Department of Transport and Main Roads

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Guideline

Asphalt Deck Wearing Surface (DWS) Rehabilitation

July 2024

Queensland Government

Contents

1 Introduction

The primary objective of this guideline is to provide guidance on the investigation and rehabilitation of asphalt Deck Wearing Surface (DWS) placed on concrete bridges (or other concrete structures).

Procedures described in this guideline include planning, investigation, design, and construction techniques. The details within this document have been compiled from:

- field experience
- historical pavement investigation data
- project learnings
- *Design Criteria for Bridges and Other Structures*
- MRTS30 *Asphalt Pavements*
- MRTS51 *Environmental Management*
- MRTS56 *Construction Surveying*
- MRTS77 *Bridge Deck*
- MRTS84 *Deck Wearing Surface*, and
- MRTS84A *Removal of Bridge Deck Wearing Surface*.

This document is intended to be a practical guide for Designers, Project Mangers, Administrators and Contractors managing the investigation, design, construction, and maintenance of a DWS.

2 Purpose of document

An inadequate DWS investigation, design and construction can cause significant construction delays, cost variations, poor in-service performance, and possible damage to the concrete structures.

This guideline aims to:

- capture the experience and techniques from successful DWS investigation and rehabilitation projects
- provide details on the DWS rehabilitation processes, including planning the investigation works, undertaking the investigation works, developing the design, and construction
- minimise the risk of damaging bridge structures during DWS investigation and construction works
- minimise unexpected and unplanned events during construction that may lead to significant delays and cost variations
- provide an understanding of a realistic timeframe for the entire DWS rehabilitation process (from planning through to completion of construction)
- highlight key elements for the successful delivery of an asphalt DWS rehabilitation project that will provide long term performance, meet the design intent, and minimise future maintenance activities, and
- improve DWS contract documentation and drawing details to minimise misinterpretation, misunderstandings, contractual disputes, construction delays and project cost variations.

3 Investigation timing

Typically, a DWS rehabilitation project consists of multiple stages:

1. Planning
2. Preliminary design
3. Detailed design, and
4. Construction.

It is recommended to undertake a detailed DWS investigation during the earlier stages of a project to prepare a fit-for-purpose DWS design and construction methodology. This will minimise project cost escalations and delays, whilst ensuring that the DWS rehabilitation works provide long term performance.

Where DWS investigations cannot be undertaken at an earlier project stage, it is recommended to assume the ‘worst case’ DWS design scenario (that is, full depth asphalt DWS replacement). This assumed DWS design is then to be revisited after DWS investigation is undertaken and the results analysed.

4 Bridge Deck Wearing Surface (DWS) components

Typically, bridge DWS components include the following:

- asphalt surfacing course
- asphalt intermediate course
- asphalt corrector course
- waterproofing membrane (WPM)
- concrete bridge deck prime
- adequately textured concrete bridge deck slab or deck units
- asphalt DWS geometric design (that is, surface crossfall and longitudinal gradient)
- edge compaction clearance
- allowance for bridge scuppers
- relieving slab, and
- bridge joints.

Refer to Figures 4(a) and 4(b) below.

Figure 4(a) – Typical DWS arrangement for deck units

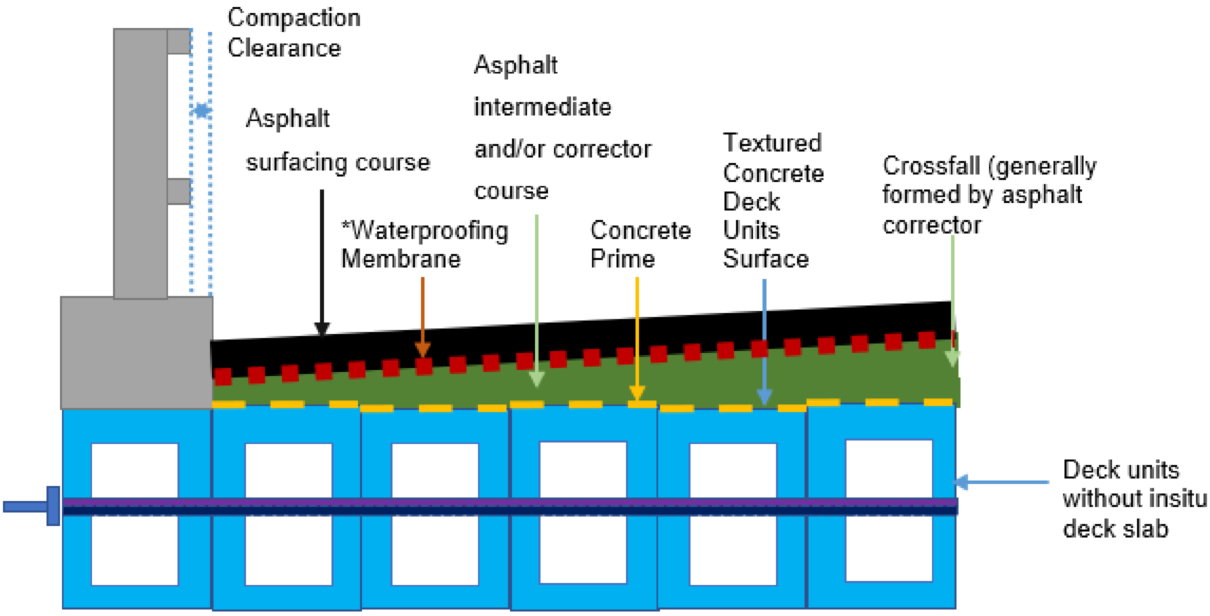
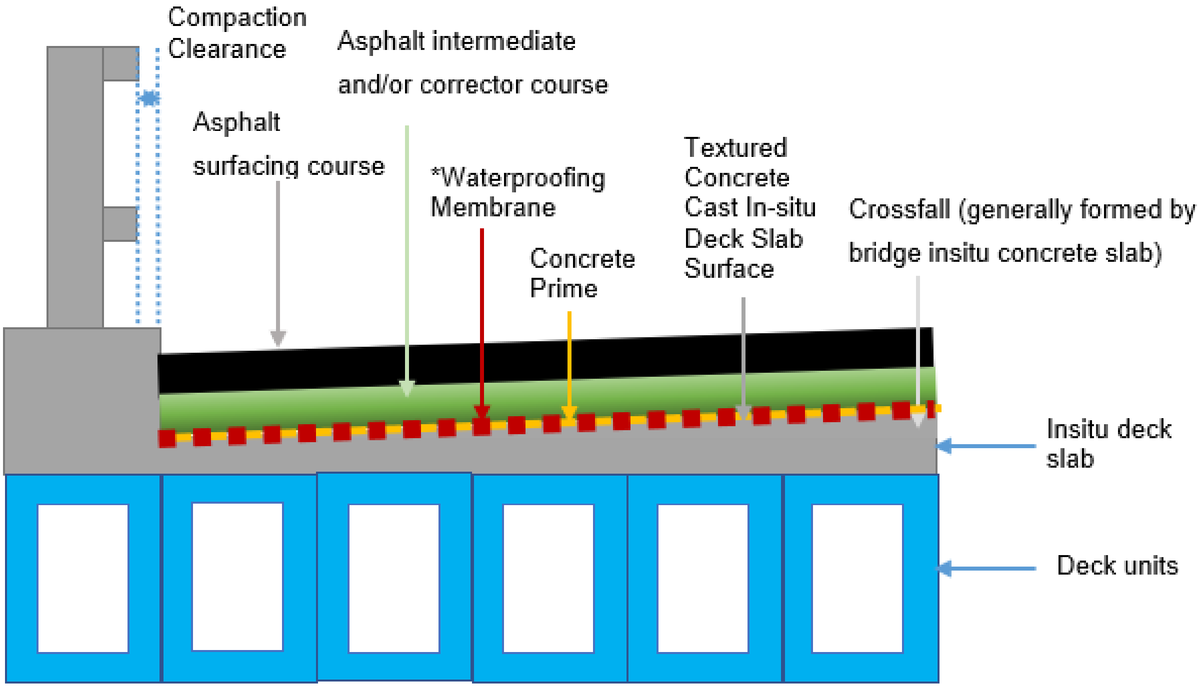


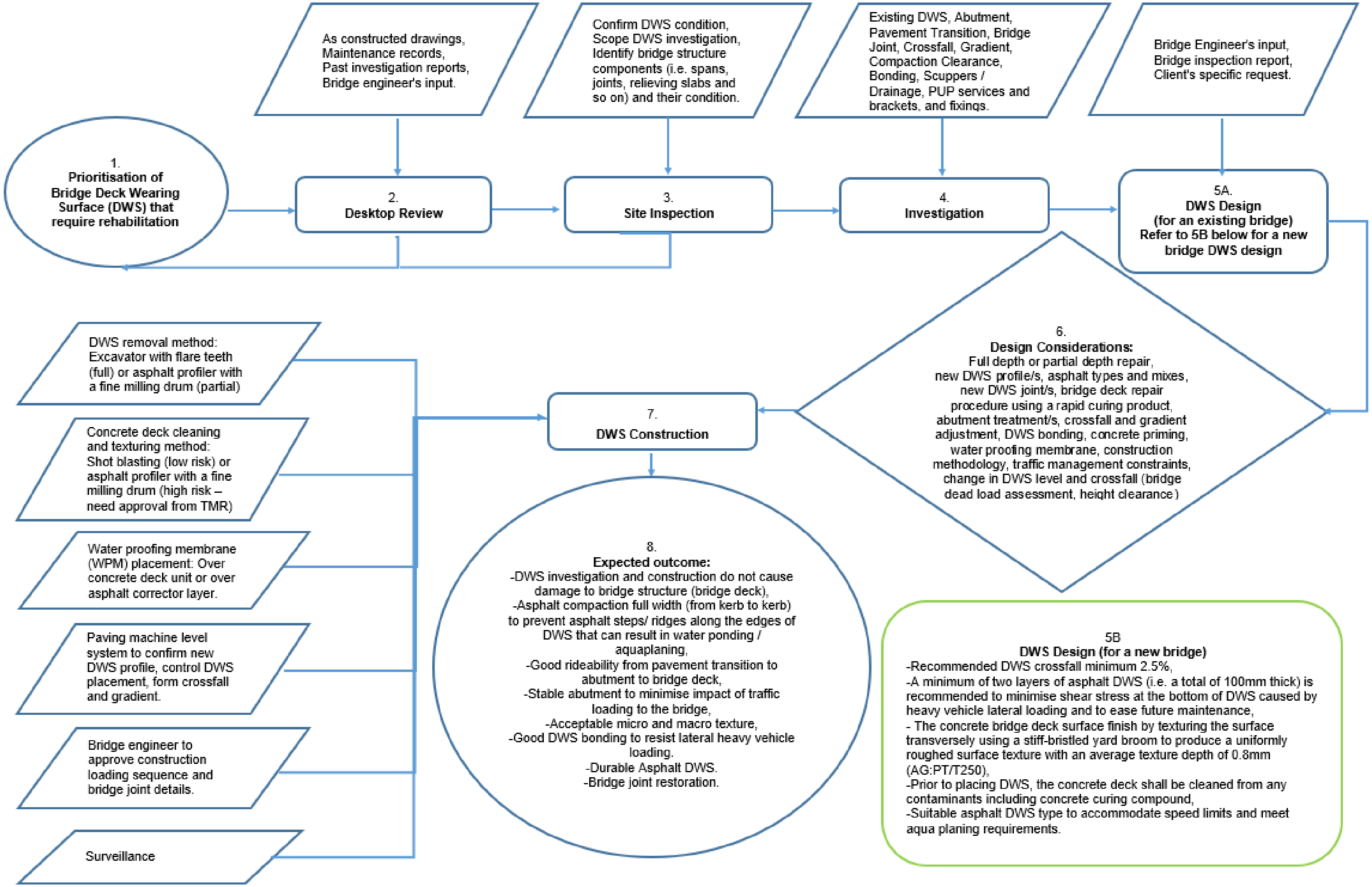
Figure 4(b) – Typical DWS arrangement for cast insitu concrete deck slab



Note:
For a bridge without concrete deck slab, a Waterproofing Membrane (WPM) is typically installed between the asphalt surfacing layer and asphalt corrector layer. WPM installation directly over precast deck units is not recommended due to the longitudinal steps or uneven surface that may cause premature failure of the WPM. For a bridge with cast insitu concrete deck slab, a WPM is generally installed over textured and primed concrete deck slab.

5 DWS rehabilitation process

Figure 5 **– Flow chart of DWS rehabilitation process**



6 DWS investigation

6.1 Objective

The purpose of a bridge DWS investigation is to identify and assess the following:

- Existing asphalt DWS profile (asphalt types, thicknesses, and condition).
- Existing WPM type and condition. The presence of a lively, tacky, rubbery, and active WPM binder over concrete bridge slab or units needs to be recorded. If this exists, it may create difficulties to texture the deck slab or unit using a shotblasting machine.
- Surface condition and surface texture of the concrete deck slab or deck units.
- Concrete deck units or concrete deck slab steel reinforcement and cover thickness.
- Adhesion and bonding between existing DWS and underlying concrete deck slab or deck units.
- Existing bridge DWS joint type and condition (preferably assessed by a Transport and Main Roads Engineering and Technology (E&T) Structural Engineer or suitably qualified Structural Engineer Consultant).
- Existing asphalt DWS geometry (that is, crossfall and longitudinal gradient).
- Bridge abutment and relieving slab stability (preferably assessed by a departmental Structural Engineer (E&T) or suitably qualified Structural Engineer Consultant).
- Defects on the bridge DWS and structure (cracking, spalling, potholes, shoving, stripping, ravelling, slab or deck delamination, deck damage (for example, exposed steel reinforcement). Refer to the department's *Guide to the Visual Assessment of Pavements* for further details on identifying DWS defects.
- Degree of bonding of the 150 mm and 450 mm diameter asphalt core samples to help identify suitable removal method during construction.
- Bridge railing overhang configuration to measure clearance for asphalt pavers and rollers to work against the bridge deck kerb.
- Existing scuppers and surface drainage condition.

