Bitumen Treated Basecourse – Rapid and Resilient Network Option

Authors:
Robert Vos – Queensland Executive, AAPA
Trevor Distin – National Technology Manager, Boral Asphalt
Peter Pezet – Technical Manager, Queensland Metro, Fulton Hogan
Warren Carter – National Technical Manager, Downer Australia

Summary
- Major floods have damaged over 9000 m of Queensland roads
- Road repair options sought for rapid repair, under traffic in remote areas
- Bitumen Treated Bases rediscovered and AAPA draft specification developed in Qld
- Demonstration project using >200 000 tonnes BTB with sealed surface
- Feedback on learning's from the project and specification application

1. INTRODUCTION

The cyclones and floods in Queensland shocking as they were have provided the roads industry with unprecedented challenges and opportunities. Damage has occurred across the whole state and, for the roads, 85% has been in pavement damage. Fast flowing waters have washed away granular material and thin road surfaces whilst the flooded pavements have weakened and deformed. Road users quickly became aware of the inconveniences of limited or no access but the economic consequences of damages and impassable roads has the long-term impact.

Figure 1: Cecil Plains East showing example of pavement damage [1]
(photo courtesy of Queensland Transport and Main Road)

At the AAPA Queensland Branch communications forum in April 2011 Shane Doran [1] of Queensland Transport and Main Roads Department presented the details on how the reconstruction will take place and the department would mobilise the resources.

2. EXTENT OF DAMAGE TO THE QUEENSLAND TRANSPORT NETWORK

The news reports and media have clearly presented the extent and magnitude of the natural disasters that have hit Queensland in 2010 and 2011. Cyclones Olga, Neville, Ului and Paul in the first quarter of 2010 were followed by flooding in South West and South East Queensland in the 3rd quarter. From January to March 2011 tropical cyclones Tasha, Anthony and Yasi added to the monsoonal flooding which impacted most of the state.

Over 9 000km of the Queensland road network was damaged by the weather events, 29 % of the state's rail network was impacted and 89 bridges and culverts were damaged. Significant pavement damage has occurred, in addition to landslips on slopes and damage to culverts and bridges.

Of the transport network, Queensland's road infrastructure bore a major portion of the damage from these natural events leaving the state little choice but to look to the National Disaster Relief & Recovery Arrangements for assistance. This assistance provides a 75% contribution from the Commonwealth Government for reconstruction of damaged infrastructure within 24 months.

By mid May 2011 the estimate of the repair bill for the Queensland Transport Network was $4.36 billion dollars. With further reporting of damage the repair & rehabilitation costs stretched to well over this value and was scaled back to an amount of approximately $5.2 billion. By late August 2011 the reconstruction program was reprioritised to standards suitable for the reduced budget and matching the status and usage of the network.

With the short time frame to undertake the reconstruction this will put pressure on all parts on the road construction and maintenance industry to deliver.

The disruption of the broad road and rail network was a reminder to all of the important part the transport network plays in providing the necessities of life, food, medical care but importantly too, in this resource rich state, the need to maintain a constant stream of exports which underpin the Queensland GDP.

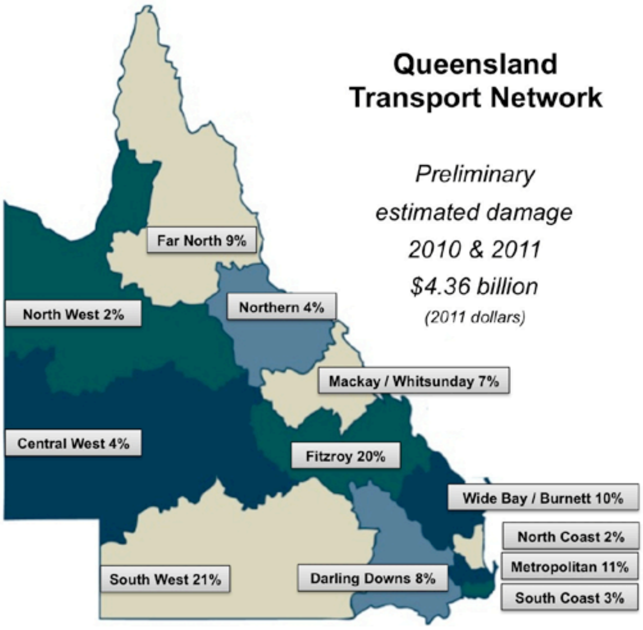

Figure 2: Queensland Transport Network reconstruction damage by region during natural disasters in 2010 and 2011 [1] and typical regional demand map for bitumen

