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# Effect of Waste Materials on Strength Characteristics of Local Clay

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**Abstract**

In this paper an attempt has been made in the direction of improving the lacking geotechnical properties of locally available clayey soil by adding admixtures i.e. sand, fly ash and tile waste in suitable proportion. The suitable proportion in which the admixtures are to be added in the clay is decided with the help of proctor compaction test to obtain the optimum mixes. These optimum mixes obtained through the experimental investigation carried were further checked for strength characteristics through California bearing ratio test. A considerable improvement in the CBR value was obtained for these optimum mixes in comparison to that of pure clay. The results of experimental investigation reveals that soil:sand::70:30 , soil:sand:flyash::63:27:10 and soil:sand:fly ash:tile waste::63:27:10:9 are the best optimum mixes on the basis of compaction characteristics and for every optimum mix CBR value shows an increasing trend. Basic purpose of this study is to use the waste materials (river sand, fly ash and tile waste) as additives so as to solve the problem of disposing them and producing a cheaper construction material. Also, the gainful effects of these waste materials when used in a composite form on the geotechnical properties of locally available clayey soil can be visualized from this study.

**Index Terms**: Local clay, sand, fly ash, tile waste and California bearing ratio test.

## 1. Introduction

Fly ash is the residue produced from the thermal power plants. Its composition basically depends on the type of coal which is fused during combustion in the power plant. It is a pozzolanic material. Nowadays fly ash has found its application in many areas like manufacturing of cement and bricks, landfiiling, construction of roads and embankments etc. and is thus moved from the category of "hazardous waste" to "useful waste material" in the year 2009 by the government of India. Similarly a large percentage of tile waste is produced in the country arising the need of its proper disposal. Stabilization of poor soil is a rapidly emerging area which can be used for proper utilization of waste material. Many geotechnical engineers have proved the successful application of these waste materials in stabilization of soil. Remond [1961] reported that pulverized fly ash can be effectively used as embankment fill material. Gioia *et al* [1972] and Lenord *et al* [1982] reported fly ash as a good structural fill material. Jirathanathworn and Chantawarangul [2003] reported that by using fly ash mixed with small amount of lime, it is possible to improve some of the engineering properties of clayey soil including hydraulic conductivity as well as strength. Kaushik and Ramasamy [2006] examined the various properties of coal ash to be used as good construction material in geotechnical applications. It is observed that fly ash exhibits high strength at compaction moisture content but poor shear strength characteristics under saturated conditions. Chauhan et al [2008] observed that optimum moisture content increases and maximum dry density decreases with increased percentage of fly ash mixed with silty sand. Bose [2012] reported that fly ash has a good potential of improving the engineering properties of expansive soil. Saha and Pal [2013] achieved improved unconfined compressive strength from the fly ash-soil-fly ash layers placed successively.

Sabat, A.K. [2012] concluded that on increasing the ceramic dust content liquid limit, plastic limit, plasticity index, optimum moisture content and swelling pressure of soil decreases while maximum dry density, unconfined compressive strength, California bearing ratio value and angle of internal friction increases. Ameta *et al.* [2013] observed that on adding ceramic waste to dune sand, improvement in MDD, CBR and shearing resistance value can be observed.

## 2. Physical Properties of Materials Used

Physical properties of soil, sand, fly ash and tile waste used in this study is given in table 1.

