ENHANCEMENT IN IMPROVEMENT OF CLAYEY SOIL WITH ADDITIONOF CALCIUM CHLORIDE, RICE HUSK ASH AND POLYPROPYLENE FIBRE - A REVIEW

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ABSTRACT:- **In India, a major portion of total land area is covered by clayey soil. Of this, a large portion is expansive soil. Structures constructed over this expansive soil may be severely damaged due to itshigh swell shrinkage behavior. So such soil needs to be stabilized to increase its strength, durabilityand to prevent erosion. As Soil stabilization is the technique used to improve the geotechnical properties of soil and has become the major practice in construction engineering Expansive soils are not stable during all moisture conditions due to swelling and shrinkage properties. Hence theyare stabilized properly to reduce extensive damage to the structures. Utilization of industrial wastematerials in improving the soil properties is cost effective and environmental friendly method. The present study is carried out to establish the viability of using the combination of rice husk ask andcalcium chloride and polypropylene fiber in stabilizing expansive soils. In experimental evaluation, the observations are made for different mixes like soil-rice husk ash, soil-rice husk ash- calcium chloride and polypropylene fiber at different proportions. Rice husk ash was as constant for all mixes to obtain the base line values and calcium chloride at 1%, 2%, 3% was added to untreated soil and polypropylene fiber at 0%, 0.5%, 1%, !.5%. Test specimens were subjected to unconfined compressive tests at 1, 3, 7, 14 and 28 curing days. Free swell index test and Atterberg limit test were conducted at 28 days curing. It was observed that mixes with calcium chloride exhibited high strength, low plasticity index and low free swell index at 28 day curing.**

KEYWORDS: Soil, rice husk ash, calcium chloride, polypropylene fiber, Clayey Soil, Water cement ratio, Dry Density.

I INTRODUCTION

Soil stabilization is an effective and reliable technique for altering important soil properties. Several reinforcement methods are available for stabilizing expansive soils such as stabilization with chemicals additives, rewetting, soil replacement, compaction control and moisture control, surcharge loading and thermal methods. These techniques have wide application in areas like construction of road, slope stabilization, railway embankments, and so on. Soils are generally stabilized. Certain types of clayey soils subjected to excessive compression, heave, collapse, low shear strength and low bearing capacity. Due to the presence of water in air voids, expansive claysare subjected to large volume changes undergo huge variation in dry and wet conditions, deep cracks occurs in dry condition and expand in wet condition . This consequence makes a severe damage to lightly loaded structures like foundations, canal beds, canal linings, pavements and poses a great problem for civil engineers. Soil stabilization occurs by improving the bearing capacity of soil with introduction of additives as binders. In the process of stabilization cementitious materials are formed to improve the engineering properties of virgin soil. Utilizationof industrial waste material in improving soil properties is an environmental friendly and cost effective method. Various ashes are involved in improving the bearing capacity of soil. Portland cement, bitumen, hydraulic lime and industrial by-products such as blast furnace slag, Rice husk ash, ricehusk ash (RHA), and cement kiln dust (CKD) have been used as soil stabilizers to improve the properties of untreated soil).

Infrastructure projects such as highways, railways, water reservoirs, reclamation etc. requires earth material in very large quantity. In urban areas, borrow earth is not easily available which has to be hauled from a long distance [1]. Quite often, large areas are covered with highly plastic and expansive soils, which is not suitable for such purposes. As Rice husk and calcium chloride is freely available from Thermal Power Plants, it can be used for stabilization of expansive soils for various uses. [2] The sample of soil used in the mix will be collected from the fields of R.S.PURA (JAMMU DISTRICT) J&K. It will be combined with rice husk ash and calcium carbonate in different proportion for further analysis. The soil will be pulverized before conducting the tests.