3. DELIVERING THE RECONSTRUCTION PROGRAM

Under the title "Transport Network Reconstruction Program (TNRP)" [1], the Department of Transport and Main Roads has embarked on a well structured delivery framework where the overall coordination and funding is through a State-wide Program Office with twelve Regional Program Offices established to design, specify, clear approval, tender and deliver the program. At state and regional level use is being made of departmental and professional consulting staff to facilitate and speedup the delivery.

Governance, accountability and transparency are being maintained in the process, which includes the Federal Inspectorate to oversee the interests of the Federal funders.

The magnitude of the required repairs can be difficult to grasp, historical funding for road repairs has been in the order of $20 million to $50 million. Unless an extended reconstruction timeframe is approved the peak annual expenditure could be as much as 100 times more.

The overarching delivery philosophies include reconstruction delivery by the regions supported by local prequalified contracting capability and use of major contractors to supplement local industry. It was anticipated that 65% of the works would be handled by private contractors and 35% by Local Government and RoadTek the construction arm of the Department. By the end of May 2011 the first tranche of projects were underway.

Figure 3: Governance and delivery hierarchy (1)

RECONSTRUCTION PROGRAM OBJECTIVES AND RISKS

The stated objectives and strategic risks of the Queensland Transport Network Reconstruction Program are included in the table reflecting the importance of resilience, value for money and the risks pertinent to a significant growth in demand.

Table 1: Transport Network Reconstruction Program – Objectives and Strategic Risks (1)

Objectives	Strategic risks
• Coordination across lines of reconstruction	• Cost escalation - materials and labour
• Resilience of network	• Decreased availability – plant and material
• Immunity enhancement opportunities	• Market unable to meet demand
• Value for money	• Attracting and retaining contractor involvement
• Timely completion	• Market overheating
• Communication and engagement	• Competing demand for resources (mining)
• Transition back to normal business	• Lack of coordination in delivery
	• Continued wet weather

The expected increases in demand over the three years for products affecting AAPA members include bitumen +200 000 tonnes, granular +10 500 000 tonnes, asphalt +300 000 tonnes and more that 70 stabilisers for foam and cement improvement of damaged granular bases. From a materials view point current supply capacity was considered adequate or flexible enough to meet those demands but some forward purchases of granular material and advanced four month warning for binder supply would be beneficial. Smoothing of the demand and a proper pipeline of all the infrastructure projects was considered to be essential. The most likely bottleneck would be in general haulage of all materials to remote and dispersed sites and the demand for skills arising from the program and the mining developments.

Region	2006	2008
Sunshine Coast	265	565
Metro	1060	2100
Toowoomba	200	200
Gold Coast	300	550
Rest of Queensland	835	875
Mobiles	950	1050
TOTALS (tonnes/hour)	3595	5340

Figure 4: Increased asphalt manufacturing capacity in Queensland to address SEQ growth

The Queensland surfacing industry reviewed their capabilities and when considering the significant expansion in the demand for stabilised bases and spare capacity in the hot-mix manufacturing and paving sector suggested that the use of bitumen treated bases should be included in the reconstruction program. By including the spare resources in the hotmix sector the strategic risks would be reduced and expand the options for delivery.

4. BITUMEN TREATED BASECOURSE (BTB) - OVERVIEW

When considering the objectives of network resilience, immunity enhancement and timely completion bitumen treated bases (BTB) well and truly ticked the boxes. BTB is well suited to remote and rural works as it is based on available granular "run-of-crusher" material, using large aggregate basecourse quality material and relatively low bitumen contents.

Bitumen treated base concepts are not new and were the basis of many thick pavements in the past. Run of crusher material as opposed the separation of discrete fractions of aggregates for later recombination into hotmix asphalt is a common way of making asphalt in the USA and is a standard product in many other countries.

