

Shear Characteristics of Fly Ash-Granular Soil Mixtures Subjected to Modified Compaction

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ABSTRACT: The gravelly soil compacted at its optimum moisture content is having higher dry density compared to all flyash gravel mixture both in Light and modified compaction. The MDD values decreases slightly with percentage of flyash for 0% to 10% and 25% to 30% in modified compaction. It is due to increase of addition of flyash can result in excess of finer fraction and leads lesser weight and cause reduced values of dry densities of flyash gravel soil mixtures. As percentage of flyash increases in soil gravel mixtures the OMC increases both in Light and modified compaction. It can be attributed that by increase of addition of flyash the water holding capacity increases due to increase of silt fraction in the soil mix. The angle of internal friction ' ϕ ' decrease from 36.24° to 29° for flyash proportions of 0% to 30% in granular soil and percentage decrease in each successive percentage fly ash in soil mixture is 5%. There was sudden decrease in the angle ' ϕ ' and is about 10% for 25% to 30% fly ash soil mixtures. For 10% to 25% fly ash soil mixtures, the value of ' ϕ ' slightly varies from 33.7° to 32° . Therefore 10% to 25% can be used effectively along with granular soil. From the results of compaction and strength tests, 20% to 25% fly ash addition to gravelly sand do not affect the properties of granular soil. The fly ash soil mixture is showing encouraging results towards utilization of fly ash with gravelly sand for low to high volume traffic conditions in pavement construction.

KEY WORDS: maximum dry density(MDD), optimum moisture content(OMC), California bearing ratio(CBR), fly ash granular soil mixtures, direct shear, angle of internal friction, water Content, percentage flyash (% FA), Cohesion

I. INTRODUCTION

The problem with fly ash lies in the fact that not only does it generated annually in India, with 65 000 acres of land being occupied by ash ponds. Such a huge quantity does pose challenging problems, in the form of land usage, health hazards, and environmental dangers. Both in disposal, as well as in utilization, utmost care has to be taken, to safeguard the interest of human life, wild life, and environment. Due to its self-cementing properties, fly ash can be an effective stabilizer for granular and fine grained materials. Fly ash by itself has little cementitious value but in the presence of moisture it reacts chemically and forms cementitious compounds and attributes to the improvement of strength and compressibility characteristics of soils. Expansive soils can be potentially stabilized effectively by cation exchange using fly ash. Utilization of fly ash towards engineering applications can solve two major issues: (i) environmental pollution problem and (ii) wastage of land due to its dump on the agricultural land. Generally, clay soils have soaked CBR values from 1.5% to 5% (Rolling's and Rolling's 1996), which provides very little support to the pavement structure. Addition of 16% self-cementing fly ash increases the soaked CBR values of heavy clay soils into the mid-30s, which is comparable to gravelly sands (Rolling's and Rolling's 1996). Prasanna Kumar (2011) studied the cementitious compounds formation using pozzolans and their effects on stabilization of soils such as black cotton soils and red earth soils for varied proportions of fly ash. There are many investigations carried out towards utilization of fly ash especially in stabilizing the swelling soils (Kate, 1998; ErdalCokca, 2001; Pandian et al, 2002; Phani Kumar and Sharma, 2004; Rao and Shivananda, 2005; Prasad et

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al, 2010; Sivapullaiah and Arif, 2011). There are few studies available in the literature relevant to the utilization of fly ash along with granular soils in the road construction. The present study is focused mainly to understand the shear characteristics of fly ash granular soil mixtures when subjected to different compactive efforts.

II. MATERIALS AND TEST METHODS

The gravelly sand used in the present study was collected from sekuru village near Guntur, Andhra Pradesh state, India. The soil collected was kept in controlled conditions in the laboratory and was used for testing as per the Indian Standard specifications given in the respective test codes. For this soil, the basic tests were conducted in the laboratory for its characterization. As per the basic properties of soils are concerned, it indicates that the soil is greyish to brown in colour and has soil proportions of gravel, sand and little fine fraction. The soil has 0.35% slit and clay, 92% sand and 7% gravel fractions. The grain size distribution curve of the soil is presented in Fig.1. The various basic properties of soil are presented in the Table.1.

The fly ash used in this investigation was collected from Vijayawada Thermal Power Station (VTPS) Vijayawada. The fly ash sample collected was stored in the air tight containers. The grain size distribution curve [IS: 2720 (Part 4)-1985] for fly ash is presented in the Fig.1 The various properties of the fly ash obtained from the Vijayawada Thermal Power Station (VTPS), Vijayawada, AP state, India are presented in the Table.2. The fly ash proportions adopted are 0%, 5%, 10%, 15%, 20%, 25% and 30% by dry weight of soil.

