

Bridge over Hawkesbury River at Windsor

April 2013



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Services

1879



Windsor Bridge Rehabilitation and Maintenance



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- History
 - Management Strategy
 - Refurbishment Components and Strengthening
 - Cost Estimate Summary
 - Life Expectancy/Ongoing Maintenance
 - Service Level Implications
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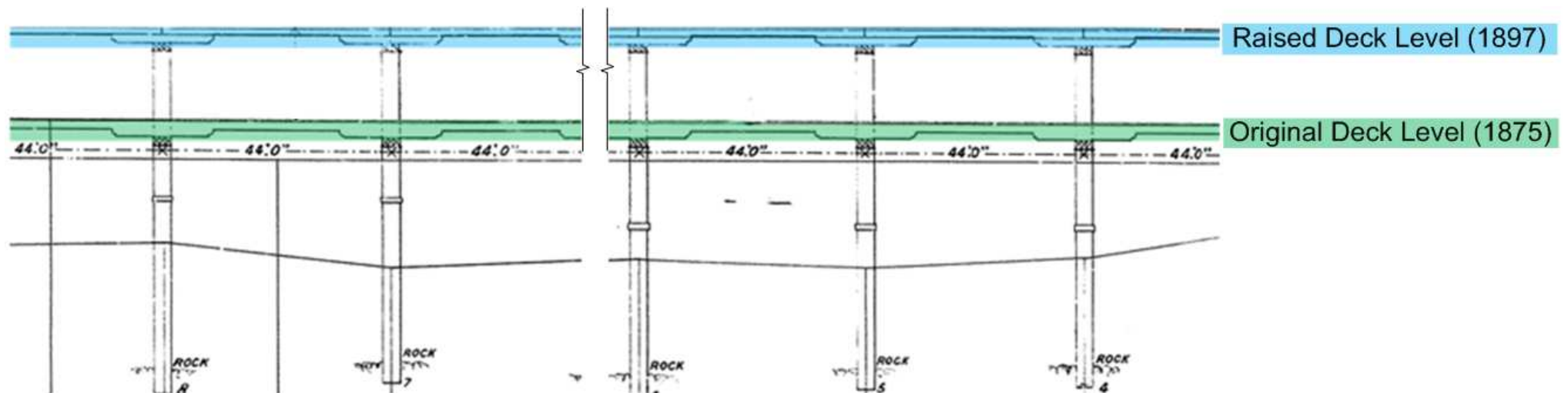
Windsor Bridge History

Bridge Construction



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- 1875 – Original bridge constructed with timber deck on cast iron piers
- 1897 – 2.4m extension of cast iron piers with timber deck
- 1922 – Timber deck, abutments and pier 10 replaced with reinforced concrete
- 1968 – Addition of footway with collapsible pedestrian railing



Windsor Bridge Management Strategy



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Action	Key Outcomes
1875 – 1993: DMR/RTA Maintenance	<ul style="list-style-type: none"> • Normal maintenance as per DMR/RTA practice (no database).
1994 – 2002 RTA Maintenance	<ul style="list-style-type: none"> • Normal maintenance as per DMR/RTA practice • BIS was developed in 1994.
2003 – 2013: RTA/RMS Level 2 inspections every two years	<ul style="list-style-type: none"> • Maintenance activities as per Level 2 reports • Level 3 Inspection and Structural Assessment in 2003 • Removal of spalling concrete to minimise risk to public.
2003: GHD Durability Condition Assessment	<ul style="list-style-type: none"> • Structure assessed to be in poor condition due to carbonation of concrete • Realkalisation recommended as long term repair solution.
2003: RTA Level 3 Inspection and Structural Assessment	<ul style="list-style-type: none"> • Bridge recommended to be replaced within five years.
2005: GHD Repair Cost Estimate and Life Cycle Cost Analysis	<ul style="list-style-type: none"> • 2 options considered for rehabilitation: <ul style="list-style-type: none"> ➢ Patch repairs: \$4.1 – 5.3m (in 2005 dollars) ➢ Realkalisation: \$2.9m (in 2005 dollars) • Repair works would still result in an inferior capacity to current design standards • Undertake underwater inspection to assess the condition of cast iron piers.

Windsor Bridge Management Strategy



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Action	Key Outcomes
2005: RTA Rehabilitation of Windsor Bridge Options	<ul style="list-style-type: none">• Cost of rehabilitation considered high and not cost effective• Replacement of bridge within 5 years recommended• Load testing recommended to establish current bridge performance• Monitoring of bridge recommended in the interim.
2005: Graphitisation investigation by CTI	<ul style="list-style-type: none">• Significant graphitisation identified – primarily below water level• Structural assessment of piers recommended.
2006: Performance Load Testing by RTA	<ul style="list-style-type: none">• Bridge is capable of carrying ST42.5 and BD62.5 provided risk management strategy is in place.
2010: Inspection and Structural Assessment by UTS	<ul style="list-style-type: none">• If RMS intends to decommission bridge in the near future, bridge in its present condition and loading will be safe for some time• If RMS intends to maintain bridge, further testing and detailed analysis recommended.

