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CHANGES IN GRADATION OF FLY ASH BLENDED GRANULAR SOIL DUE TO COMPACTION

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ABSTRACT

In this study**,** the fly ash blended granular material (gravelly sand) was subjected to modified compaction. It was taken up mainly to bring out the effect of compaction on the changes in gradation of fly ash blended gravelly sand. The fly ash proportions such as o%, 5%, 10%, 15%, 20% and 25% are used. After the compaction, the results revealed that there is almost 50% reduction in the gravel portion and the fine fraction has increased almost to 10%. However there is a change in the gradation, the strength requirements have not compromised for these mixtures. It is suggestible to utilize fly ash in the pavement construction along with gravelly sand up to 25%.

I. INTRODUCTION

Soil stabilization has become more common nowadays due to non-availability of strong and stable sub grade and sub-base soils locally. Gravelly sands are found to be strong and stable material for pavement construction. There are occasions wherein gravelly sand availability is inadequate in situ.In such circumstances, utilization of locally accessible waste materials such as fly ash can be found as a feasible choice in controlling the expenses of gravelly sand transport from faraway spots to the construction site. Use of locally available fly ash along with the locally available limited gravelly sand will solve three major issues in pavement construction. They are: (i) environmental issues, (ii) minimizing gravelly sand transport costs and (iii) avoiding the wastage of agricultural land.

Pandian et al (2002) considered the impact of two sorts of fly ash on the CBR attributes of the dark cotton soil when the fly ash was increased from 0 to 100%. By and large the CBR/strength is contributed by its cohesion and friction. The CBR of black cotton (BC) soil, which comprises of fine particles, is contributed by cohesion. The CBR of fly ash, which comprises transcendently of coarser particles, is contributed by its frictional component. Senol et al. (2002) reported that the UCS and CBR of low plasticity clay with 20% fly ash diminished following a two-hour compaction delay. White (2002) reported the utilization of the DCP for a project to gauge the stability of the shoulders and select fill below the pavement. Phanikumar and Sharma (2004) completed a study and drew out the impact of fly ash on designing properties of expansive soil through an exploratory study. The impact on parameters like free swell index (FSI), swell potential, swelling pressure, plasticity, compaction, strength and water powered conductivity of expansive soil was examined. Bhuvaneswari et al (2005) reported that the greatest dry density of expansive soil blended with fly ash happened in the water content scope of 12 to 14%. Among different rate of fly ash utilized, the density is observed to be most extreme for 25% fly ash in the blend. Scott M. Mackiewicz, E. Glen Ferguson (2005) displayed that determination of the moisture-density and moisture-strength connections of the self-solidifying ash treated materials has turned out to be a dependable premise for creating blends and assessing the hydration attributes of particular fly ash sources. Tuncer B. Edil et al (2006) concentrated on the stabilization of delicate fine-grained soils with fly ash. The soils were chosen with plasticity indices somewhere around 15 and 38. Two sorts of fly ash one is superb Class C fly ash and second one is off-particular ash (this powder don't meet the Class C or Class F criteria) were utilized as a part of the study. Lin Li et al (2009) described an assessment of the mechanical execution of fly ash blended materials. Delicate earth soil, asphaltic reused asphalt material (RPM), and road surface gravel (RSG) were stabilized utilizing class C and off-particular fly ash to make stabilized base course for construction of rigid and flexible pavements. Robert M. Creeks (2009) concentrated on the swelling soil stabilized with fly ash and rice husk ash (RHA). Remolded expansive soil was mixed with RHA and fly ash and quality tests were conducted. At the point when the RHA content was expanded from 0% to 12%, unconfined compressive strength increased by 97% while CBR enhanced by 47%. It is prescribed that the RHA substance of 12% and a fly ash content of 25% are extremely viable in fortifying the expansive sub grade soil. Likewise a fly ash content of 15% is prescribed for mixing into RHA for framing a swell diminishment layer. Zheng, Zhang and Yang (2009) expressed that the thickness by design for pavement is controlled by the subgrade stiffness, as measured by the CBR. It is found that samples which were not soaked amid testing displayed higher CBR values than those tried by standard testing methods. Emilliani Anak Geliga and Dygku Salma Awg Ismail (2010) introduced that addition of fly ash does not have impact on the strength of expansive soil. The fly powder alone is not an exceptionally solid material and henceforth reasonable measures of fly ash, for example, 50% - 60% to be added to the soil by dry weight to achieve the required execution. Prasanna Kumar (2011) considered the cementitious mixes arrangement utilizing pozzolanos and their consequences for stabilization of soils, such as blach cotton soils and red earth soils for fluctuated extents of fly ash.

