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A study on the utilization of recycled concrete aggregates (RCA) in bituminous concrete

Naresh[1], Shivani[2], Ravinder[3]
[1] Scholar, Department of Civil Engineering, Satpriya group of institutions, Rohtak, Haryana, India
[2] Assistant Professor, Department of Civil Engineering, Satpriya group of institutions, Rohtak, Haryana, India
[3] Scholar, Department of Civil Engineering, MMDU Mullana Ambala, Haryana, India

Abstract
Pounding obliterated substantial pieces produces Recycled Concrete Aggregates (RCA). The concrete glue sticking to the outer layer of normal totals even after the reusing system recognizes RCA from new totals. The diminished molecule thickness, enormous porosity, water assimilation, and unpredictability in nature of the RCA are because of this permeable concrete glue and different pollutions. The main role of this study is to inspect the exhibition of bituminous cement with different RCA rates. The objective of this exploration was to investigate into how RCA might be utilized in bituminous cement. The Marshall Stability esteem was higher for RCA contrasted with new totals with regular and changed bitumen, and the rutting twisting was higher for new totals contrasted with RCA. Aside from the water retention for the 100% RCA test utilized in this review, a portion of these noticed boundaries were inside satisfactory reaches.

Keywords: utilization, recycled concrete aggregates, bituminous concrete

Introduction
How much waste produced is expanding step by step as development movement develops at a dramatic rate. Obliterated substantial designs have been demonstrated to be a decent wellspring of development material (Nik. D. Oikonomou 2004, Sumeda Paranavithana, Abbas Mohajerani 2006, Akash Rao *et al*. 2006, P.R. Kumar and M.L.V. Prasad *et al*. October 2007, P.R. Kumar *et al*. December 2007, P.R. Kumar *et al*. Walk 2008, M. Heeralal, P The most common way of devastating annihilated substantial pieces yields RCA. RCA was first used as a filler material, yet after broad exploration (Huang *et al*. 2005, C.S. Poon 2005, M. Heeralal, P.R. Kumar *et al*. 2009), it is currently utilized as a street sub base material. RCA vary from new totals because of how much concrete glue staying on the outer layer of the first regular totals even after the most common way of reusing.
This permeable concrete glue adds to the lower molecule thickness, higher porosity, variety in the nature of the RCA and the higher water retention. In the current concentrate a portion of the discoveries of an examination of RCA on execution and properties of bituminous substantial grade I blend are managed.

Objective
Bitumen as a paving material undergoes changes like permanent deformation, low temperature cracking, and fatigue cracking, ageing and water receptivity due to high traffic intensity, high axle loads, variation in traffic and seasonal temperature variation. There is already a reasonable good amount of research on bituminous concrete made using natural aggregate. The present study was hence taken up to investigate the effect of RCA on the performance of bituminous concrete mix. The present work aims to estimate the optimum binder content for the bituminous concrete mix replacing the natural aggregate with 0, 50 and 100% of RCA and conducting Marshall's mix design to compare the results. Wheel tracking experiment with simulated wheel arrangement (5.6 kg/cm^2 contact pressure) for a specified number of repetitions (20000) on conventional bituminous concrete mixes was also carried out with a view to study the rutting potentiality of different dosages of RCA replacements in natural aggregate.

Sample Preparation for Marshall Mix Design
To control the gradation of the test specimens, the natural and recycled concrete aggregates were initially separated into various sized fractions and stored properly. The characteristics of the natural and recycled aggregate samples are shown in Table 1. When the test specimens were prepared, the aggregates were combined as per the gradation given in Mort & H [2001]. Each test specimen was batched separately. The composition of each size fraction relative to aggregate sources

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Table 1: Aggregate Test Results

S. No.	*Properties*	*RCA %*					*IS standards*
		0	*25*	*50*	*75*	*100*	
1.	Aggregate impact value %	18.04	20.69	22.2	22.94	23.6	24

