Northwest Arm Drive Bridge Long-Term Rehabilitation

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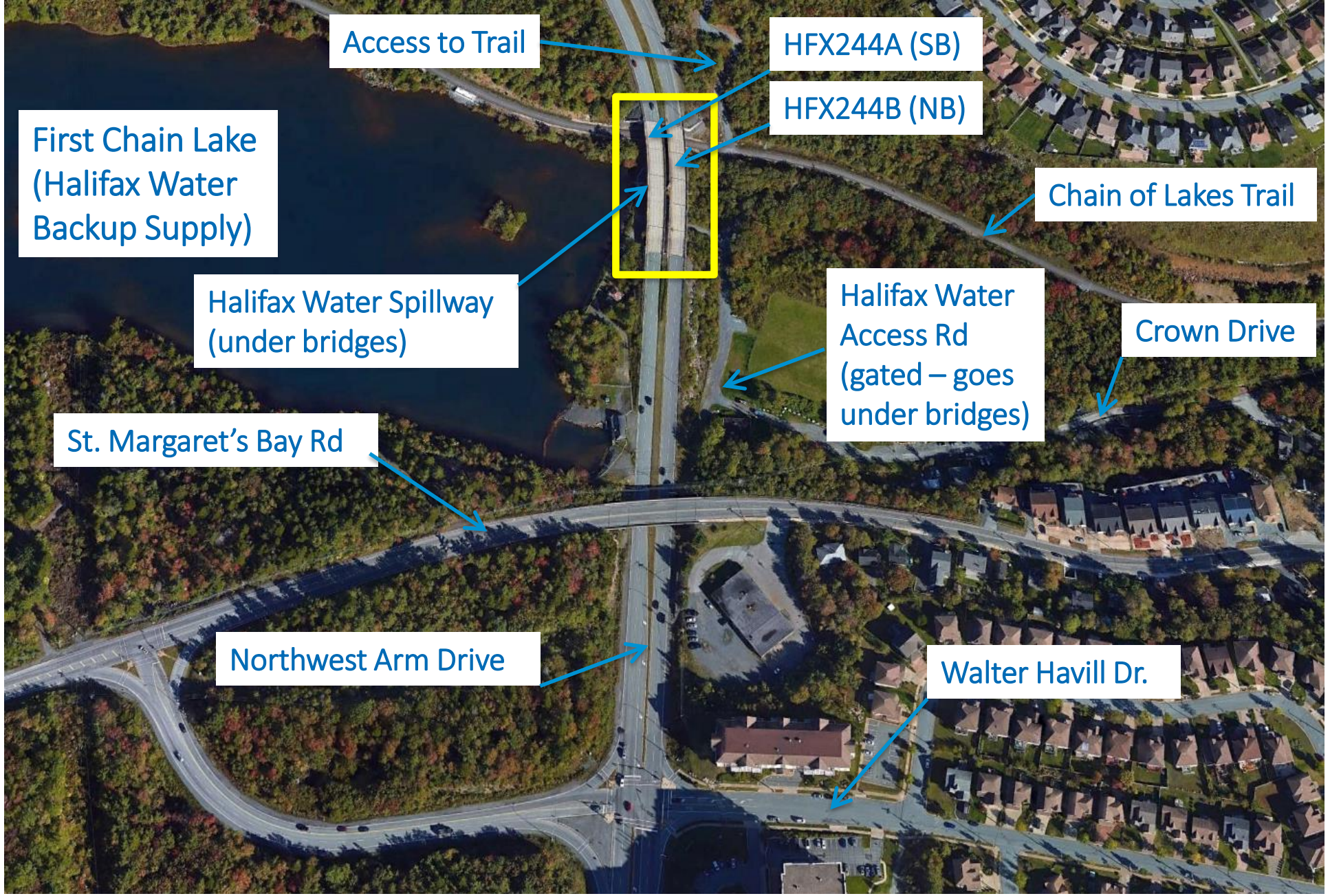
Northwest Arm Drive Bridges HFX244A & HFX244B

- Built in 1975
- 5 span concrete AASHTO girders (‘I’ shaped Girders)
- 6 girders per span
- Each span approximately 16.6m long
- 83.2m total length
- Supported on concrete hammerhead piers on spread footings
- Pier height ranges from 6m to 10m tall


Access to Trail
HFX244A (SB)
HFX244B (NB)
First Chain Lake (Halifax Water Backup Supply)
Chain of Lakes Trail
Halifax Water Spillway (under bridges)
Halifax Water Access Rd (gated – goes under bridges)
Crown Drive
St. Margaret's Bay Rd
Northwest Arm Drive
Walter Havill Dr.