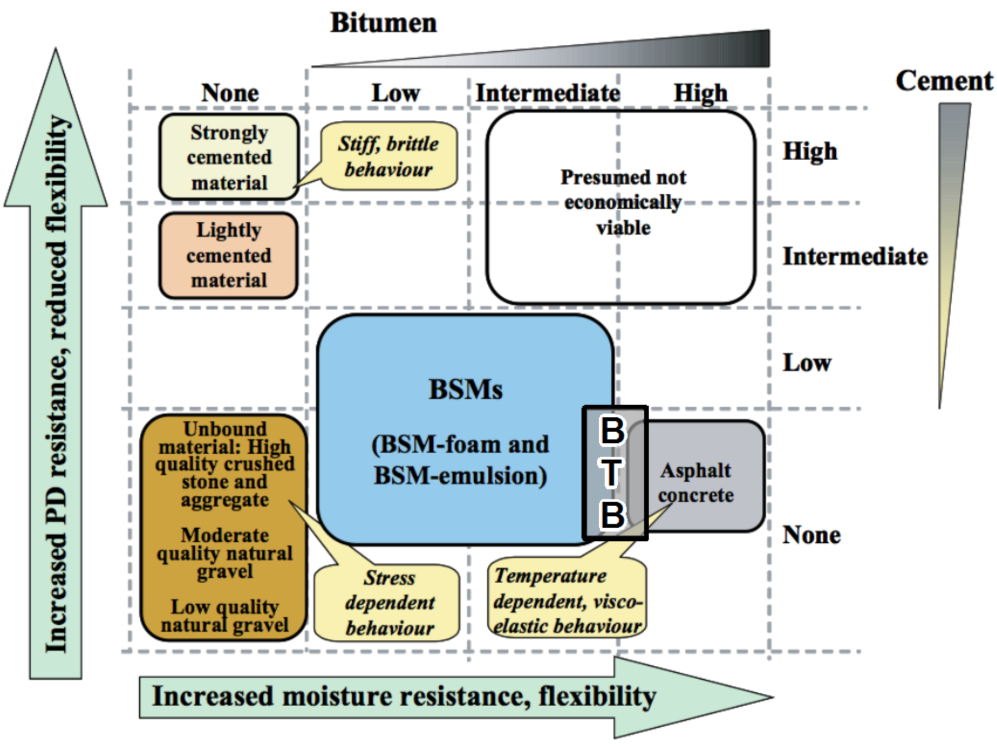

Figure 5: Asphalt Academy TG2: Conceptual Behaviour of Pavement Materials modified to include BTB

During the review of bitumen treated basecourse across the world it became clear that there were many definitions for BTB's – in the USA termed ATB or asphalt treated base with low percentages of bitumen from 3.5% to 3.8% added to the run of crusher base in a hot mix asphalt plant. In South Africa BTB referred to a 26.5 mm dense graded asphalt that was produced from a special run of crusher gradation meeting the asphalt criteria and with 4% bitumen.

The BTB considered for the local specification was that used 10 years previously in Queensland which fitted into the spectrum of bitumen stabilised / treated /bound as shown in Figure 5.

5. EXAMPLES OF BTB PROJECTS

Queensland Main Roads - Enhanced Road Condition Project - Nanango
10 years ago BTB was used by Boral asphalt in the Enhanced Road Condition Project (ERCP) project at Nanango in Queensland where it was described as is an economical, relatively dense graded asphalt mix which: [(2)]

(a) Uses an economical quarry run material or available quarry fractions.

(b) Uses crushed aggregate with good shape and a large maximum size.

(c) Avoids the use of rounded sands – crushed fines are preferred, although the use of a small percentage of natural sand has been found to improve workability.

(d) Has an aggregate grading with a smooth curve to ensure mechanical interlock.

(e) Has a relatively low binder content – after considering fatigue life.

(f) Uses production and laying procedures that limit segregation.

(g) Recognises the importance of good field compaction.

