PERFORMANCE ASSESSMENT OF PAVING FABRIC APPLICATIONS ON AUSTRALIAN ROADS

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Abstract

Australian road authorities began trials incorporating paving fabrics placed in a variety of applications in road construction in the 1980s continuing through to the late 1990s. Millions of square metres of paving fabrics have since been laid as they have become a standard selection of treatment for road authorities for over 10 years.

Australian manufactured paving fabrics have been produced and installed to perform under rigorous quality assurance to specified test values. However some test results quoted in current literature are French, based on early research whilst other criteria has been derived from the existing experience of Australian applications with various products documented in the early 1980s at time of installation.

The focus of this paper is the documentation of paving fabric surfacing performance with assessment based on design considerations, selection criteria, installation history and recent performance evaluation. Criteria for assessment took into account treatment selection considered in terms of the performance, pavement structural condition and existing surfacing condition and use in situations where the pavements have serious functional damage.

Recent performance assessment comprised visual inspection and interviews with paving fabric treatment selectors from various road authorities to confirm or otherwise, situations where paving fabrics has been of benefit. The assessment involved reviewing existing and specified installations for design concepts, selection criteria, the asset owner’s view of the expected performance and historical records of road authorities sealing for historical data.

Ultimately by taking into account the benefits and limitations of paving fabrics performance, selection of road surfacings can be further refined to assist designers and selectors in identifying conditions where selection of paving fabric treatment will return greater benefits for road pavements for improved structural performance and longer surface life. Final reporting on a selection of projects by ARRB, will include some twenty sites in Victoria, SA, WA, NSW and Qld.

Key Words: paving fabrics, spray seals, treatment, selection, assessment, performance, life, trials.

Introduction

Paving fabrics were first used in the 1930s when cotton sheets were installed as reinforcement to asphalt layers in roads in North Carolina, USA. Since the 1970s the concept of geotextile reinforcement of surfacing seals has been used successfully internationally with hundreds of millions of square metres installed worldwide.

Nonwoven needle punched geotextiles have proved themselves over time, however the impetus was taken up by the industry later in the 1980’s when road engineers looked for solutions to alternative cost prohibitive treatments. Paving fabrics were selected to fill the gap between an inadequate resealed surface and a complete rehabilitation.

Without adequate maintenance paved roads rapidly deteriorate. The escalating cost of paved road rehabilitation highlights the need for cost effective solutions to this problem. In general, rehabilitation of paved roads can be divided into:
• Those requiring minor strengthening or surface improvements
• Those requiring substantial strengthening

These categories may overlap with a single procedure able to both seal and strengthen the pavement, this being achieved by incorporating a reinforcing and waterproofing interlayer, in the form of a paving fabric to provide protection of the unbound granular road pavement beneath.

Reflective Cracking
Many pavements that are considered to be structurally sound after the construction of a new overlay prematurely exhibit a cracking pattern similar to that which existed in the underlying pavement. Reflective cracks destroy surface continuity, decrease structural strength, and allow water to enter the pavement layers. Thus, the problems that weakened the old pavement are extended up into the new overlay.

Cracking in new overlay surfaces is due to the inability of the overlay to withstand shear and tensile stresses created by movements of the underlying pavement due to either traffic loading (tyre pressure) or by moisture ingress and thermal effects. (expansion and contraction).

Fatigue associated cracking occurs when shear and bending forces due to heavy traffic loading create stresses that exceed the fracture strength of the asphalt overlay. This is a structural stability problem.

Pavement instability is generally due to heavy loading, improper drainage and time. Pavement rehabilitation strategies with flexible overlays require drainage improvements such as sub soil drains, surface sealing, structural improvements with full depth asphalt, or sub-grade reinforcement and sufficient structural overlay thickness to adequately support the design load. Increased traffic volumes and loadings induce reflective cracking within overlays that are under designed or in overlays placed on unsuitable base structures.

Structurally sound composite pavements are relatively resistant to load induced stresses. These traffic load stresses occur very rapidly and the stiffness, or fracture resistance, of both the asphalt overlay and base structure are very high. There are guidelines for typical situations facing the engineer in road maintenance, but each project should be considered in isolation and the design for paving fabric interlayers adapted accordingly.

