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Influence of fly ash, lime Sludge and Polypropylene fibre on Compaction and Strength Properties of Subgrade

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***Abstract:** The development of population, quick urbanization and more development of structures and buildings has brought about the decrease of good quality land. To improve the accessibility of good quality land, strength and compaction properties of land should be improved. The fundamental goal of this examination is to explore the utilization of fly ash, lime sludge and polypropylene fiber in Geotech highway application and to assess their impact on quality and compaction of soil, utilized for subgrade. The soil samples were gathered from the zones of Chandigarh where clayey soil is present in abundance. The laboratory testing led to decide the strength and compactive effort of the clay soil. This investigation includes three principle tests. The primary test is standard proctor test. The subsequent test is California bearing ratio and the third test is the direct shear test. Proctor test gives the compactive effort of the soil and CBR gives the subgrade strength. The outcomes acquired are thought about for the examples and inferences are drawn towards the unstability and effectiveness of admixture support at different percentages, as replacement for high quality subgrade and cost-effective approach.*

I. INTRODUCTION

clay soil subgrades make issues for construction of pavements, in view of their, cyclic swell-shrink behavior, which harm pavements requiring improvement, and low California bearing ratio (CBR) values which increases the expense of development. There are various strategies to balance swell- shrink of clay soils and increase their CBR values. Soil stabilization is one of the techniques to do so. clay soils have been stabilized using different types of industrial waste like paper sludge ash (Garcial et al., 2008), cement kiln dust (Peethamparan and Olek, 2008), fly ash and rice husk ash (Brooks 2009), fly ash and polypropylene (senol 2011), waste paper sludge ash (khalid et al.,), mine tailings (Ramesh et al., 2013), fiber reinforced fly ash (sabat and Pradhan 2014). Polypropylene fiber (Teja 2016) etc.

Stabilization of clay soil by class-F fly ash is likewise a well-known technique followed for the construction of engineering properties of clay soil. On addition of just fly ash (class-F) to clay soil, it no doubt increases the strength but there is no such substantial reduce in the swell pressure.

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That is the reason it is included alongside some other materials like rice husk ash, lime, lime sludge, lime stone, cement, cement kiln dust, sand, saw dust, quarry dust etc.

Fibers have high rigidity and tensile strength. clay soils are weak in tension, thus fiber filaments can be added as reinforcement to fly ash and lime sludge stabilized soil, to increase the strength and lessen the swell pressure.

Class F fly ash has been added to the clay soil to improve its compaction and strength properties. The fly ash content added for stabilization varies from 10 to 40%, at an increment of 10%.

Lime sludge has been added to the clay soil stabilized with fly ash. The lime sludge content added varies from 10 to 15%, at an increment of 5%.

Polypropylene fiber has been added to the clay soil stabilized with fly ash and lime sludge. The length of the fiber added is 6mm. The fiber content added varies from 0.25 to 1%, at an increment of 0.25%.

The present examination has been attempted to find the impact of fly ash, lime sludge and polypropylene fiber on compaction properties, CBR and shear strength of clay soil.

II. MATERIALS AND METHODS

The materials used in this research are clay soil, fly ash and polypropylene fiber.

A. Clay soil

i. The geotechnical properties of standard clay soil used in the experimental programme are given in the table below:

Table 1: Geotechnical properties of clay soil

Liquid limit (%)	Plastic limit (%)	OMC (%)	MDD (%)	CBR (un soaked) (%)	CBR (soaked) (%)	Shear strength (KN/m^2)
26	19.04	16	9.44	2.7	7.6	10

B. Fly ash

Class F fly ash is used having constituents (CaO, Al_2O_3, SiO_2, Fe_2O_3), available in Chandigarh.

C. Lime sludge

Lime sludge is an inert material constituted of calcium carbonate. It is obtained as a result of softening of hard water for drinking purpose, using lime softening water treatment.

D. Polypropylene fiber

Polypropylene fiber used has a length of 6mm. The fiber used in the experimental programme has been purchased from the market.

