

Laboratory Investigation of Compaction Characteristics of Flyash-Granular Soil

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ABSTRACT: A comprehensive idea on fly ash-granular soil mixtures when subjected to compaction is essential to estimate the quantity and cost of granular soil to be used in the pavement construction. In this paper, the results pertinent to the compaction characteristics such as optimum moisture content (OMC) and maximum dry density (MDD) of fly ash-granular soil mixtures were discussed. The fly ash used in the investigation was obtained from Vijayawada Thermal Power Station (VTPS) Vijayawada, AP, India and the granular soil was collected from chekuru village, Guntur, AP, India. The proportions of fly ash used are 0%, 5%, 10%, 15%, 20%, 25% and 30% by dry weight of the granular soil. The granular soil compacted at 5% addition of flyash shows high MDD values in light compaction and it is slightly decreases in case of modified compaction, when the proportions of flyash proportion used is from 0% to 30% by weight of granular soil. The addition of percentage of Fly ash in soil gravel mixture, 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. From the study, it can be seen that up to 30% of fly ash substitution to the granular soils is feasible for the road constructions

KEY WORDS: MDD, OMC, fly ash granular soil mixtures, compactive effort, Water Content, FA%.

I. INTRODUCTION

Fly ash can be used for construction of road and embankment very effectively. This utilization has many advantages over conventional methods such as: (i). saves top soil which otherwise is conventionally used, (ii). avoids creation of low lying areas (by excavation of soil to be used for construction of embankments), (iii). Avoids recurring expenditure on excavation of soil from one place for construction and filling up of low lying areas thus created, (iv) does not deprive the nation of the agricultural produce that would be grown on the top soil which otherwise would have been used for embankment construction, (v). Reduces the demand of land for disposal/deposition of fly ash that otherwise would not have been used for construction of embankment and (vi). controls the source of pollution. 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 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 compaction 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 chekuru 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

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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 in the study by dry weight of soil are 0%, 5%, 10%, 15%, 20%, 25% and 30%.

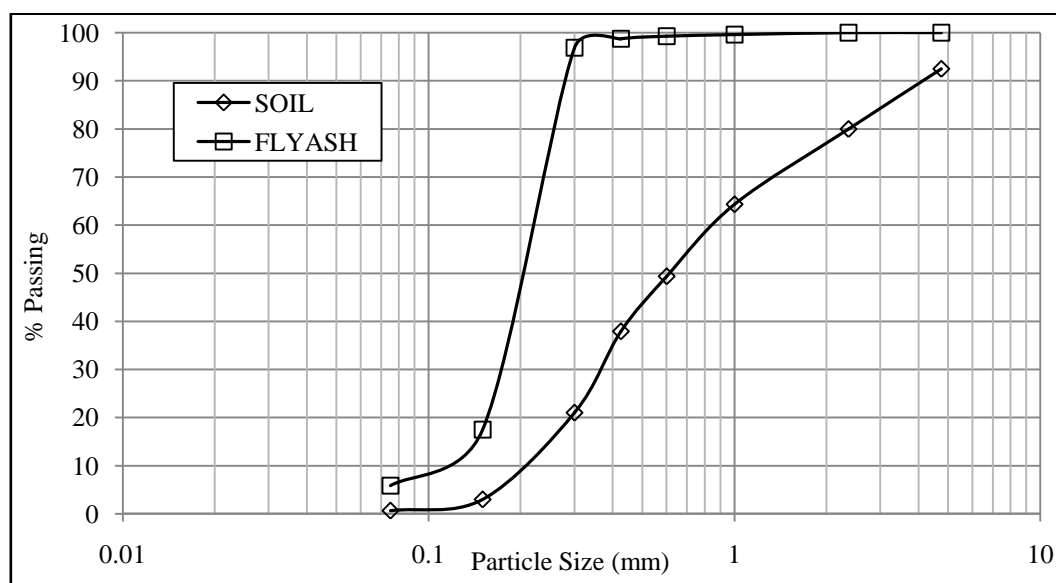


Fig.1 Grain size distribution curve for soil and fly ash

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 Light Compaction	09.36
Optimum Moisture Content, OMC (%)in Modified Compaction	08.00
Maximum Dry Density, MDD (kN/m^3) in Light Compaction	19.52
Maximum Dry Density, MDD (kN/m^3) in Modified Compaction	19.90
Un-soaked CBR (%) in Modified Compaction	55.24
Soaked CBR (%) in Modified Compaction	48.54
% 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

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Vol. 4, Issue 10, October 2015

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
Un soaked CBR (%)	34
% Gravel	0
% Sand	97.5
% Silt and Clay	2.5

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 vs. particle size for the various proportions of flyash in granular soil.

