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DESIGNING RURAL ROADS BY NANOTECHNOLOGY MATERIALS

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ABSTRACT

Nanotechnology materials have opened up many possibilities in various fields and civil engineering also have got benefitted. Zycobond and Terrasil prevent premature failures and damage to roads during its service life. Its use helps in utilization of in-situ soils that may be weak and substantial reduction in aggregate consumption (40% to 75%). It can also improve moisture susceptibility of bitumen layers that prevents pothole formation during service life. It also helps in faster pace of construction and reduction of cost. Terrasil is known to reduce soil layer permeability, and Zycobond serves as a plasticizer .Use of these chemicals helps in improvement of CBR of sub-grade soil and also preparing CTSB layer which eventually leads to (i) use the soils which otherwise are not suitable as sub-grade (ii) reduction in requirements of virgin materials and (iii) utilization of locally available materials. Usually such chemicals are used along-with cement . However a systematic laboratory evaluation need to be done to ascertain their dosage and corresponding engineering properties.

1. INTRODUCTION

In northern region of India road construction is done in two parts i.e stage -1 and stage-2. In two states namely Uttarakhand and Himachal Pradesh, the topography of the region is mostly mountainous. Hillside cutting is done in stage-1 and bituminous work is done in stage-2. Road cutting in the mountainous region is done in partial cutting and filling and the rest of the material obtained from cutting which is earth and boulder need to dispose (muck) somewhere. Therefore engineers are always in search for an optional method to reuse the material so that cost used for disposal of material after hillside cutting can be reduced. This objective was to assess the effectiveness of using base course layer aggregates made of locally accessible cutting material. To solve the issue on roadways, nanomaterials such as Terrasil and Zycobond are utilized. Terrasil is known to reduce soil layer permeability and Zycobond serves as a plasticizer. As a stabilizer, cement makes up 4% of the total weight of the soil-aggregate combination along with other chemicals.

2. MATERIAL USED IN ZYDEX FLEXIBLE PAVEMENT

i) For the bituminous layer

Zycotherm : Zycotherm (and its predecessor Zycosoil) has been adopted around the world as a next-generation anti-strip and warm mix asphalt additive technology. Zycotherm enables superior wetting and coating properties, as well as, lower production and compaction temperatures during paving

Zycobond : TerraSil is designed to be utilized with Zycobond – a UV and heat-stable, cross-linkable soil modifier that chemically binds soil particles together into a flexible crosslinked network.

ii) Bases, Sub-bases and Subgrade

Terrasil : TerraSil is a chemical technique based on organosilanes that drastically lower capillary water movement in the soil.

Terraprime : Terraprime is a cationic bitumen emulsion additive that enables a deeply penetrative prime coat that is track resistant and waterproof. It forms a permanent chemical bond between the prime coat and soil base, thereby enabling high bond strengths, track resistance and lower residual bitumen contents.

3.LITERATURE REVIEW

1) **Patel Nandan A, Prof. Mishra C. B, Mr. Pancholi Vasu V.(2015)** [(1)] in their study titled "*Scientifically Surveying the usage of Terrasil Chemical for Soil Stabilization*" found that soil treated with 0.041% Terrasil produced improved density values by reducing the void ratios .It is seen that the treated soaked CBR values are higher. The CBR of soil at 5 mm penetration is 7.21%, while soil with Terrasil (0.041%) is 10.82%. With the addition of 0.041% Terrasil to the soil, the liquid limit and plastic limit and permeability of the soils are reduced. The construction price on CL soil comes out to be Rs. 9271686 per km, whereas the price of construction on soil treated with terrasil at 0.041% is reduced by Rs. 8708166/- per km.

2) Jan Umar, Sonthwal Vinod K., Duggal Ajay Kumar, Rattan Jasvir S , Irfan Mohd (2015)[(2)] made a study on *Soil Stabilization using Shredded Rubber Tyre*. The behaviour of pavement subgrade soil stabilized with rubber tyre shred was examined in this research. It was observed that a dosage of 8% (25 mm–50 mm) of shredded tyre led to improvement in CBR by 66.28% in comparison to plain soil. The maximum dry density and the moisture content both decrease as the proportion of rubber tyre composition rises. This is caused by the light weight of tyre trash.

