RECTIFY BLEEDING ROAD SURFACES USING HOT IN-PLACE RECYCLING METHOD: HOW SHOULD IT BE DONE (MALAYSIA EXPERIENCE)

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ABSTRACTS

Hot in-place recycling (HIPR) is a pavement rehabilitation method which is relatively new in Malaysia. Since its inception in early 1990's, the process of heating up and loosening the existing bituminous surface, followed by mixing with or without a small quantity of rejuvenating agent prior to laying back at the same location in a single pass operation has been proven in reshaping uneven surface and 'removing' shallow surface cracks, minor rutting, as well as raveling and stripping. However, treating bleeding surface using this technique without adding new materials is indeed a daunting task. The challenges that arise in rectifying this type of surface defect include making sure that the excess binder content is no longer detrimental to the surfacing material, and compaction of the recycled material containing the age-hardened binder is adequate without creating too large air voids that would consequently affect the durability in the future. This paper highlights the treatment done on severely bleeding surface of the newly completed Lebuh AMJ in Melaka using the HIPR technique.

1.0 INTRODUCTION

Surface defects such as cracking, ravelling, delamination, are typical defects that can be found in every on bituminous roads age hardening of the binder. Some of these defects can occur immediately after the construction is complete and open to traffic. Bleeding is a classic defect is manifested by an accumulation of bitumen on the road surface. For newly constructed roads, bleeding would normally appear at least 6 months after construction depending on the integrity of traffic. As a practice around the world, defects that occur in the period of defects liability (DLP), shall be treated accordingly by the contractors. Methods of repair shall be decided based on investigation and agreed upon the by Superintending Officer (SO). Usually, mill and pave is a typical acceptable method to rectify the surface defects. Hot In Place recycling (HIPR) method which is relatively new in Malaysia is an option that can be used to arrest the problem. But, rectifying bleeding using HIPR method is a daunting task which needs in depth study.

2.0 OBJECTIVE OF THIS PAPER

Objective of this paper is to study the effectiveness of HIPR method in rectifying bleeding at newly constructed Lebuh AMJ in Melaka, Malaysia.

3.0 SITE SELECTION

The construction of Lebuh AMJ in the state of Melaka commenced in early 2002 as a new alignment and alternative to existing Federal Route 5 connecting the city of Melaka to the district of Muar in the state of Johor. It is expected to cater for 23 million ESAL and up to 30 million ESAL in the future. It is a dual carriageway consisting 4 lanes with average width per lane of 3.5 meter. The entire surfacing was paved using asphaltic concrete. The total length is 34 km with several 4 leg signalised intersection connecting to existing residential areas along the route. The road was completed in 2007 and under the period of defect liability (DLP) until 2009. At the end of DLP, several surface defects were found in some sections of the road. Shallow cracking, ravelling, surface irregularities, undulation and bleeding were found during joint inspection exercise between the S.O and contractor. After full investigation, a length of 2 lane-km was identified of having the above defects. Since there was no structural failure found, the existing defects were considered as functional defects that could be rectified by using the conventional mill and pave method.

Figure 1 - Lebuh AMJ alignment

However, since the road was at the beginning of its service, and the length of roads that needed repair was quite substantial, the idea of using HIPR method for treating the defects was mooted. Through surface undulation and shallow cracking could be “removed” using this technique, bleeding offered entirely a new challenge altogether. Thus, all the parties involved had agreed that design should be carried out before proceeding with the HIPR method to rectify the bleeding surfaces.

4.0 BLEEDING

Bleeding is the presence of free bitumen binder on the surface resulting from upward migration of the binder, causing low texture depth and inadequate tyre to stone contact. It can be caused by excessive application of binder with respect to the stone size. If the air voids in the mix is according to specification, but with excessive binder content, traffic will force out the excess binder to the surface. If the binder is accordingly to specification of the mix, but the air voids is too low, the similar action by the traffic will also force the binder to the surface thus manifest bleeding.

Excessive application of tack coat or prime coat would also produce bleeding with traffic pumping the binder through the paving thickness and within over the years, bleeding would also manifest.

Figure 2 - Bleeding at newly constructed Lebuh AMJ

5.0 HOT IN PLACE RECYCLING

Hot In-Place Recycling (HIPR) is an on-site, in place road pavement rehabilitation technique whereby the wearing layer of the pavement is heated, milled / scarified and then rejuvenated by adding a rejuvenating agent and / or a relatively small quantity of new mix. HIPR re-uses the entire of the existing material thus lessen the consumption of new resources and transportation of materials. It is considered as an alternative technique to improve the pavement surface for the purpose of restoration rather than mill and pave. This technique can also be used for re-profiling the pavement surface.

