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Foamed Bitumen Stabilised Pavement Construction- Possible Options for Developing Countries

J. Ramanujam & D. Volker & M. Sok & P. Evans
Department of Transport and Main Roads, Queensland, Australia

ABSTRACT: Department of Transport and Main Roads (TMR) has been developing the foamed bitumen stabilisation technique in Queensland to provide a flexible and fatigue resistant stabilisation treatment suitable for Queensland conditions. More than 600 Km of existing pavements have been rehabilitated using this technique. This technique may also be suitable for roads in developing countries.

Performance of this technique to date has been encouraging. Superior long term performance and lower maintenance are possible using the foamed bitumen stabilisation method compared to other more conventional stabilisation treatments, provided proper investigations, designs, and quality control in construction is performed. This paper will address only the construction aspect of the foamed bitumen stabilization technique based on successful experiences and lessons learned from projects. Other aspects, including mix and structural design, can be found in the technical paper written by Jones and Ramanujam (2008).

1 INTRODUCTION

1.1 Pavement Stabilisation

Granular pavements in Queensland, Australia are relatively thin compared to those constructed by most other Australian state road authorities. These pavements are also typically placed over low strength sub-grades and have relatively high deflections thus making them susceptible to cracking when stabilised with high percentages of cementitious binder. As a consequence of this lack of insitu pavement strength, Transport and Main Roads (TMR) has been developing several treatments that modify rather than stabilise the base layer of these pavements. Foam bitumen stabilization is one of the successful technique adopted by TMR.

1.2 Description of the foamed bitumen treatment

Foamed bitumen is a mixture of air, water and bitumen. It is created by injecting hot bitumen and a small quantity of cold water into a mixing chamber (Fig.1). This injection produces an instantaneous expansion of the bitumen to about 15 times its original volume, forming a fine mist or foam. This expansion is due to the water being converted into steam by the hot bitumen. Typically the foamed bitumen contains 97% bitumen, 2.5% water and 0.5% foaming additive. In this foamed state, the bitumen is ideal for mixing with fine aggregates. The foam collapses very quickly. And therefore vigorous mixing is required to adequately disperse the foamed bitumen throughout the material. During the mixing process foamed bitumen coats the finer

particles forming a mortar that binds the mixture together.

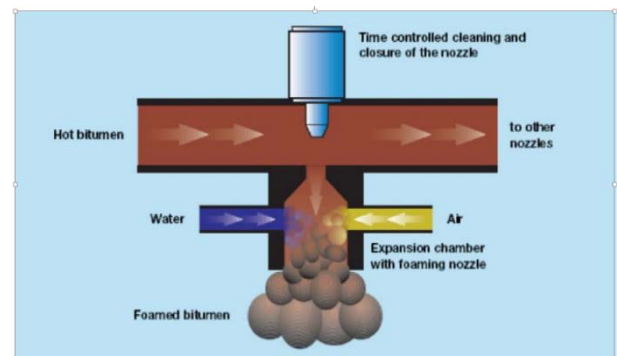


Fig.1: Bitumen Foaming Concept

In Queensland, foamed bitumen stabilisation has been undertaken using insitu stabilization method. In insitu stabilization the existing pavement material is milled and the foamed bitumen and additives are mixed directly into the material without removal from site. However, in many cases external material has been added prior to stabilization to compensate for the lack of quality, gradation, thickness and to satisfy the mix design requirements.

Alternatively a “Plant Mix/ex situ” mix method is also available. The existing material is milled and hauled to a central batch plant where foamed bitumen and additives are added and thoroughly mixed within a pugmill. The modified product is then hauled back to site for laying. While plant mix foam bitumen technology is relatively a newer technology/method its popularity is growing. This method has been used in rehabilitation of a number of flood affected, high traffic pavements in

Queensland. As the efficiencies of mobile pugmills improve, the pugmill/ paver operation will become more feasible and cost competitive in the future. A technical paper on future major trials with the plant mix process will be published.