Rice husk and calcium chloride is itself an industrial waste which imposes many health and environmental hazards Dumping Rice husk and calcium chloride is not an environmentally suitable measure as it degrades the soil and water quality nearby the dumping area. Consistent infiltration of Rice husk and calcium chloride in the agricultural fields may render the crop area infertile. On similar lines, polypropylene too is an industrial waste which can be utilized in constructional activities. Of late polypropylene has been used in many road works all across the country.[5] Rajagopalan Vasudevan, the 2018 Padma Shri awardee pioneered the art of using plastic in road construction works and through this study we aim to further find what different percentage of polypropylene can be used in road works when mixed with soil.[6]

MATERIAL USED

Following Material are used for studying the mechanical properties for his study used agriculture waste, eco-friendly material. Materials to be used are as follows:

POLYPROPYLENE FIBRE

Polypropylene fiber to which does not absorb or respond with soil dampness or leachate. Warm and degree Celsius are different properties. The polypropylene filaments utilized as a part of this examination has physical properties, particular gravity of 0.91 and a normal measurement and length from0.06mm to 20mm individually.

Properties of polypropylene fibre

S. No.	Properties	Range
1	Fibre type	Single fibre
2	Unit weight	0.91 g/cm3
3	Average diameter	0.04 mm
4	Average length	12mm
5	Breaking tensile strength	350Mpa
6	Modulus of elasticity	3500Mpa
7	Fusion point	160 degree
8	Burning point	590 degree
9	Acid and alkali resistance	Very good
10	Dispersibility	Excellent

RICE HUSK ASH

Rice husk ash is in the form of ash which is a solid wasted which is disposed in the empty barrenland as a solid waste. Rice Husk Ash is by-product material produced from the process of manufacturing puffed rice, contains large amount of iron oxide and silicate. It has higher density,stay in the top layer and then transported to a water basin with a low temperature for solidification. The end product is a solid, hard material that goes to the crusher for further processing. Annually 60,000 tons of rice husks are produced in India. It is chemically stable and its physical properties are similar to that of natural sand. The high angularity and friction angle (upto 530) of rice husk contribute to excellent stability and load bearing capacity. With specific gravities ranging from 2.8 to 3.8, rice husk aggregates are decidedly heavier than conventional granular material. Rice husk aggregate tend to free drying and are not frost susceptible.

CALCIUM CHLORIDE

Calcium chloride is a product with many beneficial properties. For highway work, its main properties are:

1. It absorbs moisture
2. It dissolves in this absorbed moisture.
3. It retains this moisture for long periods
4. It lowers the freezing point of the moisture.

It is not difficult to determine why this product is beneficial in highway maintenance. You have seen unpaved roads that are stable under wet weather conditions, yet they become dusty and show signs of raveling in dry weather; this weakness may eventually cause complete disintegration of the surface. If we can maintain moisture, similar to damp weather conditions, it is possible to hold the surface in a well-compacted state even during the hot summer months. The water absorption and retention properties of calcium chloride aid in supplying a damp condition which will give you a smooth riding dust free surface without excessive floater material that is a definite hazard tosafe driving.

