MAJOR MAINTENANCE & REHABILITATION OF CONCRETE BRIDGES

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Concrete Bridge Decks

- Large Percentage of All Bridge Decks (over 90%)
- Two Main Mechanisms of Deterioration
  - freeze thaw damage
  - corrosion of rebar – delamination of concrete
- Prevention of Freeze Thaw Damage
  - proper concrete mix design and air entrainment

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Concrete Bridge Decks

- Prevention of Corrosion Damage
  - prevent moisture/chloride entering concrete
  - ensure concrete around rebar remains passive
  - use non-corrosive rebar
- Deck Durability – New Construction
  - membrane and ACP
  - epoxy coated rebar
  - stainless steel/stainless steel clad rebar
  - corrosion inhibitors

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Deck Rehabilitation - Timing

- Optimum timing gives best life cycle cost
- Too early
  - existing deck protection still working
  - no significant damage to deck
  - future life of deck/bridge not shortened if rehabilitation delayed
- Too late
  - significant corrosion damage to deck
  - rehabilitation costs have significantly increased
  - high chlorides or other factors have significantly shortened life of deck/bridge
- Great deal of experience and judgement to determine optimum timing

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Methods/Options for Rehabilitation

- Concrete Overlays
  - provides durable long lasting wearing surface
  - less permeable – reduces moisture in deck
  - reduces rate of corrosion
- Waterproofing Membrane and ACP
  - waterproofs deck surface
  - stops additional moisture getting in deck
  - significantly reduces corrosion
  - membrane/ACP not as long lasting of a wearing surface as concrete

Methods/Options for Rehabilitation

- Thin Polymer Overlays
  - membrane without protection of ACP
  - does not add significant dead load
  - existing concrete deck in good condition
  - need very good bond with concrete
  - subject to damage from snow plows, vehicle wear, UV rays

Methods/Options for Rehabilitation

- Cathodic Protection
  - electric potential over deck surface prevents additional corrosion
  - use when existing corrosion activity very high
  - need power source at site
  - generally needs to be used with concrete overlay
  - monitoring and maintenance required to ensure system is working

Concrete Overlays

Types of Concrete Overlay

- High Density Concrete
  - started using in mid-1970's
  - low water/cement ratio – low slump
  - site batched with mobile mixer
  - placed with special finishing machine
  - very good durability
  - less permeable than normal concretes
  - still relatively high permeability

Types of Concrete Overlays

- Latex Modified Concrete
  - also started using in mid-1970's
  - latex used to replace some of the water in mix
  - also site batched
  - low permeability/high slump
  - can be used for thin overlays < 40 mm
  - difficult to finish and cracks easily
  - section of overlay can become loose if bonding problems present

Types of Concrete Overlays

- Pyrament Cement Concrete
  - cement with high fly ash content – 35%
  - on market in early 1990's
  - pre-bag mix – water added at site
  - fast setting, high strength, low permeability
  - hard to finish – shrinkage cracks
  - AAR problems – reduced bond

Types of Concrete Overlays

- Modified Silica Fume Concrete
  - small amount of fly ash in mix
  - fog curing immediately behind finishing machine
  - seven day wet curing
  - increase strength – reduces cracks
  - can be used with and without steel fibres

Types of Concrete Overlays

- High Performance Concrete (HPC) 45 Mpa – commonly used on AT decks
  - Silica fume in mix (6-8%)
  - Fly ash in mix (11-15%)
  - early use – pre-bag mix – water at site
  - presently mostly transit mix
  - low permeability – good durability
  - little more difficult to finish
  - more sensitive to shrinkage cracks when used without fibers
  - 1st trial deck in Alberta 2022 using 15% lime (GUL replacing GU) BF 1973 – Longview
    - Part of "green" initiative – lime more environmentally friendly to produce

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Types of Concrete Overlays

- HPC with Steel Fibres
  - steel fibres added to mix
  - increases tensile strength
  - reduces/controls shrinkage cracks
  - holds overlay together if debonded
  - commonly used in AT overlays

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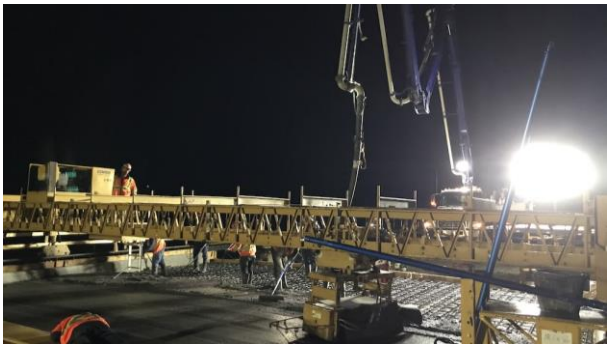

