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A Critical Review on Enhancing Soil Properties using Marble Powder and Terrazyme

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Abstract - *Everyday a huge quantity of waste is generated. With growing population and development waste disposal has become a problem, so here use of these waste for enhancing the soil properties is studied. For this purpose the wastes selected are marble powder and terrazyme and their effects on the soil characteristics is monitored.*

***Key Words*: soil stabilization, marble powder, terrazyme, OMC, MDD and CBR**.

1. INTRODUCTION

For construction purposes on the in situ soil, the basic necessity is that the soil must have high strength characteristics. If the locally available soil does not have high strength then options available are:-

1. Modify the design.
2. Replace the locally available soil.
3. Avoid the site for construction purpose.

All these above mentioned options are time consuming, highly expensive and sometimes not feasible according to the situations prevailing.

The soil is said not to be feasible for various engineering practices if accordingly it has low bearing capacity, soil has low CBR value, soil is prone to liquification, has high swelling and shrinkage characteristics, has low UCS value etc.

Also due to ever increasing population there is scarcity of land and also some sites are prone to landslides. So, now locally available soil has to be modified with some operations on it so that its strength increases up to a desirable limit and now further construction can be done. These operations which are done on the locally available soil to make it fit for the construction is called soil stabilization.

1.1 Soil Stabilisation

Any method which is done on the locally available soil to improve its engineering properties and strength is called soil stabilisation. Improvement can be done physically, chemically, biologcally, mechanically etc. This all can be done by compaction, reinforcement with fibres, introducing sand drains, addition of chemicals etc.

Also, one of the problem arising nowdays is of waste disposal. Engineers have to deal with this problem of waste disposal and one of the solution available is to use these wastes for the stabilisation of soil. This benefits as:-

1. Cost is reduced by using waste material as soil stabilizer.
2. Problem of waste disposal is solved and is eco friendly.

Wastes which can be used as a soil stabilizer are rice husk, wheat husk, coirs, fibres, banana leaves, blast furnace slag, stone dust etc.

The only thing is these wastes must be eco-friendly and economical viable. Keeping this in mind we have studied use of marble powder and terrazyme as wastes for soil stabilisation.

The success of such soil stabilization depends on the testing. The methods employed to stabilise the soil, should be verified in the lab with the soil material before applying it on the field.

2. Literature Review

Brazetti R, Murphy SR (2001) [1] In this experimental study, a step is taken to stabilize the black cotton soil for the construction of roads and buildings. In this study, strength of the Untreated black cotton soil and Enzymatic soil (Ecozyme + black cotton soil) are tested after the curing period of 0days, 7days, 14days, 21days and 28days for various Ecozyme dosages 200ml/3m3, 200ml/2.5m3, 200ml/2m3, 200ml/1.5m3. The various tests such as Preliminary test, Compaction test, Unconfined Compression Test (UCC), Soaked and Unsoaked California Bearing Ratio (CBR) test are performed for Untreated soil and Enzymatic soil and also test results are tabulated. The experimental result shows that Bio-enzyme (Ecozyme) stabilization improves the strength of the black cotton soil up to great extent, which signifies the bearing capacity and the resistance to deformation increased in the stabilized soil.

Scholen (1992) [2] also proposed that the enzymes could bond with large organic molecules that would be attracted to the clay minerals' net negative surface charge. The large organic molecules would then surround the clay minerals, neutralizing the negative charge and reducing the clay's affinity for moisture. The end result of both proposed mechanisms is a more stable clay lattice structure and a reduced affinity for moisture.

Raheem et al. (2010) [3] have reported the 28 days wet compressive strength of compressed stabilized interlocking earth blocks prepared with lime and cement alone as stabilizers added in varying quantities from 5% to 25%, with an increment of 5%. For maximum amount of stabilizer content, namely, 25%, the strength gain of the blocks is found to be 3.2 MPa and 1.2 MPa for blocks prepared with cement and lime respectively.

Mithanthaya.I.R, Harsha Kumar Rai and Ravishankar A.U (2009) [4] investigated the modified geo-technical properties of the lateritic soils by stabilizing with enzyme. Quantity changes in CBR values, UCC and Permeability were observed with four different dosages of Terrazyme. 200ml of Terrazyme was added to 2, 2.5,3 and 3.5m3 of soil. CBR value was increased by 400%, UCC value was increased by 450% and Permeability was reduced by 42%.

Maharana et al (2018) [5] studied the effects of terrazyme on atterberg limits, compaction characteristics and shearingcharacteristics. They found that liquid limit decreases from 48% for original untreated soil to 37% for treated soil, while plastic limit reduces from 26% to 17% with decrease in plasticity index from 22% to 19%. UCS value increase from 102.32 kPa to 637.58 kPa when compared to the original soil after 28 days of curing periods.