2.	Abrasion Value %	23.76	25.88	27.88	28.88	29.72	30
3.	Specific gravity	2.68	2.65	2.63	2.61	2.57	-
4.	Water absorption %	0.5	1.6	2.2	2.9	3.6	2
5.	Flakiness index %	10.62	9.46	8.12	6.88	5.06	-
6.	Elongation index %	9.45	10.15	11.47	12.03	12.68	-
7.	Combined FI & EI	20.07	19.61	19.59	18.91	17.74	25

was maintained constant. The combined aggregate was placed in a hot oven and heated up to the required mixing temperature. The quantity of aggregate is taken so as to produce a batch, which would result in compacted specimen of 63.5 mm height. Bitumen binder of specified grade was also heated to the required temperature. The predetermined quantity of heated bitumen was poured in the heated aggregate. The mixing operation was carried out manually. After obtaining a homo- geneous mix, the mix was placed in a preheated compaction mould. At the start of the compaction, desired compacting temperature was ensured. The compaction was done by a standard hammer of 4.5 Kg weight falling from 45.7 cm height by giving 75 blows on each of the face and sample was cooled for 24 hours at room temperature before being extracted using standard extraction procedure. Five specimens were prepared for BC grade I for RCA (0, 50, 100%) aggregate gradations recommended by MORT & H (2001) at 4 to 6% Bitumen Content at an increment of 0.5%.

Sample Testing

Following 24 hours the example was remolded and the example was weighed to get the dry air mass. After that the example was submerged in water to get the mass in water. The test examples after extraction were set in water shower at 60oC for 30 minutes set with its hub flat to the test head. The total get together was immediately put on the base plate of the pressure machine test arrangement. The stream dial measure was set over the aide pole and dial checks of the demonstrating ring and stream esteem were acclimated to nothing. The machine was set to activity for applying load until the most extreme worth was reached. The upsides of greatest burden and the stream dial checks are recorded and the heap was delivered. From the noticed readings the Marshall Stability and Flow values were acquired and different still up in the air by logical technique. Prior to testing the example, the heaviness of the example in air and the heaviness of the example in water were found. Since the level of the example was likewise estimated by averaging number of estimations around the outskirts of the example.

Stability and Flow Analysis

Optimum Bitumen Content (OBC) has been obtained by taking the average of the bitumen contents at which the mix has maximum bulk specific gravity, maximum stability and 4% design Air Voids from the graphs. Trials on Grade-I Conventional Bitumen mix have resulted in Optimum Bitumen Content of Bituminous Concrete with RCA (0, 50,100%). In addition to the OBC, other requisite parameters have been computed using the formulae in equations 1, 2 and3 and the properties at OBC are presented in graphically. From the graphs OBC and other properties were calculated.

$$\text{Percent Air Voids } (Vv) = \frac{Gt - Gb}{Gt} \times 100 \quad (1)$$

$$\text{Bulk Specific Gravity } (Gb) = \frac{W_{\text{air}}}{W_{\text{air}} - W_{\text{water}}} \quad (2)$$

$$\text{Theoretical Specific Gravity } (Gt) = \frac{100}{\frac{W1}{G1} + \frac{W2}{G2} + \frac{W3}{G3} + \frac{W4}{G4}} \quad (3)$$

Where,
$W1$ = Percent by weight of coarse aggregate in total mix
$W2$ = Percent by weight of fine aggregate in total mix
$W3$ = Percent by weight of filler in total mix
$W4$ = Percent by weight of bitumen in total mix
$G1$ = Apparent specific gravity of coarse aggregate
$G2$ = Apparent specific gravity of fine aggregate
$G3$ = Apparent specific gravity of filler
$G4$ = Apparent specific gravity of bitumen

The Percent of Voids in Mineral Aggregate (VMA) = $Vv + Vb$
Volume of Bitumen (Vb) = Gb $\times$ (W4/G4)
Percent Voids Filled with Bitumen (VFB) = (100 $\times$ Vb)/VMA
The variation of the variation of the bitumen binder content *versus* the VFB (%) is shown in Figure 1, while the variation of the % Bitumen *versus* the Flow Value in mm is shown in Figure 2.

