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Soil Stabilization by Phosphogypsum: A Review

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Abstract— This paper aims to present the effect of Phosphogypsum on the stabilization of black cotton soils. Soil stabilization means the improvement of stability or bearing capacity of soil by the use of controlled compaction; proportioning or the addition of suitable admixtures or stabilizers. An excellent material found for mechanical stabilization of cohesive soil is Phosphogypsum. A need is existing for thorough understanding of outcomes of various engineering tests when the Phosphogypsum is mixed with soil samples. Very few researchers have been attracted by enhancing the soil properties by Phosphogypsum. Use of Phosphogypsum with soil can be a sustainable solution for its disposal. The use of Phosphogypsum for stabilization approach is an economical and environmental settling the problems affiliated with its disposal process.

Index Terms— Soil stabilization, black cotton soil, Phosphogypsum, Grain size distribution, SPT, CBR value, OMC, Maximum dry density.

1 Introduction

In recent decades, an increase is observed in standerds of societydue to production of goods, services and job opportunities. On the other hand the disadvantage or shortcoming of industrialization is generation of different kinds of industrial wastes. There exists a vast problem of the disposal and management of these industrial wastes. One of the steps for disposal of these wastes is to find different uses in the field of engineering and manufacturing. In recent years the usage of these materials is experimented in the field of geotechnical engineering in soil stabilization.

The most challenging soil in this field is probably the expansive soils as they have low bearing capacity and poor shear strength, more importantly these soils are vurnarable to swelling and shrinkage on change in water or moisture content. These soils pose a major challenge to engineers as they cause severe damage to the structures constructed on them. Such kind of soils should be improved before construction is carried on them.

Soil stabilization is the most commonly adopted measure vto improve the bearing capacity of such low strength and expansive soils. Traditionally the soil was used to be stabilized only by binding materials such as cement and lime. But due to the serious problem of generation and disposal of solid waste as mentioned above there exist a need to find an effective way out to get rid of these solid wastes generated from factories by using them as stabilizers in expansive and low bearing capacity soil. These methods provide double advantage as they increase the Bearing capacity of soils and at the same time these methods also provide an effective and safe disposal of solid wastes.

2 Solid waste production around the world and in India

In the present scenario, utilization of industrial waste has already been started and is increasing day by day at tremendous rate. Industrial waste is known to be used in manufacturing of bricks, as aggregates, plaster boards, blocks, pavers, mortars etc. However, their use in soil stabilization has recently gained widespread acceptance with more and more industrial wastes being researched for their efficiency in modifying soil properties and serving as mechanical and chemical stabilizers. Some industrial wastes have also been used in geotechnical fill applications.

Today we see that huge quantities of industrial wastes being produced all around the world. It is estimated that cities generate 1.3 billion tones of solid wastes on yearly basis. These volumes of wastes are increasing exponentially and according to an estimate of World Bank (2012) this figure will reach 2.2 billion tones in 2025. The generation of Coal Combustion Products (CCP) is estimated approximately to be 780 million tons (2010 data). The largest producers of CCP are China 395 million tones, North America 118 million tones, India 105 million tones, Europe 52.6 million tones, Africa 31.1 million tones.

3 Phosphogypsum production in India

Phosphogypsum is obtained from filtration process of phosphoric acid plants where efficient removal of insoluble gypsum and other insolubilities are done. At an average of 4.5 - 5 Tons of phosphogypsum (dry) is generated for every Ton of phosphoric acid (P_2O_5) recovered, depending upon the source of phosphate rocks.

The quality & amount of phosphogypsum generated depends upon the process used to produce phosphoric acid, amount of calcium sulphate generated, and quality of the phosphate rock. Based on the assumption that about 5 Tons of phosphogypsum is generated for every Ton of phosphoric acid production it can be concluded that phosphogypsum generation in the Country is about 11 Million Tons per annum.

