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Use of Crusher Stone Aggregate – Bottom Ash as Sub- Base and Base Courses in Flexible Pavements

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Abstract: Flexible pavements are widely used road network made up of locally available naturally soils. Most of the soils are failed to meet the requirements of the standard specifications. There is a need to go for alternative materials. In the present investigation bottom ash has been tried for flexible pavement material with graded crusher stone particles. Compaction and CBR tests are performed to meet the specifications as per MORTH, it is identified that crusher stone – bottom ash mixes achieved high CBR values can be used as sub-base and base course materials.
Key Word: Bottom Ash, Compaction, CBR,

I. INTRODUCTION

Infrastructure development is the main parameter to assist the economic growth of any country. Road networking is one such infrastructural facilities which connects the land along and across the globe. Flexible pavement is the promising road networking facility and derives its durability from the pavement layers and its material specifications. To spread the loads from surface to bottom layers the strength of each layer is to be verified.

Some of the earlier researchers are Hung (1990) investigated the shear strength of Indian bottom ash and boiler slag, compacted to different densities using direct shear testing. Cheriaf et al. (1999) studied the pozzolonic properties of coal Bottom Ash. Yeon et al. (2011) studied engineering characteristics of fly ash and bottom ash mixes. Esteban Lopez et al.(2015) studied bearing capacity of Bottom Ash and its mixes with soils. Gourley et al (1997) studied the use of Laterite Gravel as Road Base Materials, in Southern Africa, Nunan et al (1990) made a review and experimentation of Gravel stabilization methods. Satyanarayana et al (2013) studied High Plastic Gravels stabilized with crusher dust as sub base material. Ramana murthy. v.et.al (2003, 2004), studied utilization of gravel and morrum in geo technical applications.

In the present investigation graded crusher stone – bottom ash mixes are compared with sand mixes to identify as an alternative material to graded gravel soils. The strength of these mixes are verified by performing compaction and CBR tests to verify their suitability according to MORTH specifications.

II. MATERIAL

Gravel soils are collected from local quarries of Visakhapatnam. Crushed stone are collected from stone crushing plants of Visakhapatnam. Bottom ash is collected from NPTC, Visakhapatnam.

2.1. Mixes of Graded Gravel Soils:

In the present study gravel soils are collected from different locations of Visakhapatnam regions. These collected gravel soils are dried and individualized using wet and dry sieve analysis and these individual gravel soil particles are grouped into 8 grades. These Graded Gravel soil are prepared by choosing particles ranging from 75.0mm to less than 0.002mm. And designated as G_1 to G_8 by varying gravel particles (75-4.75mm) as 85-15% and finer particles (4.75mm less than 0.002mm) as 15-85% , which are shown in the table.

Table1: Grades of Gravel Soils

Grades	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
75-4.75mm	85	75	60	50	35	25	15	0
<4.75mm	15	25	40	50	65	75	85	100

2.2 Geotechnical properties of graded gravel soils:

The above mentioned graded gravel soils are subjected to grain size distribution and their corresponding percentage finer and gradation characteristics are shown in table 2 and fig 1.

These graded gravel soils are tested for compaction characteristics (OMC,MDD) as per IS 2720 part- 8 (1983)and CBR values as per IS 2720 part 16(1986) and the results are shown in table 3, fig -1

TABLE 2 : Grain size distribution of graded gravel soils

Grain Size (mm)	Percentage finer							
	85-15	75-25	60-40	50-50	35-65	25-75	15-85	0-100
75	100	100	100	100	100	100	100	100
50	90	90	95	100	100	100	100	100
26.5	75	75	85	85	90	95	100	100
12.5	50	55	65	70	80	85	95	100
9.5	37	45	52	64	74	82	92	100
4.75	15	25	40	50	65	75	85	100
2.36	11	19	25	42	56	65	74	85
1.18	9	15	22	36	49	56	63	70
0.425	7	13	18	28	35	41	47	53
0.075	5	10	15	20	25	30	35	40
0.002	2	3	5	7	9	10	13	15