Waterproofing
The function of bitumen impregnated paving fabric is to prevent the penetration of surface water and oxygen into the road pavement. Waterproofing prevents the ingress of water and consequent pumping of the structural pavement layers under traffic loads.

Despite surface cracking in wearing courses, paving fabric impregnated with bitumen maintains its waterproofing properties. The penetration of oxygen will result in further ageing of the existing base course, with subsequent cracking occurring due to brittleness. The infiltration of moisture weakens the shear strength of base layers and with the combination of time and traffic leads to surface deformation and loss of bonding of the surface seal coat.

Paving Fabric
For over 30 years nonwoven needle punched geotextiles have been used in Australia as paving fabrics where they have been bonded to the road surface and saturated with bitumen to effectively seal the existing pavement and waterproof the overlay which can then be constructed on a base susceptible to rutting and shrinkage cracking. Where a rehabilitation measure is required, the inclusion of a paving fabric will enhance the performance of unbound granular pavements by providing a waterproof membrane and a stress alleviating function.

The oldest recorded installation of paving fabrics in Australia was in the Mackay district in Queensland in 1976, where a trial section of paving fabric was placed over a cement
treated base at Bakers Creek. Early trials in New South Wales at Brewarrina using the ALF apparatus proved the worth of heavier grade paving fabric in minimising reflective cracking and pumping under highway loading on saturated and unsaturated insitu black soil acting as the pavement base material. Paving fabrics utilise the tensile strength of the geotextile and the elastic recovery properties of bitumen to bridge cracks and inhibit reflective cracking, this in turn ensuring a waterproof surface protecting the structural integrity of road pavement. Paving fabrics can extend the life of surfacings by up to 10 years above a design life of 8-10 years to provide real benefits to life cycle costings of seals. For the additional cost, the benefit to maintenance programs by either catching up on lost time, or delaying the application of a reseal to twice the time frame normally allocated is a valuable contribution to effective asset management.

**Benefits of Paving Fabrics**
Paving fabrics, through Australian experience and research, can provide the following benefits:

- Prevent the ingress of water by providing a more flexible, homogeneous waterproof layer
- Stabilising pavement moisture content and curbing pumping through block cracks
- Bridging shrinkage cracks retarding their propagation to the surface.
- Acts as a stress absorbing interlayer allowing larger deflections in the order of 2–3 mm
- Reinforces and prolongs fatigue life when structural layers are weak/susceptible to rutting
- Cost effective alternative to expensive structural layer replacement
- Resistance to shrinkage from hot bitumen (polyester melting point; 260ºC)
- Nonwoven needle punched construction provides bitumen reservoir
- Robustness retards stone penetration and settlement
- Prolongs surfacing lifetime by a factor of 2
- Lower maintenance costs by extending the life of the existing surface
- Lower installation costs; fast, simple, easy placement
- Utilisation of existing plant or equipment
- Can be milled in the Cold Recycling Process

**Pavement Conditions**
Condition of pavements where paving fabrics can be utilised, along with required pre-treatments, are tabled below.

<table>
<thead>
<tr>
<th>Type of Distress</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surfacing Cracks</td>
<td>Cracks &gt; 7 mm wide to be pre-filled.</td>
</tr>
<tr>
<td>Block / Stabilisation Cracks</td>
<td>Cracks &gt; 7 mm wide to be pre-filled.</td>
</tr>
<tr>
<td>Longitudinal or Transverse Cracks</td>
<td>Cracks &gt; 7 mm wide to be pre-filled.</td>
</tr>
<tr>
<td>Crocodile Cracking</td>
<td>Cracks &gt; 7 mm wide to be pre-filled.</td>
</tr>
<tr>
<td>Pumping</td>
<td>Cracks &gt; 7 mm wide to be pre-filled.</td>
</tr>
<tr>
<td>Rutting</td>
<td>Pre-treatment with levelling layer.</td>
</tr>
<tr>
<td>Potholes</td>
<td>Potholes to be repaired or pre-filled.</td>
</tr>
<tr>
<td>Patches</td>
<td>Distressed, broken patches to be pre-filled.</td>
</tr>
<tr>
<td>Edge Breaking</td>
<td>Severe edge breaks pre-filled or repaired</td>
</tr>
</tbody>
</table>

