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USE OF RECLAIMED ASPHALT PAVEMENT IN BITUMINOUS ROAD

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ABSTRACT

The huge amount of Reclaimed Asphalt Pavement (RAP) obtained from damaged or abandoned pavement. Bituminous pavement is a mix of coarse aggregate, fine aggregate, mineral filler and bitumen. Due to repetition of wheel load and edging effect bituminous concrete tense to wear and tear. Using RAP in pavement construction has now become most common practice in many countries. These materials have been used not only proved to be economical but also environmentally sound. Mixing RAP in fresh materials has been favored over fresh materials in the light of the increasing cost of asphalt, scarcity of quality aggregate, scarcity of asphalt and pressuring need to preserve the environment. An experimental investigation is carried out to evaluate the possible application of RAP in bituminous pavement design and to find out its design characteristics. The strength properties of CA and Marshall design properties of bituminous mixes were performed according to the test procedure specified by AASHTO. From experimental results, it is concluded that the coarse aggregate from RAP materials in the bituminous mixes with fresh aggregates give satisfactory results.

Keywords: *Bituminous road, Marshall Mix design, Reclaimed Asphalt Pavement, Optimum Bitumen Content*

1. INTRODUCTION

Hot mix recycling is the process in which reclaimed asphalt pavement materials are combined with new materials, sometimes along with a recycling agent, to produce hot mix asphalt (HMA) mixtures. Just as in the case of conventional HMA, recycled mixtures must be designed properly to ensure proper performance. The two steps in the mix design procedure are material evaluation and mix design. The objective of the material evaluation process is to determine the important properties of the component materials to come up with an optimum blend of materials to meet the mix requirements. The objective of the mix design step is to determine the type and percentage of bituminous binder with the help of results from compacted test mixes.

Recycling waste materials has become a common practice in the last 20 years in various fields of both manufacturing and construction sectors. However in Bangladesh, the use of RAP is very limited. There is no data regarding the production of RAP in Bangladesh. It is expected that the amount is increasing with time. Now a days, it is necessary to study the use of RAP for surface course constructions.

A lot of research work has been done in the past to make use of reclaimed asphalt pavement materials into the bituminous mix to make it cost effective. Some researchers are performing their researches by using different percentages of RAP as replacement of fine sand and different types of filler is also used to improve the physical property of bituminous mix.

The study reveals that the bituminous mixes with RAP especially at 50% to 100% replacement ratio provide better performance compared to those of new conventional HMA mixtures to improve the mechanical properties, durability performance and also stripping resistance. The addition of RAP has a great influence on improving the indirect tensile strength where the highest values are achieved at 50% RAP content (Ebrahim et al., 2015), Srikant et al.,(2014) showed that the warm mix prepared at 1200°c mixing with 30% RAP content shows higher stability when compared with warm mix prepared at 110°C. Mohamady et al.,(2014) represented that 30% RAP ensured superior field performance after construction. (Tambake et al., 2014) represented that the optimum binder content is reduced by increasing the percentage of RAP content and the recommended percentage of RAP mix is 20%. (Pradyumna et al., 2013) represented that the addition of RAP improves all the properties of the bituminous mixes. This indicates that mixes with 20% RAP would perform better than the virgin mixes under similar condition. Arshad and yanjun, 2012 represented that mixtures containing RAP shows significant variability and the variability increases with the increase in RAP content.

1.1 Benefits of Recycling

Recycling of bituminous pavement materials can

- save money for local government and other purchasers
- create additional business opportunities
- save energy when recycling is done on site
- conserve diminishing resources of aggregate and petroleum products
- finally help local governments meet the goal of reducing disposal of 50 percent

1.2 Objectives

- To determine the percentage of materials in RAP.
- To determine the properties of aggregates in RAP.
- To study the use of RAP materials in bituminous mixes with fresh aggregates

2. METHODOLOGY

In this study the RAP sample was collected from Bornaly to Medical Road in Rajshahi. Quantitative extraction of bitumen from bituminous paving mixtures was done by the test procedure ASTM D2171. After extraction of bitumen from RAP, the appearance of the aggregate is shown in Figure 1. After separating RAP materials 62% coarse aggregates, 28% fine aggregates, 7% mineral filler and 3% bitumen were found. Then the RAP materials were put into the various tests and their suitability were checked for further investigations. The test results of the fresh coarse aggregate and coarse aggregate from RAP presented in Table 1. RAP aggregates were found to satisfy the requirements as per AASHTO (1987), BS (812) and LGED (2008).