IS light and modified compaction tests have been conducted on the soil with different % 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.

III. RESULTS AND DISCUSSIONS

Compaction Characteristics

In case of pure 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 19.95kN/m³ to 20.9kN/m³ similarly the optimum moisture content is decreased from 8 to 7.5%. Similarly in the case of pure flyash as the compaction effort increases the MDD of fly ash is increasing from 12.65 to 13.85kN/m³ and the 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 shown in fig.2 it can be attributed that the fly ash has low specific gravity and is a light weight material. Fig3 represents the dry density water content relations of flyash gravelly sand mixtures under the light compaction. From this figure, it can be seen that the compaction curve corresponding to 10% flyash is placed higher side as compared to the compaction curves of other proportions of flyash. The compaction curve obtained corresponding 25% flyash gravelly sand mixture is placed at lower level compared to all other curves. The compaction curves presented in the figures and are following the typical trend of compaction behavior. Under the light compaction on flyash gravelly sand mixtures, the dry density variations are found to be 18.9kN/m³ to 20.4kN/m³ for the range of water content of 3 to 11.5% .Fig 4 presents the compaction curves for different proportions of flyash added to the gravelly sand and tested under modified compaction. From this figure, it can be noticed that the compaction curves are following the typical trend of granular soils.

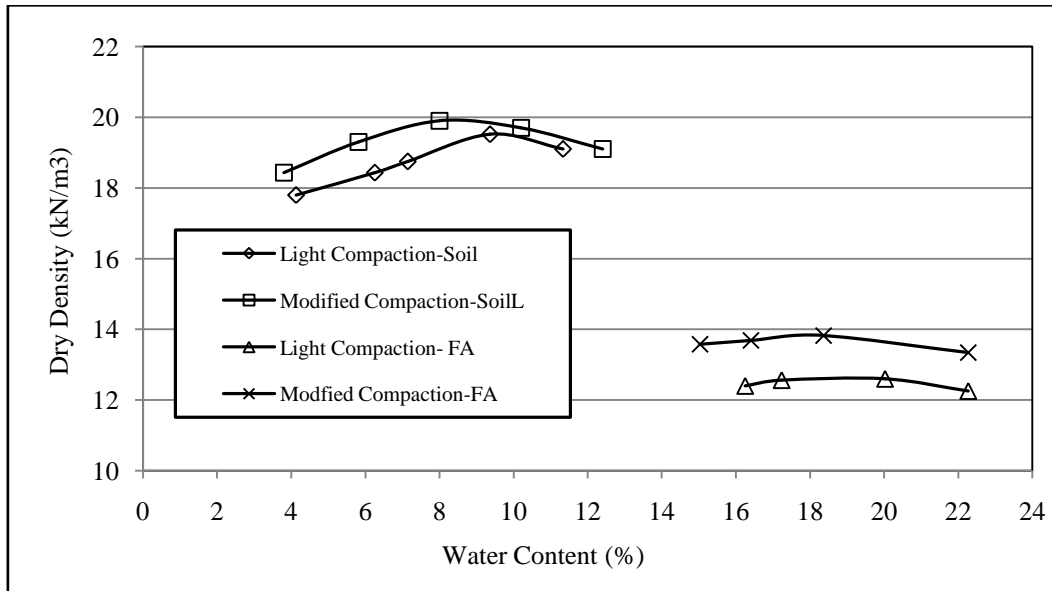


Fig. 2 Compaction curves for gravelly sand and flyash subjected to light and modified compaction

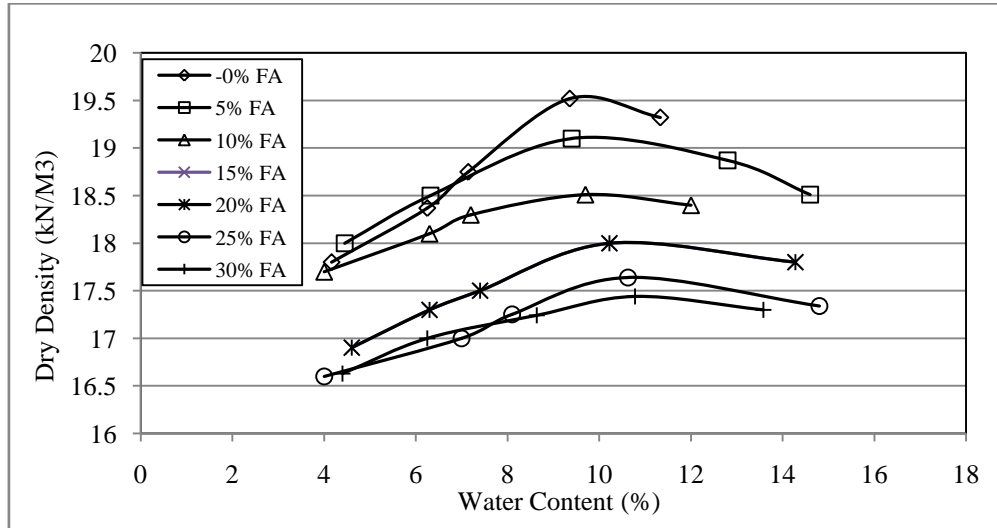


Fig. 3 Compaction curves for flyash gravelly sand mixtures subjected to light compaction.