HIPR is not commonly used in Malaysia. Instead "mill and pave" or normal overlay method is used to improve existing pavement surface. The specification for HIPR application in Malaysia is already included in the standard specification for road works of Public Works Department of Malaysia JKR/SPJ/2008-Section 4.

HIPR offers 3 types of method :

i. Reshape or re-form operation that is heating up existing pavement material, loosens the heated existing surface up to the desired depth, mixing of the scarified pavement material with rejuvenator, and laid back the remixed material at the same surface.

ii. Remix is heating up existing pavement material, loosens the heated existing surface up to the desired depth, mixing of the scarified pavement material with rejuvenator and addition of new hot mix, and laid back the remixed material at the same surface.

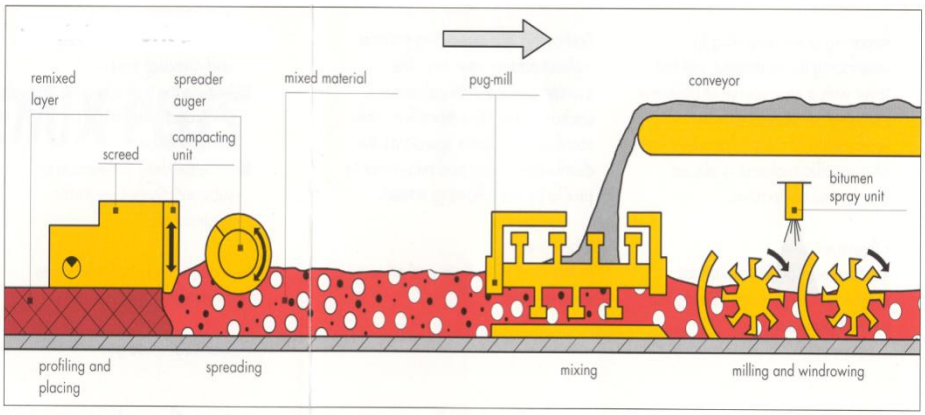

Figure 3 - Remix diagram

iii. Remix Plus is heating up existing pavement material, loosens the heated existing surface up to the desired depth, mixing of the scarified pavement material with rejuvenator and addition of new hot mix, and laid back the remixed material at the same surface, at the same operation, a new layer of fresh hot mix is laid upon the remix material to add up the bituminous structure thickness.

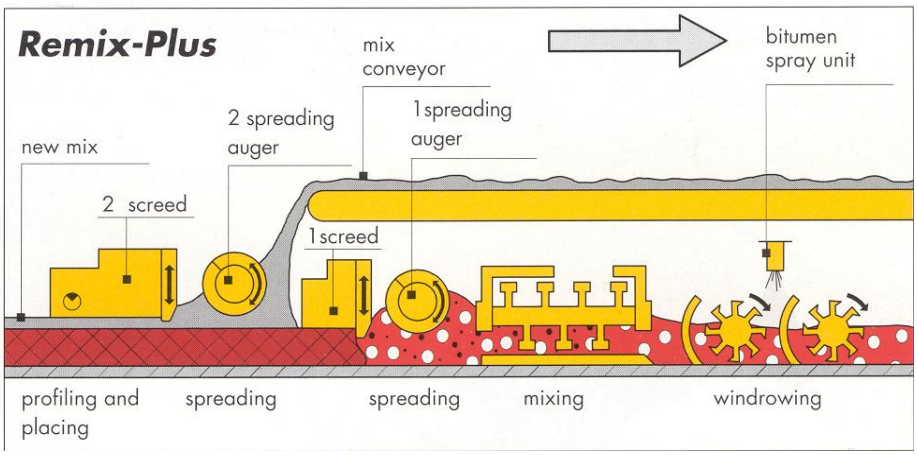

Figure 4 - Remix – Plus Diagram

6.0 HIPR SPECIFICATION IN JKR/SPJ/2008 – SECTION 4

As a response to the current trend of maintenance technologies which is focusing on recycling thus saving natural resources, Public Works Department of Malaysia (JKR) had incorporated HIPR specification in the updated JKR/SPJ/2008-Section 4 Flexible Pavement. It is an effort by JKR to promote the recycling technologies as part and parcel of road maintenance rehabilitation options.