E. Experimental programme/ methodology

- Initially the soil was mixed with the fly ash. It was added to the clay soil in the range of 10 to 40% at an increment of 10%.
- The test conducted on the soil fly ash mixes were standard proctor test. Standard proctor test was done to find the maximum dry density (MDD) and the corresponding optimum moisture content (OMC).
- This was done to prepare samples for CBR and direct shear test, in order to find the optimum percentage of fly ash to stabilize the clay soil. The tests performed were standard proctor compaction, CBR and direct shear test.
- After getting the optimum percentage of fly ash (20%) for the stabilization of clay soil, soil fly ash – fiber mixes were prepared.
- The polypropylene fiber content was added to the soil fly ash mix in the range of 0.25 to 1%, at an increment of 0.25%, by replacing clay soil with the polypropylene fiber.
- The samples were prepared at the length of 6mm of fiber. Standard proctor test was conducted on soil fly ash- fiber mixes.
- The maximum dry density (MDD) and the optimum moisture content (OMC) were found to prepare the samples for CBR and direct shear test, in order to find optimum percentage of fly ash and fiber, which came out to be 20% + 0.5% for CBR.
- The whole process was again repeated for soil fly ash – fiber-lime sludge mixes. The optimum for this came out to be (20% + 0.5% + 10%) for CBR.
- All the tests conducted followed the procedure relevant to different Indian standard codes.

III. TEST RESULTS ANALYSIS AND DISCUSSION

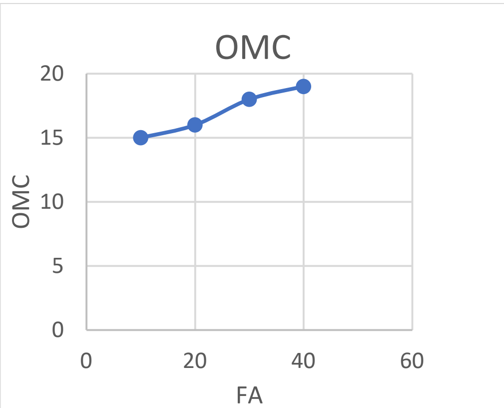

Fig. 1: variation of OMC with fly ash

The above fig. shows the variation of OMC with the different percentages of fly ash. The results show that on addition of fly ash from 10 to 40%, OMC increased from 15 to 19%. The reason for such behavior is the poor gradation of fly ash.

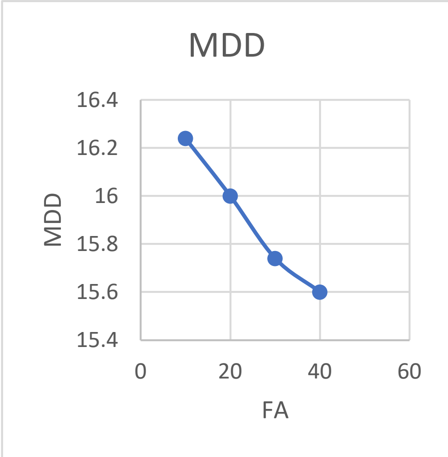

Fig. 2: variation of MDD with fly ash

Fig. 2 shows the variation of MDD with the addition of fly ash. The results show that on addition of fly ash from 10 to 40%, MDD decreased from 16.24 to 15.60. The reason for such behavior is because the fiber inclusions have less weight than the soil particles, at the same volume.