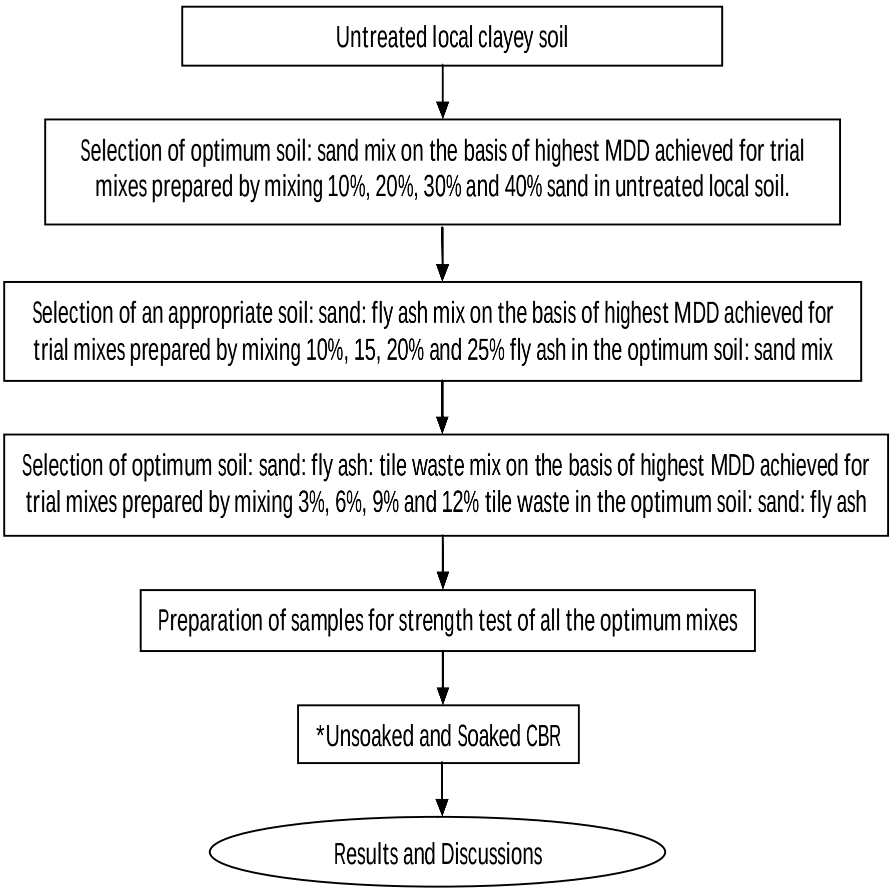
**Table 1:** Physical Properties of soil, sand, fly ash and tile waste.

| Property tested | Soil | Sand | Fly ash | Tile waste |
|---|---|---|---|---|
| Specific gravity | 2.627 | 2.633 | 1.966 | 2.4 |
| Coefficient of uniformity, Cu | - | 1.76 | - | 1.13 |
| Coefficient of curvature, Cc | - | 1.07 | - | 7.79 |
| Liquid limit (%) | 42.79 | - | 40.14 | * Tile waste |

| | | | | |
|---|---|---|---|---|
| Plastic limit (%) | 22.45 | - | NP | used was crushed in the size range smaller than 4.75mm. |
| Plasticity index (%) | 20.34 | - | - | |
| Soil classification(ASTM standard) | CL | - | - | |
| Optimum moisture content (%) | 12.0 | 6.76 | 31.52 | |
| Maximum dry density (gm/cc) | 1.926 | 1.60 | 1.18 | |

## 3. Test Methodology Adopted

All the tests were conducted in accordance with ASTM standards in the following phases as shown in the flow chart.




## 4. Result and Discussion

### 4.1. Particle size distribution analysis

Particle size distribution curves shown in fig1 depicts that soil and fly ash are uniformly graded in nature while sand and tile waste are poorly graded nature in nature.

**4.2. Compaction characteristics**

In the first phase of compaction when soil was mixed with sand in different percentages i.e. 10%, 20%, 30% and 40%, the maximum dry density increases up to 30% addition of sand from the value of 1.95gm/cc to 1.997gm/cc and then decreases for 40% sand to a value 1.96gm/cc as shown in fig.2.This happened because for the initial compositions sand occupied the void spaces in the soil-sand mix but thereafter it starts creating segregation in the mix which decreases the maximum dry density of the mix. Also addition of sand imparted a continuously reducing trend of optimum moisture content because of the coarse grained nature of sand. So, soil:sand::70:30 was selected as the optimum soil:sand mix. In the next phase of compaction fly ash was added in varying percentages i.e.10%, 15%, 20% and 25% in the soil:sand::70:30 mix. In this case the maximum dry density was found to be continuously reducing for every mix while optimum moisture content showed reverse trend as shown in fig.3. This happened because fly ash particles were lighter and has got larger specific area in comparison to that of soil and sand. In the last phase of compaction the appropriate soil-sand-fly ash mix chosen i.e. soil:sand:fly ash::63:27:10 was modified by adding different percentages of tile waste i.e. 3%, 6%, 9% and 12%. On adding tile waste increase in maximum dry density was noticed up to 9% tile waste from 1.875gm/cc to1.918gm/cc and decreases to 1.910gm/cc for 12% tile waste. Thus the most suitable and optimum mix proportion selected was soil:sand:fly ash:tile waste::63:27:10:9.