**Typical Issues with Paving Fabrics**

**General**
If at all possible, avoid cutback bitumens. If the climate conditions require a cutter to be added to the bitumen for the overlay, it is preferable that the tack coat placed prior to placement of the paving fabric is not cut back. The reason for minimising the use of the cutter is that it gets locked in the fabric and the volatiles try to escape/evaporate during hot weather, softening the bitumen. This results in bleeding, slippage of the wearing course on the paving fabric and loss of aggregate.
Delamination
• Water in base - sub soil drainage may be required
• Insufficient tack coat and/or saturation of paving fabric (allowing water ingress)
• Laying paving fabric in rain/wet conditions
• Fuel leakage/contamination between applications of paving fabric and seal

Mechanical failures
• Vertical crack movement is excessive – fabric elongation excessive
• Insufficient/lack of overlap in full width applications
• Laid in lanes and at intersections where braking load is excessive
• Holes and cracks larger than 7 mm not being repaired or pre-filled
• Laid over rough existing textured surface (asphalt levelling course required prior to paving fabric placement)

Shoving / heaving
• At intersections or sharp or high speed bends
• Slippage on old bleeding surface

Bleeding
• Too much bond coat to fabric
• Too much binder coat to stone
• Use of cutback bitumens

Specifying Paving Fabric

Thermal stability
Stability of the paving fabric must be ensured when subjected to the excessive heat of a paving operation. The melting point of polyester is 260°C and polypropylene is 165°C and normal spray temperatures for bitumen bond and binder coats is in the range of 170 – 180 °C.

Durability
The paving fabric should be protected from physical abrasion when installed. Traffic movement over the fabric should be minimised until seal coats are in place. Protection from inclement weather and prolonged UV exposure is also required.

Easy installation
Paving fabric should be rolled out mechanically to provide fast and wrinkle free application. Manual laying should only be attempted in exceptional circumstances.

Correct bond coat application rate and timely installation will ensure good adhesion and adequate stone bonding on seal coats.

General Design Considerations

Site selection
Experience has shown that the existing pavement section must show no signs of vertical movement or structural instability. To maximise the benefit of paving fabrics, pavements must be structurally sound.

Pavement evaluation
Field evaluation should include a visual distress survey in accordance with accepted methodology and deflection testing, such as a falling weight deflectometer (FWD). This data should be used to determine the effective modulus of the existing pavement section.

Crack sealing
All existing pavement cracks should be sealed by conventional methods. Cracks greater than 7 mm should be filled with suitable crack filler.

Choice of Reseal
Paving fabric selection and application is affective if applied for the right reasons in a timely manner, much the same for all reseal applications. Selection is based on the following conditions for two commonly specified weights of paving fabric.

140 gram/sqm
1. Age cracking
2. Settlement cracking
3. Fatigue cracking
4. Cracking due to expansive soils
5. Shrinkage cracking (CTB)
6. UV degradation of bitumen binder

180 gram/sqm
1. Low traffic volume
2. Low strength base course
3. Clay base road pavement
4. Remote area
5. Lack of suitable road pavement material
6. Low cost all weather surface option.

Paving Fabric Properties
The Australian installations of paving fabric for maintenance re-seals has generally used a typical 140 gsm Polyester non-woven
needle punched geotextile with a melting point in excess of 240°C.

Refer Table 2.

