The Effect of Industrial Wastes on Coir Fibre Stabilized Weak Soil

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***Abstract*— Soil reinforcement has been used in the past few decades to improve the engineering properties of soil. Soils with poor or inadequate engineering properties were usually removed and replaced or design would be changed to suit the weak soil. This would often be expensive and time consuming. In this context, soil reinforcement is an attractive alternative for its simplicity and economy. Large areas of Palakkad district in Kerala are covered with weak soils which have poor shear strength and high compressibility. The construction of civil engineering structures on such weak soils is dangerous. A number of failures of engineering structures have been reported in these areas covered with weak soil and thus improvement of the soil properties have become a necessity in this area. The weak soil found in Palakkad regions can be improved by adopting various ground improvement techniques like stabilization of soil by reinforcements or suitable stabilizers. This paper investigates the effect of various industrial wastes on coir fibre stabilized weak soil. The materials used for study include coir fibre, steel slag, foundry sand and silica fume**.

Keywords*— *Coir fibre; sisal fibre ; steel slag; silica fume

I. INTRODUCTION

Urbanisation and growth in the economy of India have led to a steep increase in the building construction activities. This in turn increased the demand for good quality earth in massive quantities. This lead to the need for stabilizing problematic soils. Large areas of Palakkad district in Kerala are covered with weak soils which have poor shear strength and high compressibility. Soil reinforcement has been used in the past few decades to improve the engineering properties of soil. Soils with poor or inadequate engineering properties were usually removed and replaced or design would be changed to suit the weak soil which would often be expensive and time consuming. In this context, soil reinforcement is an attractive alternative for its simplicity and economy. This paper investigates the effect of various industrial wastes on coir fibre stabilized weak soil. The materials used in the present study include coir fibre, steel slag, and silica fume and foundry sand. Steel slag, a by-product of steel making, is produced during the separation of the molten steel from impurities in steel-making furnaces. The slag occurs as a molten liquid melt and is a complex solution of silicates and oxides that solidifies upon cooling. Silica fume is a by product of producing silicon metal or ferrosilicon alloys. It is a by product of the ferrous and nonferrous metal casting industry. Foundry sand consists primarily of clean, uniformly sized, high-quality silica sand or lake sand that is bonded to form moulds for ferrous (iron and steel) and nonferrous (copper, aluminium, brass) metal castings. In this study compaction characteristics and shear strength characteristics of coir fibre stabilised weak soil are studied. The effect of steel slag and silica fume on the compaction characteristics and shear strength characteristics of coir fibre stabilized weak soil are also studied.

II. MATERIALS

A. Soil

The investigation was carried out on black cotton soil collected from Vadakarapathy village in Palakkad district. Geotechnical properties of weak soil are given in table 1

TABLE 1: PHYSICAL PROPERTIES OF SOIL

Properties	**Values**
Liquid Limit	51%
Plastic Limit	28.32%
Shrinkage Limit	19%
Plasticity Index	22.68%
UCC Value	23.6 KN/cm^2
Optimum Moisture Content(OMC)	21.2%
Maximum Dry density	18.2KN/m^2
Specific Gravity	2.53
Clay	51%
Silt	29%
Sand	20%
Soil Classification	CH

The materials used for this study include coir fibre, steel slag, and silicafume and foundry sand.
Coir fibre: Coir fibre is of length 10mm and diameter 0.15mm to 0.65 mm .

TABLE 2: PHYSICAL PROPERTIES OF COIR FIBRE

Property	**Values**
Colour	Light brown
Length	10mm
Average Diameter	0.4mm
Specific gravity	0.71

TABLE 3: CHEMICAL COMPOSITION OF COIR FIBRE

Constituents	Percentage
Lignin	45.84%
Cellulose	43.44%
Hemi-cellulose	0.25%
Pectin	3%
Water soluble compounds	5.25%
Ash	2.22%

Steel slag: The physical properties and particle size distribution of steel slag are given in table 4.

