ASCP AUSTRALIAN SOCIETY FOR CONCRETE PAVEMENTS

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CONCRETE PAVEMENT PRESERVATION

MAINTENANCE AND RECIFICATION TECHNIQUES

PRESERVATION TECHNIQUES

- Diamond Grinding
- Resawing/Resealing of Joints
- Cross Stitching
- Full/Partial Slab Replacement
- Routing and Sealing
- Plastic Shrinkage Cracks
- Cementitious Patching
- Thin Asphalt Overlay
- Concrete Overlays
- Dowel Bar Retrofit
- Slab Jacking

KEY POINTS

- Routine and periodic maintenance can rectify the pavement distress to improve the reliability and serviceability of concrete pavements.
- Diamond grinding and slab replacement can rectify most of the pavement distress.
- For full slab or partial slab replacement, there is a wide range of concrete mixes available depending on the road closure period.
- Diamond grinding improves ride quality, skid resistance, delineation surface texture. It also improves overall service life by the mitigation of dynamic loading.

CONCRETE PAVEMENT PRESERVATION AND MAINTENANCE

Over the service life of a heavy-duty concrete pavement, concrete pavements will gradually degrade in ride quality and the slab surface may lose some of its initial texture, leading to a reduction in skid resistance and/or increased risk of aquaplaning. This Pavement Note summarises the types and causes of occasional concrete pavement distress, preservation and rectification options, maintenance materials, requirements and specifications available to inform pavement engineers, consultants, construction staff and maintenance staff for optimal asset management.

Occasional Concrete Pavement Distress

Concrete pavement distress can be broadly categorised into the following [1]:

- Drainage-related: Erosion of subbase (due to water travelling at high pressure with each heavy vehicle movement), pumping of fines and ejection of joint sealants resulting in faulting/stepping.

- Structural: Full depth structural cracking (longitudinal, transverse, skewed and corner cracking), opened longitudinal joints, significant joint stepping and slab rocking.

- Surfacing: Scaling/rutting, loss of surface texture, loss of ride quality, potholes and plastic shrinkage cracks.

- Joints: Reduced joint interlock (due to openings > 2.5 mm) leading to stepping or spalling, and deteriorating sealants.

An increased level of maintenance might be anticipated if construction quality or material conformance criteria are not achieved during construction. Although rare, a minor shortfall in construction quality (notably compaction) can result in significant declines in reliability. This highlights the importance of a high level of client surveillance during construction.

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PRESERVATION OPTIONS

When an existing pavement no longer provides an acceptable level of service for the prevailing traffic loading and/or environmental conditions, or when the current level of service is not deemed to be adequate for anticipated changes in those conditions, some form of preservation treatment is required.

Routine and periodic maintenance can rectify occasional pavement distress to improve the reliability and serviceability of concrete pavements. Over the service life of a heavy-duty concrete pavement, between about 1% and 3% (depending on the concrete pavement type and the environment) of concrete pavement slabs will typically require slab replacements [2] due to concrete fatigue, increased traffic loads, localised weak subgrade materials, defective materials and/or faulty construction.

Typical Preservation Techniques

Conventional Diamond Grinding (CDG) is used to improve ride quality, skid resistance, delineation and extend service life by renewal of positive surface texture [3]. In addition to CDG, Low Noise Diamond Grinding (LNDG) provides a low noise surface similar in acoustic performance to asphalt pavements [3]. This treatment is full width and nominally removes 6 mm of pavement thickness. Studies have demonstrated that it improves overall service life [4], despite a reduction in thickness, by the mitigation of dynamic loading.

Resawing/resealing of joints is required typically at 10-15 year intervals to reduce the risk of incompressible materials and water from entering the joints.

Cross stitching involves drilling and fixing N12 steel stitch bars at 30° to restrain cracks or tied joints. Longitudinal joints/cracks, skewed cracks and some corner cracks can be cross stitched. Cross stitched cracks should be routed and sealed. The process is not suitable for slabs with transverse or multiple cracks.

Full or partial slab removal & replacement (R & R) is used where slabs have cracked structurally more than once, for blowouts and/or substantial joint distress. The structural capacity of the replaced slab is effectively reset. During slab R & R, the existing subbase can also be reconstructed to treat subbase issues (such as subbase erosion). In Australia, cast in situ R & R is typically used. R & R using precast concrete panels is often used overseas. These precast concrete panels may include preformed dowel slots to enable installation of dowels at the joints.

Other Preservation Treatments

Routing and sealing are used to treat spalling at cracks where sawing is unsuitable (due to the meandering nature of the cracks). Routing and sealing of cracks may be bolstered by cross stitching.

Low viscosity penetrating epoxy resin treatment can be used to repair plastic shrinkage cracks (i.e., not full depth and up to a total crack length of 1 m in any slab). This improves water tightness, not structural capacity.

Cementitious patching of spalls which are squared off is typically accompanied by resealing of adjacent joints. Partial depth repairs can provide medium term restoration of localised distress [5].

Thin asphalt overlay (approx. 35 to 70 mm) can be used to treat large areas of deficiencies in a concrete pavement. Caution is advised when considering thin asphalt overlays over PCP and JRCP due to the high risk of reflective cracking. The likelihood and magnitude of reflective cracking could be reduced (but not eliminated) via the use of a SAMI, asphalt reinforcement grid and/or a suitable PMB in the asphalt.