Table 1: Strength properties of coarse aggregate

Properties	Coarse Aggregate		Limiting Value
	Fresh	RAP	
Los Angeles Abrasion Value(Grade-A),Percent	17	20	≤ 40
Aggregate Impact Value, Percent	8	10	≤ 40
Aggregate Crushing Value, Percent	16	19	≤ 35
Ten Percent Fines Value, (KN)	300	265	≥ 100

Figure 1: Appearance of coarse aggregate from RAP

2.1 Mix Design

To investigate the behavior of asphalt mixes with different aggregates, continuously graded asphalt macadam is essential. In the continuously graded bituminous macadam, the aggregate blend is designed to be evenly graded from coarse to fine so as to arrive at a dense mix with a controlled void content, hence producing a stable and durable paving.
The objective of the study was to make a comparative study of asphalt mixes with RAP materials in varying percentages with fresh aggregate. Five types of mixes were studied and these were designated as mix types A, B, C, D and E

Mix A: in which Fresh CA is 100%
Mix B: in which Fresh CA is 90% and 10% CA from RAP
Mix C: in which Fresh CA is 85% and 15% CA from RAP
Mix D: in which Fresh CA is 80% and 20% CA from RAP
Mix E: in which Fresh CA is 75% and 25% CA from RAP

2.2 Marshall properties

Marshall Stability test of a mix is defined as the maximum load carried by a compacted specimen at a standard test temperature of 60°C. The flow value is the deformation of the Marshall Test specimen that undergoes during the loading upto the maximum load in 0.25 mm units (Tambake, Kumar, and Manjunath, 2014). Marshall Stability test is applicable for hot mix design using bitumen and aggregates. Marshall properties like stability, flow value, unit weight, total voids in a mix, voids in mineral aggregates and voids filled with bitumen were found for different percentages bitumen and RAP content. The graphs were plotted for bitumen content with Marshall Stability, unit weight and air voids. The bitumen content corresponding to maximum stability, maximum unit weight and 4% air voids were obtained from these graphs. The maximum permissible air voids is 3%-5% according to MORTH. The average value of bitumen content obtained from the 3 plotted graphs is treated as the optimum bitumen content (OBC). Marshall test results and OBC values for different percentages RAP content is tabulated in Table 2.

Table 2: Marshall test results

Aggregate Types	O.B.C. (%)	Unit Weight (kg/m^3)	Marshall Stability (kN)	Flow Value (0.25mm)	Air voids (%)	VMA (%)	VFB (%)	Marshall stiffness (kN/mm)
A	5.55	2346	16.30	14.6	3.9	13.75	70	1.12
B	5.50	2336	15.45	14.7	3.8	15.20	74	1.05
C	5.45	2320	14.40	15.1	3.6	16.00	78	0.95
D	5.37	2305	13.50	15.3	3.4	16.50	79	0.88
E	5.20	2297	11.70	15.5	3.0	17.20	81	0.75