II LITERATURE SURVEY

Leonard and Bailey (1982) [1] Effect of fine Rice husk ash and coarse Rice husk ash on natural soil was studied. The various test conducted for this project like Atterberg's Limit, Compaction, Triaxial Compression test, Chemical Analysis, Consolidation. The Attempt was made to proposed use of Rice husk ash, from the compaction test results it was observed that the variation of dry density was irregular at highermoisture contents. Bleeding was initiated at moisture contents resulted in erratic 40% and the bleeding moisture content corresponded to optimum moisture content. From the findings it was proposed that finer ash samples exhibited higher strength as compared to the coarser samples. **Martin** *et al.* **(1990) [2]** investigated that the effect of Rice husk ash on expansive soil was studied, and different experimental programmerswere carried out such as Particle size distribution, Compaction test, Permeability, Consolidation. They investigated that Rice husk ash in partially saturated state displayed an apparent cohesion due to tensile stresses of retained capillary water. Hence, the effective friction angle, Φ', was considered as the major factor for long term stability analysis. The results of the standard extractionprocedure toxicity tests showed low metal leaching characteristics of Rice husk ash. **Raza & Chandra (1995) [3]** investigated that the effect of (Rice husk ash + geo-fabric) on soil was studied, they carried various test such as Compaction, Swelling, CBR & UCS. These Studies carried out for use of Rice husk ashes to stabilized alluvial soils, so as to use them as sub grade and base course in airfield and road pavements. The tests conducted on Rice husk ash, soil and their mixtures having various Rice husk ashes: soil ratio. This study indicates that soil treated with Rice husk ash gives considerable improvement in CBR value of soil. With incorporation of geo-fabric CBR value further increased. **Boominathan and Ratnea (1996)** [4] investigated that the effect of (Rice husk ash + Sugarcane bagasse ash) on soil was investigated, there were various tests conducted for this research work such as Atterberg's Limit, Compaction and UCS. These studies have been carried out to proposed use of Rice husk ash for stabilization of soil with and without Sugarcane bagasse ash incorporate. Addition of Sugarcane bagasse ash to Rice husk ash resulted in flocculation and particle aggregation. It was observed that WL and WP were reduced with the Sugarcane bagasse ash treatment whereas UCS increased by about 25 %. The compressibility of Rice husk ash reduced to almost one fourth of the original value due to Sugarcane bagasse ash treatment. It was concluded that Sugarcane bagasse ash treated Rice husk ash could be effectively used for embankment over soft clays. **Singh** *et al.* **(1996) [5]** studied the effect of Rice husk ash on soil. There were various test programmed conducted for this research work such as Atterberg's Limits, Compaction, CBR, UCS. The Effects of different proportions mixes of fiber and Rice husk ash on local soil of Varanasi evaluated to propose suitability of Rice husk ash-soil Sugarcane bagasse ash as a base and sub base material for the roads. From this study, it can be concluded that good results were obtained when soil was stabilized with 15 % a Rice husk ash in the proportion of 1:3. Different proportions enabled an increase in the CBR value from 4.00 % to 20.70 % and the unconfined compressive strength from 134 KN/m2 to 680 KN/m^2. **Pandian (2002) [6]** The effect of two types of Rice husk ashes Raichur Rice husk ash (Class F) and Neyveli Rice huskash (Class C) on the CBR characteristics of the black cotton soil was studied. The Rice husk ash content was increased from 0 to 100%. Generally the CBR/strength is contributed by its cohesion and friction. The CBR of BC soil, which consists of predominantly of finer particles, is contributedby cohesion. The CBR of Rice husk ash consists of predominantly coarser particles which contributed its frictional components. The low CBR of Natural soils attributed to the inherent low strength, which is due to the dominance of clay fraction. The addition of Rice husk ash to Naturalsoil increases the CBR of the mix up to the first optimum level due to the frictional resistance fromRice husk ash in addition to the cohesion from BC soil. Further addition of Rice husk ash beyond the optimum level causes a decrease up to 60% and then these is an increase up to the second optimum level. Thus the variation of CBR of Rice husk ash-Natural soil mixes can be attributed to the relative contribution of frictional or cohesive resistance from Rice husk ash or BC soil, respectively. There is an increase of strength with the increase in