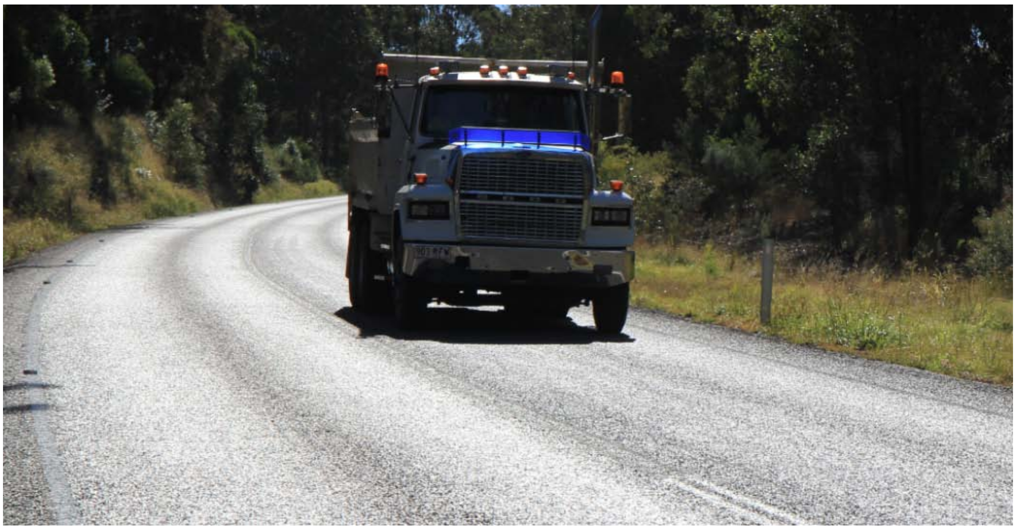

Figure 6: Under traffic for 10+ years, visually in good condition.

The project specification BTB properties reported were based on 50 blow Marshall Mix design binder content of 3.5% ± 0.3%, relative to Marshall density of 96% CV, target gradation similar to DG28 within the base course gradation and limits on the PI and Linear Shrinkage for the fine aggregate fraction. The BTB was sealed to ensure reduced water ingress into the base.

Results achieved on the project averaged a density of over 98% with bitumen content of 3.8%. During construction it was found that the surfacing binder was lost into the BTB resulting in early loss of the surfacing aggregate. This was corrected and the loss of aggregate prevented.

Queensland Mackay Regional Council
Other members of AAPA in Queensland have used BTB's on projects mostly in municipal areas. A recent example of this was reported (3) by Mackay Regional Council on numerous BTB projects subjected to heavy vehicle loading and based on Queensland Main Roads Specifications MRS11.05 unbound type 2 base material with C320 bitumen contents of 3.5 to 4.0%. Details of six projects undertaken by Fulton Hogan ranging from 150 to 350mm thickness of BTB and 50mm asphalt wearing course were evaluated and results presented. Benefits listed included immediate opening to traffic, which has very high value in a municipal environment, cost effective against traditional pavements with reduced maintenance costs. Future considerations included increased use of RAP and possibility of Warm Mix technologies.

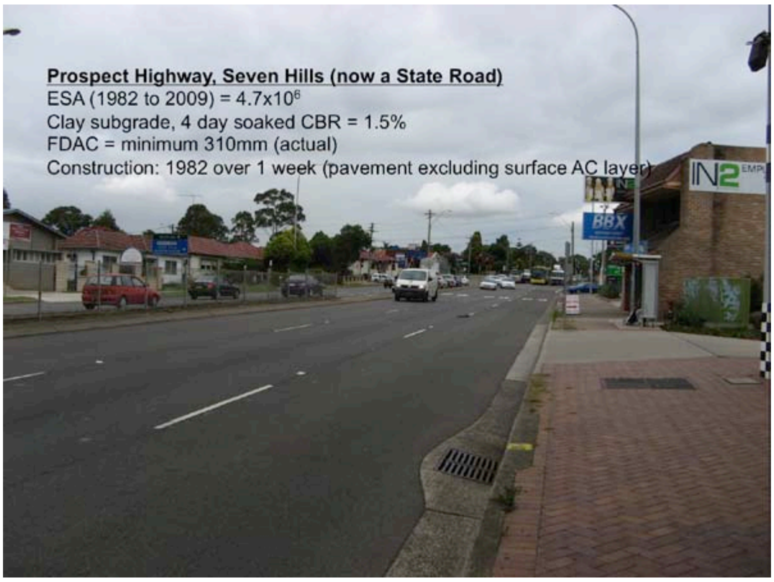

Figure 7: Prospect Highway full depth asphalt – full depth construction on weak subgrade (4)

