Concrete pavement maintenance

Session 1 - Concrete pavement fundamentals, deterioration, defect diagnosis and treatment options

16th November 2021

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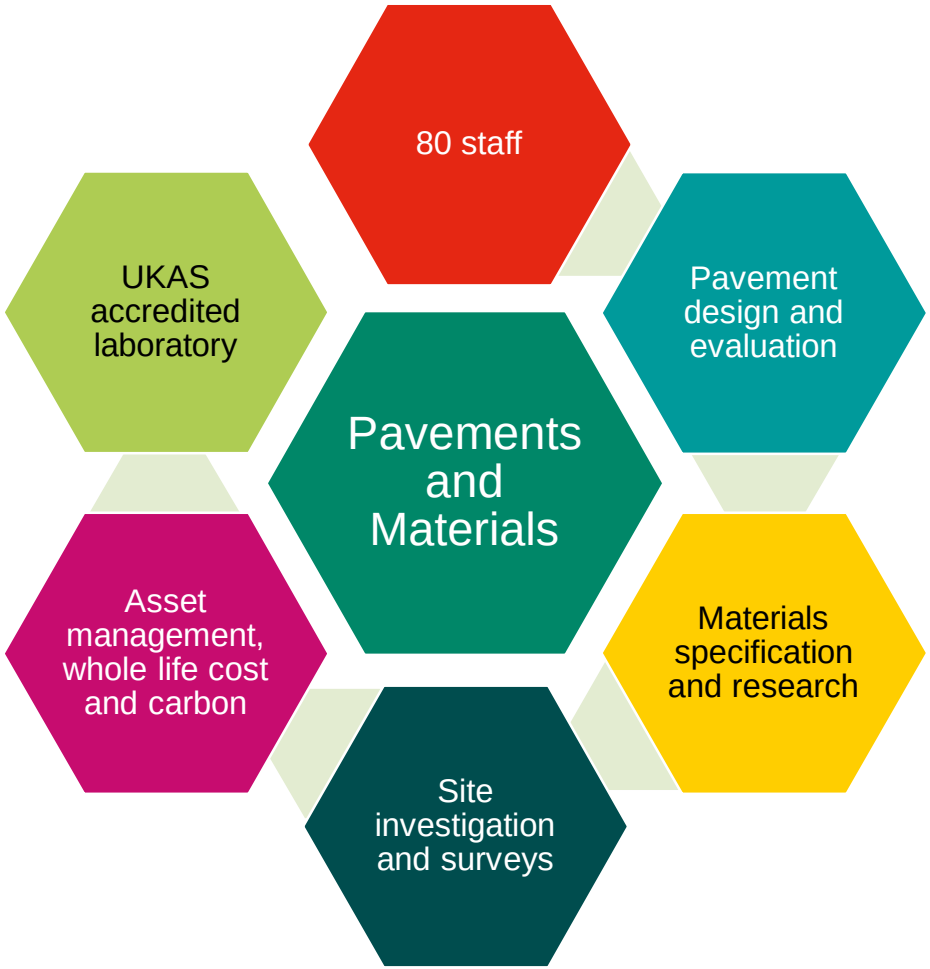
AECOM Pavement Design, Asset Management and Operations



We are a one stop shop!

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Recent and ongoing projects

National Highways

- Concrete roads design framework
- Concrete roads D&B (with Morgan Sindall)
- Concrete Pavement Maintenance Manual
- Legacy concrete pavement whole life cost and asset management
- RIS3 legacy concrete pavement planning and prioritisation

Transport for London

- Research on reflective cracking of asphalt over concrete

Defence Infrastructure Organisation (DIO)

- Updating DIO TS06 pavement maintenance manual
- High Temperature Resistant Concrete for F35 fighter jet vertical landing pads at RAF Marham

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Content

- Overview of the Concrete Pavement Maintenance Manual (CPMM)
- Basic principles of concrete pavements
- How concrete pavements fail
- How we can diagnose defects in concrete pavements
- Treatment options

Concrete Pavement Maintenance Manual (CPMM)