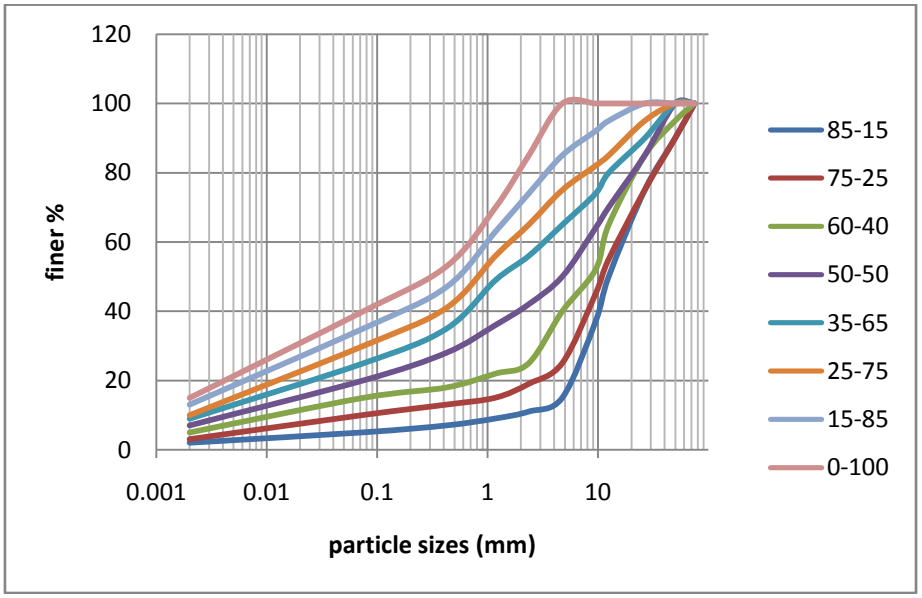

FIG 1: Grain size distribution of graded gravel soils

TABLE 3: Compaction and CBR Characteristics of Graded Gravel Soils

GRADE	COMPOSITION		OMC (%)	MDD (g/cc)	CBR (%)
	75-4.75mm	<4.75mm			
G_1	85	15	8.5	2.13	44
G_2	75	25	8.8	2.15	48
G_3	60	40	9.3	2.12	40
G_4	50	50	10.0	2.10	37
G_5	35	65	10.6	2.07	33
G_6	25	75	11.0	2.05	28
G_7	15	85	11.5	2.03	18
G_8	0	100	12.0	2.00	8

Test results showed that increasing the percentage of gravel particles (> 4.75mm) increases maximum dry density value (MDD) and decreases optimum moisture content (OMC) values, it is vice-versa with respective particles less than 4.75mm. The corresponding range of MDD values is 2.00 g/cc to 2.15 g/cc and the range of OMC values is 8.5 % to 12.5 %. It is also seen that CBR values are also increasing with increase in percentage of gravel particles which is in the range of 18 to 48.

Some of the graded soils have CBR values less than 30 are dominated by finer particles and some more of the graded gravel soil with CBR values greater than 30 are dominated by coarser particles are due to deformation of finer particles under saturated conditions. Gravel soils having CBR values greater than 30 can be used as sub-base course with mechanical modifications.

III. CRUSHED STONE AGGREGATE - BOTTOM ASH / SAND MIXES:

To compare the above graded gravel soils, gradation mixes of crushing stone with bottom ash / sand i.e. SB_1/ SS_1 …SB_7/SS7 are prepared from standard materials i.e gravel particles are replaced by crushed stone aggregate and mixed with bottom ash / sand particles.

Crusher stone aggregate and stone bottom ash / sand mixes are prepared by choosing stone aggregate in the range of 75mm to 4.75mm with percentage finer of 85-15% and bottom ash / sand of sizes from 4.75mm-0.075mm with percentage finer is varying from 15-85%. These gradation mixes are designated as SB_1/SS_1 - SB_7/SS_7 are shown in the table – 4 and their gradation curves and their corresponding gradation characteristics are shown in the table – 2.

TABLE 4: Gradations of Crushed Stone Aggregate – Bottom Ash / Sand Mixes

Grades	SB_1/ SS_1	SB_2/ SS_2	SB_3/ SS_3	SB_4/SS_4	SB_5/SS_5	SB_6/SS_6	SB_7/SS_7
75-4.75mm	85	75	60	50	35	25	15
<4.75mm	15	25	40	50	65	75	85

3.1 Compaction Characteristics:

These gradation are also tested for compaction characteristics as per IS 2720 - PART 8 (1983).

TABLE 5: Compaction Characteristics of Crushed Stone AGGR – Bottom Ash / Sand Mixes

GRADE	COMPOSITION		OMC (%)			MDD (g/cc)		
	75-4.75mm	<4.75mm	G	SB	SS	G	SB	SS
GRADE -1	85	15	8.5	4.2	3.5	2.13	2.14	2.22
GRADE -2	75	25	8.8	5.0	3.8	2.15	2.10	2.24
GRADE- 3	60	40	9.3	6.2	4.2	2.12	2.00	2.20
GRADE -4	50	50	10.0	7.5	4.6	2.10	1.85	2.16
GRADE -5	35	65	10.6	9.3	5.0	2.07	1.66	2.10
GRADE -6	25	75	11.0	11.0	5.3	2.05	1.50	2.04
GRADE -7	15	85	11.5	12.5	5.7	2.03	1.32	1.96

G – Graded gravel soil, SB – crushed stone aggregate + bottom ash t, SS – crushed stone aggr + sand