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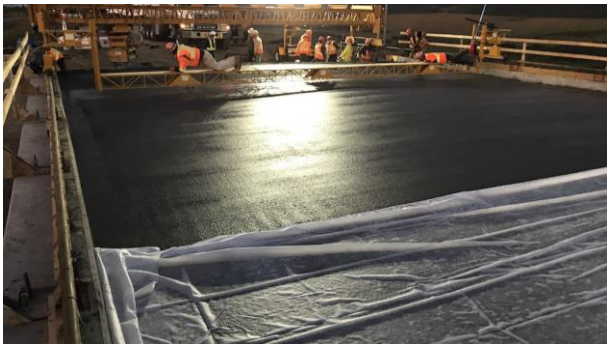

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ACP and Polymer Overlays

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Types of Membrane/ACP

- Hot Applied Rubberized Membrane & Protection Board with 2-40 mm Layers ACP (80 mm + 10 mm membrane = 90 mm)
  - used on new construction
  - dead load limits use for rehabilitation
- Sheet Membrane with 50 mm ACP
  - repair any damage to deck
  - requires fairly smooth surface
  - bond with concrete and joints between sheets main concerns
  - top of sheet rough surface to protect from and provide bond with ACP

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Types of Membrane/ACP

- Polymer Membrane with 50 mm ACP
  - requires relatively smooth surface
  - good bond with concrete decks
  - bond with ACP problem unless some aggregate in top layer
  - aggregate can affect permeability of membrane

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Thin Polymer Overlays

- Flexible Epoxy Overlays
  - two components - must be mixed properly
  - can be multi-layer system
  - very low permeability
  - requires very good preparation of concrete surface
    - rough texture but clean
  - very sensitive to weather conditions
    - concrete internally dry
  - even flexible epoxy is a relatively brittle material

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Thin Polymer Overlays

- MMA Overlays
  - more flexible, thicker material
  - single layer
  - somewhat more expensive than epoxy
  - also requires very good concrete surface preparation
  - works better on more flexible decks
- Urethane Overlays
  - use in parking garages
  - not durable enough for highway traffic

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Cathodic Protection Systems

- Conductive Wire Mesh in Overlay (Titanium)
  - requires concrete overlay
  - must eliminate all shorts between mesh and deck
  - requires monitoring
- Under Deck Conductive Coating
  - do not require concrete overlay
  - still must eliminate all shorts
  - requires monitoring
  - long-term performance not proven
  - coating system appears to dry out and become non-conductive with time

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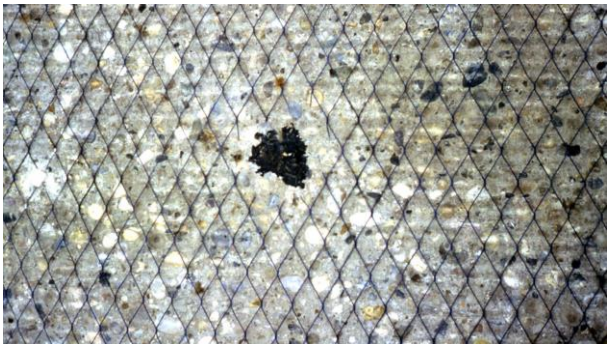

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Girder Connections and Strengthening

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Lateral Connection Between Girders

- AT has a number of concrete girder types that are placed side by side and connected together by grout-keys or connector bolts
- These grout keys have not stood up well over time
- During rehabilitation of these type bridges the lateral connections are usually upgraded and supplemented (underslung beams, lateral post-tensioning)

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Typical Shear Key – PM Girders

Grouting Girder Shear Keys

Lateral Connection Between Girders

- Short Span Girders with Bolted Connector Pockets (HC,VS,SM,SL)
  - reinforced concrete overlay (nominally 150 mm)
  - hair pin bars and grouting
- Longer Span Girders (FC, VF, FM)
  - lateral stressing
  - underslung beams
  - combination of both

Lateral Stressing and Underslung Beam – FC Girders

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Girder Shear Strengthening

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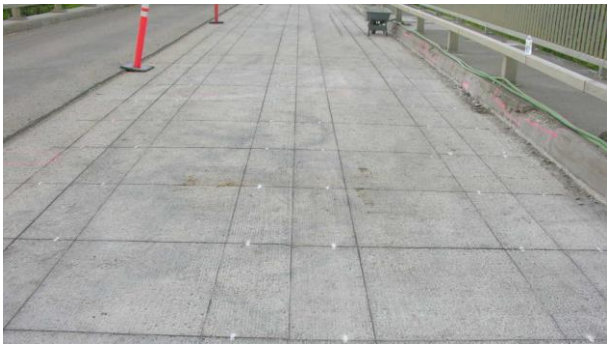

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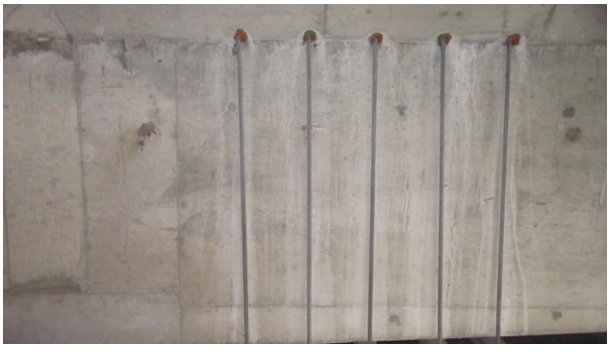

