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Using Bitumen Emulsion and Fly Ash in Sandy Soil to Increase the Strength and Properties for Landslide in Prone Areas

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ABSTRACT

Soil is the most common and most crucial material for construction work. It is the base material for construction work as well as it is natural material. For highway work or for road construction sub grade or soil is the most crucial because all load from superimposed layers is transfer to the sub grade or the lowest layer(1). In some place soil is very hard or fully compacted and in some places it is very loose or clayey. Where soil is loose or not fully compacted, there is a need of change in soil quality or in simple words enhances its strength. As we all known that most crucial part of road construction is sub grade which is all made of soil. Sometimes soil of sub grade is not of good quality even it cannot be compacted by simple roller and curing so soil stabilization and replacing the soil with new one is two options to increase the strength of soil. From both the methods whichever is economical is the best method for the work

Now let's go back to this research. The main goal of this study is to improve soil properties by mixing 2% fly ash with different amounts of asphalt emulsion. Here soil used in this experiment is sandy soil from **region of Himachal Pradesh**. Different attempts have been done on it using different quantity of bitumen emulsion from 1% to 7% but same quantity of Fly ash. After that, I check the CBR value and dry density on different value of emulsion and find out which is most economical and provides the maximum strength. In this work, Fly ash is used as filler and it gives the more strength as compare to only bitumen. The result come from this test is compared with IS codes in order to check that used material is within the limit or not.

Keywords: Bitumen Emulsion, Fly ash, Sandy Soil, CBR, Dry Density.

I. INTRODUCTION

Because we all know that soil is an important construction material of nature. Almost all types of construction are based on soil and the long-term performance of pavement structures is affected by the strength and durability of the sub-grade soil. I have been analyzing for the last five years that the cases of land slides are increasing day by day. Himachal Pradesh has seen a six-fold increase in major landslides in the last two years, with 117 in 2022 compared to 16 in 2020, according to data compiled by the disaster management department.

The state has 17,120 landslide prone areas of which 675 are near critical infrastructure and habitations. The highest number of such sites are in Chamba (133), followed by Mandi (110), Kangra (102), Lahaul and Spiti (91), Una (63), Kullu (55), Shimla (50), Solan (44), Bilaspur. (37), Sirmaur (21) and Kinnaur (15).

High intensity rainfall along with mountain slopes or rock cuts at the foothills is the main reason behind a significant number of landslides, say experts. The reasons behind the increase in landslides are extensive cutting of hill slopes for construction and widening of roads, blasting for tunnels, hydro projects and mining, said geology expert Professor Virendra Singh Dhar.

All of the above features require the principle of a site-specific treatment option that should be achieved by testing soil-stabilizer mixtures.

1.1 Soil Stabilization

It is the biological, mechanical and chemical transformation of soil engineering traits. In engineering, it is a method to increase the strength and other engineering properties of soil. Permeability, compressibility, mechanical, durability and plasticity these are the main properties which is increased by soil stabilization (2).

As we all know that soil is act as the foundation of any construction whether it is road, building or airfield. Moreover, soil is the most

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important construction material without which no construction can compete. Therefore, soil must have good strength and have properties that cater strength to all structure.

This trend is following from the Romans age even some nations are using this method from 20th century. United States and China is example of this

1.2 Bitumen Emulsion

It should consist of bitumen droplets suspended in water. The main function of emulsions is their use for surface treatments. The emulsion has good penetration and spreading ability, due to the low viscosity of the emulsion compared to bitumen applied while hot. The first thing that is mandatory to determine the type of emulsifying agent used in the bitumen emulsion, will the emulsion be anionic or cationic? First, we will discuss cationic emulsions, where there are bituminous droplets that acquire a positive charge. Second, anionic emulsions have negatively charged resin droplets.

It's actually based on their setting speed or setting time, it clearly shows how quickly the water separates from the emulsion or settles. Both emulsions are further classified into three different types. The first is the fast setting (RS), the second is the medium setting (MS) and the third is the slow setting (SS) (3). Working with all three fast-set emulsions is very risky because there is very little time left to set. Almost 6 hours is the setting time for MS Emulsion. Therefore, working with a medium-set emulsion is very easy, and you will have enough time to place the material in the right place before it sets. The type and amount of emulsifying agent controls the rate of setting. Cationic emulsion gives up water faster than anionic emulsion, this is the main difference between anionic and cationic.

1.3 Fly Ash

It is also known as pulverised fly ash. It is a coal combustion product and is composed of burned fuel of fine particles; it is taken out from the coal fired boilers along with all fuel gases. Bottom ash, it is the left out at the bottom of the boiler(4). In this contemporary era, there are lots of modern coal fired plants in which fly ash is generally gathered and captured in electrostatic precipitators. Along with this bottom ash is also removed and it is called as coal ash. Components of coal is vary from source and composition of the coal being burned, all of this some things are same for all type of fly ash and it includes silicon dioxide, aluminium oxide last but not the least calcium oxide.

