

## Silver Jubilee Bridge

### A 25 Year Repair Strategy



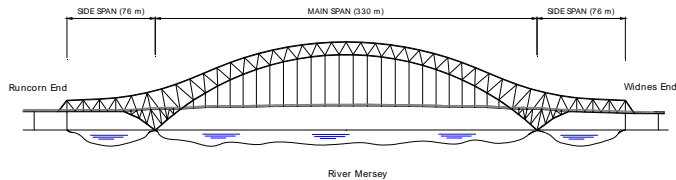
Paul Lambert  
Materials & Corrosion Technology  
Mott MacDonald  
United Kingdom



INTERNATIONAL CONCRETE REPAIR INSTITUTE

2017 Spring Convention | March 15-17 | Montreal, Canada

## Silver Jubilee Bridge



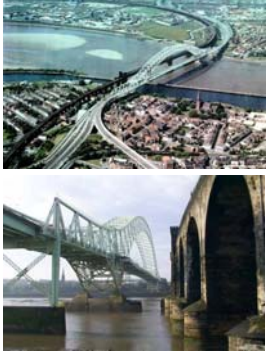
- Constructed in 1961
- Designed to pre & post WW II British Standards
- Widened in 1977
- Granted Grade II listed status in 1988

INTERNATIONAL CONCRETE REPAIR INSTITUTE

2017 Spring Convention | March 15-17 | Montreal, Canada

## Silver Jubilee Bridge

- Steel arch main span, 330m long
- Approach spans are 522m in length
- Approach viaducts have pre-cast beam ends, otherwise cast in-situ
- Widening in late 1970's employed encapsulated piers with post-tensioned crossheads
- Originally called the Runcorn Widnes Bridge, it was renamed the Silver Jubilee Bridge in 1977



INTERNATIONAL CONCRETE REPAIR INSTITUTE

2017 Spring Convention | March 15-17 | Montreal, Canada

## English Heritage Grade II

- *“Structures, predominantly buildings, are usually listed because of age, rarity, architectural merit and method of construction”*
- A Grade II structure is of *“special interest, warranting every effort to preserve it”*
- Restrictions: *“Listed buildings may not be demolished, extended or altered without special permission from the local planning authority”*
  - Including the colour of the paintwork

INTERNATIONAL CONCRETE REPAIR INSTITUTE

2017 Spring Convention | March 15-17 | Montreal, Canada

## Problems

- After 25 years in operation, the majority of problems associated with the structure were due to chloride induced corrosion of concrete reinforcement
- The bridge had been completed 2 years prior to the introduction of chloride-based de-icers in the UK
- The first areas to suffer were the approach viaduct supports where every third pier was located beneath a joint
- A further problem was that the main deck had not been waterproofed (unusual for UK) and despite high quality mastic asphalt surfacing, chlorides from de-icing salts had penetrated the concrete



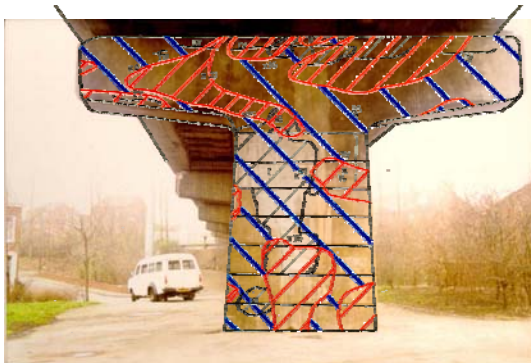
2017 Spring Convention | March 15-17 | Montreal, Canada

## Initial Investigations



2017 Spring Convention | March 15-17 | Montreal, Canada

## Initial Investigations



2017 Spring Convention | March 15-17 | Montreal, Canada

## Corrosion Prevention

- Holding repairs with inhibitors
- Corrosion inhibitors
  - Small patch repairs
- Cathodic protection (CP)
  - Impressed current systems
    - Mesh & overlay, discrete anode
    - Dry and wet spray overlays
  - Galvanic systems
    - Discrete anode, zinc hydrogel sheet
- Electro-osmosis



2017 Spring Convention | March 15-17 | Montreal, Canada

### Holding Repairs, 1992

- Public safety concerns
- Patch repair
  - Polymer modified cementitious mortar
  - Incorporating corrosion inhibitor to avoid 'ring anode' formation
- After 10+ years had prevented significant section loss and further spalling



Holding repair after 9 years



2017 Spring Convention | March 15-17 | Montreal, Canada

### Cathodic Protection, 1993 Onwards

- 1993
  - First contract awarded
- Innovations
  - Hydro-demolition
  - MMO titanium mesh and dry sprayed concrete with steel trowel finish
- Next two contracts used same system