the Rice husk ash content. Here there will be additional puzzolonic reaction forming cementitious compounds resulting in good binding between Natural soil and Rice husk ash particles. **Kanirajand and Gayathri (2003**) [7] investigated that the effect of Rice husk ash & cement analysis was carried out, UCS test Experiments used to evaluatethe factors influencing strength of cement Rice husk ash base courses. Stabilizer content was determined by conducting UCS test on stabilized Rice husk ash specimens cured at different curing conditions. It included six different curing conditions and adopted controlled and ambient conditions in the study. It was reported that, UCS of stabilized Rice husk ash specimens depends on curing, unit weight, and water content in addition to cement content and curing period. **Phanikumar and Sharma (2004) [8]** study of Rice husk ash on Engineering of soil was carried out through an experimental programme. The effect on parameters like free swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and hydraulic conductivity of expansive soil were studied. The ash blended expansive soil with Rice husk ash contents of 0, 5, 10, 15 and 20% on adry weight basis and they inferred that increase in Rice husk ash content .reduces plasticity characteristics and the FSI was reduced about 50% by the addition of 20% Rice husk ash. The hydraulic conductivity of expansive soils mixed with Rice husk ash decreases with an increase in Rice husk ash content. Due to the increase in Rice husk ash content increases in maximum dry unit weight. When the Rice husk ash content increases there is a decrease in the optimum moisture content and as a result the maximum dry unit weight increases. Hence the expansive soil is rendered more stable. The undrained shear strength of the expansive soil blended with Rice husk ash increases with increase in the ash content. **S. Bhuveneshwari** *et. al* **(2005) [9]** investigated that the effect of Rice husk ash on soil was studied, The experimental programmed was carried out by Atterberg's Limits, Compaction, UCS, and Core Cutter. Reported improvements in properties of expansive soil treated with Rice husk ash at varying percentages. Both laboratory trials and field tests have been carried out. It was observed that field application is done through mixing of the two materials (expansive soil and Rice husk ash) in required proportion to form a homogenous mixture there. Trial embankment of 30 m length by 6m width by 0.6m thickness constructed and in-situ tests were carried out. **Prof.S.Ayyappan, Ms.K.Hemalatha and Prof.M.Sundaram [10] "**Investigation of Engineering Behaviour of Soil, Polypropylene Fibres and Rice husk and calcium chloride -Mixtures for Road Construction'' (2010). In this study Polypropylene fibres with different fibre length (6mm, 12mm and 24 mm) were used as reinforcement. Soil -Rice husk and calcium chloride specimens were compacted at maximum dry density with low percentage of reinforcement (0 to 1.50 % of weight).Third, an optimum dosage rate of fibres was identified as 1.00 % by dry weight of soil- Rice husk and calcium chloride, for all soil Rice husk and calcium chloride mixtures. Fourth, a maximum performance was achieved with fibre length of 12mm as reinforcement of soil Rice husk and calcium chloride specimens. The relative benefit in CBR values due to fibres increases only up-to 1.00 % by dry weight and length up to 12mm for all soil-Rice husk and calcium chloride specimens. The results of study of a randomly oriented fibre reinforced soil- Rice husk and calcium chloride mixtures indicted that a maximum performance was achieved with 12 mm fibres in optimum dosage of 1.00 % by dry weight of soil- Rice husk and calcium chloride mixtures. **R. Saravanan, Roopa Saira Thomas, Merlin Joseph "A Study on Soil Stabilization of Clay Soil Using Rice husk and calcium chloride'' (2013) [11]** the expansive clay soil was collected from near Tiruchengode, Tamilnadu, India. The clay soil behavior was studied in addition of different percentage of Rice husk and calcium chloride. (0, 10%, 20%, 30% and 40%). The Specific gravity, Atterberg limit, Standard Proctor's compaction, Unconfined compressive tests were performed on expansive clay soil. The result shows that in addition of Rice husk and calcium chloride reduce the specific gravity and plastic index of expansive clay soil. The optimum moisture content (OMC) and maximum dry density (MDD) curves indicate that addition of Rice husk and calcium chloride increases the OMC and maximum dry density of the expansive soil. The strength properties of the expansive clayey soil have increased 21.1%. Based on the Standard Proctor's Compaction test, the Optimum Content of Rice husk and calcium chloride was found as (10 %).