Windsor Bridge Management Strategy

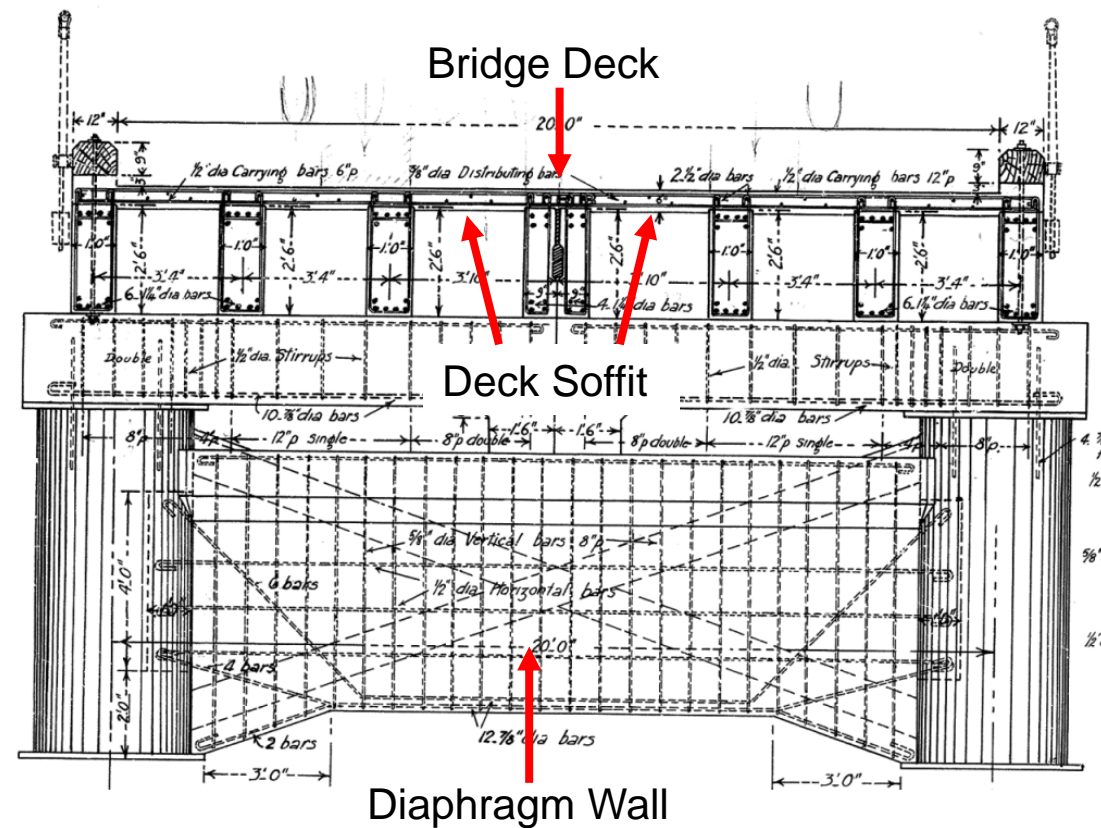


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Action	Key Outcomes
2011: Underwater Inspection by CDS	<ul style="list-style-type: none">• Horizontal and vertical cracks identified in some cast iron piers• No changes to cracks observed on Piers 5 and 6 from April to June 2011.
2011: Graphitisation Investigation by CTI	<ul style="list-style-type: none">• Significant graphitisation identified at all piers with an average residual thickness of 15mm
2013: Repeat Performance Load Testing by RMS	<ul style="list-style-type: none">• Bridge is capable of carrying HML ST45.5 and BD68 provided a reduced speed limit of 40 km/h and risk management strategy is in place.
Every six months from 2005: Bridge survey by RTA/RMS	<ul style="list-style-type: none">• No changes of vertical alignment observed since commencement of survey.

Refurbishment Components and Strengthening

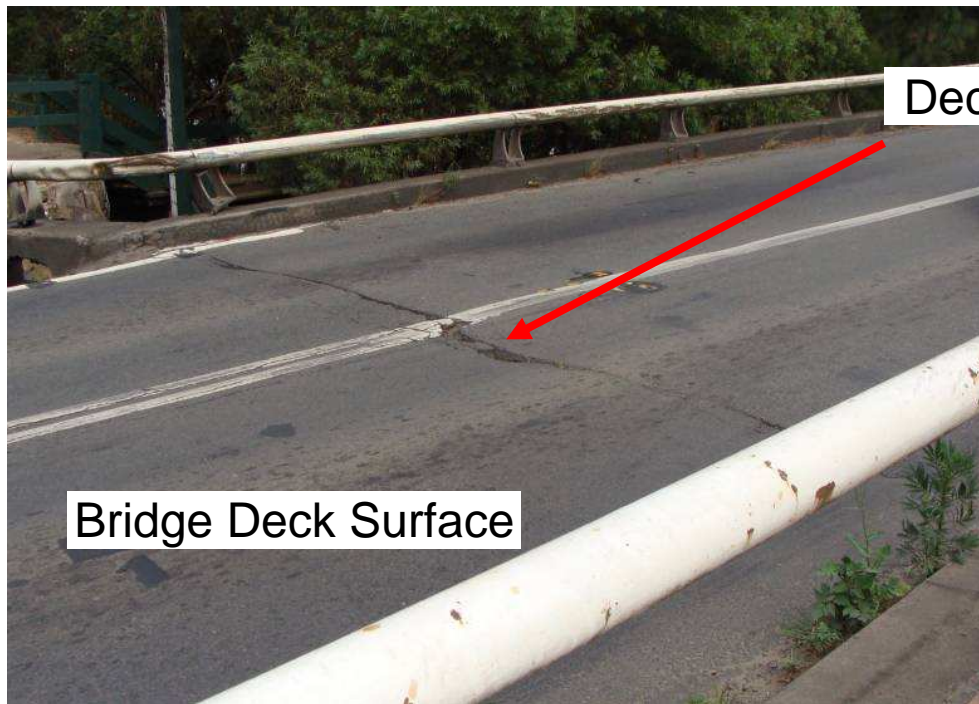
- Bridge Deck
- Deck Soffit and Joints
- Concrete Beam Ends
- Carbonation and Concrete Realkalisation
- Diaphragm Walls and Steel Bracing
- Piers
- Steel Girders



Bridge Deck

Deck Joints, Slab Repairs, Deck Drainage & Reseal

- Deck joints in poor condition and require repair
- Reseal of deck and installation of drainage system required



