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Utilization of Building Waste Material in Base Layer of Pavement Construction

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Abstract—*This research study targets to reuse building waste material including tiles, bricks and recycled aggregate in the base layer of pavement construction. Reuse of building waste material is important for material conservation as well as the energy. The waste materials generated from the demolition of building have retained usability in different forms. This study has an objective to reuse building waste material in the base layer of pavement in place of present dense layer of asphalt. The test needed for the characterization of the material are crushing abrasion, Marshall stability, water absorption, density, gradation, impact etc. The main objective of this project is to analyze the result of various tests on this waste and also to find out the economic effect of utilization of waste in base layer of pavement construction.*

Keywords*: Building waste, Reclamation, Flexible pavement, Marshall test.*

1. INTRODUCTION

From a broad point of view, disposal of C&D (Construction and demolition) waste is not only a simple environmental concern, but also has the major effect on the conservation of resources for the whole Ecosystem [1]. Since it reduces requirement of raw materials and provides alternative options. Prior to use in the construction materials it is needed to characterize the properties as per standard and to ensure the retain potential. Substitution of materials like composition was qualified and the potential need in the market of main recycled materials (aggregates, brick, wood etc,) was analyzed [3]. Construction and Demolition Waste (CDW) generated is more than one-third of the total solid waste generated in the world [4]. The buildings present a high index of environmental impact throughout their life cycles, and the generation of CDW contributes considerable variation to this environmental impact. Various type of materials are involved in building construction, so that choosing satisfactory materials and systems during the design stage is necessary to reduce the future environ-mental adverse impact of buildings [4].

2. MATERIAL

RCA (Recycled coarse aggregate) in the size range of 0-4.75 mm, 4.75–10 mm and 10–20 mm was collected from a construction and demolition site located near Mahatma Gandhi hospital to assess the variation in its composition, as well as physical characteristics.

A natural crushed aggregate of the same size range was also taken for the comparison of aggregate properties of RCA. Both types of the aggregate were analyzed in accordance with the relevant Indian Standards for their suitability to use in the base layer of pavement. Since RCA was inhomogeneous, unlike natural aggregate, therefore, RCA was required to be evaluated carefully for its compositions and other physical properties. The composition of RCA was analyzed by determining the presence of different materials in it. For this purpose, three different samples weighing 5 kg each were randomly taken out from three stock piles of RCA (10–20 mm). The average values obtained on these three samples for different percentage of RCA along with water absorption are given in Table 1. The average brick aggregate content in RCA by mass was about 0.4%. The presence of different materials was not evaluated in RCA of size range 4.75–10 mm.

3. METHODOLOGY

3.1 Aggregate characterization

In this research work, various aggregate characterization tests are carried out for evaluating its property. The basic tests performed for aggregate characterization are listed in the table 1.

Table 1: Basic characterization of fresh aggregates.

Aggregates tests with standard IS code		
Property of Aggregate	**Type of Test**	**Test Method**
Crushing strength	Crushing test	IS:2386 (part 4)
Hardness	Los Angeles abrasion	IS: 2386 (Part 5)
Toughness	Aggregate impact test	IS: 2386 (Part 4)
Specific gravity and porosity	Specific gravity test and water absorption test	IS: 2386 (Part 3)
Adhesion to bitumen	Stripping value of aggregate	IS: 6241-1971

3.2 Bitumen Characterization

The Bitumen is used as the binding material for the aggregates. The basic characterization of the bitumen is done in the laboratory to evaluate the physical properties of the selected bitumen penetration grade 80/100. The lab testing is performed following the standard IS codes specified the respective property of the bitumen.

3.3 Marshall Stability Test

In this research work, the investigation is done for the base layer, standard code MoRTH is followed for the aggregate gradation for the chosen layer of the pavement. Further for evaluating performance the Marshall Stability test is performed in the laboratory by following ASTEM D6927-06.

Table 2: Gradation of aggregates for the base layer of the pavement.

Sieve size (mm)	Percentage passing (%)	Percentage Retained (%)	Weight (gm)
25	100	0	0
20	99	1	12
12.5	60	39	468
10	39	21	252
4.75	22	17	204
2.36	19	3	36
1.18	17	2	24
0.875	16	1	12
0.3	14	1	12
0.075	9	6	72
Binder	Content	5-7.5	1200

4. RESULT AND ANALYSIS

The physical performance of the virgin and the waste materials are evaluated in the Road Testing Laboratory at Poornima institute of engineering technology Jaipur and its result is given in the table 3. There are various graphs are plotted to do comparative analysis of physical properties which is significant in the road construction.

