International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

Terrazyme Stabilized Soil-Fly Ash Mix as a Road Construction Material

Deepak Kumar Das[1], Dr. M. Maharana[2]

[1]*M.Tech scholar Indira Gandhi Institute of Technology, Sarang, Dhenkanal, Odisha, India*
[2]*Professor, Dept. of civil Engineering, Indira Gandhi Institute of Technology, Sarang, Dhenkanal, Odisha, India*

Abstract - *When the soil comes under a property of expansiveness, it creates a harmful impact on the structure doing construction because of its low bearing capacity, high permeability and low strength. After a period of time, due to its high compressibility nature cracks and settlement is a biggest problem for the structure. To reduce the expansiveness and plasticity of the soil, use of waste material such as fly ash, makes a change on such types of soils. To some extent, we all need stabilized soil in less time. For this, mixture of enzyme gives a better effect on these types of soil. In the present work, effect of terrazyme on soil-fly ash mix at an optimum value of 30% fly ash, has been investigated in different dosages. Application terrazyme (bio-stabilizer) in different dosages on a mixture of soil-fly ash makes an improvement in strength. The mixing of 30% fly ash, un soaked CBR value increased by 96% than parent soil but in the process of enzyme stabilization with adding of terrazyme at an optimum dosages un soaked CBR value exhibits a rise of 121%. After 24 hour of curing, CBR value increases by 183% that shows a tremendous change in stabilization.*

Key Words: **Fly Ash, Terrazyme, Compressive Strength, Pavement.**

1. INTRODUCTION

The term 'clayey soil' comes to mind, it defines itself as having more plasticity property. In India about 70 million hector fields are covered with black cotton which covers an area of 0.90 million hectares of land in Odisha which is around 6% of the total geographical area of the State. These soils are having high clay content (more than 50 percent) and mainly montmorillonite in nature with high coefficient of expansion and contraction. These soils are found in Maharashtra, Madhya Pradesh, Gujarat, Tamilnadu, Andhra Pradesh, and Karnataka states of India. When these soils are comes contact with water, the soil starts swell and shrink, which cause threats to the foundations, structures, roadways, railways and various other life lines [1, 2]. For that engineers are facing problem on doing construction. Area covered in Odisha consists of black cotton soil having high clay contain, low bearing capacity and low strength property. To improve stability, strength and durability of these soil for construction propose, engineers are adopting various methods like inclusion of gravel, sand, mortal etc, and also use of geosynthetic materials in foundation and road pavement constructions. In this process, the problematic soil is replaced by better quality material or the soil is treated with an additive, for making those soils effective for construction purpose. However these methods are effect to our natural resource and use of synthetic product are comes as uneconomical. For overcome these situation use of waste material i.e., fly ash and environmental friendly terrazyme are used for soil stabilization [3]. Application of enzyme on soil improves the performance for construction of dams, increases cohesion and stability, reduces permeability of road and airport runways of the treated soil [4, 5, 6, 7]. It is purely soluble in water, brown color liquid and manly non toxic in nature [8].

2. LITERATURE REVIEW

Kalyanshetti et al [9] studied the effect of fly ash in 5%, 10%, 20%, 25%, 30% and 40% proportion on black cotton soil. They found that the soil plasticity and liquid limit decreases with increase in fly ash content to it. It is observed that, with the addition of 10-15% fly ash, plasticity index reduces by 30-40%.With increase percentage of fly ash, free swelling index and swelling pressure decreases. OMC decreased and MDD increased. Adding of fly ash at 25% to 30% un-soaked CBR increased by 40 % to 45% and with increase in fly ash content Shrinkage limit goes on increasing constantly.

Pratik et al [10] studied the effect of black cotton soil by mixed flay ash in 15%,20%,30% they found the unconfined compressive stress of natural soil without fly ash which was 114kN/m2, increased to 123 kN/m2 at 20% fly ash in natural soil showing 7.89 % improvement. Also found liquid limit was decreases with increases in percentage of fly ash up 30% in natural soil which was 74.4%, decreased to 72.5% and Plastic limit was decreases with increases in percentage of fly ash up 30% in natural soil which was 38.4%, decreased to 32.93%.