- Published in 2021

- Developed by AECOM in collaboration with Britpave

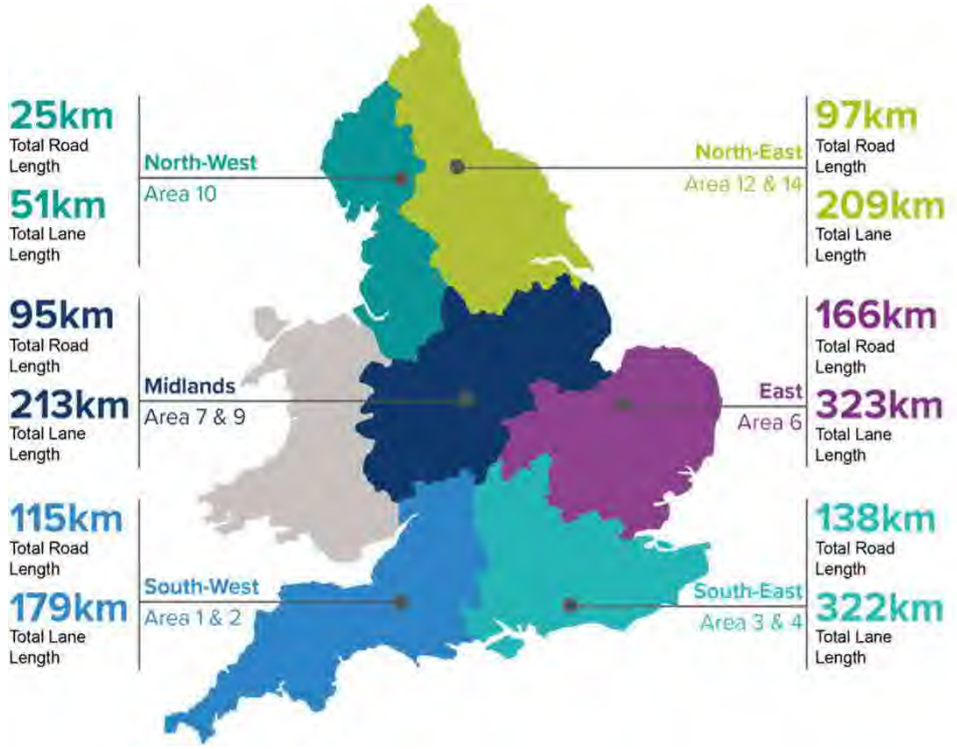
- National Highways Publication, funded by Concrete Centre of Excellence (CoE) under the Legacy Concrete Roads Programme

- Incorporates input from many other stakeholders via innovation projects, network trials and UKPLG Working Group 8

Available via National Highways Concrete CoE and at https://aecom.com/uk/pavement-design-publications/

Use of the CPMM (from a National Highways perspective)

- Part of the wider concrete roads programme to repair and reconstruct concrete pavements
- DMRB and SHW contain requirements
- CPMM is guidance only
- Focus on repair works, but with guidance on restoration of deficient pavements



Overview of the new CPMM – selected highlights

Facilitates right-first-time repairs:

- Selecting appropriate treatment based on defect characteristic
- Selecting appropriate repair material
- Undertaking repair with correct technique

Chapters:

- Investigation techniques
- Defects and features
- Defects causation and diagnosis
- Repair techniques
- Repair materials
- Restoration

Technology readiness level	Description	Assessment implication & further work recommendation
1	Basic principles observed and reported.	(Further) Laboratory investigation and validation.
2	Technology concept and / or application formulated.	
3	Analytical and experimental critical function and / or characteristic proof-of-concept.	
4	Technology validation in a laboratory environment.	Demonstration / validation of concept trial (off SRN).
5	Technology basic validation in a relevant environment.	Trafficked demonstration / validation of concept trial (off SRN).
6	Technology model or prototype demonstration in a relevant environment.	Demonstration / validation of concept trial (on SRN).
7	Technology prototype demonstration in an operational environment.	Departure from standard authorised on project basis.
8	Actual technology completed and qualified through test and demonstration.	Departure from standard authorised on project basis. Standard / specification in development.
9	Actual technology qualified through successful mission operations.	Approved for network use. Standard / specification published.