HIPR specification in JKR/SPJ/2008-Section 4 encompasses materials, mix design, job mix formulae, equipment, construction method, laying and compaction, joints, finished HIPR surface and opening to traffic.

In the mix design, it is stated that the parameters as listed below shall obtained from the existing pavement to be recycled :

i. Bitumen content.
ii. Penetration at 25^{o}C and softening point of recovered binder.
iii. Aggregate gradation (refer Table 1)
iv. Type and amount of rejuvenating agent recommended.
v. Penetration at 25^{o}C and softening point of the blended material (existing and fresh material with rejuvenating agent)
vi. Marshall properties of the proposed blended mix. (refer Table 2)

Table 1 - Aggregate Gradation for Blended Mix

MIX DESIGN	**TYPE 1**	**TYPE 2**
B.S. SIEVE	**% PASSING BY WEIGHT**	
37.5	-	
28.0	-	100
20.0	100	76 – 100
14.0	80 – 95	64 – 89
10.0	68 – 90	56 – 81
5.0	52 – 72	46 – 71
3.35	45 – 62	32 – 58
1.18	30 – 45	20 – 42
0.425	17 – 30	12 – 28
0.150	7 – 16	6 – 16
0.075	4 – 10	4 – 8
TARGET BITUMEN CONTENT	5.0 – 7.0 %	4.5 – 6.5 %
AIR VOIDS	3.0 – 5.0 %	3.0 – 5.0 %

Table 2 - Marshall Properties of Blended Mix

PARAMETER	**< 2 million ESAL**	**>2 Million ESAL**
Stability, S	➢ 500 kg	➢ 700 kg
Flow, F	➢ 2.0 mm	➢ 2.0 mm
Stiffness, S/F	➢ 250 kg/mm	➢ 350 kg/mm
Air voids in mix	3.0% - 5.0%	3.0% - 5.0%
Voids in aggregate filled with bitumen	75% - 85%	75% - 85%

7.0 SITE TESTING & MIX DESIGN

As described in Section 2.0, 2 lane-km has been identified of having shallow cracking, surface undulation and bleeding. For the purpose of this paper, only

location of having surface bleeding were investigated by taking samples taken and carrying out mix design to determine the suitability of HIPR method.

Visual condition survey was carried out to record all the defects within the research area. Five (5) core samples were extracted from this location. The samples were taken back to the laboratory for further testing. Extraction test to determine the binder content and to obtain the binder for further testing and aggregate gradation were carried out in the laboratory. Other tests that were carried out were bitumen penetration and softening point.

Table 3 - Summary of Bitumen Content Test Results

Sample No.	Bitumen Content	Remarks
1	5.97	Exceed design limit
2	5.53	Exceed design limit
3	6.04	Exceed design limit
4	6.41	Exceed design limit
5	8.04	Exceed design limit

From the results, it is shown that all 5 samples has binder content exceeding the design bitumen contents of 5.3% with tolerance $\pm$ 0.2%. This non-conformance was expected from the area whereby bleeding was conspicuous.

Table 4 - Summary of Bitumen Penetration and Softening Point Test Results

Sample No.	Penetration (dmm)	Softening Point C
1	47	47.8
2	46	48
3	52	48
4	30	48.1
5	39	52.8

The bitumen penetration test showed that the bitumen binder has hardened from initial 80-100 to a range of 39 – 52 with corresponding softening point increasing from initial 45^{o}C (typical) to a range of 47.8 – 52.80^{o}C. From the Malaysia experience of application rate of rejuvenating agent in HIPR, it was decided that 0.5% rejuvenating agent shall be added to soften the binder to about 60 penetration grade.

From the results, it is concluded that, bitumen content was excessive at the time of samples acquired and most probable during the mixing process. Grading was also not fulfilling even the general gradation limits especially on the upper limit. This grading showed that the material having much fine material thus produced less air

voids and became one of probable causes of bleeding. With all the findings, all of this was assumed to be the main reason of the bleeding manifest at the area after the road was open to traffic for 1 year.