1. The unconfined compression strength of the given soil sample has increased 21% in addition of the Rice husk and calcium chloride content.
2. The dry density of the clayey soil sample is increased 15 % of the natural soil sample.
3. The optimum content of the clayey soil sample has decreased 9% of the natural soil sample.
4. The unconfined compression test has increased 21% from the natural soil sample.
5. The optimum content of the Rice husk and calcium chloride content has found that 10% in addition of the natural soil sample.

Teresa Sunny, Annie Joy "Study on the Effects of Clay Stabilized with Banana Fibre'' (2014) [12] in this study the main objective to investigate the use of waste material such as banana fibre in geotechnical applications. Various tests such as unconfined compression (UCC), California Bearing Ratio (CBR), Atterberg limits, Compaction were carried out and the results are analysed. The percentage of banana fibre varies from 0%, 0.25%, 0.75%, 1%and 2%. The addition of banana fibre improved the properties of clay. The optimum value for marine clay stabilized with banana fibre was obtained at0.75%.It was seen that OMC value increased with the addition of banana fibre and dry density decreases. The shear strength increased from 8.5kN/m2 to 32.91kN/m2 with the addition of0.75% of banana fibre and CBR value increased from 2.79 to13.2 which makes it suitable for sub grade soil for road pavements.

Shish Pal1,Vinod Kumar Sonthwal2, Jasvir S Rattan3 "Soil Stabilisation Using Polypropylene as Waste Fibre Material''(2015) [13] On the basis of the analysis and interpretations of the results obtained from the experimental investigations carried out in the present research work, the following conclusions are drawn:

1 Compressibility of the Soil In case of the compressibility, it is concluded that there is marginal decrease in the maximum dry density (ϒd (max)), with the addition of waste fibres of the polypropylene.

2 Direct Shear Strength Parameters of the Soil The direct shear strength parameters of the soil reinforced with waste fibres of polypropylene used for the improvement of the engineering properties of the soil with 20 mm length and 0.35% weight of polypropylene by weight of dry soil sample, is found as 25.18% increase in the angle of internal friction (Φ) and 46.88% increase in cohesion (c).

3 Unconfined Compressive Strength (UCS) of the Soil The unconfined compressive strength (UCS) of the soil reinforced with waste fibres of polypropylene used for the improvement of the engineering properties of the soil with 20mm length and 0.25% weight of polypropylene by weight of dry soil sample, is found as 52.80% increase in UCS.

Wajid Ali Butt, B. A. Mir, J. N. Jha "Strength Behavior of Clayey Soil Reinforced with Human Hair as a Natural Fibre'' (2015) [14] In this study, human hair fibres were used as an additive to the high compressibility clayey soil by weight (0.5, 1.0, 1.5, 2.0 and 2.5 %) to evaluate the effect of human hair fibre on the mechanical behavior of clayey soil. Human hair fibre is a natural non-degradable waste material, which creates health and environmental problem if not disposed-off in scientific manner. This is available in abundance at a very low cost and can be easily used as a reinforcing material not only to improve poor/unsuitable construction sites for sustainable construction but also to avoid its disposal problems. The HHF randomly distributed in clayey soil samples were tested for its engineering properties by performing CBR and tri-axial test on a number of samples by using the different percentage of fibres and comparing the results with the non-reinforced soil. Fibres of average length 25 mm and average diameter of 50lm were used. Human hair fibre exhibits many advantages such as good strength properties, low cost and high toughness to biodegradability. However by increasing the HHF content, it marginally affects the dry density-moisture content relationships of composite specimens. MDD initially reduces lightly due to addition of light weight hair fibre and then practically remains same. OMC increases marginally due to moisture absorption of hair fibres. It has been seen that about 2 % fibre content is the optimum quantity to enhance CBR and undrained shear strength of clayey soil.

Jesna Varghese, Remya.U. R , Snigdha.V. K,"The Effect of Polypropylene Fibre on thethe **Strength'' (2016) [15]** The main aim of this study is to evaluate the effect of soil. The specimens with

0%,0.05%,0.15%.0.25% and 0.35%compaction, unconfined From unconfined compressive test, it was observed that the unconfined compressive strength value of untreated soil was found to be 15.1 KN/m^2 and the strength value increased with increase in addition of polypropylene fibre up to 0.05%and then decreases. There is an increase of strength of about shear strength it shows reverse trend. The strength is increased in low percentage of PPF addition, it ensures more economical in construction. So can potentially

Mamta Mishra*, U. K. Maheshwari and N. K. Saxena.; "Improving Strength of Soil using Fibre and Rice husk and calcium chloride -A Review" (2016) [16] Polypropylene is mixed with soil- Rice husk and calcium chloride mixture is improving the soil properties like permeability, strength etc. The moisture - density relationship of soil-Rice husk and calcium chloride mixtures significantly affected due to addition of fibres. The relative benefit in CBR values due to fibres increases only up-to 1.00 % by dry weight and length up to 12mm for all soil-Rice husk and calcium chloride specimens. The results of study of a randomly oriented fibre reinforced soil- Rice husk and calcium chloride mixtures indicted that a maximum performance was achieved with 12 mm fibres in optimum dosage of 1.00 % by dry weight of soil- Rice husk and calcium chloride mixtures. Polypropylene fibres reduce the water permeability, plastic, shrinkage and settlement and carbonation depth.

