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Assessment and Utilization of Expansive Soils as Highway Embankment Materials in Humid Environment

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Abstract- Waste disposal is a major issue in areas where rapid development and urbanization are occurring on a small piece of land. Due to a lack of available land, landfill waste disposal is a major environmental problem in many parts of the world.hazardous. Garbage-to-resource conversion is an appealing substitute for traditional garbage disposal. Conservation of waste into construction material has been shown to be a viable option for the management of large quantities of garbage, providing a double benefit in terms of both a solution to waste disposal and a useful byproduct.Nearly 20% of India's total land area is comprised of expansive soils, commonly referred to as Black cotton soils (Mohanty et al., 2018; Seehra 2008; Chen 1988). The physical and chemical properties of these deposits cause them to fluctuate in volume with the changing of the seasons (Bhuvaneswari et al., 2018; Sadam 2017; Snethen et al., 1975; Chen, 1988). Inflating ground causes more annual damage in terms of dollars than any other type of natural disaster (Mir, 2015; Petry, and Armstrong, 1989; Jones, and Holtz, 1973).Poor performance and high maintenance costs are typical for pavements built on these soils (Narendra et al., 2018; Magdi 2018; Chittoori et al., 2018; James et al., 2017; Manchikanti and Raju 2011; Steinberg 1992). Use of waste materials and ashes collected from diverse sources has been brought to light as a way to improve soil physical qualities at a low cost and sidestep waste management issues.The presence of the expanding lattice mineral montmorillonite in expansive soils has been documented (Khan et al., 2019; Mahmoud et al., 2018).Seehra (2008) notes that these soils have a high clay content, which is reflected in their strong swell-shrink nature, high liquid limit, and low CBR values. Prior to construction, these soils needed to be amended with a variety of waste products, including After laying several sections of untreated and treated alternatives, lab experiments were followed by field test track research.

Keywords- waste soil,shrinkage of soil, diagonal cracks, longitudinal cracks.

I. INTRODUCTION

When built over expansive soils, flexible pavements always Geotechnical engineers and other organizations have had a difficult time determining whether or not structures will show signs of distress during their service periods (Selvakumar and Soundara 2019; Chittoori et al., 2018; Manoj and Sharad 2018; Badaradinni et al., 2016; Murat et al., 2014; Saut and Seracettin 2010).

Failure of pavements system built on expanding sub grade has been documented in several sources (Mahmoud et al., 2018; Soltani 2018; Petry and Little 2002) and is attributed to a combination of poor pavement performance and high maintenance costs.

Soils high in clay minerals tend to swell when wet and contract when dry due to their unusual chemical composition (Bhuvaneswari et al., 2018; Biswajit and Nirmali 2015; Muthukumar and Phanikumar 2014; Ramana Murthy and Hari Krishna 2006; Kumar 2000). Failure of pavements manifests as settlement, cracking, undulations, unevenness, etc. due to volume changes caused by the presence of montmorillonite mineral, which imparts high swell- shrink potential to the soil during wet and dry seasons respectively (Magdi and Emam 2018; Qin et al., 2018). These soils, which span an expansive region in India totaling about two lakh square miles (Khan et al., 2019; 2 Mohanty et al., 2018; Narendra et al., 2018; James et al., 2017; Seehra 2008; Chen 1988), actively provide a significant challenge to the scientific community.

Many studies (Nigade and Viswanadham 2019; Biswajit and Nirmali 2015; Abiodun and Nalbantoglu 2015; Asgari et al., 2015; Estabragh et al., 2014; Mir and Sridharan 2013) are now investigating the efficacy of using flyash and chemicals as stabilizing agents in order to create effective treatment procedures. Environmental damage and disposal issues have resulted from India's yearly production of about 100 MMT of flyash (Nigade and Viswanadham 2019; Choudhary et al., 2009).

Highway pavements can be prepared more efficiently when flyash is used in large quantities (Ali Jamshidi et al., 2017), and flyash may be utilized successfully in combination withadditives (Murmu et al., 2018).

