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Utilisation of Ggbs And Flyash In Granular Sub Base Layer

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gineering Department, Gitam University

***Abstract**: One of the significant problem nowadays is availability of conventional construction material for the road construction which is the major scarcity the world facing these days, where series of waste material are abundantly available from many sources which are being laid as waste, while these are increasing, along with continuous spreading of urbanization along with industrialization. GGBS & Fly Ash are few of the forms of waste material which are available enormous and at a free of cost in most of the areas and is one of the top most waste products from Steel Plant and coal burning in thermal power stations causing severe health, environmental and disposal problem. In order to ensure a sustainable waste management, we need to predict its properties and should be ready to specify its utilization and a study need to be conducted to investigate the possibility of using waste materials in place of conventional material. Compaction and California Bearing Ratio (CBR) tests were conducted on conventional material for strength parameters and a comparative study is made to know the variation in strength by replacing a known percentage of conventional material with waste material under different proportions. From the study it was observed that the strength value of the mix of conventional material and waste material increased by increase in percentage of GGBS.A cost analysis has been done based on the CBR values obtained , it is found the cost is reduced by almost 21% of the cost of GSB layer in pavement by using these waste materials. Hence Flyash and GGBS can be utilised in pavement construction which also reduces the environment pollution.*
***Keywords:** Ground Granulated Blast Furnace Slag (GGBS),Granular Sub Base (GSB), California Bearing Ratio (CBR).*

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I. Introduction:

Transportation Sector has seen a rapid growth in India and this growth is rising even to the present day. The main mode of transportation to the urban and the rural areas are roads. So the development of transport network plays a major role in India to develop economically. The Conventional materials used in construction of roads are obtained by mining and other processes which cause environmental degradation. Heavy usage of these conventional materials causes deprivement of rise of their price. The Granular Sub Base (GSB) layer is very often present in flexible pavement as a separate layer beneath the base course. As a structural layer within the pavement the sub base distributes the applied wheel loads to the weaker subgrade below. Whilst the sub base material is of a lesser quality than the base course material, it must be able to resist the stresses transmitted to it via the base course and it must always be stronger than the subgrade soil. For many designs the main function of the subbase of a flexible pavement is to reduce the building cost. The main aim is to achieve required pavement thickness with the possible economic materials. The total thickness of the pavement could be constructed with a high-quality material such as that used in the base course. However it is generally preferred to make the base thinner and substitute a subbase layer of poorer quality material, although the total pavement thickness may have to be increased. The poorer the quality of the material used, the greater will be the thickness required to tolerate and transmit the stresses. The subbase also serves to absorb detrimental deformations in the subgrade such as volume changes associated with variations in water content, which might eventually be reflected in the pavement surface. Another function of the subbase is to drain off any water that infiltrates from the surface and to prevent water from the fill from rising towards the base course due to capillarity .Conventional flexible pavements are layered systems with better materials on top where the intensity of stress is high and inferior materials at the bottom where the intensity is low. Adherence to this design principle makes possible the use of local materials and usually results in a most economical design. This is particularly true in regions where high quality materials are expensive but local materials of inferior quality are readily available. As a replacement of these conventional materials, huge quantities of wastes which are causing threat to the environment can be used for the construction of these roads. Two such industrial wastes are Fly ash and Ground Granulated Blast Furnace Slag (GGBS). Studies on the strength of these materials proved that they have the properties required for the construction of roads. Molten slag is the by-product of Steel Industries which is cooled and solidified by rapid water quenching to form into a clinker like material called Granulated Blast Furnace Slag which in turn when ground forms into GGBS (Ground Granulated Blast Furnace Slag). Fly ash is a waste product from thermal power station. It causes severe environmental threat.