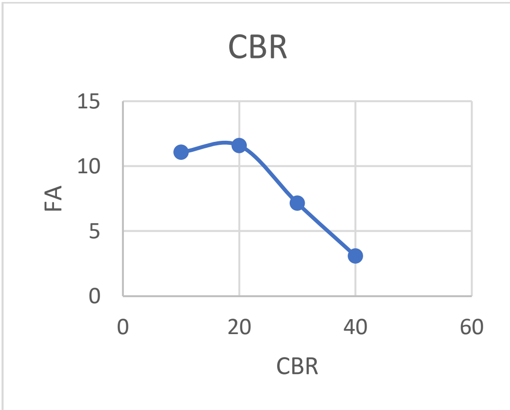

Fig. 3: variation of CBR with percentage of fly ash

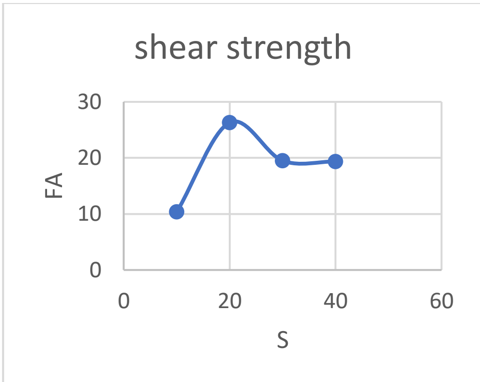

Fig. 4: variation of shear strength with percentage of fly ash

Fig. 3&4, show the variation of CBR and shear strength with the addition of fly ash. It is seen that there is increase in the CBR value from 11.09 to 11.6%, on addition of fly ash up to 20%.

Thereupon the CBR value goes on decreasing to 3.1%. The shear strength also got increased from 10.38 to 26.30, on addition of fly ash up to 20%.

Thereupon it also got decreased to 19.3 similar behavior was seen by sabat et al. (2016). The reason for such behavior is the increase of angle of internal friction with the addition of fly ash which increases the shear strength of the soil.

The reason for the decrease of CBR and shear strength thereafter is because the high content of fly ash reduces the cohesion of soil due to the reduction of clay content.

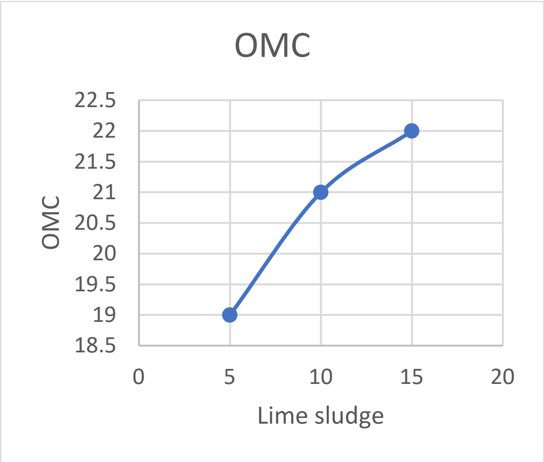

Fig. 5: variation of OMC with the addition of lime sludge to the soil stabilized with fly ash.

Fig. 5 shows the variation of OMC with the addition of lime sludge to the soil stabilized with fly ash. It is seen that OMC gets increased with the addition of lime sludge from 5 to 20% at an increment of 5%

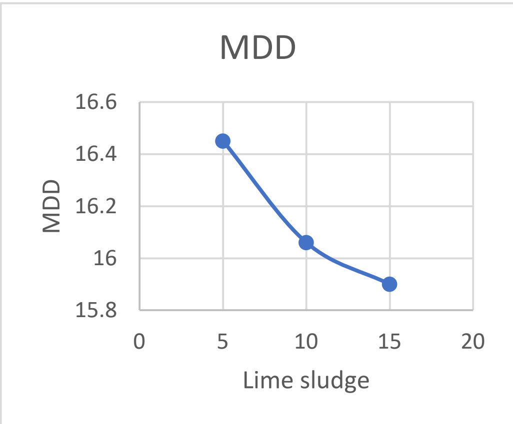

Fig. 6: variation of MDD with the addition of lime sludge to the soil stabilized with fly ash.

Fig. 6 shows the variation of MDD with the addition of lime sludge to the soil stabilized with fly ash. It is seen that the MDD gets reduced on addition of lime sludge from 5 to 20% at an increment of 5%.

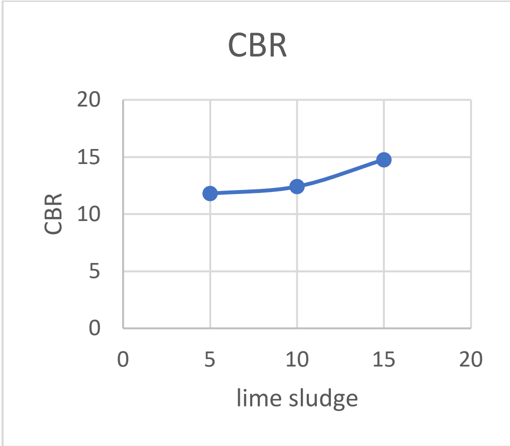

Fig. 7: variation of CBR with the addition of lime sludge to the soil stabilized with fly ash.