Kate, J.M. (1998) considered the conduct of swelling clays treated with lime and fly ash added substances. The rate of good quality fly ash required to decrease swelling attributes was around 25% and most extreme lime content is 8%. Rae, S.M. what's more, Shivananda, P. (2005) reported that lime stabilization responses result in the development of inter molecule cementation bonds that enhance quality and lessen compressibility of clay soils. Sivapullaiah Puvvadi V and Arif Ali Baig Moghal (2011) introduced the part of gypsum in the quality improvement of fly ash with lime. The impact of gypsum on the quality advancement of two class fly ash with various lime substance in the wake of curing the samples for various periods were concentrated on. Prasad, D.S.V, Anjan Kumar, M., Prasad Raju, G.V.R., (2013) concentrated on the execution of flexible pavement on clay soil and sand sub grade utilizing fly ash as sub base course with various strengthening materials. The model pavement fortified with waste plastics and waste tire elastic demonstrated better execution when contrasted with unreinforced sub base of the model flexible pavement framework. From literature survey, it is comprehend that the lot of work is being completed pertinent to stabilization of pavements particularly on clayey sub grade soil utilizing different admixtures. There are few studies wrote about usage of fly ash in pavement construction alongside the gravelly sand. In this study, a study has been wanted to comprehend the conduct of fly ash and gravelly sand blends for use in construction of pavement. The fly ash proportions by dry weight of soil used in the study are 0%, 5%, 10%, 15%, 20% and 25%.

II. MATERIALS AND METHODS

2.1 Granular Soil

The specimens utilized for the present study is collected from a depth of 1m from the surface after clearing the vegetation and loose material. The location of the sample collected is Medical in Hyderabad, Telangana. The collected soils samples were processed and stored in airtight bags. For this soil, the essential tests were conducted as per the standard procedures in the laboratory for its characterization. According to the essential properties of soils are concerned, it shows that the soil is grayish to brown in shading and has soil proportions of gravel, sand and minimal fine fraction. In the soil the percentage slit and clay is around 7%, sand is 70% and gravel is around 23%. The different essential properties of soil are introduced in Table 1.

2.2 Fly ash

The fly ash utilized as a part of this investigation was collected from the Vijayawada Thermal Power Station (VTPS) Vijayawada. The fly ash collected was put away in air tight containers. The different properties of fly ash acquired from the VTPS are presented in Table 2. The fly ash extents used in the study by dry weight of soil are 0%, 5%, 10%, 15%, 20% and 25%.

2.3 Tests Conducted

The modified compaction (IS:2720 – Part 7, 1980) and grain size analysis (IS: 2720 - Part 4, 1985) tests are conducted as per the standard test procedures of soil testing as per the Indian standards.

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Table 1 Basic properties of soil

Soil property	Value
Specific gravity	2.68
Optimum Moisture Content (OMC) in %	7.5
Maximum Dry Density (MDD) in kN/m^3	20.90
% Gravel	21.3
% Coarse Sand	14.6
% Medium Sand	38.3
% Fine Sand	18
% Silt & Clay	7.8
Soil Classification	SW

Table 2 Properties of fly ash

Properties	Value
Specific gravity	1.97
Optimum Moisture Content (OMC) in %	18
Maximum Dry Density (MDD) in kN/m^3	13.85
Fine Sand (%)	97.5
Silt & Clay (%)	2.5

III. RESULTS AND DISCUSSION

The particle size distribution patterns for fly ash gravelly sand blends and untreated soil are compared before and after subjecting them to modified compaction in the laboratory. The fly ash proportions used are 0%, 5%, 10%, 15%, 20% and 25% and 30%. Modified compaction is chosen because crushing of particles can be more in modified compaction as compared to light compaction. It will enable the practitioners to have clear idea about volume variations and quantity of material estimations for the road construction.