**4.3. California bearing ratio test results**

Upon carrying unsoaked and soaked California bearing ratio test on all the optimum mixes i.e. soil:sand::70:30, soil:sand:fly ash::63:27:10 and soil:sand:fly ash:tile waste::63:27:10:9 it was concluded that both unsoaked and soaked CBR values are considerably larger than that for pure soil thus showing the better applicability of these mixes as sub grade material in the construction of pavement because as per IRC recommendations the thickness requirement reduces by about 35% for 1.0msa traffic when CBR value increases from 2% to 5%.The varying soaked and unsoaked values of all the optimum mixes are shown in fig.5.The basic reason for the improving trend of CBR values can be the better compacted matrix structure obtained on combining all the additives in appropriate proportion in the soil.

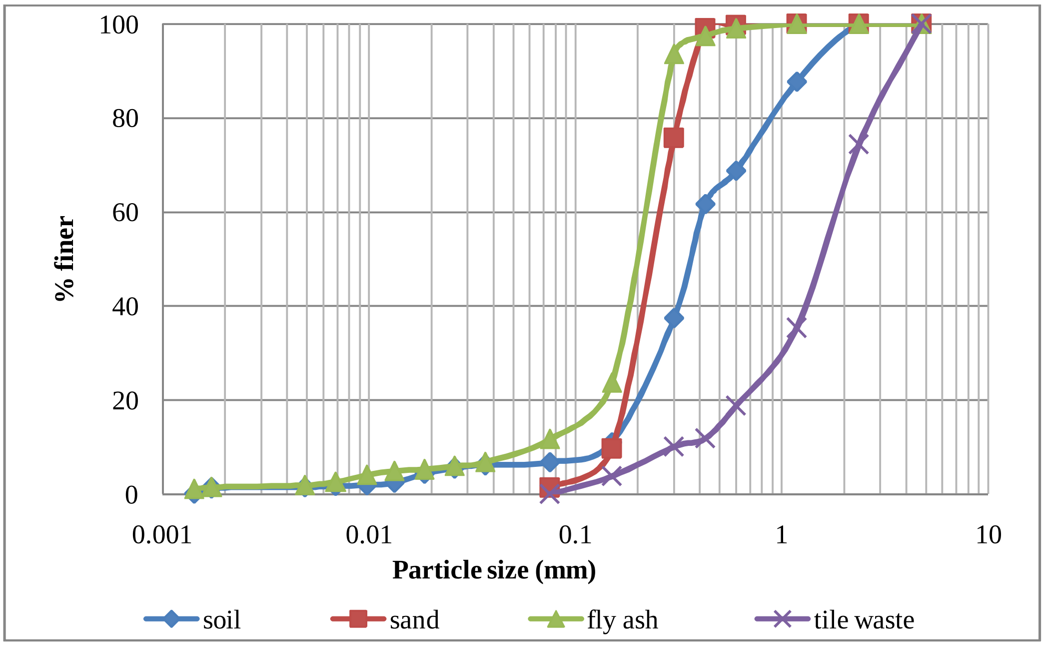



**Figure 1:** Particle size distribution curve of soil, sand, fly ash and tile waste

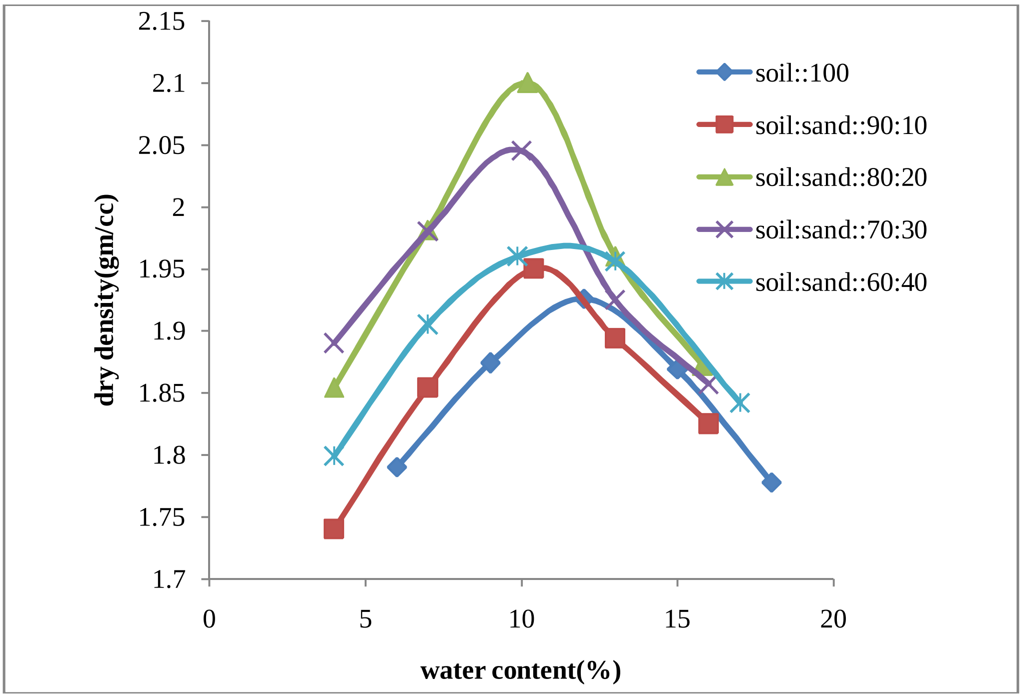



**Figure 2:** Compaction characteristics curve of soil-sand mixes

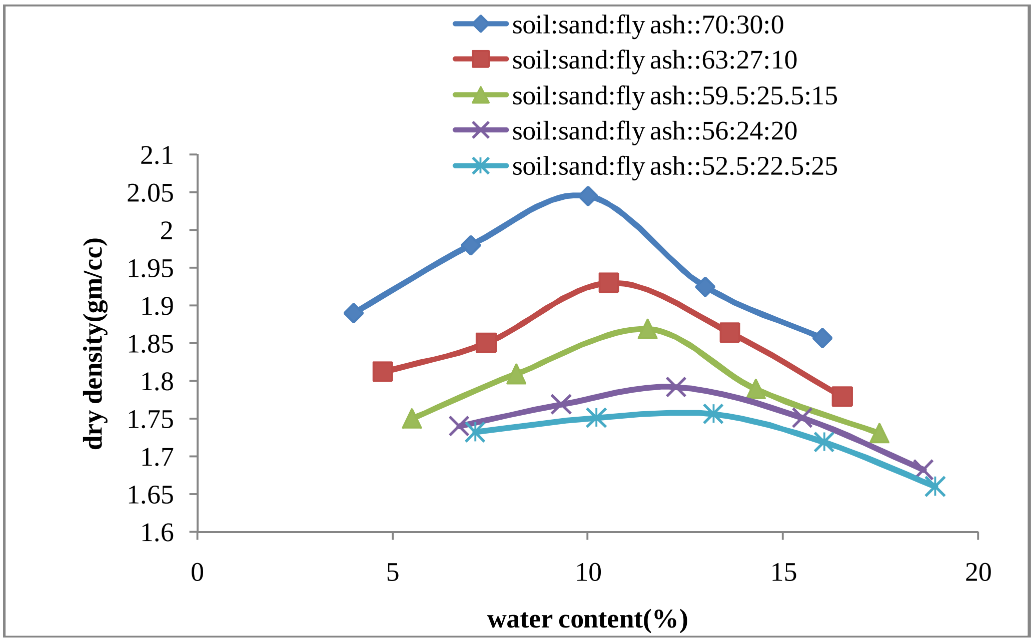



**Figure 3:** Compaction characteristics curve soil-sand-fly ash.

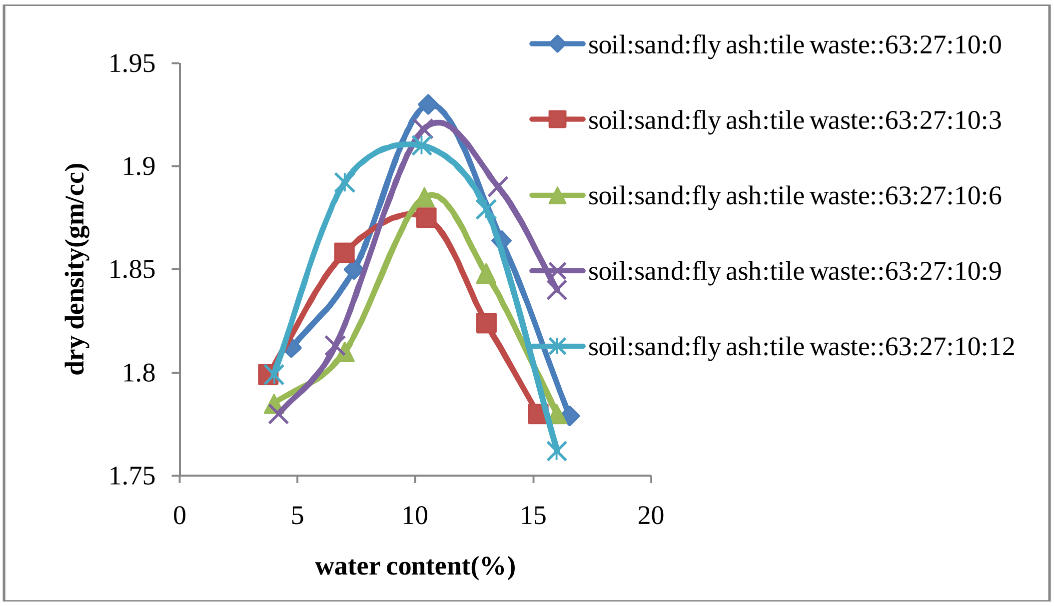



**Figure 4:** Compaction characteristics curve of soil-sand-fly ash-tile waste.

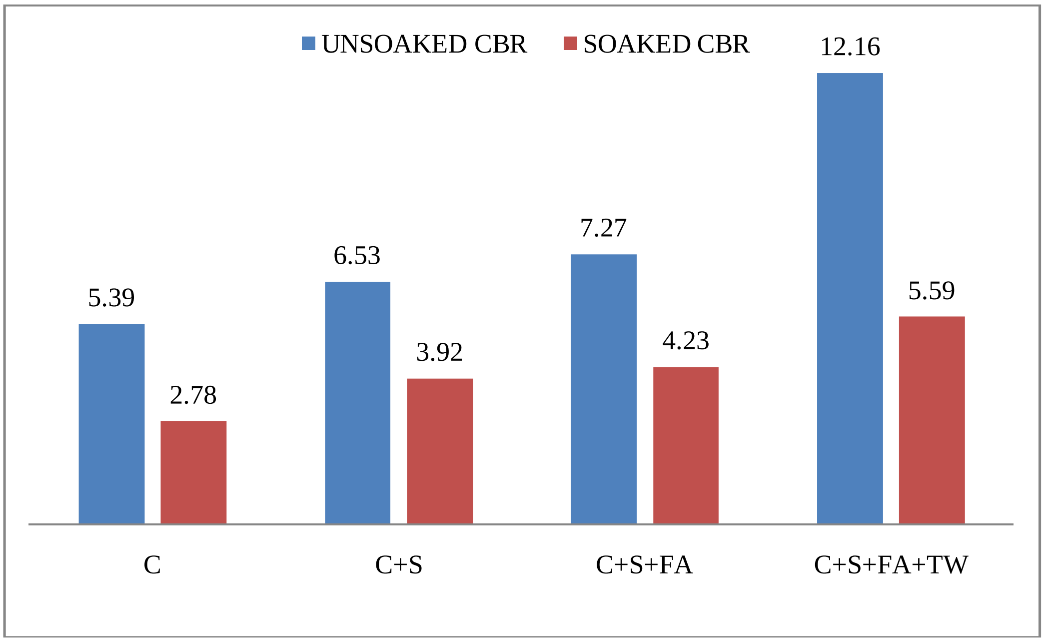



**Figure 5:** Variation of unsoaked and soaked CBR values for optimum mixes. (C–clay, S–sand, FA–fly ash and TW–tile waste)

## 5. Conclusions

1. The soil:sand::70:30 is the optimum soil:sand mix because it has the highest maximum dry density in comparison to other soil-sand mixes.
2. Addition of fly ash in the optimum soil-sand mix causes decreases in the maximum dry density and increase in the optimum moisture content.
3. Addition of tile waste in the appropriate clay-sand-fly ash mix initially causes increase in the maximum dry density and then decreases it while it does not alter the value of optimum moisture content much.
4. Soaked and unsoaked value of California bearing ratio improves with the addition of sand, fly ash and tile waste in soil in the proper proportion selected on the basis of compaction characteristics.
5. The increase in California bearing ratio value results in a better sub-grade material.

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