Cracking and bulging of asphaltic concrete at deck joints

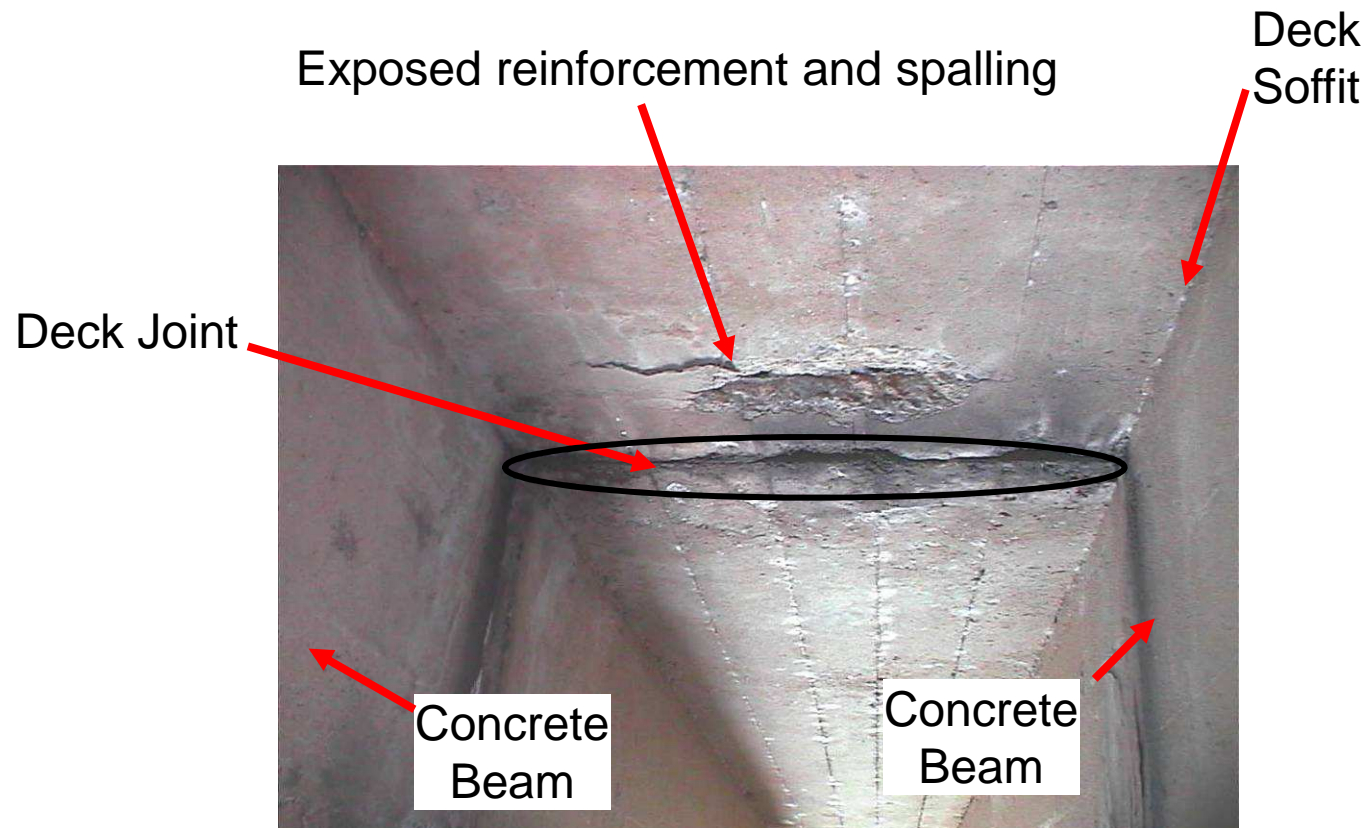
Deck Soffit and Joints

Deck Joints and Slab Repairs



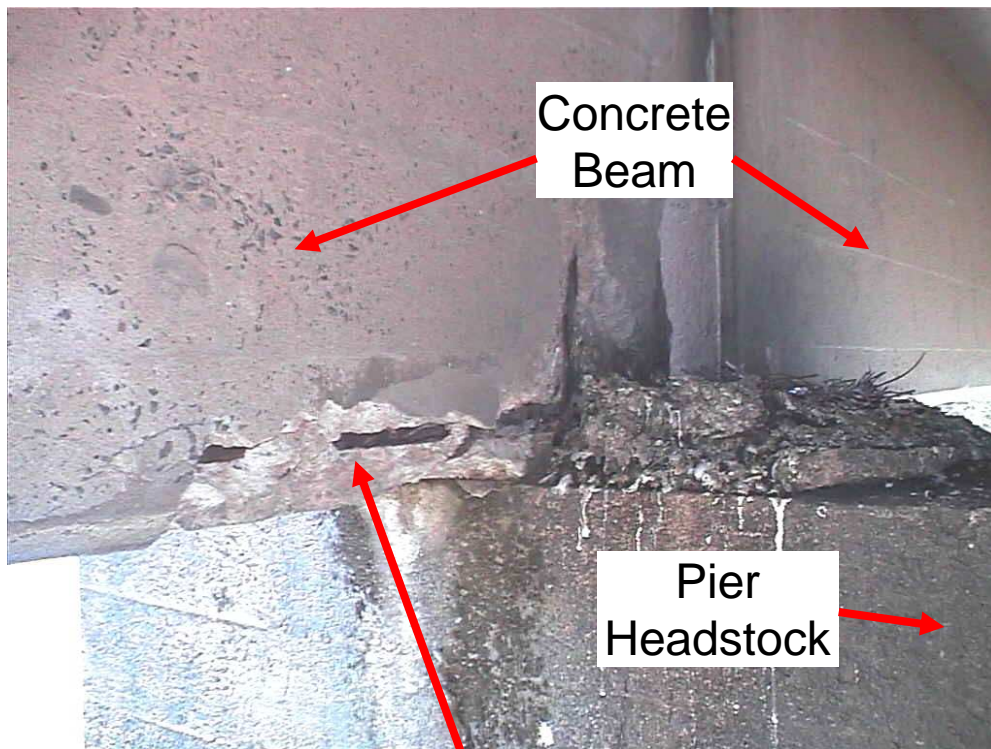
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- Cracking in deck slab soffit occurring at bridge joints

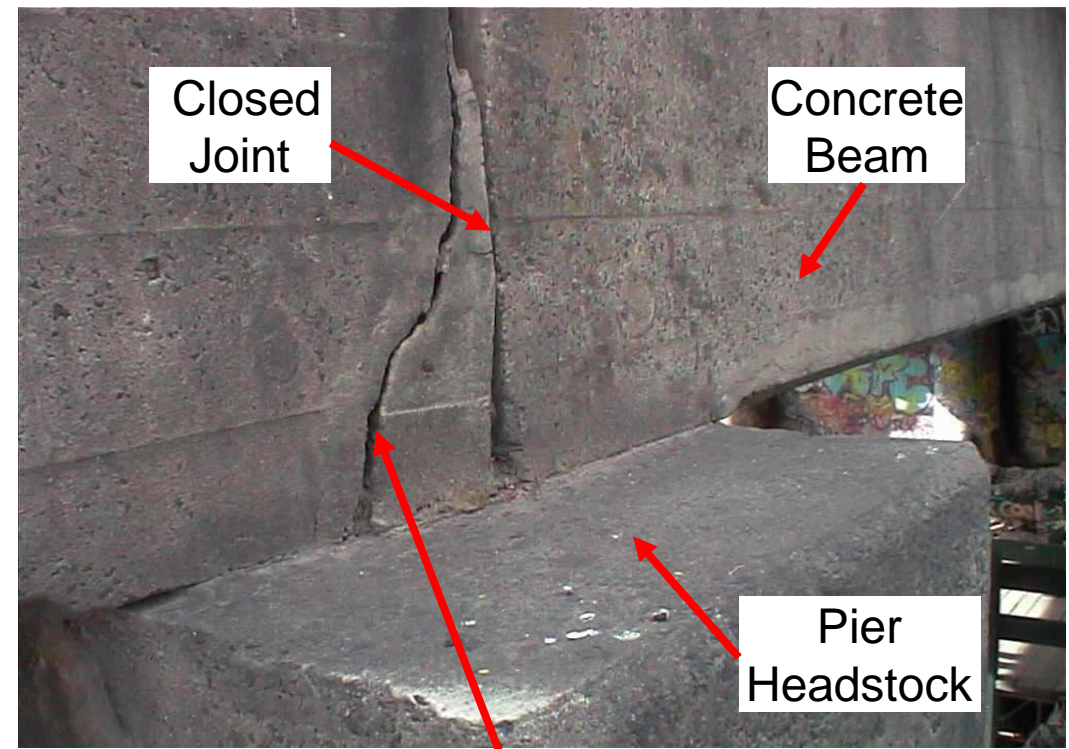


Concrete Beam Ends

- Cracked and damaged region located 0.5 – 1 m from ends of beams
- 25 locations with damaged beam ends