Some constituents of fly ash is rely on the composition of coal bed. However, it might include one or more elements listed below.

1. Arsenic
2. Boron
3. Cadmium
4. Chromium
5. Lead
6. Selenium
7. Strontium
8. Thallium
9. Vanadium
10. Mercury

In the earlier times, fly ash is very big problem because it was released in the air and it creates lots of diseases worldwide but now times change and air pollution standards changed. Now, fly ash must capture before it was release to air. About 43% of coal is recycled in United States, it is actually stored in power plant and used in land fills

In some cases ash produced is seldom classified as hazardous waste because it contain higher level of contaminants than coal ash.

Fig 1: Fly Ash

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1.4 "Objective and scope of work"

Main objectives of this experimental study are:-

1. First and foremost objective is enhance the properties of the sandy soil with the help of adding bitumen emulsion as stabilizing agent in addition to it, very low quantity of Fly ash as filler material(5).
2. Secondly, to improve the strength and geotechnical traits of soil few trials have been done with the help of emulsion. Best part of it is, using bitumen emulsion is not harmful in other words to be environmentally accepted.
3. Complete the whole work, a lot of experiments and researches are needed in the laboratory. The experiments to be carried out are specific gravity, grain size distribution and liquid limit and plastic limit test to identify the material and to obtain the maximum dry density and optimum moisture content of the soil sample, the standard Proctor form is used, the CBR test of the soil sample mixing with emulsion and fly ash.
4. Finally, the most important goal is to increase the CBR value by verifying some condition to increase the CBR value of the soil subclass.

II. LITERATURE REVIEW

Bitumen emulsion has been used as a chemical stabilizer in engineering operations for decades. On the other hand, to increase the strength of road traffic, fly ash is used as a filler. Previously, a huge amount of work was done to stabilize sand asphalt and sandy soil at various locations. My study is inspired by all these researches. Here I am using sandy soil as it is available in many states of India. All other works that seem fruitful for my work are described below.

The standard surrogate test has been widely used and recognized for characterizing soil similarity for field compaction control. In addition, the effect of gravel size and gravel content on the results of standard delegate tests is reported here. In this study, I will compare the established relationship between the total optimum water content of fine division in a sandy soil and the gravel content in standard forms using the compaction results from the designed equipment.

Olumide Moses Ogundipe (Strength And Compaction Characteristics Of Bitumen-Stabilized Granular Soil, SEPTEMBER 2014).

Mr. Prashant Chahal (A Review Paper, which is on Stability of Soil Block and using Bitumen Emulsion, IRJET)

Er. Sandeep Goyal (An Overview of Study, it is on Soil Subgrade Strength and this study shows the effect on Saturation, IJTR)

Haigh, S. K. et al. (The plastic limit of clays ,2014).

III. EXPERIMENT PROGRAMME

In this chapter, I am going to explain all tests procedure which is useful to find out the improved strength of soil (6). Here are some tests

1. Specific Gravity Test
2. Particle size distribution Test
3. Liquid limit & plastic limit test
4. Compaction test
5. California bearing ratio test

3.1 Specific gravity test

To find the specific gravity, we need to get the ratio between the weight of any substance of a certain volume divided by the weight of the same volume of water is defined as the specific gravity. Another thing is for soils, which is very easy to calculate, it's how many times the soil solids are high in rating with the same volume of water present. Therefore, it is usually as many times as the weight of the soil is greater than the weight of the water. Specific gravity is different for different soils. At the time of the experiment, very careful attention should be paid to correcting the temperature, and another important thing is that the water should be degassed distilled water. "G" is used to indicate specific gravity. It is a very important physical property that is used to calculate other important and unavoidable soil engineering properties such as void ratio, density, porosity and state of saturation.

As I explained in the previous paragraph, the ratio between the weight of solids in the soil and the weight of the same volume of water is called specific gravity. All measurements are made in a volumetric flask, which is very fruitful for the experiment, where the volume of the soil is determined and its weight is then divided by another weight of the same volume of water.

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Fig. 2 Specific Gravity Apparatus

3.2 Liquid limit Test and Plastic Limit Test

Atterberg limit test is the method to find out the liquid limit and plastic limit of soil. Firstly, soil must pass from sieve no 40 which is 425µm and it must be prepared for each test using dry and wet method, which is already described in standards. Water is used to adjust the moisture of test specimen and it is allowed for at least 16 hours for its standard condition.