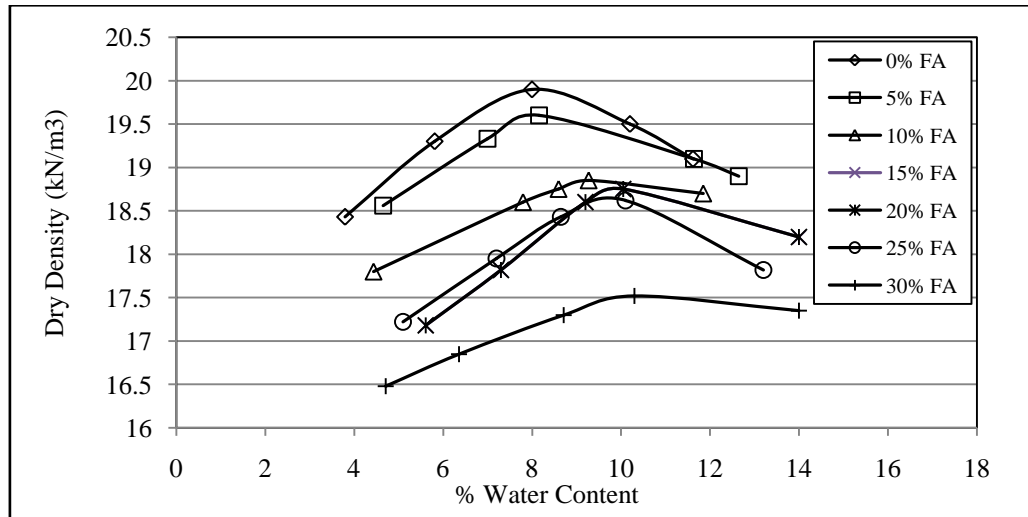


Fig. 4 Compaction curves for flyash gravelly sand mixtures subjected to modified compaction

The higher MDD is noticed for the flyash proportion of 5% added to the gravelly sand. The MDD for 0% flyash and for 10% flyash is observed to be almost the same. It is noticed that as the % of flyash increases the affinity to absorb water is increasing. From the figures it is further noticed that the dry density of flyash gravelly sand mixtures is maximum in the range of water content of 7.5% to 8.5%. To achieve the optimum condition, about 7.5 to 8.5% water content can be sufficient to add to the flyash gravelly sand mixtures wherein fly ash proportions varying from 0 to 25%. From this figure, it can be presented that the lowest and highest dry density is 19.2kN/m³ to 21.2kN/m³ respectively and in the range of water content of 3 to 12%. It can be understand that highest dry density can be possible from the modified compaction and hence for heavy traffic highway pavement constructions the modified compaction results can be used. In case of light compaction the dry densities observed are lower than the dry densities of modified compaction and hence the light compaction results can be used for low volume pavements/roads.

Influence of Compaction on MDD and OMC

The Variation in OMC with the percentage of flyash for the light compaction and modified compaction are presented in Fig 5. From this figure, it can be seen that the OMC values obtained in the light compaction are at higher level as compared to modified compaction. As the compactive efforts increases, the reduction in OMC is found to be 4 to 7% for the flyash proportions of 0 to 25%. This reduction in OMC is little higher for the flyash proportions of 0 to 10% and thereafter the reduction in OMC seems to be lower. From this trend, it can be understand that the influence of compaction effort may not be present for higher percentages of fly ash. Fig 6 presents the variation of MDD with the percentage of fly ash under light compaction and modified compaction. From this figure, it can be clearly seen that as the % of flyash increases the MDD is increasing up to about 10% of flyash and thereafter there is a reduction in MDD with further increasing of flyash content. The higher MDD values are noticed under the modified compaction. Values of OMC and MDD with the Percentage of flyash are shown in the tables 3 & 4

