

FOAM BITUMEN TRIAL AT GLADFIELD - CUNNINGHAM HIGHWAY

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1. Introduction

Stabilisation of pavements with lime/flyash and emulsion/cement are two commonly known processes in Queensland. An alternative treatment of stabilising pavements IS with foam bitumen. This method is expected to give a flexible, strong and an impermeable road pavement. This paper will discuss very briefly, some of these advantages, along with the design and construction aspects of the foam bitumen trial that was carried out in the Warwick district recently.

2. Technology

2.1 Method

Foam bitumen is a mixture of air, water and bitumen. It is typically 98% bitumen, 1% water and 1% additive. It is produced by injecting about 1% cold water into 98% hot bitumen in a foaming chamber. The bitumen expands to about 15 times its original volume and forms a fine mist of foam which is highly efficient in wetting and coating the surface of fine particles. As the foam collapses most of the water is lost in the form of steam leaving a residual bitumen with properties similar to the original bitumen. The time that the expanded bitumen takes to settle to half its expanded volume is called the half life and a desirable design value is 60 seconds.

2.2 Equipment

The Wirtgen WR 2500 recycler that was used on the trial has a purpose built foaming chamber attached to each of its 16 nozzles arranged along the length of the spray bar. The foaming chamber is connected with two pipes, one of which carries cold water from an on board water tank and the other hot bitumen from an on board bitumen tank. As the cold water is sprayed on to the flowing hot bitumen through the foaming chamber, bitumen expands to form foam bitumen which is then injected through the nozzles on to the recycling pavement material. During the mixing process foam bitumen coats the finer particles forming a mastic that will effectively disperse and bind the mixture together. The recycled material remains workable for several hours thus, allowing sufficient time for shape correction, trimming and compaction to occur.

2.3 Comparison with Traditional Method

A distinct difference between foamed mixes and asphalt and emulsion stabilised mixes is the way in which the bitumen is dispersed through the aggregate. In the later case the bitumen tends to coat all particles whilst in the foamed mixes the larger particles are not fully coated. The foam bitumen disperses itself among the finer particles forming a mortar which binds the mix together. This partial coating gives the appearance of only a slightly dark colour to the mix compared to a much darker colour that will result if the same material were to be prepared to produce asphalt.

Foam bitumen mixes can achieve stiffnesses close to those of CTBs (3000 MPa) but remains flexible like an asphalt. It is this combination of strength with flexibility that gives bitumen stabilisation the potential to become a very desirable treatment in road rehabilitation. It is

expected to provide superior fatigue properties to cementitious blends and avoid cracking. Curing time of foam bitumen is shorter than cement or emulsion bound pavements thus allowing early trafficking.

3. The trial

The trial site was located at the 103 rd km on the Cunningham highway between Freestone creek and the Cunningham gap, starting west of Gladfield vehicle inspection site. Work was carried out by SPA (Stabilised Pavements of Australia) and was completed in 6 days. Work was delayed by 2 days due to rain and the initial programme to complete the works in 4 days was not possible to be achieved. Work under the contract included: the pulverising and mixing of the pavement material for the full pavement width of 9.2m and to a depth of 200mm between the inner wheel paths and to a depth of 250 mm under the outer wheel paths; trimming, shaping and compacting the pulverised material and traffic control.

A brief description of the process which was carried out is as follows:

- Traffic was restricted to one lane width
- 2 % lime was spread on one half of pavement
- Approximately 2.4 m of the inner wheel path area was recycled to a depth of 200mm by one pass of Wirtgen 2500. This operation simultaneously achieved the pulverising and mixing of the pavement material with lime and foam bitumen (The design bitumen content was 3.5% of class 170 with diesel cutter).
- The above process was repeated for the outer 2.4m of the pavement, allowing for an 100mm overlap with the previous section. The depth of recycling was 250 mm.
- Compaction was carried out by a 15T pat foot vibrating roller followed by a 15 T vibratory and a 12 T multi tyre roller.
- Grading and trimming was carried out to achieve the design crossfalls. No imported material was used
- Traffic was allowed on the next day and the above process was repeated for the other half of the pavement.
- An OLEXOBIT SAM seal coat was applied nearly 2 weeks after the completion of the trial. This period was required to allow for the cutter to cure.