Sudheer Choudari et al [11] studied the effect of fly ash in different percentage (4%, 8%, 12%, 16%, 20%, 22%, 24% and 26%) on expansive soil found maximum dry density deceases and optimum moisture content increases with increase in percentage of fly ash. Strength gives a maximum value with an addition of 26% fly ash.

Zumrawi et al [12] for observing the engineering properties they used fly ash in 10%, 20%, 25% and 30% on expansive soil , they found that, with an increase in fly ash content the liquid limit decreases. Addition of 30% Fly ash to the expansive soil causes around reduction in the liquid limit up to 20%. For plastic limit, as fly ash increases from 0 to 30%,

there was a little increase in the plastic limit values. Also plasticity index reduces by 55% with the addition of 30% fly ash.

Rajoria et al [13] by using of bio enzyme on un surfaced roads they found reduction of dust up to 75%. They observed, when bio-enzymes were added to soil pavement, compressive strength and hardness of the soil increases. It provides flexibility and durability to the sub grade and reduces the formation of crack. Bio-enzymes reduce the swelling properties of the soil. Aggregate free pavement is possible in locally available soil with the use of bio-enzyme.

Ganapathy et al [14] studied the effect of bio enzyme in different dosages on a locally available soil. Found that increasing dosages of bio enzyme reduced the plasticity index and permeability of the soil, after 28-day of curing california bearing ratio value, unconfined compressive strength and shear strength increased.

Gowshik et al [15] studied the effect of enzyme on expensive soil, they added terrazyme in 200ml/3.0m^3, 200ml/2.5m^3 and 200ml/2.0m^3 dosages found that the liquid limit decreases from 60.2% to 56.53% and the plastic limit decreases from 32% to 30.09%. After 4 weeks of curing, the UCS value increases from 3.57% to 8.72%. They also found that the CBR value increases from 1.20% to 5.67 % and maximum dry density increases from 1.5 g/cm3 to 1.612 g/cm3.

Thomas et al [16] studied the effect of alkali activated GGBS and enzyme as compared to ordinary Portland cement (OPC) on the soil. They found that with increase of dosages of enzyme deceases the MDD and increase the OMC. After 28days of curing UCS and shear parameter increases.

Maharana et al (2018) [17] studied the effects of terrazyme on atterberg limits, compaction characteristics and shearing characteristics. 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.

From the above literature review a lot of researches have been carried out by using fly ash on expansive soils and also by using terrazyme on such soils. But in this paper combined effect of fly ash and terrazyme on soil, bearing strength and shearing strength behavior are studied for geotechnical purpose. Behavior is studied by doing laboratory test on the time of preparing sample and after 24 hour curing.

3. MATERIALS AND METHODS

The Soil sample used for the work is a Low expansive soil, collected from Sarang village at Dhenkanal district Odisha. Soil was placed in the oven for 24 hour; taking the soil for sieve analysis and swelling index are reported in table 1. Compressive strength and shear strength test were performed on the parent soil as per IS code. Results of the above geotechnical properties presented below table 1.

Table -1: GEOTECHNICAL PROPERTIES OF CLAYEY SOIL

Properties		Value
Sieve Analysis	Gravel (20 mm to 4.75 mm)(%)	0.87
	Sand (4.75 mm to 75 μ) (%)	32.30
	Silt (75 μ to 2 μ) (%)	39.83
	Clay (< 2 μ) (%)	27
Consistency limit	Liquid Limit (%)	47
	Plastic Limit (%)	23
	Plasticity index (%)	24
Specific gravity		2.71
Optimum Moisture Content (%)		16.12
Maximum Dry Density (kN/m^3)		17.17
Swelling Index		20
Unconfined Compressive strength (kN/m^2)		184
Shear strength	C(kPa)	30.33
	Φ(degree)	9.85
Bearing strength (CBR) un-soaked (%)		9.12

Soil Classification: **CI**-Inorganic clays of medium plasticity and Low expansive soil

Taking fly ash from NTPC, Talcher, Odisha. Fly ash was air dried for a week. Taking sample in 10%, 20%, 30%, 40% and 50% of fly ash by weight of the Soil for studied the behavior of the parent soil.