Pier 4 Beam 1 – Severe spalling and loss of 50% of seating area



Pier 1 Beam 1 – Wide cracks

Carbonation and Concrete Realkalisation

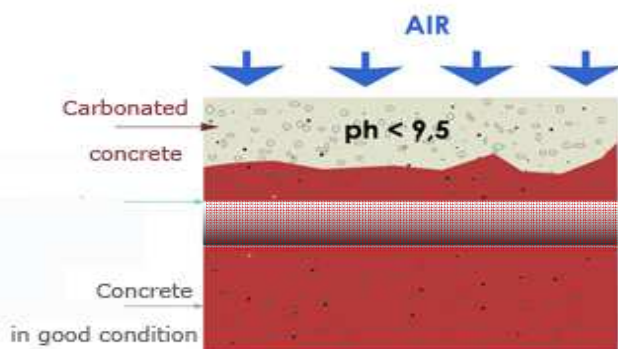
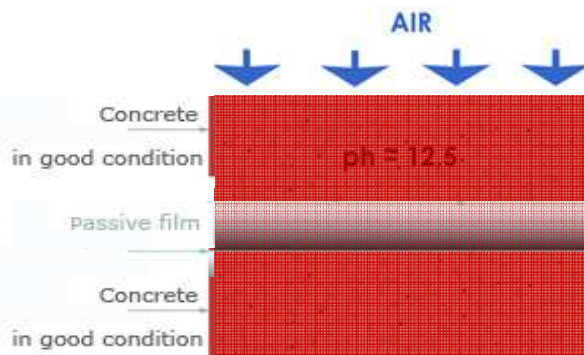
Main Deterioration Mechanism – Ferrous material (cast iron)



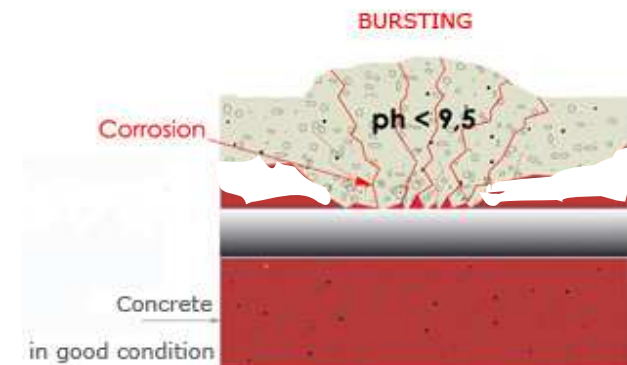
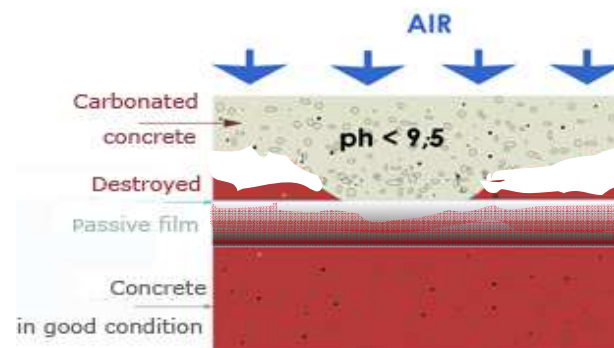
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Carbonation

- The reaction of carbon dioxide with concrete
- Starts at the surface and progressively reduces concrete alkalinity
- When the passive protection around the reinforcement is removed, corrosion begins
- Process used to arrest carbonation is realkalisation.