II. Background

The utilization of industrial by-products from the steel-making industry like ground granulated blast furnace slag and flyash a fine powder which is a byproduct of burning pulverised coal in electric generation power plants has been established in a number of applications in the civil engineering industry. The subbase or subgrade soil can be lower quality because it is located at a greater distance from wearing surface, and the stresses it receives are less intense. Local materials which are the most economic can be used. U.Arun Kumar and KV Subramanyam (2014), conducted a study to investigate the possibility of using Granulated Blast Furnace Slag. The results indicated that GBFS can be used for the partial replacement of unmodified aggregate upto 20-30% in the construction of granular sub-base layer. R. Ratnaprasad and N.Darga Kumar(2015) experimented by replacing varying quantity of soil with Fly ash and conducted CBR test. It was concluded that 20-30% Fly ash soil mix can be used for both soaked and unsoaked conditions. The study done by Tara Sen and Umesh Mishra (2012) concluded that Fly ash can be used in admixtures to enhance the performance of concrete roads and bridges. They also concluded that Fly ash and lime can be combined with aggregate to produce a quality stabilized based course. Ahmed Ebrahim Abu El-Maaty Behiry (2013) studied the effect of using steel slag mixed with limestone aggregate on increasing the density and strength of subbase layer. The result indicate that Increasing the steel slag percentage to the limestone in the blended mix increases the mechanical properties such as maximum dry density, California Bearing Ratio and resilient modulus.

Objective

The objective of the present study is to know the use of common industrial wastes like GGBS, and Fly ash as an economical alternative to conventional aggregates in construction of GSB layer of flexible pavement.

III. Material Characterisation and Methodology

The details of the Mix proportions of Fly ash, GGBS and Aggregate used in the experimental programme is given in the Table 1

Table 1: Mix Proportion

Sno	Sample	Mixed Ratio
1	Sample-A	10mmAggregate(35%)+6mmAggregate(35%)+Stone Dust (30%)
2	Sample-B	10mmAggregate (35%)+ Stone Dust (30%)+GGBS(5%)+ Fly Ash (30%)
3	Sample -C	10mmAggregate (35%)+ Stone Dust (30%)+GGBS(10%)+ Fly Ash (25%)
4	Sample-D	10mmAggregate (35%)+ Stone Dust (30%)+GGBS(15%)+ Fly Ash (20%)
5	Sample-E	10mmAggregate (35%)+ Stone Dust (30%)+GGBS (20%)+FlyAsh (15%)
6	Sample-F	10mmAggregate (35%)+ Stone Dust (30%)+GGBS (25%)+Fly Ash (10%)
7	Sample-G	10mmAggregate (35%)+ Stone Dust (30%)+GGBS (30%)+Fly Ash (5%)

Granular mix:

Granular Sub base layer is often the main load-bearing layer of the pavement and the aggregates used in construction of the pavement should be tested for different engineering properties. In this study 30% of 10mm , 35% of 6mm size and 35% of stone dust is used. Properties of Mix are listed in Table.2.

Table 2: Properties of Granular Mix

S. No	Property	Value
1.	Crushing Value (%)	27.72
2.	Impact Value (%)	21.5
3.	Specific Gravity	2.78

Flyash:

The fly ash used in this study was collected from NTPC Visakhapatnam and the various properties of the fly ash is presented in table-3:

Table 3: Properties of Flyash

S. No	Property	Value
1.	Specific Gravity	1.85
2.	Liquid Limit	NP
3.	Plastic Limit	NP
4.	Optimum Moisture Content, OMC (%)	16
5.	Maximum Dry Density, MDD (KN/m^3)	14.34

GGBS:
The GGBS used in this study was collected from Vizag Steel Plant and the various properties of GGBS is presented in the table-4

Table 4: Properties of GGBS

S. No	Property	Value
1.	Specific Gravity	2.48
2.	Liquid Limit	NP
3.	Plastic Limit	NP
4.	Optimum Moisture Content, OMC (%)	20
5.	Maximum Dry Density, MDD (kN/m3)	16.66

IV. Results And Discussion:

Compaction Test
IS light and modified compaction tests have been conducted on the aggregate mix with different % of fly ash and GGBS . Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) is determined for the above specified samples as per the[IS:2720 (PART-7)-1980].

