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A Laboratory Study on Brick Dust for GSB layer of Flexible Pavement

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ABSTRACT

Granular Sub-Base (GSB) layer has become a significant current building practise of all national highway projects in India for pavements placed on weak subgrade. One of the issues in the road construction sector is the proposed strict criteria for GSB material and its non-availability owing to limited sources. Although MORT&H allows for the use of locally accessible materials in the GSB layer, most of them do not meet the recommended standards. Brick dust is a type of brick kiln residue that is readily available in the area. This report summarises the research conducted with the goal of generating GSB mixes that include Brick Dust as a partial replacement for stone dust. The laboratory tests like Grain Size Distribution, Atterberg Limits, Heavy compaction test, Soaked and Un-soaked California Bearing Ratio (CBR) tests were carried out for GSB mixes. Based on the tests results, it is found that GSB Mix -3 with proportion 10:15 (brick dust: Stone Dust) have optimum values for MDD, OMC and CBR test. As a result, brick dust can be utilised as a partial or complete replacement for stone dust in GSB mixes. This stimulates the use of locally available brick kiln debris to a large extent. The use of brick dust in road pavement construction eliminates the problem of disposing of brick kiln waste and saves money on road construction projects.

Keywords: Flexible pavement;Brick Dust; Stone dust, OMC test, CBR

1. INTRODUCTION

When pavements are built on a weak subgrade, granular sub base is used as a layer between the subgrade and the granular base course. When the base course thickness exceeds the norm due to a poor subgrade, it is divided into two layers: granular base course and GSB. Because the material used to produce the GSB layer is inferior than that used to construct the granular base course, the GSB layer saves money during road construction. Another important role of this layer is to serve as a drainage layer for the pavement, preventing excessive wetting and subgrade deterioration. In terms of strength, it is superior to the subgrade. Sub-base course is built with a variety of materials and procedures.The use of locally available and industrial waste materials in the construction of low-volume roads like rural pavements is emphasised by MORT&H and the National Rural Roads Development Agency (NRRDA), as it overcomes the problem of disposing of large amounts of industrial waste1.

Brick Dust, a waste of brick kiln industry, is one of the locally available waste materials which can be utilised as GSB material in place of sand. The brick sector of India is the second largest brick producer with 10% annual growth after China with annual brick production of 54% [2]. It is continuously expanding due the rapid demand for bricks in construction industries. In India, about 9 to 10 million employees are working in the brick industry, but mostly of them are unskilled. India has about more than 50% brick units than china but still in India the production of bricks is about only 27% of that produced by china. Poorly organised and tremendous in size, lack of technology, poor quality control and unskilled labor are the reasons behind the less production of bricks in Indian brick industry. Because of above reasons there is less production, high consumption of fuel and large amount of waste is generated in the form of broken bricks, deformed bricks, over-brunt bricks, brick dust or Brick Dust, fly ash or coal ash depending on the type of fuel used. The various studies shows that fly ash or coal ash has its recycling value and are used in many construction activities. The rest of the waste of brick kilns is used for land filling or road side dumping, which causes environmental pollution. Brick industry is not only responsible for contaminating top earth surface but also causes the air pollution, causing environmental concern. Due to environmental concern effective waste management is required. In the present study an attempt is made for the effective utilization ofBrick Dust as GSB material.

2. OBJECTIVE OF THE STUDY

The first objective of the present study is to develop GSB mixes by using Brick Dust with or without stone dust. In the present study stone dust is replaced by Brick Dust in proportion 0%, 5%, 10%, 15%, 20% and 25%. GSB mixes with varying proportions of Brick Dust are test for CBR at the maximum dry density and optimum moisture content, to evaluate the performance of Brick Dust. This will facilitate in, saving of sand for other construction works, reducing waste from brick kilns, bring economy to the road construction and also reduce the environmental pollution, which is second objective of this study.

In GSB mixes, the materials, like, natural sand like stone dust, moorum, gravel, crushed stone, or combination of these are being used. But, in regions, where Brick Dust, is available in abundant quantity at marginal /low cost from brick kilns, it can also be used along with sand or in place of sand. However,Brick Dust finds its application in road constructions like subgrade, WMM constructions. Accordingly, Brick Dust along with stone dust has been selected for the present study to evaluate its suitability in GSB layer of road construction.