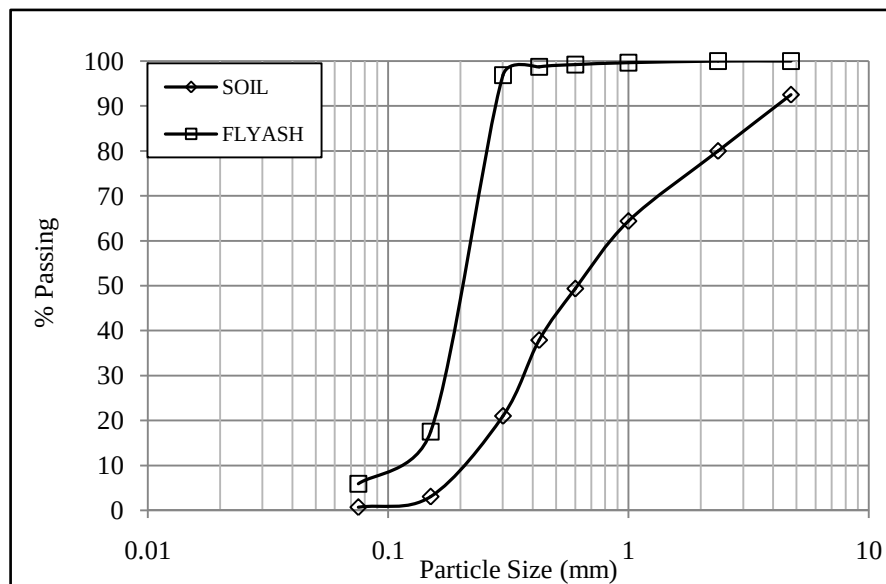


Fig.1 Grain size distribution curve for soil and fly ash

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Table 1 Basic properties of soil

Property	Value
Specific gravity	2.62
Cohesion, c (kPa) in Modified Compaction	10.85
Angle of Internal Friction, ϕ (deg.) in Modified Compaction	36.24
Optimum Moisture Content, OMC (%) in Modified Compaction	08.00
Maximum Dry Density, MDD (kN/m^3) in Modified Compaction	19.90
% Gravel	7.50
% Coarse Sand	12.50
% Medium Sand	42.10
% Fine Sand	37.25
% Silt & Clay	0.35
Effective Diameter, D_{10} (mm)	0.21
Coefficient of Uniformity, c_u	04.28
Coefficient of Curvature, c_c	0.76
Soil Classification	SW

Table.2 Properties of fly ash

Property	Value
Specific Gravity	1.97
Cohesion, c (Kpa) at OMC	10
Angle of Internal friction, ϕ (Deg.)	28
Optimum Moisture Content OMC (%)	18
Maximum Dry Density, MDD (KN/m^3)	13.80
% Gravel	0
% Sand	97.5
% Silt and Clay	2.5

Grain Size Distribution

The grain size distribution test was conducted as per the specifications given in the IS: 2720 (Part 4)-1985. The graphs plotted between percent passing versus particle size for the various proportions of flyash in granular soil.

Compaction Test

IS light and modified compaction tests have been conducted on the soil with different percentage of flyash such as 5%, 10%, 15%, 20%, 25% and 30% and determined the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) as per IS:2720 (Part 7)-1980. The modified compaction tests are adopted because the majority highway pavements are designed for high volume traffic loading.

Direct Shear Test

To understand the strength aspects of fly ash gravelly sand mixtures, the direct shear test was conducted on sample mixtures with percentage of fly ash from 0% to 30% by dry weight of granular soil compacted at modified compaction as per [IS: 2720 (Part 13)-1986] at respective optimum moisture content.

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III. RESULTS AND DISCUSSIONS

Compaction Characteristics

For gravelly sand as the compactive effort increases the water content is reducing and the maximum dry density is increasing. Due to the increase in compactive effort the maximum dry density is increased from 19.95 kN/m^3 to 20.9 kN/m^3 and the optimum moisture content is decreased from 8 to 7.5%. Similarly in the case of pure flyash as the compaction effort increases the maximum dry density (MDD) of fly ash is increasing from 12.65 to 13.85 kN/m^3 and the optimum moisture content (OMC) of fly ash is decreasing from 19.5% to 18%. The compaction curves of gravelly sand are placed high as compared to the compaction curves of flyash are shown in fig.2.

