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Research Article

Geotechnical Performance Of Stabilized Weak Soils Using A Combinations Of Waste Tyre Powder And Kota Stone Powder

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ARTICLE INFO	ABSTRACT

Weak soils are primarily defined as clayey soils, having the special characteristics that cause them to deflocculating under some circumstances, erode quickly, and be quickly transported away by water flow. Because these soils have the most potential for problems including heave, shifts, cracks, and settlement, there is an increased danger of foundation damage due to this swelling propensity. Such damage to the foundation might have serious problems, including high repair costs. Clayey soil can be stabilized to make it suitable for building, which reduces settlement and increases the soil's bearing capacity [20]. In this study, two different types of admixtures namely tyre waste powder and kota stone powder which can be used for the stabilizing the clayey soils blended with their optimum combination [11-17]. The optimal combination of tyre waste powder and kota stone powder can be arrived by the clayey soils by conducting the various geotechnical investigations with different proportions namely 6% ,8 % ,10% ,12% 14% of kota stone powder and 12 % tyre waste powder. By the research the optimal combination is arrived to 12% of tyre waste powder and 8% of kota stone powder.
Keywords - Weak Soils, Waste Tyre powder, Kota Stone powder, UCC, dispersion, Durability, SWCC.

Introduction

Soil is a nature of foundation. Any structure's foundation is essential to its stability and long-term viability, and the kind of soil it is constructed on has a significant impact on how well it works. Of all the soil types, clayey soil presents the biggest obstacles to building strong foundations. This article explores the characteristics of foundation soils, emphasising the intricacies of clayey soil and the remedies for these problems.

The mineralogical patterns of clay soil pose difficulties when building on it. Because clay soil has a distinct composition, it can create unfavourable circumstances that compromise the integrity and stability of buildings. Because of the unique mineralogical properties of clay, problems such inadequate drainage, insufficient bearing capacity, and sensitivity to shrinkage and expansion can occur. To reduce potential issues and guarantee the long-term durability and safety of the construction project on clay soil, these challenges call for thorough thought and engineering solutions.

Waste tyre powder with a wide range of uses is produced by the recycling of discarded solid tyres, especially in the production of industrial goods. Prominent tyre producers use this rubber dust in their new tyre compounds, helping to support the ecologically responsible and sustainable development of tyre materials of superior quality [8]. Rubber powder is a multipurpose material that is used in the production of tyres as well as insulating boards, sealants, and vibration-reducing panels. The performance of new tyres is improved by this creative reuse of tyre trash, which also helps to manufacture a variety of industrial components with improved functionality and durability [5].

Waste tyre powder is also used for purposes other than making tyres; it is an essential component of many other industrial goods. Using this recycled material in insulating boards guarantees effective insulation, and using it in seals improves the functionality and durability of many industrial parts. Waste tyre powder -made anti-vibration panels are a useful tool for reducing vibrations in machinery and buildings. The tyre industry's adoption of sustainable practices highlights the need of incorporating rubber dust into manufacturing processes as a means of promoting the circular economy and environmentally friendly alternatives in the manufacture of industrial goods.

One of the biggest environmental problems and a contributing factor to pollution is the production of waste tyre powder. This powder is frequently a waste product from tyre manufacturing or recycling operations, and its disposal may have a negative effect on the environment. Inadequate handling of rubber particle discharge into the environment can result in contaminated soil and water, endangering human health and ecosystems. It is becoming more and more important to discover sustainable solutions for the appropriate handling and recycling of rubber tyre waste powder in order to reduce any potential negative environmental effects as attempts to address these issues gain momentum.

Kota stone Slurry is often produced as a by-product of several manufacturing and cutting processes used in the preparation of Kota stone. The slurry is made up of a mixture of water and pulverised stone particles. To minimise the negative impact on the environment, the main task is to manage the production of Kota stone slurry effectively. This slurry must be used effectively, or the proper disposal should be planned, by coming up with creative solutions and sustainable methods. Encouraging good waste management practices within the stone business and addressing environmental concerns related to it both require this strategy. Here the combinations of the tyre waster powder and kota stone powder can be used my research by referring the various combinations of materials study [16-23].

1. Literature Review

The Author Dr.Suhail A studies is to examine how using industrial waste and lime, a byproduct of sugar factories, affects a few engineering characteristics of clayey soil that was chosen from Mosul. These qualities include permeability, durability SWCC, and unconfined compressive strength. By dry weight of soil, the experiments were conducted at various proportions of lime and industrial waste/lime at various percentages respectively.

The researcher Dr. Suhail Idrees Khattab studies looks at the The permeability and water repletion of stabilized clayey soil undergo alterations. that was chosen from the Mosl region in terms of hydraulic parameters. It was discovered that 4% was the ideal percentage for lime stabilization. According to the "suggested limits for stabilized soil suitable as a base course," a mini. uniaxial compressive strength of 1410 and 5610 kPa, respectively, can be attained with cement quantities of 7% and 19%.