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Deck Joints

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Bridge Deck Joints

- Pre – 1975 Bridges
  - lots of simple spans
  - lots of non-waterproof joints
- Existing Practice
  - continuous spans, eliminate deck joints where possible
  - joints waterproof or with drainage systems

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Types of Deck Joints

- Strip Seal Joints
  - waterproof
  - a rubber/neoprene seal attached to metal extrusion
  - moderate thermal movements (up to approx. 75 mm)
  - make sure installation fills all voids behind extrusions
  - work well but seals must be replaced from time to time

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Types of Deck Joints

- Finger Plate Joints
  - non-waterproof
  - sliding finger plates with plumbing/drainage system
  - works for large thermal movements (> 75 mm)
  - careful to fill all voids behind plates when installing
  - mis-alignment of fingers due to dead load creep and abutment rotation
  - plumbing/drainage systems need to be cleaned out from time to time

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Types of Deck Joints

- Small Movement Joints
  - small movements due to live load deflection, etc.
  - compression seals
  - types of caulking materials

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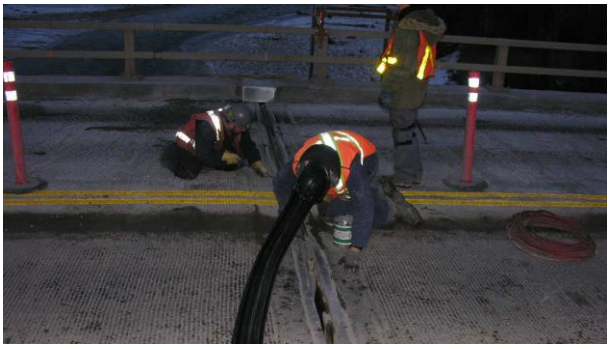

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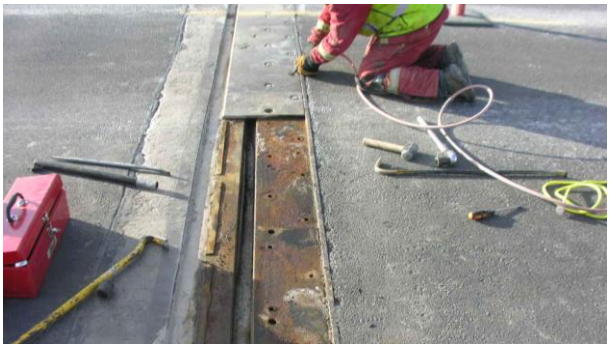

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Full and Partial Depth Deck Repairs

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High Load Repairs – Concrete Girders

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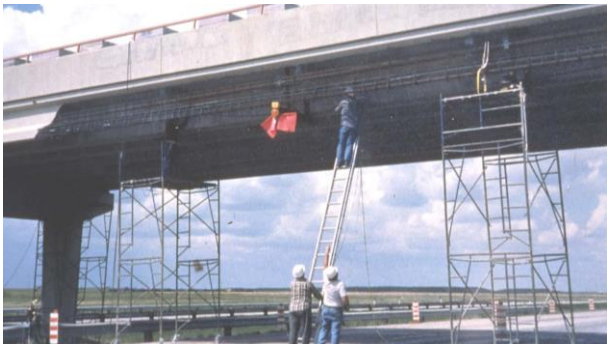

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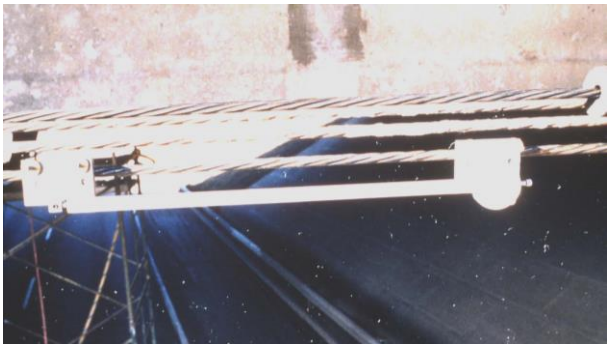

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Shotcrete Concrete Repairs

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Curb Concrete Repairs/Replacement

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Concrete Crack Repairs

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Concrete Sealing – Preventative Maintenance

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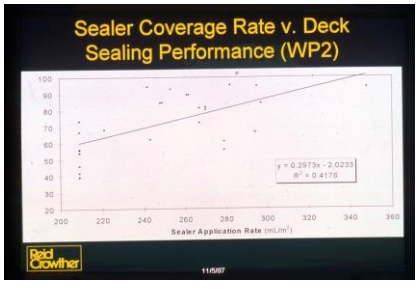

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Specifications for Bridge Construction

- Section 4 - Cast in Place Concrete
- Section 15 - Polymer Overlays
- Section 16 - Bridge Deck Waterproofing
- Section 20 – Deck Overlays and Concrete Rehabilitation

- Link to Specifications for Bridge Construction: https://open.alberta.ca/publications/standard-specifications-for-bridge-construction-edition-17

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