3) Johnson Rintu , Dr. Rangaswamy Kodi (2015)[(3)]*Improvement of soil properties as a road base material using nano chemical solution* The study focus on improvement of soil properties as a road base material using nano-chemical solution and the impact of Terrasil and cement additives on the CBR, UCS, and consistency limits of soft clay soil. The UCS strength of the untreated soil is 0.46 kg/cm^2, which classifies it as soft clay. The plasticity index decreased from 41% to 18% when more Terrasil is applied to the clay soil, up to 0.07 percent of the soil's weight. Due to the increased dosage of Terrasil introduced into the soil, permeability dramatically decreased. In all types of soil combinations, the unconfined compression and CBR strengths rise as the curing time increases up to 28 days. The maximum dosage of 0.07 percent of the Terrasil chemical improves the CBR strength of soil by around six times more for clay soil.

4) Saravanan S., Venkatasubramanian C,Muthu Dand , Ramakrishnan.K (2016)[(4)] studied *Construction of Rural Roads using C&D Waste Materials*. In this study, attempts are made to assess how C&D (Construction & Demolition) waste materials can be used in geotechnical applications, such as the formation and strengthening of rural roads, as well as to assess the effects of powdered waste bricks and cement that have been stored for a long time on the formation of rural roads. The rural road's sub-base is strengthened by being partially replacing with C&D waste materials. Using these C&D waste materials in actual practice in the rural road techniques (sub-base and embankment). It is possible to reduce the amount of laterite over time. Due to this feature, the cost of building rural

roads will decrease as their lifespan increases. CBR of the sample is 3.6% for the 15% replacement by powdered brick sample. CBR of the sample is 23.84% for the sample with 15% replacement by prolonged stored cement.

5) D.E. Ewa et.al. (2016)[5] in their study *Effects of Nano-Chemical on Geotechnical Properties of Ogoja Subgrade* examined at how Terrasil, a nano-chemical, affected the subgrade's geotechnical characteristics as a stabilizing agent.The subgrade was inorganic silty clay of high plasticity, A-7-6 (0) soil by AASHTO, and clay of high plasticity (CH) by the unified soil classification system. The un-stabilized soil had a maximum dry density (MDD) of 1190 kg/m^3 and a CBR value of 9.13 % (after 48 hours of soaking). To stabilize the soil, nano-chemical (Terrasil) was added in percentages of 0%, 2%, 4%, 6%, and up to 8%. The outcomes showed that Terrasil, a nano-chemical, improves plasticity by lowering the liquid limit, plastic limit, and linear shrinkage. Additionally, the maximum dry density rose by 9.2% to a peak of 1300 kg/m^3 before falling to 1060 kg/m^3. The inclusion of nano-chemicals also increased the optimum moisture content . For the un-soaked and the soaked, the CBR exhibited improvements of 5.6 and 2.1 percent, respectively. The study concluded that Terrasil nano-chemical addition of 4% might produce satisfactory outcomes.

6) Hattimare Devangi G. (2016)[6] in their study used *Zycosoil as an admixture in bituminous road construction.* The inference made was that Zycosoil might be utilised as an efficient anti-stripping agent to increase the resilience of asphalt mixtures to water damage and perhaps reduce the amount of water damage that occurs in asphalt mixtures. For a more firm conclusion about Zycosoil's performance and appropriate use as an anti-striping agent, it is recommended that quantitative binder and mixture studies be carried out in the near future.

7). **Srivastava Roopika, Kushwaha Prachi, Dr. Swami B. L (2016)**[7] *examined the suitability of the nano-chemical stabilizers Terrasil and Zycobond*, hence numerous laboratory tests on the soil were conducted. Depending on the kind and quantity of stabilizer used, the behaviour of the soil varies. Depending on the kind and properties of the soil, a certain amount of stabilizer may be needed to provide significant stability. Clay soil's CBR and UCS were improved by adding various nano-chemical combinations to the cement. Additionally, it helped in lowering the expansive clay soil's liquid limit, plasticity index, and free swell index.