Fig. 7 shows the variation of CBR with the addition of lime sludge to the soil stabilized with fly ash. It is seen that on addition of lime sludge to 15%, the strength gets increased. Thereupon the strength starts to get reduced.

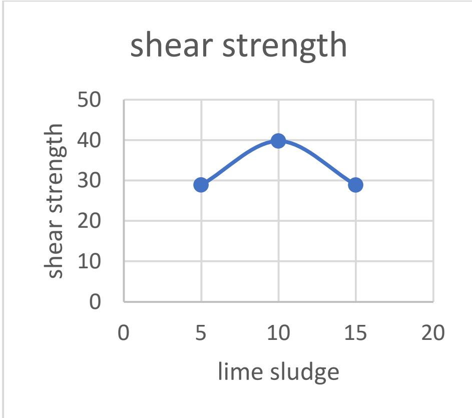

Fig. 8: variation of shear strength with the addition of lime sludge to the soil stabilized with fly ash.

Fig. 8 shows the variation of shear strength with addition of lime sludge to the soil stabilized with fly ash. It is seen that on addition of lime sludge up to 10% strength goes on increasing. Thereupon, strength is reduced.

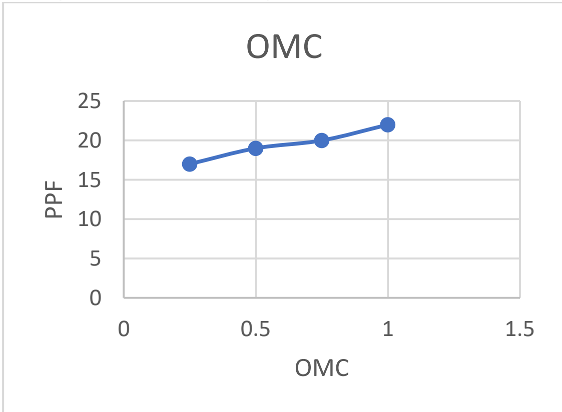

Fig. 9: variation of OMC with the reinforcement of fiber to the soil stabilized with fly ash and lime sludge.

Fig. 9 shows the variation of OMC with the reinforcement of polypropylene fiber to the clay soil stabilized with fly ash and lime sludge. The results show that the OMC gets increased on addition of fiber from 0.25 to 1%.

The length of the fiber used was 6mm. The reason for such behavior is because fiber has greater water absorb capacity as compared to the clay.

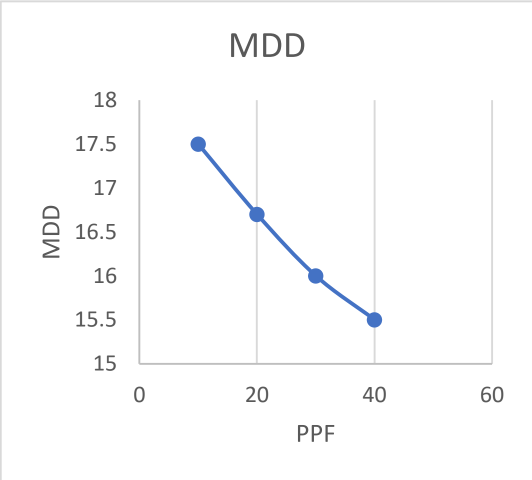

Fig. 10: variation of MDD with the reinforcement of fiber to the soil stabilized with fly ash and lime sludge.

Fig. 10 shows the variation of MDD with the reinforcement of polypropylene fiber to the clay soil stabilized with fly ash and lime sludge. The results show that on adding fiber from 0.25 to 1%, the MDD goes on decreasing. The reason for such kind of behavior is because of the replacing of soil particles with the fiber inclusions, the fiber inclusions have specific gravity less than that of the soil. In addition to this, the lubrication effect of the absorbed moisture content of fiber inclusions reduce the compaction effort.

