A Study on Enhancing CBR Properties of Graded Gravel Soils with Crusher Dust and Bottom Ash

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Abstract—Major streets and highways are perfect candidates for flexible pavement because, when laid in very thick layers, it can endure large and more frequent traffic flows. Repair work is quite straightforward since this pavement type requires frequent maintenance. Standard standards are not met by the majority of the soils. However, disposing of the massive amounts of industrial waste that are produced by fast industrialization is no easy feat. Inhaling fly ash, a significant component of coal ash and a byproduct of thermal power plants, may cause asthma attacks, inflammation, and immune system responses if it becomes stuck in the lungs. According to research, these particles are associated with the top four killers. cardiovascular disease, cancer, lung disease, and stroke. Fly ash toxics may move about in the ecosystem not just by leaching, but also via erosion, runoff, and even fine particles in the air. The chemicals in fly ash are dangerous because they may escape and travel across the ecosystem. When stone crushing facilities produce aggregate of the desired size, they leave behind a byproduct known as crusher dust. As a concentrated byproduct of crushing, quarry dust is ideal for use as aggregates in concrete, particularly fine aggregates. Quarries produce dust as a byproduct of crushing rock into different sizes; this waste product is known as quarry dust.

Index Terms—Stone Dust, Highways, Flexible Pavements, Erosion, Leaching.

I. INTRODUCTION

The improvement of a country's infrastructure is the single most important factor in boosting its economy. One example of a piece of infrastructure that links land masses all over the world is road networks. The layers of pavement and the material requirements determine how longlasting flexible pavement is, making it an attractive road networking option. Through grain-tograin contact, the bottom layers of a flexible pavement are subjected to vertical compressive stresses. The qualities of the material, such as its plasticity, density, and grain size distribution, determine the quality of the pavement layers. Soils made of well-graded, compacted gravel with a variety of particles may distribute compressive loads uniformly and provide a strong, flexible pavement layer; broken stones and gravels are common sub-base and base course materials. Because of their unique properties, gravel soils show great promise as a building material for civil engineering projects including roads, embankments, and fill. Soils with a broad range of particle sizes, from 75 mm to less than 2 µm, are able to become compacted and dense, leading to high strengths when subjected to loading. When gravel soils have an abundance of finegrained particles, such as silt or clay, they may absorb water, making them very malleable when loaded, and weakening them when saturated. We can suggest a stabilizing approach to stop these plastic deformations. Consequently, there is a heightened global emphasis on the quest for new alternative materials that make use of better methods to process the local resource.

II. LITERATURE AND REVIEW

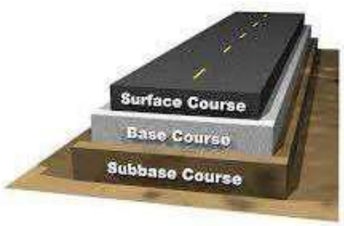
India has a road network of 4,236,000 kilometres in 2011, the third largest road network in the world. The number of kilometers of roads in India is 0.66 for every square kilometer of land. In terms of quantitative density, India's road network is on par with the US's (0.65) and surpasses both China's (0.16) and Brazil's (0.20). On the other hand, India's roads are seeing significant progress and have both modern freeways and tiny, dirt lanes. About half, or 2.1 million kilometers, of India's roadways were paved as of 2008.

2.2 Flexible pavements: Flexible pavements are those, which on the whole have low or negligible flexural strength and are rather flexible in their structural action under the loads. Thus, if the pavement or soil subgrade is undulated, the surface of the flexible pavement will likewise become undulated, since the layers of the pavement reflect the deformation of the lower layers onto their surfaces.

2.2.1 Components of Flexible Pavements:

A typical flexible pavement consists of four components

- Soil subgrade.
- Sub base course.
- Base course.
- Surface course



Bshara, et.al (2014), studied the improvements of strength characteristics of poor soil byadding the stone dust and observed better results in the strength aspects[14].

Bindhu Lal, et.al (2014), This study shows that stone dust can be satisfactorily used as a cheap stabilizing agent for sub-grade layers and sub-base layers of a Flexible Pavement. Observed that the Optimum Moisture Content, Maximum Dry Density and California Bearing Ratio properties are optimally improved by adding stone dust[14].

III. METHODOLOGY

Chapter 1 provided a critical review of the research on problematic soils, aggregate (stone), and bitumen, and Chapter 2 suggested solutions based on the use of certain industrial wastes to mitigate these issues. Using systematic flow charts, this chapter presents the methodology of the current study activity, which includes a short explanation of the experimental methodologies used to examine the qualities of conventional materials and chosen industrial wastes. There is also a detailed description of the laboratory testing techniques followed throughout the experiment in accordance with the regulations set forth by several credible bodies. In order to identify, plan, and execute effective waste management systems during stabilization, geotechnical characteristics information of different types of industrial waste is crucial. In order to determine if these industrial wastes are suitable for use in civil engineering construction operations, it is necessary to conduct experimental evaluations of their physical, index, engineering, and mechanical qualities. Utilizing industrial waste dumps requires careful geotechnical characterization. Using industrial waste in construction projects that use a lot of materials—like building highway pavement, filling basements, or backfilling behind retaining structures—is a great way to reduce landfill waste and save money. It's also a great way to solve the disposal problem.