T.S. Umesha and Dinesh, This study demonstrated that adding 3% cement or 3% lime helps strengthen the soil. For the first three days of treatment, strength gains happen quickly; after that, they happen gradually over the next 14 days. Adding lime and allowing the soil to cure both raise its Young's modulus. For stabilized soils, there is a strong lime demonstrates a stronger correlation with Young's modulus compared to cement in enhancing uniaxial compressive strength for the soil under examination.

Bhuvaneshwari,S.and Soundara,B: This paper brings, changes in the mineralogical properties and microfabric structure lead to the development of strength. Therefore, scanning electron microscopy (SEM) is used to study the complex mechanisms via which the stabilising effects present themselves at the micro fabricstructure level.

Nabeel K. Asmeel1 , Harith E. Ali1 , Abideen A. Ganiyu , and Muyideen O. Abdulkareem: The investigation gathered data from both during and after water leaching on leachate and soil samples subjected to leaching. It's demonstrate how weakly the soil-KNO_3 mixture can withstand Shielding the potassium-stabilized soil from prolonged water penetration is crucial due to leaching concerns.

Delwyn G. Fredlund, Daichao Sheng, and Jidong Zhao: The limitations of estimating soil suctions from the SWCC are the main topic of the paper, which also offers recommendations for when to apply these estimates. Hysteresis observed in soil water characteristic curves (SWCCs) during drying and wetting phases is known to cause a wide range in the possible range of estimated suction values. It has been discouraged to estimate in situ suctions using the SWCC for these and other reasonsHowever, this research presents a framework for determining the potential range of soil suction values, encompassing both maximum and minimum values, along with the median value for in situ soil suction.

The author Koteswara Rao.D, estimating soil suctions from the SWCC are the main topic of the paper, which also offers recommendations for when to apply these estimates. Hysteresis between drying and wetting SWCCs is known to cause a wide range in the possible range of estimated suction values. It has been discouraged to estimate in situ suctions using the SWCC.This study introduces a methodological framework for estimating the pectrum of soil suction values, covering both the highest and lowest ends, along with the median value, under in situ conditions.P. T. Ravichandran, P. R. Kannan Rajkumar A. Shiva Prasad, and K. Divya Krishnan:This study looked into the idea of adding crumb rubber powder to soft soil increase its strength. Here, the different amounts of crumb rubber at various proportions stabilize the 2 kinds of challenging clay soils.The CBR experiments were used to analyse how adding up to 10% more crumb rubber to stabilized soils affected their strength characteristics. The study also explores the impact of different types and quantities of stabilizers on drainage characteristics, alongside the development of strength.

Sathyapriya, Arumairaj and Subramani: The author of this study demonstrated how an ideal eco sand and bottom ash combination may be considered as a workable substitute to stabilize clay soils through efficient dispersion dynamics coupled to the interconnected network of pore spaces.

Ammaiappan M: This research regarding the compressible clays of high and low. this two distinct types of clayey soils, are used in this study. The percentages of eco-sand that were blended with them were 10%, 20%, 30%, 40%, and 50%, respectively. By performing numerous engineering property tests on clay mixtures, such as uniaxial compression strength with varying curing periods, dispersion reseaches, durability researches, and hydraulic characteristics, the ideal amount of eco-sand can be determined. The ideal % of eco-sand is found to be 40%(CH) and 20%(CI) respectively, based on the outcomes of the aforementioned experimental experiments.

Khelifa Harichane, Said Kenai and Mohamed Ghrici: The obtained results showed that samples stabilized with lime had a considerable decrease in the plasticity index for CH class clay soil. However, in regard to the soil Samples stabilized with natural pozzolana showed a significant drop in the plasticity index value when compared to those stabilized with lime, and were categorized as CL class clay. Furthermore, it was shown that the cohesiveness and internal friction angle in samples with lime added increased over time. At later stages, the cohesiveness and internal friction angle are both significantly enhanced by the mixture of lime and natural pozzolana.

Soewignjo A. Nugroho, Andarsin Ongko, Ferry Fatnanta and Agus IP: The purpose of this work is to improve shear strength by stabilizing high plasticity clay using ASK. UCS testing was conducted to compare the uniaxial Compression Strength (UCS) values of clay, clay with 6% cement, clay with lime, clay-cement with WHA, and clay-cement with lime. using clay, lime, and WHA; as well as both. Prior to the UCS test, the sample was split into 2 groups: one that underwent 28 days of curing and curing without soaking, and the other that underwent 4 days of soaking. The qu value is uniform when the environment is unsaturated. The findings indicate that, in the range of 360 kPa to 390 kPa, qu values with and without curing or soaking. When 28 days of curing are allowed, both with and without sopping, qu values range

E A Adeyanju and C A Okeke :This research examined the viability of using the CKD to stabilize clayey soil that was removed from a stretch of Sango, Ota's failing road. Being a waste product from cement, CKD is inexpensive because it doesn't require any additional processing or treatment. Manufacturing process and is useful in powdered form. The effectiveness of CKD on difficult soil determines whether or not it is suitable as a stabilizer. It was combined with clayey soil in different amounts for this study:7.5,10,12.5, and 15%. Many geotechnical experiments were done for each combination.