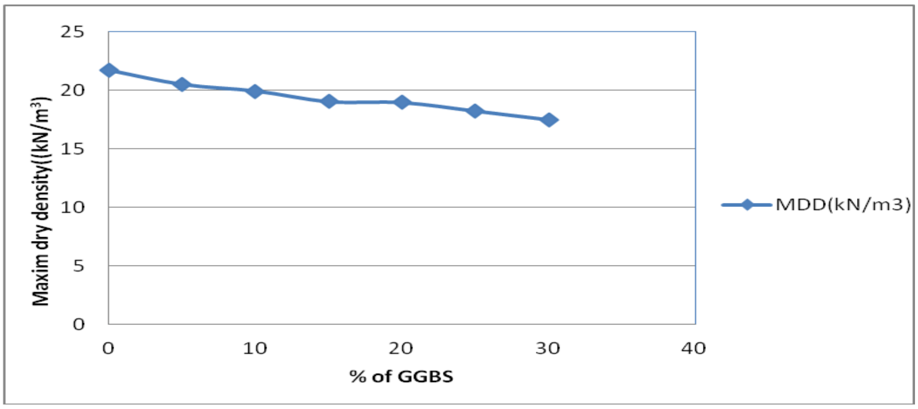

Fig1. Variation of Maximum Dry Density with % of GGBS

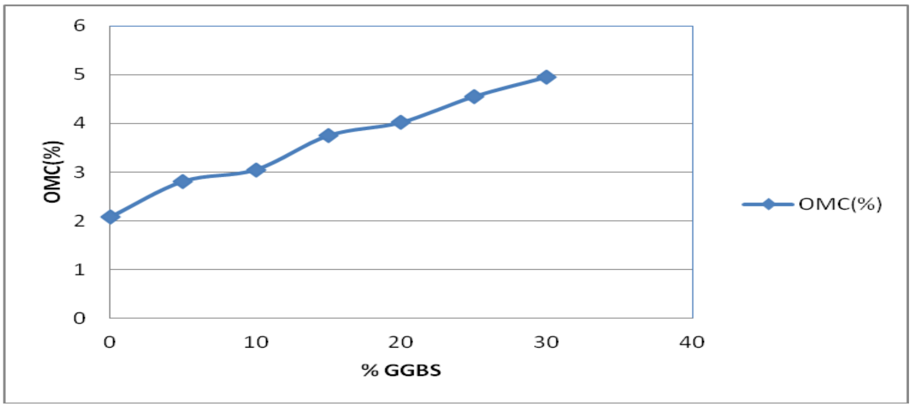

Fig 2: Variation of Optimum Moisture Content with % of GGBS

In case of natural aggregate, it was found that it has highest MDD and lowest OMC when compared to the GGBS & Fly Ash. MDD is decreasing significantly and OMC is increasing with increase in waste material proportions which you can observe in Fig 1 and Fig 2. This is due to the physical properties of natural aggregates which has the highest Specific Gravity of 2.78 where as it is 2.48 of GGBS and 1.85 for Fly ash.

California Bearing Ratio Test:
CBR is the design parameter which is considered in the construction of pavement and is the major design parameter of subgrade in the estimation of thickness of pavement. To understand CBR variations of GGBS, fly ash and aggregate mixtures a laboratory testing was carried out as per [IS:2720 (PART-16)-1979]. CBR test is carried out in both soaked and unsoaked conditions.