3.2 MATERIALS

The following In order to examine their use and compatibility across all layers of a specific flexible road pavement component, the following industrial waste materials, generated by companies in and around the north coastal districts of Andhra Pradesh, are chosen for the research.

1. Soils consisting of gravel are gathered from several sites in the Nellore areas. The stone crushing facility close to Nellore city in Andhra Pradesh, India, is the source of the aggregate.

2. The stone crushing facility next to Nellore City in Andhra Pradesh, India, is the source of the crusher dust. The Nellore Districts of Andhra Pradesh also collect crusher dust for validation purposes. As an added bonus, the findings are also checked against crusher dust mixtures from Zones I to IV.3. Coal from power plants is burned to produce pond ash, an industrial waste product.

The five aforementioned industrial waste materials undergo comprehensive laboratory testing to ascertain their physical, index, engineering, and mechanical properties. This is done to establish their potential as reinforcing materials and to ensure compatibility across all layers of the road's flexible pavement.

IV. RESULTS AND DISCUSSIONS

4.1 INTRODUCTION

Naturally occurring gravel soils are widely employed in civil engineering projects for constructing roads, buildings, embankments, and other similar structures. Grain size distribution, water interaction, strength classification, and other compositional factors determine the functional behavior of these soils. The purpose of this research is to find better ways to employ crushed stone aggregate, bottom ash, crusher dust, and sand in lieu of gravel in a variety of civil engineering projects.

4.2 MATERIALS:

Gravel soils are collected from local quarries of Nellore, Crushed stone is collected from stone crushing plants of Nellore. Bottom ash is collected from Nellore of Andhra Pradesh, India.

4.2.1 MIXES OF GRADED GRAVEL SOILS

After collecting the gravel soils, this research uses wet and dry sieve analysis to separate them into their individual particles. Then, these particles are categorized into eight categories. Particle sizes in this Graded Gravel soil range from 75.0 mm down to less than 0.002 mm. Particle sizes of the gravel range from 75 to 4.75 millimeters.

A. Particles which are >4.75mm (75-4.75mm)

B. Particles which are<4.75mm (4.75-0.002mm)..

TABLE 4.2: Grain size distribution of graded gravel soils

Grain Size (mm)	Percentage finer of grades							
	85-15	75-25	60-40	50-50	35-65	25-75	15-85	0-100
	G_1	G_2	G_3	G_4	G_5	G_6	G_7	G_8
75	100	100	100	100	100	100	100	100
53	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

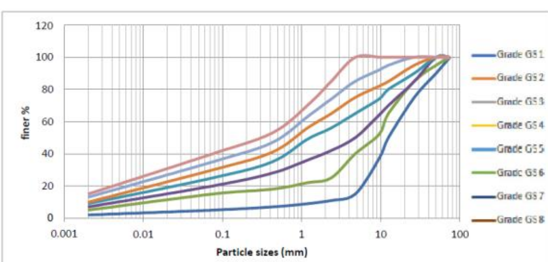


FIG 4.1: Grain size distribution curves of graded gravel soils

TABLE :4.16 VARIATION OF CBR(%) OF GRADED GRAVEL SOILS –BOTTOM ASH MIXES

GRADE	COMPOSITION		CBR (%) PERCENTAGE REPLACEMENT OF BOTTOM ASH					
	75-4.75mm	<4.75mm	0	20	40	60	80	100
GB_1	85	15	44	46	50	55	58	60
GB_2	75	25	48	52	57	60	63	65
GB_3	60	40	40	43	47	50	54	56
GB_4	50	50	37	40	43	47	50	52
GB_5	35	65	33	35	38	40	42	44
GB_6	25	75	28	30	33	35	37	39
GB_7	15	85	18	20	22	23	24	25
GB_8	0	100	8	10	13	11	8	5