The researcher Anita Widianti, provides the following: characteristics of soil combined with 0.75% fibers: various mixture's of total weight; swelling; unconfined compressive strength (UCS); and tensile strength. Seven, Fourteen, and Twenty-eight days were the cure times. ASTM testing is referred to. The test findings showed that increasing ash content and curing time increased the tensile strength, soaked CBR, UCS, and unsoaked CBR.

O. Udeh, J. L. Konna, G.Cookey, G. C. J. Nmegbu: Although surfactants have been studied, the addition of nanoparticles (NPs)—clay and, more recently, silica—is anticipated to improve recovery margin.
This combination improves foam stability and decreases surfactant loss to the reservoir formation. To determine if locally accessible Kono Boue (KB) clay NPs are suitable for CEOR applications, their interaction qualities and foam stability were examined.

Per LINDH, Polina LEMENKOVA: This study introduces the stabilizing method to an expansive clayey soil sampled in southern Sweden. Using a combination of conventional binders (lime and cement) and The studies examined the The strength characteristics of expansive soil improved through stabilization with various agents including Merit 5000 slag, fly ash sourced from SCA Lilla Edet, and ISO-certified fly ash derived from coal combustion. aiming to find an ideal binder mixture that serves as an inert ballast material for soil stabilization.

Iyappan.G.R Geetha.G Divya.S.K: The main aim of this research project are to improve the shear strength and decrease plasticity in both treated and untreated clay samples. Originally, samples of untreated clay were gathered in the vicinity of our campus. The treated samples consist of different amounts of chemical admixtures, with various proportions of addtives.
Bizualem Taye , Alemgena A. Araya:According to this study, adding molasses to the soil-cement combination It reduces shrinkage cracks and enhances the ductility of cement-stabilized soils.. When molasses and cement (4%)are added, the native soil's 1% CBR value rises to 64%, its PI value falls to 19% from 53%, and its 10.4% swell value decreases to insignificant levels.

Kamalneet Singh, Mohd Irshad Malik: Few methods and supplements were employed in this study to stabilize the expanding soil. Regaining the maximum amount of soil strength is made possible by the combination of a cementitious product and a natural fiber. Two resources that have the ability to stabilize the soil are natural fibers like bamboo fiber and industrial wastes like bagasse ash.

Catherine Mugai Dr. Eng. Benedtte Sabuni Dr. Edward Neyole Dr Faith Mugai:This study examines the effects of adding different amounts of rice husk ash (RHA), lime, and cement on the sub-grade bearing strength of clay. First, a chemical study was performed to determine the RHA's silica content. To determine the strength characteristics of the various soil prportion , a CBR test was performed. The primary stabilizing agent, RHA, was added in different amounts—0%, 5%, 10%, 15%, and 20%. The amounts of cement and lime were the same in each batch, but they differed throughout the six batches, ranging from 1.5% cement to 2% cement, 2% lime, 4% lime, and 6% lime.

Yibo Zhang, demonstrated that As the leachate permeation time increased, the permeability coefficient of modified Roller-compacted concrete (RC) with varied fly ash (FA) contents showed diverse trends, notably, post-stabilization, the 7% FA content demonstrated a notable decrease, reaching 5.98×10^{-11} m/s. Ashly.A Dr.Raneesh.K.Y:The purpose of this study is to ascertain how clayey soil treated with rice husk ash wood ash and coir pith behaves in terms of strength. In order to determine the ideal admixture percentage for achieving maximal strength, this article compares the three stabilizing agent combinations. The study's clay soil comes from the Tamarasery Taluk in Kerala's Kozhikode District. It is possible to evaluate these stabilizing agents' efficacy and conduct a comparative analysis.

Muhammad Syamsul Imran Zainia, studie eplains, the impact was investigated by substituting it with cement at weights of varying proportions for ESA. Significantly lower specific gravity (down 4.9%), a lower PI values (down 48.4%), a lower MDD values (down 5.5%), an increase in OMC (up 8.7%), and a higher USS (68.8%) are all displayed in the results.

2. Materials and Properties

Usually the high compressible clay has the most plasticity characteristics and it's taken for the research studies. The soil sample was excavating at a specified depth of 1.20 metres in accordance with normal protocol. The soil samples were gathered, dried in an oven for one day at 105 °C to eliminate any moisture, and then analysed in accordance with IS: 2720. Based on laboratory results, the clayey soils were categorized as high compressible clayThe properties of CH Soil were listed in Table 1.

Over a billion tyres are sold annually worldwide as a result of the explosive rise in the automotive and transportation industries, which has increased demand for tyres globally. Surprisingly, 50–55% of raw rubber is used each year in the tyre industry. Tyre replacements are usually necessary for safety reasons after 30,000–50,000 km of travel, which results in a massive yearly waste of approximately 17 million tonnes of tyres. These waste tyres provide a serious environmental problem since they take hundreds of years to breakdown because they are made of non-fusible or refractory polymer elastomer compounds.

