International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

REVIEW ON IMPROVEMENT IN STRENGTH OF SOIL BY ADDING WASTE FLY-ASH AND POLYPROPYLENE FIBER

Sahil Rana

Student (ME-CTM) Department of Civil Engineering, Chandigarh University (Mohali), India.

Abstract-*India is experiencing ascension in infrastructure as well as road network and highways. Roads are to be designed with smart responsibleness to meet the future performance. Future performance of flexible pavement depends on the soundness of the underlying sub grade soil. Unstable or weak soil can create vital problems for the pavement. Present analysis study insights on the analysis of advantages of stabilization of sub grade soil. Disposal of fly ash is a downside to the environment because it is produced in giant scale from the thermal power plants. Polypropylene has a extremely tensile nature, as well as it is cheap in price, available in abundance as a waste material. The aim of this analysis was to review the result of polypropylene fiber and fly ash to enhance the strength of soil. Experimental program consisting of Atterberg limit, compaction, California bearing ratio and unconfined compressive strength tests were carried out. These tests were performed on unstabilized similarly as stabilized sub grade soil at completely different percentages of stabilizers by dry weight of soil.*

Keyword- Soil stabilization, flexible pavement, clayey soil, waste polypropylene fiber, fly-ash, unconfined compressive strength.

1. INTRODUCTION

[1]Soil stabilization is the permanent physical and chemical alteration of **s**oils to improve their physical properties. Stabilization will increase the shear strength of a **s**oil and manage the shrink-swell properties of a **s**oil, so enhance the load bearing capacity of a sub-grade to support pavements and foundations. The exceptional increase in the production of fly ash and its disposal in an environmentally friendly manner are progressively changing into a matter of worldwide concern. [2] Soil is advanced mixtures of minerals, water, air, organic matter, and innumerous organisms. Various types of soil available in Asian nation(India) like alluvial soils, black cotton soils, laterites soils, mountain soils, desert soils and red soils etc. Soil is the upper most part of earth and it is least expensive and promptly accessible construction material. Soil is usually categorizes into four basic varieties such as: Gravel, Sand, Clay and Silt. Out of them, few possess montmorillonite in high quantity leading to fast swelling and shrinkage upon contact with water. Such soils do not seem to be helpful in construction directly however can be made useful after their stabilization. Soil is outlined as a loose material, composed of soil particles, produced by the disintegration of rocks and chemical decomposition. On the basis of shear strength, soil will be divided into three types: cohesion less soils, strictly cohesive soils and cohesive soils. Soil stabilization is employed for foundation, embankment and main road construction, airport and village roads to highways or superhighway. Soil stabilization improves the bearing capacity, compressibility, strength, and alternative properties of soil. Soil stabilization is the widespread methodology of soil improvement. Varied ways of soil stabilization are used like mechanical methodology, chemical methodology, thermal methodology, additive methodology (fiber reinforcement). In case of road construction the aim of stabilization of soil is to extend the soundness by increasing its bearing capacity and thus increasing its strength and reduction in pavement thickness. Soil stabilization improves the strength of the soil, thus, increasing the soil bearing capacity, decrease the permeability and compressibility of the soil mass in the earth structures, more economical each in terms of value and energy to increase the bearing capacity of the soil instead of going for deep foundation or raft foundation, improves the workability and also the sturdiness of the soil and maximize the lifecycle value of projects.