1. International Best Practice for Chemically Stabalizing Large amount soil:

Nearly twenty percent of the Earth's surface is covered by black cotton soils, which expand and contract with the seasons, damaging light-weight structures like flexible pavements, pipe lines, slopes, and canal linings (Bhuvaneswari et al., 2018; Mohanty et al., 2018; Sadam 2017; Hanifi et al., 2015; Seehra 2008; Kumar 2000; Snethern 1979).

At times, the cost of these damages will rival that of losses caused by natural disasters (Mir, 2015; Petry, 1989; Jones, 1973). Three types of waste materials and chemicals gathered from a variety of sources have been tried by researchers, field engineers, and highway groups to treat these soils (Sridevi et al., 2015). These additives, when blended with the soil, increase the stability and longevity of flexible pavements while decreasing their overall cost. Stabilization applications make use of flyash because of its self-cementing properties (Nalbantoglu, 2004, Ferguson, 1993). When soil and flyash are combined, the geotechnical parameters of the resulting mixture always change (Choudary et al., 2009). Expansive soil's California bearing ratio and resilience modulus values are significantly improved when flyash is added (Brooks 2019; Edil et al., 2006).

2. Goals of This Research:

The following are some of the goals of this investigation

- One goal of this literature research was to find effective strategies for dealing with the issues caused by expanding sub-grade soils so that an appropriate approach could be taken.
- Second, we need to test models in the lab to see how various therapies stack up against one another.
- Third, build a field test track with varying stretches of subgrade to compare how well the various sections function.

II. LITERATURE REVIEW

Extensive literature was reviewed for this study to lay the groundwork forlearning about expansive soils, their swelling process, the difficulties they create, and the numerous solutions that have been developed to mitigate their negative impacts. Prior studies were mostly reviewed in terms of their effects on stabilization with flyash and chemicals.

Thinner pavement can be designed, the life span can be increased, maintenance costs can be decreased, etc., when expansive sub-grade soil is stabilized (Bin-shafique et al., 2004). In this chapter, we'll look at the issues with installing flexible pavements over expanding soil deposits and the solutions that have been proposed by various scholars to deal with these issues.

2. The Expansive Soil Swelling Mechanism:

Geological processes result in the formation of clay minerals, which lead to the expansion and contraction of expansive soil. Minerals are inorganic chemical elements or compounds found in nature. Clay minerals are hydrated layered crystalline structures of aluminum, iron, or magnesium silicates (Grim 1959). It is the physical and chemical features of the minerals in clay soil that determine its swelling potential (Lidong Bai et al., 2009). According to many sources (Mahmoud et al., 2018; Tiza, 2016; Peck, et al., 1974), the clay soil's mineralogical composition is the most crucial grain attribute. Kaolinite, Illite, and Montmorillonite (and sometimes even more) are the minerals that make up clay soils.

These soils expand because they contain either montmorillonite or a mixture of montmorillonite and illite with an expanding lattice (Holtz and Gibbs 1956).Taylor (1959), in his explanation of the diffuse double layer hypothesis, noted that the clay particles were negatively charged because of isomorphous substitution. As a result of this negative charge, an electrostatic force exists between the negatively charged surface and the diffuse layer of positively charged cations that may be exchanged.

3. Recognition and features of Districtive Soil:

Direct expansion potential testing, as well as indirect index property evaluation and mineralogical analysis, are used to identify expansive soils (Chen 1988). Methods for qualitative and quantitative analysis, including as vibrational spectroscopy, thermal analysis, atomic absorption spectrometry, and X-ray diffraction, were developed by Whittig and Allardice (1986). In addition to the aforementioned techniques identified by various writers, Fell et al., (2005) utilized Casagrande's plasticity chart to determine expansive soil.

Similarities in diffraction data outputs might make identification challenging. Soil's capacity to store cations, measured by its Cation Exchange Capacity (CEC), is a useful indicator of its expansive potential.

In order to identify expansive soils, Holtz and Gibbs (1956) created a chart that showed how consistency limitations may be used to calculate the swelling potential of clay soils. Soils with a free swell of more than 100% are also easily identifiable by other characteristics, such as their excessive hardness and the presence of fissures in the dry state.Time for the development of maximum pressure, shape of sample, volume change effect, relation between soil structure and swell pressure, effect of stress history, and relation between swell and swell pressure were all taken into account by Seed et al., (1962) when interpreting the swelling property of expansive soil. When it comes to the actual design and upkeep of roadway subgrades, Snethen (1979) established criteria for identifying and characterizing the behavior of expansive soils, as well as suggestions for both pre- and post-construction treatments

Holland and Richards (1982) presented the issues and remedial techniques for the Australian environment, and 17 made clear about techniques like stabilization utilizing lime, prewetting of soil, and utilization of membranes to control the moisture mitigation, only to conclude and to construct road pavements on subgrades which were initially in wet condition.