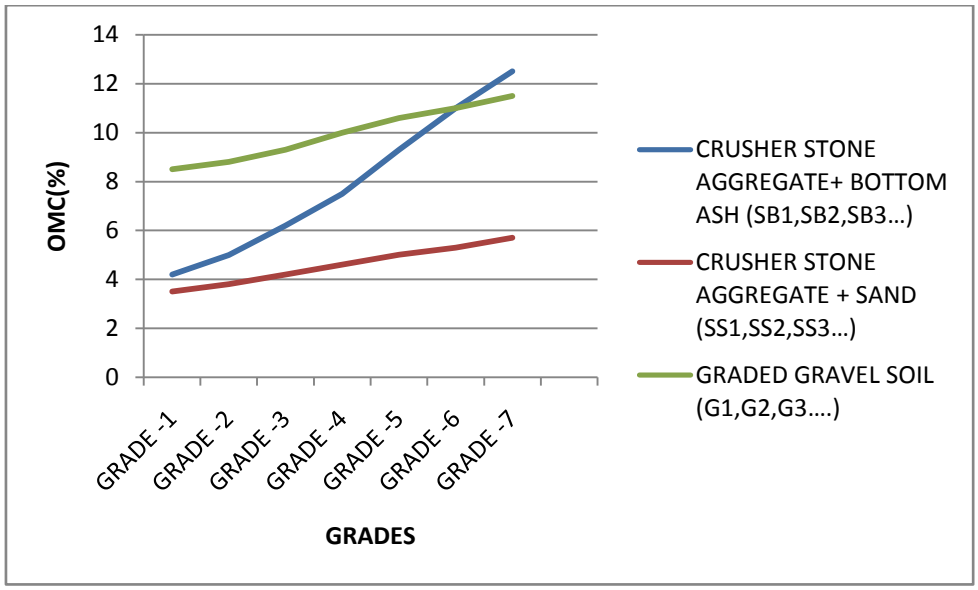

fig: 2. Variation of OMC w.r.t gradation mixes

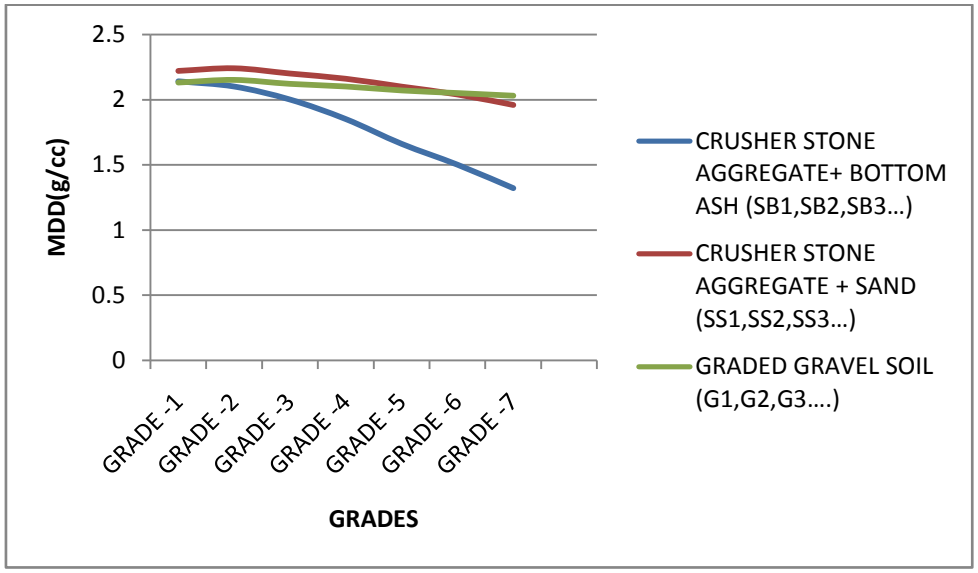

fig: 3. Variation of MDD w.r.t gradation mixes

Test results are showing that OMC values are increasing with increasing bottom ash contents which are from 4.2 to 12.5 %, with sand contents these are increasing from 3.5 to 5.7%. Comparing OMC values of graded gravel these values are very lower.

Test results of MDD values are showing that dry density values of crusher stone – bottom ash and crusher stone – sand values are increasing, which are ranging from 1.32 to 2.14 g/cc, 1.96 to 2.24 g/cc respectively.

3.2 CBR CHARACTERISTICS

To know CBR characteristics of graded gravel soils, crusher stone – bottom ash mixes and crusher stone – sand mixes samples are prepared at their OMC and MDD in CBR moulds and soaked for 4 days. After completion of curing period, these samples are tested as per IS 2720 part 16(1986).