2 CONSTRUCTION PROCESS

As TMR has had more experience with the insitu stabilisation process, it is discussed in more details in this paper. The step-by-step construction procedure is shown in Figure 2.

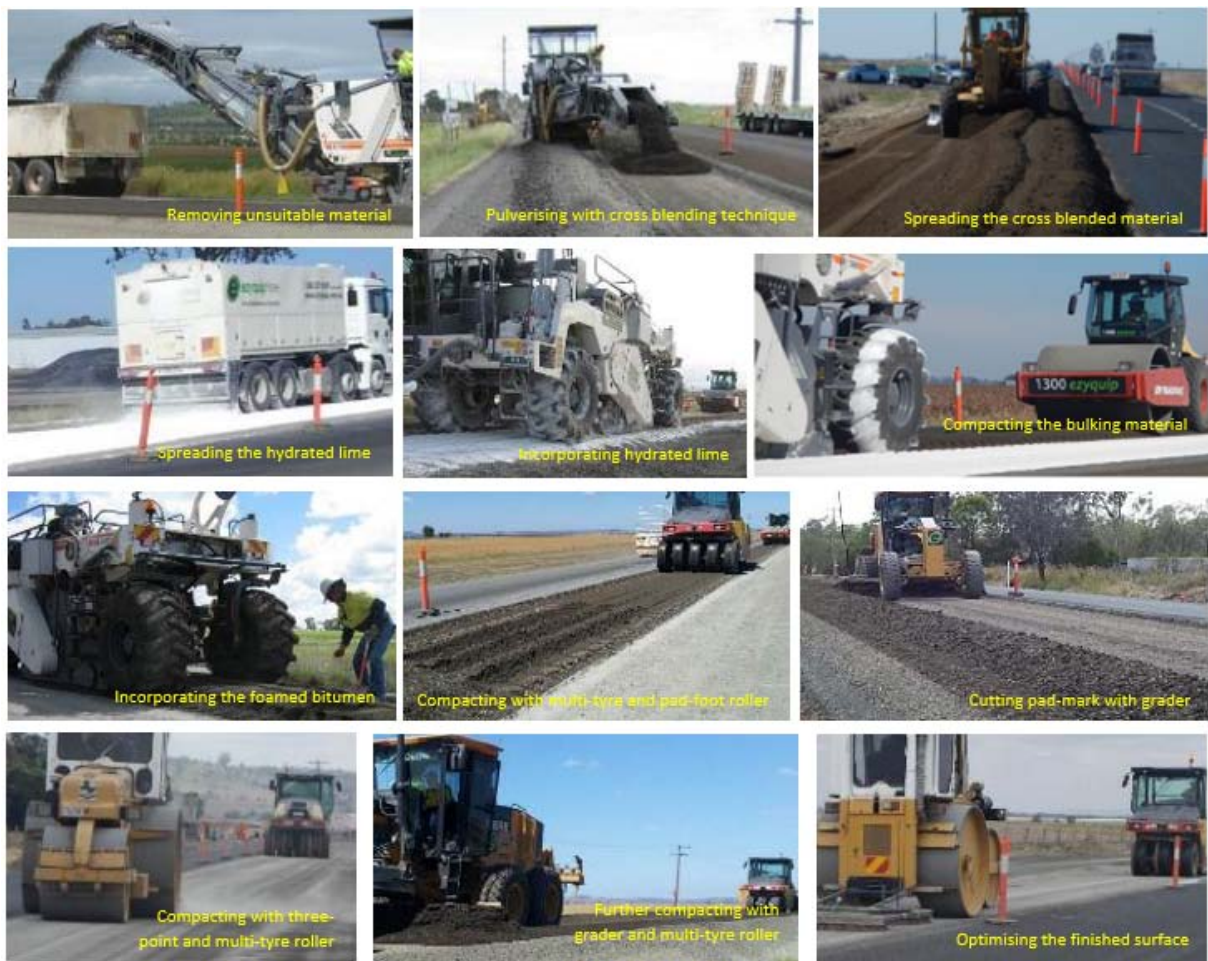


Figure 2: Step-by-step construction procedure

Description of each construction step are provided in Section 2.1 - 2.8. Refer to Volker et al (2014) for further details.