3. LITERATURE REVIEW

The research & development studies and successful field demonstration projects have proved that waste materials like fly ash, iron and steel industry slags, municipal waste, rice husk ash, marble slurry dust, brunt brick dust, recycled concrete etc. can be used for construction of roads. The studies carried out at central road research institute, India; reveal that, locally available low – grade materials like dhandla soil – gravel, kankar and stabilized soil can be used effectively and economically in pavement layers of rural roads*[18].Berthelot et al.[19] carried out investigation on cement modification of granular base and sub-base materials using Tri-axial Frequency Sweep Characterization and concluded with recommendation of adding cement to marginal quality aggregates for better performance. Carlos[20] reported that the brickbats in base course showed good record of use and performance in Bangladesh. Brick macadam bases become denser under traffic and develop high strength, while being flexible and insensitive to moisture at the same time. Kazuhiko and Kuboi [21] based on their studies recommended that the effective utilization of the waste rock powder resources as a construction material could solve the problem of environmental pollution and disposal in Japan.

Based on the various researches, Indian road congress, publications, IRC: 63 – 1976, IRC: 68-1976, IRC: 74-1979, IRC: 88-1984 and IRC: SP: 58-2001 provides guidelines for the use of locally available waste material in road pavement construction.

4. LABORATORY INVESTIGATION ON MATERIAL

Normally in GSB material, quantity of coarser fraction is about more than 50%. The coarse aggregates used in this study were of size 53 mm and 20 mm,are shown in Fig. 1.


53 mm aggregates


20 mm aggregates

Fig. 1. Coarse Aggregates

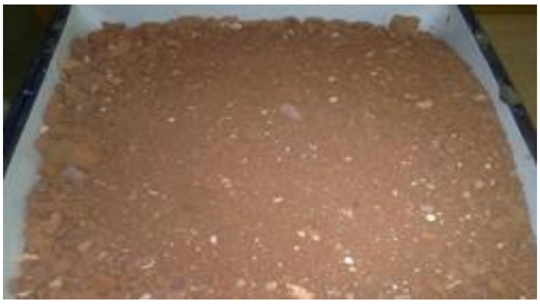
In the present study coarse aggregates are obtained from Yamuna Nagar quarry zone. The coarse aggregates of this quarry zone are strong enough and fulfil the requirements prescribed by MORT&H. The various tests were conducted on 20 mm size coarse aggregates as per MORT&H specifications and found that selected coarse aggregates fulfil the requirements of MORT&H as given in Table1.

Table 1. MORT&H specifications

Sr. No.	Physical Properties	Test Method	Recommended value as per IRC / MORT&H	Test Value
1	Aggregate Impact Value	IS: 2386 (Part 4) 1997	Shall not exceed 50%	17.53%
2	Aggregate Crushing Value	IS: 2386 (Part 4) 1997	Shall not exceed 45%	28.83%
3	Combined Flakiness and Elongation Indices	IS: 2386 (Part 1) 1997	Shall not exceed 40%	25.6%
4	Water Absorption	IS: 2386 (Part 3) 1997	Should not exceed 2%	0.85%
5	Specific Gravity	IS: 2386 (Part 3)1997	2.5 to 3.0	2.79

Generally, sands used for road construction include stone dust, crusher sand, natural sand obtained from river beds and local sands like tibba sand etc. In the present stone dust is used as fine fraction to make the blend with coarser fraction. It is greyish in colour, has fewer fines and has better engineering properties. Besides stone dust, locally available brick kiln waste Brick Dustwas also used in the present study. Brick Dust is used in place of stone dust by replacing it in proportions 0%, 5%, 10%, 15%, 20% and 25% to find its suitability as GSB material in the road construction. The finer fractions used in the study are shown in Fig. 2.

Stone Dust



Brick Kiln Waste "Surkhi"

Fig. 2. Fine Aggregates

The various tests were conducted to evaluate the properties of stone dust and Brick Dust. The observed test values for different properties given in Table 2, ensures the suitability of Brick Dust in GSB material as a sand.

