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Use of Demolished Concrete Aggregate and Brick Dust in Granular Sub-Base

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Abstract - *The Present study has been done to determine the suitableness of recycled material in pavement construction and maintenance. The construction of roads involve millions of tonnes of aggregate. And as we have limited resources, so we can also go for the replacement of part of the material or full material, this will also help in saving environment degradation in term of reduced mining and less pollution. In the present study demolished concrete aggregate(DCA) and brick dust are used in granular sub-base(GSB). The research is based on partial replacement of natural aggregates with demolished concrete aggregate(DCA) and stone dust with brick dust. In the present study we compare the results of conventional granular sub-base(GSB) mix and aggregate replaced with demolished concrete aggregate(DCA) and stone dust with brick dust using laboratory experiments. In this study the following experiments were carried out to find out the specific gravity, water absorption and aggregate impact value of the materials and besides this, maximum dry density, optimum moisture content, California bearing ratio(CBR) and permeability values at different proportion of demolished concrete aggregate(DCA) and brick dust mixed with natural aggregate were performed. Based on the test results, it is found that demolished concrete aggregate and brick dust can be used as an alternative material in partial replacement of natural aggregate and stone dust respectively in granular sub-base(GSB) mix.*

Key Words: **Granular sub-base, Demolished concrete aggregate, Pavement construction, Recycled material, Brick dust**

1. INTRODUCTION

In present time, the shortage of natural material for construction is increasing and to overcome this deficiency we have to find other avenues. One way to overcome this shortcoming is to use waste materials as partial or full replacement. Considering the scarcity of natural material in this study we have used two waste materials in granular sub-base(GSB) mixes in which the first one is demolished concrete aggregate(DCA) and the second one is brick dust. Use of demolished concrete aggregate(DCA) is not very common in India and other countries. According to an report prepared by two government agencies involved in construction sector in India, the construction waste generated annually is around 180 million tonnes. And we use this waste with little or no use. If we use this waste, then the problem of disposing it will also be over and the material that becoming less will also be filled. The second material is brick dust, a waste of brick kiln industry. Brick dust is one of the locally accessible waste material which can be used as granular sub-base(GSB) material in place of stone dust. In the present study an attempt is made for the effective utilisation of demolished concrete aggregate(DCA) and brick dust in granular sub-base(GSB) mixes. In this study the samples of granular sub-base(GSB) mix are prepared with different percentage of demolished concrete aggregate(DCA) i.e. 10%, 20% and 30% and of brick dust i.e. 5%, 10% and 15%. The laboratory experiments have been done on prepared samples and experiments are done on prepared sample to determine the maximum dry density, optimum moisture content, California bearing ratio and permeability values at different proportion of demolished concrete aggregate(DCA) and brick dust mixed with natural the aggregate. Besides this experiments like specific gravity water absorption and aggregate impact value were also conducted.

2. OBJECTIVES OF THE STUDY

In the present study, the maximum dry density, optimum moisture content, California bearing ratio(CBR) and permeability values are identified of prepared samples with different percentages of demolish concrete aggregate(DCA) and brick dust in granular sub-base(GSB) mixes. The granular sub-base(GSB) is as per MORTH (Ministry Of Road Transport And Highways) grading III.

The objectives of experimental study are as follows-:

1. To determine various physical properties of material selected for the study.
2. To find out density and strength properties of brick dust and demolished concrete mixed granular sub-base(GSB) mixes.
3. To determine the optimum proportion of brick dust and demolished concrete to be used in granular sub-base(GSB) mixes.

3. SCOPE OF THE STUDY

The materials used in in this study are 40mm, 20mm, 10 mm, stone dust, demolished concrete aggregate(DCA) and brick dust. The natural aggregates (40 mm, 20 mm and 10 mm) and stone dust used were taken from Namrup, Assam. The source of brick dust is Dayalpur Brick kiln, Kurukshetra, Haryana and demolished concrete aggregate(DCA) is taken from NIT Kurukshetra, Haryana. Constant head permeability test on granular sub-base(GSB) mixes was done at the the hydraulic gradient of of 0.6.

4. EXPERIMENTAL METHOD

The main testing program includes the :-

a) Physical Characterization of the materials used in this study.

b) Grading the material used as per MORTH Grading III (Table 400 1).

c) Preparation of GSB Mixes by replacing natural aggregate by demolished concrete aggregate(DCA) by proportion of 10%, 20% and 30%, brick dust by proportion of 5%, 10% and 15% and finally combining both brick dust and DCA at the given percentages above.

d) Performing Modified Compaction Factor Test on GSB Mixes to determine the Maximum Dry Density and Optimum Moisture Content Percentages at the different proportions of brick dust and demolished concrete aggregate(DCA).

e) Performing the California Bearing Ratio (CBR) test (soaked) and Constant Head Permeability Test on GSB Mixes at the different proportions of brick dust and demolished concrete aggregate(DCA).