7.1 Experimental Matrix

The bleeding area was divided into three (3) test section as follows :

- HIPR 50 mm depth without rejuvenating agent with addition of new mix. 600m length.
- HIPR 50 mm depth with rejuvenating agent with addition of new mix. 600m length.
- Mill and Pave 50 mm depth as a control section. 800m length

The addition of new ACW20 mix was to improve the gradation of the existing material and Marshall Properties such that they would comply with the required as stipulated in Table 1 and Table 2 respectively. The control section was treated using the conventional mill and pave method.

7.2 Aim of Treatment

The HIPR method was applied at the bleeding section with the following aims :

1. To achieve bitumen content within 5.3 $\pm$ 0.2%
2. To achieve aggregate gradation within the envelope in Table 1.
3. To achieve air voids within 3.0 – 5.0%.
4. To achieve field compaction by at least 98% of Marshall density.

8.0 CONSTRUCTION

Trial lay was carried out on 2nd August 2010 with the emphasize given to the following items :

1. Traffic management setting up
2. Machineries and equipment of HIPR are all available to produce HIPR recycling train.
3. Machineries and equipment of HIPR are functioning.
4. Establishing HIPR work sequence.
5. Establishing rolling pattern to achieve not less than 98% Marshall density for HIPR layer.
6. Compliance of mix with JKR/SPJ/2008 – Section 4, Marshall Properties of Blended Mix (refer Table 2)

A 150 meter section was excluded from the experimental section to perform HIPR trial lay. The trial lay section has defects similar to the experimental section.

8.1 Machineries

HIPR train consist of a pre-heater, remixer, tandem roller, and pneumatic tyre roller which area arranged such that to provide appropriate work sequence in HIPR operation.

Figure 5 - HIPR Recycling Train

Pre heater is used to raise the pavement temperature to about 140^{o}C – 180^{o}C. Remixer is then scarify the heated pavement up to 50mm depth. Rejuvenating agent at 0.5% application rate is then sprayed into the scarified material. New asphaltic course mix is added at the remixer hopper, blended together with the scarified material. The remixed and blended material is then laid back on the same pavement surface. Tandem roller and pneumatic tyre roller are then used in the compaction process.

Figure 6 - Pre Heater and Remixer

Rolling pattern consist of 2 passes of static mode tandem roller, followed by 2 passes of vibrating mode, 10 passes of pneumatic roller, and 2 passes of finishing static mode tandem roller was applied at the trial area. Loose sample was taken back to the laboratory for Marshall properties testing. Samples were taken for measurement of compacted core density and thickness.

From the trial lay, bitumen content in the blended material was found to be lower than the existing material. Bitumen content was found to be in the range 5.39 – 5.73% except for one sample with bitumen content of 6.62% but the air voids of the mix has increased to around 8%. Rolling pattern of 2.2.10.2, apparently produced the compaction density of 99%. While for aggregate gradation, it is fell nicely within the gradation limit of Type 2 in Table 1 : Aggregate Gradation for Blended Mix.

8.2 Treatment in the Experimental Section

The experimental section was treated either by HIPR or mill and pave method, commencing on 30th August 2010. The work was completed 2 weeks later.

The work went well in accordance to the experimental matrix plan, except that HIPR 50mm depth with rejuvenating agent was carried out with the application rate reduced from 0.5% initially to 0.3%. This change was made during the work as the blended mix looked wetter and shining than usual due to addition of rejuvenating agent. At the application rate of 0.3%, the blended mix looked like a normal mix with no indication of excessive binder. Last but not least, loose samples from the experimental section were taken for further testing in the laboratory.

8.3 Observation During the Work

The following observations were made during HIPR process ;

1. 0.5 % application rate of rejuvenating agent was too much for the existing material. Blended mix showed an appearance of a rich mix. The application rate of rejuvenating agent was then reduced to 0.3%
2. Recycled mix did not seem to be adequate when it was laid at the same place without adding new mix. Therefore it was decided that new mix to be added to the recycled mix.
3. The temperature of the recycled mix at the screed was measured at 110^{o}C.
4. Bleeding bitumen binder on top of the existing pavement was caught in flame during the preheating process.
5. Depth of scarifying was 50mm +- 5mm.
6. Hand casting during the laying work but kept to minimum.