Dry sprayed overlay being applied



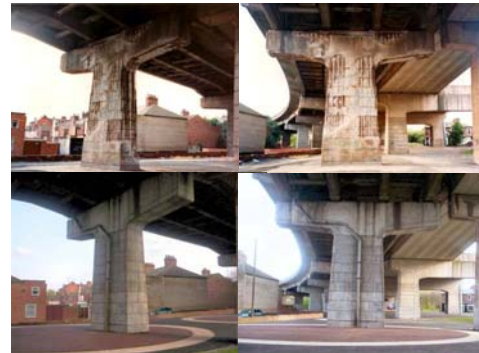
2017 Spring Convention | March 15-17 | Montreal, Canada

### Cathodic Protection, 1993 Onwards



2017 Spring Convention | March 15-17 | Montreal, Canada

### Repair Performance



Condition after 30 years service

Appearance 20 years after repair with CP



2017 Spring Convention | March 15-17 | Montreal, Canada

### Overlay Delamination

- Initial concerns over delamination from trowelling were overcome by careful QA and testing.
- Only major overlay problem encountered with wet spray, used on application adjacent to school.
- Widescale delamination occurred, apparently due to desiccation at the interface.
- Co-operation between client, consultant, contractor and material manufacturer resulted in a cost-effective solution.
- Overcoated with a PMC mortar reinforced with a two-way e-glass scrim.



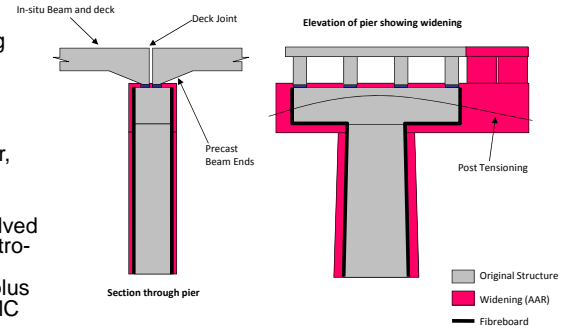
- Has proved very durable (>15 years), with no worsening of delamination and the CP continuing to operate normally.



2017 Spring Convention | March 15-17 | Montreal, Canada

### Encapsulated Piers

- Encapsulating concrete later found to have AAR
- Fibreboard retained water, worsening problem
- Problem resolved by either electro-osmosis or galvanic CP plus reinforced PMC coating



2017 Spring Convention | March 15-17 | Montreal, Canada

### Encapsulated Piers – Electro-Osmosis



2017 Spring Convention | March 15-17 | Montreal, Canada

### Encapsulated Piers – Galvanic CP



2017 Spring Convention | March 15-17 | Montreal, Canada

### Encapsulated Piers – Galvanic CP



2017 Spring Convention | March 15-17 | Montreal, Canada

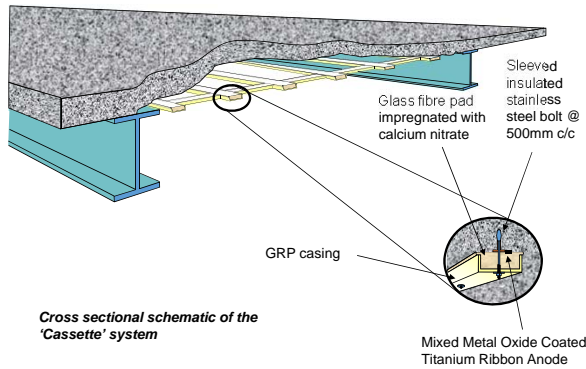
### CP of Main Suspended Deck

- Approach viaducts and piers relatively straightforward to repair – access from ground level
- Deck provides restrictions
  - Major highway link
  - 90,000 vehicles per day
  - Closure results in 65km diversion
  - Partial closure results in heavy congestion
  - 40m above River Mersey
- Plus the Grade II restrictions



2017 Spring Convention | March 15-17 | Montreal, Canada

### Surface Mounted Cassette System



2017 Spring Convention | March 15-17 | Montreal, Canada

### Surface Mounted Cassette System



2017 Spring Convention | March 15-17 | Montreal, Canada

### Pre-Cast Pre-Stressed Beams



2017 Spring Convention | March 15-17 | Montreal, Canada

### Pre-Cast Pre-Stressed Beams

- Used in widening
- Elements have generally been in better condition
  - High strength/high quality concrete
  - Not as old as in-situ concrete
- Starting to show signs of chloride induced corrosion
- Conventional repair methods are, for the most part, not applicable
- CP has only rarely been considered for pre-stressed concrete elements
- Concern over possible risk of Hydrogen Embrittlement