Used tyres and rubbers are processed into fine rubber powders using waste tyre rubber powder. Furthermore, the rubber powder machinery has the ability to completely separate the three main basic components found in tyres: rubber, steel wire, and fibre. Then, in order to accomplish waste recycling, used tyres and rubbers can be restored to their pre-vulcanization state using a rubber reducer. This rubber can then be used to create all kinds of rubber products. The generation tyre waste power is shown in the following flow chart. The properties of rubber powder are tabulated in Table 2.

Kota stones are a type of fine-grained limestone that is extracted in Rajasthan, India. With a wide range of hues and textures, these stones can be used for both outdoor and interior floors, so you can select what best suits your aesthetic tastes. Kota stone, with its non-porous composition, is a more durable and non-slip alternative than many other stone types. Its natural biodegradability contributes to its eco-friendliness [1]. In addition, the stone reflects heat very well, which makes it a great choice for areas with warm weather because it keeps the ground cool underfoot.

During the cutting and polishing processes, about 25–30% of Kota stone is wasted. The problem of how to get rid of this trash is big because dumping it straight into woods and other places pollutes the environment, harms people's health, and damages natural ecosystems. The properties of kota stone powder is tabulated in table 3.

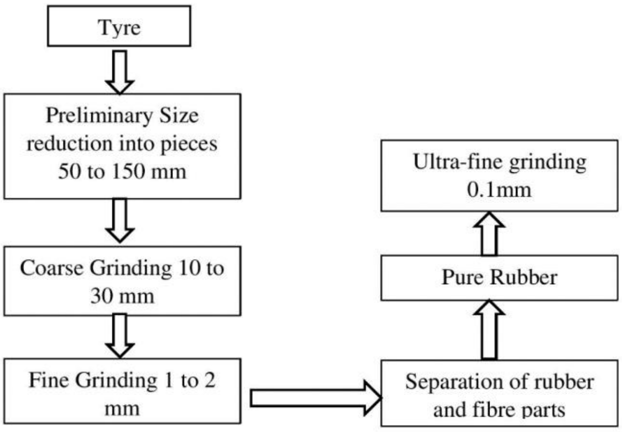

Fig.1 Flow chart – Tyre waste powder generation.

S.N	Properties	High-Compressibility Clay(CH)
1	Liquid Limit(LL), %	62 %
2	Plastic Limit(PL), %	34 %
3	Shrinkage Limit(SL), %	27 %
4	Plasticity Index %	28%
5	Maximum Dry Density g /cc	1.85
6	Optimum Moisture Content %	23.29 %
7	UCS Strength , (N / mm²)	0.182
8	Soil dispersion %	74 %

Sl.no	Chemical Composition	Percentage (%)
1	Polymeric Material (butadiene – Strene)	40-50%
2	Carbon Black	30–35%
3	Oil & Resin	15%
4	Sulphur	2-5%
5	Others	5-10%

Sl.no	Chemical Composition	Percentage (%)
1	Lime	38%
2	Silica	15-18%
3	Alumina	3-4%
4	Iron	1-2%

3. Experimental Investigation

4.1 Liquid limit & Plastic Limit: According to IS: 2720 (Part 5) 1985, the Casagrande method is a standard procedure that is frequently used to calculate the liquid limit & Plastic limit, are the important parameters in geotechnical engineering. The value of liquid limit & Plastic limit for the virgin soil is tabulated above in table no.1. The plasticity index(PI) is determined by subtracting the plastic limit from the liquid limit.So the PI value is found to be 28%. The plasticity index value is calculated by various proportions of the waste tyre powder and kota stone powder.

4.2 Unconfined Compression Strength (UCS) test:

High compressible clay (CH) soils were subjected to the Unconfined Compression Strength (UCS) test with a 12% addition of waste tyre waste. In addition, the clay soils were mixed with varying percentages of kota stone waste material (4%, 6%, 8%, 10%, and 12%). Under ideal moisture content circumstances, these tests were conducted at various curing interval times, namely 1 day, 7 days, 14 days, and 28 days respectively. The goal was to evaluate how these waste components affected the clay soils' strength properties throughout various curing times.

4.3 Study of Dispersions.

Clayey soil was evaluated using the double hydrometer test in compliance with USBR 5405 guidelines. The hydrometer test is the standard method used to determine the proportion of soil particles that are finer than 0.005 mm in size. This experiment was conducted to determine the optimal ratio of Kota stone powder and waste tyre power to add to CH soils. Assessing the finer fractions and particle size distribution of the soil was intended to enhance the evaluation of the Waste tyre power and Kota stone powder mixture's suitability and effectiveness in CH soils [3-4].

4.4 Durability Studies

For durability studies, cyclic drying and wetting processes are applied to clayey soil samples. ASTM D 559 is the std. methodology that is frequently utilized for this wet and dry cycle tests. In order to complete the one wetting/drying cycle, the prepared soil samples are treated, soaked in normal water for five hours in accordance with protocol, and then incurred to dry at 120°F for forty-two hours. The soil samples are used to quantify the volume changes that occur between the ends of the soaking and drying cycles. Pi tape measures are used to measure the diametrical changes, while Standard dial gauges positioned on the top plate are utilized for measuring vertical alterations. There are twenty-one cycles of wetting and drying with the same activities completed.