Longitudinal fractures and rutting of pavement surface are issues for the flexible pavements that have been built on these soils (Shafiqu and Abass 2018; Berg 1979; Doty and Murthy 1976; Williams 1965). Soil expansion and contraction causes problems for both lined and unlined canals (Katti and Katti 1994; Kassiff et al., 1967; Rahimi and Barootkoob 2002). When the bending generated by the vertical and horizontal movement of the embankment owing to swelling was analyzed (Rahimi and Barootkoob 2002; Kassiff et al., 1967), it was shown to be the same failure mechanism seen in canal linings constructed on expansive soil.

Many scholars from other nations have also described the damage caused by expanding soils in the construction of structures (Sadam 2017; Mir 2015; Chen 1988). Both the vertical and lateral moments (Chen 1988; Kassiff and Zeitlen 1961) caused water supply and drainage pipes to collapse. 20 large lateral swell pressures have been documented to cause distortions to foundation walls (Katti and Katti 1994; Chen 1988).

Railway tracks suffer a greater loss (Zhen Feng et al., 2014; Kassiff et al., 1967). In the United States, damage to streets, roads, and highways costs more than $1.1 billion per year (Snethen 1979). Pavement cracks in various areas are seen on Plates 2.1, 2.2, and 2.3.

Fig 1. Plate 2.1 Cracks due to Skrinkage of Soil.

Fig 2. Plate 2.2 Diagonal Cracks due to differential Heave.

Fig 3. Plate 2.Z Longitudinal cracks in Bitumen Road.

Extensive soil swelling is a leading cause of structural damage to buildings. difficulty (Khan et al., 2019) for geotechnical engineers. split andIranian province of Khoozestan; Rahimi and Barootkoob's assessment(2002). Failure can mostly be attributed to soil flocculent. canal embankment construction, low moisture content during lining. Subgrade moisture is a major operational issue of pavement that has been loaded and unloaded repeatedly by vehicles (Bhuvaneshwari et the work of Chittoori et al. Soils with a tendency to expand because infiltration of water causes a rise in pressure (Selvakumar and It is now the year of the Soundara (2019).

Irrigation and sewage systems are examples of relatively lightweight infrastructure. Structures, such as roads and buildings, that are built on expansive soil will exhibit wear and tear symptoms when in use (Shafiqu and Abass 2018). The search for alternative approaches to fix issues caused by soil expansion. A proper amount of promising outcomes include reductions in surcharge load and chemical stability solutions.

III. AUTHORIZED METHODS OF OVERCOMING

1. Expanding Soil Problems:

In order to combat the issues caused by soil expansion, several solutions are being implemented in countries all around the world right now (Anand et al., 2019;Referring to the literature (Dalvi et al., 2018; Petry and Little, 2002; Anand et al., 2006). These a troublesome subgrade can be improved with the help of these suggestions. High-strength, non-problematic (Asgari et al., 2015; Mir, 2015). Snethen et al., 1975; Murat et al., 2014; Holland and Richards, 1982; decreased swelling and subsequent shrinking (Anand et al., 2019; Rani et al., 2019).

He et al. (2019); Sivapullaiah (2010; 2010); Hari Prasad Reddy (2010; Rao) several authors (e.g., et al., 2008; Phani Kumar and Sharma, 2007; Sridharan and Gurtug, 2005) Easy compaction (Du YJ. 2004), excellent drainage (Pankaj et al. etc., using physical means (e.g., et al., 2016; Abiodun and Nalbantoglu, 2015) chemical and mechanical methods of stabilization (Little, Nair, 2009). Basma et al., 1996; Harichane et al., 2011).