Table 2 Properties of Stone Dust and Brick Dust

Sr. No.	Properties		Test Method	Recommended Value	Observed Test Values	
					Stone Dust	Brick Dust
1	Specific gravity		IS: 2720 (P3 / Sec 2) 1963	2.65 to 2.85	2.66	2.52
2	Grain Size Analysis	Grading Zone	IS: 2720 (P4) 1985	Zones I, II & III	Zone II	Zone II
		Fineness Modulus (FM)		2 to 3.5	2.22	3.05
3	Atterberg Limits	Liquid Limit (LL)	IS: 2720 (P5) 1985	Max. 25%	17.89	20.08
		Plastic Limit (PL)		------	Non Plastic	Non Plastic
		Plasticity Index (PI)		Max. 6%	NA	NA

5. EXPERIMENTALSETUP

The proportioning of materials was carried out to meet the specified gradation requirements ofMORT&H. Job mix design is done for the combination and proportioning of aggregates to obtain the required gradation of GSB mix. The GSB mix consist of 70% coarse aggregates (CA) and 30% of finer aggregates (FA).The six samples(S1 to S6) of GSB mixwere prepared with different proportions of sand and Brick Dust along with coarse aggregates. The observed grading of six GSB mix samples was conform to coarse graded granular sub-base material, grading – I, given in table 3.The grading curves for GSB mix samples and their proportions are shown in Fig. 4 and Table 3 respectively.

Table 3

GSB Material		**Material Proportioning (in %) of GSB Mix Samples**					
		S1	**S2**	**S3**	**S4**	**S5**	**S6**
Coarser Fraction (CA)	53 mm	40	40	40	40	40	40
	20 mm	35	35	35	35	35	35
Finer Fraction (FA)	Stone Dust	25	20	15	10	5	0
	Brick Dust	0	5	10	15	20	25
Total Proportion		100	100	100	100	100	100

