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A LABORATORY STUDY OF RECYCLING OF CONCRETE USING IN BITUMINOUS MIXES

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Abstract : Recycled concrete aggregate (RCA) is considered as one of the largest wastes in the entire world which is produced by demolishing concrete structures such as buildings, bridges, and dams. It is the intention of scientists and researchers, as well as people in authority, to explore waste material recycling for environmental and economic advantages. The current paper presents an experimental research on the feasibility of reusing RCA in BC mixtures as a partial replacement of coarse and fine aggregates. The engineering properties of BC mixtures containing RCA have been evaluated for different percentages of binders based on the Marshall mix design method. Test results revealed that the performance of BC mixtures is affected by RCA due to higher porosity and absorption of RCA in comparison with virgin granite aggregates. However, the engineering properties of BC mixtures containing a particular amount of RCA showed the acceptable trends and could satisfy the standard requirements. Moreover, to achieve desirable performance characteristics, more caution should be made on properties of BC mixtures containing RCA.

Keywords -Bituminous Concrete (BC), Recycled concrete aggregate (RCA), Marshall mix.

1. INTRODUCTION

Urbanization growth rate in India is very high due to industrialization. Growth rate of India is reaching 9% of GDP. Rapid infrastructure development requires a large quantity of construction materials, land requirements & the site. For large construction, concrete is preferred as it has longer life, low maintenance cost & better performance. For achieving GDP rate, smaller structures are demolished & new towers are constructed. Protection of environment is a basic factor which is directly connected with the survival of the human race. Parameters like environmental consciousness, protection of natural resources, sustainable development, play an important role in modern requirements of construction works. Due to modernization, demolished materials are dumped on land & not used for any purpose. Such situations affect the fertility of land. As per report of Hindu online of March 2007, India generates 23.75 million tons demolition waste annually. As per report of Central Pollution Control Board (CPCB) Delhi, in India, 48million tons solid waste is produced out of which 14.5 million ton waste is produced from the construction waste sector, out of which only 3% waste is used for embankment.

Out of the total construction demolition waste, 40% is of concrete , 30% ceramics, 5% plastics, 10% wood, 5%metal, & 10% other mixtures. As reported by global insight, growth in global construction sector predicts an increase in construction spending of 4800 billion US dollars in 2013. These figures indicate a tremendous growth in the construction sector, almost 1.5 times in 5 Years. For production of concrete, 70-75% aggregates are required. Out of this 60-67% is of coarse aggregate & 33-40% is of fine aggregate. As per recent research by the Fredonia group, it is forecast that the global demand for construction aggregates may exceed 26 billion tons by 2012. Leading this demand is the maximum user China 25%, Europe 12% & USA 10%, India is also in top 10 users. From environmental point of view, for production of natural aggregates of 1 ton, emissions of 0.0046 million ton of carbon exist whereas for 1 ton recycled aggregate produced only 0.0024 million ton carbon is produced. Considering the global consumption of 10 billion tons/year of aggregate for concrete production, the carbon footprint can be determined for the natural aggregate as well as for the recycled aggregate.

The use of recycled aggregate generally increases the drying shrinkage creep & porosity to water & decreases the compression strength of concrete compared to that of natural aggregate concrete. It is nearly 10-30% as per replacement of aggregate. Recycling reduces the cost (LCC) by about 34-41% & CO_2 emission ($LCCO_2$) by about 23-28% for dumping at public / private disposal facilities.

2.OBJECTIVE

The experiment was carried out to overcome the problems created due to huge requirement of the raw material for manufacturing of conventional building material and also to minimize hazards caused by industrial waste on the environment, some other objectives are :

a. To use the demolished and construction waste aggregate in the new BC mix as the recycled concrete aggregate reduces the environmental pollution as well as providing an economic value for the waste material.
b. To study the utilization of demolished and construction waste as a replacement of natural coarse aggregate.
c. To study the physical properties of demolished and construction waste aggregate by conducting experimental work.
d. To development of alternate low cost and environment suitable building materials from industrial wastes in an economical way.
e. Importance must be given to cheap and locally available building materials and hence it is necessary to check and utilize the suitable waste products to replace some of the coarse aggregate.

A comparative study has been made in this investigation between conventional aggregate using in Bituminous Concrete (BC) & RCA using in Bituminous Concrete (BC) mix with varying RCA contents (0% - 40%) . In the present study 60/70 penetration grade bitumen is used as binder and cement is used as filler.

3. EXPERIMENTAL WORK

A. Aggregates

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For preparation of Bituminous mix (BC) aggregates as per MORTH grading as given in Table.1, a particular type of binder and fiber in required quantities were mixes as per Marshall Procedure.