Various Causes and techniques of treatment that affect volume-shifting features were documented (Snethen et al., 1975; Julina and Thyagaraj 2019). The method for handling the volume shifts caused by expanding soil was discussed. via several methods by Khan et al., 2019 and Chitragar et al., 2019 methods that include and do not need the use of additives. non-additive processes that can be used to improve the material's performance but do heating; (Arasan et al., 2017; Voottipruex, 2014; Nurhayat et al., 2007) metabolites (Abhay et al. 2019; Singh and Mittal 2019; Reshmi and Dang and Khabbaz 2018; Dalvi; Anirban 2019; Tyagi and Soni 2019; Robert 2003; Tuncer; et al., 2018; Muthukumaran; Joseph; et al., 2014; Many researches (e.g., et al., 2002) etc. reported similar findings.

2. Soil Replacement Approach:

The goal of this method is to either completely eradicate expansive soil or with dirt that doesn't expand and contract. The necessary conditions for this technique are material, thickness, and coverage (Chen1988).Mohawk and Wellton's linings will be reconstructed before. Nelson (1992) proposed that soil be replaced approach that may be used when soil expansion reached.

3. Pre-Wetting Approach:

In this technique, the expanding subgrade is given room to expand by pre-wetting, followed by steady water content. That's how: as a result, there is no heaving since the soil volume has not changed.and there was no physical injury (Datye 1977; Williams 1965; Mc Dowell). 1959). Pre-wetting relies on a number of variables, including. The issues that arose were detailed by Holland and Richards (1982). Resulting from paving over a porous subgrade and reviewed key methods for getting around them, only to conclude it was helpful to have pavements over damp subgrades properties that cause edema.

3. Surcharge Loading Mode:

In this way, a large amount of non-growing covering the large soil deposit with material for efficient strain greater than or equivalent to its bursting pressure. The ferocity of because stress reduces with depth, water accumulation below a particular threshold (Chen 1988). Saad conducted the tests in the laboratory to determine how surcharge impacts cyclical behavior of Expanding soil simply ends up less pliable and flexible deformations.

4. Procedure for Managing Moisture:

The purpose of this method is to control ambient humidity.dirt after preventing further movements caused by the soil's expansion subgrades. The process of setting up was described by Chen (1988). With polyethylene membranes installed vertically as moisture barriers, barriers utilizing concrete or any other sturdy impermeable materials.The use of Steinberg's (1992) vertical fabric moistureobstacles to regulate volume by limiting the effects of moisture fluctuations. Texas Department of Transportation installed these markers along a trail segment. Division of Transportation these moisture barriers, once installed, significantly reduced the potentially disastrous changes, and lowered maintenance expenditures yearly. To wit: Evans and Mc. Manus (1999) designed low-cost and efficient moisture barriers to dampen the ground-borne noise and vibrations.

IV. HEAT TREATMENT METHOD

This method involves the forced expulsion of hot air.via holes drilled into the spongy ground. According to Charles et al.the impact of temperature on the mechanical characteristics of an expanding two hours at a temperature of 6000 °C, clay, and saw an improvement in its properties. The article describes the effect of heat on swelling characteristics. Heat treatment is applied practically in Wang et al. (2008).was talked about. Reduced behavior of clay soil volume change is possible by preheating to 2,000 degrees Celsius.

1. Technique of Reinforcement:

Materials with tensile strength, such as natural fibers and Subsoil reinforcement is achieved by inserting permeable textiles soil rigidity. This strategy, created by Henry Vidal in 1969, characteristics of a subgrade composed of expansive soil. This method is extremely cost-effective, and it excels in both static and dynamic conditions.situations of fluctuating stress. This method is based on the following principle: that the resistance to motion between earth's grains and other reinforcing materials will be treated as a single mass for the sake of calculations. A new method was developed for performing the swelling test.Utilizing a larger oedometer on clay samples reinforced with geogrids of varied stiffness, the researchers found that swelling decrease based on geo-grid reinforcement stiffness. In order to examine how roads react to car traffic, AIQadi and his crew paved a minor road that stretched for 150 meters. Bhutta, R. The pavement here was broken up into parts and geosynthetic foundation reinforcement and increased base thickness courses.