Content focus on technology readiness level 7 to 9

Basis principles of concrete

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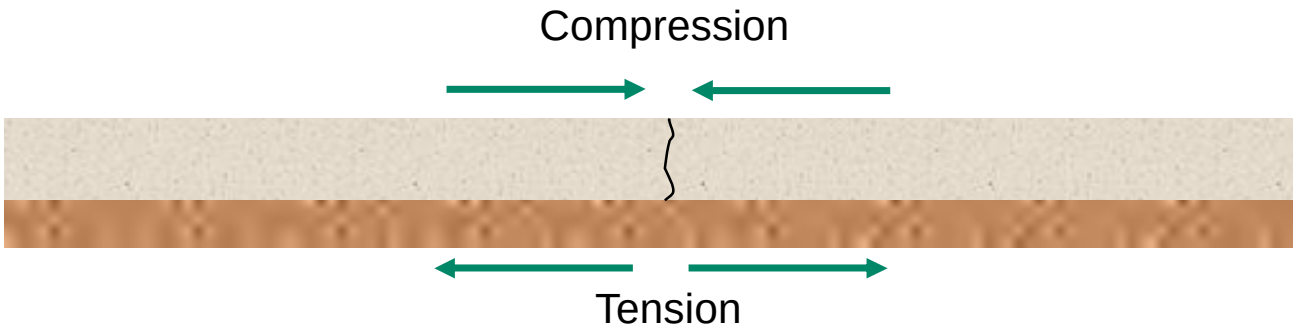
Basic principles of concrete pavements – traffic related stress

Concrete is brittle. It is strong in compression but weak in tension.

Don’t let it get into tension, otherwise it will crack!



If the stress applied regularly approaches half of the flexural strength, cracking can be expected.

How to stop cracking? By reducing the stress at the bottom of the slab:

- Increase thickness
- Increase strength
- Provide support to the slab

Basic principles of concrete pavements – non-traffic related stress

Concrete contracts and expands due to thermal changes, so it's going to crack anyway and in random places…

Why is cracking bad anyway?

- Creates a discontinuity. This generates a higher stress in the concrete for the same applied load. Higher stress = further cracking and deterioration.

- Lets water into the lower pavement layers, reducing support and in severe cases resulting in a ‘step’ across the crack.

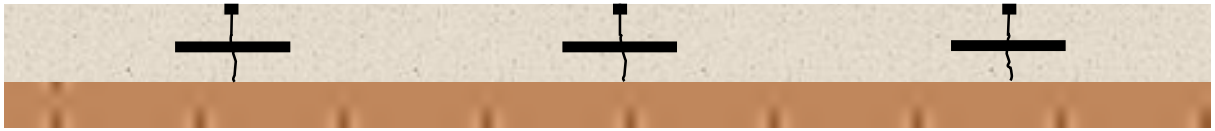
- Steps + holes + large lumps = safety and serviceability issue!

Cracking is inevitable… and it's bad… so what can we do about it???

Option 1

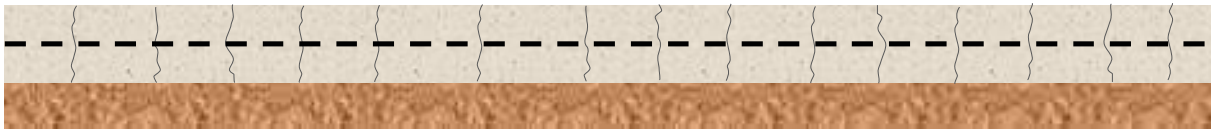
Induce cracks so they are where you want them:

- Seal them to stop water and particles entering.
- Add dowel bars for additional load transfer.



Option 2

Design the concrete to crack at regular intervals and use reinforcement to keep the cracks narrow to maintain load transfer and prevent water entering.



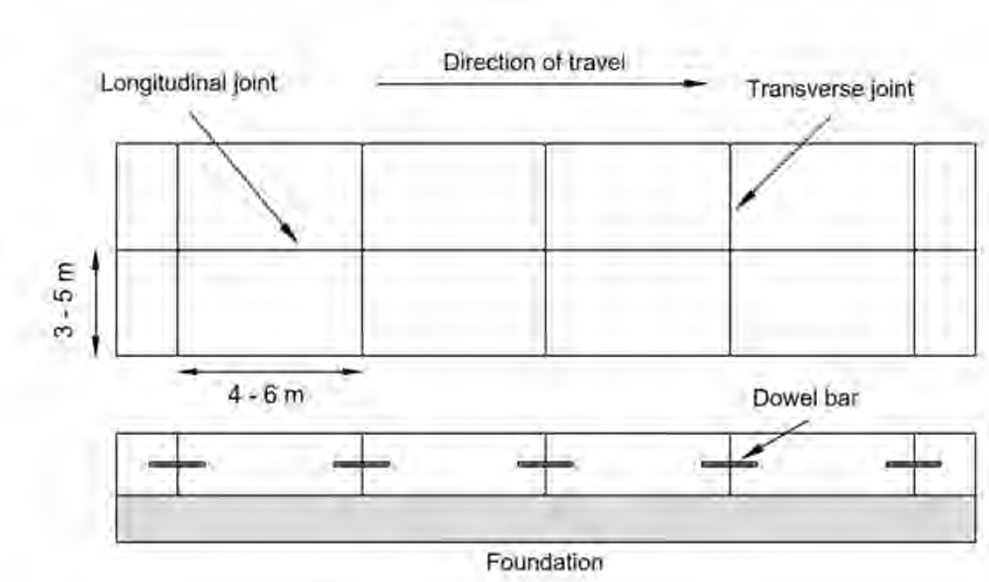
Option 1 - Jointed concrete pavements

Jointed unreinforced concrete (URC)