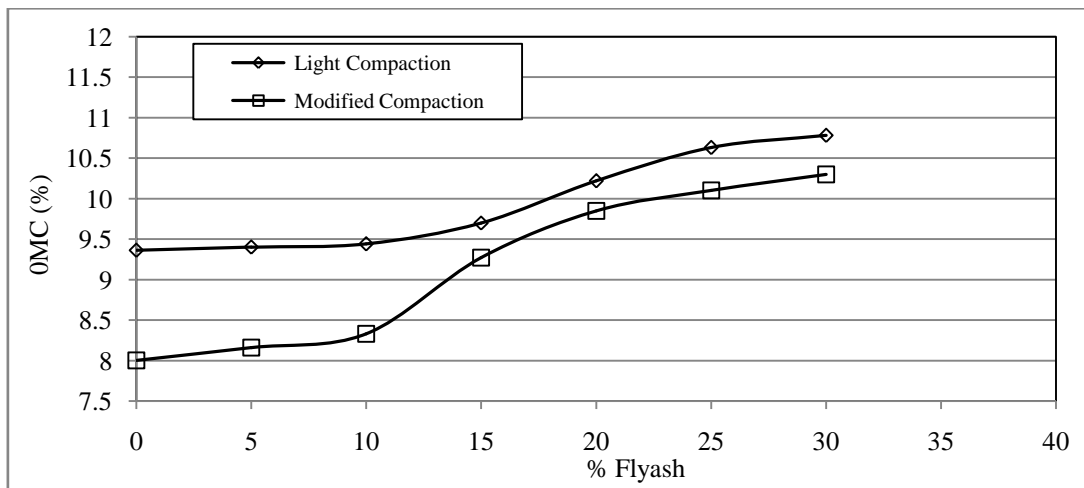


Fig. 5 Variation of OMC with the percentage flyash.

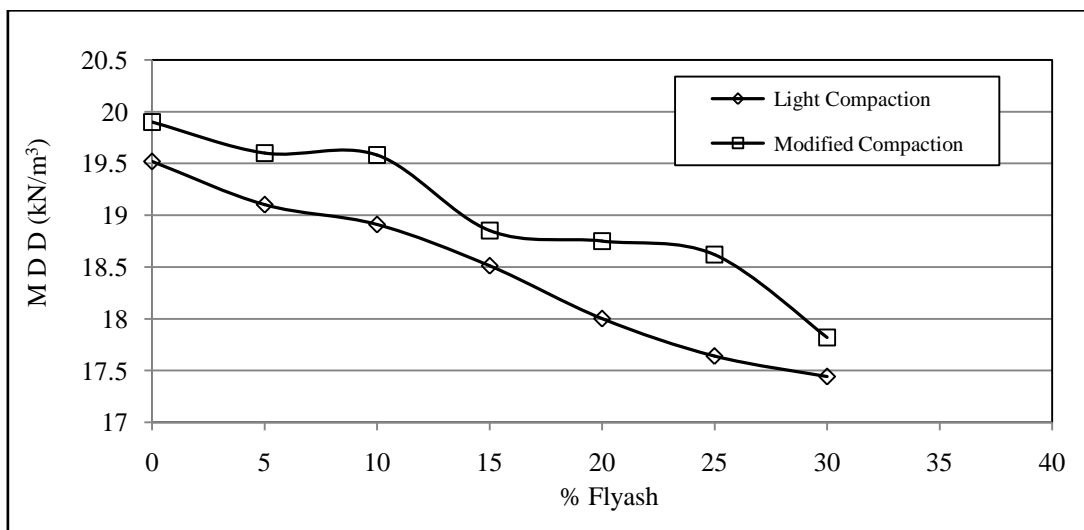


Fig. 6 Variation of MDD with the percentage flyash

Table 3 Values of OMC with the % of Flyash

% Flyash	Optimum Moisture Content (OMC) (%)	
	Light Compaction	Modified Compaction
0.0	09.35	08.00
0.5	09.40	08.15
10	09.45	08.35
15	09.70	09.25
20	10.25	10.00
25	10.65	10.10
30	10.75	10.30
100	18.55	17.90

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Table 4 Values of MDD with the % of Flyash

% Flyash	Maximum Dry Density (MDD) (kN/m ³)	
	Light Compaction	Modified Compaction
0	19.52	19.9
5	19.10	19.6
10	18.91	19.58
15	18.51	18.85
20	18.00	18.75
25	17.64	18.62
30	17.44	17.52
100	12.65	12.90

IV. SUMMARY AND CONCLUSIONS

From the discussion of the results of compaction characteristics of fly ash granular soil mixtures, the following conclusions are drawn. The maximum dry density decreases drastically from 10% to 15% and 25% to 30% in light compaction with increase 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 % Fly ash in soil gravel mixture, optimum moisture content 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. It is seen that the subgrade strength is important along with other characteristics of soil while designing the various layers of flexible pavement. As the density of granular subgrade is interrelated with the strength of granular soil, the use of fly ash in road construction as a replacement material of up to 30% can effectively be adopted for the construction of stable pavements.

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