Liquid limit: It is measured by distributing some portion of the soil sample in the brass cup of machine. Next step is to dividing it using grooving tool. Liquid limit is defined as the moisture content when it is 1/2in after 25 drops of the cup

Plastic limit: It is determined by continuously molding a small ball of moist plastic soil as well as rolling it manually into1/2in thread. To perform this test a plastic limit roller can be used. It is the moisture content at which stage the thread fall apart before being completely apart

Calculation of Atterberg soil indexes:

Plasticity Index (PI) = Plastic Limit – Liquid Limit

If a soil having high plastic limit value it means it have higher clay content. Moreover, plastic limit value is higher than mid- 20s, soil may be expansive under wet condition.

Liquidity Index (LI) = (Plastic Limit – Natural Water Content) / Plastic Index

Soil having LI 1 or more will be closer to the liquid state. If its value 0 or lower than it is harder and more brittle

Last but not on least in one and all the transition state from the liquid limit state to plastic limit is known as liquid limit (LL) at this stage all soil posses a certain small shear strength. Plastic limit (PL) is transmission from the plastic state to semisolid state.

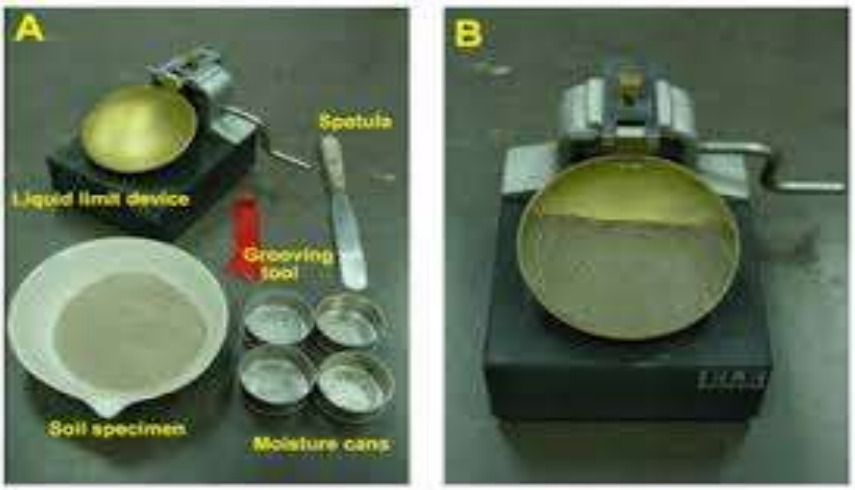

Fig. 3 Atterberg Apparatus

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3.3 California bearing ratio test

It is a very useful and important method for the ratio of the force for the entire unit area required to enter the soil with a standard load at a rate of 1.25 mm/min to the value required for subsequent penetration of the standard material. A very useful table shows the standard loads used for various penetrations for a standard material with a CBR quality of 100%. For this test, the standard load takes limestone as the main material and its CBR value is set at 2.5mm, 5mm, 7.5mm and 10mm penetration as the standard load for CBR

The CBR value can be calculated using this formula:

CBR equals (test load / standard load) 100%

The standard load for a specific depth of piston penetration is shown below.

Fig. 4 California Bearing Ratio Test

IV. RESULTS AND DISCUSSION

4.1 Specific gravity Test

First thing which I am done in this study of Specific gravity test of soil and it is a very significant property. Main function of this test is to understand the soil condition. As previously discussed here N1 is equal to empty weight of bottle, N2 is equal to dry soil with addition of weight of bottle, N3 is equal to (weight of bottle+ dry soil+ water) and N4 is equal (weight of water and weight of bottle).

Table 1: Specific gravity test result (all units in gm)

Sample No	N1	N2	N3	N4	Sp. G.
1	113.68	165.36	382.32	353.89	2.70
2	114.98	164.63	383.89	354.63	2.79
3	115.01	166.89	384.12	355.99	2.75

In this test soil material is tested for three times to ensure that test value is correct. After adding all three values and divided it by 3 we get 2.746. We done this test in room temperature of about 25°C but there is no temperature correction is done

4.2 Liquid limit Test

I took sandy soil for this study from my home town Jind city only specially from the local road routes. To find out the liquid limit we use the cone penetration test. The results of this test is given below.

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Table 2: Liquid Limit result

Sr. No.	Penetration (mm)	Moisture Content
1	14	5.6
2	18	6.5
3	20	8.8
4	23	8.9

According to the part 5 moisture content of IS 2720 1985 corresponding to cone penetration of 20mm will be taken as liquid limit of the soil and will be expressed to the nearest first decimal place.

