# EVALUATION OF RENOLITH AS A SUBGRADE STABILIZER

Anoop Singh [1], Prashant Garg [2]

**Abstract**

To achieve the desired economical growth, Government of India placed infrastructure development at top priority. Present Government set its target to construct National highway or Express way 22 km per day. Besides this thousands kilometers of low volume roads under Pradhan Mantri Gram Sadak Yojana (PMGSY) scheme are being constructed per year under central Government aid. Economy of India can further be boost up if an economical and effective solution to upgrade the subgrade is used. To find the effectiveness of stabilization method, a comparative study needs to be carried out. In the present study a comparative study is carried out to stabilize the local soil with conventional method, that is, cement stabilization and using Bio enzymes. Bio-enzymes are being used in soil stabilization as these are natural, non-toxic, non-flammable, non-corrosive liquid in form and prepared from vegetable extracts. Thus, Bio enzymes are providing a new niche in the field of soil stabilization. Renolith is one of such bio-enzyme, patented Germany made product. Renolith is liquid in form and can be added to soil after mixing in water. The proportion in which Renolith is to be added is calculated from the percentage of cement added. Experimental studies are carried out on the local virgin soil. The physical and index properties of virgin soil and soil mixed with Renolith are studied by adding the bio-enzyme in different proportion. The virgin soil samples were made using 2%, 4%, 6%, 8% and 10% cement. A curing period of 14 days was used to determine California Bearing Ratio (CBR) values, Standard Proctor’s test (MDD & OMC) and Permeability test values from cement treated samples.

Further this sample is treated with 1%, 2%, 3%, 4% and 5% Renolith. A curing period of 14 days was used to determine California Bearing Ratio (CBR) values, Standard Proctor’s test (MDD & OMC) and

Permeability test values from the treated samples. A comparison is performed between cement stabilized soil and Renolith stabilized soil.

The optimum dosage of Renolith for stabilization is also determined. To assess the stabilization process California Bearing Ratio (CBR) values, Permeability Test and Standard Proctor Test values are evaluated. Even the costs incurred in Cement stabilization and Renolith are also compared.

*Keywords*- Bio-Enzyme, Subgrade, California Bearing Ratio, Durability, Standard Proctor

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**ABSTRACT:** To achieve the desired economical growth, Government of India placed infrastructure development at top priority. Present Government set its target to construct National highway or Express way 22 km per day. Besides this thousands kilometers of low volume roads under Pradhan Mantri Gram Sadak Yojana (PMGSY) scheme are being constructed per year under central Government aid. In the present study a comparative study is carried out to stabilize the local soil with conventional method, that is, cement stabilization and using Bio enzymes. A curing period of 14 days was used to determine California Bearing Ratio (CBR) values, Standard Proctor's test (MDD & OMC) and Permeability test values from cement treated samples. Even the costs incurred in Cement stabilization and Bio enzyme are also compared.

*Keywords*- Bio-Enzyme, Subgrade, California Bearing Ratio, Durability, Standard Proctor

## INTRODUCTION

The progress of any country is marked by its transportation system in which the network of roads plays a very important part. In India, to achieve the desired economical growth, the Government has placed infrastructure development at top priority. Present Government sets its target to construct National highway or Express way 22 km per day. Besides this thousands kilometers of low volume roads under Pradhan Mantri Gram Sadak Yojana (PMGSY) scheme are being constructed per year under central Government aid. Economy of India can further be boost up if an economical and effective solution to upgrade the subgrade is used.

In order to obtain an effective soil stabilization method innovative methods need to be studied and experimented [1]. In a country like India, there is a very large variation of native soils. There is a requirement of stabilization techniques which are as per soil type. The stabilization method used and developed in another country requires a study and a series of experiments in order to understand its functionality and outcomes in the local conditions. Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, so there is a need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely and hence, soil stabilization is the technique to look for in such cases.

Commonly used methods for soil stabilization are traditional mechanical methods and chemical methods [2]. A wide variety of waste materials from agriculture and industry have been used for soil stabilization. To overcome the drawbacks of existing materials and methods for soil stabilization, there is a need for such a method and material which maintains the environmental properties, gives better performance in strength, has easier availability and is cheaper in cost. All these factors have provided for research of new stabilizers such as bio- enzymes.