Phosphogypsum is a damp, gray colored, fine grained powder, silt or silty sand material. The maximum particle size of phosphogypsum ranges between 0.5 mm and 1.0 and maximum number of particles (i.e. about 50-75 %) are finer than 0.075 mm. The specific gravity of phosphogypsum ranges from 2.3 to 2.6. and the maximum dry bulk density is about 1470 to 1670 kg/m^3, based on Standard Proctor Compaction. The gypsum cake, after filtration, usually has free moisture content between 25 and 30%. Hemi-hydrate, in the presence of free water will rapidly convert to di-hydrate and in the process, if left undisturbed will set into a relatively hard cemented mass and does not cause dust problem unless disturbed.

4 Environmental impacts associated with phosphogypsum dumping yards

Fresh & untreated Phosphogypsum is acidic in nature due to residual phosphoric acid, hydrofluoric acid and sulphuric acid within the porous structure. Because of the acidic nature of fresh phosphogypsum it may keep trace elements dissolved from the phosphate rock in a potentially mobile state (i.e leachable form) and the impurities include sulphates, fluorides, organics, residual acids, trace metals as well as naturally occurring radionuclides. The environmental concerns associated with phosphogypsum stacks are

- Fluoride uptake,
- Ground water pollution if located nearby.
- Surface water pollution if located nearby.

Main factors contributing to their transport in the environment are water and wind erosion, infiltration, leaching into surface and ground water and airborne emissions of gaseous and radioactive elements. Fine particles of phosphogypsum can be picked up and transported by wind and vehicular traffic on stacks into adjacent areas. Dust particles containing fluoride is a concern for operational and non operational stacks. Elevated levels of fluoride have been found in soil/vegetation adjacent to the stacks.

5 Literature review

Cheah Chee Ban., Dr.Eng. (2016);This study explored the mechanical and durability performance of High Calcium Wood Ash and Perfluoroxy alkaline hybrid HCWA-PFA geopolymer load bearing mortar blocks, which use a very low amount of alkaline activator (i.e., maximum 5% of binder weight), and under different curing regimes (lime-saturated water curing and moist curing).

Paulo J. Venda Oliveira; Luís D. Freitas (2016) This work analyzes the effect of soil type on the process of enzymatic calcium carbonate (CaCO3) precipitation. This methodology is tested for the stabilization of five soil types (poorly graded sand, two silty sands, a silty soil, and an organic soil) in order to examine the impact on strength and stiffness, based on the results of unconfined compression strength (UCS) and scanning electron.

Ehsan Yaghoubi; Arul Arulrajah(2015) ; In this research, two types of recycled waste materials, RCA and polyethylene plastic blends (HDPE and LDPE), were evaluated for their stiffness and resilient characteristics. Because the polyethylene plastics in this research were used in the form of granules instead of reinforcing fibers, a slight degradation of Recycled Concrete Aggregate (RCA) properties was observed.

Jinsong Qian; Guoxi Liang;(2015) The paper is to highlight the influence of cement addition on laboratory characterization of lateritic gravel and the feasibility of cement– lateritic gravel for use in base construction, relatively comprehensive laboratory experiments were carried out on cement–lateritic gravels from République du Mali in Africa. It is shown, that although natural laterite gravels were gap-graded due to the lack of sand-sized and silt-sized particles, the aggregate breakdown and addition of cement would change the gradation and that the cement–lateritic gravel met the strength requirement for base-course construction in Africa. However, low contents of clay mineral properties of the fine grains in lateritic gravel resulted in the ineffectiveness of the cement reactions between lateritic gravel and cement, and then cement–lateritic gravels had poor water stability.

Nima Latifi, Suksun Horpibulsuk, (2015), Problematic soils with high compressibility and low shear strength are often treated with traditional chemical stabilizing additives such as cement and lime to improve their engineering properties. These additives are generally recognized as having less than ideal environmental impacts—in particular, the high quantity of greenhouse gases that are generally created during their production. area analysis tests, and particle size analysis (PSA) tests using a laser diffraction approach. From the results of the strength and compressibility testing, 1 and 1.5% xanthan gum contents were found to be optimum levels of additive use for the montmorillonite and kaolinite clays, respectively.

