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# THE USE OF CRUMB RUBBER FOR REPLACING FINE AGGREGATE IN COLD MIXTURE ASPHALT


## Introduction

In Indonesia, hot mix asphalt (HMA) is the most commonly used as asphalt pavement on new roads, overlays, and pavement patching. HMA needs high quality of aggregate to produce life-long pavement, such as tough and abrasion resistant aggregates. Compared to cold mixture asphalt (CMA), HMA also consumes more energy to heat the mixture. As the car tyres become a major global waste problem, it needs more attention on the use of recycled car tyres in the pavement design. The end product of recycled car tyres which is crumb rubber has various sizes depending on the diameter of the crumbs. For the environmental impact, the use of CMA, local aggregate and alternative waste material beside natural aggregate in asphalt mixture could be considered.
The objective of this study was to investigate the effect of crumb rubber size on performance of cold asphalt mixtures.

## Material and Methods

This study was conducted on two stages. First stage performed the mix design to determine optimum bitumen content (OBC). Second stage was to investigate the effect of crumb rubber size on performance of cold asphalt mixtures (CMA). Crumb rubber asphalt mixtures were prepared at OBC. In this study, crumb rubber with mesh size #20 (0.841 mm), #40 (0.42 mm), #60 (0.25 mm) were incorporated into CMA as a replacement material of fine aggregates.

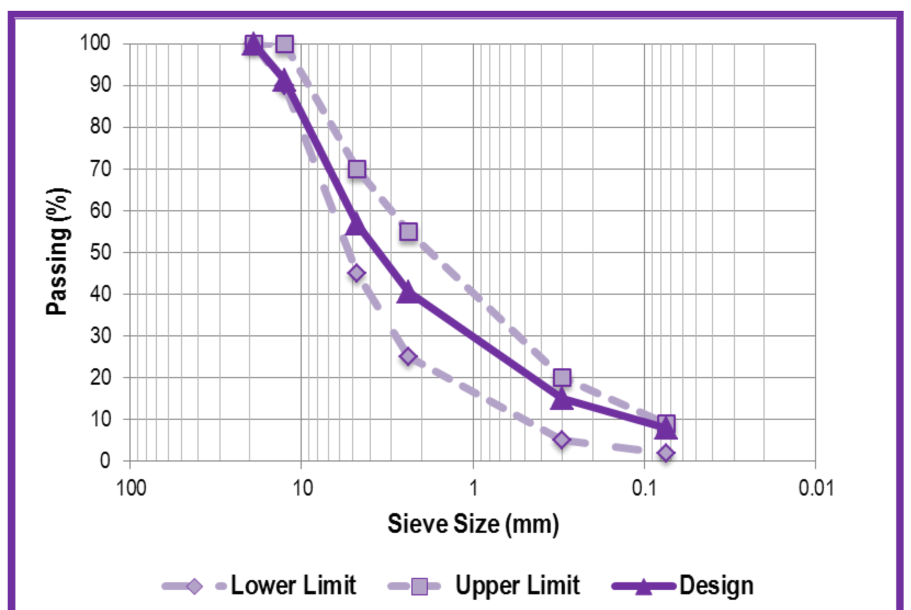
In order to incorporate crumb rubber into the CMA, a 50% by weight of fine aggregate was replaced with an equal volume of each size of crumb rubber. All factors in mixtures were keeping constant. The aggregate gradation for mix design was selected according to Dense Graded Emulsion Mixtures (DGEM) Type IV Specification. In order to improve CMA at the early ages strength of the mixtures, fly ash as filler material (2% by weight of total aggregates) was used in all mixtures.

Properties of asphalt emulsion CSS-1h

| Properties | Units | Method | Results | Specifications |
|---|---|---|---|---|
| Test on Emulsions | | | | |
| Viscosity, Saybolt-Furol at 25° C | second | SNI 03-6721 | 23.275 | 20-100 |
| Storage stability, 24 hours | % | SNI 03-6828 | 0.33 | 1 max. |
| Particle charge | - | SNI 03-3644 | Positive | Positive |
| Sieve test, retained on No. 20 | % | SNI 03-3643 | 0.00 | 0.10 max. |
| Distillation | | | | |
| Residue | % | SNI 03-3642 | 63.46 | 57 min. |
| Test on Residue from Distillation test | | | | |
| Penetration at 25° C, 100g, 5 sec | 0.1 mm | SNI 06-2456 | 51.60 | 40-90 |
| Ductility at 25° C, 5 cm/min | cm | SNI 06-2432 | 107 | 40 min. |
| Solubility in trichloroethylene | % | SNI 06-2438 | 98.992 | 97.5 min. |