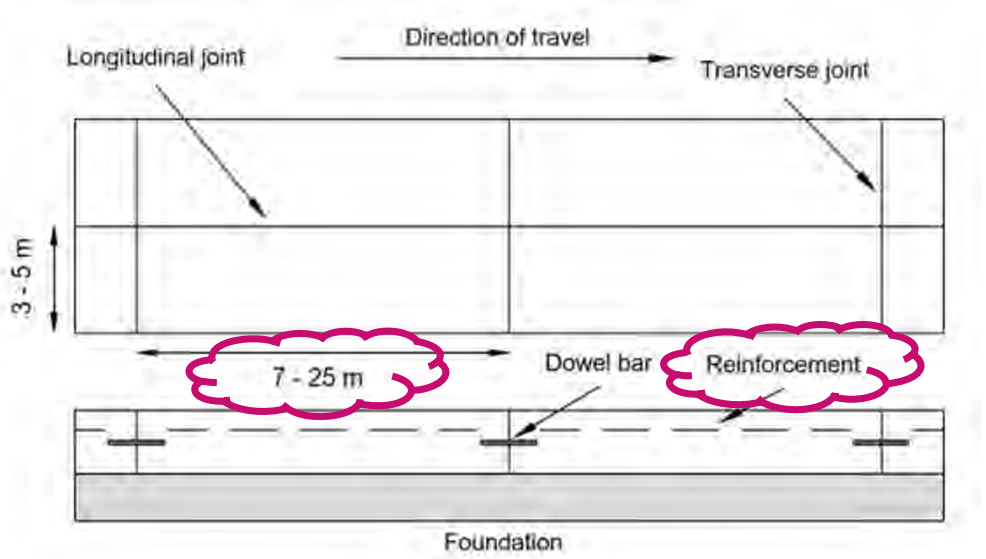
Jointed reinforced concrete (JRC)

Option 1 - Jointed concrete pavements – typical details

Jointed unreinforced concrete (URC)



Jointed reinforced concrete (JRC)



Option 2 - Continuously reinforced concrete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Jointed concrete pavements
How do they fail?
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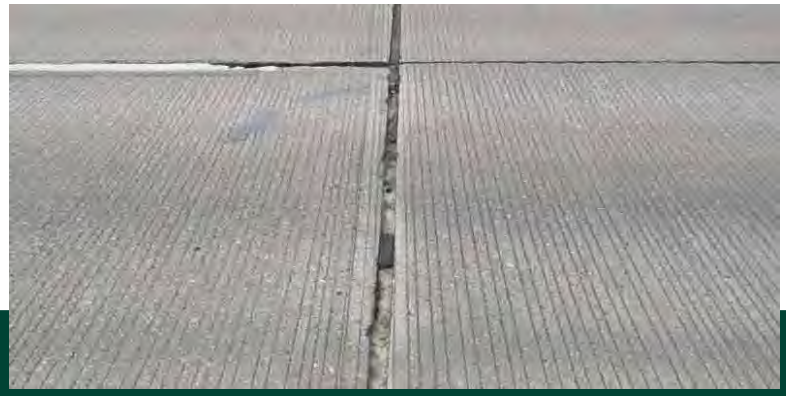
Mainly at joints…

Deep joint spall

Corner crack

Failure at joints

Typically a combination of…



Excessive stress

External stresses

Edge loading + Loss of support

+

Internal stresses

Expansion

Dowel bar corrosion

Freeze thaw

Restraint

Hard particles

Dowel / tie issues

…but also in the middle of slabs…

Transverse crack

Longitudinal crack

and sometimes catastrophically…

Stepping or faulting

Compression failure or ‘blow up’