1.1 Fly ash –

There are three types of ash produced by thermal power plants: Fly ash, bottom ash and pond ash. The waste material produced on combustion of small-grained coal at high temperatures in power plants is known as fly ash. Fly ash is the by-product of coal fired electric power generating plants. Fly ash is a solid waste material created by the combustion of coal**.** Thermal power stations use small-grained coal as fuel, which generates large quantities of fly ash as byproduct. [3]There are about 151(By ENVIS centre on Fly ash) thermal power plants in India, which form the major source of fly ash in the country. With the commissioning of super thermal power plants and with the increasing use of low grade coal of high ash content, the present production of fly ash is about 177 (By ENVIS centre on Fly ash) million tonnes per annum. This has posed a significant disposal and ecological problem. Although the beneficial use of fly ash in concrete, brick making, soil stabilization treatment and other applications are recognized, only 61% (107.75 Million tonnes) of the entire fly ash is being used in our country presently in such applications. Fly ash has been used with success in several projects to improve the strength characteristics of soils. Fly ash is often used to stabilize bases or sub grades, to stabilize backfill to reduce lateral earth pressures and to stabilize embankments to improve slope stability. The primary reason fly ash is employed in soil stabilization applications is to improve the compressive and shearing strength of soils. Fly ash has a high amount of silica and alumina, which increase the soil strength. To manage the swell characteristics caused by moisture changes. Improvement of soil strength by utilizing this waste material in geotechnical engineering has been wide suggested from environmental point of view. Because of rising of urbanization and industrialization, minimization of industrial waste is significant issue in present days. The use of this waste material safely is gaining importance now-a-days. It is also used to Land fill and dyke rising, Structural fill for reclaiming low areas, soil stabilizing in pavement and sub-base. Fly ash increase strength and bearing capacity of soil, increase sturdiness(durability) of soil and increase the resistance to erosion, weathering or traffic loading, used to control the swell-shrink characteristics caused by moisture changes and used to reduce the pavement thickness as well as cost value.

1.2 POLYPROPYLENE –

[4] Polypropylene is the world's second-most widely produced synthetic plastic, after polyethylene. The latest report of the market research company expects the demand for this type of plastics to grow by, on average, 3% per year until 2024.Due to increased demand of this waste material is also produced on large scale. This fiber waste can be utilized for various engineering applications such as concrete, soil stabilization etc. Introducing polypropylene fiber in soil shows significant changes in the shear and ultimate strength along with enhancement of other engineering properties e.g. compaction, porosity, improve tensile cracking strength of soil, capillary absorption, resistance to weathering, filtration capacity, durability etc. Stabilizing clayey with polypropylene fiber decreases effect of swelling percent, in this way the cost will be decreased. Therefore, laboratory tests were conducted to study the effects of polypropylene fiber on swelling characteristics of expansive soil. Test results indicated that introducing fiber reduced swell percent of expansive soil. As the fiber content increased, the unconfined compressive strength was increased. Finally, it can be said that stabilization of expansive soils with polypropylene fiber is an effective method. [5] Plastic waste once mixed with soil behaves like a fiber reinforced soil. Once plastic waste fibers are distributed throughout a soil mass, they impart strength property and reduce the possibility of developing potential planes of weakness. Intermixture of plastic waste fibers with soil is administered in a concrete mix plant or with a self-propelled rotary mixer. Plastic waste fibers can be introduced either systematically or mixed randomly throughout the soil. An earth mass stabilized with separate, randomly distributed plastic waste fibers resembles earth reinforced with chemical compounds such as lime, cement etc, in its engineering properties.

Table 1: Characteristics of the Polypropylene Fibers

Property	**Value**
Specific gravity	0.91
Unit Wt.	0.91g /cm3
Nature	Inert
Breaking tensile strength	350 M pa
Water absorption	Nil

2. LITERATURE REVIEW

M.K. Vaidya et al. objective of present investigation is to quantify the optimum quantity of randomly distributed fibers and cement on the performance in terms of unconfined compressive strength especially when it is planned to be used as sub base for foundation and also in highways The results obtained so far reveals that there is significant improvement in the compressive strength with inclusion of randomly distributed fibers. Conclusions deduced from the present study are as follows. The stabilization of the fly ash with cement alone or in conjunction with polypropylene fibers is effective in order to enhance the either strength parameter-compression as well as tensile strength. The strengths (UCS as well as BTS) increase up to 1% fiber in all the mixes and thereafter, it decreases. The value of the strengths (UCS and BTS) increases with increase in curing period. The rate of gaining the strength in most of the cases is rapid during initial phase of curing, up to 14 days. The value of strengths (UCS as well as BTS) in respect of un- soaked sample is higher than that in case of soaked sample. Durability of stabilized fly ash gets improved due to formation of Pozzolanic reaction with the addition of cement. Both the strengths- compressive as well as tensile- is found to be higher in case of 20% cement contents and corresponding to 1% fiber in case of either samples, i.e., un soaked and soaked, indicating the optimum performance of the mix with 20% cement contents and 1% fibers.