Strain gauges are installed in these areas so that we can: moisture detectors thermocouples, piezoelectric pressure sensors, and sensors connected to a data retrieval system that inferred ections. Pressure cells were installed in these regions moisture detectors, thermocouples, piezoelectric strain gauges, and other sensors sensors that were hooked up to some sort of data-gathering apparatus and the importance of geosynthetic stabilization has been demonstrated. Geomembranes were used in experiments by Steinberg (2000) to Geomembranes are a proven solution to the problems caused by expanding soils surface that requires less upkeep and provides a better riding experience duration of service. The research of Puppala and Musenda (2000) examined the consisting of individual, non-oriented polypropylene strands fiber cured over varying lengths of time at varying percentages.

Results shown that a 7.5% concentration was the sweet spot.Reinforcement using wheat-straw fiber and lime's coupling effect Yixian et al. (2019) looked at the process of stabilization of Hefei clayey soils. by use of SEM and triaxial testing in a UU condition analysis. Different amounts of lime (2%) were used, as well as (4%) and (6%), Thinly sliced 13mm lengths of wheat straw were combined with 0.2%, 0.4%, and and 0.6% by dry weight of soil, leading to the inference that water provision Wheat straw fiber channels aided in enhancing the lime process of stability.

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1.1 Piling Approach:
Piling is a long, skinny shaft that's outfitted with Subsoil materials can be varied to lessen heave caused by expansive soil. These will soak up the expanding pressures that regulate the vertical shifts in light-weight structures built on wide grounds. The planning and variety of methods used in building The practice of using under-reamed piles to prevent the expansion and contraction of DE, P. D. (1978) updated the literature on foundation soils.Geo pile and group pile tests revealed the following.observed that less spaces between them resulted in less shaking.impact if distance between piles is greater than four times their diameter.

In 2007, Rao et al. performed pull out load experiments on a field size on GPAs where L/D ratios might range from 0 to 1.resistance when evaluated as a group than it did individually.from a value of 2.5 to a value of 10. L/D for GPA is 5 (GPA is 200 mm in diameter, length 1000 mm), had the best reaction to being pulled out. Greater encouragement GPA provided more resistance when evaluated as a group than it did individually.

In 2011, Mohammad and Shaik analyzed the efficacy of Micropiles are used to support lightweight buildings Widespread dirt accumulations. The miniature replica was built in a laboratory setting tank with 50cm square dimensions. Widespread dirt was pressed down till it was just 20 cm high. Model heaps were delineated with a ring both sand and no sand. When water was poured over model piles, the heave of the model pile was reduced by 94% when it was enclosed by sand.

Muthukumar performed heave experiments in the lab in Unreinforced and Granular Piles by Phanikumar (2014) bolstered beds of loose, wide dirt. The beds were checked for heave at depths and radii, we determined that earthquakes tend to occur at decreased with depth, and heave diminished more if there was back-up available.The family of isobars will remain within the pavement system under cyclic loading since the dimensions of the field test track segments were designed in such a way. The thickness of the subgrade and subbase courses, respectively, was placed at 0.5 m and 0.2 m. Two 0.075 m thick layers of WBM III base course were installed. Plate 4.1 depicts a three-dimensional model of the test track.

V. FIELD INVESTIGATION

Through controlled laboratory experiments, researchers have examined how flyash and other chemical components affect the expanded soil's geotechnical qualities.

Laboratory results were double-checked using field test track research. On the JNTUK campus, not far from the Geotechnical Engineering Laboratory, is a field test track. Subgrade, subbase, and base course construction procedures, as well as cyclic plate load testing, were detailed in this chapter.

1. Field Test Track Setup:
The process of building a field test track entails a number of distinct phases, including site preparation, trench digging, subgrade and treated section paving, and subbase and base course paving. Table 4.1 details the treated and untreated subgrades that were made available along these sections. Each length is 2 meters by 1.5 meters. The field test track is 8 meters in length and 1.5 meters in width, with four separate sections. Field test track lengths were evaluated based on their relative performance by monitoring heave and their reactions to cyclic stress in both dry and wet conditions.

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2. Excavation of Testing Field:
The area was cleared, and then a trench of 8 by 1.5 by 0.85 meters was dug. As it is needed to offer varying subgrades along the length of the track, the complete length was divided into four sections each of 2 m long and 1.5 m broad, separated by a four inch sand wall. Plate 4.2 displays the open excavation created during constructing the field test track.