3.1 Particle Size Distribution of Soil Sample I Blended with Fly Ash

The Particle size distribution curves for fly ash gravel sand mixtures are presented in Figs.1 to 9. Fig. 1 presents the grain size distribution curves for untreated gravelly sand and for fly ash. From this figure, it is seen that the fly ash is showing almost uniform gradation, whereas the soil is showing well graded granular soil.

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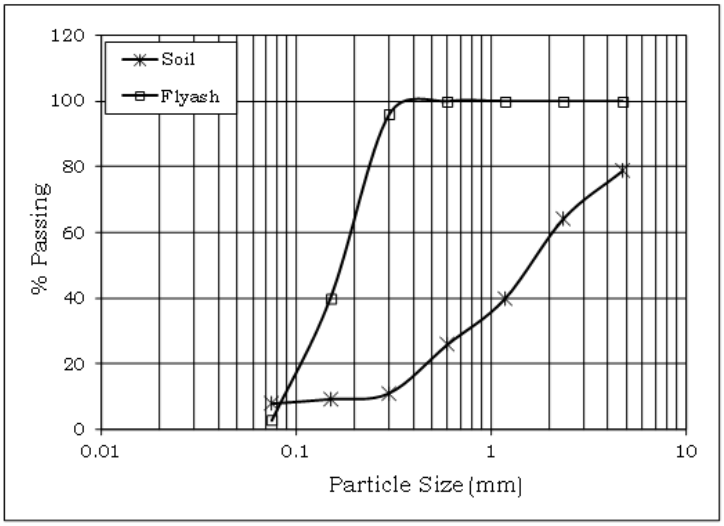

Fig: 1 Particle size distribution curves of gravelly sand and fly ash before compaction

The particle size distribution curves of fly ash gravelly sand mixtures mixed at different proportion of fly ash such as 0%, 5%, 10%, 15%, 20% and25% are presented in Fig.2 These curves are concerning to fly ash granular soil mixtures without subjecting to compaction i.e., before compaction. From this figure, it is observed that as the fly ash increases from 0% to 25%, the percentage fraction passing below 0.075mm is increasing from 8% to 22%. From these curves, it is also noticed that from the particle size 4.75mm to 1mm, the curves are moving parallel with smaller spacing, whereas from particle size below 1mm to further lower sizes, the curves are moving parallel with wider spacing. This shows there is a much deviation in the gradation of fly ash mixed gravelly sand for the particle size underneath 1mm.

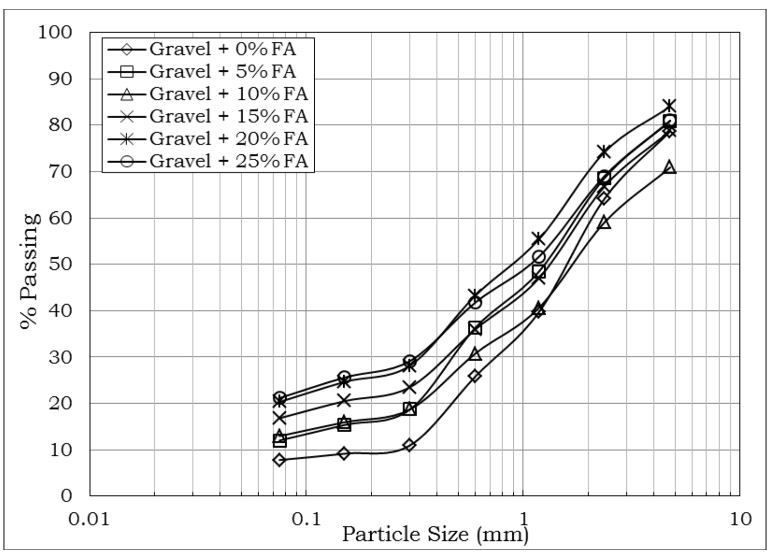

Fig: 2 Particle size distribution curves for fly ash blended gravelly sand before compaction

