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REVIEW OF DIFFERENT STABILIZERS ON RAMMED EARTH CONSTRUCTION

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Abstract: Rammed earth is an ancient construction technique that consist of unsaturated loose soil compacted of inside a formwork. It is important to select proper stabiliser to stabilise or to improve the engineering or physical properties of available soil to get higher stability and strength for rammed earth wall construction. Stabilisation in Rammed Earth Construction shows social, financial and environmental sustainability. Its shows that its embodied energy is lower when compared to other construction materials like steel and concrete. This Review paper aims for the analysis of selection of feasible option of different stabilises for the application in rammed earth wall construction within specified criteria.

Keywords: Soil stabilization, Engineering properties, Physical properties, Formwork, Environmental sustainability, Embodied energy

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1. INTRODUCTION

1.1 Rammed Earth Construction

1.1.1 Definition: "Rammed earth is simple to making, non-combustible. Thermally, strong, and durable. However, constructions such as walls can be laborious to construct of rammed earth without machinery, e.g., powered tampers, and they are susceptible to water damage if inadequately protected or maintained". (Keable, Rowland 2012)

1.1.2 About: Rammed earth includes compressing a damp mixture of. Earth that has suitable quantities of sand, gravel, clay, and/or an added stabilizer into an externally supported frame or mould, forming either a solid wall or separate blocks. Historically.additives.such.as lime or animal blood were used to stabilize it, while modern construction adds lime, cement or asphalt emulsion. To add diversity, modern builders add coloured oxides or other materials like bottles, tyres, pieces of wood. (Keable, Rowland 2012)

The construction of an entire wall begins with a temporary frame, denominated the "formwork", which is generally made of timber or plywood, as a mould for the required shape and sizes of each section of wall. The form must be durable and well fixed, and the two opposing faces must be clamped together to prevent bulging or deformation caused by the large compressing forces. Damp material is filled into the formwork to a depth of 10 to 25 cm (4 to 10 in) and then compacted to almost 50% of its original height. The material is compressed in batches, so as to gradually erect the wall up to the top of the formwork. Tamping is historically manual method with a long ramming shaft, and is very laborious, but modern construction can be made less so by employing pneumatically powered tampers. (Keable, Rowland 2012)

After the wall is finished, it is strong enough to instantly remove the formwork. This is essential if a surface texture is to be applied, e.g., by wire brushing, carving, or mould imprint, because the walls become too hard to work after nearly one hour. Construction is optimally done in warm weather so that the walls can dry and harden. The compression strength of the rammed earth increases as it cures; some time is necessary for it to dry and as long as two years can be necessary for complete curing. Exposed walls must be sealed to prevent water damage. In modern differences of the technique, rammed-earth walls are constructed on top of conventional footings or a reinforced concrete slab base. Where blocks made of rammed earth are used, they are generally stacked like regular blocks and are bonded together with a thin mud slurry instead of cement. Special equipment, usually powered by small engines and often portable, are used to compress the material into blocks. (Keable, Rowland 2012)

Presently more than 30% of the world's population uses earth as a building material. Rammed earth has been used globally in a wide range of climatic conditions. Rammed-earth housing may resolve homelessness caused by otherwise costly construction techniques. (Keable, Rowland 2012)

1.2 Soil Stabilization

1.2.1 Definition: - "Soil stabilization is a technique aimed at increasing or keeping the stability of soil mass and chemical adjustment of soil to enhance their engineering properties." (Sachin N. Bhavsar et al. 2014)

1.2.2 Introduction: Stabilization allows for the founding of design criteria as well as the determination of the proper chemical additive and admixture rate to be used in order to achieve the preferred engineering properties. Benefits of the stabilization process can include higher resistance values, decrease in plasticity, lower permeability, reduction of road thickness, elimination of diggings material hauling or handling. Stabilization of expansive soils with admixtures controls the potential of soils for a change in volume, and increases the strength of soils. Soil stabilization is done by various systems by adding fly ash, rise husk ash, chemicals, fibres, adding lime, by different geo materials like geo synthetic, geo grid and geo form. Soil stabilization allows engineers to distribute a larger load with less material over a longer life cycle. **(**Sachin N. Bhavsar et al. 2014)

2. LITERATURE REVIEW

2.1 Cement Stabilization

2.1.1 G.W.T.C. Kandamby 2017, provided an analysis by a brief review work which shows that valuable properties of soil are enhanced by replacing it with cement like strength, durability, thermal performance, energy saving and cost helpfulness. It also shows that structural properties and non-structural properties of Rammed Earth has been improved by adding cement as stabilizer. The amount of stabilizer is defined with respect to the expected compressive strength.