Coarse aggregates consisting of stone chips collected from a local source, up to 4.75 mm IS sieve size. Its specific gravity was found as 2.75. Standard tests were conducted to determine their physical properties as summarized in Table.2.

Fine aggregates consisting of stone crusher dusts were collected from a local crusher with fractions passing 4.75 mm and retained on 0.075 mm IS sieve. Its specific gravity was found as 2.6.

B. Filler

Aggregate passing through 0.075 mm IS sieve is called as filler. Here Portland cement (Grade 43) is used as cement whose specific gravity is 3.1.

C. Binder

Here 60/70 penetration grade bitumen is used as binder for preparation of Mix, whose specific gravity was 1.03. It's important property is given in table.3.

Table.1 MORTH gradation for BC (NMAS 13 mm)

IS Sieve (mm)	Percent Passing	
	Specification Grading	Grading adopted
19	100	100
13.2	90-100	95
9.5	70-88	75
4.75	53-71	60
2.36	42-58	50
1.18	34-48	40
0.600	26-38	32
0.300	18-28	20
0.150	12-20	15
0.075 (filler)	4-10	5
Binder Content % by weight	5-7	5.0, 5.5 & 6.0

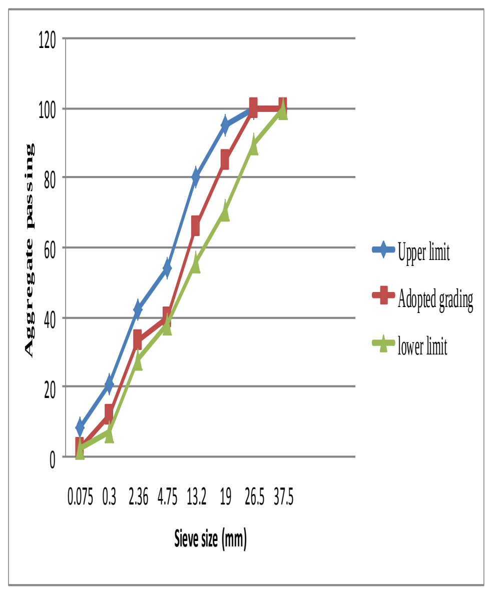

Fig.1: Aggregate gradation curve for BC

Table.2 Physical properties of natural aggregates

Property	Specification	Test Result
Aggregate Impact Value (%)	Max 24%	17.13 %

Aggregate Crushing Value (%)	Max 35%	18.80 %
Los Angeles Abrasion Value (%)	Max 30%	24.31 %
Combined Flakiness and Elongation Indices (%)	Max 35%	16.18 %
Soundness - Magnesium Sulphate	Max 18%	10.45 %
Coating And Stripping of Bitumen Aggregate Mix	Minimum Retained Coating 95%	98%
Water Absorption (%)	Max 2%	0.15%

Table. 3 Properties of Binder

Property	Method of Test	Test Result
Specific gravity	IS : 1202-1978	1.03
Penetration at 25°C (cm)	IS : 1203-1978	67.7
Softening Point (°C)	IS : 1205-1978	48.5
Ductility (cm)	IS : 1208-1978	71
Flash Point (°C)	IS : 1209-1978	175
Fire Point (°C)	IS : 1209-1978	189

D. Dismantling Of the Material

The concrete from the dismantled buildings are taken and by using hammer we break the concrete blocks as we do this manually we get irregular shapes and hence after preparing of the recycled aggregate we need to sieve the material through IS 20mm sieve and hence we get the required size of the aggregate. The following figures show the preparation of the recycled aggregate from the dismantled building material.

Fig.2: Concrete waste

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Fig.3: Recycled Coarse Aggregate

Table.4 RCA & NCA TESTING RESULTS

TEST	RCA	NCA	Permissible Value
Specific gravity	2.22	2.68	2.6-2.8
Water absorption	0.35%	0.15%	Max 2 %
Impact factor test	24%	17.13	Max. 30

E. Marshall Stability

The marshall mixing of ingredients & mould casting was done as per the following procedure (STP 204-8).

Marshall testing: The Marshall test was done as procedure outlined in ASTM D6927 – 06.

Marshall Stability Value : It is defined as the maximum load at which the specimen fails under the application of the vertical load. It is the maximum load supported by the test specimen at a loading rate of 50.8 mm/minute (2 inches/minute). Generally, the load was increased until it reached the maximum & then when the load just began to reduce, the loading was stopped and the maximum load was recorded by the proving ring.

Marshall Flow Value : It is defined as the deformation undergone by the specimen at the maximum load where the failure occurs. During the loading, an attached dial gauge measures the specimen's plastic flow as a result of the loading. The flow value was recorded in 0.25 mm (0.01 inch) increments at the same time when the maximum load was recorded.

The Marshall Stability and Flow Values are shown in Table – 5.