## BIO-ENZYME FOR SOIL STABILIZATION

An organic catalyst which speeds up the chemical reaction is called the Bio-enzyme. The reactions that occur due to enzyme would otherwise occur at a very slow speed and wouldn't be part of the end product [3]. This very important property of bio enzyme has led to its usage in soil stabilization and for process of stabilization a very small fraction of the bio enzyme is required. As the enzymes are organic the reactions take place when the conditions are provided for a reaction to occur. For an enzyme to be dynamic in soil, it must have portability to reach at the response site. The liquid is accessible in the soil mass gives intends to portability of the atoms of bio-enzyme, the particular soil science gives the response site, and time is required for the compound to diffuse to the response site. A compound would stay dynamic in a soil until there are no more responses to catalyze. Chemicals would be required to be enhancing the soil in particular.

Each enzyme supports a chemical reaction within molecules. The enzymes themselves remain same during the reactions. They act as host for other molecules, speeding up the normal chemical and physical reaction. The enzyme increases the water absorption capacity of soil and makes it denser. The result of reactions is improvement in the chemical bonding of soil particles which creates a more lasting structure that is more defiant to weathering, water penetration and wear and tear[4].

### Renolith

The Renolith, a licensed item was produced in Germany [5]. Renolith and the concrete polymer-shaping street adjustment concoction were further grown in Australia in 1995–96. Renolith essentially enhances the quality of soil in the concrete adjustment handle in an assortment of streets, for example, overwhelming pull streets, thruways, country streets, pathway development, hard stands and rail earthworks topping. It additionally enhances the adaptability of standard concrete balanced out asphalt.

Renolith can be used as a mixture with water in varying proportions. The prepared mixture can be then used in a cement based aggregates or different types of soils. Renolith results in an exothermic reaction when mixed with a soil to be stabilized [6]. The reaction produces a very dense layer which results in stabilized soil.

The Renolith stabilizer coats the soil particles and makes a physical bond among the soil particles when the mixture water evaporates, leaving behind a soil–polymer. This soil polymer has high tensile strength and elasticity [7]. These properties can lessen the likelihood of any Cement-settled asphalt breaking created by the shrinkage of the concrete or street base on compaction and can give enhanced porousness qualities.

## EXPERIMENTS RESULTS AND DISCUSSIONS

The local soil samples were made using 2%, 4%, 6%, 8% and 10% cement by weight of soil. A curing period of 14 days was used to determine California Bearing Ratio (CBR) values, Standard Proctor test (MDD & OMC) and Permeability values from cement treated samples.

Further this sample is treated with 1%, 2%, 3%, 4% and 5% Renolith by weight of cement. A curing period of 14 days was used to determine California Bearing Ratio (CBR) values, Standard Proctor test (MDD & OMC) and Permeability values from these treated samples.

**Soil Type**: Local Soil (Silty Sand (SM))

The properties of virgin soil are determined such as Sand Content, Plasticity Index, Fineness

Modulus (FM), Specific Gravity and USCS soil classification. Table 1 shows these characteristics.

Table 1: Properties of Virgin Soil

| Properties | Values |
|---|---|
| Sand Content | 46% |
| Plasticity Index | 0%(Non-Plastic) |
| Fineness Modulus(FM) | 3.07 |
| Specific Gravity | 2.74 |
| USCS soil classification | Silty Sand(SM) |

The Atterberg's Limits for the three exposure conditions, namely Sealed condition, Air Dried and Oven Dried are shown in Table 2.

Table 2: Comparison of Atterberg's Limits for three exposure conditions

| Sealed Condition | | |
|---|---|---|
| LL | PL | PI |
| 31 | NP | NP |
| Air Dried Conditions | | |
| LL | PL | PI |
| 28 | NP | NP |
| Oven Dried Conditions | | |
| LL | PL | PI |
| 25 | NP | NP |

**Results of Renolith CBR and Cement CBR**

This section discusses the comparative results between CBR achieved with use of Renolith and CBR achieved with use of cement. In Table 3 Standard Proctor test results are shown.