3. Subgrading Process:
Testing on the Field As will be shown in the next sections; the track was built over both untreated and variously treated portions of subgrade. Subgrade on top of the existing natural bed (4.2.1). The first section benefited from a subgrade made of naturally expanding soil. The subgrade was laid using compacted air-dried expansive soil that had passed a 4.75 mm screen. At OMC, they soaked the soil with water and gave it a good stir. Layers of prepared moist expanding soil with a compacted thickness of 5 cm were placed down. The moisture and dry density of each layer were both optimized by compacting. Ten layers of compacted subgrade, each measuring 5 cm in depth, were used to achieve the final 50 cm depth. Expansion caused by water was reduced with the use of a hand roller and earth rammer. expansion caused by water was reduced with the use of a hand roller and earth rammer. Subgrade density and moisture content were measured after being compacted. 4.2.2.2 Subgrade with a chemical treatment placed above the existing natural bed In the remaining three sections, treated subgrade was used. Flyash and chemicals like NH4Cl, MgCl2, and AlCl3 were used to amend a large area of soil. Extensive soil was amended with the optimal quantity of flyash and chemical components as determined by laboratory experiments. The selected chloride compounds were introduced to the dry soil and flyash as chemical solutions since they are all readily soluble in water. Plate 4.3 displays the chemical solution preparation process.

Table 4.1 Field Test Track with different Subgrade condition

Sl. No.	Test Stretch	Subgrade	Subbase	Base Course
1	Untreated	Expansive soil	Murrum	WBM III
2	Treated	Expansive soil + 10% FA + 1% NH_4Cl	Murrum	WBM III
3	Treated	Expansive soil + 10% FA + 1% $MgCl_2$	Murrum	WBM III
4	Treated	Expansive soil + 10% FA + 1% $AlCl_3$	Murrum	WBM III

The vast air-dried soil and flyash contents were extensively combined. On Plate 4.4, you can see the blended flyash and dry soil. The mixture was then wetted down with the chemical solution. After compacting the material, it was layered into trenches at a thickness of 5 centimeters. Ten layers were put for a total compacted thickness of 50 centimeters. Plate 4.5 4.2.3 shows the process in which hand rammers and hand rollers were used to compress all the layers to a dry density of 0.9 and a moisture content of 0.7.

Plate 4.3 displays the chemical solution preparation process. The vast air-dried soil and flyash contents were extensively combined. On Plate 4.4, you can see the blended flyash and dry soil. The mixture was then wetted down with the chemical solution. After compacting the material, it was layered into trenches at a thickness of 5 centimeters. Ten layers were put for a total compacted thickness of 50 centimeters. Plate 4.5 4.2.3 shows the process in which hand rammers and hand rollers were used to compress all the layers to a dry density of 0.9 and a moisture content of 0.7.

4. Sub-base Laying Onto Compacted Subgrade:
This job include laying and compacting well-graded murrum on the untreated and treated expansive soil subgrade sections that have been prepared. The dry mixture was compressed to its maximum dry density, and then water was added to make the wet mix. It was compressed and layered to a total thickness of 20 centimeters. An earth rammer and roller, both operated by hand, were used to compress the soil after each layer was added. When replenishing the water supply, we accounted for potential evaporation losses. Plates 4.6 and 4.7 show

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that the compacting process was maintained until the target dry density was metLayers of stone metal were carefully laid out. A hand roller with smooth wheels and a vibratory compactor were used to pack down each layer.

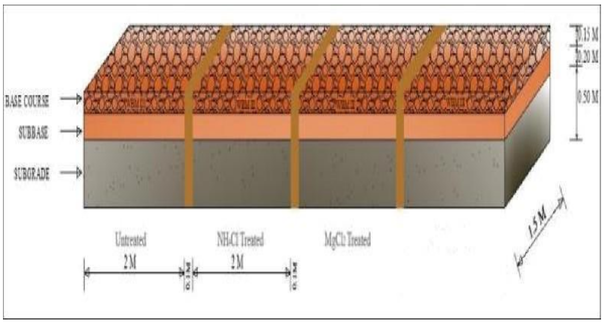

Fig 4. Plate 4.1 Field Test Track over expansive soil Subgrade.