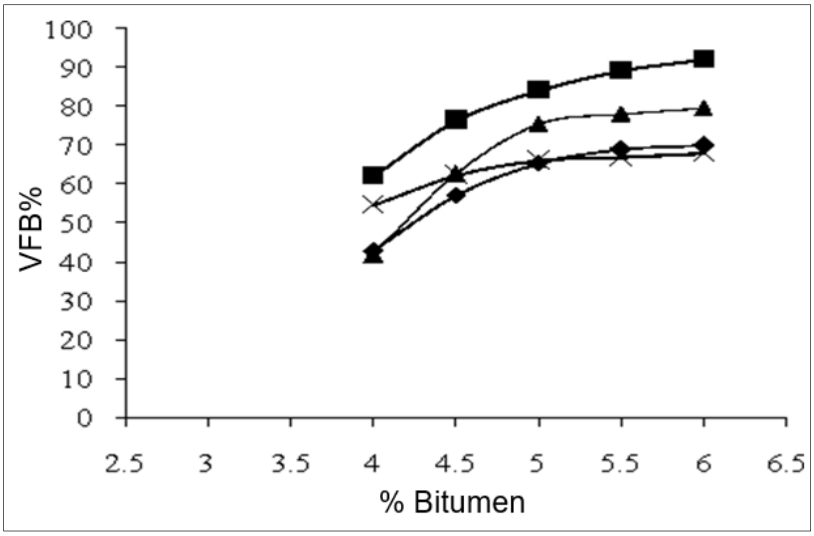

Fig 1: Bitumen Binder Content *vs.* VFB

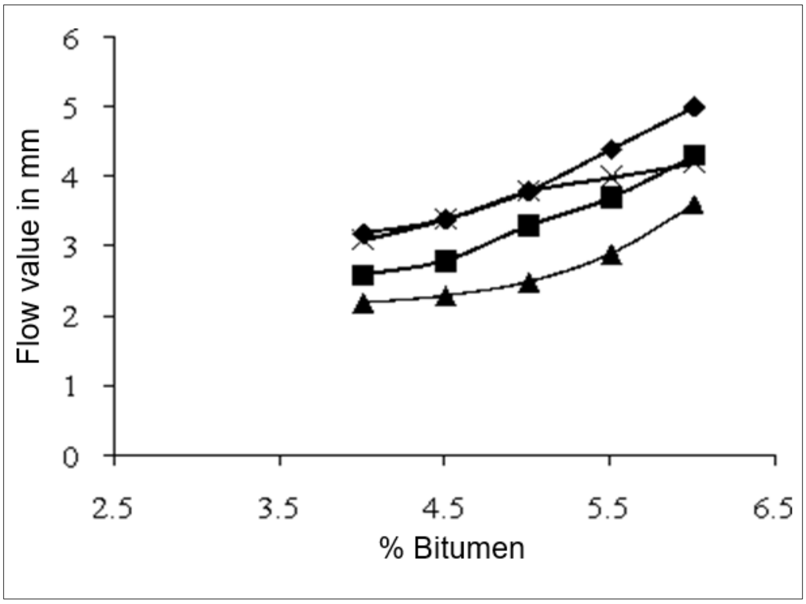

Fig 2: Bitumen Binder Content *vs.* Flow

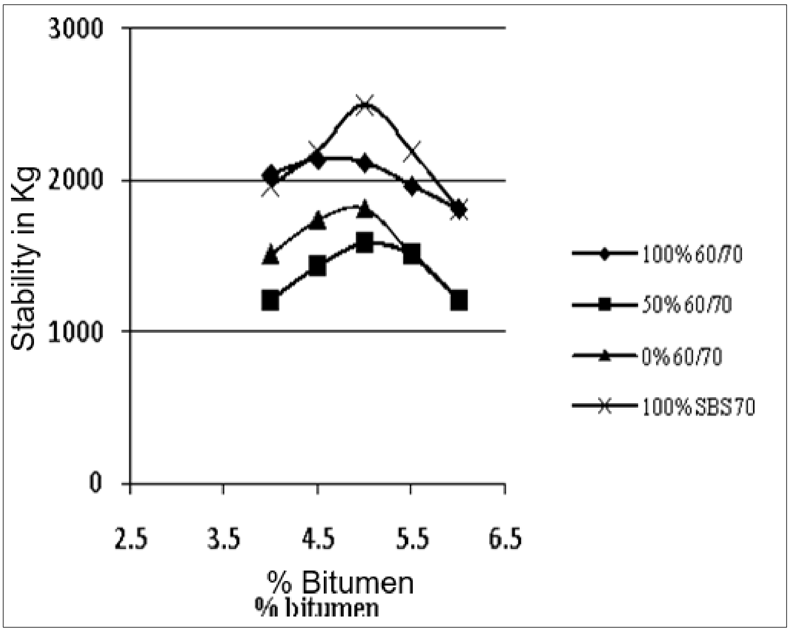

Fig 3: Bitumen Binder Content *vs.* Marshall Stability

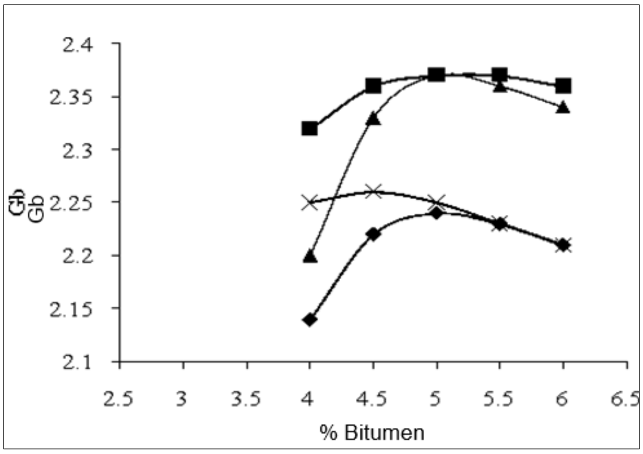

Fig 4: Bitumen Binder Content *vs.* Bulk Specific Gravity

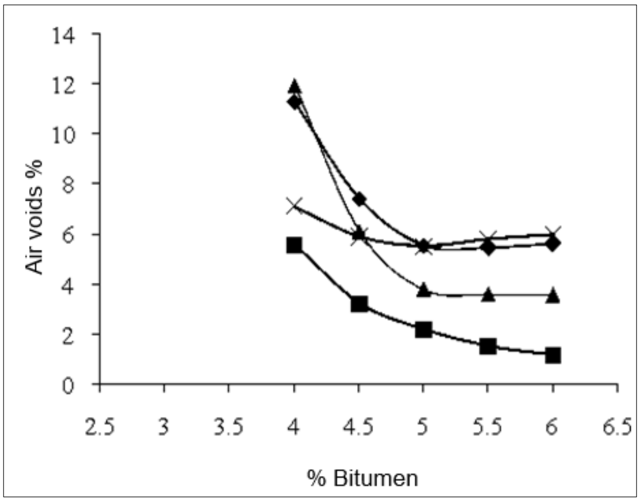

Fig 5: Bitumen Binder Content *vs.* Air Voids

Calculation of OBC

From the Figure 3, the percentage of Bitumen *versus* Marshall Stability value is the Marshall Stability Value peak value noted as B_1. From Figure 4, the percentage Bitumen *versus* G_b the peak value is noted as B_2 and from Figure 5 that is the percentage bitumen *versus* at a bitumen percentage of 4% of voids is noted as B_3. The Optimum Bitumen Content is OBC = $(B_1 + B_2 + B_3)/3$.

Rutting Test

The rutting test was carried on a small scale laboratory based simulated wheel track test for evaluating the conventional grade Bituminous Concrete G-I Mixes with respect to permanent deformation characteristics, roller compacted samples were prepared on a calibrated roller compaction equipment. The mould was of 30 cm × 30 cm × 7.5 cm and a compacted thick- ness of 6 cm. Each sample was allowed to stay in the mould for 24 hours and extracted later. After 24 hrs the mould was placed on a Wheel tracking equipment as shown in Figure 6.

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Fig 6: Details of the Rutting Test

The load on the test wheel assembly was adjusted to result in a contact pressure of 5.6 Kg/cm^2, which is the usual contact pressure intensity observed in the field. Later, wheel-tracking test was performed on all the samples and the progressive rut depth values were noted down from the dial gauge attached for every 1000 revolutions test was performed for 20,000 revolutions on three RCA % BC G-I mix. Permanent deformation observations for Bituminous Concrete Mix of G-I for three RCA replacements were plotted and presented in graph and table. Visual representation of the rut depth for RCA 0, 50, 100% replacements in natural aggregate as shown in Figure 7 and the trends are represented in Table 2.