Table 3: Standard Proctor's Test Results

| Sample + % Cement by wt. of soil | OMC(%) | %increase in OMC | MDD(Kg/ $m^3$) | % increase in MDD |
|---|---|---|---|---|
| 0 | 17.00 | --- | 1770.25 | --- |
| 2 | 16.82 | -1.06 | 1810.35 | 2.27 |
| 4 | 16.50 | -2.94 | 1845.35 | 4.24 |
| 6 | 16.45 | -3.24 | 1870.27 | 5.65 |
| 8 | 16.07 | -5.47 | 1925.06 | 8.75 |
| 10 | 15.88 | -6.59 | 1980.65 | 11.89 |

Table 4: Comparison between CBR values for 2% cement with varying Renolith dose with 14 days curing

| Renolith dosage by wt. | Unsoaked CBR | Increase in Unsoaked CBR(%) | Soaked CBR | Increase in soaked CBR(%) |
|---|---|---|---|---|
| 0% of cement | 17 | __ | 8 | __ |
| 1% of cement | 20 | 17.65 | 9 | 12.50 |
| 2% of cement | 23 | 35.29 | 11 | 37.50 |
| 3% of cement | 29 | 70.59 | 16 | 100.00 |
| 4% of cement | 31 | 82.35 | 17 | 112.50 |
| 5% of cement | 29 | 70.59 | 14 | 75.00 |

In Table 4, comparison is performed between the CBR values of Renolith treated samples and Cement treated samples. The percentage of cement is fixed at 2% whereas the percentage of Renolith varies from 1% to 5%. The samples have been cured for 14 days. From the results its seen that there is increase in the CBR values till 3% Renolith then at 4% there is just a slight increase and at 5% Renolith CBR decreases.

Table 5: Comparison between CBR values for 6% cement with varying Renolith dose with 14days curing

| Renolith dosage by wt. of cement | Unsoaked CBR | Increase in Unsoaked CBR(%) | Soaked CBR | Increase in soaked CBR(%) |
|---|---|---|---|---|
| 0% of cement | 39 | __ | 21 | __ |
| 1% of cement | 42 | 7.69 | 21 | 00.00 |
| 2% of cement | 48 | 23.08 | 33 | 57.14 |
| 3% of cement | 53 | 35.90 | 37 | 76.19 |
| 4% of cement | 54 | 38.46 | 37 | 76.19 |
| 5% of cement | 50 | 28.20 | 33 | 57.14 |

In Table 5, comparison is performed between the CBR values of Renolith treated samples and Cement treated samples. The percentage of cement is fixed at 6% whereas the percentage of Renolith varies from 1% to 5%. The samples have been cured for 14 days. From the results its seen that there is increase in the CBR values till 3% Renolith then at 4% there is just a slight increase and at 5% Renolith CBR decreases.

Table 6: Comparison between CBR values for 10% cement with varying Renolith dose with 14days curing

| Renolith dosage | Unsoaked CBR | Increase in Unsoaked CBR(%) | Soaked CBR | Increase in soaked CBR(%) |
|---|---|---|---|---|
| 0% of cement | 43 | __ | 31 | __ |
| 1% of cement | 46 | 6.98 | 34 | 9.68 |
| 2% of cement | 54 | 25.58 | 38 | 22.58 |
| 3% of cement | 61 | 41.86 | 45 | 45.16 |
| 4% of cement | 62 | 44.19 | 44 | 41.93 |
| 5% of cement | 56 | 30.23 | 40 | 29.03 |

In Table 6, comparison is performed between the CBR values of Renolith treated samples and Cement treated samples. The percentage of cement is fixed at 10% whereas the percentage of Renolith varies from 1% to 5%. The samples have been cured for 14 days. From the results its seen that there is increase in the CBR values till 3% Renolith then at 4% there is just a slight increase and at 5% Renolith CBR decreases.

**Permeability with Cement and Renolith**

In Table 7, the results of permeability with 2% cement with varying dosage of Renolith are shown for curing period of 14 days. It's observed that there is decrease in permeability as there is increase in percentage of Renolith by wt. of cement.

Table 7: Results of 2% cement with varying dosage of Renolith

| Renolith Dosage by wt. of cement | Co-efficient of Permeability (K)(m/sec) |
|---|---|
| 0% | $8.11\times10^{-5}$ |
| 1% | $1.44\times10^{-5}$ |
| 2% | $5.05\times10^{-6}$ |
| 3% | $2.01\times10^{-6}$ |
| 4% | $9.51\times10^{-7}$ |
| 5% | $6.80\times10^{-7}$ |

Table 8: Permeability Results of 6%cement with varying Renolith dosages

| Renolith Dosage by wt. of cement | Co-efficient of Permeability (k)(m/sec) |
|---|---|
| 0% | $0.47\times10^{-5}$ |
| 1% | $4.72\times10^{-6}$ |
| 2% | $1.14\times10^{-6}$ |
| 3% | $2.88\times10^{-7}$ |
| 4% | $5.74\times10^{-7}$ |
| 5% | $0.32\times10^{-7}$ |

In Table 8, the results of permeability with 6% cement with varying dosage of Renolith are shown for curing period of 14 days. It's observed that there is decrease in permeability as there is increase in percentage of Renolith by wt. of cement.