6.2 Investigation risk

DWS investigations should only be undertaken by contractors with demonstrated competency and experience in such investigation work. Contractors should follow appropriate investigation methodologies whilst under experienced supervision. These requirements assist in minimising the following DWS investigation risks:

- Asphalt coring and/or asphalt saw cutting into the underlying concrete deck slab / deck unit, steel reinforcement and/or prestressed strands.
- Asphalt coring not undertaken to the full depth of the DWS, and unable to expose the underlying concrete deck slab / deck unit surface.
- Asphalt core thickness and Ground Penetrating Radar (GPR) scanned depth locations not accurately recorded by survey and cannot be relied upon for the design and construction.

- Measured asphalt DWS thicknesses and properties are not accurate or representative of the existing condition, thus potentially causing construction delays.
- Underestimation of the bond of the existing DWS to the underlying concrete deck slab or deck units, thus potentially causing construction delays.
- Measured concrete deck surface texture is not an accurate representation of the existing condition, thus potentially causing construction delays.
- Failure to identify bridge deck concrete cracking, spalling, delamination, or other bridge deck defects, thus potentially causing project delays and cost variations.
- Moisture ingress from wet asphalt coring and saw cutting procedures, which may result in accelerating the deterioration of the DWS and concrete bridge deck (this is critical on bridges that are exhibiting Alkali Silica Reactivity (ASR)).
- Improper or inadequate asphalt reinstatement which may fail under traffic loading prior to completing the DWS rehabilitation.

> DWS investigation activities can be procured under the department's current Standing Offer Arrangement (SOA) TMRPR1481 for Provision of Pavement Investigation and Material Testing Services.
>
> For further information regarding the procurement and completion of a detailed DWS investigation, please email Technical Publications.

6.3 Investigation methodology

A comprehensive investigation methodology (or investigation brief) for the DWS investigation works is required. An example DWS investigation methodology which has provided satisfactory outcomes for DWS investigation, design, and construction, is provided in Appendix A.

6.4 Scanning and asphalt core quantities

Quantity of DWS depth measurement data is dependent on using an appropriate GPR concrete scanner with the necessary accuracy. Cores of the asphalt DWS shall be taken to calibrate the GPR measurements which is a critical step to ensure accuracy of DWS thickness measurements across the entire bridge structure.

Table 6.4(a) – Typical DWS thickness variations

Typical DWS thickness variations	DWS over a cast insitu concrete deck slab	DWS over deck units
Thinner at mid-spans and thicker at piers and abutments due to hogging (longitudinal thickness variations)	Occasional cases	All cases
Thinner along the bridge kerb and thicker along the centre line (transverse thickness variations)	Some cases[1]	Most cases[2]
Across length and width of a bridge deck that has been widened or extended	All cases	All cases

Typical DWS thickness variations	DWS over a cast insitu concrete deck slab	DWS over deck units
Retrofitted relieving slab at a different level with concrete bridge deck	All cases	All cases

Notes:

[1] An example would be where a DWS was placed to a current crossfall standard (that is, the bridge concrete deck slab crossfall 1.0% but asphalt DWS crossfall 2.5%).

[2] Typically, the DWS crossfall is formed by the asphalt and therefore asphalt DWS is thicker at the crown and is thinner towards the edges. An exception to this would be one-way DWS crossfall.

The DWS depth spot scanning and calibration core locations shall be planned such that it adequately represents the DWS thickness variations across the entire bridge deck slab.

Table 6.4(b) – Recommended GPR scanning and coring locations

Recommended DWS GPR scanning and coring and locations	DWS over a cast insitu concrete deck slab	DWS over deck units
Longitudinal spacing	**GPR scanning[1]** 1. Maximum 7.0 m grid spacing to include middle spans, piers, abutments or relieving slab footprints, and pavement transitions. 2. For a long span bridge, additional test locations at a quarter (¼) span and (⅛) span may be required to meet 7.0 m maximum spacing grid. **DWS coring** 1. Two cores each span per lane (up to 15 m long span). 2. For a span > 15 m, additional coring per lane is required i.e. additional two cores per lane up to extra 15 m long span and thereafter. 3. One core each relieving slab per lane. 4. One core at each pavement transition per lane, and 5. Minimum two large diameter coring to assess concrete deck roughness and residual binder / prime.	**GPR scanning[1]** 1. Maximum 4.0 m grid spacing to include middle spans, piers, abutments or relieving slab footprints, and pavement transitions. 2. For a long span bridge, additional test locations at a quarter (¼) span and (⅛) span may be required to meet 4.0 m maximum spacing grid. 3. Spot scanning are required at both ends of bridge deck planks / units (outside bridge joints). **DWS coring** 1. Two cores each span per lane (up to 15 m long span). 2. For a span > 15 m, additional coring per lane required i.e. additional two cores per lane up to extra 15 m long span and thereafter. 3. One core each relieving slab per lane. 4. One core at each pavement transition per lane, and 5. Minimum two large diameter coring to assess concrete deck roughness and residual binder / prime.

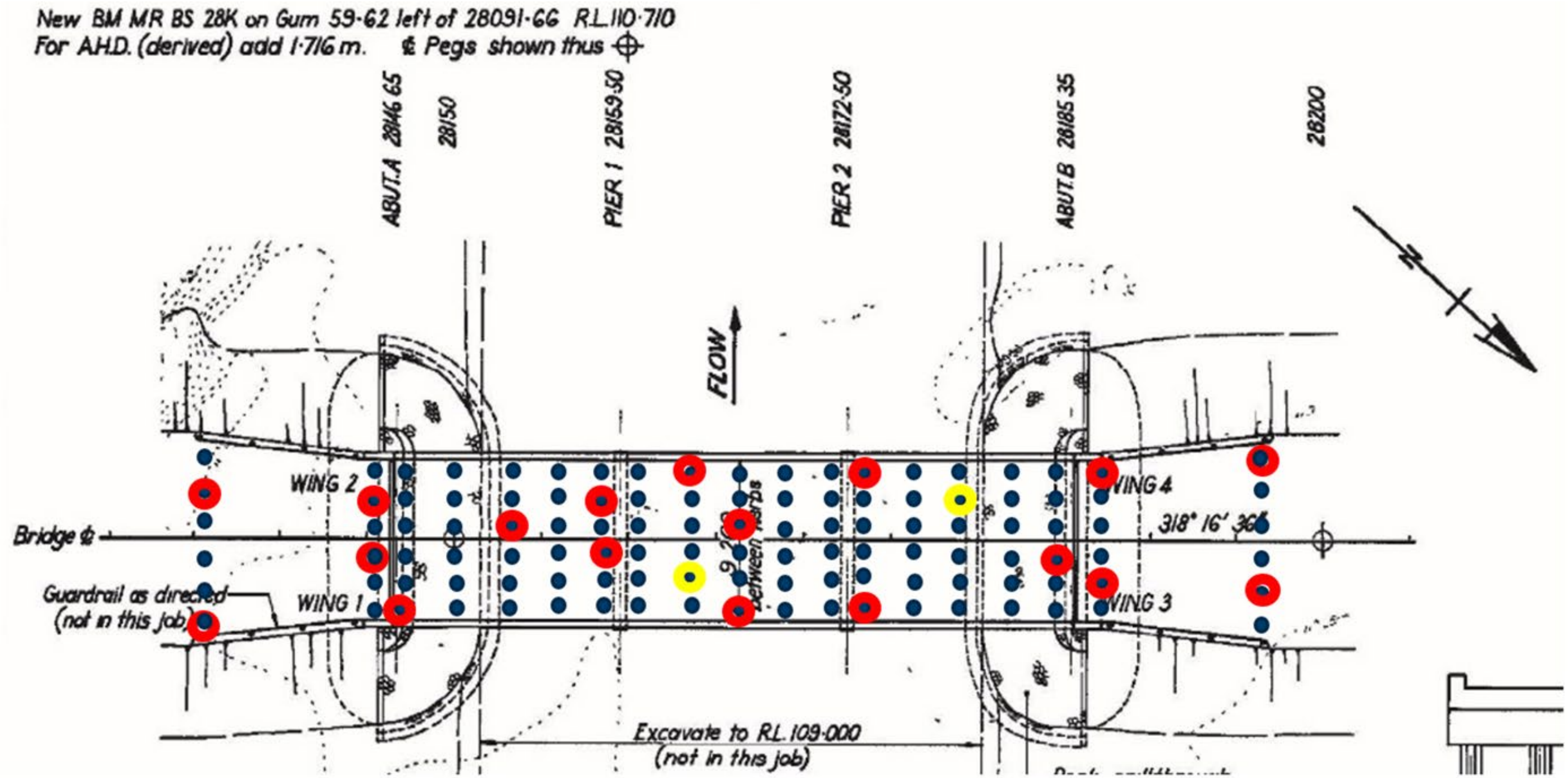
<table>
<tr><th>Recommended DWS GPR scanning and coring and locations</th><th>DWS over a cast insitu concrete deck slab</th><th>DWS over deck units</th></tr>
<tr><td>Transverse spacing</td><td colspan="2">GPR scanning[1]
1. DWS edge (or nearest if not possible)
2. DWS centre lane (between wheel paths), and
3. DWS lane line (or nearest if not possible).
DWS coring
Refer above (longitudinal section spacing).</td></tr>
<tr><td>Additional testing (as required)</td><td colspan="2">GPR scanning[1]
At transition between original bridge deck and widened / extended bridge deck.
DWS coring
At defected asphalt DWS surface: cracking, rutting, delaminate, flushing, and so on.
At transition between original bridge deck and widened / extended bridge deck.
To support GPR Spot Scanning depth calibration complying with required accuracy.</td></tr>
</table>

Note:

[1] Moisture in the asphalt DWS (at surface and/or within layers) and at concrete bridge deck surface will likely cause inaccurate GPR readings.

Refer to a sample layout with marked 3.25 m longitudinal grids survey of a DWS over bridge deck units below.

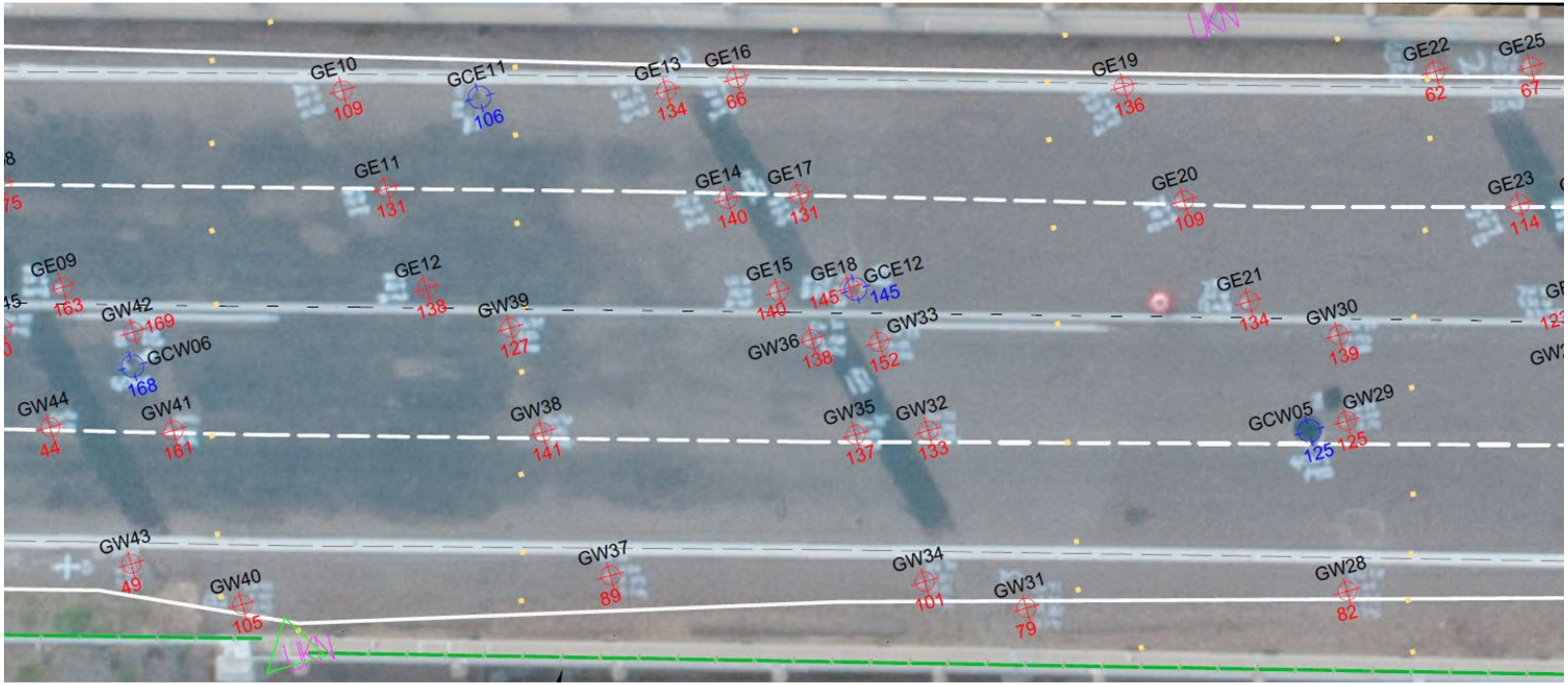
Figure 6.4(a) – Example of GPR scanning and coring layout



Notes:

- *114 locations GPR scanning using a Proceq GP8000, GP8100 (or equivalent)*
- *18 locations 150mm diameter cores – TMR to confirm core locations on site.*
- *2 locations 450mm diameter cores - TMR to confirm core locations on site.*

Figure 6.4(b) – Example of GPR scan (red) and core (blue) measurements (all shown in mm)



6.5 Survey pickup for crossfall and longitudinal gradient

Survey pickup of the existing DWS is required.