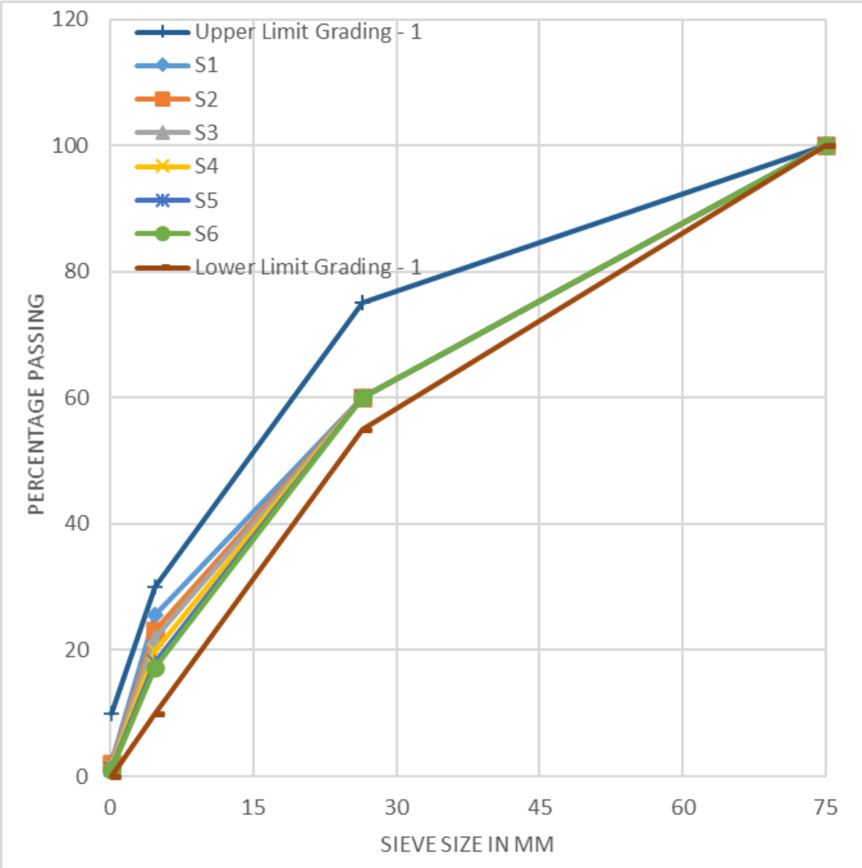


Fig.3Grading Curves for GSB Mix Samples

To evaluate the suitability of coarse graded GSB mix samples S1 to S6, Heavy Compaction Test and CBR (Soaked & Un-Soaked) test were conducted. The MDD and OMC for the GSB mix samples were obtained by test method, IS: 2720 Part 8, reaffirmed 1995. The CBR was determined at the MDD and OMC for each sample using test method, IS: 2720 Part16, reaffirmed 2002. The CBR test is conducted for both un-soaked and soaked (at 4 days soaking) conditions.

6. RESULTS AND DISCUSSION

The relationship between the dry density and moisture content was obtained by IS Heavy compaction test as per IS: 2720 (Part 8). The materials passing 20 mm sieve were used for the test, and the coarser size fractions (i.e.more than 20 mm) are suitably adjusted by lower size fractions.The heavy compaction tests results shows that the MDD and OMC for different coarse graded GSB mixes obtained by blending Brick Dust and stone dust in different proportions are in range of **2.194**to**2.346**g/cc and **5.10**to**7.05**per cent respectively.It is found that GSB mix sample S3 with 15% Brick Dusthave the highest MDD and OMC among the samples with values**2.346**g/cc and **6.10**per cent respectively.

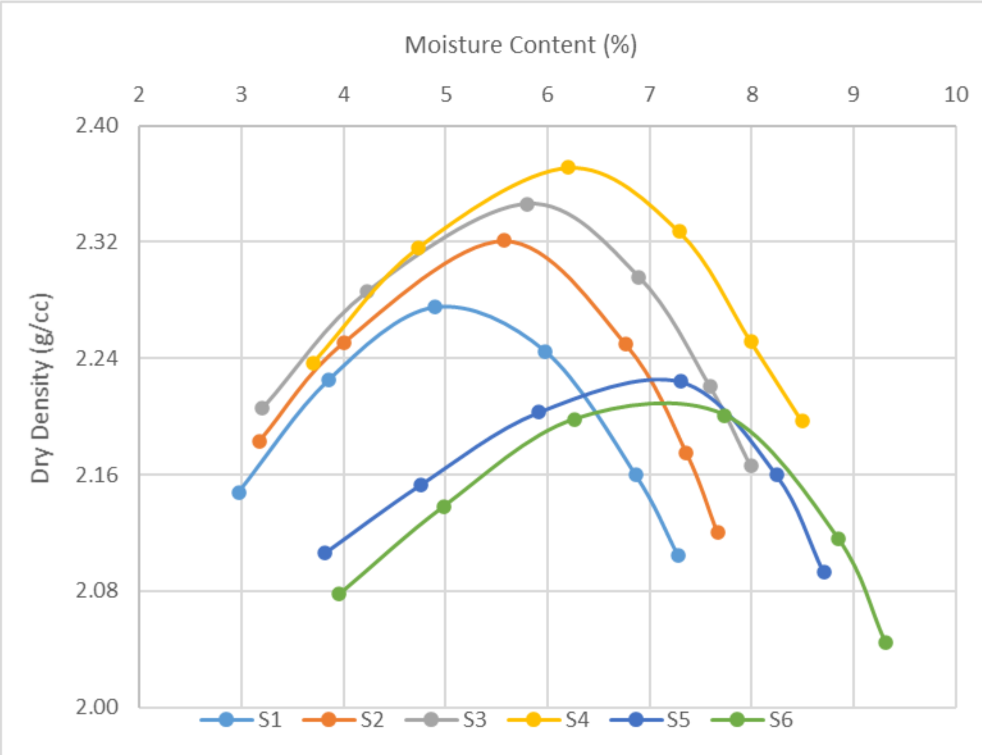


Fig.4Moisture-Density values of GSB mix samples

The strength of GSB mix samples was evaluated in terms of un-soaked and soaked CBR values as per IS: 2720 part 16. The soaked CBR values were evaluated at the density and moisture content likely to develop in equilibrium condition, which shall be taken as density relating to a uniform air voids content of 5 per cent, for soaking CBR test the samples were soaked for 4 days period.The samples S1 to S6 for CBR test were remoulded at OMC and MDD. It is observedthat the CBR valuescorresponding to MDD and OMC under heavy compaction were more than 30 per cent as required by MORT&H specifications, tabulated in Table 4.