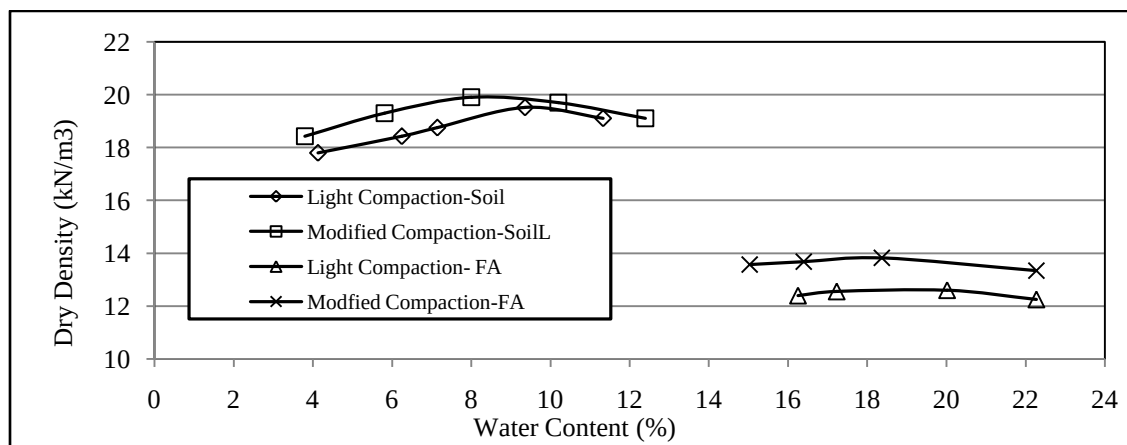


Fig. 2 Compaction curves for gravelly sand and flyash subjected to light and modified compaction

Shear Characteristics

To understand the strength aspects of fly ash gravelly sand mixtures the direct shear test was conducted and the results are presented in Fig. 3 to 7. The tests were conducted on sample mixtures compacted at modified compaction at respective optimum moisture contents.

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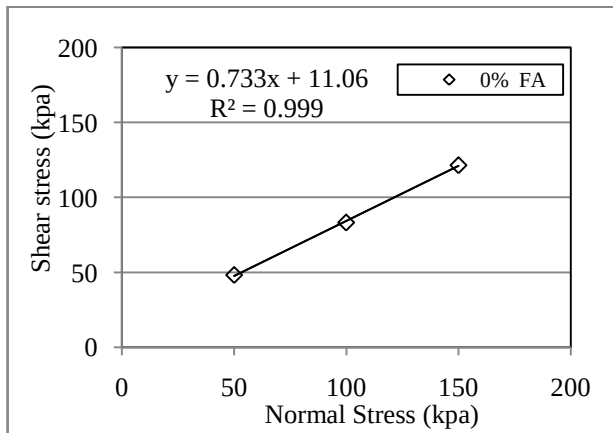


Fig. 3Strength envelopes for Gravelly sand tested at Modified

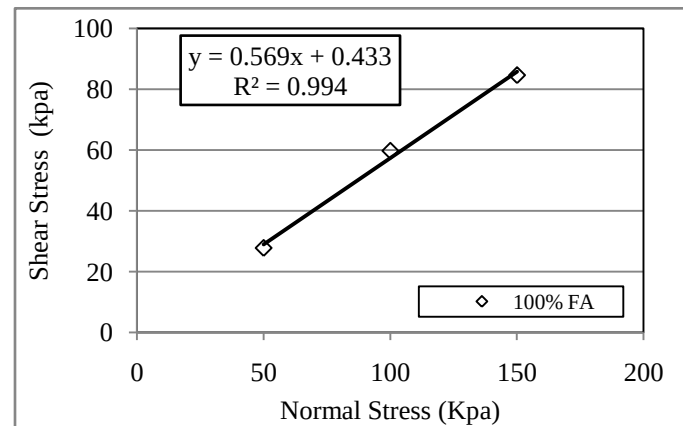


Fig.4 Strength envelopes for fly ash tested at modified compaction

Fig 3 presents the strength envelope of gravelly sand sample prepared at modified compaction. The strength envelope obtained for modified compaction is showing small pseudo cohesion. Fig. 4 presents the strength envelope for the flyash prepared at modified compaction showing small pseudo cohesion. Fig 5 presents the strength envelopes of flyash gravelly sand mixtures prepared at respective optimum moisture contents (OMCs) obtained from the modified compaction test results. From the results the variation friction angle with the percentage of fly ash is studied and presented in the fig.6. There is a reduction in angle of internal friction as the percentage of fly ash increases in the mixture. From this figure, it can be clearly seen that up to about 30% of fly ash addition to gravelly sand causing no drastic reduction in the angle of internal friction. Whereas, the strength envelopes corresponding 10% to 25% of flyash are moving parallel with a merged manner. From this behavior, it can be understand that up to about 10% to 25% of fly ash addition to gravelly sand, imparting more inter locking and bonding due to the modified compaction. The values of angle of internal friction and cohesion corresponding to percentage of fly ash from 0% to 30% are tabulated in table 3. From the test results the variation of cohesion with the percentage of fly ash is studied and is shown in fig. 7. The cohesion is maximum for 5% flyash granular soil mixture and is decreasing gradually and attains maximum value for 30% flyash granular soil mixture. The values of angle of internal friction and cohesion with different percentage of flyash are shown in the table 3.