Farshid Maghool; Arul Arulrajah; Suksun Horpibulsuk(2015); and Yan-Jun Du Steel is an inherently never-ending product, in terms of recycling and reuse. The steelmaking process creates an industrial by-product termed as slag. Ladle furnace slag (LFS) is produced at the final stages of the steelmaking process in ladle refining furnaces.

Mohd Fadzil Arshad; Norazlan Khalid(2014) The suitable optimum percentage of WPSA was determined about 10% to stabilize the sandy clay of high plasticity soils at the compressive strength about 737kPa. This Class-C of WPSA can be used in single additive without any combination of additives for pozzolanic reaction. The addition of 10% WPSA were increased the unconfined compressive strength of the clay soil until 28 days and this strength will get higher might be beyond to 28 days. The addition of 10% WPSA were increased the CBR value about 1.5 times compared to control sample for unsoaked condition and 3.6 times compared to control sample for soaked condition. The clay soil stabilized using Waste Paper Sludge Ash WPSA considered effective to enhance clay soil strength for long periods and to enhance the CBR value. This will reduce the construction cost, reducing the conventional additives such as lime and cement and solving disposal problems and towards the green environmentally without disposal materials.

R Barani Dharan (2011) In this paper present investigation is to assess the usefulness of industrial waste as a soil admixture, and focused to improve the compressive strength of the black cotton soil. Waste paper sludge ash Waste Paper Sludge Ash (WPSA) is waste product from the Paper mill industries. The WPSA can produce a cementitious material because WPSA contains a large amount of CaO while it is pozzolanic material. WPSA is incinerated from waste paper sludge. In this present study the soil sampling was done on 2 different sites as per IRC recommendations. The soils were classified as CH as per Indian Standard Classification System. Different percentages of waste paper sludge ash i.e. 4%, 6%, 8%, 10 and 12% were used to stabilize the black cotton soil. The soil was evaluated using physical and strength performance tests such as specific gravity, plasticity index, compaction, California bearing ratio (CBR) and unconfined compressive strength test (UCS). From the results it is observed that at the optimum percentage of 8% WPSA shows improvement in unconfined compressive strength (UCS) from 165 KN/m2 to 417.5 KN/m2 and 138 KN/m2 to 349.5 KN/m2 for soil samples 1 and 2 respectively. Furthermore California bearing ratio (CBR) values improved from 5.1 % to 26.4 % and 3.8 % to 18.6 % for soil samples 1 and 2 respectively.

Gabriele Fava,(2010) In this project, the ash coming from burning of paper mill sludge from primary mechanical separation process, fired as single fuel, was studied in order to evaluate its use as supplementary cementitious material in concrete manufacturing. Due to its high fineness and consequently high water absorption, it requires a higher dosage of water, so that the use of paper ash should not be higher than 10% by weight of cement.

6 LITERATURE SUMMARY

Based on the review, the following points can be concluded.

- This study shows that soil stabilization is benefic stabilizing weak soil, most waste material like fly ash, rice husk and egg shale is used which one of the waste utilization and also works as stabilizing agent which gives better results.
- Solid wastes from industries should be encouraged to be used as stabilizers instead of expansive chemical stabilization and cement or lime stabilization which is comparatively expansive.
- From the above review it can also be concluded that phosphogypsum and other such industrial wastes can be disposed effectively by using it as a stabilizer in soil at the same time it should also be emphasized that these wastes do not affect productivity of soil or should not pollute the underground water.
- The use of Phosphogypsum as a soil stabilizer could solve the negative environmental impact on region as well as put an end to stacking huge quantities of PG resulting from the phosphoric acid plant.

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REFERENCES

[1] Nima Latifi, .1; Suksun Horpibulsuk,, "Improvement of Problematic Soils with Biopolymer—An Environmentally Friendly Soil Stabilizer." for ASCE journal in 2015 Pg. 04016204-1 to 04016204-11 (Journal Style)

[2] Jinsong Qian; Guoxi Liang (2015) "Laboratory Characterization of Cement–Lateritic Gravel for Use in Base Construction." for ASCE Journal in 2015. Pg. D4015001-1 to 7. (journal style).