Cement stabilized rammed earth (CSRE) is a mixture of soil, Portland cement and water. Through mechanical or manual compaction and cement hydration the mixture hardens with soil particles bonding together to form a dense mass. Successful use of CSRE for walls can be seen in Australia, USA, Europe, Asia and many other countries (B.V.V. Reddy and P.P. Kumar).

The basic control factors for satisfactory achievement in cement stabilization are selection of good soil, adequate cement content, proper moisture content and adequate compaction. Selection of soil for CSRE technology is taken into grant and maintained less than 30% clay content while performing the research activities on load bearing walls. On site soil has been selected through jar test as jar test has proved accurate results in previous experimental works.

The composition of 5-20% gravel, 45-60% sand, 20-35% silt and clay has been recommended for better performance of wall construction. Composition can be checked by performing jar test (C. Jayasinghe and N. Kamaladasa).

Testing program has revealed that the best category of soil are those with linear shrinkage (LS) < 6.0 and clay and silt content ≤ 20% or with LS < 6.0 and clay and silt content 21 – 35%. These two categories have shown the highest stabilization success. (B. Steve).

2.1.2 G.W.T.C. Kandamby 2018, in this research paper authors have worked on analysis of use of cement stabilized rammed earth for load bearing wall with fairly precise finishes- case study G.W.T.C. kandamby is conduct many test on different type of soil with different proportion of cement.

From the results it is concluded that the Compressive strength of Cement Stabilized Rammed Earth wall panels in cement and soil combination 1:8 are, were for sandy soil compressive strength is 3.06 to 3.99, for gravel compressive Strength is 1.84 to 2.09, and for clay soil compressive strength is 1.98 to 2.03.

2.1.3 Chintha Jayasinghe et al., 2007, in this case study authors have worked on the stabilized earth walls. Gravelly and sandy lateritic soils are usually suited for the stabilization with the well accepted. The shrinkage of the SREW panels should be prudently attended since excessive shrinkage can lead to wide cracks between the cement stabilized soil columns and the rammed earth walls. The studies into the shrinkage characteristics of altered composition of soils will be very useful. It is also useful to determine the effects of curing on the shrinkage characteristics.
The shrinkage strain for different type of soils is different, were for sandy laterite soil shrinkage strain is 0.0029, for clayey laterite soil shrinkage strain is 0.0028 and for gravely laterite soil shrinkage strain is 0.0017.

2.2 Cement + lime stabilization

2.2.1 Kenneth Mak et al. 2014, in this research paper author have worked on replacement of cement with metal oxide and permazyme presented no development in compressive strength, whereas the additional of cement with resin systems showed an increase in capacity ranging from 52% to 220%. For the analysis of effect they have conducted following tests, like Compressive tests of specimens were completed on a universal testing machine and water absorption by RILEM.

2.2.2 Abhirami Suresh, Dr. K B Anand, 2016, in this research paper author work on analysis of a study on stabilized rammed earth for construction by the soil under the study is suitable for rammed earth creation in the aspect of particle size distribution and consistency limits. Through liberated compressive strength test 7% cement and 13% water has been selected as the best amount for the soil

2.2.3 Steve Burroughs, 2016, in this research paper author worked on Recommendation for the Selection, Stabilization, and Compaction of soil For Rammed Earth Wall Construction by 219 tests on 104 different soils. After the experimental study it is observed that the soil had linear shrinkage of 6% and a soil content of 56%.

2.2.4 K. P. Arandara, C. Jayasinghe, 2008, in this research paper author worked on Surface Covering for Stabilized Earth Walls covers the result of a details study which attentions on the toughness of the stabilized earth and also use for the walling material.

2.3 Brick Dust and Marble Powder stabilization

2.3.1 Sachin N. Bhavsar et al, 2014, in this research paper authors concluded that the impact of brick dust on black cotton soil is positive. By changing soil by half of its dry weight by brick dust it gives maximum improvement in the engineering assets of black cotton soil. So use of brick dust is preferable for stabilization because it gives positive results as stabilizer and also it is a waste consumption. Effects of burnt brick dust on black cotton soil by replacement with burnt brick dust as a stabilizer by 30%, 40% and 50% proportions respectively.

2.3.2 Sachin N. Bhavsar, Ankit J. Patel, 2014, in this literature paper author concluded that, by stabilization of black cotton soil for 30% replacement by marble powder and brick dust the properties related to soil are improved. For marble powder Liquid limit, Plastic limit, Plasticity index values are decreasing.

As same they have found increment in maximum dry density and reduction in optimum moisture content. It is clearly identified from result that swelling and shrinkage behavior of soil is reduced after stabilization. For replacement of marble powder they get 0% of swelling in soil and also shrinkage is reduced by 17.7%. As same for brick dust swelling is only 0f 10% and shrinkage reduced by 14.3 %. Result great decrement in enlargement and reduction behavior of soil which can be helpful to our future construction uses and waste of land can be reduced by using black cotton soil itself as a construction material or a base of any construction.