TABLE 4: PHYSICAL PROPERTIES OF STEEL SLAG

Physical properties	Values
Particle shape	Irregular
Appearence	Black and glassy
Specific gravity	2.83
Gravel (%)	0
Silt and Clay (%)	0
Sand (%)	100

Silica fume: It is an ultrafine powder collected as a by-product of the silicon and ferrosilicon alloy production and consists of spherical particles with an average particle diameter of 150 nm

TABLE 5: PHYSIAL PROPERTIES OF SILICA FUME

Physical properties	Values
Particle shape	Rounded
Appearence	White
Specific gravity	2.2
Gravel (%)	0
Silt and Clay (%)	3.58
Sand (%)	96.48

Foundry Sand: It is a byproduct of the ferrous and nonferrous metal casting industry'

TABLE 6: PHYSIAL PROPERTIES OF FOUNDRY SAND

Physical properties	Values
Particle shape	Rounded
Appearence	Gray
Specific gravity	2.62
Gravel (%)	0
Silt and Clay (%)	6.95
Sand (%)	93.05

III. METHODOLOGY

In this study weak soil is treated with varying percentages of coir fibre from 0-1.5% in increments of 0.25% by dry weight of soil. Indian standard light compaction tests were conducted on the soil treated with varying percentages of coir fibre and the optimum dosages were determined. Moreover result indicated that the addition of coir fibre increased the strength of weak soil. The coir fibre stabilized soil was then treated with steel slag (3%, 6%, 9%, 12%), silicafume (5%, 10%, 15% ,20%) and foundry sand(10%,20%,30% and 40%) and their optimum dosages were determined.

IV. RESULTS AND DISCUSSIONS

B. Characteristics of coir fibre stabilized soil

Different amount of Coir fibre ie 0.25, 0.5, 0.75, 1, 1.5% dry weight of the soil were used to stabilize the soil and standard proctor test is carried out for each percentage of fibre.

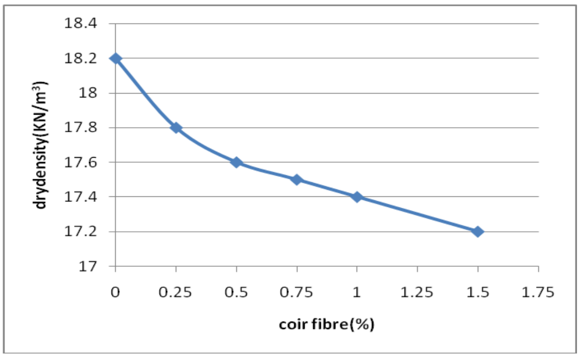

Fig.1 Variation of maximum dry density

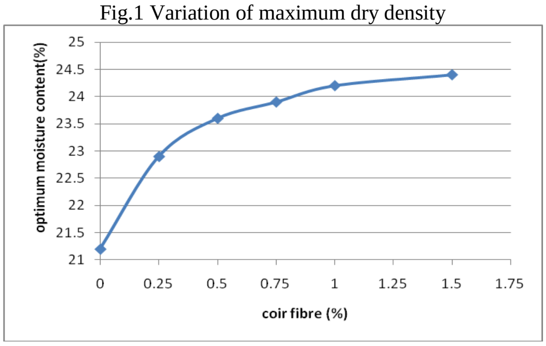

Fig.2 Variation of OMC

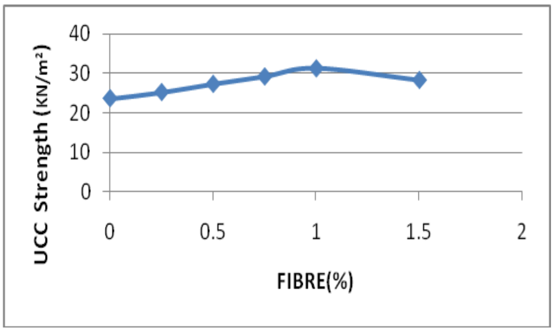

Fig.3 Variation of UCC strength

The variation of dry density for various percentages of coir fibre is shown in figure 1. It is seen that dry density of soil decreases with increase in fibre content. The decrease in dry density of soil is due to lower density of fibre when compare to soil. The variation of optimum moisture content for various percentages of coir fibre is shown in figure 2. The optimum moisture content increases with increase in fibre content.