At the end of the first day of the trial, rebound deflections of the order of 0.75mm were measured on the treated pavement, which is an indication of its ability to gain strength rapidly and the potential to allow for early trafficking. Traffic was allowed on the day after each day's work and the surface did not show any signs of early distress.

Since completing the trial, traffic has being allowed on the finished but unsealed road, for nearly two weeks with no failures observed. Given the very high content of commercial

vehicles on the Cunningham highway these field observations indicate that the surface is withstanding the impacts of early trafficking very well.

4. Pavement Investigation and Design

Two pits were dug to examine the pavement material. The results showed that the pavement consisted of a 125mm base layer of coarse blend crushed rock overlaying a 200mm of subbase of similar material, but of a finer blend.

Laboratory tests showed a subgrade of a silty clay type with a PI of 35% and 60% passing .075mm sieve. High swell characteristics are associated with this type of material. DCP showed an insitu CBR of less than 2 % increasing to 10% with depth.

The surfacing consisted of multiple surface treatments of +30mm of seals with several flush spots on the wheel paths.

A critical factor in the design process is to test the grading of the material to be recycled. To much fine or coarse material is not suitable for foam bitumen recycling treatment. The material must fall within a given grading and if not, mechanical modification will be required by adding suitable quantities of fine or coarse material to correct the grading deficiency. Approximately the percentage passing .075mm sieve must be between 5 and 20%. If high PIs are encountered lime will be needed to reduce the plasticity.

Material taken from field pits were volume blended in the proportion of the depths of surfacing, base and subbase material to be recycled, to represent a recycle depth of 200mm. The blended samples were then mixed with 1 % lime to address the plasticity problem and to provide anti-stripping properties and several samples were prepared using varying quantities of foam bitumen. The lime percentage was increased to 2 % in the field to account for a greater amount of plastic subgrade material that was expected to be contaminated with the pavement material. 2% diesel was added to all bitumen used in the lab samples to provide increased penetration and better mixing. A number of samples were prepared by varying the bitumen contents from 3 % to 4% and lab tests were carried out on these samples to determine a number of properties, including Indirect tensile strength (ITS), soaked ITS, retained ITS, bulk density, dynamic creep and resilient modulus. The bitumen content range for which these properties showed optimum values was determined and a suitable design bitumen content was selected from within this range. A dry density-moisture content curve was also plotted to determine the optimum moisture content for compaction.

Average values of a number of test results obtained from lab testing are shown below and a comparison of these with similar properties for gravel, asphalt and cement/flyash materials will provide the basis for an understanding of some of the attributes of foam mixes.

- bitumen 3.5%
- OMC 3.5%
- bulk density 2.3 t/m³
- ITS (KPa) 380
- soaked ITS 240

- retained ITS 65% this indicates that a bitumen stabilised pavement will perform well in the presence of water.
- dynamic creep modulus (MPa) 54
- resilient modulus 1300 Mpa. This is an unexpectedly low value for bitumen mixes. values upto 2500 MPa are achievable with these mixes compared with 300 for gravels, 2500 for asphalts, and 3000 for CTBs.
- retain resilient modulus 62 % Again demonstrating the small effect of water on strength loss.
- relative density 98% modified AASHTO

The structural design was based on the following design parameters:

- subgrade: 70 MPa (CBR 10%)
- subbase: 220 MPa (CBR 45%)
- recycled base: 2500 MPa for a 200/250 mm thick layer

5. Costs

The cost of the foam bitumen trial amounted to \$ 15.50 per m2 which included all additives, including bitumen and \$5000 for establishment. The cost of the bitumen surfacing is not included in this price. In comparison ,a 200mm lime/flyash treatment costs \$6 to 9 per m2 and a 200mm emulsion/cement costs \$12 to 14 per m2 while a 175mm advacrete/cement will cost about \$12 to 14 per m2. The high cost of foam bitumen treatment must be balanced against the likely reduced maintenance costs during it's design life.