F. Void analysis

For analysis of voids, the samples were weighed in air and also in water so that water replaces the air present in the voids. But by this process some amount of water will beabsorbed by the aggregates which give erroneous results.

The Void analysis values are shown in Table-5.

4. RESULTS & DISCUSSIONS

A. Optimum Bitumen Content

2 curves were plotted, i.e: Marshall stability vs. Bitumen content & Marshall flow vs. Bitumen content

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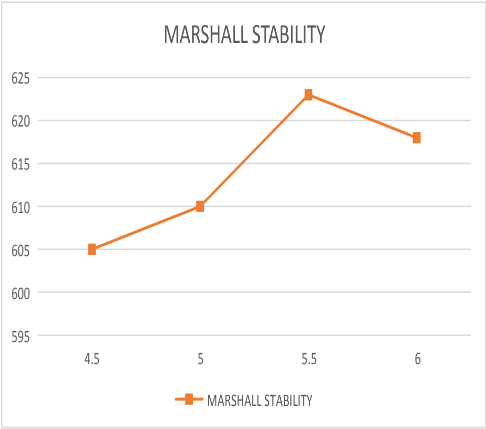

Figure.4 Marshall stability vs. Bitumen content

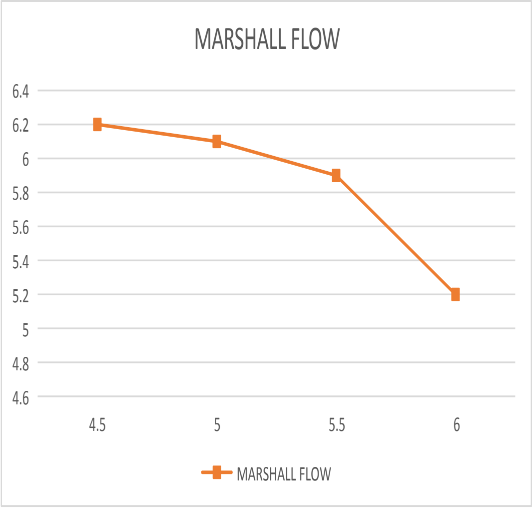

Figure.5 Marshall flow vs. Bitumen content

B. Plotting Curves for Marshell tests

6 curves were plotted. i.e:

- Marshall Stability Value vs. RCA Content
- Marshall Flow Value vs. RCA Content
- VMA vs. RCA Content
- VA vs. RCA Content
- VFB vs. RCA Content
- Bulk unit weight vs. RCA Content

For each % of RCA, 3 samples of BC have been tested. So the average value of the 3 were taken. The mean values are shown in Table 4.1.

Table.5 Data of marshall properties

S. No	RCA (%)	Unit weight (G_{mb})	Mean VMA (%)	Mean VA (%)	Mean VFB (%)	Mean Stability (Kg)	Mean Flow (mm)
1	0	2.304925	16.3666	5.275	67.769	626.666	5.93
2	10	2.293893	16.7667	4.1525	75.2336	623	5.43
3	20	2.275731	17.42578	3.346	80.7985	618.33	4
4	30	2.258427	18.05365	2.727	84.895021	606.66	3.23
5	40	2.219557	19.46404	2.6788	86.237184	588	2.8

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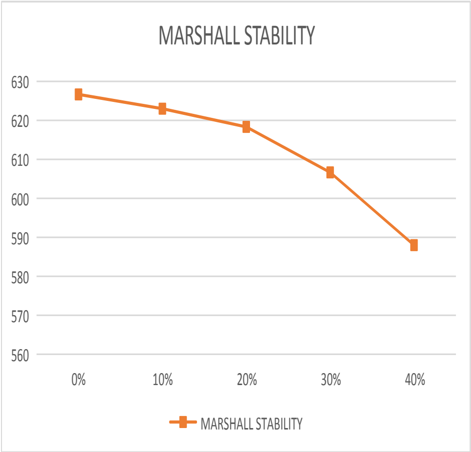