Table -2: PROPERTIES OF FLY ASH

properties	value
Liquid limits (%)	84
Plastic limits (%)	Non-Plastic
Specific gravity	2.04
Optimum Moisture Content (%)	23.9
Maximum Dry Density (kN/m^3)	12.65

Proctor's standard compaction test - To find out OMC and MDD value taking various percentage of fly ash (0%, 10%,

20%, 30%, 40% and 50%) with soil sample, Proctors compaction test was done as per IS: 2720 part 7(1980) [18].

California bearing ratio test - Test was carried out by taking soil sample with varying proportion of fly ash by mass followed by maintaining initial dry density and OMC from standard proctor test. Test was carried out as per standard procedure laid down in IS: 2720 part16 (1987) [19].

Introducing bio enzyme known as terrazyme at a optimum value of soil plus fly ash mixture. Using the terrazyme because of it reaction with the clay particle is very effective and make stabilized very quickly. Application of terrazyme leads to agglomeration of particles at the microstructure level that leads to the denser appearance of the clay particle as compared to that of the untreated soil [20]. Taking at optimum value of fly ash at 30% terrazyme was added with the mixture in different dosages. Similar experiments were conducted on the time of preparation and after 24 hour curing.

Table -3: PROPERTIES OF TERRAZYME

Specific Gravity	1.05
Boiling point	100^0C
Hazardous component	None
Appearance	Brown in colour
Odour	Non-obnoxious
Solubility in water	100%

Table -4: DOSAGES OF TERRAZYME

Dosages	200ml/m3 of soil	ml/kg of soil
1	5.0	0.021
2	4.0	0.027
3	3.0	0.036
4	2.0	0.054

Bulk density 1.83 g/cc for 30% fly ash of soil sample.

Dosage 1: 200ml for 5 m^3 soil =1.83 x 5.0 x 1000 = 9150kg.
For 1kg = 0.021ml of enzyme

Dosage 2: 200ml for 4 m^3 soil =1.83 x 4.0 x 1000 = 7320kg.
For 1kg = 0.027ml of enzyme

Dosage 3: 200ml for 3 m^3 soil =1.83 x 3.0 x 1000 = 5490kg.
For 1kg = 0.036ml of enzyme

Dosage 4: 200ml for 2 m^3 soil =1.83 x 2.0 x 1000 = 3660kg.
For 1kg = 0.054ml of enzyme

4. RESULTS AND DISCUSSION

4.1 Swelling characteristics

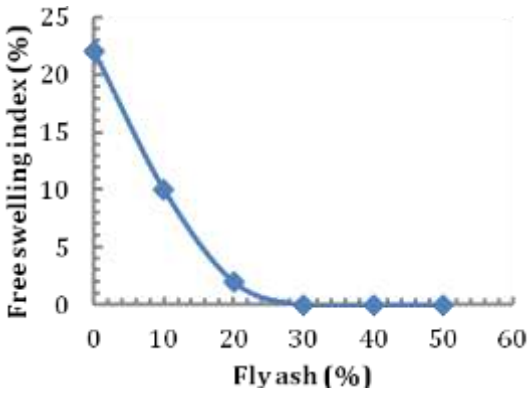

Fig -1: Effect of fly ash on the free swell index of soils

The variation of free swelling index with different percentages of fly ash is presented figure 1. From this figure it is found that free swelling index is 20% of parent soil without fly ash, after adding fly ash in 10% to 50%, the free swelling index is gradually decreases and becomes to zero. At 30% of fly ash free swelling index reduces to 100%. It's happens due to pozzolanic reaction of fly ash with clay particles of soil.