2.1 Removing of unsuitable material

The existing treatments such as asphalt patches or geotextile seal must be removed and replaced with suitable material as specified in MRTS07C (DTMR, 2014).

2.2 Pulverisation with cross blending technique

Prior to stabilization, the existing pavement material shall be pulverised to a depth of 50mm shallower than the proposed stabilised depth. With a profiler, the pulverised material can be cross blended, and will therefore be well mixed and uniform.

2.3 Granular overlay and shape correction

Where required, proposed imported unbound granular material is spread by a truck and a grader. The spread material is compacted, shaped and trimmed to the profile as per design.

2.4 Incorporation of secondary stabilising agent

The secondary additive, usually hydrated lime, is uniformly spread onto the corrected layer at the proposed spread rate. The lime is incorporated into the pavement to a depth of 50mm shallower than the proposed stabilised depth using a recycler. Water is added if necessary to bring the moisture content of the blended material to a preferable range of 55% – 75% of the Optimum Moisture Content (OMC). After lime incorporation, the bulky surface

is compacted as close as possible to the proposed finished surface level.

2.5 Incorporating the foamed bitumen

A foaming capable recycler, such as Wirtgen WR2400/WR240, has been used to incorporate foamed bitumen into the pavement to the proposed design depth. In case an anti-foaming agent has been added to the bitumen before it was supplied to the project, an anti-foaming agent is required to be added at least half an hour before the bitumen is used. To achieve the requirements of a minimum of 10 times expansion ratio and a 20 seconds half-life, the bitumen to be injected into the recycler's chamber shall be at a temperature range between 170 °C and 190 °C. To achieve the required compaction of 102%, the target moisture content of the foamed bitumen stabilised pavement needs to range from 55% to 75%, preferably on the dry side.

2.6 Compaction and trimming

Compaction starts immediately after the foamed bitumen incorporation with a 21 tonne multi-tyre roller, followed by a 21 tonne pad-foot roller, a Global Positioning System (GPS) grader and a three-point roller. The multi-tyre roller and grader are used for the final compaction to provide a tight, well compacted and impermeable surface, and to ensure that the design geometry is achieved. At the end, the three-point roller can be used with a broom attached, followed by the multi-tyre roller, to optimize the finished road surface.

2.7 Curing

Prior to sealing, a water truck should be continuously watering the constructed pavement. MRTS07C [1] requires the pavement to be maintained in a damp condition until sealed or covered by a subsequent layer, taking care not to flood or slurry the pavement surface. A minimum of 2 days should be allowed for the foamed bitumen stabilised layer to be cured prior to trafficking.

2.8 Sealing

After construction, the maximum time delay prior to sealing is dependent on trafficking arrangements, but should not exceed 7 days. If the sealing is delayed, the stabilised layer may begin to deteriorate or develop a slick surface during wet weather. A full seal (preferably with a polymer modified binder) or asphalt should follow the primer seal to provide a waterproof, long-life surfacing.

3 CONSTRUCTION CONSIDERATIONS

Experience has shown that successful outcomes will occur if the practical considerations in the Section below are implemented.

3.1 Field construction

Field construction must be completed in the order outlined in Section 2. This procedure was adopted for Gore Highway 28A, the largest foamed bitumen stabilisation project in Queensland to date.

According to the back analysis outcomes using Falling Weight Deflectometer (FWD) data, the flexural moduli of foamed bitumen stabilised base generally ranges between 2,000MPa and 5,000MPa ().