Figure.6 Marshall Stability Value vs. RCA Content

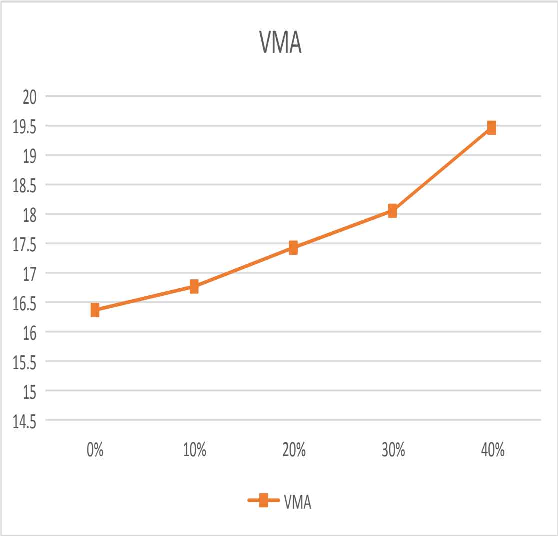

Fig .8 VMA vs. RCA Content

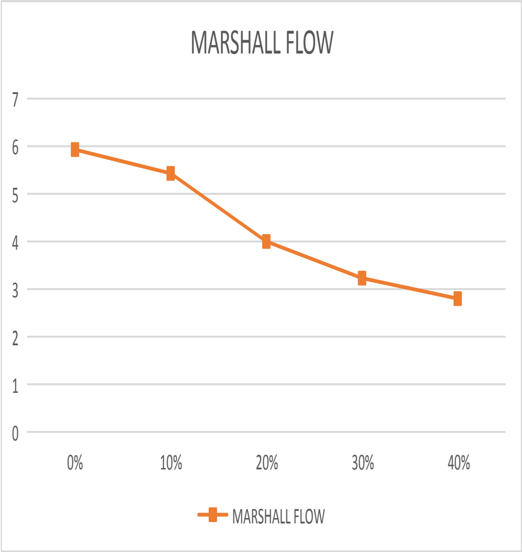

Figure.7 Marshall Flow Value vs. RCA Content

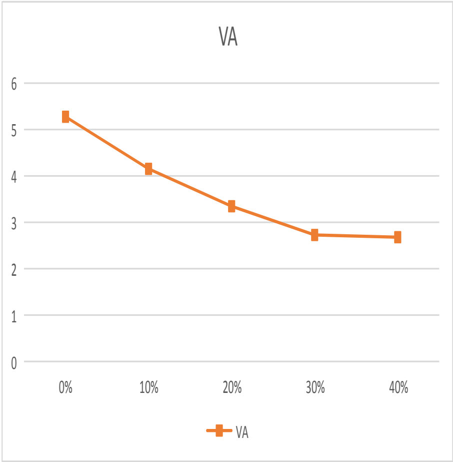

Fig .9 VA vs. RCA Content

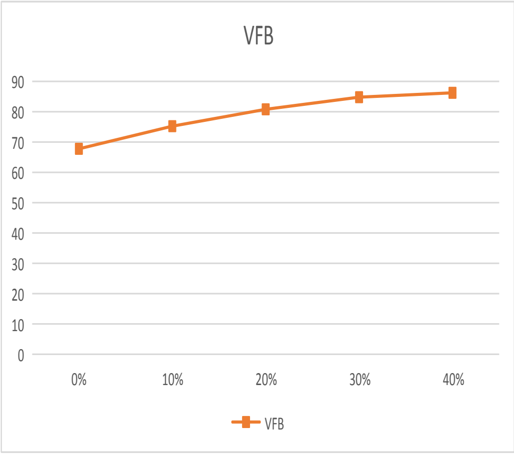

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Fig .10 VFB vs. RCA Content

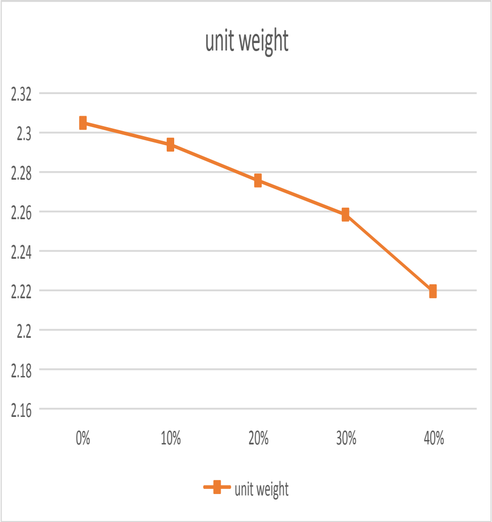

Fig .11 Unit weight vs. RCA Content

5. CONCLUSION

a. Various tests conducted on RCA are compared with Indian code and the results are satisfactory and hence these can be used as aggregates.
b. Due to use of RCA in construction energy, cost of transportation are saved.
c. Up to 30% replacing of RCA we get satisfactory strength.
d. Production cost decreases remarkably.
e. Due to lack of treatment of RCA adequate strength is not archived but by applying some treatment processes we can further improve the strength of the RCA.
f. Water absorption of RCA is high when compared with conventional aggregate.

6. FUTURE WORK

Further we can still investigate whether the increase in the strength of bc mix is decreasing or increasing because as we are using RCA due to presents of some chemical impurities there may be a chance of decrease in the strength suddenly so by further investigation we can find the faults and hence we can find out some treatment for that in the initial stage and hence this type of mix can be feasible in the future.

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