International Journal of Applied Engineering & Technology

SUSTAINABLE SOLUTIONS FOR SUBGRADE IMPROVEMENT: MARBLE DUST, JUTE FIBER, AND LIME BLEND IN PAVEMENT SUB-GRADE ENGINEERING

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ABSTRACT

The use of waste materials to modify the characteristics of poor soils has become in importance in geotechnical designing. Recent years have seen a lot of research focused on how this waste material affects soil characteristics. This paper aims to discuss the impact of marble dust powder, jute fibre, and lime on the subgrade display. Then, soils that had different amounts of marble dust added to them were tested. To evaluate the display of the soils mixed with marble dust, the CBR test and modified delegate have been used. to carry out a series of research facility tests and investigation in order to investigate the impacts of jute fibre content on the strength influence system. The expansion of jute fibre with a 0.6% substance and a length of 6 mm to a wide soil model set up at most extreme dry thickness and proper wetness content created the best fibre building up results. This investigation discovered that blending lime in with marble dust powder and jute fibre while settling soil affected the dirt's solidarity limits. The expense of the stabilizers used to settle the subgrade soil is kept to a base thanks to this technique, which likewise assists with lessening plastic contamination.

Keywords:Marble dust, Jute fibre, Lime, Pavement sub grade soil, Influence effect Soil reinforcement.

1. INTRODUCTION

Subgrade properties determine the thickness of pavement layers. In readiness of subgrade for street development, utilizing many ordinary materials is, for the most part, certain due to monetary and normal considerations. Along these lines, recognizing and treatment of poor subgrade soils is a principal objective. Substitution of unfortunate soil is one of the standard choices. In any case, it is costly and unreasonable in the street projects in light of the gigantic volume of these works.

Improvement of unfortunate soils using lime, Portland concrete, and different engineered mixtures is a fruitful arrangement. In any case, using these admixtures increment the aggregate sum of spending plan. Lately, utilizing industrial side-effects in the improvement of unfortunate soils is famous as it works on the climate and reduces the cost. Marble dust is one such waste material. The marble dust is created from the cutting and honing of marble stone.

The extent of marble slurry made consistently is in the scope of 5-6 million tons. The marble dust powder has a huge proportion of lime content and had been proposed by different well-informed authorities, which helps in Change. A couple of assessments examined the overhaul of red tropical soils by the development of marble dust powder in different rates.

The technique for incorporating indiscriminately conveyed discrete fibres into soil network for supporting soil began from bygone eras, and, it is invigorated from the ordinary idiosyncrasy that the participation between plant roots and the including shallow zone soil of a trademark slope could protect the inclination from storm wash. Besides, diverged from the customary soil support technique referred to above, soil upheld with randomly dispersed discrete strands has a couple of remarkable and crucial advantages or superiorities. Hence, randomly conveyed fibre-upheld soils hang out in geotechnical planning for the second time which shows a promising opportunity for the utilization of soil support by with no obvious end goal in mind scattered discrete fibres. Likewise, it is essentially noticed that the blending and arrangement techniques of haphazardly circulated discrete filaments supported soil are somewhat less complex and simpler which are much like the method involved with adding lime, concrete or different added substances into soil mass. In like manner, the advancement of potential planes of weakness that could be made agreed with arranged support are restricted on account of the way that discrete strands randomly conveyed inside soil mass could additionally foster the shear strength of fibre-developed soil all over and thusly causing isotropic strength characteristics for soil upheld with for arbitrary reasons scattered discrete fibres.

Lime adjustment improves the development exercises by lessening as far as possible and expanding as far as possible, which brought about a diminishing in the pliancy record of the soil. This change of flexibility document works on the usefulness of the reasonable out soil as compressibility and volume change of the dirt reduce with a decline in the adaptability record. Lately, supporting the dirt is transforming into the most well-known part of mechanical change. The audit drove on slight earth soil investigated the appropriateness of supporting soil with sisal fibre and polypropylene strands to augment shear strength limits, which show the ability of this support in reducing opposing consequences for roads, structures, holding plans, and water supply lines. Preliminary focus on clearing soil upheld with polypropylene fibre shows that most prominent dry thickness, extend properties, and shrinkage limit decline with the development of polypropylene fibre and extension in unconfined compressive strength, CBR, and unbending nature was taken note. Anyway, it littly influences the plastic properties of the dirt.