A maximum 6.0 m longitudinal grid survey is recommended. The longitudinal grid survey shall include critical cross-sections: piers, mid-spans, abutments or relieving slabs, and pavement transitions.

Undertake a minimum of three (3) survey pickups transversely (perpendicular to vehicle traffic direction) for each cross section. That is, close to both bridge kerbs / barrier walls / parapets and the road centre. Additional survey locations at line lanes can be considered for a multi-lanes bridge.

Existing DWS crossfall and longitudinal gradient information shall be collected for DWS design purpose. The data will be analysed to help determine if the existing crossfall and gradient can be retained or corrected.

Figure 6.5(a) – Example of DWS crossfall survey pickup

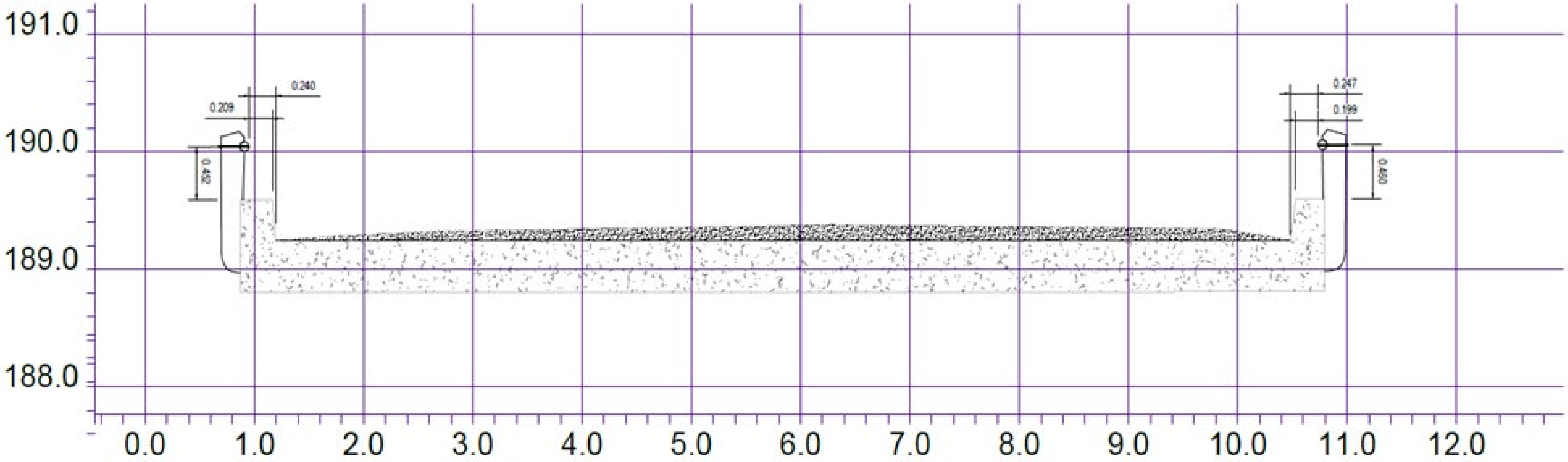
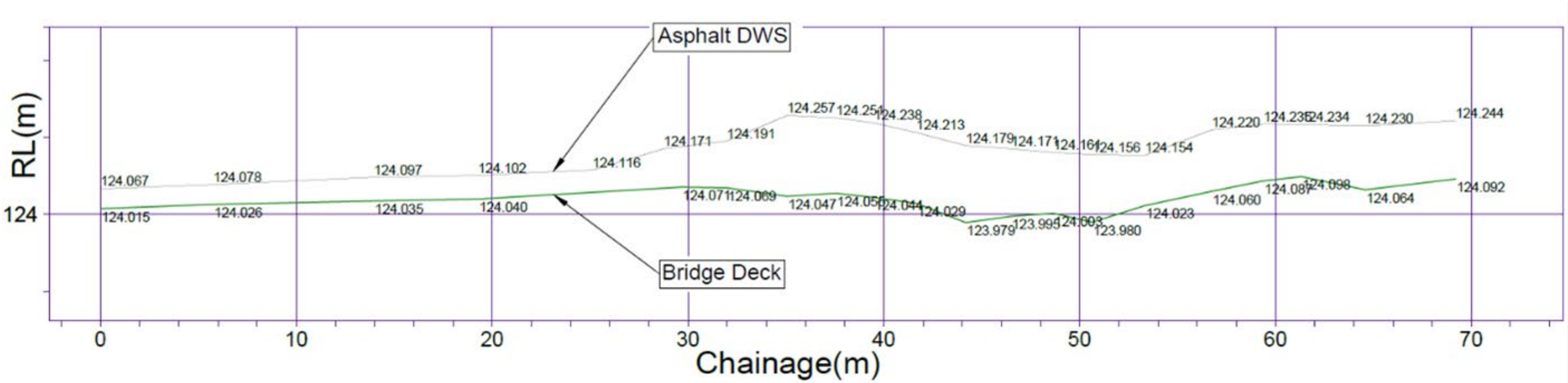


Table 6.5 – Crossfall chart (supplement to Figure 6.5(a))

Crossfall chart		
Chainage	**Westbound**	**Eastbound**
CH72166	1.03%	2.87%
CH72181	1.63%	0.55%
CH72196	1.93%	3.65%
CH72211	0.52%	2.18%
CH72226	1.72%	2.77%

Figure 6.5(b) – DWS longitudinal gradient



6.6 Edge or kerb clearance

The intention of bridge rail and kerb clearance survey is to measure and record the available clearance between the bridge railing and kerbs. This will confirm if asphalt paving and compaction can be undertaken between the kerbs using typical plant (paver and rollers).

A bridge railing type in Figure 6.6(a) prevents an asphalt roller to compact asphalt DWS against the kerb and will leave out an uncompacted asphalt strip along the edges as shown in Figure 6.6(e). This raised uncompacted asphalt strip will obstruct or delay surface water discharge to nearby scupper drains and may cause aquaplaning issue.

A steel cylinder wheel attachment as shown in Figure 6.6(d) is usually required to compact asphalt along the edges where compaction clearance is not available.

Figure 6.6(a) – Bridge railing flush or intruding beyond the inside face of the concrete kerb

Figure 6.6(b) – Bridge railing setback from the inside face of the concrete kerb

Figure 6.6(c) – Twin steel drum asphalt roller with approximately 60 mm offset to the drum on each side

Figure 6.6(d) – Twin steel drum roller with a steel cylinder attachment to help compact the asphalt DWS edges at the concrete kerb

Figure 6.6(e) – Uncompacted asphalt DWS resulting in a stepped asphalt strip along the concrete kerb

Figure 6.6(f) – Uncompacted asphalt DWS edge resulting in poor surface drainage

7 DWS design

To successfully undertake DWS rehabilitation design, the following parameters must be considered by the Designer:

- DWS configuration and thicknesses. Refer to Section 4 of the department's *Design Criteria for Bridges and Other Structures.*
- Asphalt and binder selection. Typically, AC14 and AC10 with A15E binder is used for asphalt DWS. A stiffer asphalt binder A10E or A5E may be used for asphalt DWS in a high stress and a heavy traffic environment. Refer to MRTS30 *Asphalt Pavements.*
- Priming of bridge deck concrete surface.
- WPM binder, spray rate, aggregate size and spread rate. Recent experience shows that 14 mm aggregate prevent seal pick-up by construction vehicles or plants.
- Crossfall and gradient adjustments (if required).
- Abutment strengthening including relieving slab.
- DWS expansion and fixed joint types.
- Asphalt tie-in (ramp) details at the abutment, relieving slab and adjoining pavement.
- Texture depth requirements on exposed concrete bridge deck and any treatments required to improve the surface texture, and
- Aquaplaning and surface drainage checks. In a high-speed environment (> 80 km/h), dense grade asphalt may not be suitable and open grade or stone mastic asphalt surfacing may be required.

For a bridge that will be inundated (for example, floodplain areas), the Designer must also consider the following:

- Heavy duty dense grade asphalt with PMB binder is recommended (that is, AC14H and/or AC10H with A15E).
- Type B WPM with S25E binder and 10 mm or 14 mm aggregate.
- Recommend minimum asphalt DWS thickness of 100 mm, and

- Asphalt compaction compliance for all asphalt layers (including intermediate and corrector courses) must be achieved.

To determine design levels, the thickness of WPM seal should be taken as the Average Least Dimension (ALD) of the cover aggregate. If the ALD is not known at the time of design, the ALD can be estimated as approximately 60% to 65% of the nominal cover aggregate size.

In addition to the above, the Designer may use the survey pick-up data from the DWS investigation process to provide the following:

- A 2D or 3D model of existing asphalt DWS, asphalt over abutment and pavement transition drawings showing road crossfalls and gradients.
- A 2D or 3D model of proposed asphalt DWS profile with road crossfall and gradient drawings and calculations.

It is recommended that the proposed asphalt DWS total weight shall be equivalent or less than the existing asphalt DWS and comply with crossfall and gradient requirements.

> Based on the assessment and analysis of the DWS investigation results, it is important to determine a suitable DWS treatment and provide accurate design advice to ensure the successful completion of DWS rehabilitation works with minimum delays.

A full depth asphalt DWS removal and replacement treatment shall be nominated by the Designer if:

- asphalt cores show a poor condition for the full depth or at the lower part asphalt course (for example, brittle, oxidised, excessive voids, binder stripping, moisture, or crumble)
- asphalt cores indicate a poor bonding or delamination at the interface between asphalt DWS and concrete bridge deck
- moisture is identified at the interface between asphalt DWS and concrete deck
- asphalt cores show a full depth defect (for example, cracking), and/or
- retained lower part asphalt course is less than 40 mm thick.

> A full depth DWS removal and replacement treatment (which includes total removal of the existing DWS, cleaning and texturing the concrete bridge deck, concrete priming, waterproofing membrane, asphalt corrector layer and asphalt surfacing layer) will require additional resources and time to complete.
>
> If the design option is to retain the lower layer and to mill and replace the upper DWS layer only, but during construction the need for a full depth DWS rehabilitation is deemed necessary, there will be significant increase to project cost and construction timeframe. Furthermore, inadequate plant and equipment due to inaccurate DWS design may result in rework and project delays.

A partial upper layer asphalt DWS resurfacing (mill and fill) shall be nominated by the Designer if:

- asphalt core data shows the existing asphalt layer(s) are in good condition

- asphalt core data indicates a good bond at the interface between asphalt DWS and concrete bridge deck
- asphalt core data shows the defects are within the upper layer only and does not propagate to the lower layer(s) of asphalt course, and/or
- retained lower part asphalt course is greater than or equivalent to 40 mm thick.

A partial upper layer DWS resurfacing (mill and fill) process is easier, faster, and less expensive compared to a full depth asphalt removal.

However, for partial upper layer DWS resurfacing, the retained lower layer asphalt DWS must be in good condition and of adequate thickness, otherwise the lower layer may crumble and breakdown causing the newly constructed upper DWS layer to fail prematurely due to the underlying weak support conditions.

In the event the lower layer of asphalt DWS crumbles and undergoes debonding during the milling works, a full depth DWS removal and replacement treatment will be required.

Based on experience and feedback, partial milling using an asphalt profiler with a fine or micro milling head is preferred as to generate uniform milled surface and minimise lower layer asphalt DWS pick up or damage.

It should be noted that regular maintenance and resurfacing of the upper asphalt layer (that is, mill and resurfacing every 10 -12 years) ensures a durable asphalt DWS and protects the lower layer(s) of asphalt.

Other items that the Designer must consider includes the following:

- Cleaning of the residual binder from the concrete deck slab or deck units.
- Retexturing of the concrete deck slab or deck units.
- Concrete prime of the existing concrete deck slab or deck units.
- For deck units, WPM shall be installed on the asphalt corrector (refer to Figure 4(a)).
- For concrete deck slab, WPM shall be installed on the flat concrete deck surface (refer to Figure 4(b)).
- For bridge DWS joint replacement / reinstatement, replacing the joints as like-for-like to the original design may not be suitable. For example, an existing DWS fixed joint may need to be replaced with a joint that allows for movement.
- A separate DWS design may be required for each bridge component such as the bridge deck, abutment and pavement transition.