Fig 5. Plate 4.2 Open cut for field test track.

Fig 6. Plate 4.3 Preparation of chemical solution in the field.

Longitudinally, rolling began on the outside edges and worked its way in. Binding material (murrum) was applied on the compacted coarse aggregate layer after rolling it to a thickness of 91. Vibrations were used to cause binding material to settle into the pores of course aggregate, and this was facilitated by dry rolling. After the coarse aggregate was swept, rolled, and sprinkled with water until it was set and keyed, the process was complete. Plate 4.9 displays the finalized field test track.

Fig 7. Plate 4.5 Flyash mixing with expansive soil.

Fig 8. Plate 4.6 Subbase compaction with earth rammer.

Fig 9. Plate 4.7 Subbase compaction with hand roller.

Layers of stone metal were carefully laid out. A hand roller with smooth wheels and a vibratory compactor were used to pack down each layer. Longitudinally, rolling began on the outside edges and worked its way in. Binding material (murrum) was applied on the compacted coarse aggregate layer after rolling it to a thickness of 91. Vibrations were used to cause binding material to settle into the pores of course aggregate, and this was facilitated by dry rolling.

After the coarse aggregate was swept, rolled, and sprinkled with water until it was set and keyed, the process was complete. The finalized field test track may be seen in Plate INVESTIGATIONS ON-SITE Different subgrade treatments' relative performance was evaluated by in- situ testing. Both dry and rainy seasons were tracked on the built field test track. Field test tracks had their lowered levels measured as they expanded and contracted owing to subgrade swelling and shrinking. Similar estimates were made for the response of tract stretches in field tests caused by cyclic plate loading inboth wet and dry seasons.

Plate 4.8 Process of laying the Base Course

Plate 4.9 Completed Field Test Track

Fig 10.

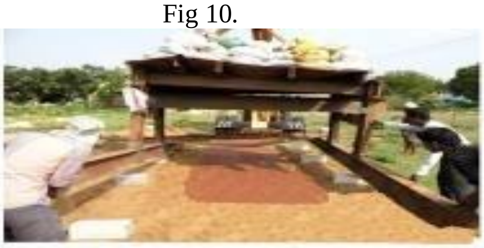

Plate 4.10 Installation of loading platform on Field Test Track

Plate 4.11 Loading Platform with sand bags

5. Tests for Cyclic Plate Loading:

All of the stretches underwent cyclic plate load testing throughout both the dry and rainy seasons, as required by IS requirements. Test Configuration Display (4.3.2.1) A reaction loading platform with sand bags to increase the reaction capacity, a loading column to transfer the load, a hydraulic jack to apply the load to the test plate, dial gauges to measure the deformation, etc. are all shown in Fig.4.1 of the schematic diagram of the cyclic plate load test setup As may be seen in Plate 4.10, the testing site's reaction loading platform frame was positioned dead center above the test track. Plate 4.11 depicts the usage of sandbags to increase the loading frame's response capability. The response girder test plate was centered and leveled below 94. For optimal leveling, a 5-millimeter-thick layer of fine sand was placed beneath the test plate. The test plate was centered using a plumb bob, and then leveled using a sprit level, to prevent eccentric loading. In accordance with the requirements, a 5 kPa load was given to the seats initially.

4.3.2.2 Procedures for Testing After everything was set up, first readings were taken from the dial gauges. The dial gauges attached to the test plate were used to measure the amount of settling after the initial load was applied.

The resulting deflection when the load was removed was measured. Once rebound stops happening or slows down significantly, the dial gauges are checked again. The same force is used in successive cycles until the interval between the settlements becomes minimal.Dial gauge readings were recorded at the end of the process to see if they were consistent with the intended next loading step. IRC Standards recommend using tyre pressures of 500, 560, 630, 700, and 1000 k Pa, thus we conducted cyclic plate load testing at these levels. During cyclic loading, the plate's total and elastic deformations were measured.