6. Trial monitoring

Pavement Rehabilitation section has developed a methodology for the monitoring of the trial which will include the carrying out of a large no of insitu, lab and non destructive tests. This monitoring process is designed to help us to gain a greater understanding of some of performance related issues of bitumen stabilised pavements, including:

- strength gain with age
- initial crack and rut occurrence and traffic levels when these occur
- rate of increase in roughness
- quantify the ultimate strength developed.
- rate of deterioration measured in terms of increase in deflection
- the gap between field tests and lab tests and seek modifications to achieve better designs in the future.
- monitor long term performance using one year's performance data and hopefully predict a design life

7. Short Term Performance

7.1 Deflection Levels

Deflection testing (with a Heavy Weight Deflectometer) results has indicated significant lowering of the deflection levels and increase in the deflection ratio levels as compared to the corresponding values before treatment. These are as shown in figures 1 to 4 respectively. From the figures shown, it can be seen that the deflection levels have reduced from an average of 1mm to an average of 0.5 mm. Similarly the deflection ratios have increased from an average of 0.5 to 0.7. A deflection ratio in the range of 0.6 to 0.8 indicates the presence of a strong but flexible pavement. This non destructive test for monitoring the structural strength will be continued over the next few years in order to assess the structural performance.

Using the deflection results a back analysis was carried out. A comparison of the results with the design is as shown below.

| Layer | Design Modulus Values | Back Analysed Modulus Values |
|-----------------|-----------------------|------------------------------|
| Subgrade | 70 MPa (CBR 10) | 40 MPa (CBR 3) |
| Subbase | 220 MPa (CBR 45) | 200 MPa (CBR 40) |
| Stabilised Base | 2500 MPa | 1250 MPa |

Table 1- Back Analysis Results

7.2 Design Vs Field

The following is a comparison of the design and field properties:

| Property | Design | Field |
|--|-----------|-------|
| Bitumen Content % | 3.5 | 4.02 |
| OMC %/Bulk Density t/m ³ | 3.5 / 2.3 | |
| Indirect Tensile Strength KPa | 380 | 1043 |
| Indirect Tensile Strength - Soaked KPa | 240 | |
| Creep MPa | 54 | |
| Resilient Modulus MPa | 1300 | 1208 |
| Retained Resilient Modulus % | 62 | |

Table 2- Design Vs Field Values

It is to be noted from the results that the resilient modulus in the field is similar to the design modulus. In addition the field cores exhibit a very high indirect tensile strength value. More cores will be taken in the future to confirm this result.

8. Conclusions

The Foam Bitumen Trial section is only 5 months old. Hence it is too early to conclude on any short term performance data. However, based on the information during trial and subsequent field performance and testing the following factors are to be noted:

Advantages

- Easy Application - The foam bitumen is sprayed directly into the recycler's mixing chamber
- Rapid Strength Gain - The road was trafficked immediately after compaction was complete. The deflection results taken the day after the first lot indicated values less than 0.75 mm confirming adequate structural strength is available for immediate trafficking.
- Additive Content - The trial showed that it required only a small percentage of cement to improve the early strength significantly.

Disadvantages

- Cost - Relatively more expensive as compared to other forms of stabilisation.
- Sealing Work - The trial indicated that the seal design requires special attention. There were stripping problems with a polymer modified seal (with no primer seal) sprayed after two weeks of completion. A slurry seal is commonly used on Foam Stabilised pavements in South Africa.
- Bitumen Temperature - The process requires hot bitumen (180^o C) for the foaming action to be successful.
- Grading - The success of this technique (based on literature survey) appears to be very sensitive to the grading of the host material. The preferred should be closer to a standard 'C' grading. An additional requirement is the percentage passing the 075 mm sieve should be between 5 to 15 %. This may force the user to obtain imported material to mix with the existing to achieve the grading requirements.
- Purpose Built Equipment - The recycling equipment requires expansion chambers etc., to carry out the foaming and associated work. Most other additives could be used with an ordinary high production recycler.