Table 3: Comparative analysis of physical properties of aggregates (RCA and NCA).

Physical properties	RCA	NCA
Specific gravity	2.24, 2.45	2.71
Aggregate crushing value (%)	23.8–30.7	20.2–28.17
Bulk Density (kg/m^3)	1470–1520	1570–1650
Water absorption (%)	4.23 (10–20 mm)	0.48
Water absorption (%)	6.8 (4.75–10 mm)	0.74
Impact Value, (WAIV) %	18.5–21.1	12.4
LA Abrasion (%)	30.2–33.8	21.3–21.6

Bulk density graph is plotted for the virgin mixture as well as the waste mixture and found that the optimum bitumen required for the recycled building waste aggregate to achieve maximum density in more than the virgin aggregate (Fig.1.). The requirement of binder content for the waste materials depend on the nature of the waste used for the sample preparation.

Table 4: Comparison of bulk densities of the mixtures of virgin aggregates and recycled aggregates

Bitumen content (%)	Virgin	Waste
4	1.93	1.87
5	2.01	1.96
6	2.02	1.99
7	1.98	1.94

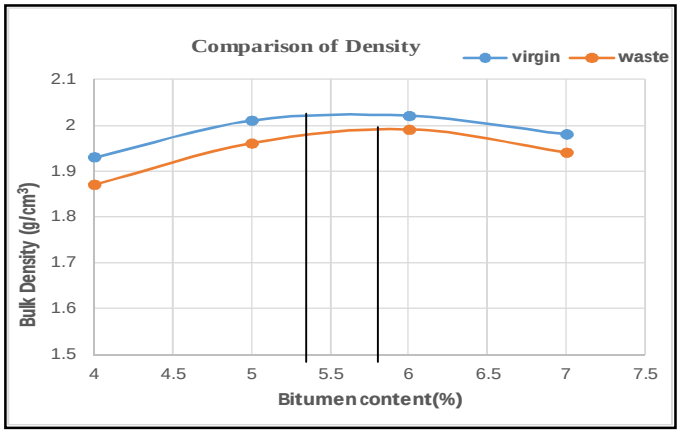

Fig. 1: Bulk density vs Bitumen content for fresh and Waste materials

The Marshall Stability test is conducted and the test result is listed in the table 5. The graph is plotted Stability vs bitumen content for achieving the optimum bitumen required for achieving maximum stability (Fig. 2). The comparative

analysis of the stability of the waste materials with the fresh material is done with the plotted graph of Fig. 2. It is observed that the waste building materials aggregate requires more bitumen than the virgin aggregates to achieve maximum stability.

Table 5: Marshall stability test result for the fresh and waste aggregates

Bitumen (%)	Stability (KN)	
	Virgin Agg.	Waste Agg.
4	6.2	6
4.5	6.8	6.1
5	7.9	6.9
5.5	8	7.5
6	6.8	6.3
6.5	6.5	6.3

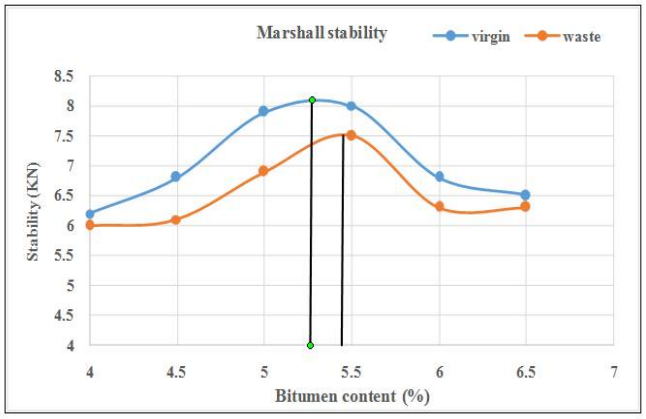

Fig. 2: Stability vs Bitumen content for the fresh and waste materials.

5. CONCLUSION

It is seen from the result of comparative analysis of building waste materials with virgin aggregates that the waste materials have retained un-used properties and these properties can be utilized in different forms. Due to locally availability use of the waste material results in an economical design of the pavement structure with lower initial investment. The material conversation and the energy conversation can provide better opportunity to memorize the pollution problem in the nearby environment.

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