Tarkeshwar Pramanik, S. Kishor Kumar and J.P. Singh (2016) [6] has studied about the behaviour of Soil for Sub Grade by using Marble Dust and Ground Granulated Blast Furnace Slag and found that ,the characteristics of soils vary significantly with Marble dust-GGBS content. The Optimum Moisture Content (OMC) increases and Maximum Dry Density (MDD) decreases with increase in percentage of Marble dust-GGBS and with increase in 20%-20% of Marble dust and GGBS percentage compressive strength of soil increases.CBR value for soaked and unsoaked condition increases with increases in percentage of Marble dust and GGBS.

Panagiotis Ch. Eskioglou (2009) [7] examined the adequacy of marble dust as a soil stabilizer. The study revealed that the geotechnical parameters of black cotton soils are enhanced significantly by the addition of marble dust. Huge plasticity index reductions happened with marble dust treatment, particularly for high PI soils. Results demonstrated that plasticity decreased by 15 to 30% and strength increased by 25 to 50 %. The most noteworthy strength increase was accomplished at 8% marble dust after 28 days. Increments in the unconfined compressive strength of soil occurred with the addition of marble dust.

Akshaya Kumar Sabat, Radhikesh P. Nanda (2011) [8] examined the impact of marble dust on strength and durability of rice husk ash stabilized expansive soil and found that addition of marble dust increases the strength,decreases the swelling pressure and made the soil rice husk ash mixes strong. The ideal mixture of soil: rice husk ash: marble dust was observed to be 70:10:20.

Sachin N. Bhavsar, Hiral B. Joshi, Priyanka K. Shrof, Patel Ankit J. (2013) [9] evaluated swelling potential of expansive soil in its natural state as well as when mixed with varying proportion of marble dust (from 30 to 50%). It is concluded that the impact of marble powder on black cotton soil is positive. It gives maximum improvement in the swelling and linear shrinkage properties of black cotton soil.

Puneet Agarwal et al (2017) [10] A significant increase in Unconfined Compressive Strength (U.C.S), up to 200% was observed after a soil sample was treated with bio-enzyme namely Terrazyme. The treating duration played a pivotal role in the outcome and soil treated for 7 days with the bio-enzyme gave higher strength.

Rozhan Sirwan Abdulla, Nadhmiah Najmaddin Majeed (2014) [11] investigated the soil from two spots Bastora and Erbil Airport with Bastora soil as CH soil and Erbil Airport as CL soil. The marble waste powder was included in percentages of 10%, 20% and 30% by weight of soil. The results demonstrate that increase in percentage of marble dust decreases liquid limit, plasticity index and plastic limit and swelling potential.

Sandeep Panchal et al (2017) [12] In this study different type of geotechnical tests were performed on the soil sample under study with and without enzyme. Consistency limits, dry density and CBR values of a local soil sample by mixing different dosages of Terrazyme with different curing periods showed great improvement. The duration of treating bio-enzyme on the local soil played an important role in the improvement of strength. The CBR value with the third dosage having two week curing period showed great outcome and percentage increase as compared to local soil sample without Terrazyme is 131.49%.

Venika Saini et al (2015) [13] In this work, the performance of Bio-Enzymatic soil has been scrutinized. From the results obtained by the tests conducted on the soil, the following observations were made. Bio Enzymes are organic, non-toxic and biodegradable in nature. The end products obtained by usage of Terrazyme are biodegradable in nature and their effect is perpetual. The initial cost for the application of Terrazymemay be high as compared to other traditional proposals but the benefit of using Terrazyme such as the zero maintenance cost and long durability makes this approach economically cost-effective.

Joydeep Sen et al (2015) [14] In order to use this technology for low volume roads, the properties of soil modified with the bio-enzyme have been studied. Based on results from the testing done on soil treated with bio-enzyme, field trials were carried out using bio-enzyme on some of the roads in India. Also, it was found that in the dearth of granular subgrades, bio-enzyme treated soil surfaces can be used to realize the pavement design requirement, provided with a thin bituminous surfacing. It was also found that after adaptation of the IRCmethod for soil CBR, the thickness of bio-enzyme stabilized soil reduces

around 25 to 40 per cent.