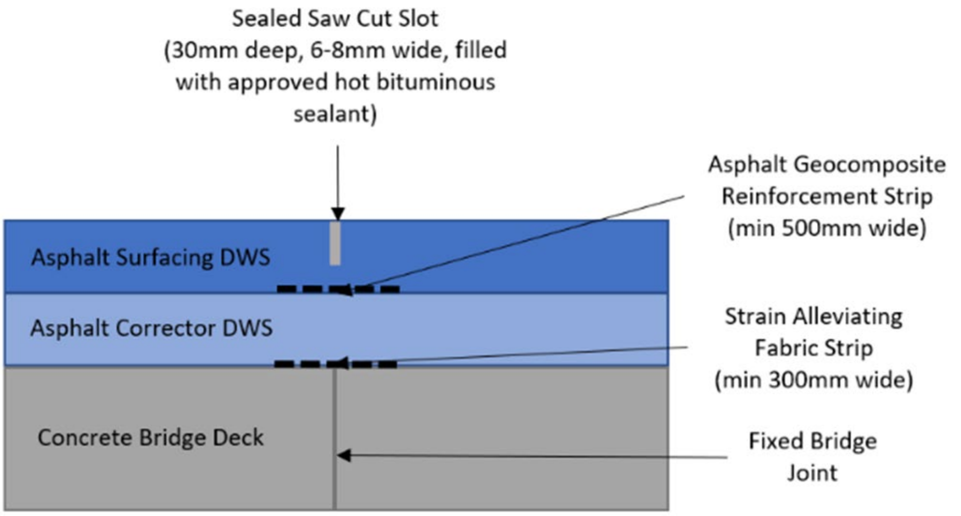
A comprehensive DWS design is required which includes detailed design drawings. An example of DWS drawing notes which provide satisfactory outcomes for DWS design and construction, is provided in Appendix B.

8 DWS joint design

Bridge DWS joint should be assessed during DWS investigation and if required be replaced in conjunction with the DWS rehabilitation works.

The department's E&T Branch, Structures Review and Standards Unit (TMRStructuresE19@tmr.qld.gov.au) or suitably qualified Structural Engineer Consultant shall be contacted for DWS joint assessment and replacement advice.

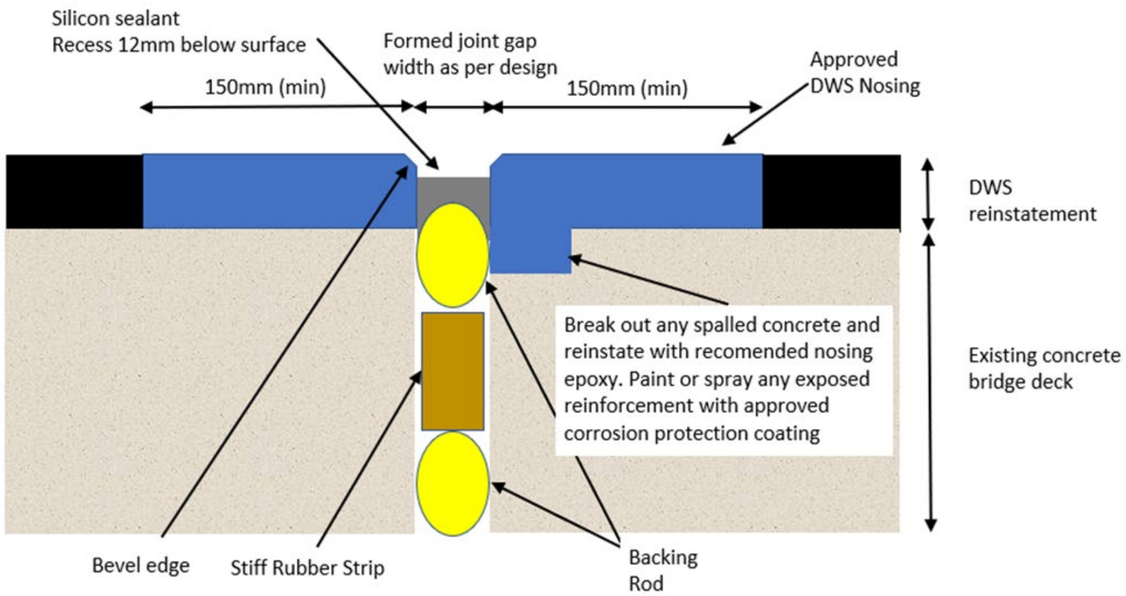
Figure 8(a) – Typical DWS fixed joint detail (sealed saw cut)



Note:
1. Sealant shall not overbanding asphalt DWS. A temporary cloth or masking tape can be used to prevent residual sealent ovebanding asphalt DWS surface.

Some components of DWS sealed saw cut joint shall be installed prior to placement of the asphalt DWS surfacing layer. Saw cutting and sealing should be undertaken as soon as the asphalt surfacing layer cools down and firms.

Figure 8(b) – Typical DWS expansion joint detail



Ideally, DWS expansion joint shall be installed as soon as the asphalt DWS is placed and compacted and prior to opening to traffic. If not possible, DWS expansion joint shall be installed within fourteen (14) days of DWS asphalt placement with the following conditions:

- A temporary cover plate placed over the joint to prevent loose material entering bridge joint void, to protect bridge nosing from damage and to protect asphalt DWS depression at the joint.
- Expandable foam may also be used to protect loose debris entering bridge joint voids.
- An initial saw cut (30 mm deep and 6-8 mm wide) on the expansion joint is required within 24 to 48 hours of asphalt DWS placement to prevent unplanned cracking of the newly installed asphalt DWS due to joint movements.

9 DWS contract documentation

For DWS tendering and construction, it is recommended that the following DWS rehabilitation documents are included in the contract documents and provided to the Contractor:

- DWS and bridge joint detail drawings
- DWS investigation report
- DWS design report
- DWS joint report
- latest bridge inspection reports, and
- bridge structure As Constructed drawings.

10 DWS construction

10.1 Contractor's responsibility

The following shall be noted as the responsibility of the Contractor:

- Undertake DWS rehabilitation work without damaging the structure. If Contractor causes any damage to the structure, it should be rectified to the satisfaction of the Administrator at the Contractor's cost.
- Verify the accuracy of the provided or available DWS investigation report data. The scope of the DWS verification works are to be approved by the Principal and the Administrator.
- If DWS investigation has not been undertaken, the Contractor will need to undertake a comprehensive DWS investigation.
- Reconfirm and refine the designed DWS profile design and configuration (if requested by the Principal or the Administrator).
- Reconfirm DWS crossfall and gradient design (if requested by the Principal or the Administrator).
- Manage vibration effects to bridge and surrounding structures as per MRTS51 *Environmental Management* Clause 8.6. Recommend contacting the department's E&T Branch, Structures Review and Standards Unit (TMRStructuresE19@tmr.qld.gov.au) to obtain the latest advice on vibration limits on a bridge and surrounding structures.

- Avoid and minimise environmental harm. This includes air quality from dust, smoke, and offensive odours and other air pollutants as per MRTS51 *Environmental Management*.

10.2 Methods to remove the existing DWS

The following table notes the various methods for removing the existing DWS based on observed resistance to extract asphalt cores during the DWS investigation (refer to Section 6). To accurately use the guidance provided in the below table, full depth asphalt core must be extracted from the existing DWS. If asphalt core is too shallow, or broken during extraction, then the extracting effort may not be quantifiable.

Table 10.2 – Methods of removing existing DWS based on resistance to extract asphalt cores

Scale	Resistance to extract asphalt cores	Bonding assessment	Recommended method to remove existing asphalt DWS
1	**Easy to extract** • DWS core sample is easily popped and removed. • An intact upper layer delaminated from lower layer. • Lower layer is stripped or deteriorated. • Easily extracted using hand tools (screwdriver, a pry flat bar or a core extruder).	Poor bond strength	Excavator with suitable sharp teeth attachments.
2	**Easy to extract** • DWS core sample is popped (full depth and intact) using a core extruder, or • An intact upper layer delaminated from lower layer. Lower layer is easily extracted using hand tools (screwdriver, a pry flat bar or a core extruder).	Poor bond strength	Excavator with suitable sharp attachments.
3	**Extract with mild to medium force** An air chisel (or similar small power tool) is used to break the bond between the core and bridge deck: • an intact full depth core is extruded • an intact upper layer is extruded; lower layer is extracted using an air chisel or other small power tools, or • core sample is broken into pieces using a small power tool. No or very minimal remain on existing concrete deck.	Medium bond strength	Excavator with suitable sharp teeth attachments, and Asphalt profiler with a fine or micro milling teeth on standby.
4	**Very difficult to extract** Extract using power tools with high resistance, a jack hammer or similar medium power tool is required to extract the core: • intact upper layer core and broken lower layer core • full depth core or lower layer must be cut or broken up with jack hammer or similar medium power tool to extract, and/or • some of the core sample remains on the concrete deck requiring use of power tools (jack hammer / air chisel) to remove.	High bond strength	Asphalt profiler with a fine or micro milling teeth to remove existing DWS in multiple passes at a maximum cutting depth of 50 mm for each pass and up to residual 25 mm thick existing DWS. A coring rig must be on standby during asphalt DWS removal operation to confirm residual asphalt DWS depth, and Excavator with suitable sharp teeth attachments for final removal (remaining 25 mm).

In addition to bonding assessment undertaken during the asphalt core extraction, a site torsional shear strength Test Method Q721 (on a 150 mm diameter cored asphalt) can also be undertaken to confirm the result. Generally, a torsional strength test result > 40 Nm indicates a good bonding. For this test, a rapid curing adhesive shall be used to bond a torquing plate to asphalt DWS surface to allow the testing to be undertaken in a single shift. The epoxy adhesive to glue the steel plate to the asphalt DWS surface should have > 100 Nm torsional shear strength. Prior to torsional testing, ensure asphalt DWS coring is undertaken to the full depth. If asphalt core is too shallow, it will provide a misleading 'high' torsional result. Testing can be undertaken when the epoxy is fully cured. A torque wrench with approximate torque capacity of 0–200 Nm should be used.

The site bonding assessment and torsional test results can be used to determine suitable removal method for a full depth asphalt DWS replacement.

Figure 10.2(a) – A 150 mm diameter torsional test plate glued onto the cored asphalt

Figure 10.2(b) – A torque wrench used to spin the plate apparatus to assess the bonding

10.3 Construction loading

Prior to asphalt DWS removal and construction, a suitably qualified structural engineer shall review and approve DWS removal and paving plant configuration on bridge structure. Loading assessment and approval for departmental assets shall be sought from the department's E&T Branch, Structures Management Unit (TMRStructuralAssessment@tmr.qld.gov.au).

Typical asphalt DWS removal and construction plant configurations are shown below.

Figure 10.3(a) – Partial removal of existing DWS using profiler (upper layer milling)

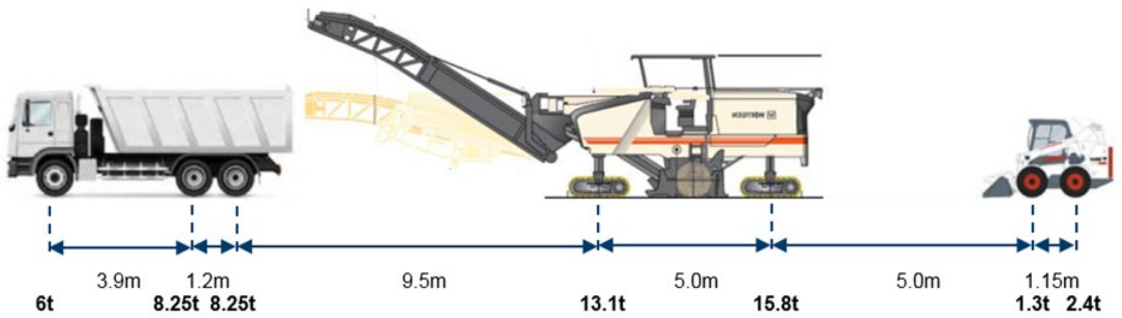


Figure 10.3(b) – Full removal of existing DWS using excavator with suitable teeth attachments