LITERATURE REVIEW

Okagbue and Onyebi assessed marble residue's true capacity as an offsetting added substance to red tropical soils. The boundaries that were tried included atomic size scattering, express gravity, Atterberg limits, standard compaction qualities, compressive strength, and CBR (California Bearing Ratio). Flexibility diminished by 20% to 33% with fluctuated helpful conditions, but strength and CBR expanded by 30% to 46% and 27% to 55%, separately.

Cai et al. investigated the effects of lime and polypropylene fibre on a clayey soil's designing characteristics. Tests for unconfined pressure, direct shear, expanding, and shrinking were performed on treated samples. Reduced expanding and shrinking potential was brought on by the expansion of lime content. According to the results of the filtering electron microscopy investigation, using lime produced a substance response between lime and soil and significantly altered soil texture.

Al-Mukhtar et al. used small investigation to provide an explanation of the development of geotechnical features that appear in the broad soil behavior because of the lime-mud reactions, which are primarily pozzolanic responses. Using scanning electron microscopy, attention was given to changes in the key geotechnical characteristics connected to the small level surface and construction of untreated and lime-treated compacted soil examples.

Instead of concrete, Savastano et al. (2000) used waste jute fibre as reinforcement for composites made of concrete. The addition of coconut fibre ranged from 0.25% to 1% for the purpose of studying its impact on vast soil. According to IS code, the following tests were conducted on sweeping soils and soil containing jute fibre: compaction characteristics, doused California bearing ratio test, and undrenched California bearing ratio test.

Krishna et al (2001) According to the findings of the current investigation, taking jute fibre into account increases the soil's CBR value. When the Jute fibre content increases, the OR value of the soil also increases, and this increase is significant up to a fibre content of 5%.

Hamid and co. (2002) Figure 7 illustrates the CBR benefits of plain soil that has been built up indefinitely using different still-air mixtures. According to the current investigation, it is assumed that taking jute fibre into account increases the soil's CBR value. At the point when the Jute fibre content is extended, the dirt's CBR esteem likewise increments, and this increment is critical at 0.75% fibre concentration. It is likewise contended that the length of the fibre altogether affects the CBR worth of soil. The development in fibre length likewise builds the dirt's CBR esteem.

2. MATERIALS AND METHOD

2.1. Materials

The materials used in this research are marble dust, jute fibre and lime.

2.1.1. Marble Dust

Marble has typically been used as a building material since ancient times. Thus, marble waste is an important substance that requires sufficient natural removal effort. Moreover, recycling waste without proper oversight might result in environmental problems that are more serious than the waste itself. A byproduct of the marble-making process is marble dust. The cutting system produces a significant amount of powder. As a result, roughly 25% of the initial marble mass is lost as dust. Directly releasing these wastes into the atmosphere can lead to natural problems, such as an increase in soil alkalinity, effects on plants and animals, and so on. The distribution of marble powder from the sifter is seen in Figure 1.

Figure 1: Marble Dust Used in this Study

2.1.2. Jute Fibre

This study utilized jute fibre, one of the most important and helpful normal strands known as "gold fibre," as a dirt supporting material. Likewise, involving regular strands to help soil has acquired ubiquity in geotechnical plan because of its reasonable viability, openness, and non-defilement. Jute fibre diminishes the greatest dry thickness while expanding the ideal dampness content and CBR worth of jute fibre upheld soil, as per research results distributed by Aggarwal and Sharma (2011) who zeroed in on subgrade credits using jute fibre support. Preceding testing, the more extended jute fibres were sliced with scissors to the vital lengths, and they were then dried in an oven at a consistent temperature until they arrived at a steady weight.The visible and microscopic photos of the jute fibre used in this review are shown in Figure 2.

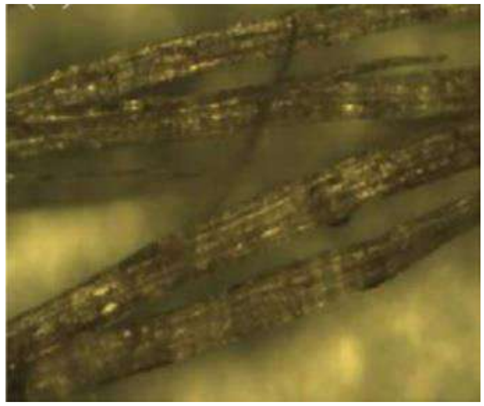

Figure 2: Microscopic view of photograph jute fibre

2.1.3. Lime

In this review, hydrated lime from the Senkele lime handling manufacturing plant in Ethiopia that is reasonable is utilized. Table 1 shows the manufactured combination of this hydrated lime, with a beginning shortfall of 19.06%.

