 'Simultaneous removal of Arsenic and toxic metals from contaminated soil laboratory development and pilot scale demonstration' *Elsevier Ltd.*

[8] J. Prabakar ,R.S. Sridhar (2002) 'Effect of random inclusion of sisal fibre on strength behaviour of soil' *Researchgate*

[9] K. Balaji & C . Sheba (2019) 1587 'Soil Stabilization using Phosphorus Pentoxide' *International Research Journal of Engineering and Technology (IRJET)* Volume: 06 Issue: 06 June 2019 .

[10] M. Amrutha & Dr. K.Y Raneesh. (2016) 'Effect of Strength Characteristics of Expansive Soil Using Sisal Fibre and Waste Materials' *International Journal of Science and Research (IJSR)* Volume 5 Issue 9.

[11] S. Mazloomi , S. Nasseri , R. Nabizadeh , K. Yaghmaeian , M. Alimohammadi, S. Nazmara And A. Hossein Mahvi (2016) 'Remediation of fuel oil contaminated soils by activated persulfate in the presence of MnO^2 ' *Soil & Water Resource.*

[12] S. M. Kavitha ,B. S Mohamed C. Muniyappan& V. Sathish Kumar (2019) ' Stabilization of soil using sisal polypropylene and hybrid fibers' *International Journal of Advance Research Ideas and Innovations in Technology*

[13] V. S Mathada, Sandyarani & Sharanakumar (2018) 'Stabilization of black cotton soil by using Sisal fiber' *International Research Journal of Engineering and Technology (IRJET)*

[14] W. Yankai, L. Yanbin, and B. Niu (2014) ,Assessment of the Mechanical properties of sisal fiber reinforced silty clay using Triaxial shear tests.'*The Scientific World Journal.*