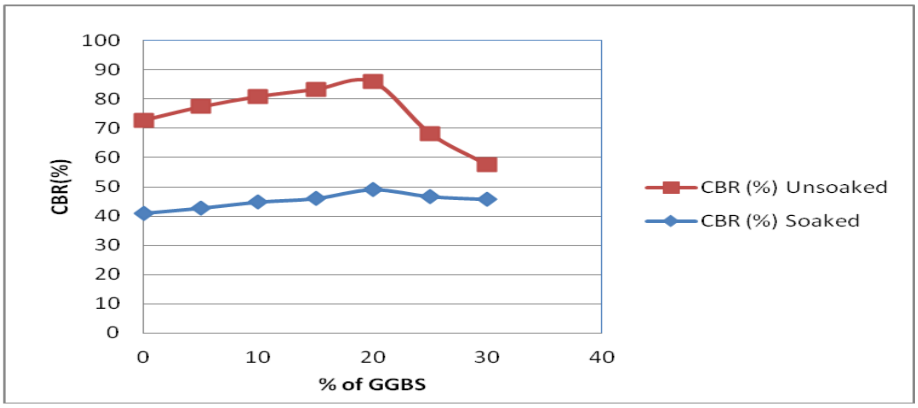

Fig 3: Variation of CBR value with % of GGBS

From the test results plotted in the Fig 3 it was found that due to pozzolanic activity of GGBS %CBR value increased simultaneously on increasing % GGBS in the sample mix. GGBS is both pozzolanic and cementitious because it has some lime of its own for the silica to react with when wetted.

Cost Analysis:
Based on the results obtained a cost analysis is made by taking into considerations is given by IRC and the estimation is as follows.

A. Length of the road assumed for cost analysis = 1000 m (1 Km)
B. CBR Value of Conventional Sample- 72.84 % (Aggregate)
C. Thickness of GSB layer for CBR@ 72.84 % from IRC = 9 cm (0.09 m)
D. Width of two lane road with raised kerbs= 7.5 m

Volume of GSB layer = (A* C* D)
= 0.09*7.5*1000 = 675 m^3 (1 Unit= 2.83 m^3)
=Cost per unit -Rs.1500/-
Cost of aggregate used per 675 m^3 : (675/2.83) * 1500 = Rs. 3,57,773.85 /-
Aggregate replacement considered with 5% Fly Ash, 30% GGBS

E. CBR Value for replaced aggregate = 87.5 %
F. Thickness of GSB layer for CBR@ 87.50 % from IRC - 7 cm (0.07 m)
G. Width of two lane road with raised kerbs= 7.5 m
H. Length of the road to be estimated= 1000 m (1 Km)

Volume of GSB layer (F* G* H) = 0.07*7.5*1000 = 525 m3

I. 35% of 525m3-183.75 m3
J. 30% of 525 m3- 157.5 m3
K. 5% of 525m3 -26.25 m3
L. Maximum Dry Density (MDD) of mix sample- 19.76 KN/m3
M. Volume of 35% sample= I* L*9.81= 183.75* 19.76*9.81= 35619.12 Kg
N. Volume of GGBS from M = 30530.68 Kg= 33.65 tonnes
O. Volume of Fly Ash from M= 5088.44 Kg
P. Cost of GGBS used – (N*3000/-) = Rs.1,00,963.46/- (1 tonne-Rs.3000/-) (33.65*3000=1,00,950)
Q. Cost of Fly Ash used- [O*(7/40)] = Rs.890.47 /- (Rs.7/- per 40 kgs)
R. Total Cost of mix of GSB layer = Rs.2,82,728.02/-

Difference in cost = Rs. (3,57,773.85- 2,82,728.02) =Rs. 75,045.83/- (Per Km)
From the above calculations, it is found the cost is reduced by almost 21% of the cost of GSB layer in pavement. Hence Flyash and GGBS can be utilised in pavement construction which also reduces the environment pollution.

V. Conclusions:

1. Replacing aggregates with various percentages of GGBS, the MDD of various blended mixtures has decreased.
2. Compaction and CBR increases with increasing the GGBS content upto 30%.

3. Replacing aggregate with various percentages of Fly Ash, the OMC of various blended mixtures decreased due to absorption of water by fly ash.
4. This method reduces the cost by nearly 21 % of cost of GSB layer in pavement design.
5. GGBS is both pozzolanic and cementitious because it has some lime of its own for the silica to react with when wetted which increases the strength

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