Physical properties of aggregates

| Properties | Units | Results | | | Specifications |
|---|---|---|---|---|---|
| | | F1 | F2 | F3 | |
| Specific gravity, bulk | - | 2.534 | 2.772 | 2.523 | - |
| Specific gravity, SSD | - | 2.580 | 2.820 | 2.548 | - |
| Specific gravity, apparent | - | 2.644 | 2.908 | 2.587 | - |
| Water absorption | % | 1.650 | 1.680 | 0.977 | 3 max. |
| Los Angeles Abrasion | % | 36.04 | 38.66 | - | 40 max. |



Aggregate gradation for design mixtures

## Results

The optimum bitumen content (OBC) was determined considering the maximum soaked stability mixture which was at 8% by mass of total mixture. The stability increased with an increase in curing time, because CMA required longer curing times. Although the use of recycled crumb rubber reduced the stability of CMA, but still met the minimum requirement as in standard specification. The finer crumb rubber in the CMA mixtures produced the higher stability and less void in mixtures, which is closely related to durability of mixtures.

In general, the finer crumb rubber as fine aggregate replacement in CMA had better properties than the larger sized crumb rubber. Also, the mixtures had a good comparison to HMA specification, as HRS-A and AC-WC.

Properties of the DGEM Type IV

| Properties | Units | Bitumen content (%) | | | | | Specifications |
|---|---|---|---|---|---|---|---|
| | | 8 | 8.5 | 9 | 9.5 | 10 | |
| Soaked Stability | kg | **1294.045** | 1109.841 | 1155.202 | 1153.555 | 1070.673 | 300 min. |
| Void in Mixture (VIM) | % | **6.810** | 6.724 | 7.411 | 8.022 | 7.141 | 5 – 10 |
| Void in Mineral Aggregate (VMA) | % | **22.402** | 23.286 | 24.786 | 26.199 | 26.406 | - |
| Void Filled with Bitumen (VFB) | % | **69.646** | 71.213 | 70.387 | 69.448 | 73.165 | - |
| Asphalt Film Thickness (AFT) | μm | **15.757** | 16.931 | 18.118 | 19.318 | 20.532 | 8 min. |

Comparison of mixtures to HMA specifications

| Properties | 7 days of curing | | | | Specifications | | |
|---|---|---|---|---|---|---|---|
| | NO CR | #20 | #40 | #60 | DGEM Type IV | HRS-A[1] | AC-WC[2] |
| Soaked Stability (kg) | 1277.211 | 522.832 | 654.568 | 903.820 | 300 min. | 450 min. | 800 min. |
| VIM (%) | 6.917 | 10.906 | 11.957 | 8.220 | 5 - 10 | 4 - 6 | 3 - 5 |
| VMA (%) | 22.484 | 25.806 | 26.681 | 23.569 | - | 18 min. | 15 min. |
| VFB (%) | 69.282 | 57.785 | 55.219 | 65.124 | - | 68 min. | 65 min. |
| Flow (mm) | 4.572 | 8.213 | 7.281 | 8.043 | - | 3 min. | 2 - 4 |
| Retained Stability (%) | 90.347 | 91.439 | 79.874 | 89.189 | 50 min. | 75 min. | 75 min. |

Note: [1]Hot Rolled Sheet Wearing Course (HRS-A); [2]Asphalt Concrete Wearing Course (AC-WC)

## Discussions & Conclusions

From this study, it can be recommended that crumb rubber can be incorporated into CMA as a replacement material of fine aggregates. It has been shown that at 50% crumb rubber replacement, the CMA with crumb rubber had stability that meet the standard specification. The finer crumb rubber in the CMA mixtures produced the higher stability. The finer crumb rubber (#60) in CMA also produced the required Void in Mixture (VIM) as in standard specification. Replacement of fine aggregate with crumb rubber on CMA is expected to overcome the environmental problems by reuse the waste materials to preserve the natural aggregates.

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