Category 2: Industry Excellence in Consulting, Research or Education

Implementation of Foamed Bitumen in Queensland – a 25-year Journey

Damian Volker and Jothi (Rama) Ramanujam
Queensland Department of Transport and Main Roads

Queensland Government
Department of Transport and Main Roads

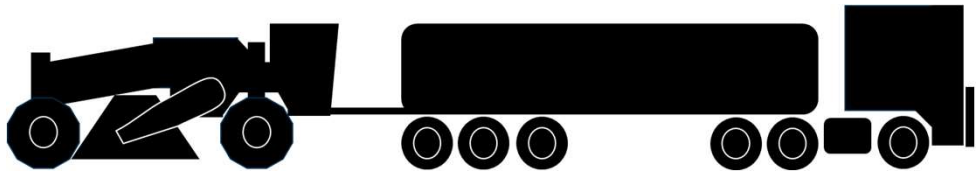
2021 AustStab Awards of Excellence

Proudly sponsored by CATERPILLAR®

AustStab
Pavement Recycling and Stabilisation Association

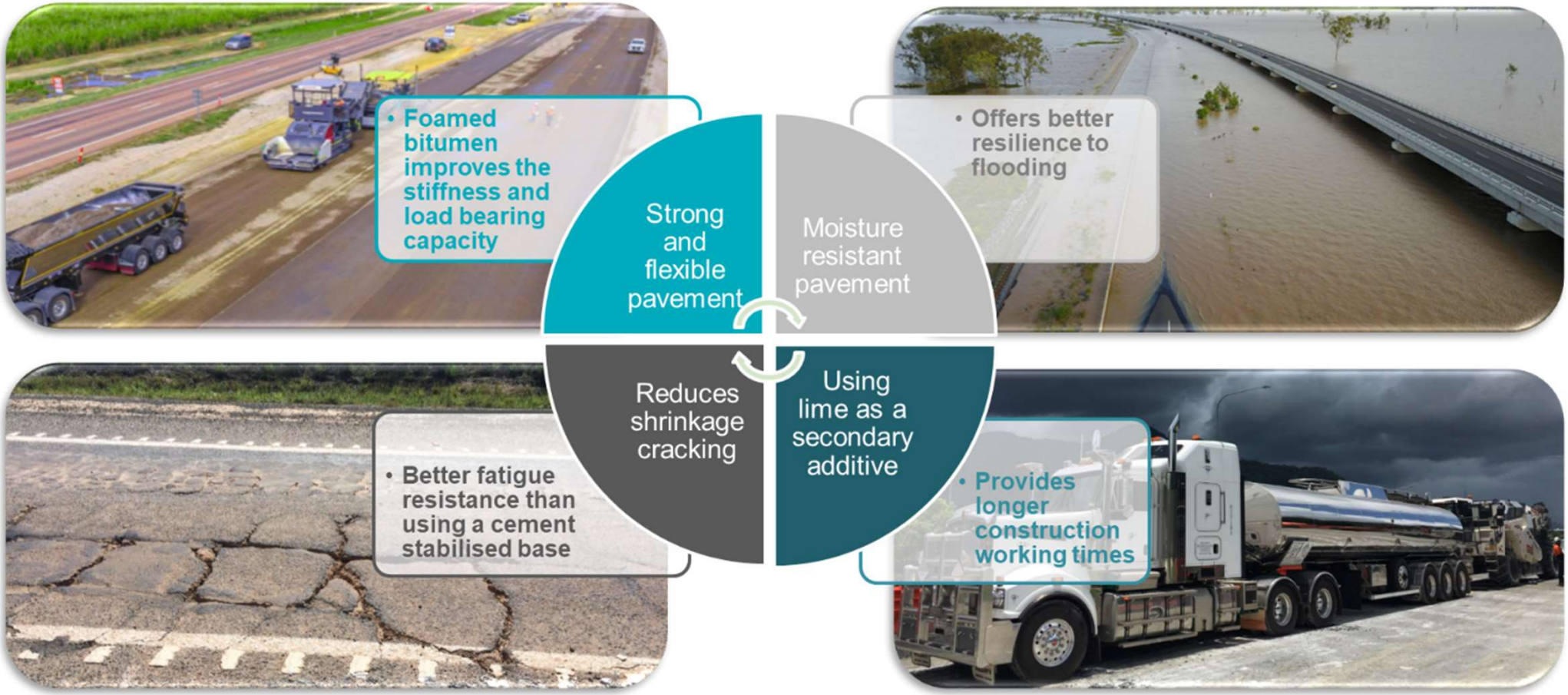
Overview and Objectives

- The Department of Transport and Main Roads (TMR) has the largest amount of foamed bitumen stabilised pavement in Australia. Since 1997, more than 1000 km of existing pavements from State controlled roads in Queensland have been rehabilitated using this technique. In recent years, foamed bitumen has also been utilised in the construction of new pavements and rehabilitating a growing number of council roads and airports across the country.
- The ongoing development of foamed bitumen from its initial introduction by Jothi Ramanujam (Rama) in 1997 is 25 years later paying significant dividends to the Department. Foamed bitumen pavements have proven to be more resilient to flooding and have demonstrated immunity to severe weather events, having survived unscathed in some of Queensland's worst-hit areas.
- There have been many challenges over the years and most of TMR's improvements have come through learning from failures. The success of foamed bitumen has not been achieved overnight. For 25 years Rama has promoted and pioneered foamed bitumen pavement recycling and stabilisation through continual development in:
  - Investigation and design;
  - Laboratory mix design testing;
  - Performance monitoring and analysis;
  - Design guidelines;
  - Construction techniques; and
  - Construction specifications and training (particularly project-linked training to specifically target education onsite of personnel involved in the delivery of stabilisation works).



- Implementing foamed bitumen stabilisation in Queensland has been a journey and example of continual development and improvement of sustainable innovation and engineering and our stabilisation contractors have partnered with TMR every step of the way. The success of foamed bitumen has significantly benefited economic and social outcomes in Queensland and has led to the promotion of stabilisation in local governments, airports and other state road authorities.

Why the implementation of foamed bitumen in Queensland?



Proudly sponsored by CATERPILLAR®

AustStab
Pavement Recycling and Stabilisation Association

Why implement foamed bitumen?

- Granular pavements in Queensland 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.