Table 2. Paving Fabric Properties

<table>
<thead>
<tr>
<th></th>
<th>Mass AS3706.1</th>
<th>g/sqm</th>
<th>MARV Typical</th>
<th>139</th>
<th>184</th>
<th>147</th>
<th>200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thickness</td>
<td>AS3706.1</td>
<td>mm</td>
<td>MARV Typical</td>
<td>1.43</td>
<td>1.86</td>
<td>1.58</td>
<td>2.09</td>
</tr>
<tr>
<td>Wide Strip Tensile</td>
<td>AS3706.2</td>
<td>kN/m</td>
<td>MARV Typical</td>
<td>8.9/7.4</td>
<td>10.6/9.0</td>
<td>13.9/10.5</td>
<td>16.3/12.5</td>
</tr>
<tr>
<td>MD/XMD</td>
<td></td>
<td></td>
<td></td>
<td>42/52</td>
<td>55/65</td>
<td>47/56</td>
<td>57/67</td>
</tr>
<tr>
<td>Wide Strip Elongation</td>
<td>AS3706.2</td>
<td>%</td>
<td>MARV Typical</td>
<td>245/215</td>
<td>290/255</td>
<td>305/280</td>
<td>412/348</td>
</tr>
<tr>
<td>Trapezoidal Tear</td>
<td>AS3706.3</td>
<td>kN</td>
<td>MARV Typical</td>
<td>240</td>
<td>240</td>
<td>240</td>
<td>240</td>
</tr>
<tr>
<td>Minimum Melt Temp.</td>
<td>-</td>
<td>Degrees C</td>
<td>240</td>
<td>240</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bitumen Retention @</td>
<td>ASTM D6140</td>
<td>litres/sqm</td>
<td>Typical</td>
<td>1.1</td>
<td>1.4</td>
<td>1.1</td>
<td>1.4</td>
</tr>
<tr>
<td>160 deg°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

Cost Considerations

Paving fabric used in reseal rehabilitation construction is regularly specified each year as part of the annual reseal contracts in South Australia, Victoria, New South Wales and Queensland. Application of the standard 140 gsm paving fabric reseal is generally costed at around $7.00/sqm, a traditional reseal costing in the order of $4.00/sqm.

Heavier 180 gsm paving fabrics designed for low traffic roads laid on existing clay base courses were the basis of the trials in New South Wales at Brewarrina using the ALF apparatus, which proved the worth of paving fabrics, with the cost in 1991 for normal reconstruction of a 300mm sealed pavement costing $100,000/km compared with a simple geotextile reseal at $65,000/km.

Life Cycle Considerations

Life cycle costing applies more to maintenance reseal programs, where the real consideration for incorporating a 140g paving fabric into a seal design is what benefit the additional 7-8 year life will give, when the whole surfacing life span extends to the predicted 15 years with a paving fabric interlayer.

Paving fabric incorporated into a reseal will cost roughly the same amount as a standard reseal for invested or borrowed funds over an 8 year period, the expected standard pavement life. The additional funds required for a paving fabric seal will equal the investment of two standard seals over a 15 year life, but provide for a once only application in 15 years.

Therefore the extension of pavement life provides:

1. Longer maintenance time frames
2. Revision of maintenance planning
3. Savings through less frequent maintenance and traffic disruption
4. Allowance for priorities to other roads in a network
5. Safety through the provision of more stable and skid resistant surfaces
6. Provision of asset investment choice
7. Management of the political aspects of assets.

Design

Seal design with paving fabrics is similar to normal seal design, except that an allowance is made for the bitumen absorption of the paving fabric in the total bitumen requirement. Design should consider the appropriate allowances for existing surface texture, traffic count, vehicle mass or ESA’s and prevailing pavement temperature. The use of an adhesion agent/additive is recommended.

The design of the paving fabric seal requires the following consideration:

1. Obtain paving fabric absorption rate from manufacturer
2. Determine existing surface texture and allowance for voids
3. Design the seal application rate
4. Determine the total application rate
5. Determine bond coat application rate (paving fabric to existing surface)

6. Determine binder application rates from total rate for:
   - first seal coat application rate
   - second seal coat application rate.

Typical bitumen application rates:
- Bond coat; 0.6 – 0.9 litres/sqm
- First seal coat; 0.9 – 1.1 litres/sqm (14mm stone)
- Second seal coat; 0.7 – 0.9 litres/sqm (7mm stone)

Installation
The geotextile should be rolled out slowly (using a fabric applicator) immediately after spraying the tack coat and as close behind the sprayer as practicable. The dispensing of fabric should be controlled by adjusting the rubber spreader bar to match road profile to ensure wrinkle free application. All wrinkles smaller than 5mm can be dispersed and smoothed by brooming.

