



Use of Scrap Rubber in an Asphalt Overlay to Reduce Reflective Cracking

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SUMMARY

This paper describes the use of granulated scrap rubber (less than 1mm particle size) added to the binder of an asphalt mix placed over a portland cement concrete pavement. The rubber was added in the proportion of 25% by mass of binder and the total binder content in the mix was 11%. Aggregate grading was adjusted to give an air voids content of 6%. Adjoining sections of conventional asphalt mix were placed for comparison purposes. Within a few months almost all the joints in the underlying concrete pavement had reflected as cracks in the conventional asphalt surface but it was two years before even a few slight cracks appeared in the rubberised asphalt. After three years' service the extent of cracking of the rubberised asphalt is very limited.

1. INTRODUCTION

Imparting additional flexibility to bituminous materials by incorporation of rubber is an ideal that has been sought by road engineers for many years. The Country Roads Board, Victoria (CRB) has tried various types and proportions of rubber with mixed results. Success with large concentrations (up to 25% by mass) of scrap rubber in sprayed bituminous surfacing lead to the trial of a similar binder in an asphalt mixture. For maximum flexibility the binder content was selected at what was considered the highest practicable level and the mixture was placed over a jointed portland cement concrete pavement in December 1979. Observations to date show a greatly enhanced resistance to reflective cracking.

2. DEVELOPMENT OF RUBBER MODIFIED BINDERS

2.1 Early Experiments

Early experiments in the CRB used natural rubber in small concentrations, typically 2% by mass of the bitumen binder. In sprayed work the rubber modified binder gave improved aggregate bond but very little improved resistance to reflective cracking. Similarly, asphalt with rubber modified binder at this concentration showed little improvement in resistance to reflective cracking.

The next step was the use of synthetic rubber in place of natural rubber. It was considered that the synthetic rubber would have better heat stability than natural rubber at the temperatures associated with asphalt mixing and placing. A trial section placed over a newly constructed concrete pavement in 1976 is still under observation. At this stage it appears that there has been no improvement in performance of the synthetic rubber modified mix compared with the conventional asphalt control areas.

At about the same time some trials were made with a proprietary blend of synthetic rubber and bitumen. The initial trials gave disappointing performance and it appeared that the formulation developed in Europe was not effective with locally manufactured bitumen. The same proprietary line of products has since been reformulated and is intended that trials will be included in the CRB's 1982/83 experimental programme.

2.2 Proprietary Granulated Rubber/Asphalt Mixture

A proprietary design of asphalt mixture using granulated rubber was offered to the CRB in 1976. Rubber particles of approximately 5mm nominal size were added to the asphalt mix in the proportion of 3% by mass of the total mix. A similar volume of the 5mm mineral aggregate fraction was left out of the mix to provide space for the rubber particles. The rubber was considered as part of the aggregate and not part of the binder. Bitumen binder content in the rubberised mix was increased to 7.5% compared to typically 5.2% in a normal mix.

The first trial section deteriorated after a few months and was removed. The deterioration was considered to be due to entry of water into the mix. A small replacement section was placed using a higher binder content and is now performing satisfactorily but the earlier problems caused a loss of interest in further trials. (Bethune 1978).

2.3 Bitumen Scrap Rubber Seals

The use of granulated scrap rubber in bitumen seals by the CRB commenced in 1975. The bitumen scrap rubber mixture provides a tough resilient binder which has been successfully used in suppression of

reflective cracking in seal coats. Discussion on bitumen scrap rubber seals is outside the scope of this paper but has been reported elsewhere (Bethune 1978, Oliver 1981 and Allen 1982).

The rubber being used in the bitumen scrap rubber seals is generally produced by grinding and screening of buffings obtained from the preparation of used car and truck tyres for retreading. Scrap rubber used by the CRB includes the following requirements:

- (a) Grading 2.36 1.18 0.600
 Sieve size AS (mm)
 Percentage passing
 (by mass) 100 80-100 15-40
- (b) Particle length
 3mm maximum
- (c) Bulk Density
 350 kg/m³ maximum

The bulk density test is used to characterise the morphology of the rubber particles. This is based on findings by the Australian Road Research Board that morphology, which is a function of the form and texture of the rubber particles, influences the reaction of the rubber with bitumen (Oliver 1981).

3. BITUMEN SCRAP RUBBER ASPHALT MIX

3.1 Selection of Design Criteria and Manufacturing Process

It seemed a logical step to apply the bitumen scrap rubber seal binder to an asphalt mix. In a preliminary trial the bitumen and scrap rubber were pre-blended before mixing with the aggregate. For production purposes it was simpler to add the granulated scrap rubber separately direct into the asphalt mixer. Experience with mixing of bitumen extended epoxy asphalt for the West Gate Bridge (Rebbechi 1980) had shown that separate binder components could be adequately blended in a pugmill mixer with an increase of mixing time. In addition the asphalt would remain hot for at least 30 minutes after mixing due to the haul time in the asphalt trucks, thereby providing the digestion time normally allowed in bitumen scrap rubber binders for sprayed work.

A mixing time of 60 seconds after addition of all components was used compared with a normal mixing time of about 30 seconds.