T.Subramani, D.Udayakumar "Experimental Study on Stabilization of Clay Soil Using Coir Fibre'' (2016) [17] this experimental study deals with the use of coconut Fibre for soil stability. Reinforcing the soil with coir Fibres/coir geo-textiles is a cost effective solution to the ground/soil improvement problems. The study includes the properties of coir Fibre and clay and experimental workouts such as triaxial test, Stress state during a triaxial test, California bearing ratio, unconfined compression test, direct shear test have been conducted on soil and soil mixed with varying amount of coir Fibre (0.25, 0.50, 0.75, and 1.0%) and concluded results are followings:-

1. The strength of soil-coir mix increases with increasing the percentage of coir Fibre.
2. CBR and UCS values of soil-coir Fibre mix increases with increasing percentage of Fibre.
3. Maximum improvement in U.C.S. and C.B.R. values are observed when 0.5% of coir is mixed with the soil.
4. It is concluded that proportion of 0.5% coir fibre in a soil is optimum percentage of materials having maximum soaked CBR value. Hence, this proportion may be economically used in stabilization of clay soil.

C. M. Sathya Priya1, S. Archana2, A. Bichu Albert3, A. D. Deeraj4 "STABILIZATION OF CLAYEY SOIL USING POLYPROPYLENE FIBRE'' (2017) [18] This study investigated the effect of adding polypropylene fibre and strength behaviour of clayey soil. The effect of fibre reinforcement on clayey soil was studied by using the results obtained from a series of swell, liquid limit, compaction and unconfined compression test. Based on the result presented in this paper the following conclusions are drawn. With increase in the fibre content, the free swell index value of reinforced soil decreases to zero at 1% of fibre. Due to increase in the fibre content, the liquid limit of reinforced soil increases due to the replacement of soil grains by fibre. The maximum dry density of the soil increases with the addition of fibre content up to 1% of fibre and then decreases with the addition of 1.5% fibre. This is due to the fact that the dry unit weight of fibre is more than that of the soil. In view of increase in the fibre content, the UCC values of reinforced soil increases up to 1% fibre and decreases with the addition of 1.5 % fibre. From this investigation, it is clearly indicated that the free swell index value of the reinforced soil decreased drastically which means that the soil is not subjected to any volumetric changes with the addition of fibre. Hence addition of 1% of stabilizer was taken as the optimum percentage of PP fibre for stabilizing the soil. Also the strength of the clayey soil was improved due to fibre addition and can be concluded that PP fibre can be used effectively for the stabilization of clayey soil.

III. CONCLUSIONS

1. The Optimum Moisture Content (OMC) and Maximum Dry Density values obtained from virgin soil were 12% and 1.965 g/cc respectively.
2. Through Standard Proctor Test, it was concluded that maximum dry density and optimum moisture content were obtained at 3% Rice husk and calcium chloride mixed in soil. Compared to virgin soil, a marginal 8.22% increase in Maximum Dry Density was observed.
3. At 1% polypropylene fibre mixed with 3% Rice husk and calcium chloride content, a marginal increase of 4.88% in MDD value was observed. At 3% Rice husk and calcium chloride content, MDD was found to be further improved as compared to just Rice husk and calcium chloride mixed with soil.
4. In comparison to virgin soil (Clayey Sand – SC group) the soil mixed with 3%Rice husk and calcium chloride gave a substantial increment of 26.98% in CBR value. Thus it was concluded to fix the percentage of Rice husk and calcium chloride a 3% to further analyse effect of polypropylene in the soil mix.
5. As compared to soil mixed with 3% Rice husk and calcium chloride, 1% polypropylene mixed with 3% Rice husk and calcium chloride gave CBR value of 4.33. Thus 8.25% increase in CBR value was observed.
6. In comparison to virgin soil, an overall gain of 37.46% of CBR value was obtained with 3%Rice husk and calcium chloride and 1% polypropylene fibre mix.
7. When virgin soil (Clayey Sand) mixed with 3%Rice husk and calcium chloride gave a substantial increment of 73.78% in Cohesion value and 18.26% in Angle of Internal Friction. Thus it was concluded to fix the

percentage of Rice husk and calcium chloride a 3% to further analyse effect of polypropylene in the soil mix