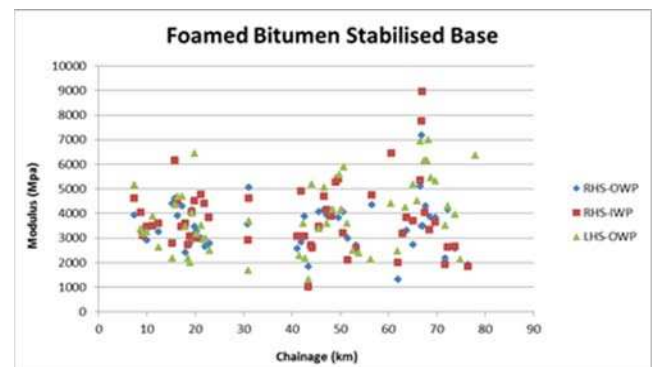


Figure 3: Backanalysed Flexural Modulus

3.2 Foamed bitumen incorporation

The introduction of foamed bitumen must not be delayed more than 2 hours after the lime has been mixed into the pavement. This is to prevent the lime working on the fines and changing the particle surface area.

3.3 Pulverising depth

The pulverising pass should be less than the final stabilisation depth to ensure that “lenses” of unstabilised and uncompacted material are not present below the stabilised layer.

3.4 Moisture content

Although the control of moisture content is of prime importance for the optimum compaction conditions, there is currently no automated process available that can ensure that moisture will be at a uniform and optimum level during the recycling process. It is therefore vital that an experienced operator controls the stabilisation process and acceptable moisture conditions are maintained.

3.5 Achieved thickness

The stabilised layer's thickness is one of the most critical factors contributing to the pavement's design life. A minor reduction in layer thickness may result in a significant drop in pavement life based on a lesson learned from the Gore Highway 28A project (Volker et al, 2014). Therefore, the depth control with an appropriate tool, such as a dumpy level (Figure 4) or survey model (Figure 5), used on site is crucial.

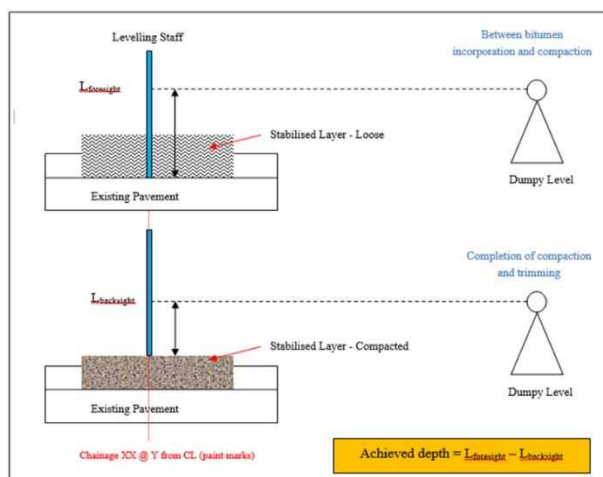


Figure 4: Depth check through dumpy level



Figure 5: Survey model- real time control

3.6 Testing Foaming properties

During construction, the testing for foaming properties shall be conducted to verify the quality of the bitumen foam. Based on the past experience from Gore Highway 28A project (Volker et al, 2014), the testing should take place when the recycler (Wirtgen WR240/2400) is in motion.

3.7 Excessive cement

Shortly after construction, major failures were observed at the Macalister Deviation (Volker, 2013). One of the possible causes, based on the investigation results, was the excessive cement applied as the secondary additive in the foamed bitumen stabilised pavement.

3.8 Existing cement treated patches

In the Gore Highway 28A project (Volker et al, 2014), the cement concentration in the existing treated patches had been diluted through cross blending technique. Thus, there were no associated issues observed.

However, from the case study on Gladfield, approximately 10% of the pavement exhibited signs of minor fatigue distress (Kendell et al, 2001) after several years of traffic loading. These fatigued areas correlated relatively consistently with pavement failures that were stabilised with cement during previous maintenance.

3.9 Field dry density

Samples for the reference dry density are collected from random locations directly behind the recycler. The samples must be compacted not more than an hour after being foamed bitumen stabilised. Delay in compacting will result in lower reference dry density, causing faulty interpretation of the relative dry density.

4 CONCLUSION

The Queensland Department of Transport and Main Roads has used foamed bitumen stabilisation successfully as a rehabilitation technique for existing unbound granular pavements. To ensure that the expected design life is achieved, a proper construction process and appropriate controls should be implemented as documented in this paper.

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