Adjoining or adjacent rolls should be overlapped by a minimum of 100 mm, with the overlapped join receiving additional binder as described above. Placing of fabrics along straight alignments is relatively straightforward and should be used with extreme caution on curves of less than 100m radius. Where the paving fabric is to be placed around a curve, it should be ‘cut and butted’ at regular intervals along the inner side of the curve (to minimise overlap thickness). Resulting overlaps should be hand sprayed with additional bitumen so that the geotextile is fully saturated. Wrinkles larger than 25 mm should be treated in the same manner.

For all reseal applications, the fabric should be applied over the full width of the pavement. Paving fabric should be rolled prior to the seal coat. Where rolling and/or construction traffic causes the tack coat to bleed up through the fabric, a blinding coat of 7 mm aggregate may be applied in advance of the seal coat to prevent pick-up. Rollers or vehicles should not stand on the laid fabric as this may lead to a build-up of binder on the surface of the fabric. Trafficking of the paving fabric should be limited to a minimum, with aggregate seal coatings placed as soon as possible.

Aggregate should be spread onto the binder as soon as possible after spraying. Rolling should be carried out with a rubber tyred roller with the rolling sequence working from the middle outwards to the pavement edges. Rolling duration should be in accordance with specification.

Case Studies
RN 7200 Sturt Hwy – Accommodation Hill
Location; MM90.9 – MM98
Resealed; 1996
AADT; 3800
Stone; 14/5mm
Paving Fabric; Sealmac PF1
Bond coat; C170
Binder Type; S35E/C170
Application Rates; 0.8/1.45/0.75
Existing condition; small crazing and continuous block cracking.
Pavement 1996 - Approx location MM91 Laying PF1
Pavement shape and strength good despite poor existing surface condition

Review 2009; Good general condition, Holding together well despite some pumping occurring. Some stone smoothing evident. Ongoing rehabilitation on various sections of the Sturt Hwy has incorporated PF1 paving fabric since 1996.
Pavement 2009 - MM 93. Some pumping occurring in wheel path

RN 8400 Jubilee Hwy – Mt Gambier
Location; MM349 – MM354
Resealed; 1996
AADT; 7100 (logging traffic)
Stone; 16/7mm
Paving Fabric; Sealmac PF1
Bond coat; C170
Binder Type; S15E/C170
Application Rates; 0.8/1.45/0.75
Air Temp; 30 deg C.
Existing condition; small crazing and block cracking.

Sealing 1996; Paving fabric application to outer lane where heavier traffic loads occur. Spray rate designed for heavy logging traffic, resulting in low application rates to combat potential for bleeding.
Review 2009: Good general condition, Holding together well despite the heavy loads. Some reflective cracking around culvert crossings.

Road now considered beyond another spray seal, however due to regional location rendering the application of asphalt not practical. Road rehabilitated with paving fabric PF1 two coat reseals as of 2009. Jubilee Hwy has had ongoing staged applications of paving fabric since 1996, for its entire length of 6 km.
Pavement 2009 - MM 349 pavement on wheel path
Surface in good condition despite some stone wear

Harcourt North road – Bendigo Region
Location; 15km north of Castlemaine
Sealed; 1996
AADT; 300
Stone; 14/7mm
Paving Fabric; Sealmac PF1
Bond coat; C170
Binder Type; S35E/C170
Area; ~2,100sqm

Existing condition; Severe surface degradation and horizontal cracking, subject to spring water flow in pavement courses. Road required complete rehabilitation, however reconstruction was limited because of narrow road width and a irrigation water channel culvert structure limiting traffic flow under construction conditions. 30mm asphalt correction placed before sealing.
Review 2009: Good general condition, holding together well.


Pavement 2009 - Paving fabric edge of seal
Seal appears in good condition, little stone wear. Paving fabric providing edge stability.

**Bendigo – Sutton Grange Road**
Location: South of Bendigo
Sealed: 1996
AADT: 500
Stone: 14/7mm
Paving Fabric: Sealmac PF1
Bond coat: C170
Binder Type; S35E/C170
Area; ~5,600 sqm

Existing condition; severe surface degradation and horizontal cracking. Road required complete rehabilitation, however reconstruction was limited because of narrow road width and close proximity of trees and property. Nominal 30mm asphalt regulation layer was placed before sealing.