2017 Spring Convention | March 15-17 | Montreal, Canada

### Pre-Cast Pre-Stressed Beams



2017 Spring Convention | March 15-17 | Montreal, Canada

### Pre-Cast Pre-Stressed Beams – Galvanic CP

- Electrical continuity of steel
  - Welding or shot firing not feasible
  - Achieved using metal straps, cable ties and tie wires
- Breakouts
  - Assessment of extent of corrosion
  - Hydrodemolition
  - Residual stress in elements / loss of bond
- Anode system
  - Zinc hydrogel sheet anode, overcoated to camouflage and prevent self-corrosion
- Monitoring
  - From 7 days before installation onwards
  - In operation since August 2011



2017 Spring Convention | March 15-17 | Montreal, Canada

## Other Works

- Maintenance of Protective Coating
  - Historically used lead-based primers and metal spray
  - Now use water based and low solvent formulations with glass flake fillers
  - 5% treated each year therefore a continuous job
  - Change of colour not possible



2017 Spring Convention | March 15-17 | Montreal, Canada

## Other Works – Coatings



2017 Spring Convention | March 15-17 | Montreal, Canada

## Other Works

- Maintenance of Protective Coating
  - Historically used lead-based primers and metal spray
  - Now use water based and low solvent formulations with glass flake fillers
  - 5% treated each year therefore a continuous job
  - Change of colour not possible
- Resurfacing & Deck Waterproofing
  - Unusually for UK did not originally have waterproofing



2017 Spring Convention | March 15-17 | Montreal, Canada

## Other Works – Deck Waterproofing



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works

- Maintenance of Protective Coating
  - Historically used lead-based primers and metal spray
  - Now use water based and low solvent formulations with glass flake fillers
  - 5% treated each year therefore a continuous job
  - Change of colour not possible
- Resurfacing & Deck Waterproofing
  - Unusually for UK did not originally have waterproofing
- Joint Replacement
  - Buried, rail and mechanical



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works – Joint Replacement



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works

- Maintenance of Protective Coating
  - Historically used lead-based primers and metal spray
  - Now use water based and low solvent formulations with glass flake fillers
  - 5% treated each year therefore a continuous job
  - Change of colour not possible
- Resurfacing & Deck Waterproofing
  - Unusually for UK did not originally have waterproofing
- Joint Replacement
  - Buried, rail and mechanical
- Bearing Replacement
  - Mostly at beam ends located beneath joints



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works – Bearing Replacements



2017 Spring Convention | March 15-17 | Montreal, Canada



### Other Works

- Maintenance of Protective Coating
  - Historically used lead-based primers and metal spray
  - Now use water based and low solvent formulations with glass flake fillers
  - 5% treated each year therefore a continuous job
  - Change of colour not possible
- Resurfacing & Deck Waterproofing
  - Unusually for UK did not originally have waterproofing
- Joint Replacement
  - Buried, rail and mechanical
- Bearing Replacement
  - Mostly at beam ends located beneath joints
- Cable Wrapping
  - Preferable to coating as could be carried out without closing bridge



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works – Cable Wrapping



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works

- Maintenance of Protective Coating
  - Historically used lead-based primers and metal spray
  - Now use water based and low solvent formulations with glass flake fillers
  - 5% treated each year therefore a continuous job
  - Change of colour not possible
- Resurfacing & Deck Waterproofing
  - Unusually for UK did not originally have waterproofing
- Joint Replacement
  - Buried, rail and mechanical
- Bearing Replacement
  - Mostly at beam ends located beneath joints
- Cable Wrapping
  - Preferable to coating as could be carried out without closing bridge
- Parapet Upgrade
  - Original parapets not capable of resisting modern heavy goods vehicle impact



2017 Spring Convention | March 15-17 | Montreal, Canada

### Other Works – Parapets



2017 Spring Convention | March 15-17 | Montreal, Canada

## The Future of SJB

- There remains an on-going requirement to maintain the bridge
  - CP – now fully integrated into a single monitoring and control system
  - Protective coatings – continuing requirement
- New second road crossing – Mersey Gateway
  - Due to be completed in 2017



2017 Spring Convention | March 15-17 | Montreal, Canada

**M M**  
**MOTT  
MACDONALD**

[paul.lambert@mottmac.com](mailto:paul.lambert@mottmac.com)

[www.mottmac.com](http://www.mottmac.com)



2017 Spring Convention | March 15-17 | Montreal, Canada