Fig. 3 presents the particle size distribution curves for fly ash granular soil blends prepared at 0%, 5%, 10%, 15%, 20% and 25% of fly ash and subjected to modified compaction. These plots have been produced essentially to comprehend the particle size distribution variations of fly ash gravelly sand blends in the wake of subjecting to modified compaction and thus to know the impact of compaction on the gradation response. From this figure, it can

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be seen that the percentage fraction passing below 0.075mm size is increasing from 12% to 24% when fly ash percentage increases from 0% to 25%. From this figure, it is further noticed that there is not much change in the percentage fraction passing for the fly ash gravelly sand mixtures concerning to fly ash proportions of 5%, 10%, 15%, 20% and25% for the particle size range of 4.75mm to 1mm. From the particle size 1mm and below it, there is a wider gap between the grain size curves and showing the percentage fraction passing is more as fly ash content increases from 0% to 25%.

Further to know the effect of compaction on fly ash gravelly sand blends, the curves are presented in Figs. 4 to 9 for the fly ash proportions 0%, 5%, 10%, 15%, 20% and25% respectively. Fig.4 presents the particle size distribution curves for untreated soil before and after the compaction. From this figure, it can be seen that there is about 10% increase in percentage passing and it is a uniform increase from particle size 4.75mm to 0.3mm and there after the increase in percentage passing is narrowed.

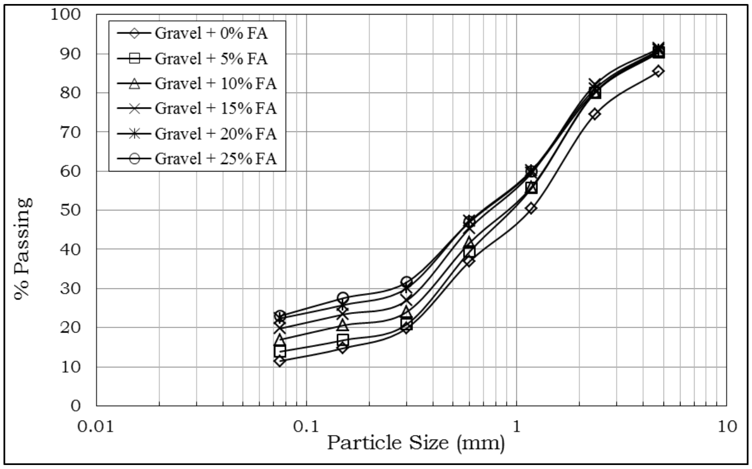

Fig: 3 Particle size distribution curves of fly ash blended gravelly sand after subjecting them to modified compaction

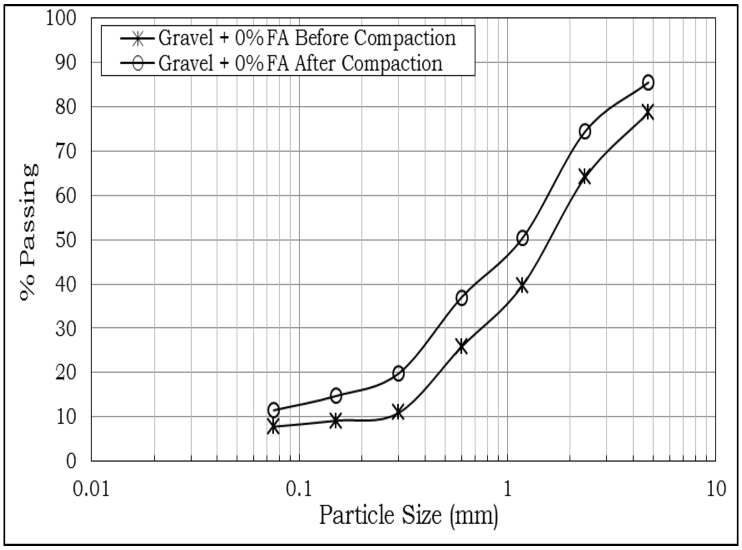

Fig: 4 Particle size distribution curves for granular soil before and after the Compaction

