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CLAYEY SOIL TREATED WITH FOUNDRY SAND AS A HYDRAULIC BARRIER MATERIAL

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ABSTRACT: Foundry sand is a material used in metal casting industry. The main content of foundry sand is silica sand, small percentage of clay, coal dust. In past, foundry sand was used as landfill material. The foundry sand can be used in many of the geotechnical field. In recent studies foundry sands used as a material for hydraulic barrier, sub base etc. The beneficial use of foundry sands can be made by determining typical strength parameters. Clay is distinguished from other fine-grained soils by differences in size and their properties. This study deals with the study of compaction behavior, plasticity characteristics and performance of foundry sands as a hydraulic material at different proportion of foundry sands to clay .In order to study the behavior of foundry sand with clayey soil tests such as Atterberg limits, compaction tests, permeability tests, unconfined compressive strength tests, volumetric shrinkage strain tests are conducted. Laboratory tests were carried out by adding foundry sand up to 30%with clay .The specimens were moulded at varying water content -2%,0%,+2%,+4% of optimum moisture content.

INTRODUCTION

The use of waste materials is continuously advancing in the field of soil improvement. Soil which lack some properties are made suitable as a construction material either by chemical treatment or blending with other materials to make them suitable for geotechnical applications. A large amount of sand as a part of metal casting process is used in metal foundries. The foundry sand is the excess sand that is removed from metal casting foundries. The production of waste foundry sand is increasing rapidly in India which causes severe disposal problems. Due to the above reasons, the utilization of foundry sand is attracting lots of researches. Some of the application areas of foundry sand includes highway bases ,retaining structures, flow able fills and pavement bases .The objective of this paper is to study the compaction behaviour, plasticity characteristics and performance of foundry sands as a hydraulic material at different proportion of foundry sands to clay, thus to determine the acceptable zone The design parameters for hydraulic barrier are hydraulic conductivity of less than or equal to 10^{-7}cm/s, adequate shear strength and volumetric shrinkage strain.

LITERATURE REVIEW

Various researches have studied the behavior of foundry sand as a hydraulic barrier([1],[2],[3]) and found that If Liquid Limit is greater than 20,Plasticity index greater than 2 the hydraulic conductivity of foundry and will be smaller than$1\times10^{-}7$cm/s. Barriers constructed with foundry sand are more resistance to environmental distresses. Investigation on varying compactive energy found that decrease in hydraulic conductivity at low compactive energy([3],[9]).The improvement in strength is achieved below 40% of addition of foundry sand to clay ([6],[7],[8]).The reduction in liquid limit improves the drainage property of soil. Blending foundry sand is effective way of reducing plasticity of waste heavy clay ([4]).

EXPERIMENTAL PROGRAM

Materials Used

The soil used in this study was locally available clay obtained from Kallur,Thrissur and foundry sand was obtained from AUTOCAST Pvt.Ltd, Cherthala,Alappuzha. According to IS soil classification system (IS 2720) clayey soil was classified as highly plastic clay (CH). The properties of clayey soil and foundry sand are given in Table 1.

Table 1: Physical properties of clay & foundry sand

Property	Clay	Foundry Sand
Specific gravity	2.51	2.52
Liquid limit(%)	58	30
Plastic limit(%)	27	24
Plasticity index(%)	31	6
Shrinkage limit(%)	14	-
Optimum moisture content O M C(%)	27	17
Maximum dry density, γd (kN/m^3)	14.8	16.6
Percentage of Clay(%)	52	14.9
Percentage of Sand(%)	21	75
Percentage of Silt(%)	27	10.1
Unconfined compressive strength(kN/m^2)	63.7	-
IS soil classification	CH	ML

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Method of Testing

The laboratory test was carried out in accordance with IS soil classification systems. Liquid Limit, Plastic Limit-IS 2720 (Part5):1985,Light Compaction- IS2720(part7) :1980, Unconfined Compressive Strength test –IS 2720 (Part 10):1991,Permeability test-IS 2720 Part 15:1965 Volumetric shrinkage strain- IS 2720 (Part 6):1972.