Plate 4.12 Observations during Cyclic Plate Load Test

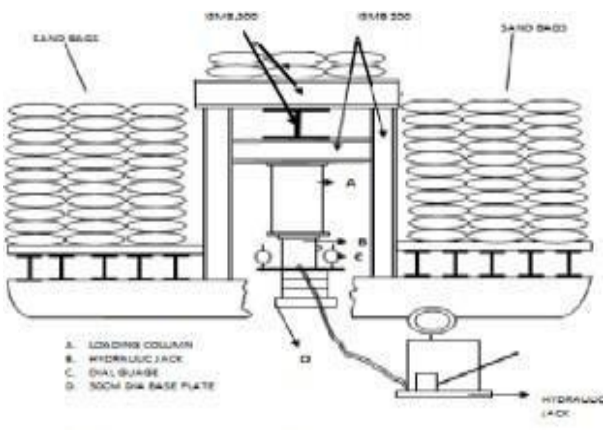

Fig. 4.1 Arrangement of Cyclic Plate Load Test

VI. RESULTS

Table 5.26 Summary of results of Cyclic Plate Load Test during Wet season

Pressure	Untreated		Flyash + NH_4Cl treated subgrade		Flyash + $MgCl_2$ treated subgrade		Flyash + $AlCl_3$ treated subgrade	
(kPa)	TD (mm)	ED (mm)	TD (mm)	ED (mm)	TD (mm)	ED (mm)	TD (mm)	ED (mm)
0	0	0	0	0	0	0	0	0
500	7.25	1.47	4.26	0.95	3.72	0.91	2.26	0.68
560	8.51	1.61	4.98	1.04	4.12	0.95	2.99	0.88
630	10.11	1.81	5.87	1.12	5.07	1.05	3.71	0.95
700	12.56	2.06	7.47	1.35	5.74	1.11	5.09	1.05
1000	21.25	2.31	12.95	2.1	9.61	1.71	7.92	1.57
1200			15.22	2.32	11.41	1.92	9.76	1.66

Table 5.25 Summary of results of Cyclic Plate Load Test during Dry season

Pressure (kPa)	Untreated		Flyash + NH_4Cl treated subgrade		Flyash + $MgCl_2$ treated subgrade		Flyash + $AlCl_3$ treated subgrade	
	TD (mm)	ED (mm)	TD (mm)	ED (mm)	TD (mm)	ED (mm)	TD (mm)	ED (mm)
0	0	0	0	0	0	0	0	0
500	4.27	1.05	3.1	0.81	2.5	0.66	1.57	0.54
560	5.72	1.34	3.96	0.94	3.25	0.79	2.06	0.68
630	7.53	1.62	4.76	1.01	3.97	0.91	2.81	0.87
700	9.12	1.77	5.90	1.21	4.91	1.05	3.67	0.94
1000	15.31	2.26	8.82	1.74	6.65	1.36	5.01	1.25
1200			9.94	1.88	7.22	1.38	6.25	1.36

VII. CONCLUSION

Lab tests have provided a clear image of the various additives utilized and the optimal contents for stabilization of expansive soil. These sections of the test track underwent cyclic load testing in both dry and wet conditions, as well as heave measurement monitoring.These findings are based on analyses of test tracks used in the field.One noticeable difference between treated and untreated portions is the decreased amount of heave in the former. For flyash plus NH4Cl treated lengths, the maximum heave is decreased by 50%, for flyash plus MgCl2 treated spans, by 70%, and for flyash plus AlCl3 treated stretches, by 80%.To compare the cyclic loading responses of untreated and treated lengths of field test track, cyclic plate load experiments were carried out during both dry and rainy seasons.

Under cyclic pressure, treated stretches show much less total and elastic deformations than untreated stretches.During the dry season, overall deformation was reduced by 42% for flyash+NH4Cl treated lengths, 57% for flyash+MgCl2 treated stretches, and 67% for flyash+AlCl3 treated stretches when tested at a specific pressure of 1000 kPa. Similarly, the elastic deformation is decreased by 23% for flyash combined with NH4Cl, 40% for flyash combined with MgCl2, and 45% for flyash combined with AlCl3.During the rainy season, the total deformation under a specific pressure of 1000 kPa was reduced by 39% for flyash+NH4Cl treated lengths, 55% for flyash+MgCl2 treated stretches, and 63% for flyash+AlCl3 treated stretches.

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