Protection removed \Rightarrow Corrosion initiates

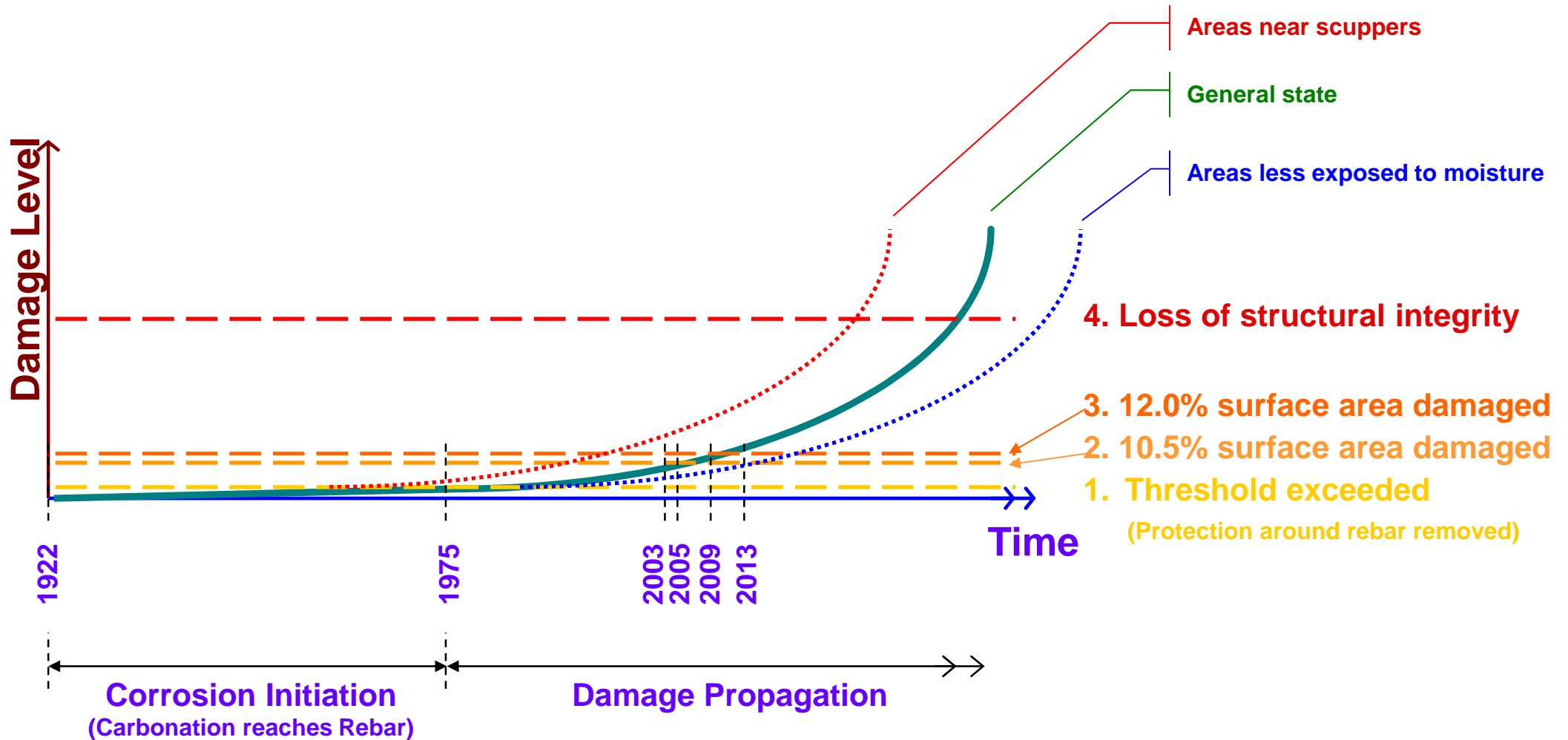


Carbonation and Concrete Realkalisation

Concrete Damage Model - Carbonation

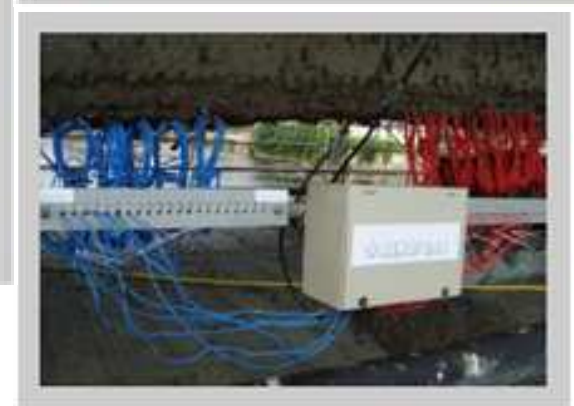
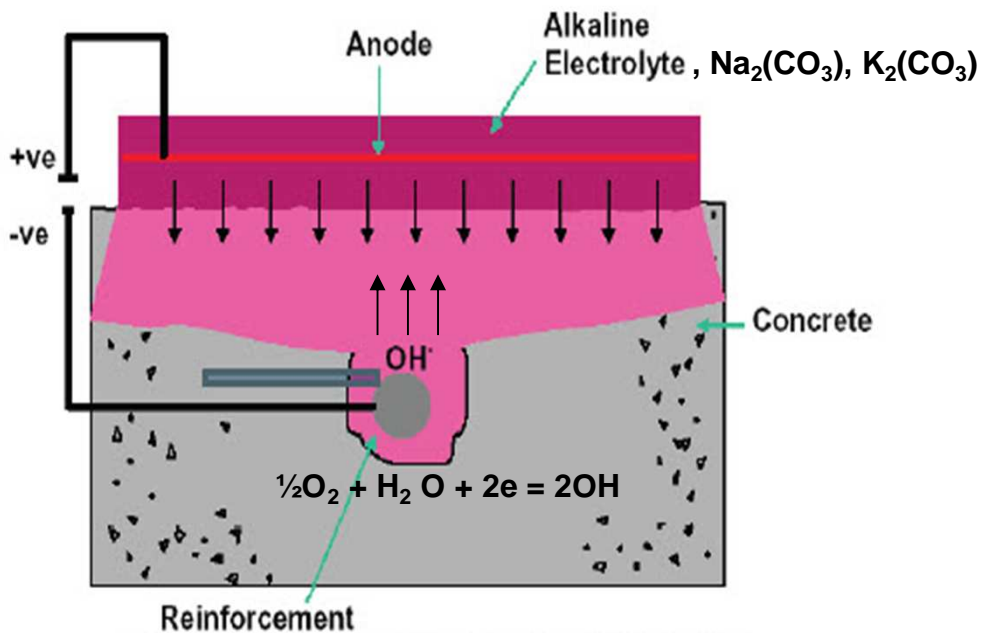


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Electrochemical realkalisation

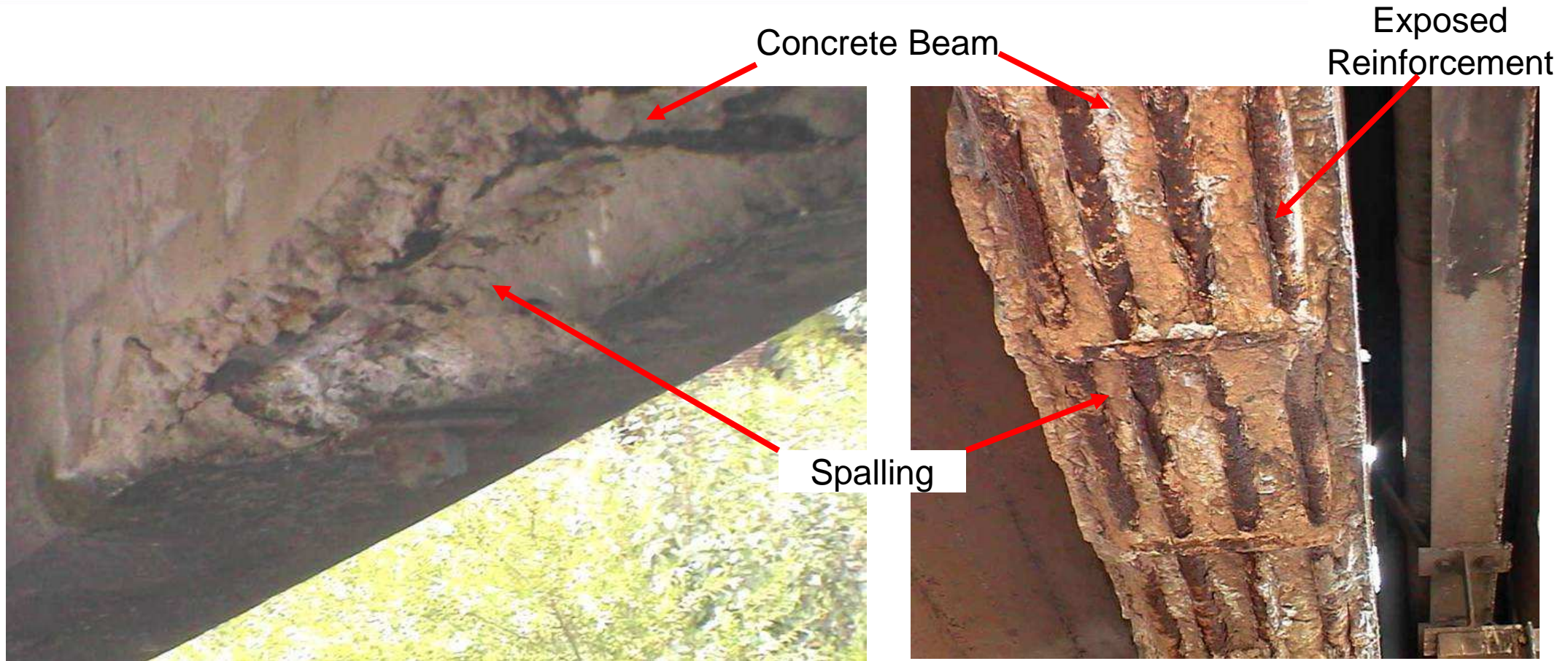
- Bridge over Cooks River at Marrickville - only local full scale application of electrochemical realkalisation in NSW.