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Similarly for the other percentages of fly ash such as 5%, 10%, 15%, 20% and25% addition to soil, the grain size distribution curves obtained before and after the modified compaction (Figs. 5, 6, 7, 8 and 9) are showing almost similar trend as compared to untreated gravelly sand (Fig. 4). From the Figures, it can be clearly seen that there is about 5% to 10% increase in the finer fraction due to subjecting of samples to the modified compaction. Further the results pertinent to before and after compaction are presented in Tables 3 and 4. From these tables further analysis is carried out. The variation in gradation has been brought out with before compaction (BC) and after compaction (AC) for Gravel (G), Coarse Sand (CS), Medium Sand (MS), Fine Sand (FS) and Silt & Clay (SC) with the percentage fly ash. These gradation variations are presented in Figs. 10 to 14. From Fig.10, it is seen that there is a clear reduction in gravel about 50% for all soil fly ash mixtures subjected to compaction. The reduction in coarse sand fraction when subjected to compaction is shown in Fig.11. From figure, it is noticed that for all soil fly ash mixtures, the reduction in coarse sand is about 20%. Similarly from the Fig.12, the reduction in medium sand is about 33% for up to fly ash proportions 5% to 15% and thereafter the reduction noticed is about 23%.

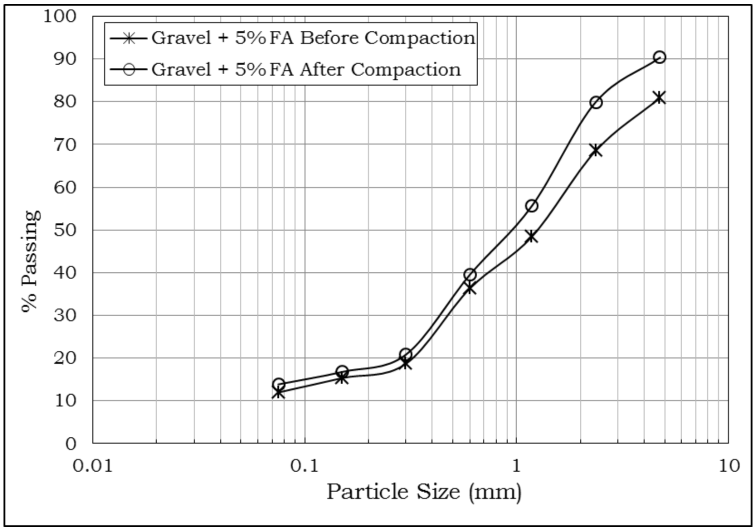

Fig: 5 Particle size distribution curves for 5% fly ash blended soil before and after the compaction

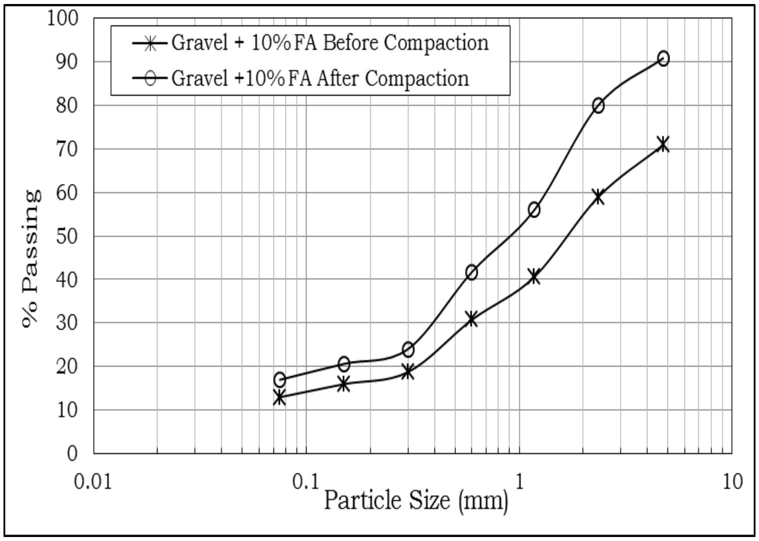

Fig: 6 Particle size distribution curves for 10% fly ash blended soil before and after the compaction