TABLE - 6 : COMPARSION OF GRADED GRAVEL SOILS, CRUSHER STONE AGGREGATE – BOTTOM ASH MIXES AND CRUSHED STONE AGGREGATE- SAND MIXES

GRADE	COMPOSITION		CBR (%)		
	75-4.75mm	<4.75mm	G	SB	SS
GRADE -1	85	15	44	80	82
GRADE -2	75	25	48	85	88
GRADE- 3	60	40	40	76	80

GRADE -4	50	50	37	64	68
GRADE -5	35	65	33	54	57
GRADE -6	25	75	28	40	43
GRADE -7	15	85	18	32	34

G – Graded gravel soil, SC – crushed stone aggregate + bottom ash, SS – crushed stone aggr + sand

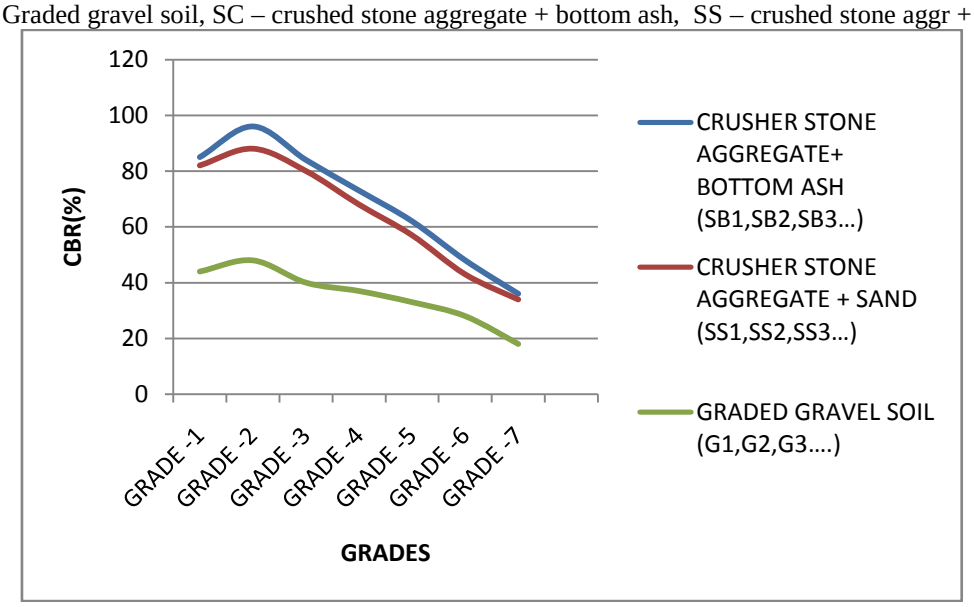

fig: 4. Variation of CBR w.r.t gradation mixes

Test results of CBR values are showing that CBR values of crusher stone – bottom ash and crusher stone – sand values are increasing coarse particles which are ranging from 32 to 85 and 34 to 88 respectively.

Comparing the compaction characteristics of graded gravel (G_1 to G_7) soils with the mixes of crusher stone with crusher bottom ash(SB_1 to SB_7) and the crushed stone aggregate with sand (SS_1 to SS_7) the following identifications are observed.

Replacement of gravel particles by crusher stone particles and finer particles (<4.75mm) of gravel soils with bottom ash particles achieved high dry densities similar to mixes of crushed stone particles with sand particles. it is also observed that CBR values are also high similar to that of graded mixes of crushed stone aggregate - sand. High CBR values and dry densities due to filling up of more bottom ash / sand particles in the voids of crusher stone particles, nature of crusher stone particles with gravel particles and non plastic nature of mixes as a whole w.r.t graded gravel soils.

Gradation mixes SB_1 to SB_4 have exhibited MDD values 1.85 to 2.14 g/cc and CBR values are in the range of 64 to 85 can be used as base course materials. Gradation mixes SS_1 to SS_4 have exhibited MDD values 2.16 to 2.24 g/cc and CBR values are in the range of 68 to 88 can be used as base course material.

Gradation mixes SB_5 and SB_7 have exhibited MDD values 1.32 to 1.66 g/cc and CBR values are in the range of 32 to 54 can be used as sub- base course materials. Gradation mixes SS_5 to SS_7 have exhibited MDD values 1.96 to 2.10 g/cc and CBR values are in the range of 32 to 57 can be used as sub- base course material

IV. CONCLUSION:

Graded gravel soils attained CBR values in the range of 18-48. Mixes of crusher stone aggregate particles with bottom ash / sand particles i.e SB_1 to SB_4 and $SS_1$to SS_4 CBR values in the range of 68 to 88 can be used as base course materials. and mixes of crusher stone aggregate particles with bottom ash / sand particles i.e SB_6 to SB_7 and SS_5 to SS_7 with CBR values in the range of 32 to 57 can be used as sub- base course material. Hence utilization of huge quantities of bottom ash upto 65% can reduce thrust on natural soils.

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