Pradip D. Jadhao and P. B. Nagarnaik (2008) purpose of this investigation was to identify and quantify the influence of fiber variables (content and length) on performance of fiber reinforced soil- fly ash specimens. A series of laboratory unconfined compression strength tests and California bearing ratio tests were carried. Polypropylene fibers with different fiber length (6mm, 12mm and 24 mm) were used as reinforcement. Soil -fly ash specimens were compacted at maximum dry density with low percentage of reinforcement (0 to 1.50 % of weight). Four primary conclusions were obtained from this investigation. First, inclusion of randomly distributed fibers significantly improved the unconfined compressive strength of soil fly ash mixtures. Second, increase in fiber length reduced the contribution to peak compressive strength while increased the contribution to strain energy absorption capacity in all soil fly ash mixtures. Third, an optimum dosage rate of fibers was identified as 1.00 % by dry weight of soil- fly ash, for all soil fly ash mixtures. Fourth, a maximum performance was achieved with fiber length of 12mm as reinforcement of soil fly ash specimens.

S.Ayyappan et al. (June-2010) purpose of this investigation was to identify and quantify the influence of fiber variables on performance of fiber reinforced soil- fly ash specimens. A series of laboratory unconfined compression strength tests and California bearing ratio tests were carried. Polypropylene fibers with different fiber length (6mm, 12mm and 24 mm) were used as reinforcement. MDD showed increase of 1.20 % to 8.40 % and 1.01 % to 2.45 % in fly ash and soil fly ash mixtures respectively, due the addition of fibers. MDD of soil decreases by 0.27 % to 5.41 % due to addition of fibers. The decrease in OMC varies from 3.53 % to 20.35 % and 6.32 % to 8.54 % in fly ash and soil fly ash mixtures respectively ,whereas increases by 0.85 % to 6.72 % in soil. Soil -fly ash specimens were compacted at maximum dry density with low percentage of reinforcement (0 to 1.50 % of weight).Four primary conclusions were obtained from this investigation. First, inclusion of randomly distributed fibers significantly improved the unconfined compressive strength of soil fly ash mixtures. Second, increase in fiber length reduced the contribution to peak compressive strength while increased the contribution to strain energy absorption capacity in all soil fly ash mixtures. Third, an optimum dosage rate of fibers was identified as 1.00 % by dry weight of soil- fly ash, for all soil fly ash mixtures. Fourth, a maximum performance was achieved with fiber length of 12mm as reinforcement of soil fly ash specimens **Venkata Koteswara Rao Pasupuleti et al. (July-2012)** this study revealed that the fiber reinforcement improves the CBR values in admixture stabilized soil. In the present work, an attempt is made to compare the quantity of the earth required for the sub grade with and without fly ash stabilization. By addition of the fly ash and fiber to the expansive soils the CBR value is increased. By addition of fly ash alone the CBR of the mixture is increased nearly 2.7 times where as by addition of fiber only CBR is increased by 1.6 times only. For addition of fibers alone thickness reduction will be 19% and by addition of fly ash only the reduction is 40%. By addition of both fiber and fly ash the reduction in the thickness is 60%. For 1.5% of fiber and 15 % of fly ash the thickness of the pavement is decreased by 60% and the 8610 m3 of soil can be saved for one kilometer length of the road. In soaked condition the maximum thickness reduction achieved was 45% by addition of fly ash only the reduction is 40%. Hence a 9870 mt3 of earth for one kilometer length of the road for a six lane road can be saved. **Gyanen. Takhelmayum et al. (Jan-2013)** present investigation is to evaluate the compaction and unconfined compressive strength of stabilized black cotton soil using fine and coarse fly ash mixtures. The percentage of fine and coarse fly ash mixtures which is used in black cotton soil varied from 5 to 30. In the study concludes that with percentage addition of fine, coarse fly ash improves the strength of stabilized black cotton soil and exhibit relatively well-defined moisture-density relationship. It was found that the peak strength attained by fine fly ash mixture was 25% more when compared to coarse fly ash. The maximum dry density is in the range of 1.35 g/cc for 95% soil and 5% fly ash mixture and lowest density was about 0.6g/cc for 70% soil and 30% fly ash mixture. This variation of density is primarily due to alteration of gradation of soil mixtures. The decrease of the maximum dry unit weight with the increase of the percentage of fly ash is mainly due to the lower specific gravity of the fly ash compared with expansive soil and the immediate formation of cemented products by hydration which reduces the density of soil. The decrease in dry density