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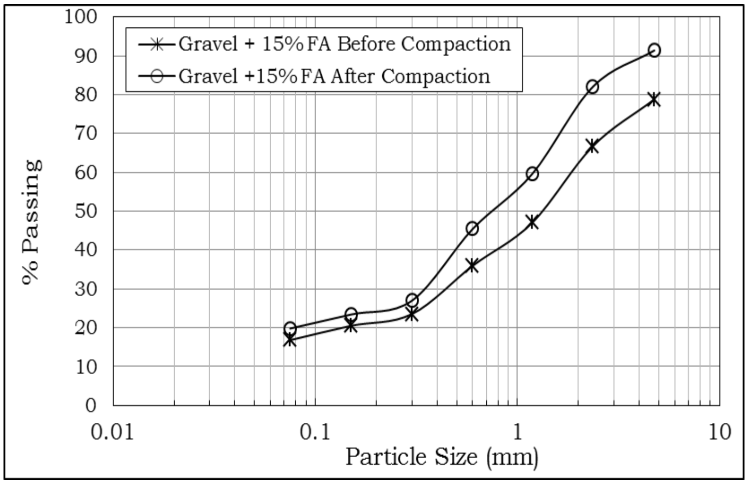

Fig: 7 Particle size distribution curves for 15% fly ash blended soil before and after the compaction

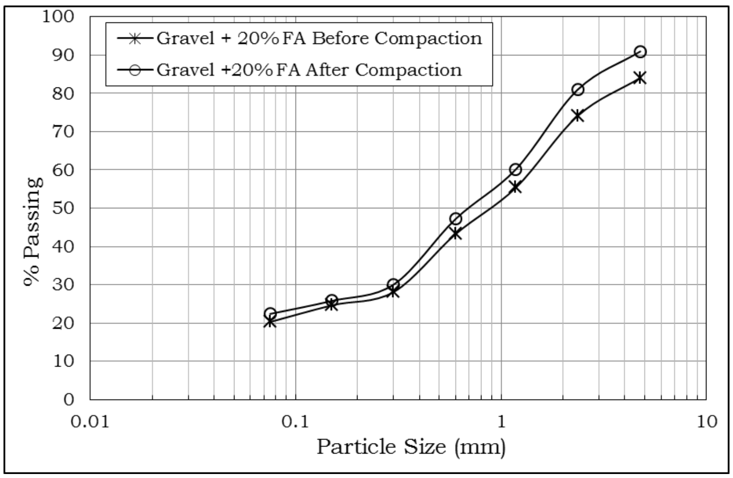

Fig: 8 Particle size distribution curves for 20% fly ash blended soil before and after the compaction

Table 3 Particle size distribution of fly ash mixed gravelly sand before subjecting to modified compaction

Proportion /Soil fraction	FA (0%)	FA (5%)	FA (10%)	FA (15%)	FA (20%)	FA (25%)
Gravel	21.30	19.05	29.10	21.20	15.95	19
Coarse Sand	14.60	12.40	11.90	12.05	9.90	12
Medium Sand	38.30	32.25	28.25	30.80	30.90	27.25
Fine Sand	18	24.30	17.80	19.15	22.95	20.60
Silt & Clay	7.80	12	12.95	16.80	20.30	21.15

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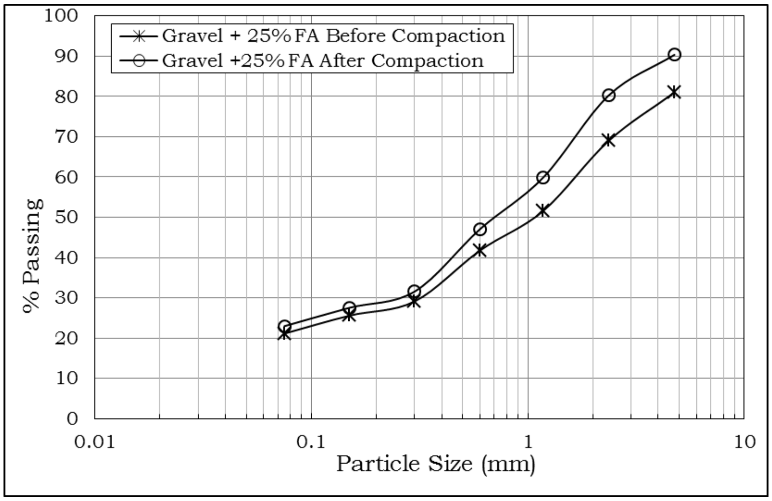