4.2 Standard proctor test

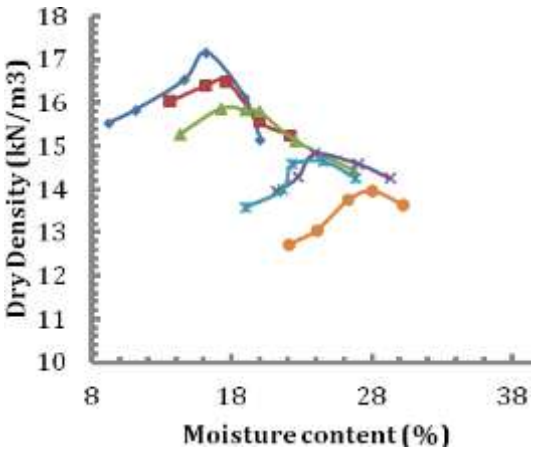

Fig -2: Compaction curves of soil and fly ash mixture

After doing compaction test on soil without and with fly ash in various percentage, found the changes in optimum moisture contain (OMC) and maximum Dry Density (MDD), that presented from the above curve. The OMC and MDD of parent soil is 16% and 17.17 kN/m^3 respectively but increasing of fly ash content OMC and MDD value gradually changed. OMC value increases whereas MDD value decreases respectively. OMC value increases from 16% to 28% and

MDD value decreases from 17.17 kPa to 13.97 kPa with increase of fly ash contain from 0 to 50%.

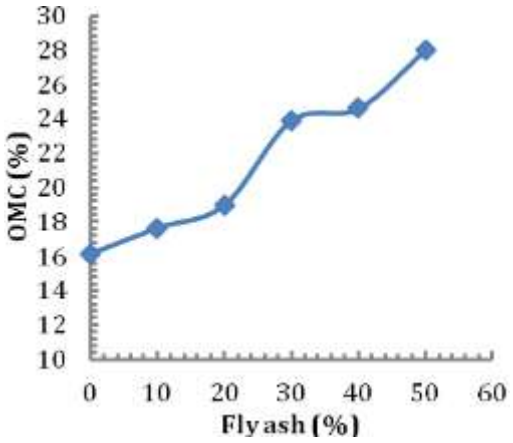

Fig -3: Effect of fly ash on the optimum moisture content of soils

In the present study, at 50% fly ash content, the OMC of soil increases by 73%, whereas, the MDD of above soils decreases by 22%. The results indicate that addition of fly ash is more effective to compaction.

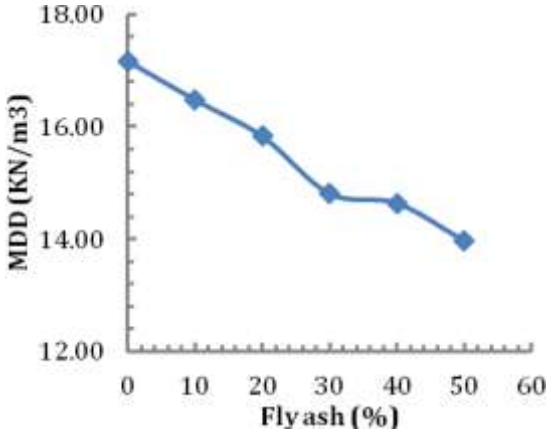

Fig -4: Effect of fly ash on the maximum dry density of soils

4.3 California bearing ratio Test (CBR)

The Un-soaked Samples are prepared and tested as per Is code procedure to fine out the CBR value, it is found that the compressive strength of samples are increased gradually. From those at 30% fly ash sample showing a maximum value. The curve from figure 5 showing how the variation is occurs. In the present study, the maximum decrease in CBR is being observed at 30% to 40% fly ash content. The CBR of soil are increased by 96% respectively at 30% fly ash content.