Table 4 Test Values

GSB Mix Samples	S1	S2	S3	S4	S5	S6
Proportions of Brick Dust ::Stone Dust	0:25	5:20	10:15	15:10	20:5	25:0
OMC (%)	5.10	5.90	6.10	6.25	7.05	6.95
MDD (g/cc)	2.250	2.325	2.346	2.277	2.196	2.194
Un-Soaked CBR (%) at 2.5 mm	48.70	50.32	52.35	49.51	46.27	45.45
Soaked CBR (%) at 2.5 mm	36.53	39.37	42.61	37.74	34.50	34.90

The test results shows that the un-soaked and soaked CBR values ranges from 45.45 to 52.35 per cent and 34.50 to 42.61 per cent respectively, at 2.5 mm penetration. The GSB mix sample S3 with 10 % Brick Dust and 15% stone dust, have the maximum un-soaked and soaked CBR values of 52.35 and 42.61 per cent respectively. The Fig 5&6 shows the variation in CBR values for both soaked and un-soaked at 2.5 mm and 5.0 mm penetration.

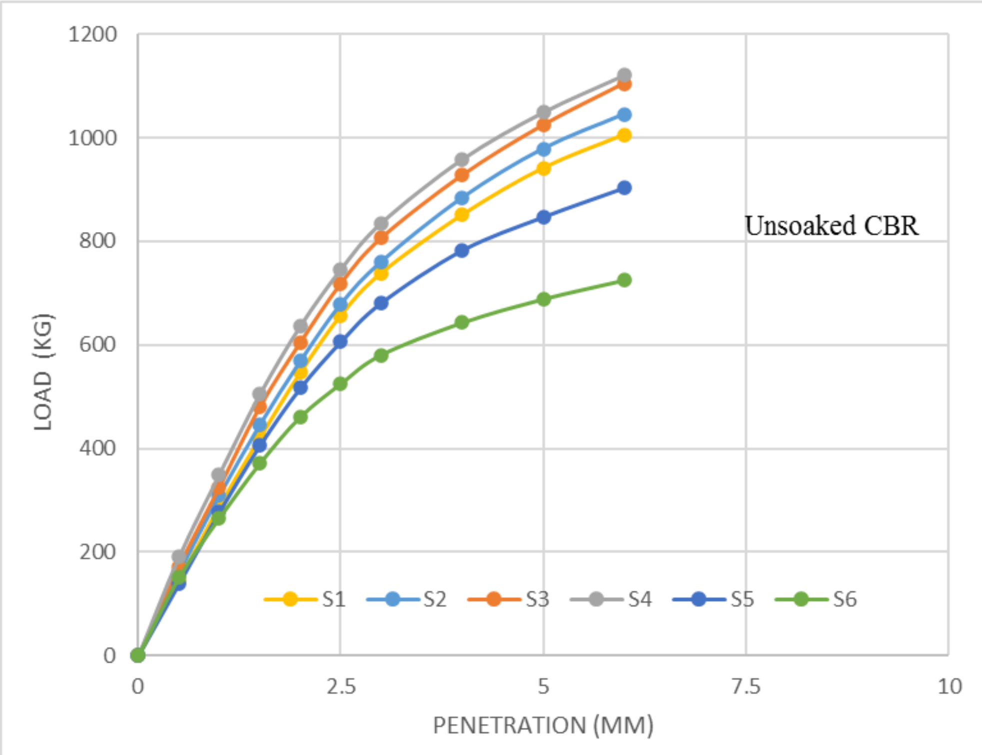


Fig.5CBR values of GSB mix samples

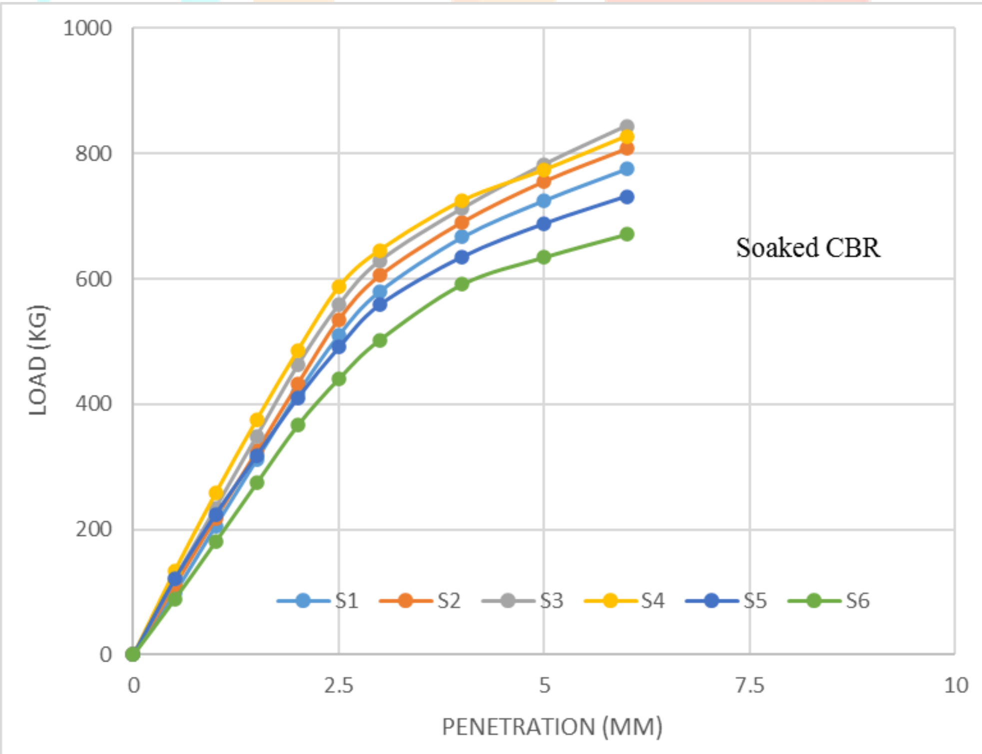


Fig.6CBR values of GSB mix samples

7. CONCLUSION

The study " A Laboratory Study on Brick Dust for GSB layer of Flexible Pavement" has been carried out with a view to judge the suitability of locally available Brick Dust in road construction works as per MORTH Specifications. For this purpose, six types of GSB mixes were formed by partially and completely replacing sand with that of Brick Dust. The main conclusions drawn from the study are:

1. Gradation of the fine aggregates indicates that both stone dust and Brick Dust fall in grading Zone-II. The fineness modulus for stone dust and Brick Dust are found to be 2.22 and 3.05 respectively. The gradation and fineness modulus indicate that both can be used for structural works.
2. Both stone dust and Brick Dust have liquid limit less than 21 % and are non-plastic in nature. They fulfill the requirement of plasticity for road construction.
3. Maximum dry density (heavy compaction) for various GSB mixes is found to be varying between 2.194 gm/cc to 2.346 gm/cc. It is found to be maximum for GSB Mix – 3 with Brick Dust and stone dust in the ratio 10:15.
4. OMC is found to increase with increase in proportion of Brick Dust from 0% to 25%.
5. The test results on all six GSB mixes are found to fulfill the MORTH requirements of gradation, CBR and plasticity indicating that these combinations can be used in GSB construction of road works.
6. The CBR value of GSB Mix – 3 (Brick Dust: Stone:: 10:15) shows maximum values for both Unsoaked and soaked test conditions. A saving in the cost of sand in GSB can be achieved by replacing sand with that of Brick Dust.
7. The use of locally available Brick Dust in road construction in GSB will not only result in achieving economy in the road projects, but also save on environmental degradation by minimizing mining pollution and energy used in the quarrying of sand/stone dust.

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