2009 assessment; Surface condition excellent, blemish free, can last another few years. Road has been highly trafficked with very heavy loads over 18 months in 2008/09 with Calder Hwy construction traffic.
Pavement 2009 - Paving fabric at edge of seal

Seal appears in good condition, little stone wear. Paving fabric providing edge stability.

Pavement Trial – Appila South Australia
Location; 1km – 2km
Sealed; 1990
AADT; 300
Stone; 14mm Single Seal
Paving Fabric; Sealmac PF2 (180 gsm)
Bond coat; C170
Binder Type; C170 (5% adhesion additive)
Application Rates; 0.8/1.45/0.75
Existing condition; Existing low strength sub-base, 150mm weak rubble base course laid 1990.

Sealing 1990; Trial was instigated to establish viability of geotextile reinforced seals on low volume roads that enable construction with no or little road reconstruction requirement. The site was chosen because of the existing low strength rubble base course and low volume traffic count.
Review 1997: Good general condition, PF2 appears similar to 1990 and holding together well despite poor drainage. No evidence of reflective cracking although adjacent un-reinforced section showed reflective cracking and excessive edge wear.
Reseal 2009: Original seal holding up well after 19 years. Some stone loss and voids have been rectified with a 7mm seal applied to surface to top up stone profile and enrich lost binder to the original single 14mm seal.

**Conclusion**
The results of test sections and installations as detailed in the above case studies in South Australia and Victoria over the last 19 years has shown that geotextile seals can enhance the principal functions of conventional surfacings to extend the field of application of commonly specified seals. Many more paving fabric applications exist in Queensland and New South Wales that are achieving life spans over 15 years, however as yet they have not been reviewed and expert road authority opinion gleaned to assess their current performance. Non woven needle punched geotextiles provide, because of their construction, a three dimensional bitumen reservoir for optimum bitumen absorption and tensile strength to act in a stress alleviating function. Ensuring the correct performance of paving fabrics is achieved, installation with proper procedures and application with correctly determined spray rates is essential.

Considering the above case studies and taking account of the vast area of application of paving fabric over the last 20 years, evidence of paving fabrics extending the life of surfacings by up to 10 years above the design life of 10 years provides real benefits to life cycle costings of seals. For marginally additional cost, the benefit to maintenance programs by either catching up on lost time, or delaying the application of a reseal to twice the time frame normally allocated, is very real.

Paving fabrics have the ability to provide a water proof interlayer in a spray seal to enhance the strength and life span of a pavement. Reflective cracking is retarded and contained to the extent that paving fabric provides an effective stress alleviating and waterproofing membrane over a bound pavement.

The evidence presented can allow road engineers to embrace a broader scope of existing conditions where seals can out perform traditional methods for similar existing surface failures. There is also increasing awareness that the cost benefits are evident as the paving fabric treated surfaces show their strength and longevity in outlasting conventional seals.

Comments over this evaluation period in 2009 include remarks of 'we are expecting more and more of paving fabrics', 'we are selecting paving fabric where no other options would work' and 'paving fabrics help restore roads to a normal maintenance cycle'. This evaluation generally concluded that paving fabrics were selected where road surface condition has passed the point of conventional reseal considerations, where normal spray seal applications would last only 7-8 years, or fibre reinforced or rubber
additive options. As shown in the case studies examined, paving fabrics were selected where the road would otherwise require total rehabilitation, to maintain and extend the design surfacing life.

Acknowledgements
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References

Qld Government, Paving Geotextiles in Asphalt and Sprayed Seal Surfacings, Issue No. 8

Department of Transport, Energy and Infrastructure, South Australia. Resealing Records

VicRoads, North Western Branch, Bendigo, Victoria. Resealing Records


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The author is currently employed as Business Development Manager for Geotextiles and Drainage, Geofabrics A/Asia, suppliers of drainage products, ground stabilisation and paving fabrics to the civil engineering industry. Rod Fyfe has over 14 years experience with paving fabric applications with Geofabrics Australasia as previous State Manager for South Australia and Northern Territory.

Past experience includes the position of Contracts Administrator and Estimator with construction contractor Stockport Civil, five years designing civil projects with Kinhill Engineers, one year with the Corporation of City of Adelaide and the Department of Main Roads Bridge Section, Tasmania, for seven years.

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