The variation of unconfined compressive strength against the fibre content for the soil reinforced with coir fibre is shown in figure 3. The unconfined compressive strength is highest at 1%. The maximum strength obtained using coir fibre alone 31.3kN/m^2

C. Effect of steel slag on coir fibre stabilized soil

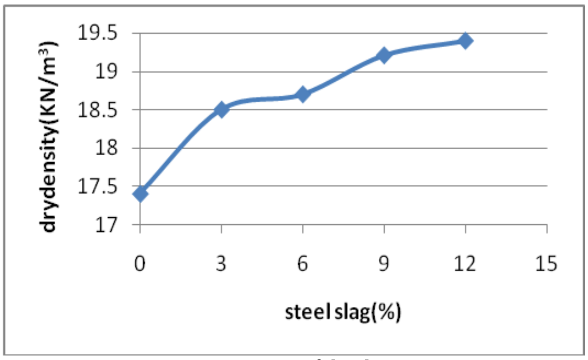

Fig.4 variation of dry density

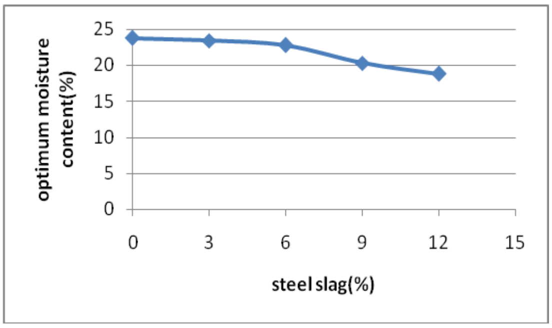

Fig.5 variation of optimum moisture content (OMC)

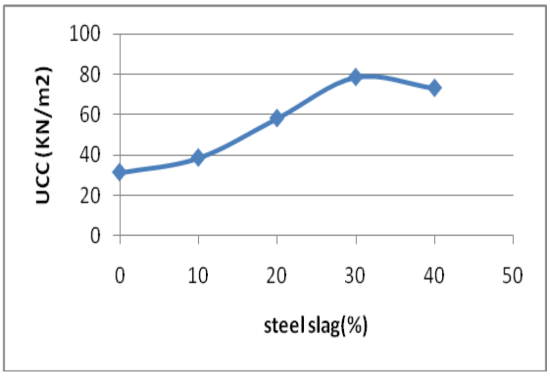

Fig.6 Variation of UCC strength

The variation of optimum moisture content for various percentages of steel slag are shown in figure 8. The optimum moisture content decreases with increase in steel slag. The variation of dry density for various percentages of steel slag are shown in figure 7. It is seen that dry density of soil increases with increase in steel slag content

The variation of unconfined compressive strength against various percentages of steel slag for the soil reinforced with steel slag is shown in figure 9. The unconfined compressive strength is highest at 9% steel slag. The maximum strength obtained using steel slag on coir reinforced soil is 78.62kN/m^2

D. Effect Of Silica Fume On Coir Fibre Stabilized Soil

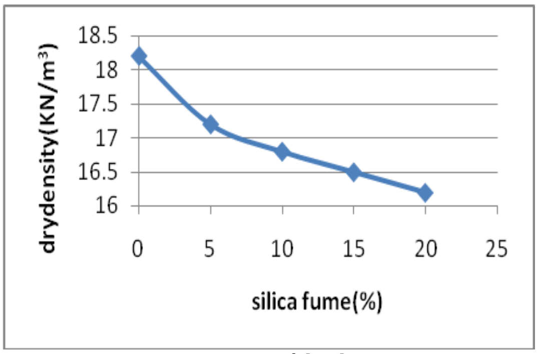

Fig.7 Variation of dry density

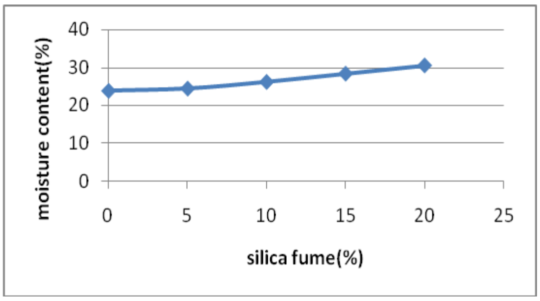

Fig.8 Variation of optimum moisture content (OMC)