PriyankaShaka et al (2016) [15] Based on IS classification, red soil is classified as Clayey sand and the black cotton soil as highly compressible clay. Laboratory testing showed that decrease in liquid limit and plasticity index was observed with the increase in dosages of Terrazyme. Also, the Terrazyme dosage of 200ml/0.75m3 of dry soil garnered the best result. Further increase in the dosage does not alter the plasticity characteristics of soils substantially. CBR Value of the soil sample was increased by 2.75%. 3.345%. 3.47% and 3.56% by application of the bio-enzyme with a dosage of 200ml/0.75m3. With further increase in the dosage of the enzyme, no substantial increase was recorded.

Lacuoture and Gonzalez (1995) [16] conducted a comprehensive study of the TerraZyme soil stabilizer product and its effectiveness on sub-base and sub-grade soils. The reactions of the soils treated with the enzyme was observed and recorded and compared to the untreated control samples. The variation in properties was observed over a short period only and it was found that in cohesive soils there was no major variation in properties during the early days but the soil showed improved performance progressively.

Isaac et al (2003) [17] studied effectiveness of Terrazyme on lateritic and clay type soil collected from Kerala. The reactions of the soils treated with enzyme were recoded for 8 weeks. The CBR value increased in all soil type in the range of 136 to 1800 percent that of the original value by addition of Terrazyme, which proved its suitability as a stabilizing agent. Terrazyme is useful for clay soil and sand but is less significant to silty soils; clayey and sandy soils had increase in CBR by 700 percent.

Swathy M Muraleedharan1, Niranjana (2015) [18] conducted laboratory tests on clay of high plasticity treated with Terrazyme. The effect of enzyme on soil in terms of Plasticity Index, Compaction, Unconfined Compressive Strength (UCC), and California Bearing Ratio (CBR) were studied. The dosage of bio-enzyme added to the soil was 0ml, 0.1ml, 0.2ml, 0.3ml and 0.4ml per kg soil on bio stabilized soil .The soil properties showed improvement in stabilizing with enzyme dosage of 0.2ml/kg. The treated soil was observed to be having lesser plasticity index values. For the optimum dosage, the MDD of the up to 6% and OMC decreases up to 19%. At the optimum dosage, there was an increase of 351%in the UCC strength and 352% in CBR value of soil.

Table 1:- Summary of literature review

Author Name and Year	Material Used	Test/Technique or Method Used	Remarks
Brazetti R, Murphy SR (2001) [1]	Ecozyme and black cotton soil	Proctor test, UCC test and CBR test.	The experimental results are shows that Bio-enzyme (Ecozyme) stabilization improves the strength of the black cotton soil up to great extent, which signifies the bearing capacity and the resistance to deformation increased in the stabilized soil.
Scholen (1992) [2]	Bioenzyme and clayey soil	Proctor test, UCS test and CBR test.	The study indicates that bioenzyme's organic molecules surrounds the clay minerals, neutralizing the negative charge and reducing the clay's affinity for moisture.
Raheem et al. (2010) [3]	Cement and lime	Compressive strength test	Earth blocks are prepared using cement and lime with varying quantities. As cement and lime content is increased compressive strength also increases. With maximum content of cement and lime of 25% compressive strength comes out to be 3.2MPa and 1.2MPa respectively.
Mithanthaya.I.R, Harsha Kumar Rai and Ravishankar A.U (2009) [4]	Terrazyme and laterite soil	CBR test, UCS test and permeability	Quantity changes in CBR values, UCC and Permeability were observed with four different dosages of Terrazyme. 200ml of Terrazyme was added to 2, 2.5,3 and 3.5m3 of soil. CBR value was increased by 400%, UCC value was increased by 450% and Permeability was reduced by 42%.
Maharana et al (2018) [5]	Terrazyme	Liquid limit test, plastic limit test, and UCS test.	The study concluded that liquid limit decreases from 48% for original untreated soil to 37% for treated soil, whileplastic limit reduces from 26%