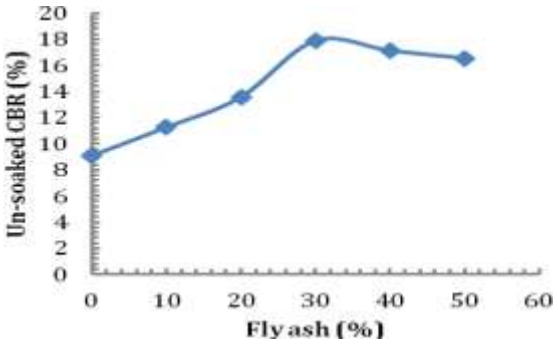

Fig -5: Effect of fly ash on the un-soaked CBR of soils

4.4 EFFECT OF TERRAZYME ON SOIL-FLY ASH MIXTURE ON CBR TEST.

Similarly to find out the effect of the soil plus fly ash at 30% fly ash contain using enzyme in a dosages of 200ml/5m3 of soil, 200ml/4m3 of soil, 200ml/3m3 of soil and 200ml/2m3 of soil, CBR test is conducted on the time of prepared sample and after 24 hour curing. Have found a change after 24 hour curing gave more bearing strength then on time test and with increased the terrazyme dosages increased the bearing strength. Found at dosage 4 of terrazyme gave a maximum bearing strength. Results are presented below in fig. 6 and table 5.

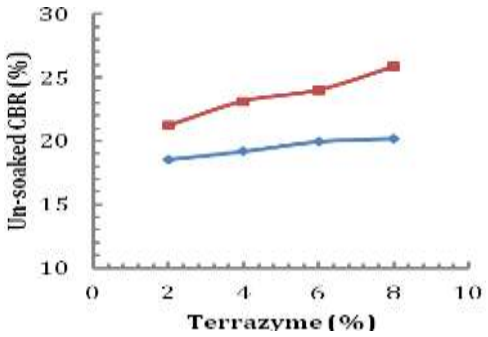

Fig -6: Effect of fly ash on the un-soaked CBR of soils

Table -4: CALIFORNIA BEARING RATIO OF SOIL-FLY ASH-TERRAZYME MIXTURE

Sample + Dosages	On time (o hour curing) (%)	24 hour curing (%)
70% Soil + 30% Fly Ash + 200ml terrazyme/5m^3 of soil	18.57	21.21
70% Soil + 30% Fly Ash + 200ml terrazyme/4m^3 of soil	19.21	23.14
70% Soil + 30% Fly Ash + 200ml terrazyme/3m^3 of soil	19.98	24.00
70% Soil + 30% Fly Ash + 200ml terrazyme/2m^3 of soil	20.21	25.84

The mixing of dosage 1 to 4 of terrazyme with soil-fly ash mixture, un soaked CBR value increased from 103% to121% at zero hour curing period but after 24-hours of curing, CBR value increases from 132% to 183% than parent soil that shows effectiveness of terrazyme on the treated soil.

As per IRC: 37-2012 for a pavement design the sub grade should have a minimum CBR of 8 percent for roads having traffic of 450 commercial vehicles per day or higher [21]. For a minimum requirement of city road traffic having 2msa the thickness of pavement are designed as per CBR percentage. For 3% of CBR the thickness will be 635 mm. Similarly for 5%, 6%, 7%, 8%, 9%, 10% and 15% CBR the thickness will be 510, 470, 445, 445, 415 and 355mm respectively. From experimental result using at 8% terrazyme, observed the CBR comes to 25.84% after 24 hour curing that 183% higher than CBR of parent soil. Keeping in view from above result, reduction of pavement thickness may be possible to some extent for designing. So that it will comes as an economically effective solution.

5. CONCLUSIONS

The experimental results of the present study lead to the following concluding remarks.

1) With varying fly ash content un-soaked California Bearing Ratio (CBR) tests of soil conducted, the CBR increased gradually with the increase in fly ash content up to 30% by weight of the total mixture and the increase was by 96%, then it decreased. Using of terrazyme on 30% soil-fly ash mixture at the time of preparation CBR increased then 24 hour curing. It was increased by 183% then parent soil at dosage 200ml of terrazyme on 5m3 of soil at the 24 hour curing period.
2) Enzyme stabilization works very effectively on clay particle, it reduces the stabilization time and it's a cost effective solution too.

REFERENCES

[1] Rajesh Prasad Shukla, Niraj Singh Parihar Stabilization of Black Cotton Soil Using Micro-fine Slag J. Inst. Eng. India Ser. A (September 2016) 97(3):299–306 DOI 10.1007/s40030-016-0171.

[2] R.P. Shukla, N. Parihar, R.P. Tiwari, B.K. Agrawal, Black cotton soil modification using sea salt. Electron. J. Geotech. Eng. 19, 8807–8816 (2014).