4.5 Hydraulic Properties of clayey soils:

To evaluate two crucial hydraulic parameters, the value of co efficient of permeability of the soil and its Soil water Characteristic Curve (SWCC) were comprehensively examined. This in-depth analysis aimed to comprehend the soil's water-transmission capacity as well as its water-retention behavior under various moisture levels. To understand the hydraulic behavior of the soil and provide guidance for different technical applications, the study examined the permeability properties and SWCC [2].

4.5.1 Permeability Test of clayey soil:

The procedure for determining the value of the coefficient of permeability was carried out in according to IS: 2720 (Part 36)-1997. In this test, different mixture ratios —4%, 6%, 8%, 10%, and 12% of Kota stone were compared with a 12% addition of waste tyre powder. In order to provide important information for engineering applications, the goal was to assess the permeability characteristics of the soil under various combinations of waste tyre powder and Kota stone.

4.5.2 Soil Water Characteristic Curve (SWCC)

The entire suction was arrived using the ASTM 2008 Standard method, which was created especially to determine the ideal ratio of waste tyre powder and Kota stone powder when combined with CH soil. By evaluating the overall suction, this approach sought to ascertain the best blend of these elements, offering vital information for maximizing the soil mixture's technical qualities [5-10].

4. Results and Discussion

*5.1*Study of Unconfined compressive strength.

The outcomes of experimental research involving the replacement of highly compressible clay with varying amounts of Kota stone powder (4%, 6%, 8%, 10% & 12%) and 12% waste tyre powder are analyzed in the results and discussion section. Numerous factors are examined in this inquiry, including as the uniaxial compressive strength (UCS) with different proportions of curing, durability, and hydraulic qualities. The results lead to the determination of the ideal ratios, and it is found that 12% tyre waste powder and 8% high compressible clay work well together.
Table 4 Uniaxial compressive strength with various curing period for different % of Kota Stone powder with 12% of waste tyre powder.

The different mixings are denoted by the follows.

Mixing 1 - Soil Sample + 12% Tyre Powder (TP) +4% Kota Stone Powder (KSP) –"0" day Curing
Mixing 2- Soil Sample + 12% Tyre Powder (TP) +4% Kota Stone Powder (KSP) –"1" day Curing
Mixing 3 - Soil Sample + 12% Tyre Powder (TP) +4% Kota Stone Powder (KSP) –"7" day Curing
Mixing 4 - Soil Sample + 12% Tyre Powder (TP) +4% Kota Stone Powder (KSP) –"14" day Curing
Mixing 5 - Soil Sample + 12% Tyre Powder (TP) +4% Kota Stone Powder (KSP) –"28" day Curing
Mixing 6 - Soil Sample + 12% Tyre Powder (TP) +6% Kota Stone Powder (KSP) –"0" day Curing
Mixing 7- Soil Sample + 12% Tyre Powder (TP) +6% Kota Stone Powder (KSP) –"1" day Curing
Mixing 8 - Soil Sample + 12% Tyre Powder (TP) +6% Kota Stone Powder (KSP) –"7" day Curing
Mixing 9 - Soil Sample + 12% Tyre Powder (TP) +6% Kota Stone Powder (KSP) –"14" day Curing
Mixing 10 - Soil Sample + 12% Tyre Powder (TP) +6% Kota Stone Powder (KSP) –"28" day Curing
Mixing 11 - Soil Sample + 12% Tyre Powder (TP) +8% Kota Stone Powder (KSP) –"0" day Curing
Mixing 12- Soil Sample + 12% Tyre Powder (TP) +8% Kota Stone Powder (KSP) –"1" day Curing
Mixing 13 - Soil Sample + 12% Tyre Powder (TP) +8% Kota Stone Powder (KSP) –"7" day Curing
Mixing 14 - Soil Sample + 12% Tyre Powder (TP) +8% Kota Stone Powder (KSP) –"14" day Curing
Mixing 15 - Soil Sample + 12% Tyre Powder (TP) +8% Kota Stone Powder (KSP) –"28" day Curing
Mixing 16 - Soil Sample + 12% Tyre Powder (TP) +10% Kota Stone Powder (KSP) –"0" day Curing

Mixing 17- Soil Sample + 12% Tyre Powder (TP) +10% Kota Stone Powder (KSP) –“1” day Curing
Mixing 18 - Soil Sample + 12% Tyre Powder (TP) +10% Kota Stone Powder (KSP) –“7” day Curing
Mixing 19 - Soil Sample + 12% Tyre Powder (TP) +10% Kota Stone Powder (KSP) –“14” day Curing
Mixing 20 - Soil Sample + 12% Tyre Powder (TP) +10% Kota Stone Powder (KSP) –“28” day Curing
Mixing 21 - Soil Sample + 12% Tyre Powder (TP) +12% Kota Stone Powder (KSP) –“0” day Curing
Mixing 22- Soil Sample + 12% Tyre Powder (TP) +12% Kota Stone Powder (KSP) –“1” day Curing
Mixing 23 - Soil Sample + 12% Tyre Powder (TP) +12% Kota Stone Powder (KSP) –“7” day Curing
Mixing 24 - Soil Sample + 12% Tyre Powder (TP) +12% Kota Stone Powder (KSP) –“14” day Curing
Mixing 25 - Soil Sample + 12% Tyre Powder (TP) +12% Kota Stone Powder (KSP) –“28” day Curing