Table 1: Chemical composition of the hydrated lime used in this study

Contents	SiO_2	CaO	Na_2O	MgO	Fe_2O_3	Al_2O_3	K_2O	Others
Percentage of composition	6.21	59.47	0.61	3.91	3.57	2.18	0.79	1.394

2.2. Method

A series of experiments were completed using the CBR technique (in accordance with ASTM D1883) to determine the potential strength of soil in addition to the tests carried out to determine the qualities of the materials employed (control soil and altered soil) (untreated and treated). By using the modified delegate test on both treated and untreated soils, ASTM D1557 was able to determine the optimal moisture content at which a particular type of soil will become generally thick and reach its maximum dry thickness. Five rates of marble powder were added to the soils to prepare the instances for testing. Similar to the control test, an example was created without using marble dust. On each example, the CBR test and the modified delegate test were applied to determine the optimal CBR worth. All estimates were repeated numerous times, and the average value was noted.

The level of the soil's dry load has been used to calculate how much lime has to be supplied. In order to achieve the largest dry thickness at the appropriate moisture content determined by the compaction test, the examples for compaction, CBR, were compacted. The interaction between the soil and the lime is done in an effective way. The lime is first thoroughly mixed with the soil at the correct moisture content. It is visible that the stabilizers have been incorporated into the soil throughout the mixing process.

Jute fibres were integrated into the dirt utilizing the going with strategies. Before being sieved to a size under 2 mm, a reasonable measure of clearing soil that had been grill dried was squashed anyplace near a machine. Furthermore, dry soil of unequivocal weight and jute fibre were gauged and looked at. Thirdly, the strands were slowly integrated into dry soil by hand until they were all effectively conveyed inside the dirt organization.The soil-fibre composite was then continually moistened with predetermined water content over the course of 24 hours, allowing water to diffuse sufficiently inside of it.

3. RESULTS AND DISCUSSION

3.1. California Bearing Ratio (CBR)

The three soil tests for the California bearing ratio test were completed using five different amounts of marble powder. Marble dusts were mixed with soil at various rates (5,10,15,20,25%). Figure 3 depicts the results of the CBR test. The figure showed how the soils' CBR is affected by the expansion of marble dust rates. The highest CBR value obtained was 14.17 percent (soils combined with 27% marble dust). The area where the soil is not treated with marble dust had the lowest reported value (CBR was 5.67%). The rising game plan of cementitious mixtures (calcium silicate hydrate) coming about because of the association between the calcium carbonate in the marble powder, soil, and water prompted the expansion in MDD regard.

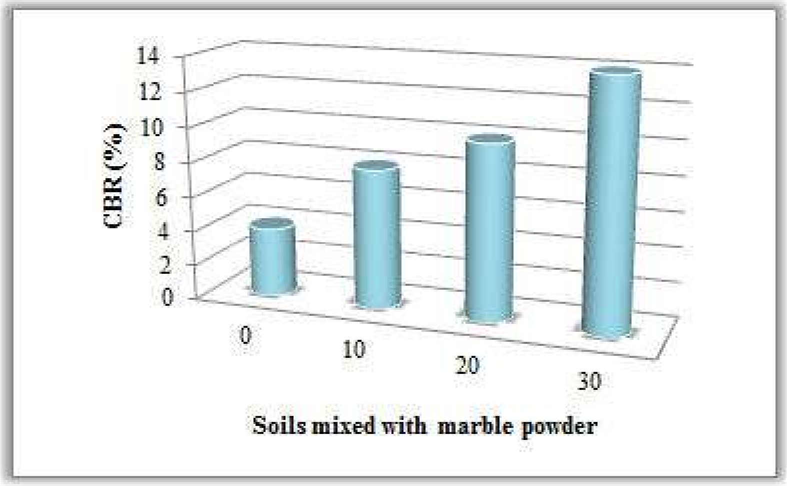

Figure 3: The CBR Values of Untreated and Treated Samples with Different Percentages of Marble Dust