Table 9: Results of 10%cement with varying Renolith dosage

| Renolith Dosage by wt. of cement | Co-efficient of Permeability (K)(m/sec) |
|---|---|
| 0% | $4.08\times10^{-7}$ |
| 1% | $4.02\times10^{-7}$ |
| 2% | $3.79\times10^{-8}$ |
| 3% | $3.22\times10^{-9}$ |
| 4% | $2.47\times10^{-9}$ |
| 5% | $1.89\times10^{-9}$ |

In Table 9, the results of permeability with 10% cement with varying dosage of Renolith are shown for curing period of 14 days. It's observed that there is decrease in permeability as there is increase in percentage of Renolith by wt. of cement.

**Cost comparison of Flexible Pavement Design**

For the cost comparison we have designed flexible pavement of varying traffic intensity such as 2 msa, 5 msa and 10 msa according to IRC37:2001. One Kilometre long road pavement is designed, having 2 lanes of 7.5m wide carriageway and 12.5m wide road pavement.

In Table 10, two Flexible Pavement Layers have been designed, one pavement is stabilized with 2% cement only and the second pavement is stabilized with 2% cement+3% Renolith by wt. of cement because from results when soil is stabilized with 2% cement by weight of soil only. The CBR value obtained is 14 and when soil is stabilized with 2% cement+3% Renolith by weight of cement, CBR obtained is 26.

Table 10: Thickness of Flexible Pavement Layers with varying traffic intensity

| Traffic Intensity (msa) | Layers of pavement | Thickness of layer (mm) for 2% Cement | Thickness of layer (mm) for 2% cement+3% Renolith of cement |
|---|---|---|---|
| 2 msa | SDBC | 25 | 25 |
| | DBM | 50 | 40 |
| | G.BASE | 225 | 225 |
| | GSB | 175 | 100 |
| 5msa | SDBC | 25 | 25 |
| | DBM | 50 | 40 |
| | G.BASE | 250 | 250 |
| | GSB | 210 | 150 |
| 10msa | BC | 40 | 40 |
| | DBM | 65 | 40 |
| | G.BASE | 250 | 250 |
| | GSB | 260 | 200 |

Taking 300 mm soil depth ( 0.3x1000x7.5 = 2250m$^3$ of soil) and taking density of soil as 1810 Kg/m$^3$. Weight of soil of 1 km long and 2 lane 7.5m wide carriageway (12.5 m wide road pavement) will be = 40,72,500 Kg. In Table 10, volumes of different layers of pavement are calculated according to design.

Table 11: Volume of layers of Flexible pavement with varying Traffic intensity

| Traffic Intensity (msa) | Layers of pavement | Volume of layer (m$^3$) for 2% Cement by weight of soil | Volume of layer (m$^3$) for 2% cement+3% Renolith by weight of cement |
|---|---|---|---|
| 2 msa | SDBC | 187.5 | 187.5 |
| | DBM | 375 | 300 |
| | G.BASE | 1687.5 | 1687.5 |
| | GSB | 1312.5 | 750 |
| 5msa | SDBC | 187.5 | 187.5 |
| | DBM | 375 | 300 |
| | G.BASE | 1875 | 1875 |
| | GSB | 1575 | 1125 |
| 10msa | SDBC | 300 | 300 |
| | DBM | 487.5 | 300 |
| | G.BASE | 1875 | 1875 |
| | GSB | 1950 | 1500 |

## CONCLUSION

The following are the main conclusions drawn from this study:

1. The addition of Renolith increases CBR and MDD values of silty sand or sandy silt soil.
2. Use of Renolith helps to achieve high CBR values with use of less percentage of cement which was before possible with use of more percentage of cement. Soil stabilized with 10% cement gives unsoaked CBR 37 and soaked CBR 31. Similar results for CBR values are obtained with 6%cement + 3% Renolith of cement which are unsoaked CBR 47 and soaked CBR 32. These are the results for 14 days curing period.

3. The quantity of cement with Renolith is approximately half to obtain the same CBR value as with the use of cement only.
4. Permeability of the soil decreases with use of Renolith.
5. From the results obtained it is found that optimum dose of Renolith is 3% by weight of cement used for soil stabilization.
6. With the use of Renolith, about 15 to 28% reduction in the cost of pavement construction can be achieved.

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