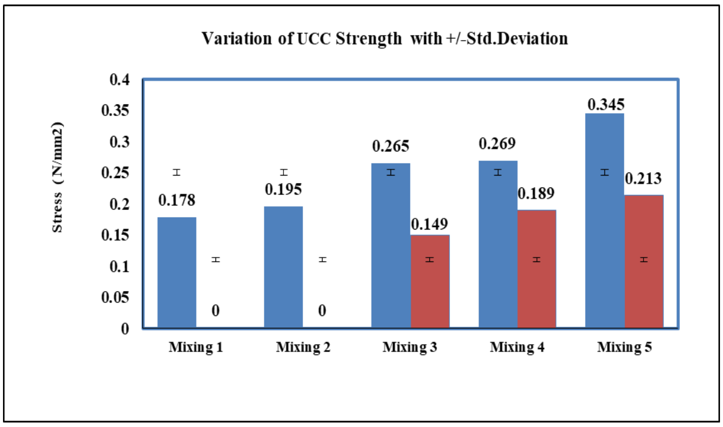

Fig.2 Soil + 12 % WTP + 0% KSP- Various curing days

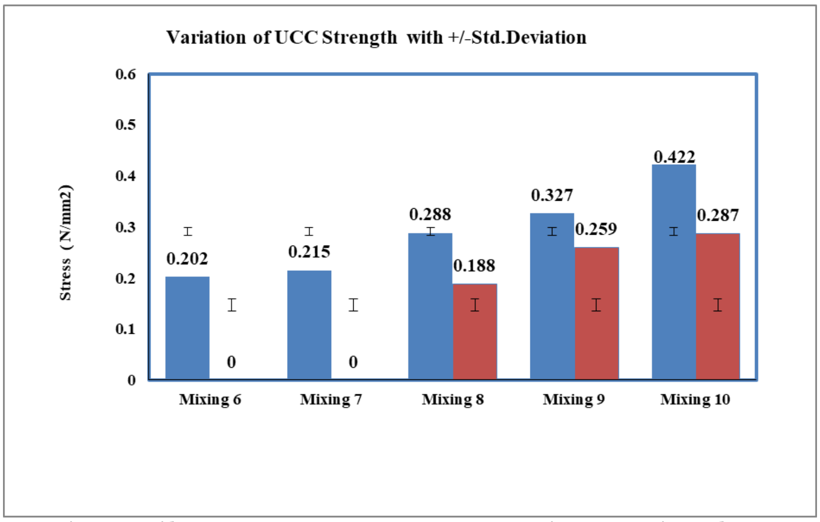

Fig.3 Soil + 12 % WTP + 4% KSP- Various curing days

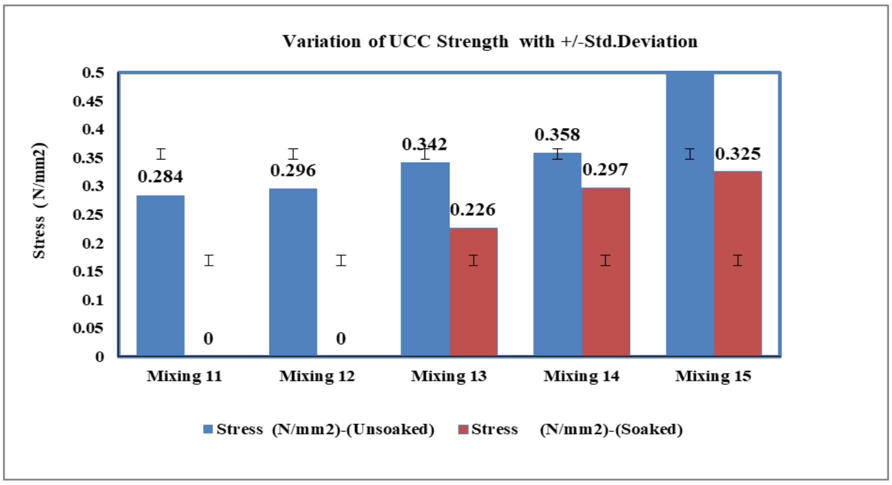

Fig.4 Soil + 12 % WTP + 6% KSP- Various curing days

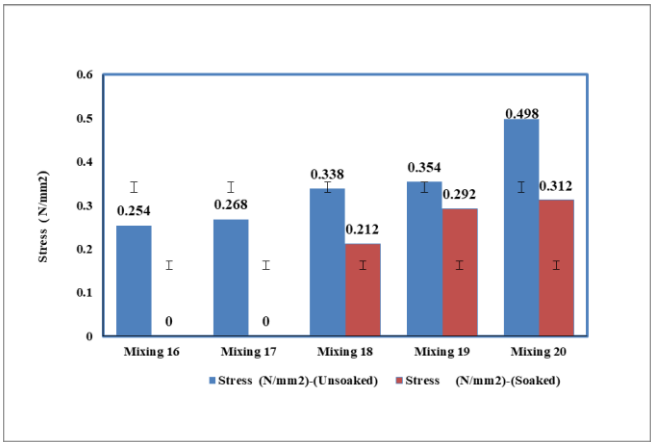

Fig.5 Soil + 12 % WTP + 8% KSP- Various curing days

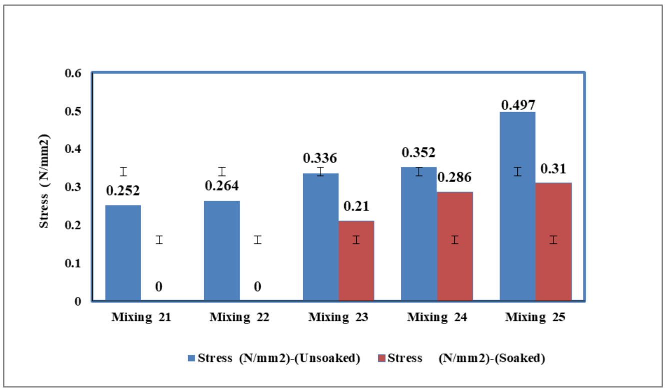

Fig.6 Soil + 12 % WTP + 10% KSP- Various curing days

The incorporation of kota stone powder in waste tyre powder has significantly increased the clayey soil's unconfined compression strength by promoting better void packing and reduction between soil particles. A comparable rise in the maximum dry density has occurred at the same time. When 4%, 6%, 8%, 10%, and 12% of kota stone were added to high compressible clay, the unconfined compression strength values showed notable increases of 94%, 109%, 77%, 96%, and 97% after a 28-day curing period. According to the statistical analysis, there is a 0.155 N/mm² standard deviation, a 0.291 mean, a 0.287 median, and a 0.353 range. Together, these data highlight the beneficial effects of kota stone powder and waste tyre powder on the clayey soil's engineering properties.