2.3.3 Sachin N. Bhavsar, Ankit J. Patel, 2014, in this research paper author worked on analysis of swilling & shrinkage properties of extensive soil using brick dust as a stabilizer. For analysis of result they conducted test of replacement of black cotton soil from the brick dust it is identified that the values of atterbergs limits are decreasing. By replacing soil by 50% brick dust liquid limits reduced 13.7%, plastic limit reduced 5.467% and plasticity index reduced by 8.24% than the value of black cotton soil.

2.3.4 Sachin N. Bhavsar, Ankit J. Patel, 2014, In this research paper author worked on analysis of Effect of waste material on swelling and shrinkage properties of clayey soil by replacement of soil by stabilizer the value of maximum dry density is increased by 13.45% where optimum moisture content reduced by 5.94% for marble powder in comparison of soil. As same after stabilized with brick dust the value of maximum dry density improved by 9.64% and optimum moisture content reduced by 3.78% than the values of soil. For the analysis of effect they have conducted following tests, Grain Size Analysis, Atterbergs Limits, Modified Proctor Test, Linear Shrinkage and Free Swell to determine swelling and shrinkage properties.

2.3.5 Sachin N. Bhavsar, Ankit J. Patel, 2014, in this research paper author concluded that the stabilization with marble powder by replacement of black cotton soil 30% replace with marble powder and brick dust. For the analysis they conducted following test, Particle size distribution, and atterbergs limits, swelling index, linear shrinkage, and modified proctor test.

After completion test they concluded that the stabilization of black cotton soil for 30% replacement by marble powder and brick dust the properties related to soil are developed. For marble powder Liquid limit, Plastic limit, Plasticity index values are decreasing. As same we have found raise in maximum dry density and reduction in optimum moisture content. It is clearly identified from result that swelling and shrinkage behavior of soil is reduced after stabilization. For replacement of marble powder we get 0% of swelling in soil and also shrinkage is reduced by 17.7%. As same for brick dust swelling is only 0f 10% and shrinkage reduced by 14.3 %. Result great decrement in swelling and shrinkage behavior of soil which can be helpful to our future construction uses and waste of land can be reduced by using black cotton soil itself as a construction material or a base of any construction.

By the replacement of black cotton soil from the marble powder and brick dust it is identified that the values of atterbergs limits are decreasing. Above figure shows that the by replacing soil by 30% by marble powder liquid limits reduced 5.6%, plastic limit reduced 1.572% and plasticity index reduced by 4.08% than the value of black cotton soil. As same for replacement of 30 % soil by brick dust liquid limits reduced 9.5%, plastic limit reduced 3.937% and plasticity index reduced by 5.57% than the value of black cotton soil.

After completion of modified proctor test they concluded that the replacement of soil by stabilizer the value of maximum dry density is increased by 11.69% where optimum moisture content reduced by 5.72% for marble powder in comparison of soil. As same after stabilization by value of maximum dry density increased by 5.84% and optimum moisture content reduced by 2.53% than the soil values.

By adding marble dust and brick dust as stabilizers swelling is reduced. For particular marble 0% swelling is measured which conclude that it is a perfect stabilizer to reduce swelling. The brick dust also showing the great decrement in soil swelling.

2.3.6 Sachin N. Bhavsar, 2014, In this research paper author worked on analysis of Impact of Marble Powder on Engineering Properties of Black Cotton Soil By replacing soil its dry weight by marble powder it gives maximum improvement in the swelling and linear shrinkage properties of black cotton soil.

For analysis they conducted test, atterbergs limits, modified proctor test, linear shrinkage, and free swell index.

3. CONCLUSION

As per above literature it is identified that, by replacement of cement the properties of soil like strength, durability, thermal performance are improved. The mixture proportion 1:8 of cement and soil obtain compressive strength for gravel, sandy soil, and clayey soil as 2.09, 3.99 and 2.03. It also shows very low shrinkage strain of 0.0029, 0.0028, and 0.0017 for sandy laterite soil, for clayey laterite soil and for gravel laterite soil respectively.

By replacement of soil with combination of cement and lime does not give any improvement in compressive strength. Whereas the replacement of cement with resin system showed an increase in capacity ranging from 52% to 220%.

By replacement with other materials like brick dust and marble powder it gives maximum enhancement in engineering assets of black cotton soil. By the replacement of 50% brick dust the liquid limit reduced by 13.7%, plastic limit reduced by 5.467% and plasticity index reduced. Whereas for the replacement of marble powder and brick dust increase maximum dry density as 13.45% and 9.64% and reduced optimum moisture content as 5.94% and 3.78%.replacement of marble powder with black cotton soil improved the swelling and linear shrinkage properties of black cotton soil.

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