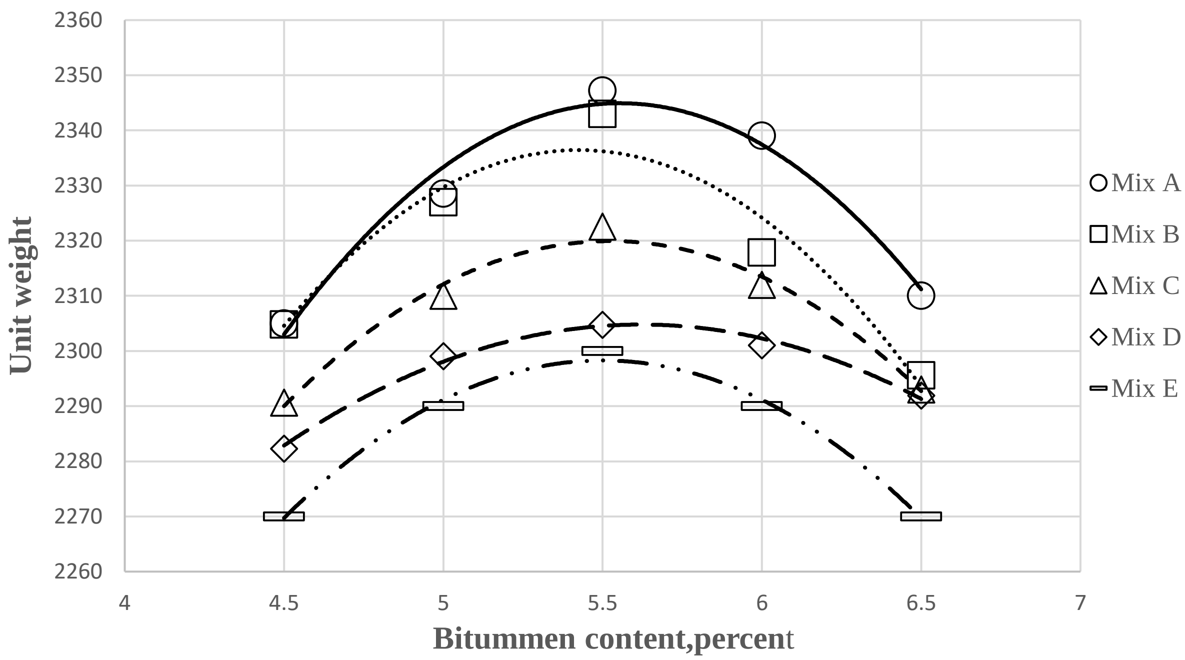

Figure 2.1: Relationship between Unit weight and percent bitumen content for different mixes

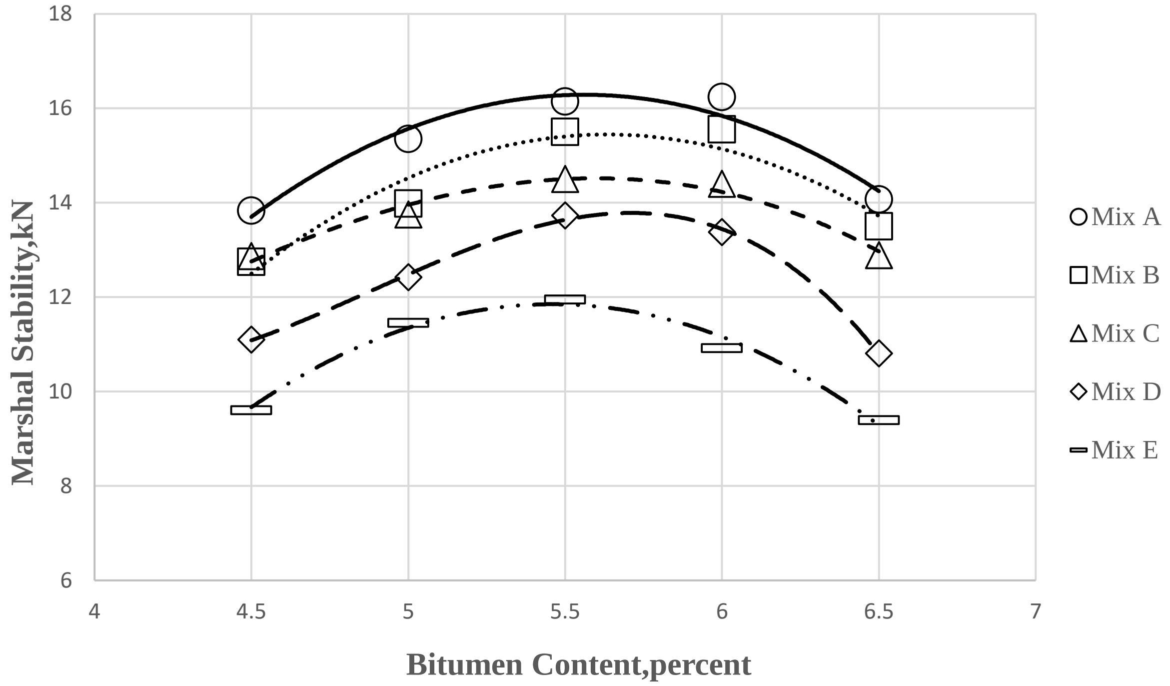

Figure 2.2: Relationship between Marshall Stability and percent bitumen content for different mixes