Carbonation and Concrete Realkalisation



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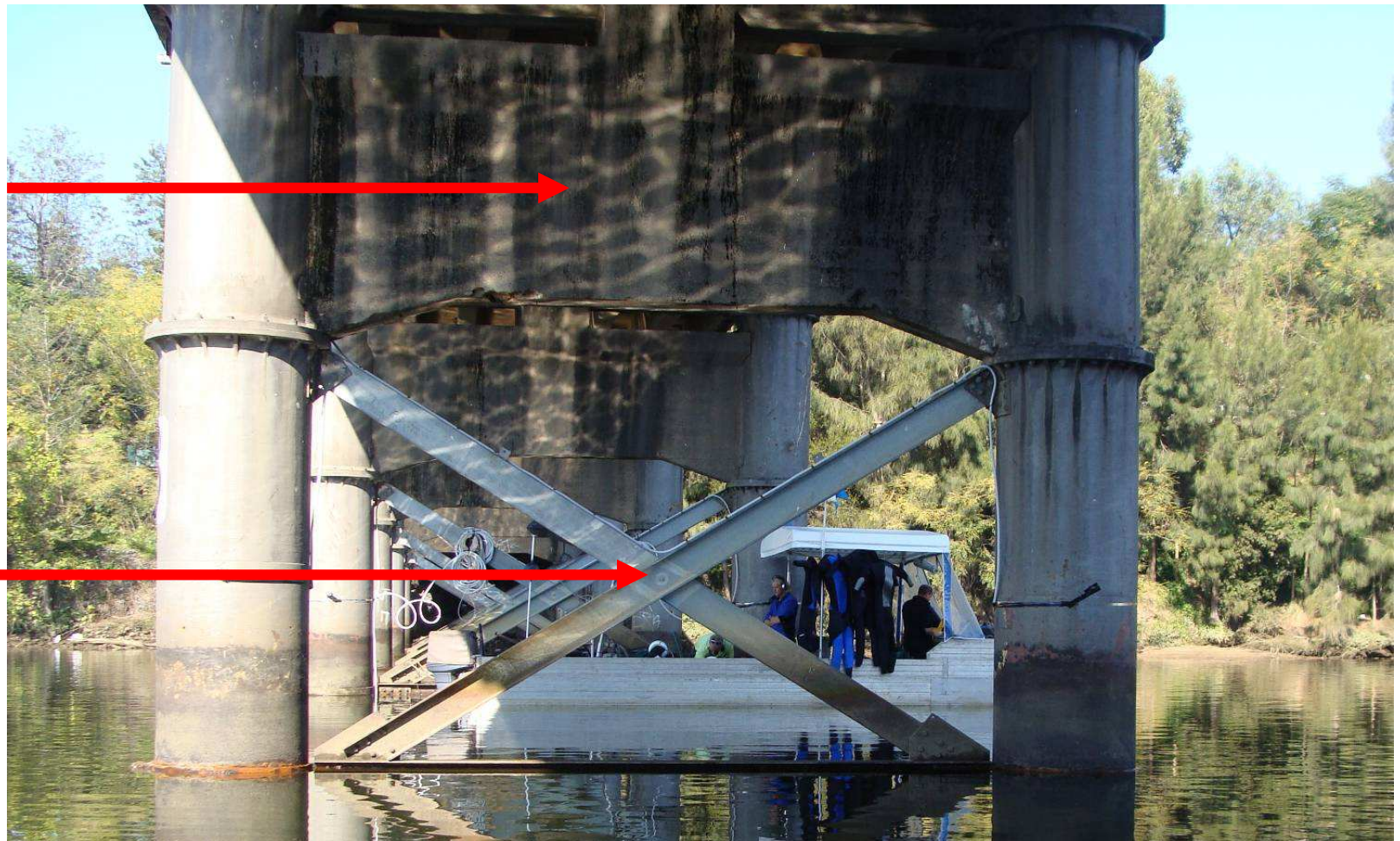


Span 2 Beam 1 – Typical spalling with exposed reinforcement and section loss

Span 4 Beam 8 – Severe spalling with exposed reinforcement and section loss

Diaphragm Walls and Steel Bracing

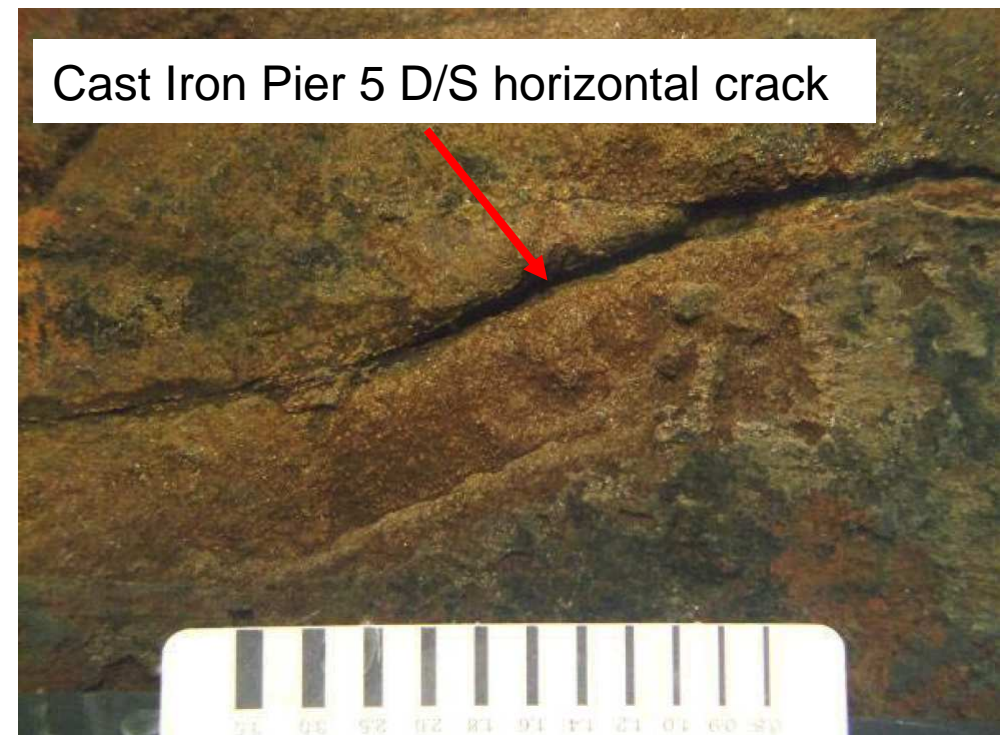
Concrete
Diaphragm Wall



Steel Bracing

Graphitisation and Cracking of Piers

- Cast iron piers in poor condition some with total circumferential cracking and significant graphitisation with section losses
- Core samples show more than 20mm of graphitised material below water
- Average residual structural thickness ~ 15mm (0mm in some areas)



Graphitisation and Cracking of Piers

Graphitic corrosion (aka graphitisation)

- A form of deterioration of cast iron in which the metallic components are selectively converted to corrosion products leaving the graphite intact (No structural strength).