[3] Arulrajah, A., Mohammadinia,"Stabilization of recycled demolition aggregates by geopolymers comprising calcium carbide, fly ash and slag precursors." Constr. Build. Mater., 114, 864–873 (journal style)

[4] Farshid Maghool1; Arul Arulrajah2 "Laboratory Evaluation of Ladle Furnace Slag in Unbound Pavement-Base/Subbase Applications" in the year (2016) by American Society of Civil Engineering

[5] Yan-Jun Du; Bo-Wei Yu "Physical, Hydraulic, and Mechanical Properties of Clayey Soil Stabilized by Lightweight Alkali-Activated Slag Geopolymer"; in the year 2016 in the Journal American Society of Civil Engineers 2016 Pg.04016217-1 to 04016217-10. (Journal Style).

[6] Shuying Wang; Ronaldo Luna ; "Effect of Plasticity on Shear Behavior of Low-Plasticity Fine-Grained Soil " published for ASCE journal 2016. Pg. 04016228-1 to 04016228-9 (journal style)

[7] Paulo J. Venda Oliveira1; Luís D. Freitas; "Effect of Soil Type on the Enzymatic Calcium Carbonate Precipitation Process Used for Soil Improvement" published in ASCE journal in 2016. Pg. 04016263-1 to 04016263-7 (journal style).

[8] M. S. Al-Hwaiti ; "Influence of treated waste phosphogypsum materials on the properties of ordinary portland cement in "Bangladesh Journal of Scientific and Industrial Research " in the year 2015 under Bangladesh J. Sci. Ind. Res. 50(4), 241-250, 2015

[9] Kunal R. Pokale1, Yogesh R. Borkar ; "Experimental Investigation for Stabilization of Black Cotton Soil By using Waste Material - Brick Dust " International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 02 Issue: 05 | Aug-2015 .Pg. 727-728, (journal style).

[10] Mrs. S. Mary Rebekah Sharmila "Study on Engineering Behaviour of Black Cotton Soil Treated with Waste Paper Sludge Ash" presented at International Conference on Engineering Innovations and Solutions (ICEIS-2016) in the year 2016 Pg. 95-98 (journal style).

[11] Jijo James"Effect of phosphogypsum on strength of lime stabilized expansive soil" in International Journal of Applied Sciences, vol-9 No. 5, 2014 Pg. 1109-1116 (journal style).

[12] Rekha Raveendran; "Comparison Between Paper Sludge And Rice Husk Ash As A Stabilizing Agent For Soft Soil" IOSR Journal of Mechanical and Civil

Engineering (IOSR-JMCE) in 2016. Pg. 8-11 (journal style)
[13] IS: 1498-1970, "Classification and identification of soils for general Engineering purposes", Bureau of Indian Standards, New Delhi.
[14] IS: 2720 (Part I) - 1983, "Methods of Test for Soil - Preparation of Dry Soil Sample for Various Tests", Bureau of Indian Standards, New Delhi.
[15] IS: 2720 (Part III) - 1987, "Methods of Tests for Soil – Determination of Specific Gravity", Bureau of Indian Standards, New Delhi.
[16] IS: 2720 (Part V) – 1985, Methods of Tests for Soil: Determination of liquid limit and plastic limit, Bureau of Indian Standards, New Delhi.
[17] IS: 2720 (Part VI) – 1972, Methods of Tests for Soil: Determination of shrinkage factors, Bureau of Indian Standards, New Delhi.
[18] IS: 2720 (Part VII) - 1987, "Methods of Tests for Soil – Determination of Water Content-Dry Density relation using Light compaction", Bureau of Indian Standards, New Delhi.
[19] IS: 2720 (Part X) - 1973, "Methods of Tests for Soil – Determination of Unconfined Compressive Strength", Bureau of Indian Standards, New Delhi.
[20] IS: 2720 (Part XL) - 1977, "Methods of Tests for Soil – Determination of Free Swell Index of Soils", Bureau of Indian Standards, New Delhi.