- Traditional pavement stabilisation involved using a high percentage of cement additive resulting in the development of a fully bound cement treated base layer. Shrinkage cracks often develop at regular intervals in these pavements due to the shrinkage properties and high stiffness of the stabilised material. Deep lift stabilisation (depths up to 350mm) using cementitious binders is a common technique used by most Australian state road authorities. Although these state road authorities have changed from Portland cement to slower setting cementitious additives (such as slag/lime blends), the aim is still to obtain relatively high unconfined compressive strengths. This leads to high stiffness materials which also suffer from cracking problems.
- Implementation of Foamed Bitumen Stabilisation (FBS) as a method to modify pavement material strength and reduce the permeability of the original granular pavements.
- Because of the lack of insitu pavement strength, TMR has been developing several treatments that modify rather than stabilise the base layer of these pavements. Pavement modification typically involves using treatments that modestly improve the material strength and reduce the permeability of the original granular materials. By modifying rather than stabilising these granular materials, fatigue cracking of the treated layer is minimised. In conjunction with a detailed laboratory mix design, pavement modification can often be achieved using stabilisation additives such as lime/fly ash and foamed bitumen.
- Engineering and Technology branch of TMR has undertaken long term monitoring of foamed bitumen stabilisation projects to improve mix design procedures, construction techniques and structural design methodologies.
- The utilisation of foamed bitumen is not only delivering savings for TMR on the cost of construction, but also on the cost of maintaining and rehabilitating roads after natural disasters (such as cyclone Debbie).

Queensland Government's objectives for the community

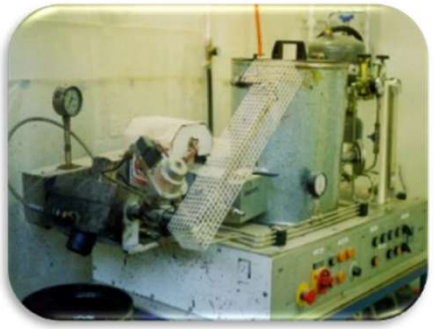
How does TMR meet these objectives? By delivering resilient and cost effective foamed bitumen pavement solutions in collaboration with the stabilisation industry.

Proudly sponsored by CATERPILLAR®

AustStab
Pavement Recycling and Stabilisation Association

Where it all began – and the challenges along the way

- TMR's first Foamed Bitumen trial was in 1997, performed by Stabilised Pavements of Australia.
- The use of the foamed bitumen stabilisation technique started as a trial on the Cunningham Highway (Gladfield) in 1997. This was a very poor performing section of highway built on expansive black soils. The enthusiasm and initiative shown by Warwick District staff encouraged Engineering and Technology Branch of TMR to develop this technique further. This included acquiring the first laboratory foamed bitumen mix design apparatus (pictured).
- In 1999, a 17km section of the New England Highway near Allora was constructed with the foamed bitumen stabilisation technique. Again this was a very poor performing section of highway built on expansive black soils. This project has now withstood 20 years of service with minimal maintenance.
- The implementation of foamed bitumen stabilisation has since occurred across the Queensland road network.