Table -1: Experiments Performed

Property	Test Performed	Specified Limits
Specific Gravity	Specific Gravity Test (Is:2386 Part 3)	-
Water Absorption	Water Absorption Test (Is: 2386 Part 3)	Maximum 2%
Strength Of Aggregates	Aggregate Impact Value Test (IS: 2386 Part 4)	40% For Sub-Base
Maximum Dry Density & Optimum Moisture Content	Heavy Compaction Factor Test (IS: 2720 Part 8)	-
CBR	CBR Test(IS: 2720 Part5)	30%
Permeability	Permeability Test (IS: 2720 Part 17)	-

Table-2: Specified Limits for GSB III as per MORTH 2013(Table 400-1)

Percentage of GSB Mix Passing through Sieve Sizes		
Sieve size(mm)	Upper limit(%)	Lower limit(%)
53	100	75
26.5	75	55
4.75	30	10
0.075	5	-

For the ease, the naming of the GSB Mixes is done based on Demolished concrete aggregate(DCA) and Brick Dust Content in it. The naming of GSB Samples are given in the following table

Table -3: Naming of the GSB Mixes

SAMPLE NAME	DCA(%)	BRICK DUST(%)
M00	0	0
M01	0	5
MO2	0	10
M03	0	15
M10	10	0
M20	20	0
M30	30	0
M11	10	5
M12	10	10
M13	10	15
M21	20	5
M22	20	10
M23	20	15
M31	30	5
M32	30	10
M33	30	15

5. LABORATORY STUDY

5.1. The Physical Properties of the materials used in the study is given in the following table:-

Table -4: Physical Properties of the materials used in the study

MATERIAL	SPECIFIC GRAVITY	WATER ABSORPTION(%)	AGGREGATE IMPACT VALUE(%)
40mm Aggregate	2.66	0.50	18.29
20mm Aggregate	2.74	0.61	13.12
10mm Aggregate	2.76	0.64	13.19
Stone Dust	2.60	NA	NA
DCA	2.51	1.91	15.18
Brick Dust	2.64	NA	NA

5.2. The Grain Size Distribution of Materials is given in the following table:-

Table -5: Percentage of Materials Passing through Sieve Sizes

Sieve Size(mm)	40mm	20mm	10mm	Stone Dust	DCA	Brick Dust
53	100	100	100	100	100	100
26.5	13.68	100	100	100	100	100
4.75	0	0	1.07	100	6.57	86.20
0.075	0	0	0	5	0	11

In the experimental study, for the preparation of GSB Samples, the materials listed above are mixed in a ratio to give the desired proportion of GSB grading III as in Table 2.

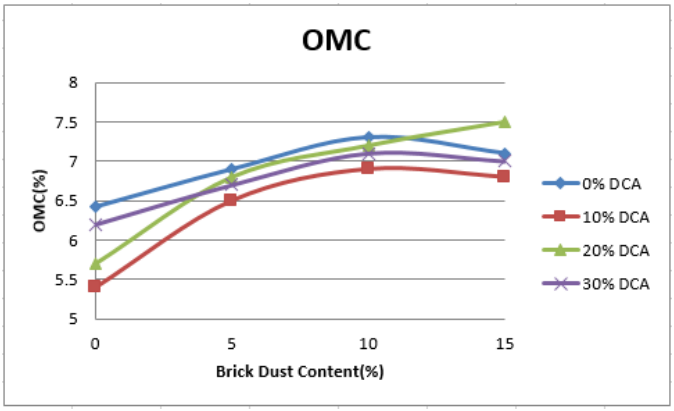
5.3. The Maximum Dry Density, Optimum Moisture Content, soaked CBR and Permeability Values (at hydraulic gradient of 0.6) of the GSB mixes are as follows:-

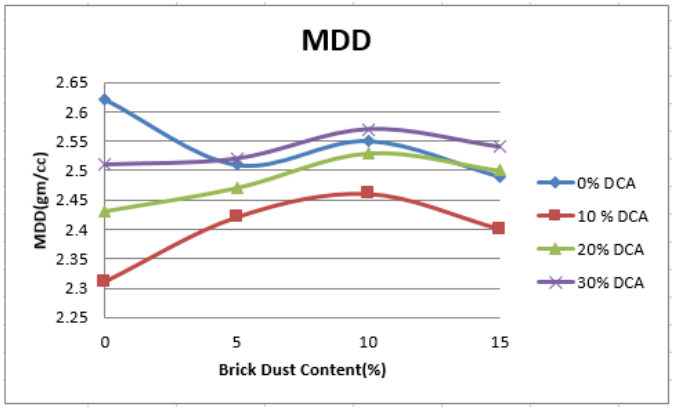
Table -6: Maximum Dry Density, Optimum Moisture Content values