8. The shear quality parameters of clayey sand soil were determined by coordinate shear test delineates the value of cohesion enhanced for soil admixed with 3% Rice husk and calcium chloride and various polypropylene fibre reinforcement of 0.5%, 1% and 1.5% are 68.28%, 72.16% and 84.46% respectively. The increment of the internal angle of friction (φ) was observed to be 29.53%, 34.99% and 52.61% individually. Thus, a net increase in the cohesion and the internal angle of friction φ were seen to be 84.46%, from 0.309 kg/cm2 to 0.57 kg/cm2 and 52.61%, from 27.82 to 30.75 degrees.
9. The fibrous mix develops resistance towards sudden failure by improvising upon grain contact of the overall mix.
10. With overall gain of 37.46% of CBR thickness of subgrade reduced to around 25 mm in rural roads as per IRC: SP 72-2007.

IV. REFERENCES

[1] Desai, I. D. and Oza, B. N. (1997) "Influence of anhydrous calcium chloride on shear strength of expansive soils" *Proc., 1st Int. Symp. On Expansive Soils*, HBTI, USA.

[2] Al-Rawas, A. (2002). "Micro fabric and mineralogical studies on the stabilization of anexpansive soil using cement bypass dust and some types of slags." Can. Geotech. J., 39(5),1150–1167.

[3] Mymrin, V. A., and Ponte, H. A. (2005). "Oil shale Rice husk ash utilization as independent binder of natural clay soil for road and airfield base construction." Part. Sci. Technol., 23(1), 99–107

[4] Rao, S. M., and Thyagara, T. (2007). "Swell-compression behaviour of compacted clays under chemical gradients." Can. Geotech. J., 44(5), 520–532.

[5] Akbulut, S., and Arasan, S. (2010). "The variations of cation exchange capacity, pH, and zeta potential in expansive soils treated by additives." Int. J. Civ. Struct. Eng., 1(2), 139–154.

[6] Rao, K., Rao, G. V. V. R., and Pranav, P. (2011). "Stabilization of expansive soil with rice husk ash, lime and gypsuman experimental study." Int. J. Eng. Sci. Technol. (IJEST),3(11), 8076–8085.

[7] Fattah, M.Y., Raphil, F.H. and Al-Soudany, K.Y.H. (2013).Improvement of clay soil characteristics using rice husk ash, J. Civ. Eng. Urban., 3(1), pp. 12–18.

[8] Thomas, R.K., James, W.K., Charles, K. and George, T. (2017). Soil stabilizationusing rice husk ash and natural lime as an alternative to cutting and filling in road construction, J. Constr. Eng. Manage., 143(5), 1- 1. Tripathy, S., Rao, K. S., and Arpan Sen, Rishabh Kashyap, (2012) ''Soil Stabilization Using Waste Fiber Materials, 'Thesis, National Institute of Technology, Rourkela Construction Earthworks Manual_Nov2011

[9] [3] S. Bhuvaneshwari, R. G. Robinson, S. R. Gandhi "STABILIZATION OF EXPANSIVE SOILS USING RICE HUSKASH" Rice husk and calcium chloride India 2005

[10] Raj Kumar, R.L. Ahuja, N.T. Singh, S.K. Ghabru, "Characteristics and Classification of Alkali Soils on Siwalik Hills of Satluj-Yamuna Divide, North-West India", Haryana Agricultural University, Hissar-125 004, 1995

[11] H. S. Chore, a a Kumthe, S. B. Abnave, S. S. Shinde, S. S. Dhole, and S. G. Kamerkar, "Performance evaluation of polypropylene fibres on sand-Rice husk and calcium chloride mixtures in highways." J. Civ.