The physical properties of clay and foundry sand are given in Table 1. The particle size distribution curve of clay and foundry sand are given in Figure 1.Compaction tests are conducted on clay with varying percentage of foundry sand from 5% to 30% and optimum mixes were obtained. After obtaining optimum mixes of clay unconfined compressive strength tests, permeability tests, volumetric shrinkage tests were conducted at varying molding water content -2%,0%,+2%,+4% of OMC.

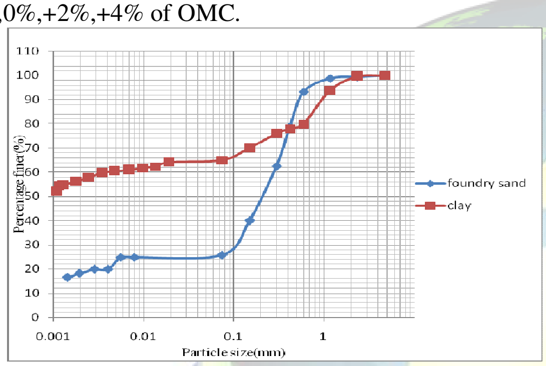

Figure 1: Particle size distribution of clay and foundry sand

RESULTS AND DISCUSSIONS

Atterberg Limit Tests

Results of Atterberg limit tests are shown in Table 2 and Figure 2. It can be seen that, generally, with increasing foundry sand content, the liquid limit(LL), plastic limit(PL) and plasticity index(PI) decreased. By addition of foundry sand Liquid limit decreased up to 20% then it increased.

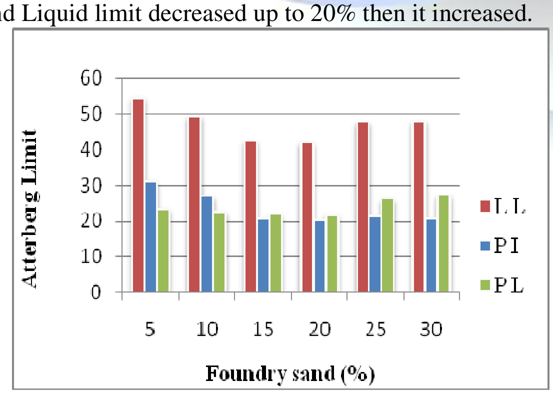

Figure 2: Variation of Atterberg limit with varying percentage of foundry sand

Table 2: Atterberg Test Results

Foundry sand (%)	5	10	15	20	25	30
LL	54	49	43	42	47	48
PL	24	23	22	21	27	28
PI	30	26	21	21	20	20

Compaction Tests

The water content-dry density curves of clayey soil mixed with foundry sand content varying from 5% to 30%are shown in Fig. 3. It is observed that maximum dry density of clay-foundry sand composite increases with increase in sand content up to 25% after which it is reduced. The optimum percentage of foundry sand is 25% and the maximum dry density is 15.7kN/m^3. The voids between the foundry sand particles are occupied by the clay particles when the sand content is less but larger sand content segregates the particles and the maximum dry density decreases. The variation of maximum dry density and optimum moisture content with foundry sand is shown in Figure 4 and Figure 5.