			to 17% with decrease in plasticity index from 22% to 19%. UCS value increase from 102.32 kPa to 637.58 kPa when compared to the original soil after 28 days of curing periods.
Tarkeshwar Pramanik, S. Kishor Kumar and J.P. Singh (2016) [6]	Marble Dust and Ground Granulated Blast Furnace Slag	Proctor test and CBR test.	The study indicates that the Optimum Moisture Content (OMC) increases and Maximum Dry Density (MDD) decreases with increase in percentage of Marble dust-GGBS and With increases 20%-20% of Marble dust and GGBS percentage compressive strength of soil increases.CBR value for soaked and unsoaked condition increases with increases in percentage of Marble dust and GGBS.
Panagiotis Ch. Eskioglou (2009) [7]	Marble dust and black cotton soil.	Liquid limit test, plastic limit test and UCS test.	The study revealed that huge placticity index reductions happened with treatment with marble dust. . Results demonstrated that plasticity decreased by 15 to 30% and strength increased by 25 to 50 %. The most noteworthy strength increase was accomplished at 8% marble dust after 28 days.
Akshaya Kumar Sabat, Radhikesh P. Nanda (2011) [8]	Marble dust and rice husk ash	Compression strength test.	The study found that addition of marble dust increases the strength,decreases the swelling pressure and made the soil rice husk ash mixes strong. The ideal mixture of soil: rice husk ash: marble dust was observed to be 70:10:20.
Sachin N. Bhavsar, Hiral B. Joshi, Priyanka K. Shrof, Patel Ankit J. (2013) [9]	Marble dust and black cotton soil	Atterberg limits	Marble powder was added in varying proportion of 30-50%. It is concluded that the impact of marble powder on black cotton soil is positive. It gives maximum improvement in the swelling and linear shrinkage properties of black cotton soil.
Puneet Agarwal et al (2014) [10]	Terrazyme	Proctor test and UCS test.	The experimental study showed that there was increase in Unconfined Compressive Strength (U.C.S), up to 200% was observed after a soil sample was treated with bio-enzyme namely Terrazyme. Curing period payed an important role.
Rozhan Sirwan Abdulla, Nadhmiah Najmaddin Majeed (2014) [11]	Marble dust and CL and CH soil.	Liquid limit and plastic limit test	The marble waste powder was included in percentages of 10%, 20% and 30% by weight of soil. The results demonstrate that increase in percentage of marble dust decreases liquid limit, plasticity index and plastic limit and swelling potential.
Sandeep Panchal et al (2017) [12]	Terrazyme and soil	Consisitency limits, proctor test and CBR test	The study used different dosages of terrazyme with varying curing periods. Percentage increase as compared to local soil sample without Terrazyme is 131.49%.
Venika Saini et al (2015) [13]	Terrazyme	Proctor test and UCS test.	After performing tests economic studies were done. It was found that use of terrazyme will be economical for the project as well as eco-friendly.
Joydeep Sen et al (2015) [14]	Terrazyme and soil subgrade	Proctor test and CBR test.	The study was done to see the effect of terrazyme on soil subgrade for highways in India. It was found out that terrazyme treated soil subgrade can reduce the thickness of pavement from 25 to 40%, thus cost effective.
PriyankaShaka et al (2016) [15]	Terrazyme and red soil	Consistency limits, proctor test and CBR test.	The study indicated that with increase in terrazyme liquid limit decreases.with further increase in quantity of terrazyme no further decrease occurs in liquid limit. Also. CBR Value of the soil sample was increased by 2.75%. 3.345%. 3.47% and 3.56% by application of the bio-enzyme with a dosage of 200ml/0.75m3. With further increase in the dosage of the enzyme, no substantial increase was recorded.

Lacuoture and Gonzalez (1995) [16]	Terrazyme and soil	Consisitency limits, proctor test and CBR test.	A comprehensive study of the TerraZyme soil stabilizer product and its effectiveness on sub-base and sub-grade soils was conducted. The variation in properties of treated and untreated soil was observed over a short period only and it was found that in cohesive soils there was no major variation in properties during the early days but the soil showed improved performance progressively.
Isaac et al (2003) [17]	Terrazyme and lateritic soil and clay soil.	Proctor test and CBR test.	The reactions of the soils treated with enzyme were recoded for 8 weeks. The CBR value increased in all soil type in the range of 136 to 1800 percent that of the original value by addition of Terrazyme, which proved its suitability as a stabilizing agent. Terrazyme is useful for clay soil and sand but is less significant to silty soils; clayey and sandy soils had increase in CBR by 700 percent.
Swathy M Muraleedharan1, Niranjana (2015) [18]	Terrazyme and expansive soil.	Plasticity Index ,Compaction, Unconfined Compressive Strength (UCC), and California Bearing Ratio (CBR)	The results indicated that the treated soil was observed to be having lesser plasticity index values. For the optimum dosage, the MDD increases up to 6% and OMC decreases up to 19%. At the optimum dosage, there was an increase of 351% in the UCC strength and 352% in CBR value of soil.

3. CONCLUSIONS

After going through the exclusive literature survey regarding the use of various waste materials for enhancing the engineering properties of soil following conclusions were made:-

- Strength of weak soil can be improved by using waste materials like, marble powder, CKD, fly ash, etc.
- Bioenzymes like terrazyme can be used as reinforcement in soil stabilisation.
- Combination of marble powder and terrazyme can improve strength.
- The utilisation of the waste product in soil stabilisation is a cost-effective fixation of waste product.

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