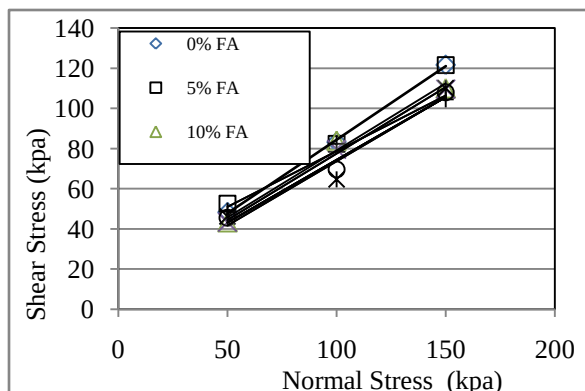


Fig. 5Strength Envelops for fly ash Gravelly sand mixtures tested at Modified compaction

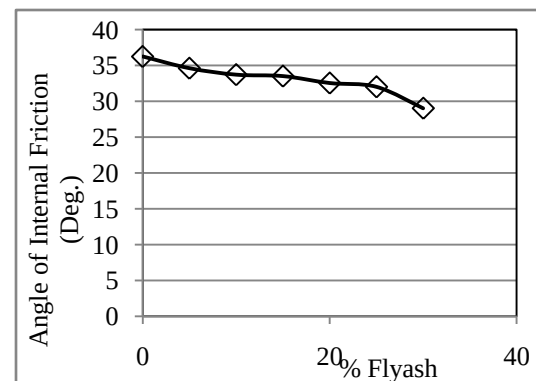


Fig. 6Variation of angle of internal friction with the percentages of fly ash

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Table 3 Values of angle of internal friction and cohesion of Granular soil with percentage of fly ash

% Fly ash	Angle of internal friction, ϕ (Deg.)	Cohesion c(Kpa)
00	36.25	10.85
05	34.5	16.15
10	33.5	12.00
15	33.5	11.00
20	32.5	9.50
25	32.0	11.50
30	29.0	22.50
100	29.5	0.40

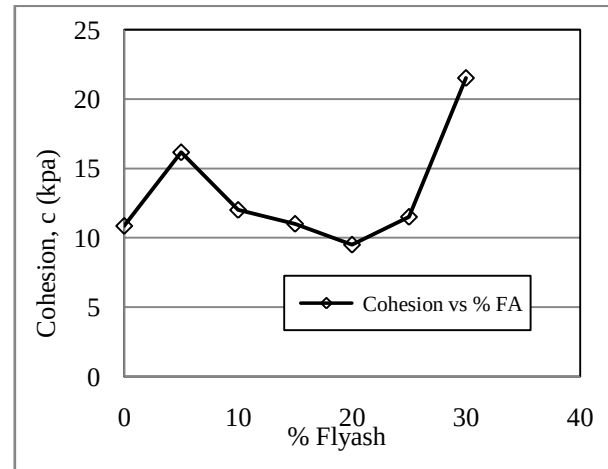


Fig.7 Variation of cohesion with different percentage of flyash

IV.SUMMARYAND CONCLUSIONS

The maximum dry density (MDD) decreases drastically from 10% to 15% and 25% to 30% in light compaction with increase of percentage of fly ash from 0% to 30%. But from 0% to 10% and 25% to 30% fly ash, the MDD decreases slightly in modified compaction. The addition of percentage fly ash in soil gravel mixture, optimum moisture content (OMC) increases both in light and modified compaction and increases slightly from 0% to 10% and drastically increases from 10% to 25% and slightly increases from 25% to 30% in light compaction and modified compaction. For 0% to 30% fly ash, the angle of internal friction ' ϕ ' decreases from 36.24° to 29° and percentage decrease in each successive percentage fly ash from 0% to 25% in soil mixture is 5%. There was sudden decrease in the angle of internal friction ' ϕ ' and is about 10% for 25% to 30% fly ash soil mixtures. For 10% to 25% fly ash soil mixtures, the value of ' ϕ ' slightly varies from 33.7° to 32° . Therefore 10% to 25% can be used effectively along with granular soil. From the results of compaction and strength tests, 20% to 25% fly ash addition to gravelly sand do not affect the properties of granular soil. The fly ash soil mixture is showing encouraging results towards utilization of fly ash with gravelly sand for low to high volume traffic in pavement construction.

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