Eng., vol. 39, no. 1, pp. 91–102, 2011.
[12] Ghanshyam Dass, (1977), "Geology and Sedimentology of the lower tertiary rocks of Morni Sarahan Dadahu region Haryana and Himachal Pradesh", PhD. Thesis, Centre of Advanced Study in Geology, Panjab University, 1977
[13] R. Saravanan, R. S. Thomas, and M. Joseph, "A Study on Soil Stabilization of Clay Soil Using Rice huskash." vol. 1, no. 2, pp. 33–37, 2013.
[14] Mr.Redij Pushpak Vilas* Mr.Palkar Manish Pramod* Mr.Sawant Siddhesh Vasant Prof. Mr. P.B. Rajmane "Use of Waste Polypropylene from Plastic Industry in Road Construction" International Journal of Engineering Technology, Management and Applied Sciences, 2017
[15] Hemant Kumar Gupta, Anant Kumar Gupta,Sarika Awasthi"Enhancement in Stabilization Properties of Soil Using Waste Polypropylene Plastic Fibre", International Journal of Engineering Technology Science and Research, 2017
[16] Shish Pal1,Vinod Kumar Sonthwal2, Jasvir S Rattan3 "Soil Stabilisation Using Polypropylene as Waste Fibre Material'' International Journal of Innovative Research in Science, Engineering and Technology 2015
[17] Prof.S.Ayyappan, Ms.K.Hemalatha and Prof.M.Sundaram "Investigation of Engineering Behavior of Soil, Polypropylene Fibres and Rice husk and calcium chloride -Mixtures for Road Construction'' International Journal of Environmental Science and Development, Vol. 1, No. 2, June 2010.
[18] Teresa Sunny, Annie Joy "Study on the Effects of Clay Stabilized with Banana Fibre'' International Journal of Scientific Engineering and Research (IJSER) 2014.
[19] Wajid Ali Butt ,B. A. Mir , J. N. Jha "Strength Behavior of Clayey Soil Reinforced with Human Hair as a Natural Fibre'' Geotechnical and Geological Engineering 2015.
[20] Jesna Varghese, Remya.U. R , Snigdha.V. K,"The Effect of Polypropylene Fibre on the Behaviour of Soil Mass with Reference to the Strength Parameters"International Journal of Engineering Research and technology 2016.
[21] Mamta Mishra*, U. K. Maheshwari and N. K. Saxena.; "Improving Strength of Soil using Fibre and Rice husk and calcium chloride -A Review" International Research Journal of Engineering and Technology (2016)
[22] T.Subramani, D.Udayakumar "Experimental Study On Stabilization Of Clay Soil Using Coir Fibre'' International Journal of Application or Innovation in Engineering & Management (IJAIEM) (2016).
[23] C. M. Sathya Priya1, S. Archana2, A. Bichu Albert3, A. D. Deeraj4 "STABILIZATION OF CLAYEY SOIL USING POLYPROPYLENE FIBRE'' International Research Journal of Engineering and Technology (IRJET) (2017)
[24] IS: 2720 Part 5: Methods of test for soils, Determination of liquid and plastic limit of soil.
[25] IS: 2720 (Part 7) (1974), "Indian Standard Methods of Test for Soils: Determination of Moisture Content-Dry Density Relation using Light Compaction", Bureau of Indian Standards.
[26] IS: 1498 (1970), "Indian Standard Methods of Test for Soils: Classification and Identification of Soil for General Engineering Purposes", Bureau of Indian Standards.
[27] IS: 2720 Part 16: Methods of test for soils, Laboratory determination of CBR Value of Soil.
[28] IS: 2720 Part 13: Methods of test for soils, Direct shear test.
[29] IS: 2720 Part 16: Methods of test for soils, Laboratory determination of CBR Value of Soil.
[30] Dragan Cakmak Elmira Saljnikov, Chemical Soil Stabilization. 1965, National Academic of Sciences.
[31] O G Ingles, JB Metcalf, Soil Stabilization Principles and Practice. 1973, New York, Wiley.
[32] M. Budhu, Soil Mechanics and Foundation. 2010.
[33] P. Purushothama Raj, Soil Machanics And Foundation Engineering. 2008. Dorling Kindersley (India) Pvt. Ltd.

[34] Dr. K.R. Arora, Soil Mechanics and Foundation Engineering. Seventh Edition 2008, StandardPublishers Distributers.