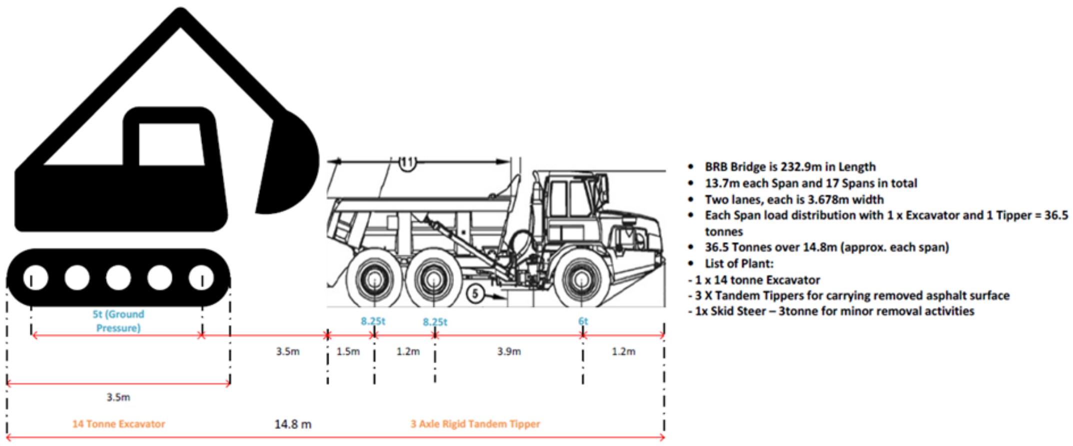


Figure 10.3(c) – Waterproofing membrane seal installation

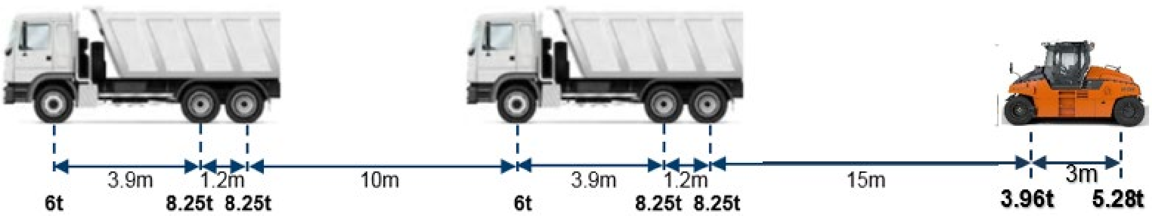
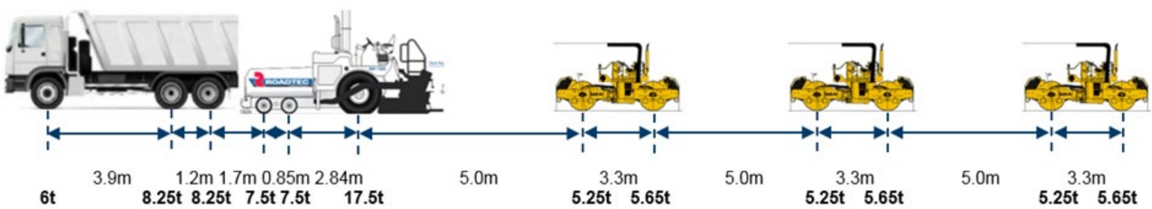


Figure 10.3(d) – Asphalt DWS paving and compaction



10.4 DWS removal

During the removal process of existing DWS, it is critical that no damage occurs to the concrete bridge deck. Any damage caused to the concrete bridge deck has potential to reduce the structural integrity of the bridge and increase the likelihood of structural issues during the service life of the structure.

The DWS investigation report shall identify the strength of the bonding between existing DWS and the concrete deck. Based on bonding assessment, the most suitable DWS removal methodology(ies) can be selected (refer to Section 10.2).

Where the DWS rehabilitation design is partial removal of the upper layer of DWS, the only suitable removal method is by using an asphalt profiler (or milling machine).

Abutment and pavement transition sections usually require partial or complete milling off the upper asphalt layer using an asphalt profiler.

Where rehabilitation of DWS requires the complete removal of the existing DWS, the preferred method of removal is using an excavator with sharp teeth attachments. Removal of DWS with an excavator with sharp teeth attachment has a lower risk of damaging the concrete bridge deck. In past projects, either a 14 or 20 tonne rubber tracked excavator with sharp teeth attachments has efficiently and effectively removed the existing DWS where the bond strength to the bridge deck is rated as poor to medium. As shown in the Figures 10.4(a), (b) and (c) below, a set of chisel shape 'flare' teeth is proven to be effective to remove existing asphalt DWS.

Where existing asphalt DWS sits directly over uneven or stepped deck units (typically 600 mm wide), in addition to a standard general purpose excavator bucket with sharp teeth, a narrow trenching bucket (less than 600 mm wide) with a welded sharp plate can be used efficiently for final deck unit cleaning. This narrow trenching bucket can be used to scrape each deck unit efficiently to remove any residual asphalt, seal, binder, and prime. It is critical to clean the bridge deck units as much as possible as shotblasting / texturing machine cannot operate on uncleaned bridge deck units with thick residual DWS.

Where required, diagonal and/or horizontal cuts can be undertaken on the existing DWS to provide initial 'opening up' for the excavator teeth. The saw cut operation on the DWS must be performed such that it does not damage or cut into the concrete bridge deck.

Figure 10.4(a) – Custom made excavator bucket's sharp or flare teeth

Figure 10.4(b) – Prefabricated excavator bucket's sharp or flare teeth

Figure 10.4(c) – An excavator with a standard size general purpose bucket with sharp teeth in action

Figure 10.4(d) – Narrow trenching bucket with welded plate across the teeth

Where the existing DWS is brittle and has a high bond to the underlying concrete deck, removal using an excavator may not be effective. Furthermore, the removal of highly bonded asphalt DWS will require significant force from the excavator which may cause the bridge to sway. In this instance, a staged removal process using an asphalt profiler is required as follows:

1. Using a milling machine (asphalt profiler with standard profiling drum) to remove the upper DWS layer(s), and
2. Using an excavator with suitable bucket and teeth to remove the lower DWS layer.

Prior to milling off, upon discussion with profiler operator, it is recommended to depth probe (by jack hammering or coring the existing asphalt DWS) at approximately 2.5 m running interval and at least three depth probes each cross section (transversely) to cover a 2.0 m wide profiler drum. The milling operation shall be limited up to a maximum depth of 50 mm cut for each pass. Multiple profiling / milling runs may be required.

In all cases, using a profiler to remove any part of the existing asphalt DWS is considered a high-risk operation. In particular, on a bridge deck with upward deflection (hogging) and stepped longitudinal joints. Machine and/or human error can result in excessive milling depths which damages the concrete bridge deck. Therefore, this option should be considered very carefully and is to be approved and supervised by a departmental asset owner and the department's E&T Structures Review and Standards Unit (TMRStructuresE19@tmr.qld.gov.au).

Based on past experience, vibrations on the bridge incurred by the asphalt DWS removal using an excavator (14 to 20 tonne) with suitable attachments and teeth are usually below the compliance limit. Depending on bridge type and condition, vibrations incurred from a profiler during asphalt DWS removal may exceed the compliance limit. It is recommended to contact E&T Structures Review and Standards Unit (TMRStructuresE19@tmr.qld.gov.au) for advice if a profiler is to be used to remove asphalt DWS.

The following tools and machineries should also be available on site for final concrete deck cleaning:

1. bobcat or a positrack (with attachments)
2. smaller excavator(s) (6-10 tonnes), and
3. vacuum truck with broom attachment.

Figure 10.4(e) – A small excavator using a blade attachment to remove residual asphalt DWS

If DWS construction is on a multi-lane bridge, and construction is to be undertaken one lane at a time through a single lane closure setup, to achieve a satisfactory longitudinal cold joint, a longitudinal saw cut is required at the lane line (or centreline) plus minimum 150 mm offset toward the running lane. When completing the adjoining lane, ensure to cut back / overlap 150 mm towards the lane line. Ensure the cold joint is running along the lane line and not within the wheel paths. Where possible, cold joints should be avoided which may require the closure of the entire bridge during the rehabilitation works.

Kerbs, parapets, scuppers, joints rails and other road / bridge furniture must be protected during the DWS removal process.

10.5 DWS joint removal

Removal and replacement of the bridge DWS fixed joint is usually undertaken simultaneously with DWS removal without requiring a specialised removal process. After DWS removal, the existing concrete joint nosing and gap infill are to be assessed and repaired as required. Repair material and resources shall be allocated to ensure availability to undertake repair (if required) during DWS removal.

Removal and replacement of bridge DWS expansion joint is a more complex process. Depending on the existing joint type and allocated construction window, expansion joint removal may be undertaken prior to the DWS removal or in a same shift as the DWS removal. Suitable power tools and removal methodology is important to ensure removal can be undertaken timely and efficiently without damaging the concrete bridge deck nosing. After removal of DWS expansion joint, the existing concrete joint nosing and gap infill are to be assessed and repaired as required.

If the expansion joint cannot be installed immediately after the asphalt DWS placement and the bridge needs to be open for traffic, a temporary steel cover plate is recommended to be placed over the temporary asphalt joint strip. A temporary cover steel plate is to be installed to protect concrete bridge nosing damage from traffic and to protect the asphalt DWS from caving in and causing hazards to road users.

It is important to ensure loose debris does not fall into the bridge joint voids. Any loose debris in the bridge joint void will need to be removed.

Some common mishaps during bridge DWS expansion joint removal includes the following:

1. a handheld quick concrete saw cutter cutting through concrete bridge deck
2. holding anchor or bolt accidentally removed or displaced during the removal operation damaging the concrete deck nosing
3. existing DWS joint nosing (to be removed) has not been weakened, cut or debonded sufficiently resulting in damage to concrete deck nosing during the attempt to remove the existing nosing, and
4. loose debris falling into the bridge joint gap cavity preventing controlled horizontal bridge joint movement.

Figure 10.5 – Temporary metal cover plate to protect an expansion joint

10.6 Cleaning and retexturing concrete bridge deck

A clean and textured concrete bridge deck significantly contributes to the bonding and long-term performance of the asphalt DWS.

10.6.1 Cleaning

Residual existing materials including concrete curing compound, road grime, concrete prime, bitumen seal and asphalt shall be cleaned from the concrete bridge deck prior to placement of new DWS. It is very important to remove residual prime and/or binder as the new concrete prime will need to penetrate the concrete bridge deck to achieve the best bonding.

If the surface texture depth test result is 1.0 mm or higher, retexturing (refer to Section 10.6.2) is often not required, but the residual prime and/or binder will need to be removed as much as possible (recommend targeting a minimum 80% residual prime / binder removal).

An excavator using a wide bucket with sharp (flare) teeth and/or a narrow bucket with a welded sharp blade are generally able to remove most of residual materials off the concrete deck slab or deck units.

A ride-on shot blasting machine with suitable steel pellets can be used to remove left over residual bituminous materials after the concrete surface has been cleaned using an excavator.

A bobcat rotary broom with a combo sweeper brush attachment (60-70% nylon and 30-40% steel wire) can also be used to clean residual bituminous materials from the concrete bridge deck.

However, lively, tacky, rubbery, and active bituminous materials on the concrete deck slab or deck units will not be able to be removed efficiently using an excavator, shotblasting machine, or bobcat rotary broom. Therefore, if a lively bituminous material is identified during pavement investigation and construction, an alternative method to clean and texture the concrete bridge units or slab shall be proposed.

In past projects, a bobcat with a poly planer head (two row of teeth) was able to clean most of residual tacky and alive binder (refer to Figure 10.6.1(c)).

Be mindful that asphalt DWS removal process may also reduce (or smooth out) the existing texture depth on concrete bridge deck.

Below is an example of a simple methodology to remove residual bituminous materials from a concrete bridge deck:

1. Scrape residual binder as much as possible using excavator bucket with sharp teeth.
2. Clean residual prime using a bobcat rotary broom with a sweeper combo brush (30-40% steel wires and 60-70% nylon) and also a manual steel broom to clean up corners and hard to reach areas.
3. If a bobcat with a combo sweeper brush cannot remove residual sticky bituminous materials, scrape deck units with a bobcat with a poly planner attachment.
4. A small ride-on shotblasting machine should be on standby on the first night of asphalt DWS removal in case Steps 1 to 3 above is not able to clean residual prime and/or binder.