Concrete overlays (bonded or unbonded depending on traffic level) between 50 mm and 250 mm in thickness can be applied to effectively extend the service life of the existing concrete by capitalising on the substantive support provided by the existing pavement.

Dowel bar retrofit restores load transfer capacity at transverse joints by the installation of dowels into slots which are backfilled with a grout.

Slab jacking using pressure grouting or expanding resin can be undertaken to lift concrete slabs to reduce load-induced movements at joints and cracks. This is typically applied at bridge approach slabs where supporting earthworks at abutments experience consolidation.


Dowel Bar Retrofit


Cross Stitching


Conventional Diamond Grinding


Slab Replacement


Slab Jacking


Epoxy Resin Treatment

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Guide to Selection of Appropriate Treatments

The following table provides a guide to selection of appropriate treatments.

Treatments	Drainage-related distress			Surface distress						Joint / crack distress			Structural distress			
	Subbase erosion	Pumping of fines	Ejection of joint sealant	Loss of shape (Ride quality)	Transverse joint stepping (≤ 10 mm)	Scaling / rutting	Loss of surface texture	Potholes / punchout	Plastic shrinkage cracks	Loss or degradation of joint sealant	Spalling at joints	Spalling at cracks	Full depth structural cracking	Opened tied longitudinal joints	Transverse joint stepping (> 10 mm)	Low load transfer and slab rocking
Typical preservation treatments																
Diamond grinding (CDG/LNDG)				■	■	■	■								□	
Slab replacement					■	■	■	■	■		■	■	■	■	■	■
Cross stitching													□	■		
Joint resawing/resealing			■							■						
Other preservation treatments																
Thin asphalt overlay				■	■	■	■				■	■			□	
Bonded concrete topping						■	■									
Penetrating epoxy resin									■							
Cementitious patching								■			■	■				
Routing and sealing											□	■				
Dowel retrofit					□										■	■
Slab jacking	■														■	■
Installation of subsurface drainage	■	■														
Subbase reconstruction	■	■													■	■

■ Typically, suitable.

□ May be suitable depending on the nature and severity of the distress.

Major Rehabilitation Using Concrete or Asphalt Overlay

For existing concrete pavements that are experiencing widespread slab distress that cannot be economically repaired and retained, a major rehabilitation may be required. Such treatments could include **thick asphalt overlay** (placed on the existing concrete pavement with a SAMI, asphalt reinforcement grid and/or polymer modified binder in the asphalt), **consolidated slab replacement**, **unbonded concrete overlays** which use the existing concrete pavement as a subbase (prior to which selected slabs and joints should be stabilised or rectified), and **slab fracturing techniques** (crack and seat, or rubblisation) which both aim to inhibit reflective cracking in the subsequent asphalt overlays. Rubblisation, however is considered a low value capitalisation of residual support provided by the existing concrete pavement, and should only be used in rare cases.

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MAINTENANCE MATERIALS

Concrete for Slab Replacement

For full slab or partial slab replacement, there is a wide range of concrete mixes that may be used, depending on the size of the targeted area, pavement type and traffic level. The currently available concrete mixes include:

- Special-class 40 MPa paving concrete (with or without calcium chloride accelerating admixture)
- High early strength Special-class 40 MPa (with calcium sulfoaluminate cement)
- Steel fibre reinforced concrete (with or without non-corrosive accelerating admixture)
- Steel fibre reinforced concrete (with calcium sulfoaluminate cement)

Typically, high early strength concrete (HES) is required for lane closures of less than 12 hours (eg overnight slab replacement). Slab replacement materials involve the use of concrete gaining relatively high early age strength, traditionally from the use of chemical accelerators or specialised cements.

Cementitious Patching Material

For spall repairs, typically proprietary cementitious materials are used. The patching material should contain aggregate no larger than one third of the depth of the spall repair, bond effectively with the existing concrete pavement, match or exceed the base concrete strength, be of similar colour to the concrete base, and be UV stable, non-shrink, non-expansive, and of similar coefficient of thermal expansion to concrete.

END OF LIFE PERFORMANCE

Experience in the USA and Australia has demonstrated conclusively that concrete pavements do not suddenly fail at the end of their nominated life. In reality, pavements which have exceeded theoretical capacity for fatigue loading or erosion will experience a protracted decline in performance reliability below the original design threshold (for an anticipated level of maintenance). In other words, concrete pavement deterioration rates will gradually increase beyond the nominal design period (eg, 40 years). Depending on the significance of the pavement corridor (eg, highway, airport or commercial pavement), increased levels of deterioration may be tolerable, and the pavement may be affordably retained through preservation, particularly when compared with full replacement costs.

CONCLUSIONS

The causes and types of occasional concrete pavement deterioration are summarised in this Pavement Note along with possible rectification techniques that will assist pavement engineers and maintenance crews. From a technical standpoint, these techniques assist in promoting pavement longevity and offer a safe and comfortable driving experience on concrete pavements. If these cost-effective maintenance treatments are followed, the longevity of rigid pavements can be significantly improved.

REFERENCES

1 Austroads, 2019, 'Guide to Pavement Technology Part 5: Pavement Evaluation and Treatment Design, New South Wales

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Various images were used from publicly-available documents for which thanks is acknowledged - these include Austroads, FHWA, CPTech, forconstructionpros.com, and dissertations.

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