with increase in fine fly ash content is due alteration of gradation of soil mixtures. Whereas decrease in dry density with the increase in coarse fly ash mixture was attributed due to cation exchange between additives and expansive soil which decreases the thickness of electric double layer and promotes the flocculation. **C. Gumuser and A. Senol (Nov. 2013)** experimental program was undertaken to investigate the effects of Multifilament (MF19average) and Fibrillated (F19average) polypropylene fiber on the compaction and strength behavior of CH class soil with fly ash in different proportions. The soil samples were prepared at three different percentages of fiber content (i.e. 0.5%, 1% and 1.5% by weight of soil) and two different percentages of fly ash (i.e. 10% and 15% by weight of soil). The fiber inclusions increased the strength of the fly ash specimens and changed their brittle behavior into ductile behavior. The inclusion of fiber reinforcement within unstabilizedunreinforced specimens and stabilized-reinforced specimen's soil caused an increase in the CBR. Increasing fiber content could increase the peak axial stress and decreases the stiffness and the loss of post-peak strength, weakens the brittle behavior of fly ash stabilized reinforced specimens. The increase in strength of combined fiber and fly ash inclusions is much more than the sum of the increase caused by them individually. **Akshaya Kumar Sabat and Abinash Pradhan (2014)** investigate that optimum percentage of fly ash for stabilization of expansive soil is found to be 20%. At 20% addition of fly ash to soil there is, 58% increase in UCS, 91% increase in soaked CBR and 38% reduction in swelling pressure. The UCS of fly ash stabilized soil goes on increasing up to 1% addition of polypropylene fiber; thereafter it decreases irrespective of the length of the polypropylene fiber. The maximum value of UCS is achieved with sample reinforced with 12 mm length fiber. There is 70% increase in UCS as compared to fly ash stabilized soil and 170% increase in UCS as compared to virgin soil. The soaked CBR of fly ash stabilized soil goes on increasing up to 1% addition of polypropylene fiber thereafter it decreases irrespective of the length of the polypropylene fiber. The maximum value of soaked CBR is achieved with sample reinforced with 12mm length fiber. There is 81% increase in soaked CBR as compared to fly ash stabilized soil and 247% increase in soaked CBR as compared to virgin soil. The swelling pressure of fly ash stabilized soil goes on decreasing with increase in percentage addition of polypropylene fiber irrespective of the length of polypropylene fiber. The maximum reduction of swelling pressure occurs on sample reinforced with 12 mm length of fiber. At 1.5% addition of 12 mm length polypropylene fiber, the swelling pressure is zero. Making sample a non-swelling material. At 1% addition of polypropylene fiber the swelling pressure reduces to 17kN/m2. The optimum percentage of polypropylene fiber for reinforcement of expansive soil stabilized with optimum percentage of fly ash (20%) is found to be 1% and the optimum length as 12 mm. From the economic analysis it is found that there would be, 7% and 13.6% saving in cost of construction per square meter of pavement area, for the pavement having sub-grade stabilized with 20% of fly ash and reinforced with 1%, 12 mm length polypropylene fiber. **Ravi Mishra and S.M Ali Jawaid (Nov-2014)** in this study samples were prepared by mixing different percentage of fly ash with different percentage of soil, with an aim to compare strength gain with geo-fiber. Fly-ash mixed with highly compressible soil and reinforced with geo-fiber may find potential applications in road and embankment constructions with due regards for its strength characteristics, durability, longevity and environmental safety. In order to achieve good quality structural fills, the MDD values obtained from standard proctor test may be adopted as a benchmark value. Best result obtained when 38% fly ash, 60% soil and 2% geo fiber is mixed maximum CBR of 5.24% is found and after this when the percentage of flyash is increased the CBR value decreases. **Phani Kumar. V (Jan-2015)** investigates soil stabilizing with waste materials like fly ash and polypropylene, which decreases the cost of laying of pavements. From the results of this project the dry density and CBR (Soaked and Un-Soaked) values are increasing with increase in the replacement of soil with fly ash and polypropylene up to certain limit and thereafter it will be decreases. The percentage at which the maximum values of dry density and CBR (Soaked and Un-Soaked), are obtained is known as Optimum percentage of fly ash and polypropylene. The optimum percentage of fly ash is 15% and the optimum percentage polypropylene is 25%. **P.P.Nagrale et al. (Jan-2016)** Present research study insights on the evaluation of benefits of stabilization of sub grade