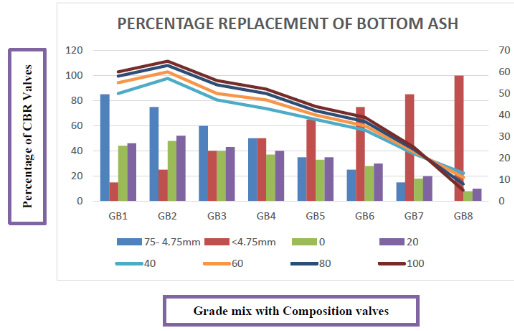


Fig :4.15 Variation of CBR w.r.t gradation mixes

4.2.3. APPLICATIONS:

The CBR values of graded gravel soils (G1, G2, G3, G4, G5) vary from 48 to 33.The liquid limit is between 24 and 33 and the plasticity index is between 7 and 13.Soils G6, G7 that are graded gravel have CBR values between 18 and 28, a Liqiud limit between 35 and 38, and a plasticity index between 15 and 17. The following graded gravel soils are suitable for use as sub-base course material according to MORTH: WL<25, IP<6, and CBR>30. For use as base course material, CBR >60 is recommended. The graded gravel soils that were tested did not match the standards set by MORTH. To achieve the MORTH criteria, stabilization was necessary for these graded gravel soils.

4.3 INTERACTION OF GRADED GRAVEL SOILS BY CRUSHER DUST PARTICLES

4.3.1 INTRODUCTION

To study the performance of graded gravel soils with crusher dust as geotechnical materials like sub base ,base course and fill material in construction of roads Tests are conducting tests on these materials about their characterizations and suitability w.r.t standard specifications. As the amount of bottom ash in graded gravel-bottom ash mixtures increases, the maximum dry density drops from 2.02 g/cc to 1.28 g/cc, according to the test findings. As additional bottom ash particles are incorporated into the gravel particles, resulting in a compacted and cohesive matrix, the maximum dry density value decreases. As the proportion of bottom ash increases, these values also rise in the event of optimal moisture content levels. Graded gravel soils have lower OMC values than blends of graded gravel and bottom ash. This is because, in contrast to gravel soils that have a high concentration of tiny particles, bottom ash particles occupy this space instead.

CONCLUSION

- *In graded gravel soils, the findings reveal that the maximum dry density (MDD) values and optimum moisture content (OMC) values are affected by the proportion of gravel particles (> 4.75mm). The inverse is also true for particles smaller than 4.75mm.*
- *In the same vein, OMC levels vary from 8.5% to 12.0% and MDD values from 2.00 g/cc to 2.15 g/cc.*
- *The CBR values are likewise rising as the proportion of gravel particles increases, which may be anywhere from 18% to 48%. There are graded soils with CBR values larger than 30, which are dominated by coarser particles, and graded soils with CBR values less than 30, which are G6, G7, G1, G2, and G3.*
- *The deformation of smaller particles under saturated circumstances under loading causes the CBR values to vary. With certain mechanical adjustments, gravel soils with CBR values above 30 may be used as a sub-base course.*
- *G1, G2, G3, G4, and G5 graded gravel soils have CBR values between 48 and 33. Properties: plasticity index 7–13, liquid limit 24-33. The CBR, liquid limit, and plasticity index of graded gravel soils G6, G7, and G8 are between 18 and 28, 35 and 38, and 15 and 17 respectively.*
- *The following graded gravel soils are approved for use as sub-base course materia according to MORTH: WL<25, IP<6, and CBR>30. On the other hand, base course material may be produced with CBR >60.*
- *The tested graded gravel soils did not meet the requirements established by MORTH. Stabilization was required for these graded gravel soils to meet the MORTH requirements.*
- *Results from tests on blends of graded gravel and crusher dust show that their maximum dry densities initially reach 2.24 g/cc before falling to 2.04 g/cc.*
- *A more compacted and cohesive matrix, caused by the increased participation of crusher dust relative to gravel particles, results in an increase in the maximum dry density value.*
- *As the proportion of crusher dust increases, these values decrease in the event of optimal moisture content. When compared to graded gravel soils, the OMC values of mixtures including crusher dust are consistently lower.*
- *As opposed to gravel soils, which contain a high proportion of fine particles, this is because crusher dust particles occupy the space instead.*
- *With an increase in the proportion of crusher dust particles, the maximum dry densities of graded gravel soil - crusher dust mixtures go from 2.00g/cc - 2.13g/cc to 2.04 g/cc - 2.24 g/cc, according to test findings.*
- *Experiments on mixtures of graded gravel and bottom ash have shown that the maximum dry density drops from 2.02 g/cc to 1.28 g/cc as the amount of bottom ash increases. As additional bottom ash particles are incorporated into the gravel particles, resulting in a compacted and cohesive matrix, the maximum dry density value decreases. As the proportion of bottom ash increases, so do the ideal moisture content levels.*
- *The OMC values of the graded gravel-bottom ash mixes ranged from 9.2% to 13.0%, which is more than the values of graded gravel soils, which range from 8.5% to 11.5%. Based on the results of the tests conducted on graded gravel-sand mixes, it was found that increasing the percentage of sand increases the maximum dry density up to 2.20 g/cc, after which it decreases to 2.06 g/cc.*

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