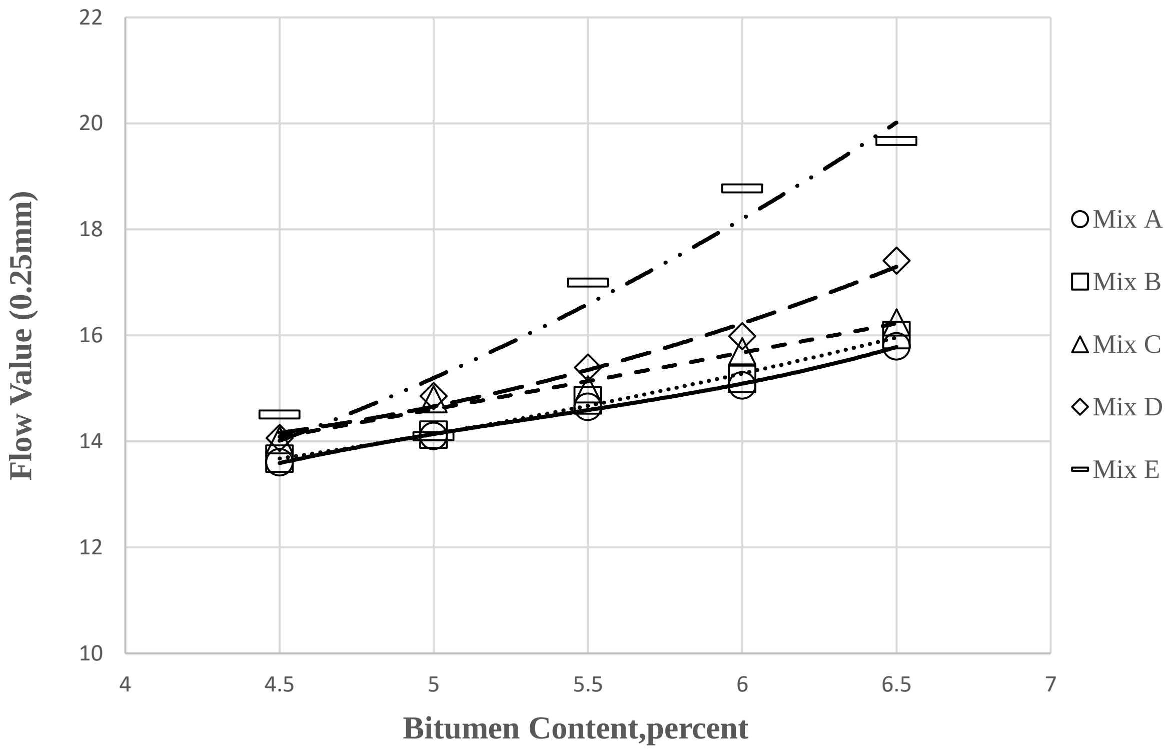

Figure 2.3: Relationship between Flow Value and percent bitumen content for different mixes