Other failures

Excessive stress

Low temperatures

High temperatures

External stresses

Loss of support

Internal stresses

Thermal Contraction restraint

Dowel / tie bar issues

or

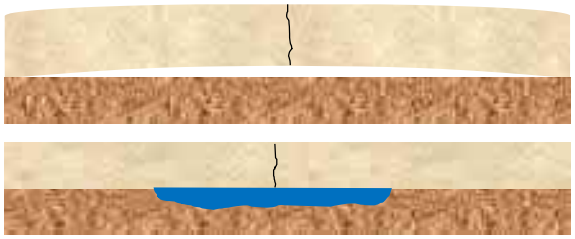
Internal stresses

Thermal expansion restraint

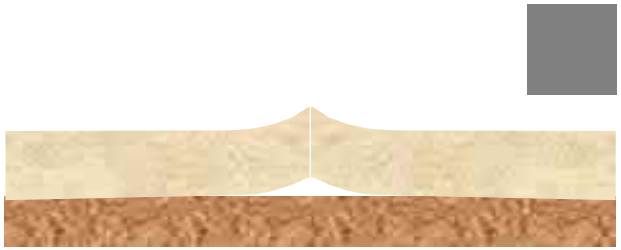
Insufficient joint space

Hard particles

Locked joints



Cracking and maybe stepping



‘Blow ups’

And there are also surface defects

Crazing

Pop-outs

Shallow spalls (confined to joint groove)

Typical causation:

- Materials
- Workmanship
- Carbonation (ageing)

Typical causation:

- Workmanship
- Inadequate maintenance

Continuously reinforced concrete pavement

Failure modes

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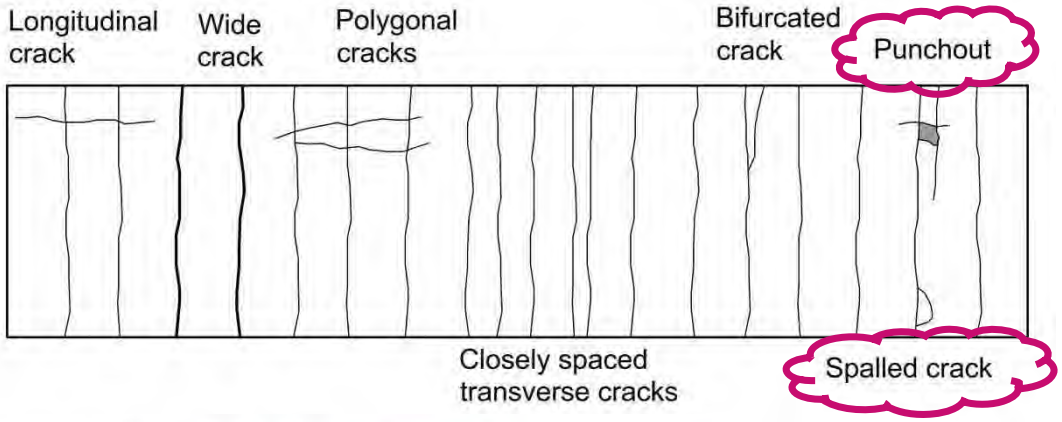
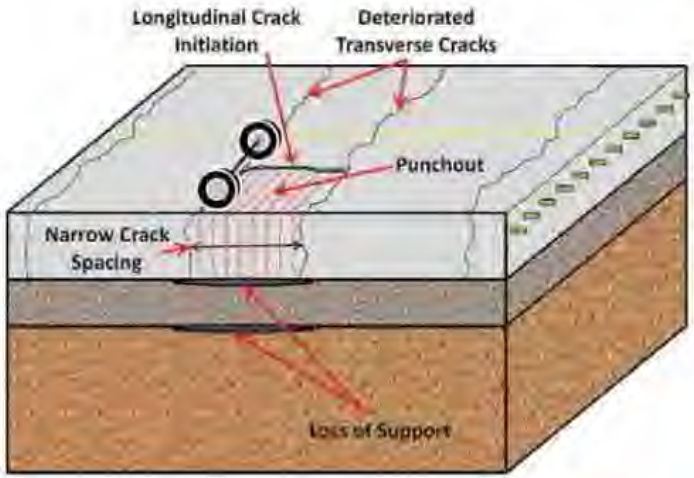
Continuously reinforced concrete pavement (CRCP) - defects





Source: FHWA

How can we diagnose defects?

Experience:

What is the defect?