The higher the binder content the greater the expected flexibility of an asphalt mix. It was considered that the highest practicable binder content for a stable mix would be about 12% by mass. It was expected that the rubber would reduce susceptibility to bleeding or flushing at this unusually high binder content. To provide space for the required volume of binder the aggregate grading was adjusted to give 28% voids in the mineral aggregate (VMA).

Based on the above, the proportions of components for mix design were as follows:

	% by mass of total mix
Aggregate	86.0 – 89.0
Added filler (hydrated lime)	1.0 – 2.0
Bitumen (Class 170)	7.5 – 9.0
Scrap rubber	2.5 – 3.0

3.2 Mix Properties

The properties of the selected asphalt mix were as follows:

- (a) Aggregate grading (including filler)

Sieve size AS (mm)	% passing	Sieve size AS (mm)	% passing
19.0	100	1.18	13
13.2	99	0.60	10
9.5	72	0.30	7
6.7	44	0.15	5
4.75	35	0.075	3.2
2.36	20		

- (b) Mix proportions (%)

14mm rhyolite aggregate	30
10mm rhyolite aggregate	28
7mm rhyolite aggregate	12
3mm minus rhyolite aggregate	23
Fine sand	5
Filler, hydrated lime	2
	100
Combined mineral matter	89.0
Granulated scrap rubber	2.8
Bitumen Class 170	8.2
	100.0

- (c) Mix properties (Marshall method, 50 blow compaction)

Stability	4.01kN
Flow	5.2mm
Air voids	6.0%
VMA	28%
Bulk Density	2.162 t/m ³
Binder film thickness (including rubber as part of binder)	22.6 microns

4. SITE CONDITIONS

The site chosen for the trial was a portland cement concrete pavement on the Maroondah Highway through the commercial centre of Ringwood, an outer Melbourne suburb. Traffic volume (1979) was 34,516 vehicles per day (12 hour count 7.00 a.m. – 7.00 p.m.).

The pavement was constructed in 1960 and consists of 200mm of concrete over 50mm of sand and 250mm gravel. Longitudinal joints are generally 3.3m or 3.7m apart and there are transverse joints at about 4.5m intervals.

Slight movement at the joints over the years and loss of jointing material had resulted in an uneven riding surface. Although some movement had occurred the slabs were stable.

Prior to commencing the work, a record was made of slab joints over a length of 250m. Joints were filled with a bitumen/sand mixture and before placing asphalt the surface was tack coated with cationic bitumen emulsion at a rate of approximately 0.5 l/m².

5. PLACING

Approximately one half of the selected area was surfaced with 109 tonne of asphalt complying with current CRB requirements for wearing course asphalt. The remainder was surfaced with 109 tonne of the rubberised asphalt. Average thickness of the conventional asphalt was 35mm and of the rubberised asphalt 38mm.

Temperature of both types of asphalt mix on site was 155°C-160°C.

Compaction was done with a tandem steel wheel roller of 9 t mass and a pneumatic tyred multi wheeled roller of 12 t mass.

The conventional asphalt was rolled with a minimum of 4 passes of the steel wheeled roller followed by 10-16 passes of the pneumatic tyred roller. Compaction achieved was a mean of 97.2% of laboratory compacted density.

The rubberised asphalt was rolled with 4 passes of the steel wheeled roller. Further passes of the steel wheeled roller tended to cause cracking of the surface. Some pick-up occurred with the pneumatic tyred roller and pneumatic tyred rolling was generally held back until the asphalt had cooled to about 80°C. In spite of the delay in rolling, a mean of 98.5% of laboratory compacted density was achieved.

6. OBSERVATIONS OF PERFORMANCE

Within a matter of few weeks after placing, isolated hair cracks appeared in the conventional asphalt surfaced area. After two months the hair cracks had extended to about 50% of the underlying joint pattern and within a year virtually the whole of the underlying joint pattern was distinctly visible.

No cracking was observed in the rubberised asphalt until two years after placing when a few fine transverse cracks appeared near one end of the work. One of those cracks was also associated with slight deformation of the surface at the pavement joint.

After 2½ years, cracks in the conventional asphalt have increased up to 3mm in width and there is risk of spalling at the edges of cracks unless some maintenance treatment is carried out.

Cracks in the rubberised asphalt at this stage are limited to less than 5% of the underlying joint pattern.

Due to the coarse grading of the rubberised asphalt mixture it presents a noticeably coarser surface texture than the conventional asphalt. The coarse texture has generally been maintained and there is

no noticeable deformation in wheel paths or at traffic stopping places.

The early indications of success of the rubberised asphalt has lead to further uses of the material in other similar situations. These include the carriage-way opposite the first trial and an old concrete pavement in an inner urban commercial centre. All work done to date is performing satisfactorily.

7. CONCLUSIONS

The addition of granulated scrap rubber to the binder of an asphalt mix and use of a high binder content have resulted in a mix with considerably improved resistance to reflective cracking.

The cost of the rubber modified mix is approximately 50% greater than a conventional mix so that its use is limited to special circumstances where it can provide a cost benefit.

8. ACKNOWLEDGEMENT

This paper is presented with the permission of the Chairman of the Country Roads Board, Mr T.H. Russell. However, responsibility for the content and opinions expressed therein remain with the author and should not be taken as necessarily reflecting the attitude of the Board or of individual officers.

9. REFERENCES

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