New South Wales Blacktown
Reporting on full depth asphalt pavements (4) that have performed like "perpetual pavements" over the last 25 to 30 years, some of bases laid in the early 1970's were 40mm sized run-of-crusher material. Where subgrades were weak, the asphalt was grader spread and compacted to provide a strong platform for subsequent layers. The resilience and durability of this thick asphalt was assessed against traffic loading, maintenance costs and traffic loading and these heavy-duty pavements. Their whole of life cost comparison to alternate pavement types showed they were the preferred option, also they could be constructed much more rapidly and at a lower cost due to lower haulage costs and disposal costs of excavate material.

6. BITUMEN TREATED BASECOURSE SPECIFICATION DEVELOPED THROUGH AAPA

At the March 2011 meeting of the National Technical Committee it was agreed that the AAPA suite of guides would be updated to include recommendations on the use and specification for Bitumen Treated Bases. Acknowledging the potential in Queensland, that state's Technical Committee was tasked to develop a project level specification to help establish or confirm the necessary performance requirements of the mix and attempt to have that trialled during the reconstruction projects in the state. A small working group representing all the asphalt producers was established with the Queensland Transport and Main Roads (TMR) specifications used as the basis for the project specification.

Fortuitously a contract was called incorporating BTB on the Warrego Highway east of Roma which provided an opportunity to engage with TMR technical and field staff in reviewing the AAPA Queensland developed specification. A combined BTB steering committee has been established which incorporates AAPA members & TMR staff and continue to develop the specification with feedback obtained from the project.

Figure 8: BTB Steering Committee inspecting Nanango project mid 2011

The Warrego Highway project envisages the use of BTB as an overlay on the existing sealed surface with shoulders widened and strengthened with BTB. An estimated 200 000 tonnes of BTB will be used on the project.

7. DRAFT SPECIFICATION DETAILS

Whilst not intended to be an asphalt substitute the draft specification was modelled on Queensland Transport and Main Roads Specification, Technical Standards and Annexure format to facilitate integration into existing contracts. As the draft document included flexibility in choice of material properties, binder contents and engineering properties a comprehensive Guide Note was included to cover the reasoning behind the documents.

The specification development was done through a small working groups consisting AAPA's National Technical Committee members and members from the Queensland Branch Technical Committee.

The primary objective was to ensure that there was flexibility within the draft specification to allow for some experimentation in developing the most appropriate BTB. At the same time the BTB was intended to be as cost effective as possible favouring the use of locally available materials, limited addition of any lime or expensive additives and holding the binder content as low as possible.

Key aspects included in the specifications were:

Table 10.3.1 – Grading limits (Particle Size Distribution Envelopes)

AS Sieve Size (mm)	Percentage Passing by Mass	
	Grading C	Grading B
53.0	100	100
37.5	100	85 – 100
19.0	80 – 100	55 – 90
9.5	55 – 90	40 – 70
4.75	40 – 70	28 – 55
2.36	30 – 55	20 – 45
0.425	12 – 30	10 – 25
0.075	5 – 12	4 – 10

1. **Granular Material**
   This was based on the MRS 05 document – Type 2.1 B or C grading with lowered and narrowed 0.075mm limits to allow for the binder. Tighter limits were put on Plasticity

Index maximum 4 and Linear Shrinkage maximum 2 to limit the influence of any clay content.

2. **Bitumen**
   Percentage range 3.5% to 4.5%, class 320

3. **Mix design& parameters**
   Based on a 50 blow Marshall design. Air Voids initially at 4% to 6% range but the option to relax to 6% to 10% was considered as that was used on the previous BTB project for QTMR.