8) Mane S R Rohith et. al.(2018)[8] made a study to evaluate the *effectiveness of one of the stabilizers viz., Zycobond, Terrasil* manufactured by Zydex industries vis-a-vis that of traditional stabilizer, the cement. The study's focus is just on the stabilizing process's mechanism as it relates to CBR values macroscopic outcomes. The investigation is limited to a single type of soil and two commercial stabilizers, namely Terrasil and Zycobond from M/s Zydex. This study's primary goal was to enhance the CBR characteristics of soft clayey soil. When Zycobond and Terrasil were added to the clayey soil, the soaked CBR value improved by 2.17 to 3.2 percent for a dosage of 0.6 kg of Terrasil and Zycobond. It has been seen that the CBR value lowers from 2.17 percent to 1.42 percent as the dosage increases.

9) Padmavathi V., E. C. Peter Nirmala, Rao P. N., and Padmavathi M. (2019)[9]*Stabilization of Soil Using Terrasil, Zycobond and Cement as Admixtures* In this work, c- Ø soil (SC) with 31% fines and a plasticity index value of roughly 15% is mixed with nanomaterials like Terrasil, Zycobond, and cement to increase its strength capabilities both at OMC and SMC conditions. The admixtures that are applied are Terrasil, Zycobond alone, and mixtures of 3% cement + Terrasil + Zycobond, 6% cement + Zycobond, and 3% cement + Terrasil. Terrasil and 3% cement were used to prepare the blocks. Shear parameters were obtained from direct shear tests on samples compacted with OMC using a typical proctor compaction test to assess the strength and stability of the stabilized soils. The shear characteristics significantly increase when both Zycobond and Terrasil are added to 3% cement, indicating that this admixture combination can provide the strongest and most stable results. Cohesion and angle of internal friction have increased significantly in soil that has been combined with 6% cement and Zycobond. Therefore, depending on the need, this can also be effectively employed to enhance the soil's strength characteristics in the location.

10) Singh Chauhan Govind, Tripathy Saswat (2019)[10] studied the *influence of Zycotherm on properties of bituminous concrete*. This research work makes an effort to examine the use of conventional design mix with the usage of nanomaterials, specifically Zycotherm and Nano clay, as an additive in bituminous concrete. The first step

in determining the ideal bitumen content was to create graphs for the stability, flow, air voids, and bulk unit weight with regard to the bitumen content percentage by weight. The bitumen content that was determined to be optimum in WMA specimens with bitumen contents ranging from 4.5% to 6.5% at 125°C temperature determined to be 5.54%, which is lower than HMA at 160°C and also WMA at other temperatures. The amount of Zycotherm in each sample ranged from 0.1% to 0.5% by weight of bitumen (with an optimal bitumen content of 5.5%). The laboratory investigation finds that adding the additive enhanced the stability value, and the ideal Zycotherm content was also established. According to an experiment, bituminous concrete mixes have a great potential for using nano particle additions. The addition of Zycotherm as an additive increases the pavement's toughness, which lowers the cost of maintenance.

11) Meeravali Karumanchi , Ruben Nerella , Rangaswamy Kodi (2020)[15]*Stabilization of soft-clay using nanomaterial Terrasil*. The goal of the paper's investigation is to use nanomaterials to treat locally accessible in situ materials to improve their engineering performance. Nanomaterial engineering properties like compressibility and permeability. Enhanced soil support strength and treated Kuttanad soft clay. The soil mixtures were created using various concentrations of a nano chemical known as Terrasil and soft clay. In order to determine permeability, experimental findings on prepared soil combinations have been made. Terrasil is added to clay soil in amounts ranging from 0.02 to 0.07% of the dry soil weight. Compared to the untreated state, the plasticity index dropped from 31.91% to 22.24%With 0.02 to 0.15% of the soil's weight in terrasil is added to clay soil. Untreated soil had a UCS of 31.3 kPa treated soil had a UCS of 75.7 kPa (for optimum terrasil at the end of 28 days of curing).