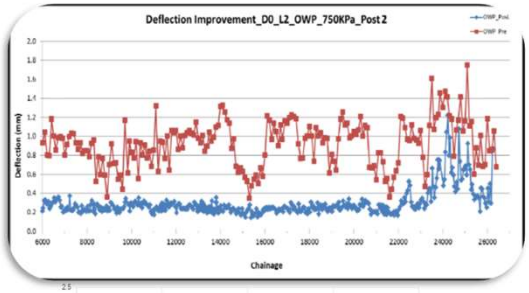
Proudly sponsored by CATERPILLAR®

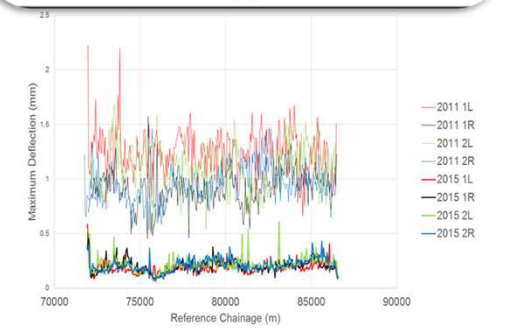
AustStab
Pavement Recycling and Stabilisation Association

Research and Analysis – Rigorous lab testing and field research

Specific Challenges

25 years ago, as with today, there was a reluctance to adopt a new technology. Without the determination of E&T staff together with District Engineers and the Stabilisation industry, the current success of FBS in Queensland would not have been realised.





There has been a significant number of learnings from the failures along the way.

- Foamed bitumen design procedures and construction best practices in Queensland today, are all underpinned by the learnings from early failures.
- Very early learnings included the appropriateness of materials for foamed bitumen and the importance of good support conditions.
- In more recent times, some of the challenges with foamed bitumen in Queensland have related to cement as the secondary agent. Construction issues associated with cement have been overcome with the use of hydrated lime. Expansive subgrades have also caused issues with the reflection of longitudinal environmental cracking.
- TMR have introduced geosynthetics into the design and construction process to mitigate this reflective cracking risk. Plant-mixed foamed bitumen has been more widely used as a result of this evolution of foamed bitumen design.
- TMR is also about to review the foamed bitumen mix design process to ensure controlled stiffnesses of the FB product.

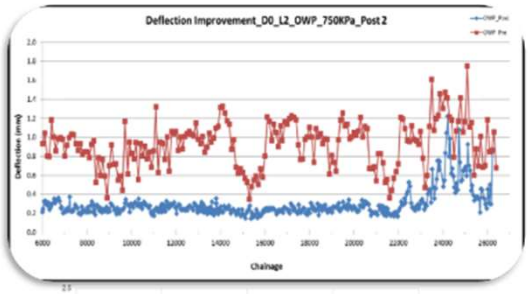
AustStab
Pavement Recycling and Stabilisation Association

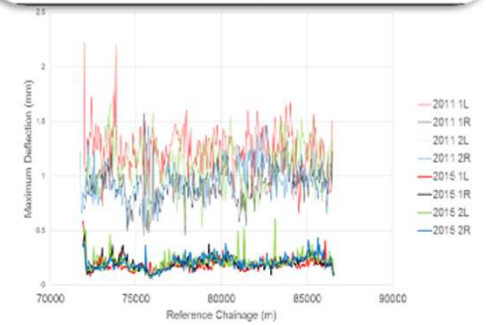
Research and Analysis – Rigorous lab testing and field research

Research and Analysis

Research and analysis have been key to the success of the implementation of FBS:

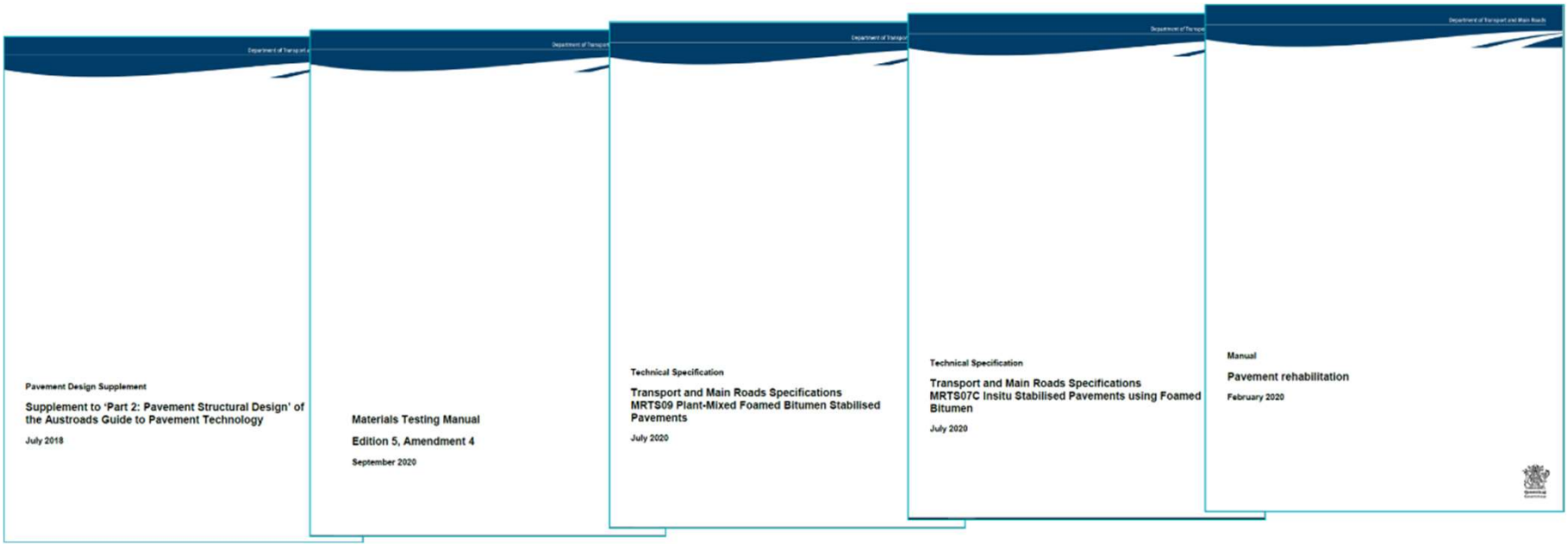
- Modulus testing of the field mixed foamed bitumen was introduce in 2012 to monitor the quality of foamed bitumen during construction.
- Other performance based research that TMR is actively involved in is:
  - Testing cored specimens;
  - FWD (falling weight deflectometer); and
  - ALF testing with ARRB and Austroads.





- The FWD data pictured in this slide demonstrates the structural improvement that foamed bitumen provides. Deflections are graphed pre and post construction of the insitu foamed bitumen stabilisation technique (<0.4mm is very sound, >1mm is very weak).
- Innovations and savings that have arisen from rigorous laboratory and field research has justified the continuing research programs.
- Engineering and Technology Branch extensively use and appreciate the great value that our TMR laboratories provide for the Department.

Development of Foamed Bitumen design, testing and construction documents



With assistance from industry, TMR has developed a range of:

- Technical Notes;
- Guidelines;
- Testing procedures; and
- Specifications and Methodology for Structural and Mix Designs.

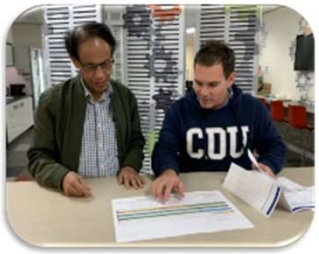
TMR report a success rate of near 100% if the pavement is correctly designed and constructed using TMR's specifications.

Austroads has since adopted TMR's methodology Australia-wide which is a clear endorsement of the design methodology developed under Rama's leadership and expert input.

Proudly sponsored by CATERPILLAR®

AustStab
Pavement Recycling and Stabilisation Association

Promotion, consultation and training



Empowered by TMR's objective of embracing critical and creative thinking, E&T has promoted and shared the successes and learnings of foamed bitumen stabilisation at forums, workshops and conferences at local, state, national and international levels.

Empowered by TMR's objective to focus on our people delivering the future transport network, E&T has promoted and shared the successes and learnings of foamed bitumen stabilisation through:

- project-linked training; and
- the development of new testing, design and construction procedures.

In addition to internal foamed bitumen stabilisation training, TMR also participated in external training courses with CPEE.

Engineering and Technology Branch advise/consult to all TMR Districts and provide on the job specific training for our projects (both Administrators and Contractors).