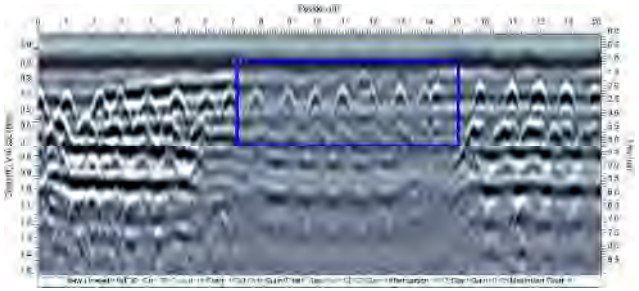
Are there other defects?

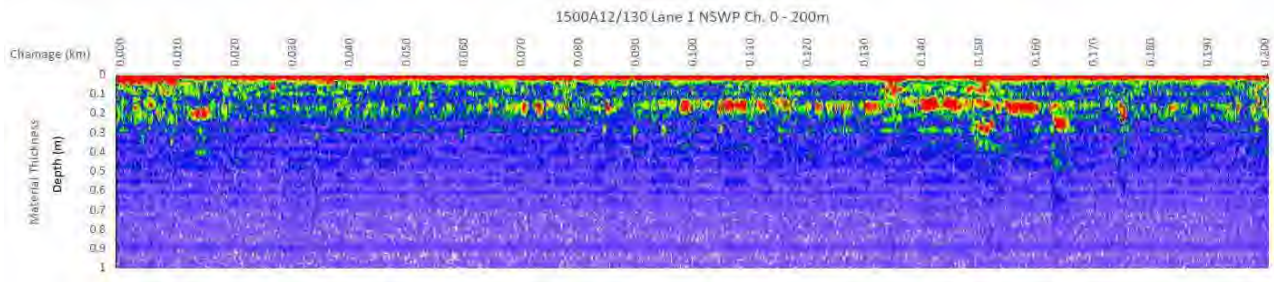
Where has it occurred?

When has it occurred?

Followed by:

- Invasive testing
- Non-invasive testing





Treatment options

See CPMM Section 4 and Appendix B.

Defects

Surface defects

Up to 1/3rd slab depth

Shallow spalls
Pop outs
Scaling
Crazing

Structural defects

> 1/3rd slab depth

Cracks

Narrow

Wide

Deep spalls
Stepping
Settlement
Blow ups

Shallow repair

Inlaid crack repair

Full depth repair + drainage!

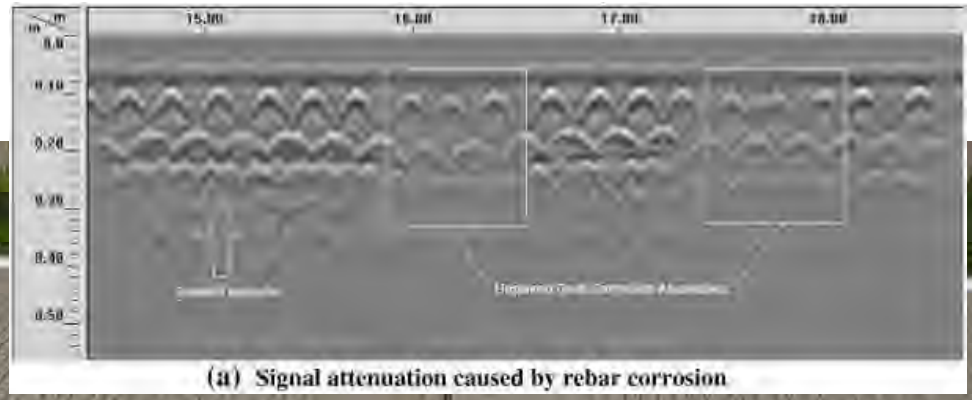
Defect diagnosis example – deep spalling

What? Deep joint spall (at this point).

Where? Dowel bar position?

When? During service life.

Deep joint spall causation	Diagnosis
Traffic and environmental loading	Potential contributor (aged pavement)
Poor slab support (erosion)	No other issues apparent, unlikely.
Incompressible materials in joint space	Too large, unlikely.
Dowel bar restraint? Corrosion?	Likely, check location coincides with dowel bar.



(a) Signal attenuation caused by rebar corrosion

When it comes to spalls, always assume the worst!

Treatment options – spalls and corner cracks

Treatment options	Benefits	Limitations
Full depth repair	Long-term repair	Expensive?
Shallow repair?	Lower cost?	Likely poor performance

- Always assume the worst, or use a flexible material for a holding repair.

Questions?

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Next session: Next week Tuesday 23rd November 2021 12:00 – 13:00

- Repair good practice
- Repair materials
- Overlay techniques