3.2. Maximum Dry Density (MDD)

Five rates of powdered marble dust were used in the standard delegate test on the soil test. Different portions of marble dust (5,10,15,20,and 25%) were added to the soil. The highest value of MDD was 1.76 g/cm3 when 12% marble dust was used. MDD of untreated soils was 1.8 g/cm3, as opposed to that. The MDD is shown in Figure 4 for several situations. The MDD increases with the rate of marble dust (e.g., 1.8 g/cm3 for untreated soils, 1.76 g/cm3 for soil mixed with 12% marble). The results also demonstrated that the MDD starts to decline at marble rates that are increased by over 12%. This is as a result of soil particles growing into enormous estimated groups, changing the surface. This contact encourages the growth of a herd. This increase in the void ratio corresponds to a decrease in MDD.

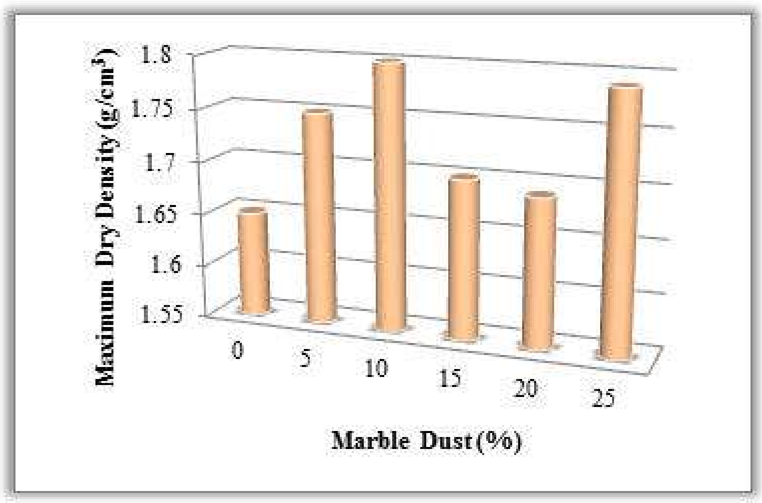

Figure 4: Effect of Marble Dust on MDD

Figures 5 shows the trend between fibre content and the shear strength parameters of varying fibre length reinforced expansive soil at the state of MDD.

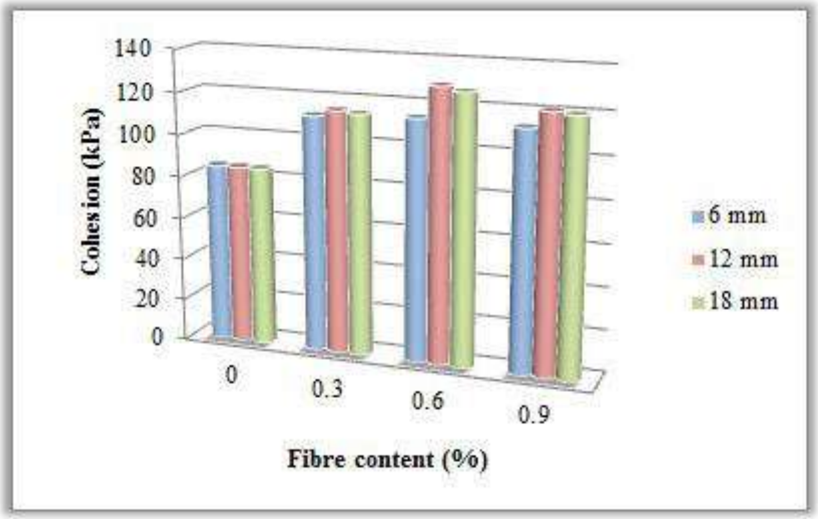

Figure 5: Curves of cohesion between fibre content

On broad, the association of upheld soil developed with expanding fibre content to a limited extent of 0.6% fibre content, so, all in all further development in fibre content made the association debilitate. Regardless, fibre content verifiably influences the scouring point of fibre-constructed soil inside. It means a lot to take note of that, at 0.9% fibre content, the inside scouring point of soil built up with fibres of changing length was lower than that of unreinforced soil, which might be connected with the way that the underlying soil particles were supplanted by strands, expanding porosity inside the dirt mass and diminishing conservativeness and the successful contact district between soil particles.