Figure 10.6.1(a) – A bobcat rotary broom with a combo sweeper brush attachment

Figure 10.6.1(b) – A small ride-on shotblasting machine

Figure 10.6.1(c) – Bobcat with a poly planer head with multi-row teeth

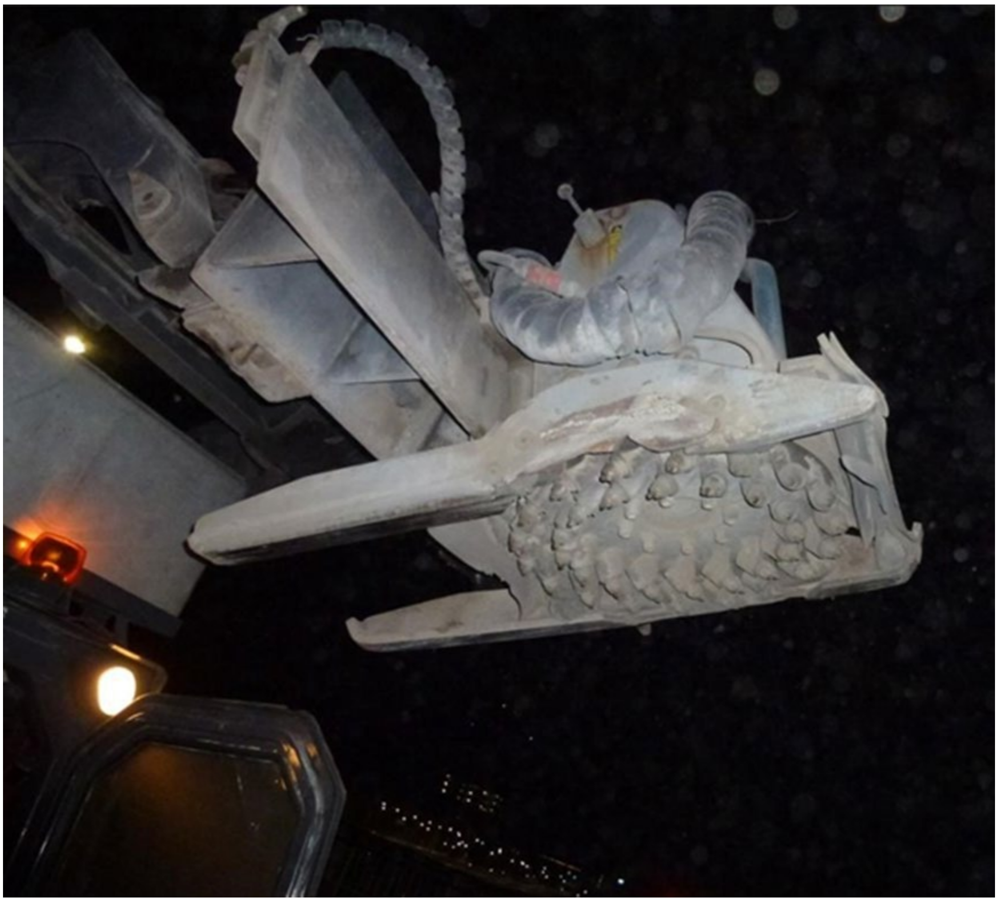
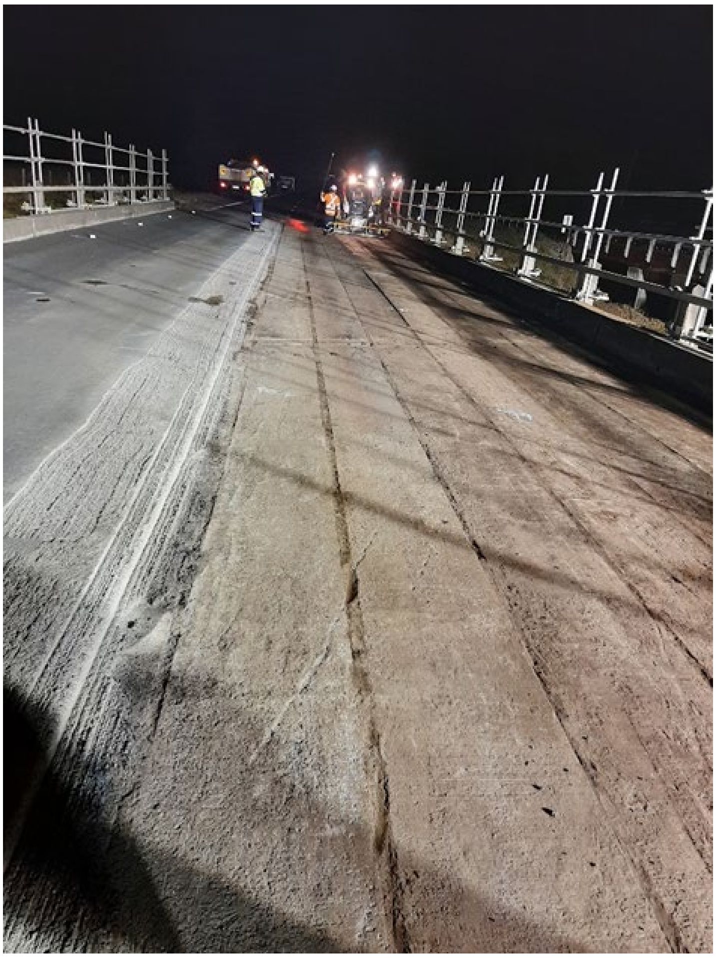


Figure 10.6.1(d) – Bituminous materials on concrete bridge deck units prior cleaning / sweeping

Figure 10.6.1(e) – Concrete bridge deck units after cleaning / sweeping



10.6.2 Retexturing

A specialist road shotblasting Contractor or a selected line removal Contractor can provide concrete surface retexturing treatment.

Shotblasting treatment using a ride-on shot blasting machine with suitable steel pellets is a low-risk method to improve the texture depth of a concrete bridge deck to a minimum 0.8 mm (Test Method AG:PT / T250 *Modified Surface Texture Depth (Pestle Method)*. Multiple shot blasting runs may be required to achieve the required cleanliness and texture depth.

Selection of steel pallets sizes is one of the important factors to achieve required texture depth. Depending on concrete deck surface hardness, steel pellets S390 (diameter 1.0-1.4 mm), S460 (diameter 1.2-1.7 mm), S550 (diameter 1.4-2.0 mm), and combined pellet sizes at certain proportion have been used to successfully texture concrete bridge deck.

In a DWS rehabilitation situation, where asphalt DWS is not subject to high vehicle lateral stresses (DWS longitudinal and transverse gradient ≤ 3%, no bends, and no traffic lights on bridge deck and abutment), subject to approval from the Principal and E&T's Pavement Rehabilitation Unit, a surface texture depth test result ≥ 0.6 mm may be accepted.

A concrete bridge deck with residual a lively, rubbery, and sticky bituminous materials cannot be shot blasted, as the bituminous materials could clog the machine.

An asphalt profiler with a micro or fine milling drum may be used to texture a bridge with a cast insitu concrete deck slab. This operation is considered high risk as machine and/or human error can result in excessive milling depths which damages the concrete bridge deck. Therefore, this treatment will require approval from a departmental asset owner and the department's E&T, Structures Review and Standards Unit (TMRStructuresE19@tmr.qld.gov.au).

It is imperative that the concrete surface is dry prior to retexturing the concrete bridge deck. If some moisture is identified on the surface, a road dryer may be used to remove excess moisture. However, if the moisture is excessive, the concrete deck may need to be allowed to dry out over a day or two prior to retexturing. Moisture on the concrete deck during retexturing operation will cause wet slurry to form which will be difficult to remove. The wet concrete slurry will also absorb the concrete prime, therefore adversely affecting the bond between the asphalt DWS and the concrete bridge deck surface.

Upon completion of cleaning and retexturing operation, loose materials and dust shall be completely removed from the bridge deck surface. A vacuum / sweeper truck is recommended to be used for a final surface clean up, supported with handheld blowers.

Figure 10.6.2(a) – Final cleaning and retexturing concrete bridge deck using a large shot-blasting machine

Figure 10.6.2(b) – Final cleaning and retexturing concrete bridge deck using a small shot-blasting machine

10.7 Concrete bridge deck crack repairs

Concrete bridge deck must be inspected upon completion of cleaning and retexturing of the concrete surface. Crack inspections shall be undertaken and any repair works shall be nominated by the department's E&T Structural Engineer or a suitably qualified Structural Engineering Consultant. Where construction time is limited, concrete repair product with short curing time may be considered.

10.8 Clearance along the bridge kerb

The contractor must check the clearances to kerb to ensure compaction equipment, (and other plant), will be able to operate the full width from kerb to kerb (refer to Section 6.6).

If the bridge railing prevents full width compaction operation, the Contractor may need to prepare a customised steel cylinder attachment to a roller to compact along the kerb edges. Alternatively, the bridge railing could be temporarily dismantled to allow for asphalt compaction.

10.9 Concrete bridge deck priming

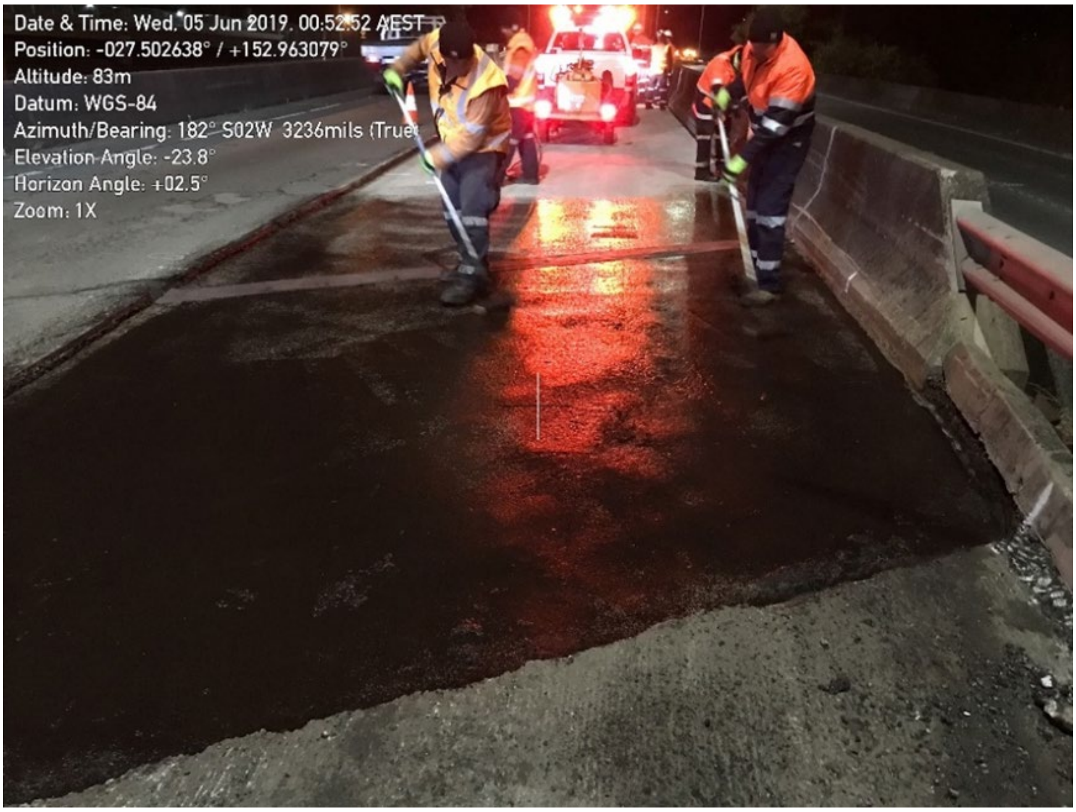
Concrete prime is an important part of DWS system as it acts as the 'glue' to bond the DWS to the textured concrete bridge deck. The prime shall be uniformly sprayed on to dry concrete surface using suitable sprayer method. Most importantly, the prime must be allowed to cure adequately to activate 'glue' or 'bonding' capability. In conjunction with a good mechanical bonding from a well-prepared concrete deck surface (cleaned and adequately textured), chemical bonding from an adequately cured concrete priming will function as a bonding interlayer that glues the asphalt DWS to the concrete bridge deck.

The current approved concrete prime (refer to the department's Product Index for Bridges and Other Structures) is an emulsion base prime that requires between 4 to 24 hours curing time, depending on weather conditions at the time of spraying.

To accelerate emulsion prime curing (for example night works), the following methodology can be adopted:

1. Preheat concrete deck with a road dryer if concrete deck temperature is below 15°C.
2. Preheat the emulsion based concrete prime to 60°C.
3. Spray uniformly to cover entire bridge deck area (manufacturer recommends a spray rate of 0.3 -0.4 L/m²).
4. Ensure the prime is breaking (change colour from brown to shiny black).
5. Ensure the prime is dry (change from shiny black to dull black).
6. Use paint rollers to spread and remove excess prime.
7. Use a road or jet blower to accelerate curing, noting the following:
    a. the jet blower shall not track wet primed surface
    b. the blower head shall be able to be adjustable and tilted up / down
    c. surface temperature on concrete deck slab / unit under treatment shall not exceed 30°C, and
    d. ensure dust or dirt is not blown into the primed area under treatment.
8. Achieve minimum 80% area of dry touch prime (dull black colour).

Figure 10.9(a) – Paint rollers used to spread and remove excess of concrete prime



Source: The Department of Transport and Main Roads

Figure 10.9(b) – Jet blower road heater used to accelerate concrete prime curing

10.10 Waterproof Membrane (WPM) installation

In addition to the requirements of MRTS84 *Deck Wearing Surface*, the following construction learnings can contribute to the longevity of a WPM bituminous seal:

- Selection of seal binder. PMB S25E binder is typically used for bridge WPM seal. Upon approval from pavement engineer, a stiffer binder may be used.
- Selection of aggregate size, 10 mm or 14 mm aggregate is typically used.
- Binder spray rate between 1.5 L/m² and 1.8 L/m² is typically applied depending on the concrete deck surface texture.
- Aggregate spread rate that provides 'adequate windows' of 1100 / ALD is typically adopted (for example, a 10 mm aggregate with an ALD of 6.5 mm will require spread rate of 170 m²/m³). It is important to remove all loose aggregate after spreading using a vacuum / sweeper truck. Loose aggregates may affect the adhesion of asphalt DWS to WPM seal through a 'ball bearing' or 'loose marbles' effect. Field spread rate of aggregate tests (Test Method Q711A) is recommended to check spread rates.
- Rolling to commence immediately after spreading the aggerate using multi tyre roller(s).
- The exposed WPM spray seal shall not be opened for traffic as this could cause the following damage:
  - crushed exposed WPM aggregates and reduced bonding of upper layer (typical damage by steel drum rollers), and
  - aggregates puncture through the seal binder, compromising the waterproofing membrane (typical damage by construction vehicles).

Figure 10.10(a) – A vacuum truck with side brushes removing loose aggregates

Figure 10.10(b) – WPM seal with adequate 'windows' between the aggregate

10.11 Asphalt placement

Placement and compaction of asphalt layers shall comply with MRTS30 *Asphalt Pavements*. In addition, to prevent damage to bridge structure (and minimising vibrations) during asphalt compaction, only tandem oscillating roller(s) operating in oscillating mode shall be used to compact the asphalt layer(s). Oscillating roller(s) can be supported by steel smooth drum roller(s) and pneumatic multi tyre roller(s) on static mode. Asphalt paver is allowed to vibrate. Based on past experience, vibrations from tandem oscillating roller(s) and asphalt paver are below the compliance limit on a bridge. Vibrations from a conventional roller on a vibratory mode will likely exceed the compliance limit. An asset owner or a bridge engineer may limit vibrations on an old bridge structure by not allowing oscillating roller but static rolling only. In this instance, the risk of under compacted asphalt DWS layers increases.