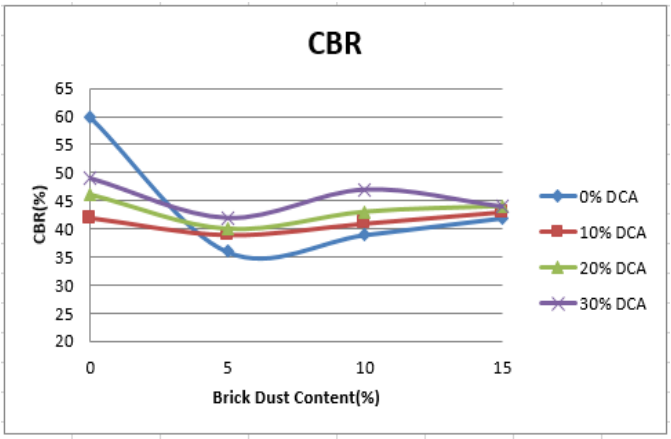
SAMPLE NAME	MAXIMUM DRY DENSITY(g/cc)	OPTIMUM MOISTURE CONTENT(%)
M00	2.62	6.43
M01	2.51	6.9
M02	2.55	7.3
M03	2.49	7.1
M10	2.31	5.4
M20	2.43	5.70
M30	2.51	6.2
M11	2.42	6.5
M12	2.46	6.9
M13	2.44	6.8
M21	2.47	6.8
M22	2.53	7.2
M23	2.50	7.5
M31	2.52	6.7
M32	2.57	7.1
M33	2.54	7.0

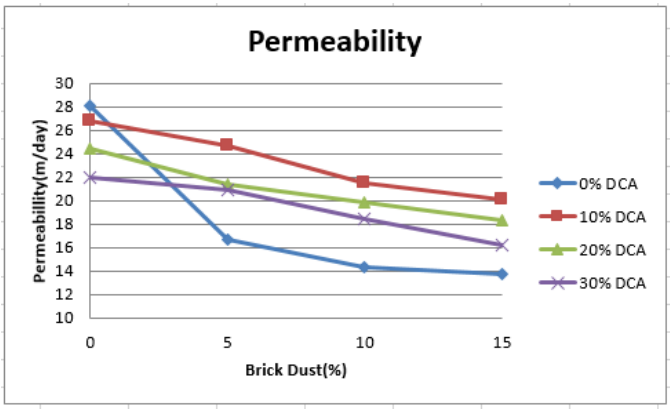
Table -7: Soaked CBR values and Permeability values

SAMPLE NAME	SOAKED CBR VALUE(%)	PERMEABILITY TEST(m/day)
M00	60	28.06
M01	36	16.66
M02	39	14.34
M03	42	13.73
M10	42	26.77
M20	46	24.43
M30	49	21.96
M11	39	24.67
M12	41	21.52
M13	43	20.11
M21	40	21.34
M22	43	19.87
M23	44	18.37
M31	42	20.93
M32	47	18.47
M33	44	16.22









6. RESULTS AND DISCUSSIONS

The CBR Value of the GSB mixes prepared by partially replacing Natural Aggregate with Brick Dust and DCA lies within the specified limit in the code of Practice i.e., MORTH(2013): Specifications of Road and Bridge Worksi.e. 30% . From the study, it can be seen that with an increase in the percentage of Brick Dust in the GSB sample the properties such as Maximum Dry Density and Permeability Values are decreasing but the CBR values are increasing and are within specified limits of MORTH. And with an increase in the percentage of DCA in the GSB sample the properties such as Maximum Dry Density, CBR Values and Permeability Values are increasing. And with an increase in the percentage of Brick Dust and DCA in the GSB sample the properties such as Maximum Dry Density, CBR Values and Permeability Values are first increasing then after decreasing but the CBR values are within specified limits of MORTH. It has been found in research that after partial replacement of Brick Dust with 10% of Stone Dust and DCA with 30% of natural aggregate, then the values are within specified limits of MORTH.

7. CONCLUSIONS

Based on laboratory study it can be concluded that:-

1. The test result for GSB mix by using DCA and brick dust are found to fulfil the MORTH requirement of gradation.
2. Replacement of Brick Dust and Demolished Concrete Aggregate lies within specified limits and 10% replacement of Brick Dust and 30% replacement of DCA shows best results as compared to other percentage replacement.
3. Brick Dust and DCA can be used as an alternative to natural aggregate in GSB.
4. This will not only help in the conservation of natural aggregates but will also help in the utilization and disposal of waste materials.

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