The variation of optimum moisture content for various percentages of silica fume is shown in figure 11. The optimum moisture content increases with increase in steel slag. The variation of dry density for various percentages of silica fume are shown in figure 9. It is seen that dry density of soil decreases with increase in steel slag content

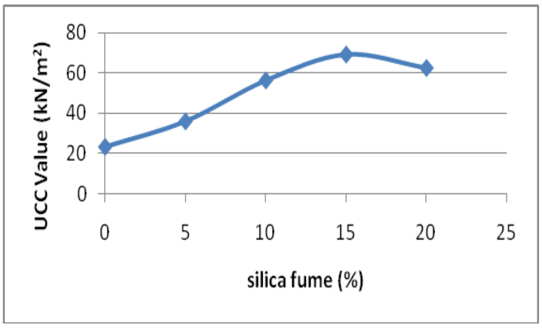

Fig.9 Variation of UCC strength

The variation of unconfined compressive strength against various percentages of silica fume for the soil reinforced with silica fume is shown in figure 4. The unconfined compressive strength is highest at 15%. The maximum strength obtained using silica fume on coir reinforced soil is 69.23kN/m^2.

E. Effect Of Foundry sand On Coir Fibre Stabilized Soil

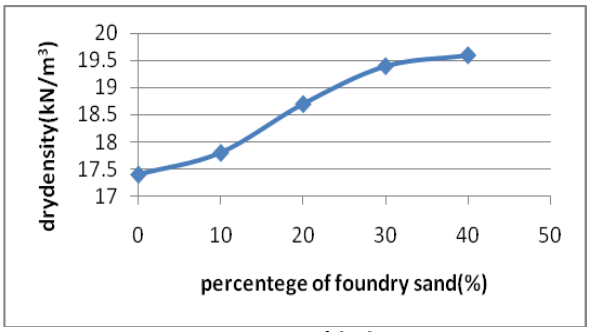

Fig.10 Variation of drydensity

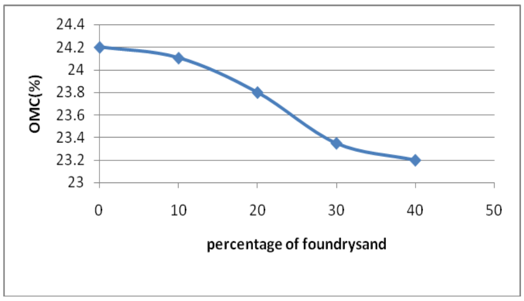

Fig.11 Variation of optimum moisture content (OMC)

The variation of optimum moisture content for various percentages of foundry sand is shown in figure 14. The optimum moisture content decreases with increase in steel slag. The variation of dry density for various percentages of foundry sand are shown in figure 13. It is seen that dry density of soil increases with increase in steel slag content

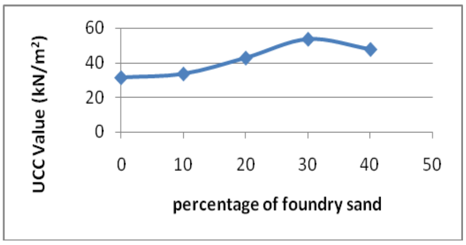

Fig.12 Variation of UCC strength

The variation of unconfined compressive strength against various percentages of foundry sand is shown in figure 15. The unconfined compressive strength is highest at 30%. The maximum strength obtained using silica fume on coir reinforced soil is 53.73KN/m^2.

V. CONCLUSION

- Coir fibre reinforced soil showed significant improvement in strength and the maximum strength obtained using coir fibre alone is 31.3kN/m^2 at 1% fibre content.
- The percentage increase in strength of soil by addition of steel slag is 32%
- The maximum strength obtained using steel slag on coir reinforced soil is 78.62kN/m^2 at 9% steel slag by dry weight of soil.
- The percentage increase in strength of soil by addition of steel slag is 151.182%
- The maximum strength obtained using silica fume on coir reinforced soil is 69.23kN/m^2 at 15% silica fume by dry weight of soil.
- The percentage increase in strength of soil by addition of silica fume is 121.8%
- The maximum strength obtained using foundry sand on coir reinforced soil is 53.73kN/m^2 at 30% foundry sand by dry weight of soil.
- The percentage increase in strength of soil by addition of foundry sand is 71.66%

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