Table 10.3.3 – Bitumen Treated Base Design Requirements

Property	Unit	Limit	Value	
			Grading C	Grading B
Air Voids in the compacted job mix	%	Minimum Maximum	6 10	6 10
Stability	kN	Minimum	6	6
Flow	mm	Minimum	2	2
Stiffness	kN/mm	Minimum	1.5	1.5
Voids in mineral aggregate (VMA)	%	Minimum	11	11
Maximum density	t/m^3	-	Tbr	Tbr

Tbr to be recorded

Table 10.3.4.1 – Bitumen Treated Base Design Performance range

Property	Unit	Limit	Value	
			Grading C	Grading B
Wheel Tracking rut rate rut depth	mm/kCycle mm	Maximum Maximum	≤ 0.35 ≤ 5.0	≤ 0.35 ≤ 5.0
Indirect tensile resilient modulus @25°C	MPa	Range	2 000 to 7 000	2 000 to 7 000
Fatigue life of compacted bituminous mixes subject to repeated flexural bending	Cycles to Failure % decrease in initial modulus	Report Report	Report Report	Report Report

Note: The Administrator retains the authority to approve the design if these properties above are exceeded.

4. **Compaction**
   Specification called for both measurement against maximum density MD or compared to Marshall density of production mix. Based on the previous work this was set at >90%CV MD or >96%CV relative to Marshall.

5. **Armour coating**
   The permeability of BTB is not well documented. As concerns were expressed about potential stripping a 7mm seal with class 320 binder, rolled into surface, as an armour coat was included.

Early contract outcomes

The draft specification has been taken over on the Warrego Highway Contract by the consulting engineer and will be trialled with feedback provided to improve and possible simplify the draft.

Higher compaction levels and a binder content of 4.05% are being targeted on the contact to reduce permeability and to address the concerns of the BTB Steering committee on potential stripping of the bitumen. Note that the vertical ingress of water was addressed with the inclusion of the armour coat and the final surfacing seal.

At binder content of the 4.05% nominated early results have densities +2% above those requirements. Air voids on the above mix averaged at less than 6%.

Provision was made to allow the hot mix asphalt plant to include bitumen foaming to promote coating of the granular, fine and filler material and this has been used on the works. The contractor is using a materials transfer device and auger fed paver to reduce the possibility of segregation of the BTB.

The QTMR BTB Steering Committee will continue to monitor the outcomes of the contract and is undertaking an evaluation of the previous Nanango BTB project.

Figure 9: Traffic backs as flooding cuts the Warrego Highway at Gorrie Creek near Toowoomba- January 2011 (Courier Mail photo by Glenn Hampson)

8. OVERVIEW

Bitumen Treated Base – providing improved resilience to natural disasters

The Queensland floods have identified the need to maintain mobility and quickly restore damaged road pavements. With frequent flooding and long inundation, many of the thinly surfaced conventional granular pavements are easily scoured away or left in weakened state for an extended period after the water recedes.

Bound granular pavements improve on the resilience of the granular base, foam stabilised granular materials helps. But, fully bound bitumen bases, making use of regionally available granular basecourse standard crushed rock, provides significantly improved resilience to water damage and can be reopened to traffic much earlier. Importantly with the rush to get the reconstruction complete BTB can be built extremely quickly with much reduced traffic accommodation and provide an easier construction program.

With care in the handling of the raw materials BTB can be a high volume product for use in areas that have traditionally not had access to fully bitumen bound bases due to limitations in crushing capabilities.

REFERENCES

1. Presentation to the April 2011 AAPA Queensland Communications Forum, “The Challenges of Reconstructing Queensland’s Transport Network” by Shane Doran, Queensland Transport & Main Roads Department.
2. “Bitumen Treated Base (BTB) Principles and Practices” Boral Asphalt TR15, 1999 by Ken Wonson, Boral Asphalt.
3. “Is Bitumen Treated Base a viable option in pavement construction” presentation to 5th Australian Road Engineering & Maintenance Conference 2010 by Bill Moffat, Mackay Regional Council.
4. “A road pavement for very rapid construction – 25 to 35 years of success”, presentation at AAPA NSW feedback to Local Government, May 2011 by Paul Ritchie, Ritchie Civil Engineering Pty Ltd.