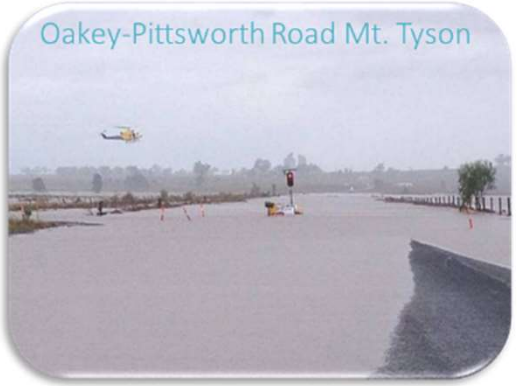
With a large emphasis on Technical Transfer, this also includes assisting Local Government, Industry, Universities, Research bodies and other State Road Authorities.

After industry consultation, E & T are currently developing a training program to improve the understanding of the TMR specifications across the Queensland road sector.

Proudly sponsored by CATERPILLAR®

AustStab
Pavement Recycling and Stabilisation Association

Resilience of Foamed Bitumen pavements



These foamed bitumen pavements survived unscathed after flooding from natural disasters in Queensland.

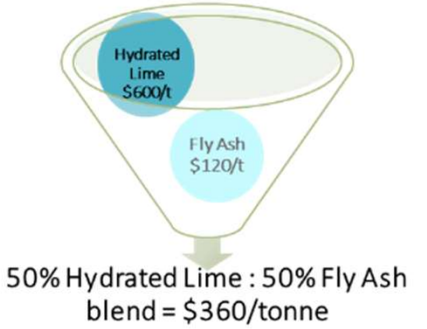
Investing in research and innovation has paid big dividends for TMR, with millions of dollars saved in the wake of Cyclone Debbie through more resilient pavements.

The use of foamed bitumen on state-controlled roads was an integral part of Queensland's recovery from 2017's Tropical Cyclone Debbie. During this event, major roads and intersections in Jimboomba and Rockhampton were inundated by more than 3m of water for several days. Once the waters subsided, the roads were checked and found completely intact with no repairs required. They were then able to be re-opened to traffic. As a direct result of the resilient foamed bitumen base on these roads, developed by Rama, TMR was able to save millions of dollars in road reconstruction costs and minimise inconvenience to rural communities whose livelihoods rely on these roads being open. Pictured is Yeppen Floodway, Mt. Lindesay Highway, and Oakey-Pittsworth Road.

A few other examples of Queensland roads with foamed bitumen that have withstood flooding events include:

- Jacobs Well Road, Staplyton (3km section) – This section was inundated for a week during a 2004 flood event. When the flood water subsided, the road was fully operational again to local traffic.
- Flinders Highway (14km – some sections inundated) – Some sections were inundated during the 2019 North Queensland flooding event. There were no photos captured during the flooding due to inaccessibility. Other pavement types that were adjacent to this foamed bitumen section were significantly damaged. This 14km section was unscathed.
- Oakey-Pittsworth Road, Aubigny (2km section) – During construction of the Oakey-Pittsworth project in 2014 a significant flood event occurred. There was no effect on the FBS base, which was only a few days old. With standard road surfaces, an event like this would have meant the pavement could have washed away.
- Logan Motorway (west bound), Marsden – In 2006 a 14km section of the Logan Motorway was affected by long periods of rain preventing completion of the asphalt layer over the FBS base layer. When the rain stopped, there were no noticeable failures and the asphalt layers were completed. This road section is now 13 years old and performing well.

Emerging technologies and continual improvements to design and construction



Tying in with TMR's research, analysis and monitoring of foamed bitumen performance, continuing research and investigation is also performed on emerging technologies, along with the application of continual improvements to design and construction practices.

This approach ensures that the implementation of innovation is based on sound laboratory research.

Plant-mixed foamed bitumen (PMFB) was only introduced into the Department in 2012. In 2020 the 28km bypass of Toowoomba was constructed using PMFB.

Fly ash is also being more commonly used to supplement lime. This is resulting in a reduction in secondary agent costs and reducing the need for hydrated lime, whish is in high demand.

Foamed Bitumen flood resilience – Oakey-Pittsworth Road

In 2014 after the Darling Downs communities were again inundated by floods, the Oakey-Pittsworth Road was the lead story on the local news. This road was in the process of being repaired following inundation in 2010 and 2011. After the 2010/11 events the road was closed for several days whilst repairs were undertaken and was speed and load restricted until rehabilitation in 2014. The news story reported that the road was able to be opened immediately after the flood waters receded. This was due to the use of the Foamed Bitumen Stabilisation treatment and permitted the road to connect communities immediately after being inundated by floods. This event was only days after the successful completion of rehabilitation.