5.2 Clay Soil dispersion:

The conventional dual (double) hydrometer test was performed on soil specimens with an optimal combination of kota stone powder and waste tyre powder in accordance with USBR 5405 recommendations. Figure 7 shows the results graphically from this double hydrometer examination.

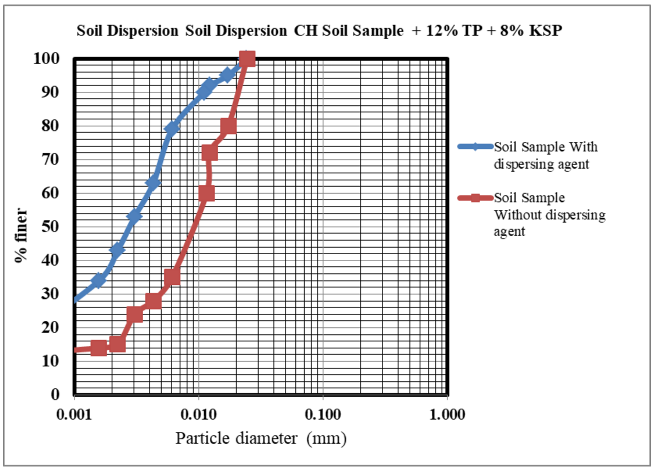

Fig.7 Soil + 12 % WTP + 10% KSP-Soil Despersion

5.3 Durability Studies

In this experiment, different ratios of 12% waste tyre powder to kota stone powder were combined with clayey soil, especially 4%, 6%, 8%, 10%, and 12%. The resulting values are shown in the table below, and the test results have been graphically represented in graphs.

Sl.No	Number of cycles	@ 4% KSP	@ 6% KSP	@ 8% KSP	@ 10% KSP	@ 12% KSP
1	0	100	100	100	100	100
2	1	55	89	80	92	92
3	2	30	78	70	78	78
4	3	-	65	50	69	68
5	4	-	0	35	45	48
6	5	-	-	5	37	35
7	6	-	-	0	30	32
8	7	-	-	-	15	16
9	8	-	-	-	-	10
10	9	-	-	-	-	5