4.CONCLUSIONS

After going through the studies carried out by different authors, the following inference have been noticed

a) When all other factors were constant, the improvement in CBR value was greater the longer the soaking duration (up to 28 days were seen in this study).
b) Terrasil and Zycobond plays important role in the improvement of the CBR values.
c) The findings show that the CBR value is continuously increasing with the longer curing duration.
d) Nanomaterials decrease the permeability of soil and makes the stabilized layer impermeable

5.GAPS IN LITERATURE

a) The studies were confined to roads of the plain region there is no consideration of roads of the mountainous region.
b) Various observations were done on stabilized layer using hot mix but no work is done on cold mixes in any paper
c) The studies were on basis of lab performance, no evaluation is done on basis of field aspects
d) No clear guidelines are existing regarding the economical aspects of the between stabilized layer and the conventional layer.
e) Similar studies need to be performed on other different types of soil.

6. SCOPE OF WORK

The study is confined to comparing the laboratory results obtained from soil aggregate mixed with nanomaterials stabilized layer with conventional road construction methods as per MORD Specifications for Rural Roads (2014) and IRC SP-89 (part-II) -2018.

Based on the above discussion title of the project work is stated as “Designing Rural Roads by Nanotechnology Materials”

7. OBJECTIVES OF STUDY

a) To study the viability of a modified and stabilized alternative material layer replacing the conventional structural layer of the pavement.

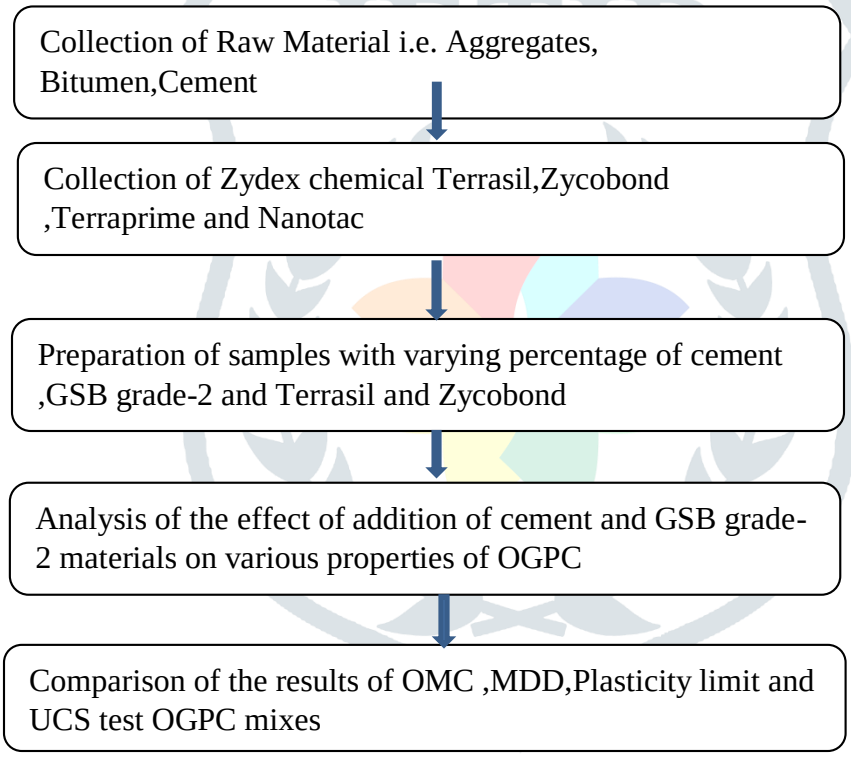
b) To determine the UCS and CBR value of locally available material at various doses using Zycobond and Terrasil.

c) To investigate the viability of using inexpensive, locally available material obtain from hillside cutting of mountainous roads in place of natural, high-strength stone aggregates.

d) To make a comparison between the cost of construction with the conventional flexible pavement with new stabilized layer technology.

8. RESEARCH METHODOLOGY

In this research proposal, the chronological order of various activities to perform the analysis is given:



9.EXPECTED OUTCOMES

On completion of the study, it is expected that

a) Local materials will be used in construction
b) Appropriate dosage of Terrasil and Zycobond required to be added to utilize local material will be determined
c) These shall lead to reduction in the requirements of fresh aggregates.
d) Reduction in overall cost of the project.

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