Corrosion Product

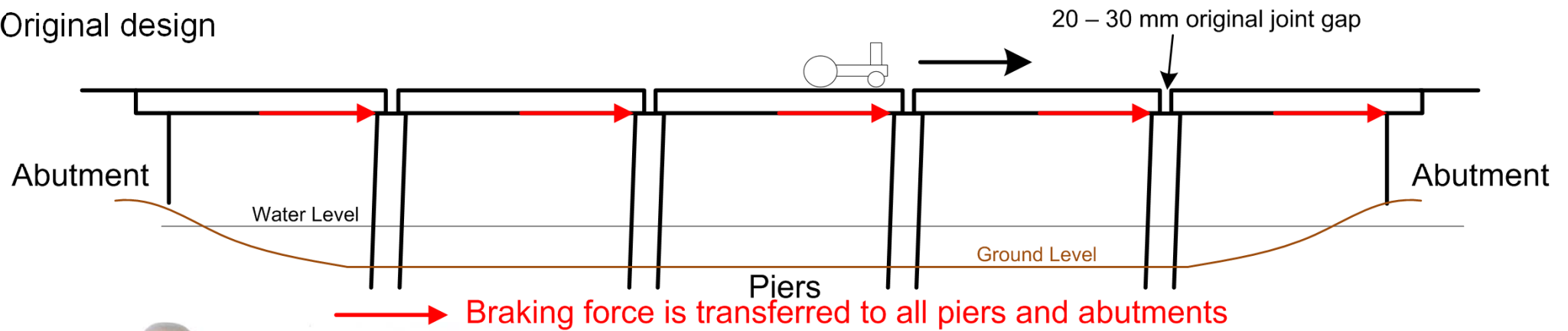
Graphite

How the Bridge Works



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Original design



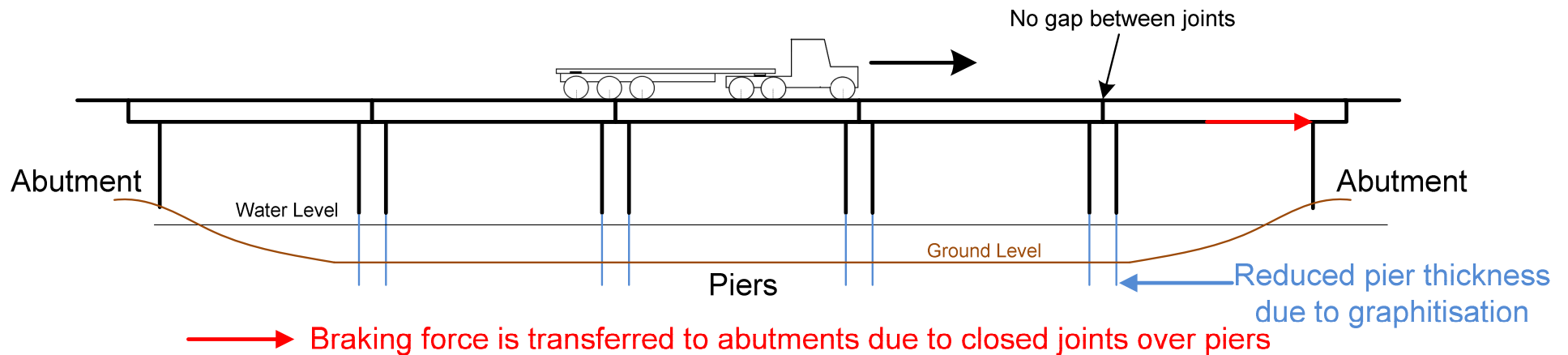
1908 Ruston Proctor
Traction Engine – 9.5t



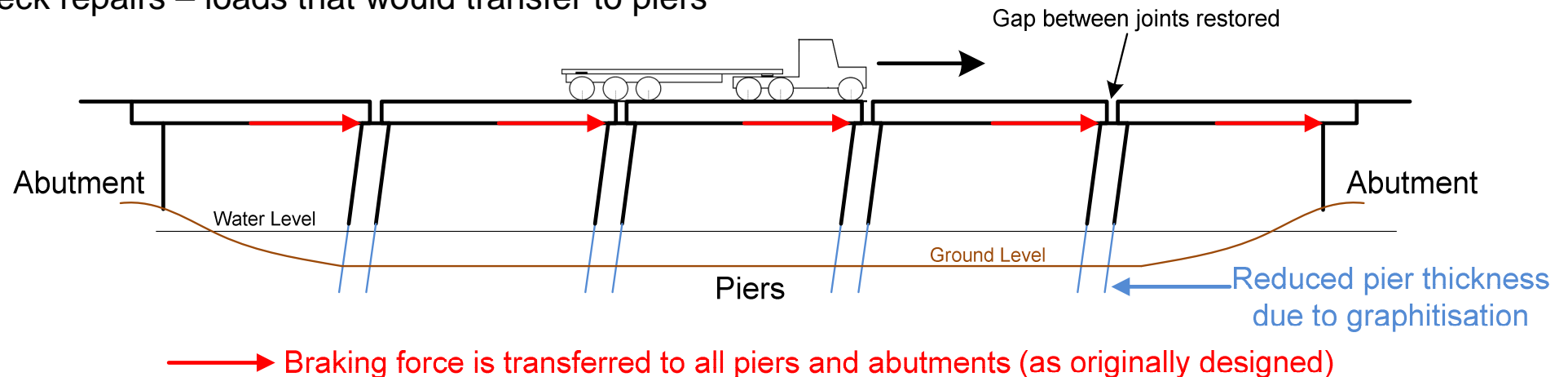
HML Semi Trailer – 45.5t

How the Bridge Works

Currently locked up – low loads on piers



After deck repairs – loads that would transfer to piers

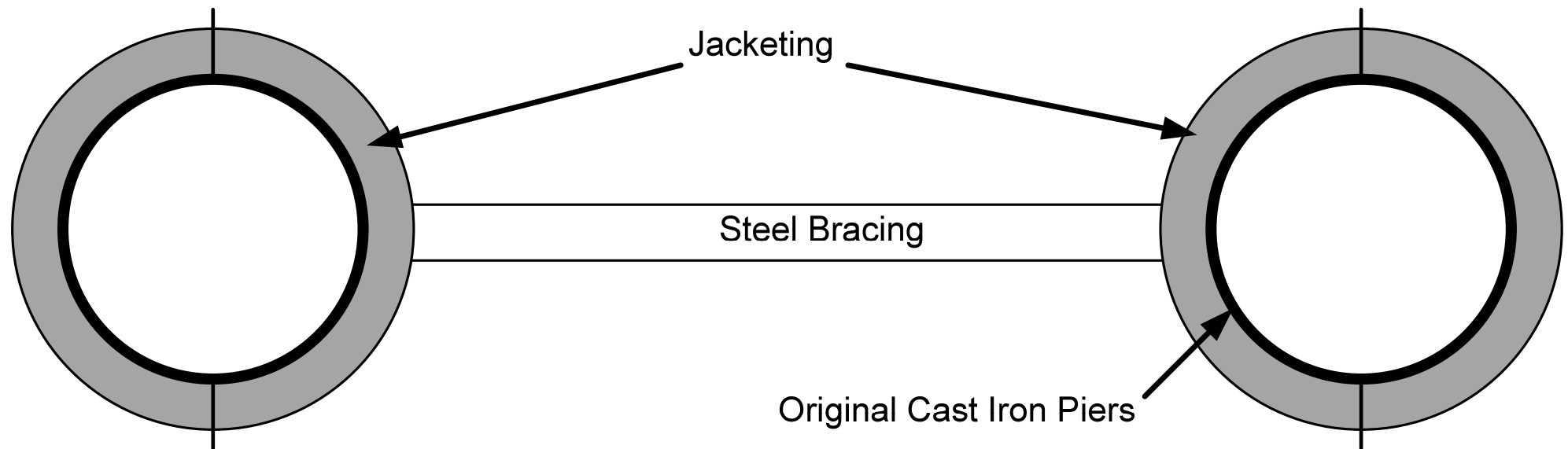


Graphitisation and Cracking of Piers



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- Upgrade of piers required to satisfy minimum T44 design standard capacity
- Jacketing to be installed around outside of cast iron piers.