Fig: 9 Particle size distribution curves for 25% fly ash blended soil before and after the compaction

Table 4 Particle size distribution of fly ash mixed granular soil after subjecting to modified compaction

Proportion /Soil fraction	FA (0%)	FA (5%)	FA (10%)	FA (15%)	FA (20%)	FA (25%)
Gravel	14.50	9.65	9.15	8.60	9.05	9.65
Coarse Sand	11.05	10.40	10.75	9.35	9.95	10.10
Medium Sand	37.45	40.45	38.35	36.60	33.80	33.20
Fine Sand	25.50	25.60	24.80	25.65	24.80	24.05
Silt & Clay	11.50	13.90	16.95	19.80	22.40	23

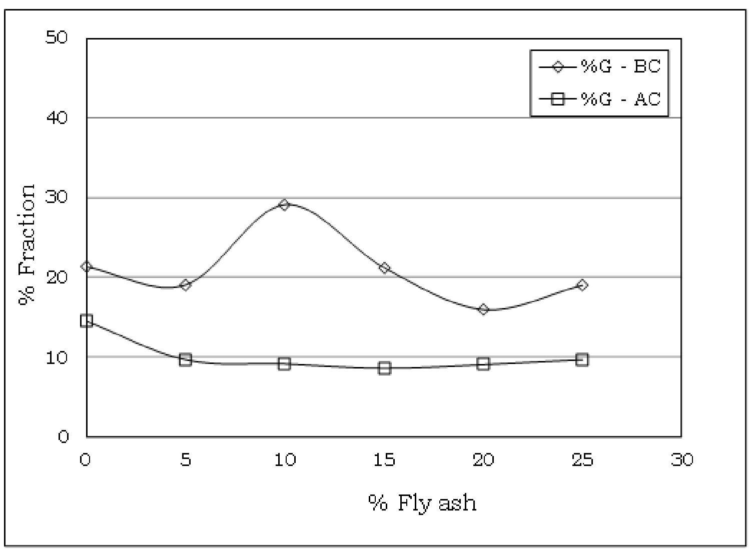

Fig: 10 Variation of gravel fraction in soil fly ash mixture before and after compaction effort

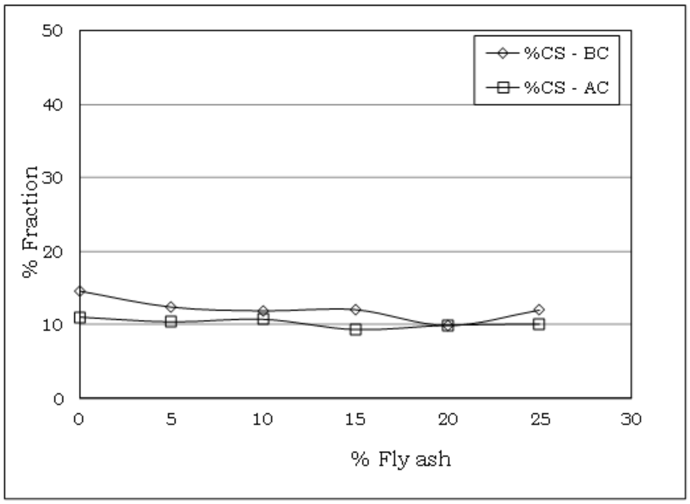

Fig: 11 Variation of coarse sand fraction in soil fly ash mixture before and after compaction effort

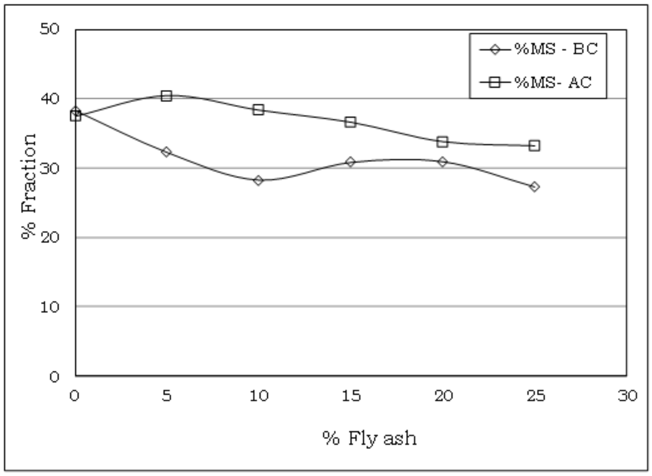

Fig: 12 Variation of medium sand fraction in soil fly ash mixture before and after compaction effort