4.3 CBR Test

After performing the Proctor test, the next test is to measure the resistance of the material. This test is performed under density and humidity conditions. The main function of this test is to find out or understand the strength of the subgrade before the construction of the road shoulder. Currently, this test is mainly investigated for the needs of field connection of flexible road thickness. IS: 2720 (Part 16) only all values and procedures given in this code are used for this test. Even I am using this code for my work and found it very useful and fruitful. In this test, a round and cylindrical plunger with a diameter of 50 mm penetrates the material of the road section at a rate of 1.25 mm/minute. After every 0.5 mm of masonry, the load is recorded, for example for 0.5 mm, 1 mm, 1.5 mm, 2 mm, 2.5 mm, 5 mm, 5.5 mm, 6 mm, up to 12 mm up to 13 mm. Express the side penetration on the X-axis in (mm) and express the load in kg on the Y-axis with corresponding points and prepare a graph for different samples.

In this test, the CBR values at 2.5 mm and 5.0 mm penetrations are specially calculated for each sample from the respective graphs. Many times it is seen that at 2.5mm the CBR test value is higher and this value is taken. It is defined as the ratio of the test load to the standard load, indicated as a percentage for a given plunger penetration. All values are expressed as percentages.

Exhibit A:

Mold size: - standard volume 2250 cc

Sample A:- In this case normal soil is used for testing Sample A proctor test result used.

Maximum dry matter value: - 1.99 g/cm3

Optimum moisture content: - 8.1%

This test was performed in three main conditions. This was done first in the non-soaked state and is known as case A1, secondly after two days of soaking, known as A2 and last but not least after four days of soaking, known as A3. This test value was calculated at 2.5 mm penetration and 5 mm penetration.

Table 3 Sample A Un-soaked condition CBR test

S.No.	Penetration(mm)	Load(KN)
1	0.5	3.0
2	1.0	3.6
3	1.5	4.3
4	2.0	4.9
5	**2.5**	**5.17**
6	3.0	5.35
7	3.5	5.9
8	4.0	6.15
9	4.5	6.85
10	**5.0**	**7.39**
11	6.0	7.95

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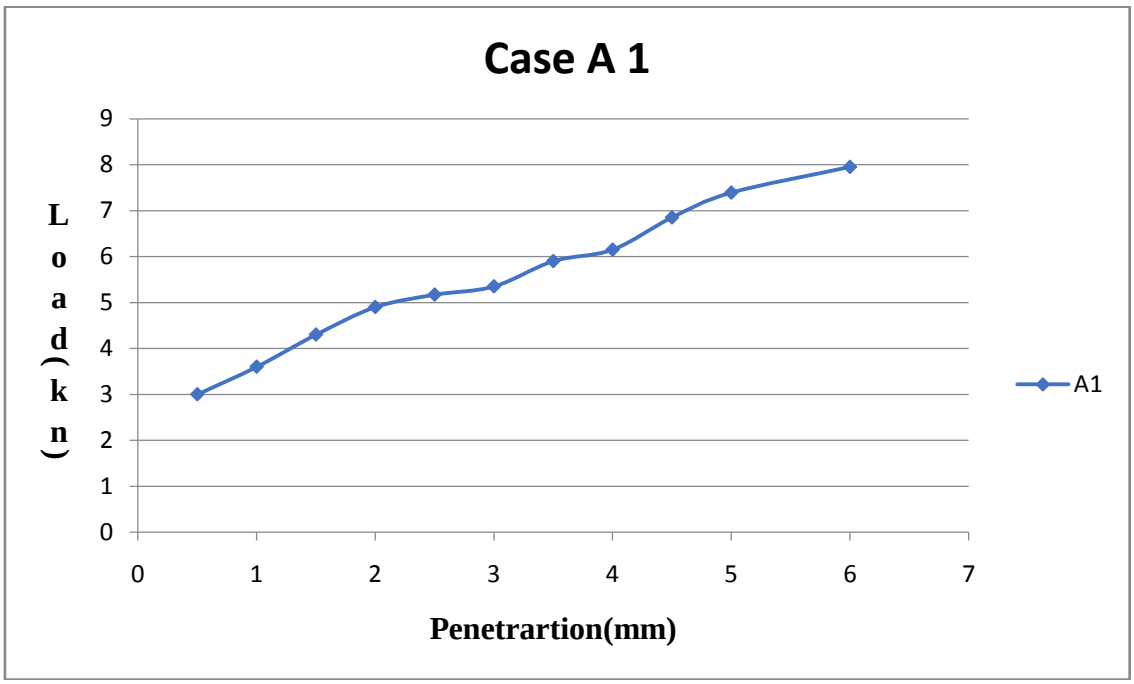

Fig. 5 Un-soaked condition Case A1 graph

V. CONCLUSIONS

1. Best result come at the value of 3% bitumen emulsion and 2% of fly ash. After this point strength is start decreasing.
2. One more important thing finds out in this study that fly ash plays vital role in increasing strength of soil.
3. It is also found that in order to satisfy the design criteria bitumen content is to be increased.
4. One of the other major advantage of using fly ash as filler in this experiment that it reduces the waste from the land; which is one of major issue for all over the nowadays

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