9.0 TEST RESULTS

Samples of the blended mix were taken from behind the paver and tested in the laboratory. The results are as follow :

9.1 Bitumen Content

Table 5 - Percentage of Bitumen Content After Recycling

Sample No.	Quantity of Rejuvenating Agent (%)	Bitumen Content %	Remarks
1	0	6.67	Exceeding limits
2	0	5.4	Within limits
3	0.3	5.73	Within limits
4	0.3	5.42	Within limits
5	0.5	5.39	Within limits

The bitumen content of the recycled mix was found to be lower than the existing. This was presumably attributed to the process of evenly remixing and re-laying of the blended material by the Remixer. It was also found that the aggregate gradation of recycled mix was within the Type 2 Aggregate Gradation of Blended Mix (refer Table 1). It was also assumed that the new ACW20 mix aggregate gradation had improved the existing gradation to be within the gradation limits. Virtue of binder contents and aggregate gradation of the recycled mix were within the limits, it was anticipated that bleeding would not re-occur within the experimental section.

9.2 Air Voids

Table 6 - Percentage of Air Voids in Mix

Sample No.	Quantity of Rejuvenating Agent (%)	Air Voids	Remarks
1	0	5.19	Slightly higher but acceptable
2	0	5.39	Slightly higher but acceptable
3	0.3	5.35	Slightly higher but acceptable
4	0.3	5.38	Slightly higher but acceptable
5	0.5	4.64	Within limits

Air voids of mix were found to be slightly higher than the limits and were considered acceptable.

9.3 Stability and Flow

Table 7 - Percentage of Revujenating Agent with Stability and Flow Properties

Sample No.	Quantity of Rejuvenating Agent (%)	Stability (kg)	Flow (mm)
1 (without reju)	0	1409.1	4.9
2 (without reju)	0	1185.5	3.2
3 (0.3% reju)	0.3	1589.3	5.8
5 (0.3% reju)	0.3	1124.9	3.1
3 (0.5% reju)	0.5	1833.3	4.5

Stability and flow was found to be in compliance with Table 2 : Marshall Properties of Blended Mix for >2 million ESAL.

10.0 MONITORING

As the aim of this research is to assess the effectiveness of HIPR technique in rectifying pavement bleeding, the monitoring is kept to visual condition survey. 6 month after work completion, on 24th February 2011, visual survey has been carried out at the research area. The work area can be describe as below :

10.1 HIPR 50 mm depth without rejuvenating agent with addition of new mix

No bleeding was found within this section. Pavement surface was found to have a good texture.

Figure 7 - Pavement surface at the HIPR without addition of rejuvenating agent

10.2 HIPR 50 mm depth with rejuvenating agent (0.3%) with addition of new mix

Bleeding was found within this section with visibility of colouring of pavement surface.

Figure 8 - Bleeding at the HIPR with addition
of 0.3% rejuvenating agent

10.3 HIPR 50 mm depth with rejuvenating agent (0.5%) with addition of new mix

This section only contains of 50 meter length. During the work, recycled material looked wet and shining suspected from excessive binder content and addition of

rejuvenating agent. It is confirmed at this section, bleeding had became apparent even after 6 months.

Figure 9 - Apparent bleeding at the HIPR with addition of 0.5% rejuvenating agent

11.0 CONCLUSION

Based on observation made during construction and laboratory testing on existing materials, early performance of the experimental section, the following conclusions could be drawn :

1. If HIPR method was to be used to rectify bleeding, rejuvenating agent should not be added. It was observed that bleeding did not re-appear after 6 months in the HIPR without rejuvenating agent section.

2. The addition of new asphaltic concrete mix would improve the gradation of the recycled mix.

3. The addition of new asphaltic concrete would also reduce the binder content in the existing material.

Furthermore, the whole section shall be monitor 6 month from now as it will be 1 year after HIPR work. Further monitoring and findings shall provide much confidence in rectifying bleeding using HIPR method.

12.0 FUTURE STUDY

There are plenty of areas of this research that would be worth to further study.

1. Producing the guideline of rejuvenating agent application rate to rectify bleeding. Even though in this study, for bitumen content within 2 years of service, no rejuvenating agent shall be added had produced no bleeding after 6 months from repair work, it is better to have a guidelines on addition of rejuvenating agent to existing material. Bleeding on pavement would last until rehabilitation work take place, but for ageing bitumen in the pavement, it shall

have at least minimum condition to add on the rejuvenating agent for HIPR to work.

2. Special adjustment of new material to be to add to existing material. This is to compensate material grading and bitumen content in producing stable and appropriate blended mix. It was not initially in the work that has been done, but this scope can play an important role to rectify bleeding using HIPR.

3. Producing guidelines on bitumen properties such as penetration and softening point for blended mix.

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