[3] G. P. Ganapathy, R. Gobinath, I. I. Akinwumi, S.Kovendiran Bio-Enzymatic Stabilization of a Soil having Poor Engineering Properties, Int J Civ Eng (2017) 15:401–409 DOI 10.1007/s40999-016-0056-8.

[4] Brazetti R (1998) Considerations about the influence of different additives in organic micromorphological, mineralogical, physical, mechanical and hydraulics characteristics of a lateritic soil. Escola Politecnica de Sao Paulo, Sao Paulo.

[5] Brazetti R, Murphy SR (2001) Objective performance measurement of actual road sites treated with an organic soil stabilizer. In: First road transportation technology transfer conference in Africa, Dar Es Salaam, Tanzania.

[6] Guthrie WS, Simmons DO, Eggett DL (2015) Enzyme stabilization of low-volume gravel roads. Transp Res Rec J Transp Res Board 2511:112–120.

[7] Isaac KP, Biju PB, Veeraragavan A **(2003)** Soil stabilization using bio-enzyme for rural roads. In: Integrated development of rural an arterial road networks for socio-economic development, Delhi.

[8] Sravan Muguda and H. B. Nagaraj, Effect of enzymes on plasticity and strength characteristics of an earthen construction material, Muguda and Nagaraj *Geo-Engineering (2019) 10:2* https://doi.org/10.1186/s40703-019-0098-2

[9] Mahesh G. Kalyanshetti, Satish Basavaraj Thalange, "Effect Of Fly Ash On The Properties Of Expansive Soil" International Journal of Scientific & Engineering Research Volume 4, Issue 5, May-2013 ISSN 2229-551.

[10] Pratik Somaiya, Yashwant Zala, Rushikesh Dangar, "Stabilization Of Expansive Soil Using Fly Ash".

[11] Sudheer Choudari and Y. Bhargava Gopi Krishna "Effect Of Flyash On Compaction Characteristics Of Expansive Soils, Nearanandapura, Visakhapatnam, Andhra Pradesh, India" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181 Vol. 4 Issue 03, March-2015.

[12] Magdi M. E. Zumrawi, Mohammed H. Mohammed "Effect of Fly Ash on the Characteristics of Expansive Soils in Sudan".

[13] Vijay Rajoria, Suneet Kaur, "A Review on Stabilization of Soil Using Bio-Enzyme" International Journal of Research in Engineering and Technology eISSN: 2319-1163 | pISSN: 2321-7308.

[14] G. P. Ganapathy, R. Gobinath, I. I. Akinwumi, S.Kovendiran Bio-Enzymatic Stabilization of a Soil having Poor Engineering Properties, Int J Civ Eng (2017) 15:401–409 DOI 10.1007/s40999-016-0056-8.

[15] Gowshik, A. V. Karthick Rajeshwar, M. Mohanasundram, "Experimental Study Of Expansive Soil Stabilized With Terrazyme" International Journal of Engineering Research & Technology (IJERT).

[16] Ansu Thomas, R. K. Tripathi, L. K. Yadu, A Laboratory Investigation of Soil Stabilization Using Enzyme and Alkali-Activated Ground Granulated Blast-Furnace Slag, Arabian Journal for Science and Engineering (2018) 43:5193–5202 https://doi.org/10.1007/s13369-017-3033-x.

[17] Manisha Pardhi, M. Maharana, "Soil Stabilization By Using Terrazyme" IGIT Sarang, M.Tech Thesis , 2018.
[18] IS: 2720, Part 7(1980), Determination of Water content- Dry density relation using light Compaction.(2011).
[19] IS: 2720, Part 16(1987), Laboratory Determination of CBR.(2002).
[20] Sravan Muguda and H. B. Nagaraj, Effect of enzymes on plasticity and strength characteristics of an earthen construction material, Muguda and Nagaraj *Geo-Engineering (2019) 10:2* https://doi.org/10.1186/s40703-019-0098-2.
[21] Tentative Guidelines For The Design Of Flexible Pavements IRC:37-2012 Edition in December 2012 Reprinted : June, 2013.