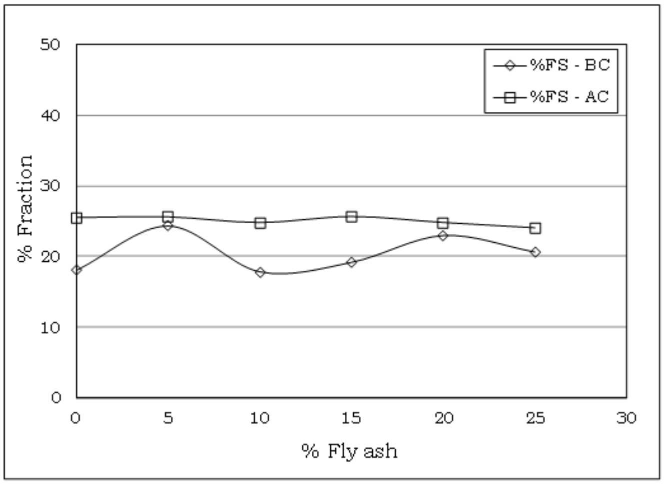

Fig: 13 Variation of fine sand fraction in soil fly ash mixture before and after compaction effort

In Fig.13, the reduction in fines and is about 38% for up to fly ash proportions 5% to 15% and thereafter the reduction noticed is about 8%. The reduction in silt and clay due to compaction is shown in Fig.14 and from this it is noticed the reduction is about 50% for all the fly ash soil mixtures.

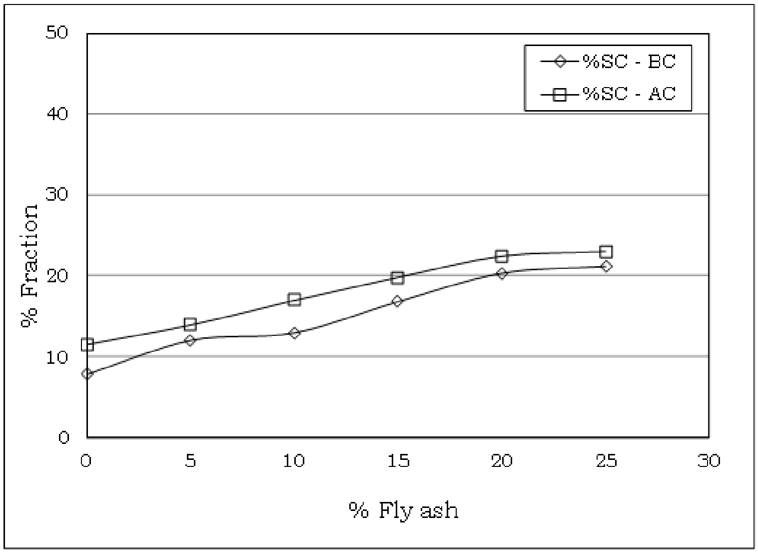

Fig: 14 Variation of silt and clay fraction in soil fly ash mixture before and after compaction effort

IV. CONCLUSIONS

From the results some interesting points are noticed. Though, it is a known fact that when soil is subjected to compaction, there would be obviously changes in gradation of soil, but from this work the quantification of gradation change is brought out. The gravel portion is crushed more as compared to the other fractions of soil such as sand, silt and clay. Also, overall there is an increase in the % silt and clay content (particle size less the 0.075mm) due to compaction. Also from the strength tests such as CBR, it is notice that no compromisation in CBR and its minimum value is not less than 20 even for the gravelly sand blended at 25% fly ash. In order to utilize the fly ash for the pavement construction along with gravelly sand a minimum amount of 25% is used.

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