3.3. Fibre Content

The mechanical qualities of wide soil are altogether affected by how much jute fibre blending into the dirt mass. Fig. 6 shows an investigation of the shear strength of plain, ceaseless soil upheld by various paces of jute fibre (Fl = 12.0 mm) under four different vertical tensions.

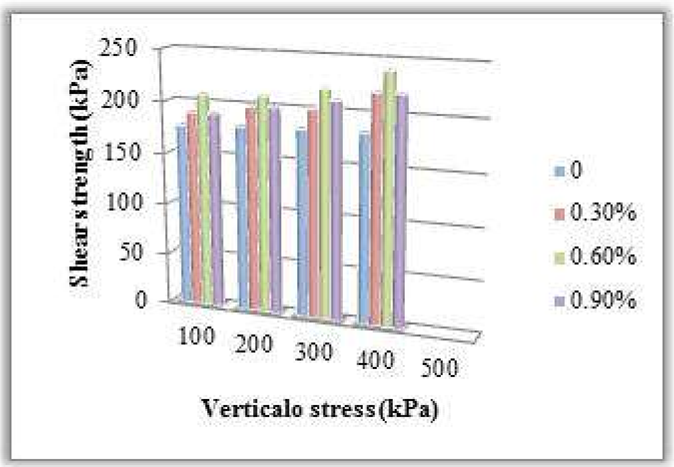

Figure 6: Comparison of shear strength

As can be displayed in Fig. 6, discrete jute fibre appropriated arbitrarily assisted with facilitating further develop the shear strength of expansive soil under fluctuated vertical tension. Also, the shear strength augmentation was affected by the fibre content, with 0.6% fibre content having the best effect. The fibre emotionally supportive network can be made sense of as follows: when shear disappointment of fibre-constructed soil happens, the versatile tension made in the fibre because of relative dislodging between fibre surface and the enveloping soil particles will then again circle back to the enveloping soil particles. Then, the moving of soil particles close to the dirt/fibre association point will be constrained by the strands safeguarding the soil mass going about as an unmistakable sling The misfortune altogether for fibre-upheld soil made the shear strength fall when the fibre content surpassed 0.6%.

3.4. Statistical Analysis

A factual analysis was completed to show the significance of the growth of marble powder in the earth on the MDD and CBR. In order to thoroughly investigate the results, an ANOVA test was used in this review.

The quantifiable analysis shown in Table 2 demonstrates that P-esteem is lower than 0.05 and F-detail is higher than F-Basic, demonstrating that the qualities of the dirt are improved by adding various amounts of marble dust powder.

Table 2: The Findings from Measurable Research on the Effect of Marble Residue Content on CBR and MDD

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	376.07	4	199.04	7.520	0.0183	5.704
Within Groups	504.99	17	34.199			
Total	881.06	21				

This result is consistent with earlier research, which showed that the dirts were much enhanced when combined with marble dust. However, earlier studies did not fully explore the effects of using various marble dust concentrations on the security of the dirts.

4. CONCLUSION

According to the soil heaviness, different marble dust rates of 5%, 10%, 15%, 20%, and 25% were used in the experiment. These various marble dust rates were evaluated relative to the untreated (control) soils. Our reasoning is based on the findings of this review, which demonstrate that adding marble residue to sensitive soils significantly increased the maximum dry density (MDD) as compared to untreated soils. The most notable benefit of MDD was provided by soils mixed with 10% of the marble dust, which also makes them less susceptible to distortion. Yet, the factual analysis showed that the portions of the marble dust added to the dirts were not substantial. The quantifiable analysis showed that, when compared to untreated soils, adding marble residue to soils fundamentally improved the CBR. In this way, when subjected to heavy weights, the dirts have a much bigger carrying percentage. The results demonstrated that the CBR values increased in step with the rates of the marble dust.

In light of the benefits of economy, non-defilement, and openness that jute fibre had as well as the unequaled further creating effects of jute fibre backing to the strength of expansive soil, the chance of utilizing randomly passed discrete jute fibre on to develop the sweeping soil got from the Hefei region is promising. The physical and mechanical qualities of wide soil are essentially affected by fibre content. The shear strength of clearing soil is variable, however the presentation of jute fibre into wide soil really forestalled the deficiency of shear strength for expansive soil in the wake of arriving at the top, which added to the shift of deviatoric stress-critical strain twists from strain-unwinding to strain-cementing.

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