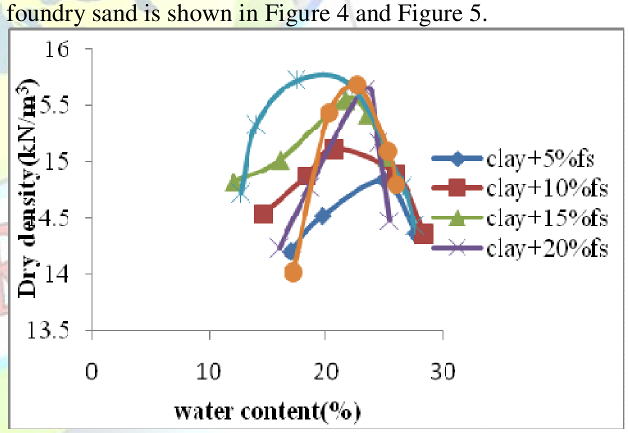

Figure 4: Compaction characteristics of clay-foundry sand mixes

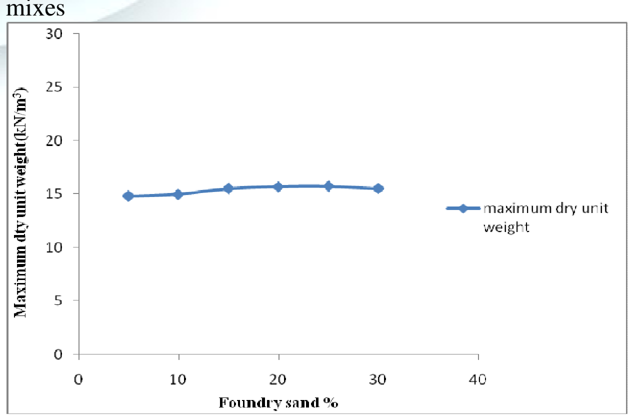

Figure 5: Variation of maximum dry density with foundry sand

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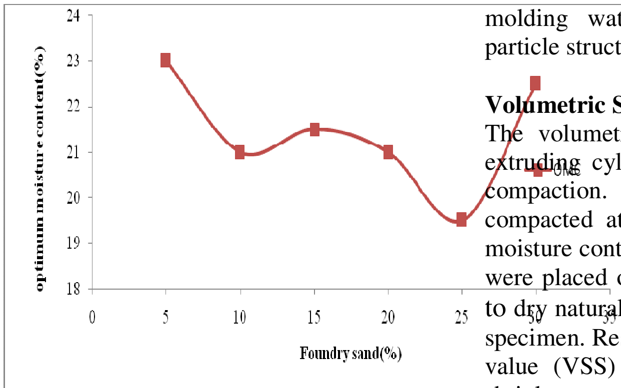

Figure 6: Variation of Optimum Moisture Content (OMC) with Foundry sand

Unconfined Compressive Strength Tests

The specimen was prepared according to IS 2720 (part 10)-1991 at a molding water content of -2%,0%/,+2%,+4%OMC to 5%,10%,15%,20% and 25%foundry sand. Arbitrarily selected a minimum of 200kN/m^2 as the minimum required strength of soil to be used in compacted soil liners required to support the maximum bearing stress in a landfill. The variations of unconfined compression test with water content are shown in Fig.7. The unconfined compressive strength increased to a value of 205.8kN/m^2 as the molding content increases up to +2% of OMC and the decreased.

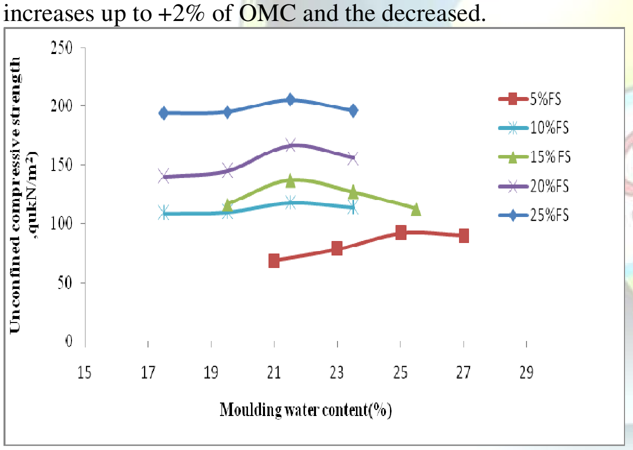

Figure 7: Variation of unconfined compressive strength test with varying moulding water content

Hydraulic Conductivity

Hydraulic conductivity is the key parameter affecting performance of liners and cover .hydraulic conductivity is determined by falling head method. The relationship between hydraulic conductivity and moulding water content with varying percentage of foundry sand to clay (5% to 25%) is shown in Figure 8. Generally the hydraulic conductivity obtained its lowest value at the wet side of compaction, especially at +2% OMC for most of the specimens. Beyond +2% OMC and before+2% OMC there is generally an increase in hydraulic conductivity values. The increasing molding water content facilitates deflocculating of the particle structure, reducing the void.