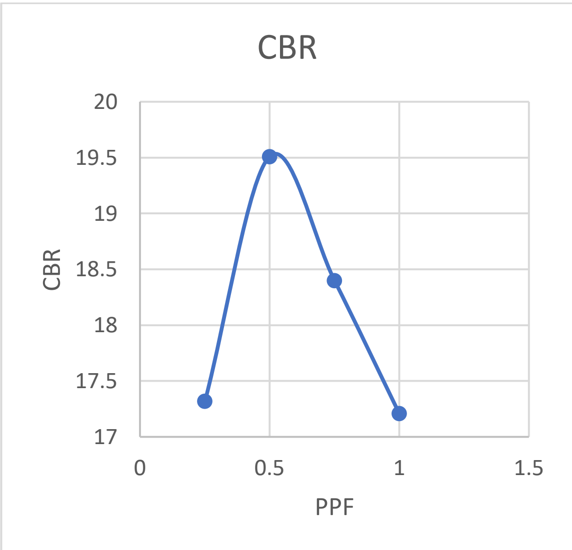

Fig. 11: variation of CBR with the reinforcement of fiber to the soil stabilized with fly ash and lime sludge.

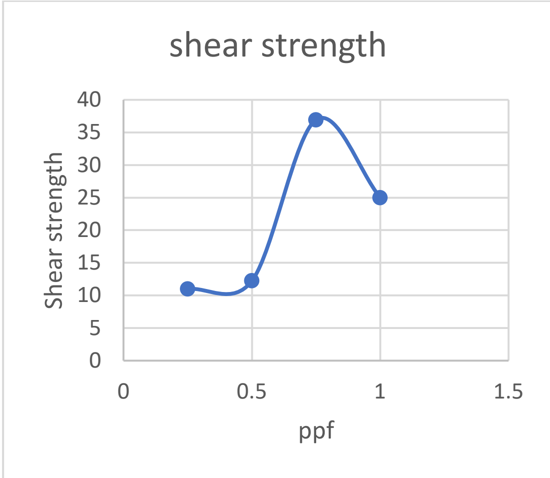

Fig. 12: variation of shear strength with the reinforcement of fiber to the soil stabilized with fly ash and lime sludge.

Fig. 11&12 show the variation of CBR and shear strength with the reinforcement of fiber to the soil stabilized with fly ash and lime sludge. It is seen that on addition of fiber to the soil fly ash and lime sludge mix, the CBR value initially increases up to 0.75% of fiber and then starts to decrease thereupon. Also, the shear strength of the soil initially increases up to 0.75% of addition of fiber and then decreases. This kind of behavior is seen because polypropylene fiber has high tensile strength and the mechanical bond is developed between the fiber and the soil fly ash mix, resulting in the increase in the CBR value of the soil. Furthermore, increment of fiber reduces the strength because the binding between the fiber and the soil gets reduced.

IV. CONCLUSION

The following conclusions are drawn for this investigation:

1. The clay soil was introduced to the addition of fly ash initially. The optimum moisture content (OMC) went on increasing while maximum dry density (MDD) went on decreasing. Also, the optimum percentage for fly ash to stabilize the clay soil came out to be 20%.
   The value of CBR got increased from 7.6 (that of virgin soil) to 11.6. the shear strength also got increased to 26.30 KN/m^2.
2. The optimum percentage of polypropylene for reinforcing the soil came out to be 0.5% (CBR) and 0.75% (shear strength).
   The CBR value got increased to 12.72% and the value of shear strength came out to be 36.94 KN/m^2. The length of the fiber used was 6mm
3. The OMC and MDD followed the same trend as above, i.e., OMC got increased with the addition of fiber and MDD got decreased.
4. The optimum percentage of lime sludge came out to be 10%. The CBR value got increased to 14.01. Also, the shear strength of the stabilized soil was 39.8 KN/m^2

5. Thus, there was a considerable improvement in the strength and other properties of clay soil, making it suitable for subgrade and other constructions as well.
6. Also, it is found that tons of fly ash and lime sludge are produced annually. However, this study was beneficial in solving the disposal concerns of solid industrial waste.

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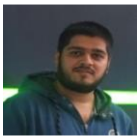

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