Table 2: Variation of Wheel Load Repetitions & Rut Depth

S. No.	*RCA %*	*OBC %*	*Correlation equation*	*Wheel load repetitions & rut depth in (mm)*	
				20000	*100000*
1.	0	5.0	Y = 0.0002X + 0.7867	4.54	20.78
2.	50	4.8	Y = 0.0002X + 0.5996	4.03	20.60
3.	100	5.0	Y = 0.0002X + 0.4084	3.56	20.48

Discussion On Results

Bituminous blends of BC G-I were intended for its properties at Optimum Binder content. The Gradation utilized for this object was BC G-I of MORTH detail (2001) in view of its mid point degree with slight changes in the degree. The security of the blend was found with Marshall Mix configuration process with the fluctuated fastener content of 4% to 6% with 0.5% addition each time. Mass thickness of 0% RCA BC G-I blend was more prominent than 50 and 100 percent RCA utilized in the current review. 100 percent RCA showed lesser Bulk Density. Voids loaded up with Bitumen in the event of customary bitumen blend was more when contrasted and the adjusted blends (70%) with 100 percent RCA. Flow value of modified mix was less when compared to that of conventional mix with 100% RCA, indicating better quality. Both the results were within the specified limits. Better stability value was noticed in BC G-I with 100% RCA with conventional as well as modified bitumen. 100% RCA had more percentage of Volume of Voids (11.28%) with conventional bitumen 60/70 grade than Modified Bitumen SBS 70 (7.12%). The Bituminous concrete G-I mix with 0, 50, 100% RCA was compared against rutting potentiality. The Bituminous concrete G-I mix with 100% RCA has performed better than the other two percentages.

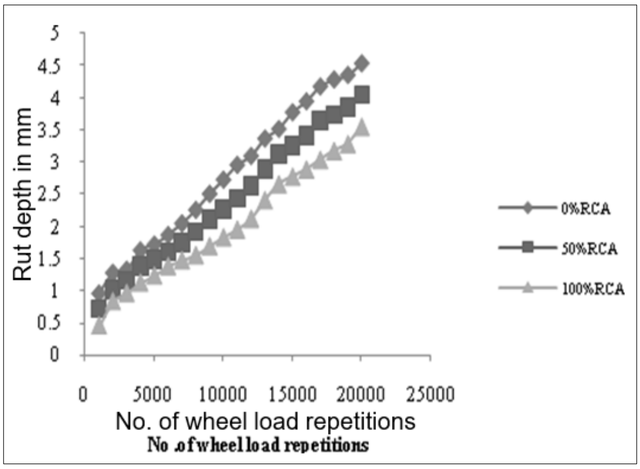

Fig 7: Rut Depth *vs.* No of Wheel Load Repetitions

Conclusions

The accompanying ends can be drawn in view of the research center examinations on the job of reused totals in bituminous blends.

a. The total properties of RCA are inside the cutoff points for the bituminous blend plan according to the MORT&H, aside from the water assimilation for 100 percent reused total blends.
b. It was presumed that mass thickness, voids in mineral totals, voids loaded up with folio in the compacted bitumen examples containing RCA, were lower than those for the control blend made with regular totals.
c. The Marshall Stability an incentive for 100 percent RCA is more contrasted with half and 0% RCA.
d. The Marshall Stability an incentive for 100 percent RCA is something else for changed bitumen (SBS70) contrasted with traditional bitumen grade 60/70.
e. The stripping an incentive for the 100 percent RCA is inside in the cutoff points in wet and dry circumstances.
f. Under lab conditions, Rutting deformity is less for 100 percent RCA contrasted and 0% RCA.

Scope for Future Study

The results found in this study are encouraging. However, further investigations are required to examine the findings in this research using different percentages of recycled concrete aggregates in bituminous concrete and examine the field conditions for the long run performance.

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