Only long term monitoring results could indicate whether superior performance and low maintenance would outweigh the disadvantages outlined above.

9. References

1. 'Cunningham Highway Foam Bitumen Trial' - Preliminary Report by D.P. Fernando
2. ' Comparison of Stabilising Agents using the deep lift cold in place recycling process'
Report by A.A. Louden & Partners
3. ' Preliminary Designs for the Cunningham Highway Trial' - Report by A.A. Louden &
Partners

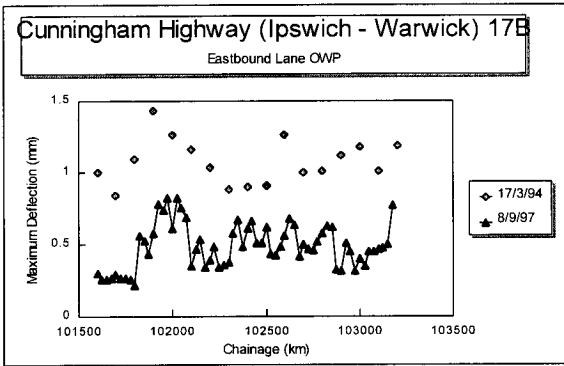


Figure 1 - Deflection Levels (Before and After)

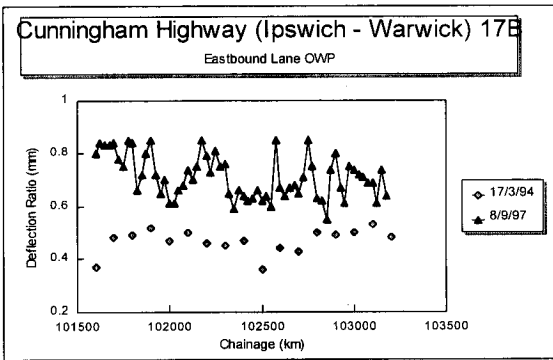


Figure 2 - Deflection Ratios (Before and After)

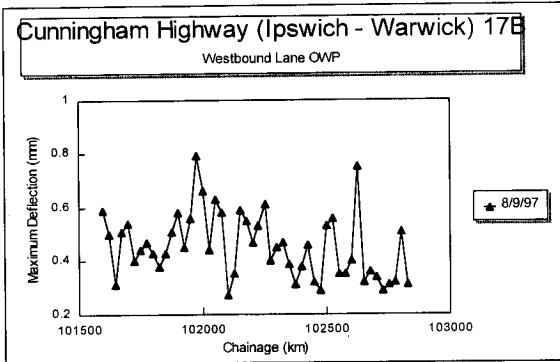


Figure 3 - Deflection Levels (After Recycling)

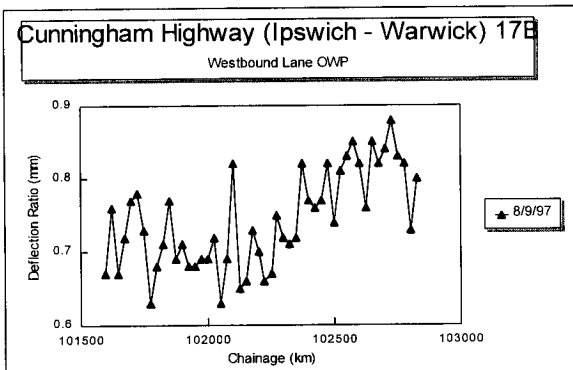


Figure 4 - Deflection Ratios (After Recycling)