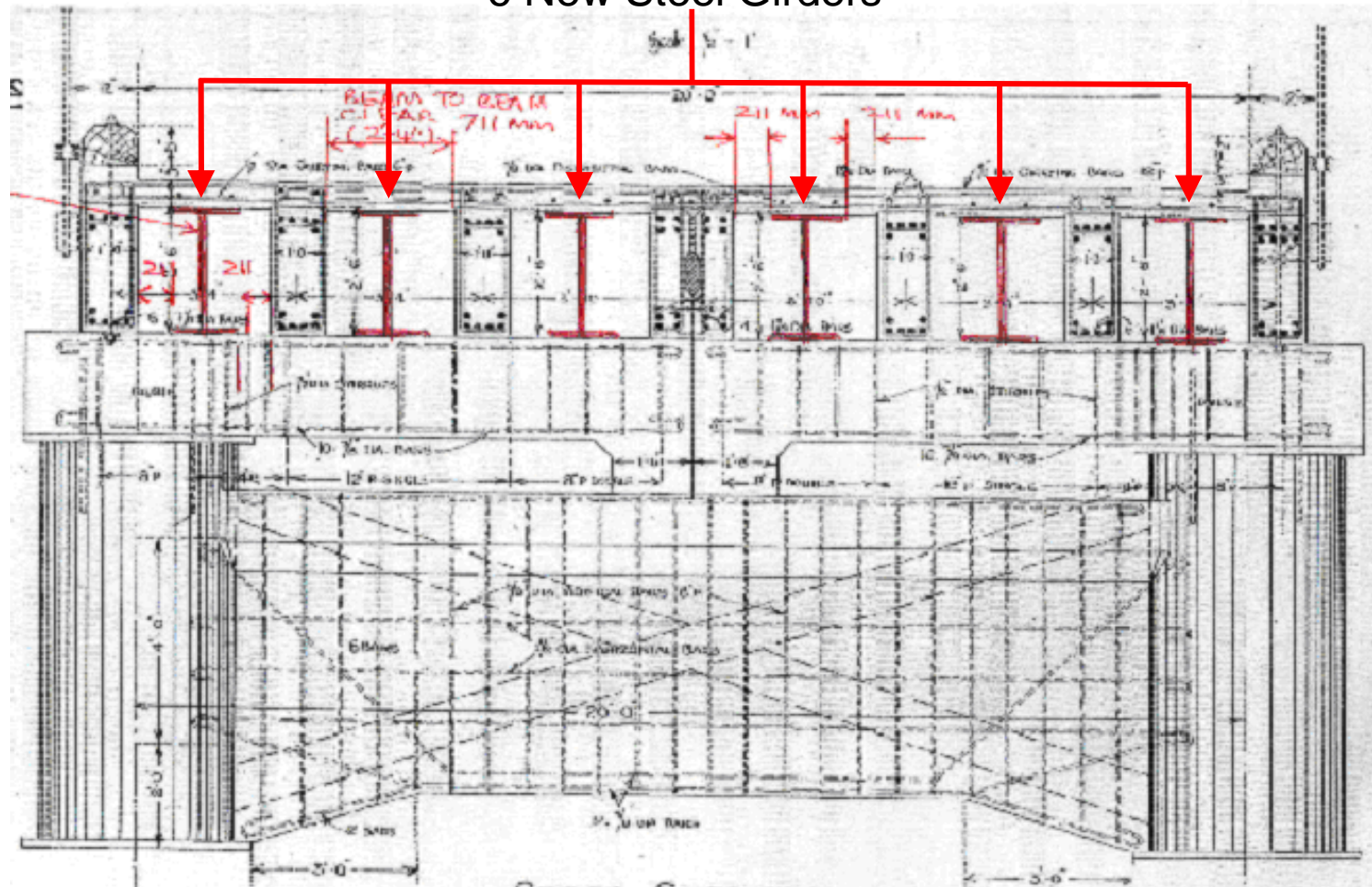
- Existing bridge does not comply with current standards
- Installation of intermediate steel girders proposed to improve capacity
- T44 Loading as per NAASRA – 1976
- Would require (minimum) one lane operation during construction

Steel Girders



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6 New Steel Girders



Rehabilitation Estimate



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Repair activity	Estimate
1. Deck joints, slab repairs, deck drainage & reseal, repair beam ends	\$394,650
2. Re-alkalisation and repairs of concrete	\$1,576,600
3. Repairs to diaphragm walls	\$126,000
4. Repairs to steel bracings	\$33,500
5. Miscellaneous items	\$31,000
6. Strengthening to cast iron piers with concrete jacketing	\$3,600,000
7. Installation of steel girders, position centrally between the existing concrete beams	\$1,910,000
Sub Total	\$7,671,750
Design & project management	\$2,301,525
Contingencies	\$3,068,700
Total (in 2005 dollars)	\$13,041,975
Total (adjusted for 2011 dollars)	\$18,500,000

Source: Report on Rehabilitation of Windsor Bridge – May 2005
RTA Bridge Rehabilitation Projects Section. Updated in 2011

Service Level Implications / Ongoing Maintenance



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Existing Windsor Bridge Maintenance Program

Required over 100 years

Realkalisation Option

Activity	Cost / Activity	Maintenance Cycle	TOTAL
Anti Carbon + Wet Jet	\$255,878	Every 10 Years	\$57,911,912
Realkalisation	\$2,924,320	Every 50 Years	\$27,602,963
Concrete Patching – assume 10% of soffit per visit	\$783,300	Every 10 Years	\$177,281,364
Mill, Waterproof and Resheet	\$175,812	Every 25 Years	\$21,233,446
Routine Inspections by Boat	\$3,000	Every Year	\$5,584,927
Re-dowel Joints – Assume 50%	\$755,866	Every 10 Years	\$169,898,402
Replace Scuppers	\$84,885	Every 25 Years	\$10,251,842
Replace Guardrail	\$168,000	Every 50 Years	\$15,224,354
TOTAL			\$484,989,210

Outcome



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- Manage the existing bridge until it is replaced with a new bridge.
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Any Questions Please?



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Realkalisation and repairs of concrete



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- Realkalisation cost of \$1,576,600 was based on a GHD 2005 report.

	GHD '05 Report
Concrete Repair	450,000
Realkalisation	944,000
Coating	82,600
Engg and temporary works	100,000
Subtotal	\$1,576,600
Adjustment to 2011 costing (Factored up by 6% per annum)	\$2,236,400

GHD 2009 estimate was \$2.6M (\$2.93M in 2011 dollars)

- Miscellaneous repair items include:
 - Removal of debris from pier ledges
 - Cleaning and painting of footway stringers and cast iron cylinder at Abutment A
 - Inspection and repair of Pier 10 concrete columns
 - Reinstatement of spalled concrete at both abutments
 - Replacement of damaged traffic barrier railing.