Volumetric Shrinkage (VSS)

The volumetric shrinkage upon drying was measured by extruding cylindrical specimens, compacted using the light compaction. Clayey soil –foundry sand mixtures were compacted at – 2%, 0%, +2% and +4% of the optimum moisture content (OMC). The extruded cylindrical specimens were placed on a laboratory bench at a uniform temperature to dry naturally. And measure the diameter and height of the specimen. Researchers suggested a safe Volumetric shrinkage value (VSS) value of less than or about 4% volumetric shrinkage strain (VSS) upon drying for soil liners when compacted cylinders as used to predict field desiccation due to cracking. The variation in VSS with moulding water content at 5% to 25% foundry sand is shown in Figure 9

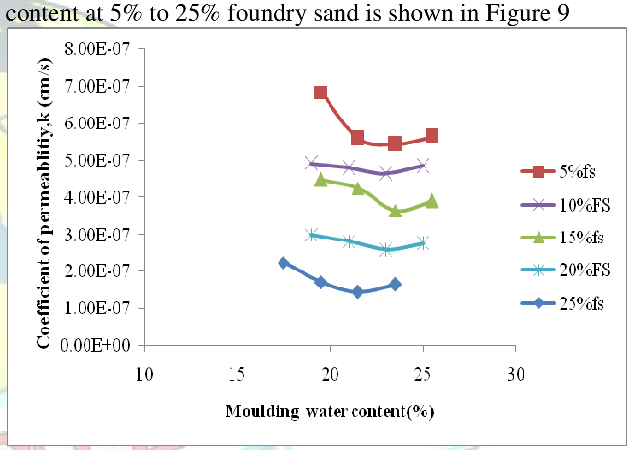

Figure 8: Variation of permeability with moulding water content

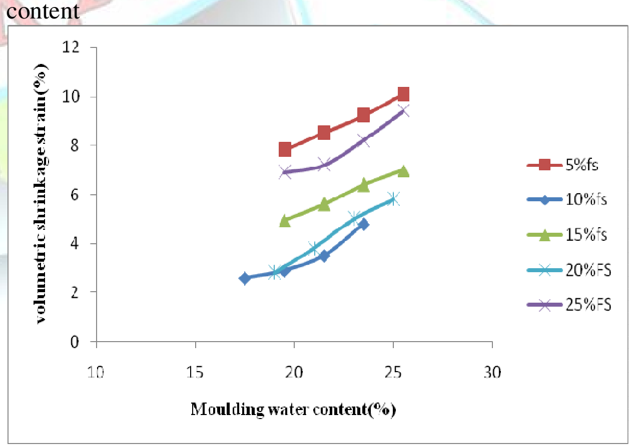

Figure 9: Variation of volumetric shrinkage with moulding water content

ACCEPTABLE ZONES

The parameters for the design of hydraulic barriers include a low hydraulic conductivity less than 10^{-7}, the volumetric shrinkage strain should be less than 4% and high value of unconfined compressive strength, greater than 200kN/m^2.

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The acceptable range of mouding water content is shown in Table 3.The acceptable moulding water content range is between 17.5 to 23.5% at 25% of foundry sand.

Table.3 Acceptable range of moulding water content

Engineering criteria	Foundry sand %		
	5	15	25
	Moulding water content range %		
K,cm/s			21.5-23
UCS, kN/m^2			19.5-23.5
V S S(%)		18.5-20	17.5-21.5
Acceptable Range %	17.5-23.5		

CONCLUSIONS

The addition of foundry sand increased the maximum dry density and decreased the optimum moisture content. The optimum percentage of foundry sand is 25%. The maximum dry density is 15.7(kN/m^3). In order to determine the suitable acceptable zone for the three important parameters hydraulic conductivity, unconfined compressive strength and volumetric shrinkage specimens were compacted at -2%, 0% +2% and +4% of the optimum moisture content. For the Unconfined compressive strength, the result show a general improvement in strength for up to 25% with foundry sand, this is largely as a result of the pozzolanic input of foundry sand which produced stronger bonds. Treatment with foundry sand produced improvement in volumetric shrinkage strain. The recommended acceptable zone that produced a convergence of the specification requirements of the three important parameters for the design of hydraulic barrier achieved at 25% treatment of foundry sand and at moulding water content ranges 17.5% to 23.5%.

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