Survey pickup of existing asphalt DWS level (including at abutment and pavement transition area), of exposed concrete bridge deck and relieving slab shall be undertaken to provide a 2D or 3D model of proposed asphalt DWS configuration, which should be provided for Administrator approval. This proposed DWS profile is to confirm or supersede the previously provided design DWS. Depending on existing crossfall, gradient and rideability, the following two options can be considered.

1. Match existing asphalt DWS level, existing asphalt over relieving slab and existing asphalt over pavement transition sections.
2. Adjust crossfall and/or longitudinal gradient to meet the original design requirement and to improve rideability by ensuring smooth transition from bridge deck to pavement transition.

Option 1 is relatively simple to achieve. Option 2 will require work in close collaboration with the surveyor and asphalt paver operator to achieve the desired outcome.

For both Options 1 and 2, the proposed asphalt DWS weight shall not exceed the existing DWS weight.

Crossfall and gradient adjustment may affect surface flows and aquaplaning, and therefore will require diligent planning.

Figure 10.11(a) – Oscillating roller

Figure 10.11(b) – Asphalt compaction along the edges – bridge railing with adequate compaction clearance

Figure 10.11(c) – Asphalt compaction along the edges with a steel cylinder – bridge railing doesn't have compaction clearance

Figure 10.11(d) – Use of computerised asphalt grade level control (red panel) for improved asphalt DWS thickness precision

10.12 Engineering survey

During the DWS investigation and design, the survey requirements include:

- Existing asphalt surface Reduced Levels (RL) above concrete bridge deck, abutment and pavement transition.
- Measured concrete bridge deck and relieving slab RL from concrete scanning and asphalt cores.
- New asphalt corrector layer(s) RL above concrete bridge deck, abutment and pavement transition.
- New asphalt surfacing RL above concrete bridge deck, abutment and pavement transition.
- A 2D or 3D model of existing asphalt DWS, asphalt over abutment and pavement transition RL drawings showing road crossfalls and gradients.

- A 2D or 3D model of proposed asphalt DWS profile with road crossfall and gradient RL drawings and calculations. The proposed asphalt DWS total weight shall not exceed the existing asphalt DWS and comply with crossfall and gradient requirements.

During DWS rehabilitation process:

- The designed or provided DWS configuration and thickness shall be verified and refined by the Contractor.
- The Contractor is to engage a surveyor that meets the competency requirements to undertake a Construction (road or structure), Ground and Feature Model (GFM), and Control Surveys at the appropriate category levels as specified in the current TMR Surveying Standards to verify DWS profile design, crossfall and longitudinal gradient by undertaking a detailed level survey on existing asphalt DWS surface including abutment and pavement transition section. Level survey pick up is also to be undertaken on exposed concrete bridge deck surface, relieving slab and milled pavement transition.
- An As Constructed Survey shall be undertaken on the deck units and bridge deck in accordance with the bridges section of Clause 11 As Constructed Survey in MRTS56 *Construction Surveying* capturing DWS thickness variations across the bridge deck (at piers / abutments, mid-spans, edges and centreline). The height accuracies may be relaxed to ± 5 mm.
- The collected As Constructed Survey information is used to build a DWS profile model(s) with suitable DWS crossfall and longitudinal gradient as requested by the Administrator.
- Verified and refined DWS profile design including crossfall and longitudinal gradient adjustment shall:
  - comply with MRTS30 *Asphalt Pavements* thickness and compaction, and
  - be submitted to Administrator for approval.
- A precision level control (Paveset, Pavesmart, or equivalent) is recommended for asphalt placement at DWS, abutment, and pavement transition to ensure smooth rideability, and also ability to monitor placed asphalt quantity on the bridge.

Figure 10.12(a) – Example existing DWS reduced surface level (contour) map

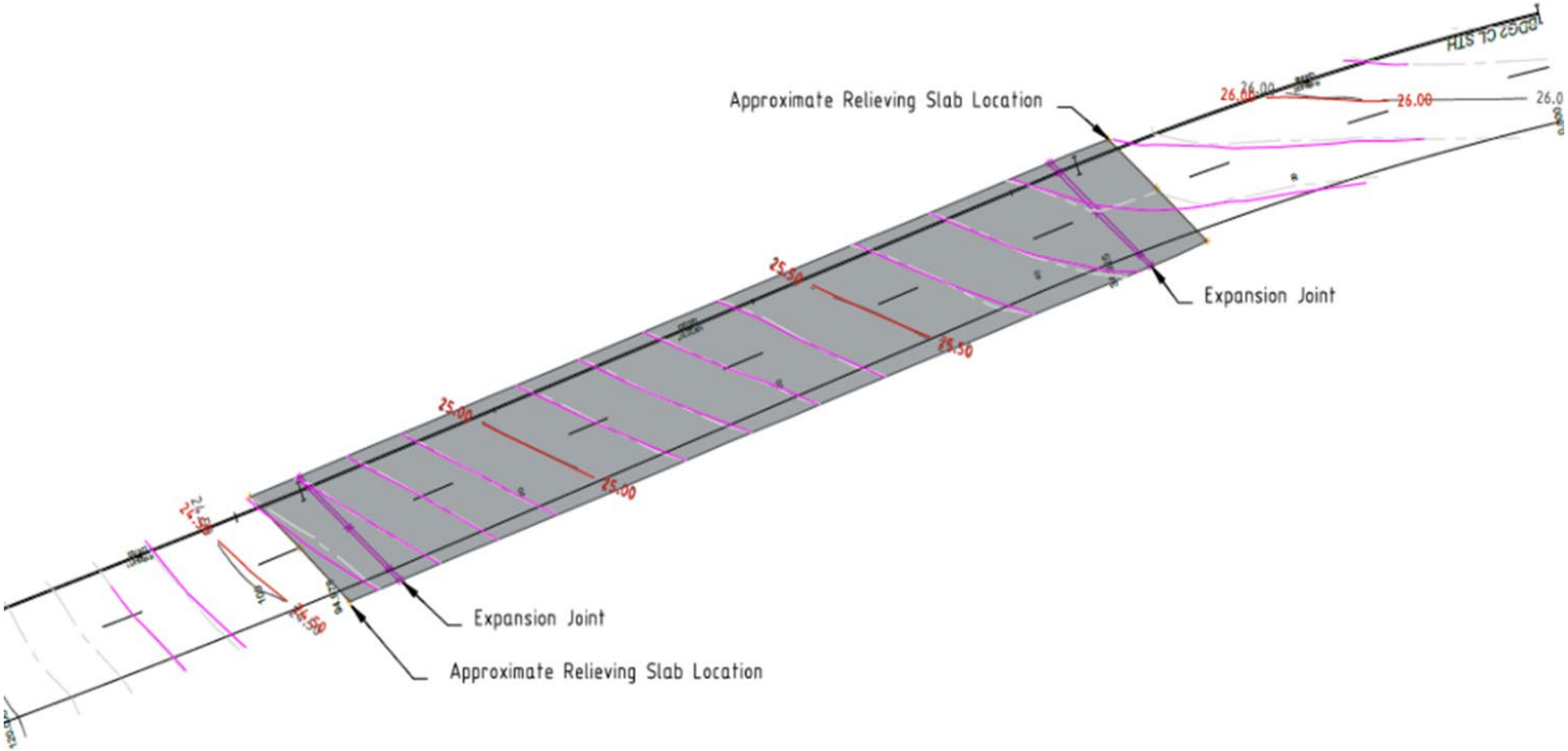


Figure 10.12(b) – Example existing DWS thickness

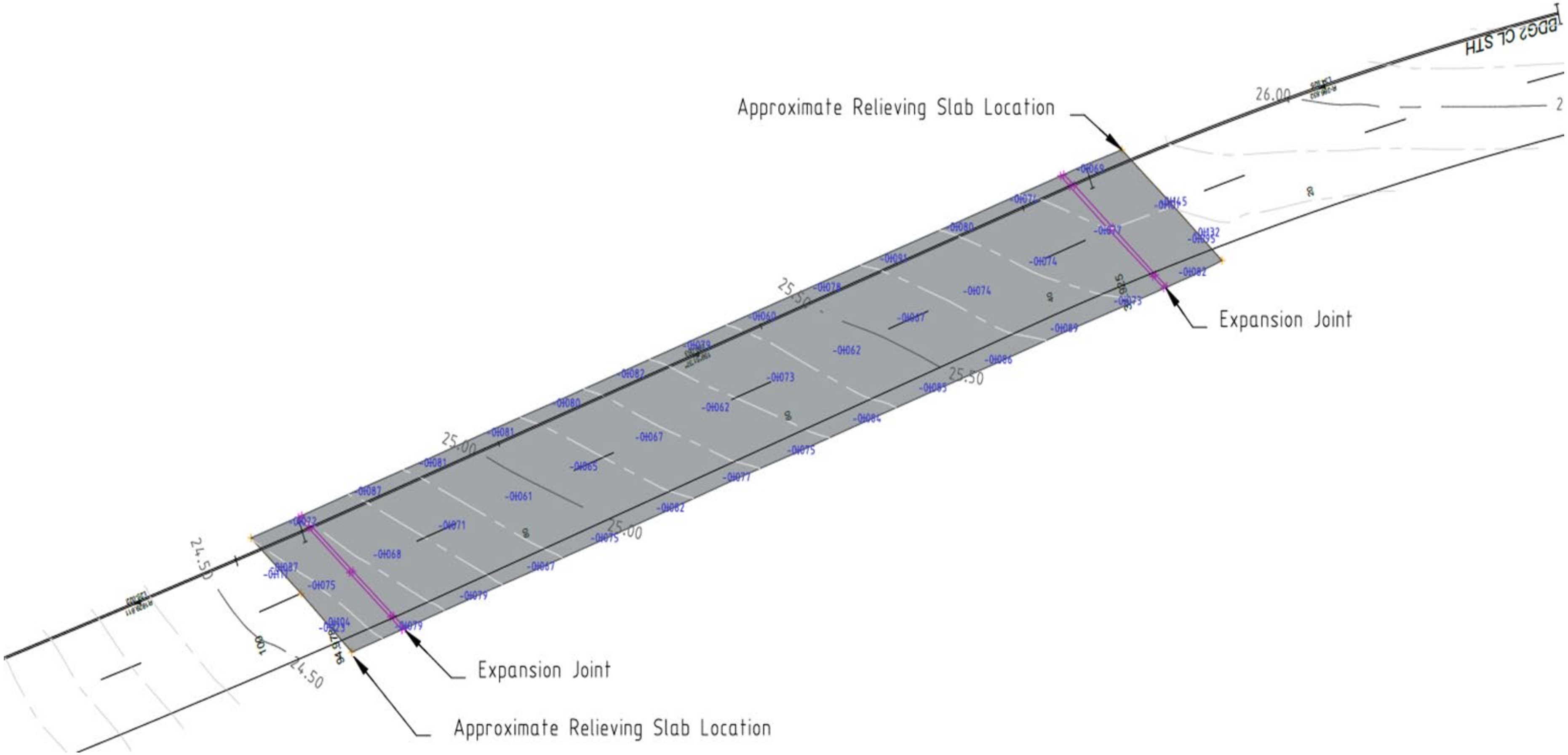
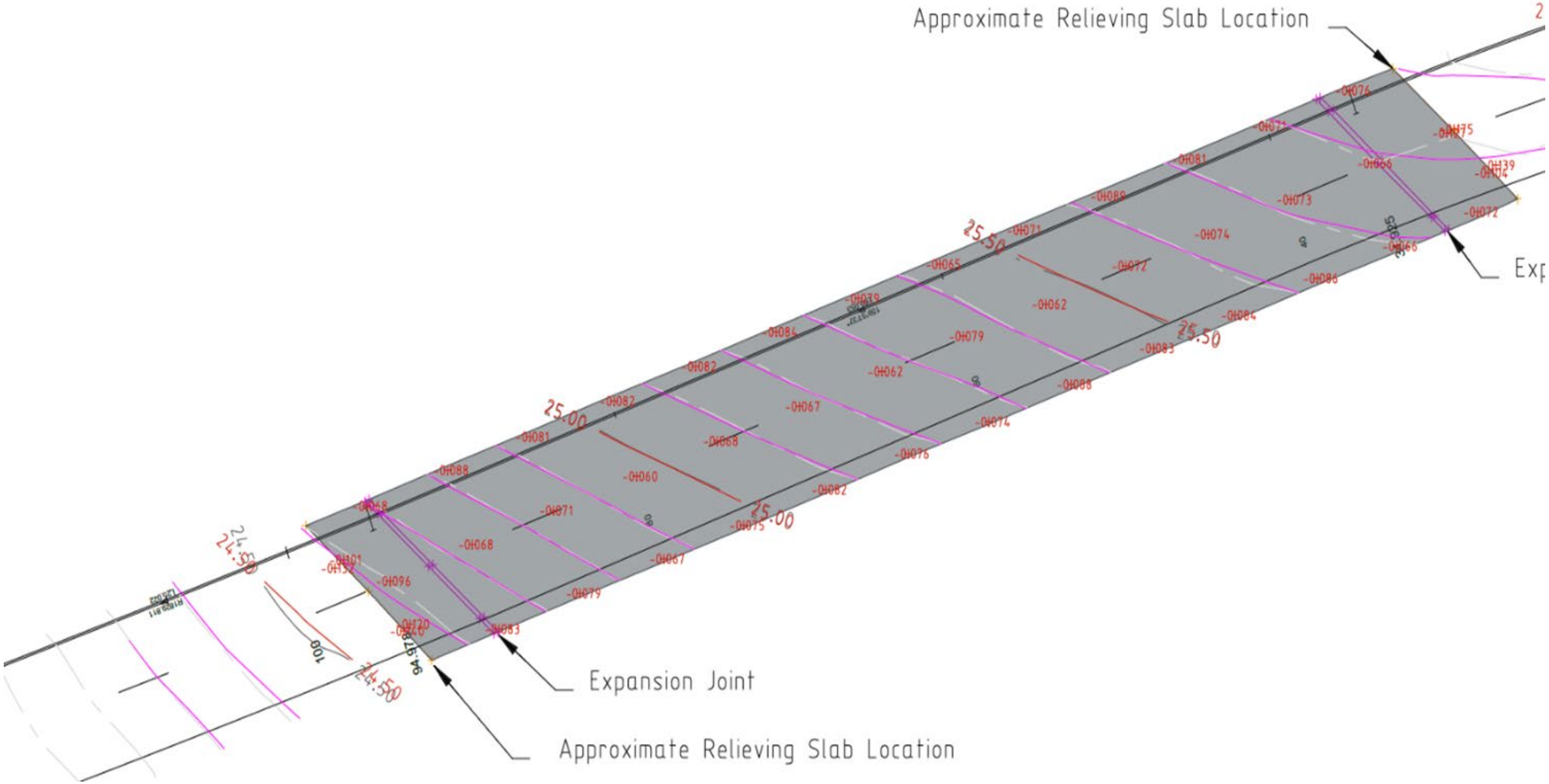