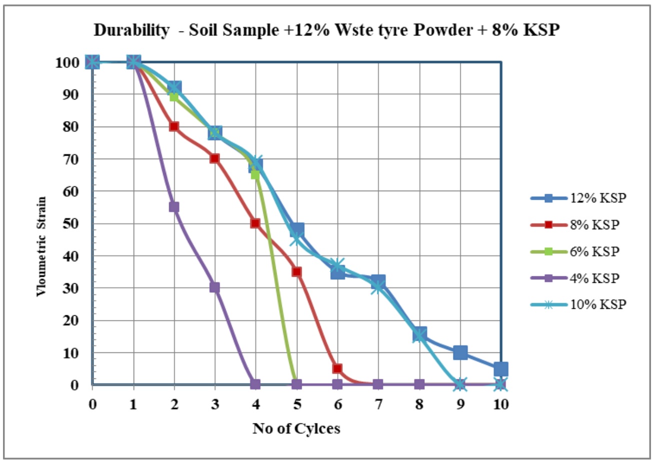

Fig.8 Soil + 12 % WTP + 10% KSP-Durability

Clayey soils have lower compressive load resistance because of the existence of the mineral montmorillonite. The combined soil sample may, however, have much less resistance. The test findings make it clear that soil samples with the optimum amount of kota stone powder were able to withstand up to 10 cycles of drying and wetting for highly compressible clayey soil.

5.4 Hydraulic Properties:

Tests were conducted on highly compressible clayey soils to determine their permeability and soil water characteristics curve (SWCC).

5.4.1 Permeability Test:

The variable head Permeability test was conducted to determine the coefficient of permeability as part of the assessment. These tests were carried out using different concentrations of kota stone powder (4%, 6%, 8%, 10%, and 12%) in addition to 12% waste tyre powder, in compliance with the standard IS: 2720 (Part 36) - 1997. These tests' outcomes are shown below.

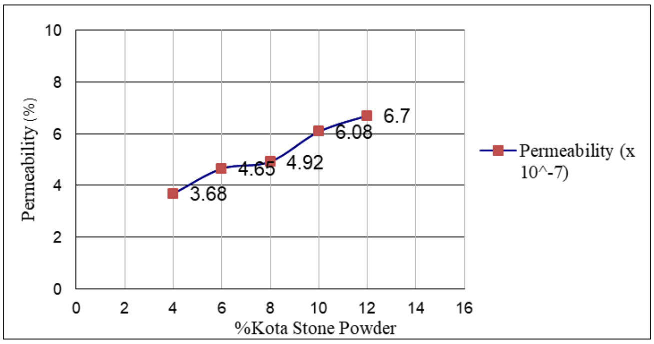

Fig.9 Soil + 12 % WTP + 10% KSP-Permeability

Permeability values increase steadily when kota stone powder is added, according to the results that were obtained. The extremely compressible clay's coefficient of permeability increased significantly to 6.70 * 10^-7 cm/s at the ideal percentage of kota stone powder. The stabilized soil treated with waste tyre powder and kota stone powder has modified soil grains, which is the cause of this occurrence. An increase in permeability was seen as a consequence of the flocculated structure that formed as a result of the expected reduction of this ionic layer.

5.4.2 Soil Water Characteristic Curve:

On clayey soil, total suction tests were performed using the ASTM 2008 methodology. The best dosage of combination tyre powder and kota stone powder was then determined by plotting the soil-water characteristic curve (SWCC).

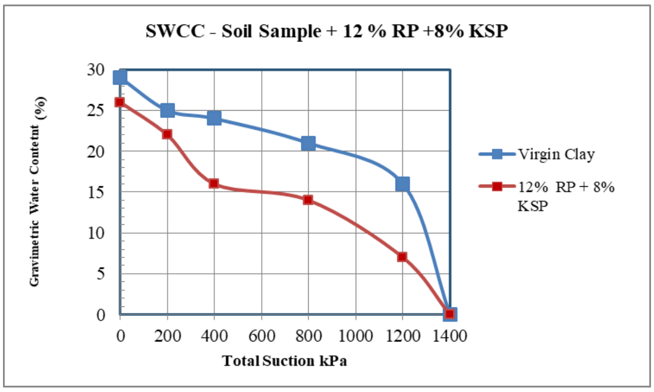

Fig.10 Soil + 12 % WTP + 10% KSP-SWCC

The graph suggests that both the air ingress threshold and residual suction in the soil sample analysis demonstrated an increase corresponding to the boundary effect and transition regions.
During this observation, there was a notable shift in the atmospheric conditions, with the air ingress threshold increasing from 112 kPa to 188 kPa. Additionally, there was an improvement in residual suction, which rose from 932 kPa to 1034 kPa. Alongside these changes, there was an expansion observed in both the transition and border impact areas.

5. Conclusion.

Conclusions from the experimental research were applicable to a soil sample as follows.
i) Following the completion of the 28-day curing period, the unconfined compressive strength was increased by 78.5 percentage for the soil sample with respect to optimal combinations of 12% waste tyre powder and 8% Kota stone powder.
ii) At optimal combinations of waste tyre powder and Kota stone powder the soil sample dispersive value is decreased to 43% from 75%. Consequently, the soil phase changed from high dispersal to intermediate dispersal.
iii) In relation to optimal combination of waste tyre powder and Kota stone powder, the durability of soil serves as a significant indicator of the performance of weak soils, particularly (highly compressive clay)
iv) At the optimal combination of waste tyre powder and Kota stone powder, the corresponding Waste tyre powder and kota stone powder performed as a smaller nano particles to occupied the soil sample voids, significantly increasing the soil's water-retention capacity.

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