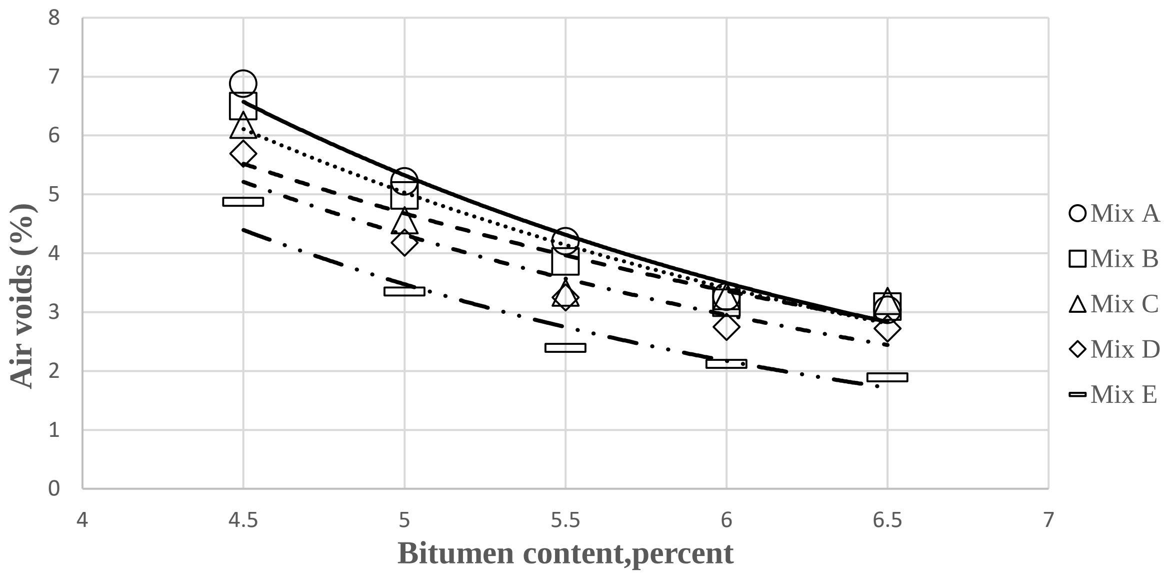

Figure 2.4: Relationship between percent air voids and percent bitumen content for different mixes

3. ANALYSIS OF RESULTS

From the Marshall test results it is seen that the optimum bitumen content percent is decreased as the RAP percent increase. This happens due to the old bitumen filled the pores of the RAP. It also occurs due to the presence of some amount of rounded shape coarse aggregate. Rounded shape particles quickly slips to gain stability and for that reason amount of OBC reduced. Moreover, increasing RAP percent from zero to 25% decreases the optimum bitumen content from 5.55% to 5.2%. This means that saving in optimum bitumen content by about 7% is achieved.

Unit weight is decreasing with the increasing percentages of RAP content. It is remarked that, increasing RAP percent from zero to 25% reduce the unit weight by only 2%. From the Table 2 it is noticed that, the mix stability is decreasing as RAP percent increase. Due to the presence of some smooth and round shape aggregates in the mix shear resistance decreases, ultimately results in decrease in stability. It is also noted that, increasing RAP from zero to 25% decrease the stability value from 16.3 to 11.7 kN i.e. decreased by about 28%. The mix flow increases as the RAP percent increases. When RAP percent increases from zero to 25%, the flow value increases from 14.6 (0.01 inch) to 15.5 (0.01 inch).

The total air voids in a mix is an important factor that must be considered when designing bituminous Concrete mixture. 3% to 5 % of the total mix volume is the limiting of the total air voids in a mix. When air voids are lower than 3% bleeding of bitumen will occur. Otherwise, for air voids percent greater than 5% of the mix, the pavement will be weak and unstable. From these considerations the bituminous binder is a very sensitive element in pavement design. From the table 2 it is seen that increasing the RAP percent will decrease the corresponding air voids ratio. This causes due to the old bitumen filled the aggregate pores which minimize the voids percent. Increasing the RAP percent from zero to 25% decreases the air voids percent from 3.9% to 3%.

From Table 2 it is found that the voids in mineral aggregate and voids filled with bitumen are increased as the RAP percent increases. This causes due to the ineffective old bitumen in the aggregate pores which prevent the new bitumen from occupying deeply the aggregate pores. With the increasing percentages of RAP Marshall stiffness gradually decreases because Marshall stability value gradually decreases and flow value increases gradually.

4. CONCLUSIONS

On the basis of experimental results of this study, the following conclusions are drawn.

- Aggregates collected from RAP known as waste aggregates are suitable for the bituminous mixes from the consideration of aggregate properties.
- Although stability gradually decreases with the increase of RAP aggregates in the bituminous mixes with fresh stone aggregates, the characteristics of mixes satisfy the Marshall Design criteria.

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