Figure 10.12(c) – Example designed DWS thickness



Appendix A – Example DWS investigation methodology

- Undertake a desktop review to assess the following information:
  - As Constructed bridge drawings
  - historical maintenance records
  - local knowledge, and
  - Level 2 and/or Level 3 bridge inspection reports.

  This information can only be used for identifying the initial DWS investigation scope. This information cannot be solely relied upon for DWS rehabilitation designs as it may be outdated and inaccurate. Regular maintenance activities can often change the DWS configuration with no details recorded. Information discrepancies can pose a significant risk to DWS rehabilitation works potentially causing construction delays.

- Undertake **site visit** to inspect and visually assess the DWS to help scope the required investigation works.

- Field investigation works shall include the use of a high frequency **Ground Penetrating Radar (GPR)** concrete scanning system (4000 Mhz and above) to estimate asphalt DWS depth, concrete cover thickness, and steel reinforcement depth.

  A GPR concrete scanner such as the Proceq GP8100 Concrete GPR Array or equivalent (refer to Figure A1) that has the capability to scan the asphalt DWS thickness to an acceptable level of accuracy (asphalt coring required for calibration) should be used.

  GPR depth scanning shall be undertaken on a dry DWS to obtain high accuracy readings.

  Wet asphalt DWS and/or trapped moisture within asphalt DWS / concrete bridge deck slab or units will compromise reading accuracy.

- Prior to the commencement of asphalt coring, **probe the asphalt DWS thickness** (refer to Figure A2 using a hand-held hammer drill with a minimum 28 mm diameter drill bit at least 200 mm long.

  The probing process shall be undertaken to estimate existing asphalt DWS depth and prevent coring through the asphalt DWS into the underlying concrete bridge deck or deck unit.

  An experienced drilling / coring operator should be able to feel material changes from asphalt to concrete deck by assessing changes in drill resistance / penetration effort and change in colour of drilling dust.

  Cease drilling immediately when a change in drilling dust colour is observed.

  A minimum of one depth probe is required for each core investigation location.

  If probing asphalt depth using a handheld hammer drill with a minimum 28 mm diameter drill bit is not successful, a spade / chisel bit should be used for removing asphalt DWS with a chiselling angle of approximately 45° to prevent damage to concrete deck units.

- **Dry coring** equipment (refer to Figure A3) shall be mounted to a trailer or a vehicle for stability and safety.

Dry coring shall utilise a suitable dust vacuum extraction system to continuously extract dust during coring operations.

Dry coring allows for the visual assessment of the change in colour of the coring dust and prevent over–coring into the underlying concrete.

Suitably experienced coring operator and/or supervisor should be undertaking the works and should be able to immediately recognise the change in coring resistance and change in colour of the coring dust.

Selection of coring barrel size (50 mm, 150 mm or 450 mm) will be required based on asphalt DWS investigation intent:

- 50 mm diameter core is typically used for DWS depth checking, to supply information for automatic level control / depth DWS design. Paveset, Synergy PaveSmart or equivalent.
- 150 mm diameter core is typically used to identify DWS profile (asphalt condition, number of layers, bonding and waterproofing membrane type and condition). 150 mm diameter cores will allow for further laboratory testing (grading, binder cent, etc) should this be required, and
- 450 mm diameter core is typically used to expose the underlying concrete bridge deck and allow assessment of its condition (that is, concrete deck surface texture, water proofing seal condition, DWS bonding to the concrete, and any residual wax curing compound). Larger openings provide an opportunity to undertake texture depth testing. Furthermore, a 450 mm extracted core sample can also provide adequate quantity of asphalt material for further laboratory evaluation and testing. Extracting a 450 mm diameter core sample intact in one piece can be a challenge if the asphalt layer thickness is greater than 100 mm. If the layer thickness is greater than 100 mm, it may be required to cut the core into smaller pieces for extraction.

Wet asphalt coring is not permitted for the following reasons:

- the water / moisture may penetrate surrounding asphalt sublayer(s), resulting in asphalt binder stripping and asphalt ravelling under repeated traffic loads
- moisture could penetrate concrete deck or deck unit and deteriorate the concrete structure, if the structure is exhibiting Alkali Silica Reactivity (ASR)
- assessing the coring dust colour changes is not possible with wet coring, and
- any trapped moisture within the DWS layers cannot be identified due to water contamination from the coring equipment.

Visually assess the bond / adhesion between asphalt DWS and underlying concrete slab or deck unit by observing resistance to extract asphalt DWS core (refer to Table 10.2).

Visually assess the surface of the concrete bridge slab or deck unit after removal of the asphalt DWS cores and record any visible defects including cracking.

Visually assess existence of a lively, tacky, rubbery, and active bituminous material on the concrete bridge slab or units. If this exists, it may cause difficulties to texture of the deck slab or unit using a shotblasting machine. A specialised high pressure water blasting machine may be able to remove residual rubbery binder.

Record details of the extracted asphalt cores condition and thickness (including photographs, notes and measurements).

- Undertake **texture depth test** (Austroads *Test Method ATM 250 Modified Surface Texture Depth (Pestle Method*)) on exposed concrete deck (refer to Figure A4) to measure the existing concrete surface texture.

  Insufficient concrete deck surface texture will result in poor bonding or lack of adhesion of the DWS to the underlying concrete deck which may result in slippage and premature failure.

- **Survey** locations of all cores and GPR scan locations X, Y, and RL coordinates (refer to Figure A5).

  Survey accuracy (of at least ± 20 mm horizontal at least ± 5 mm for height) shall be used to record test location coordinates, level / elevation of existing DWS and level / elevation exposed concrete deck at each test location.

  Horizontal and vertical datums and coordinate reference systems shall be adopted as prescribed in the *TMR Surveying Standards*. Survey information in electronic form shall be provided in 12D archive format using the *TMR Surveying Standards*.

  All surveying requirements shall be confirmed with the department's region / district Principal Surveyor. If a region or district does not have a Principal Surveyor, then all enquiries to the Principal Surveyor shall be made through TMR_Spatial_Enquiry@tmr.qld.gov.au.

- Undertake asphalt **core hole reinstatement** (refer to Figure 6.3(f)) as below:

  Option 1: Hot Mix Asphalt (AC14H):

  – remove or vacuum dust and loose materials from the coring hole
  – ensure the hole is dry and remove any moisture
  – apply emulsion tack coat to the base and sides of the hole
  – apply a strain alleviating membrane tape at the base of the hole
  – fill the hole with AC14H hot mix asphalt
  – compact asphalt using mechanical compactor in layers as per Table 8.6.1 MRTS30 *Asphalt Pavements*, and
  – allow adequate time for cooling prior to opening for traffic.

  Option 2: Elastomeric Concrete (bridge nosing product):

  – select a departmental approved product that is fast curing and has a minimum compressive strength of 20 MPa and a minimum bond strength of 10 MPa
  – remove or vacuum dust and loose materials from the coring hole
  – ensure the hole is dry and remove any moisture
  – apply a strain alleviating membrane tape at the base of the hole

- prepare two-component rapid curing liquid elastomeric concrete as per manufacture recommendation
- fill the hole with elastomeric concrete, and
- ensure to cure adequately to achieve a minimum of 20 MPa prior to opening for traffic.

Option 3: Cold Mix Asphalt:

- select cold mix asphalt product that is approved by the Principal or Administrator
- remove or vacuum dust and loose materials from the coring hole
- ensure the hole is dry and remove any moisture
- apply emulsion tack coat to the hole base and sides
- apply a strain alleviating membrane tape over the hole base
- fill the hole with Cold Mix Polymer Asphalt
- compact asphalt using a mechanical compactor in layers as per MRTS30 *Asphalt Pavements*, and
- allow for curing as per the manufacturer's recommendations prior to opening for traffic.

Selection of the appropriate asphalt core reinstatement option is typically based on availability of reinstatement material, and the duration that the reinstated core holes will be exposed to traffic (time frame between DWS investigation and construction).

Option 1: Hot Mix Asphalt or Option 2: Elastomeric Concrete reinstatement is the preferred method based on its proven long-term performance.

Figure A1 – DWS GPR depth scanning

Figure A2 –DWS depth probing with handheld drill

Figure A3 – DWS coring (to calibrate CPR depth scanning)

Figure A4 – Assessment of concrete bridge deck surface texture using sand patch test method

Figure A5 – Survey pick up of DWS scan and locations, DWS crossfall, and gradient

Figure A6 – Hot mix asphalt reinstatement

Appendix B – Example DWS drawing notes

- The proposed DWS design assumes that existing DWS weight meets the bridge loading requirement, and therefore the new design will match the existing as closely as possible, while also having the required crossfall and gradient adjustments.
- Upon review by a department's E&T Structural Engineer or suitably qualified Structural Engineer Consultant, if the existing DWS weight exceeds the allowable limits and requires weight / thickness reduction, the proposed DWS asphalt design will need to be redesigned.
- Replace full depth of asphalt DWS matching existing asphalt thickness and with some minor adjustment to road crossfall and longitudinal gradient to ensure acceptable rideability.
- The proposed DWS configuration is only for estimating purpose and shall be confirmed with the paving machine level system survey results.
- The proposed DWS design is for sections at the piers and abutments as they are the thickest DWS sections compared to mid-spans. The asphalt thickness at the mid-spans will likely be thinner due to the hogging effect.
- Flat boarding or feathering placement of the lower asphalt corrector layer shall be minimised. Asphalt thickness of surfacing layer shall meet the nominated layer thickness limits in MRTS30 *Asphalt Pavements*.
- Proposed DWS design:

  50 mm AC14H (A15E) surface layer

  6 mm Type B waterproofing membrane (10 mm aggregate PMB seal)

  30 -55 mm AC10H (A15E) corrector layer

  Concrete prime (refer to the department's *Product Index for Bridges and Other Structures)*

  Total asphalt thickness 86 mm at kerb side and 111 mm at the centre line

  Design DWS crossfall to match existing as much as possible so that 1.5% ≤ crossfall ≤ 2.5%

- Proposed asphalt design on abutment:

Option 1 (with a retrofitted relieving slab) – preferred option:

  Overlay retrofitted relieving slab with the following:

  50 mm AC14H (A15E) – Surfacing layer 1

  6 mm Waterproofing Membrane Type B (10 mm aggregate PMB Seal)

  30 -55 mm AC10H (A15E) – Base corrector layer

  --------Concrete prime (refer to the department's *Product Index for Bridges and Other Structures*)

  Total asphalt thickness 86 mm at kerb side and 111 mm at the centre line

  Design DWS crossfall to match existing as much as possible so that 1.5% ≤ crossfall ≤ 2.5%

The assumption is that relieving slab surface level matches the existing concrete deck level

Option 2 (without a retrofitted relieving slab):

Milling off asphalt to the design level

50 mm AC14H (A15E) – Surfacing layer 1

50 mm AC14H (A15E) – Surfacing layer 2

6 mm → Waterproofing Membrane Type B (10 mm aggregate PMB Seal)

Asphalt Geocomposite as per MRTS104 *Asphalt Geosynthetics for Delaying Pavement Reflective Cracking*

AMC00 prime

106 mm total asphalt thickness

DWS crossfall is to be designed to provide smooth rideability.

- Proposed asphalt design on pavement transition:

Refer to Option 2 above.