soil. Two types of soil (Soil A and Soil B) having CBR of 1.45 and 4.67 and three types of stabilizers namely hydrated lime, class F fly ash and polypropylene fiber (aspect ratio of 100) were selected for the laboratory investigation. Tests were performed on unstabilized as well as stabilized sub grade soil at different percentages of stabilizers by dry weight of soil. Percentage of lime varied from 1.5, 3.0, 4.5 and 6 %, for fly ash stabilization it was 5, 10, 15 and 20 % whereas percentage of fiber varied from 0.25, 0.50, 0.75 and 1 %.Maximum value of failure Stress is observed in both sub grade soil-A and soil-B, when stabilized with 4.5 % lime, 10 % fly ash and 0.5 % fibre. There is significant reduction in plasticity index as compared to unstabilized soils which is attributed to the change in soil nature due to flocculation and agglomeration. Results of laboratory investigation revealed that 4.5 % lime, 10 % fly ash and 0.5 % of fiber were optimum for the improvement of strength characteristics of sub grade soil stabilization. **Jesna Varghese et al. (March-2016**) this paper presents how polypropylene fibers influence on shear strength parameters of the soil. Effect of polypropylene fiber on maximum dry density and optimum moisture content with different fiber inclusion were studied**.** It was observed that the unconfined compressive strength value of untreated soil was found to be 15.1 KN/m2 and the strength value increased with increase in addition of polypropylene fiber up to 0.05% and then decreases. There is an increase of strength of about 454.37%. That may be due to increase in interfacial shear strength at 0.05 %. The strength is increased in low percentage of PPF addition, it ensures more economical in construction. So finally it was concluded that the polypropylene fiber can potentially stabilize the clayey soil. **Muske Srujan Teja (Sept-2016)** objective of this study is to investigate the use of polypropylene fiber materials in geotechnical applications and to evaluate the effects of polypropylene fibers on shear strength of unsaturated soil. Based on direct shear test on soil sample, with fiber reinforcement of 0.05%, 0.15% and 0.25%, the increase in cohesion was found to be 10%, 4.8% and 3.73% respectively. The increase in the internal angle of friction was found to be 0.8%, 0.31% and 0.47%. Since the net increase in the values of c and Ø were observed to be 19.6%, from 0.325 kg/cm2 to 0.3887 kg/cm2 and 1.59%, from 47.72 to 48.483 degrees respectively. The results from the UCS test for soil sample are also similar, for reinforcements of 0.05%, 0.15% and 0.25%, the increase in unconfined compressive strength from the initial value are 11.68%, 1.26% and 0.62% respectively. The results obtained are compared for the samples and inferences are drawn towards the usability and effectiveness of fiber reinforcement at various percentages (0, 0.05, 0.015, and 0.025) as a replacement for deep foundation or raft foundation, as a cost effective approach. **Saurabh. Sanjay Deshpande and M.M. Puranik (April-2017)** concluded that the black cotton soil mixed with fly ash and polypropylene fibers can be considered to be good ground improvement technique especially in engineering projects on expansive soils where it can act as a substitute to deep/raft foundations, reducing the cost. The Unconfined Compressive Strength of soil increases with the increase in polypropylene percentage. The optimum percentage of fly ash is 15 % and that of polypropylene is 1.5 % from the U.C.S. point of view. Thus it is concluded that this project is to meets the challenges of society to reduce the quantities of wastes, producing useful material from non-useful waste materials that lead to the foundation of sustainable society.

3. CONCLUSION

On the basis of literature review we reached on following observations:

1. There is a need to utilize the waste fibers of polypropylene obtained from the various industries across the country for the stabilization of the soil and sustainable development.
2. The reinforcement of soil mixed with fly ash further increases the strength of soil used for construction.
3. Fiber reinforced soil can be considered to be good ground improvement technique specially in engineering projects on weak soils
4. Length and content of polypropylene have important role in developing the strength properties of stabilized soil. As the strength properties are mostly affected by size of fiber than by content of fiber.
5. The C.B.R. value is increased. Therefore resulting in less thickness of pavement in high rainfall area.
6. Fly ash and polypropylene fiber is also cheap material and available in abundance.
7. If fly ash and polypropylene is used for soil stabilization it will reduce the environmental hazard caused by waste.

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BIOGRAPHY

Sahil Rana pursuing M.Tech in Construction technology & management from Chandigarh University (Mohali), India