HFX244A & HFX244B

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EXISTING GIRDER CONDITIONS

EXISTING GIRDER CONDITIONS

EXISTING GIRDER CONDITIONS

EXISTING PIER CONDITION

EXISTING PIER CONDITION

EXISTING DECK & BARRIER

Northwest Arm Drive Bridges HFX244A & HFX244B

Rehabilitation Approach

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TRADITIONAL REHABILITATION

- **Traditional Method and Typical Longevity:**
  - Bearing Repairs / Replacement (15-20 years?)
  - Girder End Repairs (7-10 years?)*
  - Diaphragm Repairs (10- 15 years?)
  - Deck End Repair (20 years?)
  - Joint Replacement (5-10 years?)*

*governs life of repairs

- **Depends on Multitude of Factors Both During Construction and Afterwards.**

TRADITIONAL REHABILITATION

- 5-10 years maximum before rehabilitation required again.
- Additional traffic delays
- Additional expenditure
- Poor Performance

PROJECT GOALS

- Long Lasting Rehabilitation
- Cost Effective
- Addresses all Concerns with Bridge Condition
- Minimize Traffic Disruption
- Prevent Future Water Damage

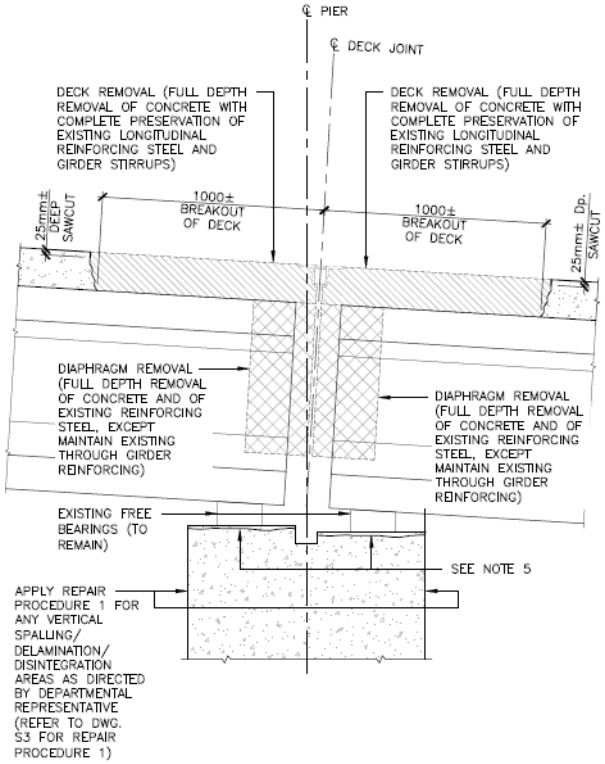
NEW BRIDGE DESIGN MEASURES FOR LONGEVITY

- Integral or Semi-Integral Abutments
- Continuous Girders and deck
- Improved materials and construction practices

REHABILITATION APPROACH

- Trial a new approach to rehabilitating concrete bridges that have multiple simple spans and expansion joints
- Eliminate all joints in bridge through engineering design
- Integrate all piers with the bridge girders and deck
- Convert abutments to semi-integral
- First application of this approach in Nova Scotia

PIER INTEGRATION



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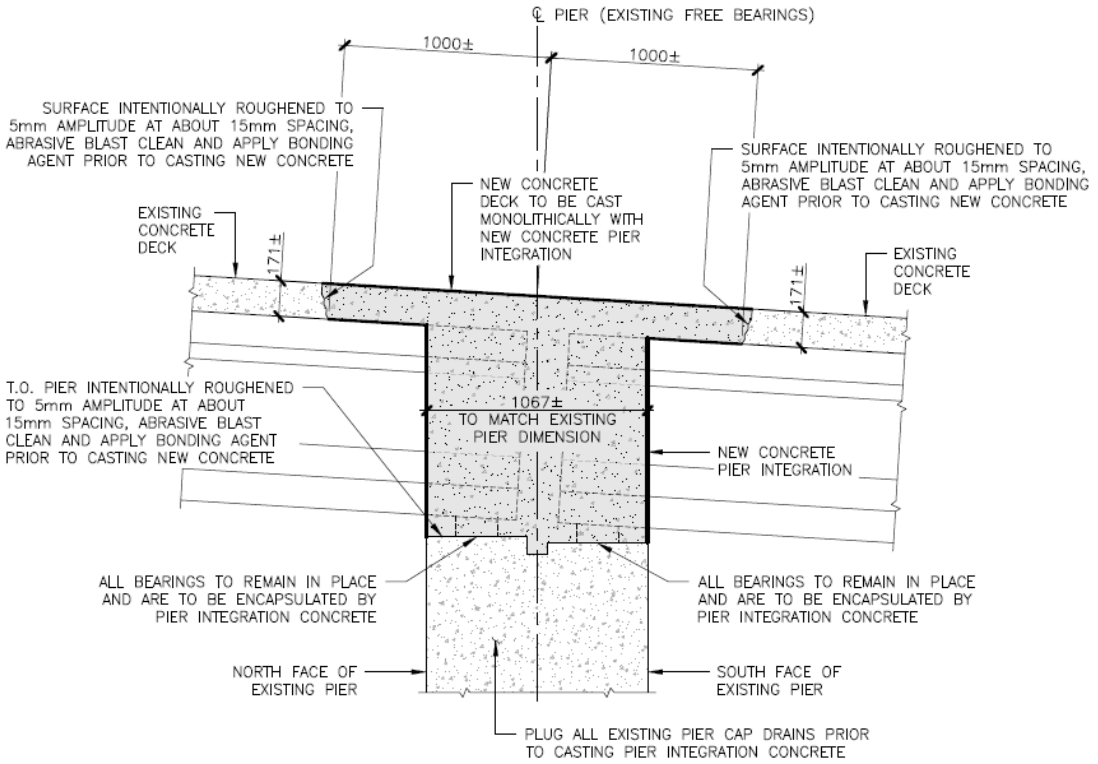

TO THIS

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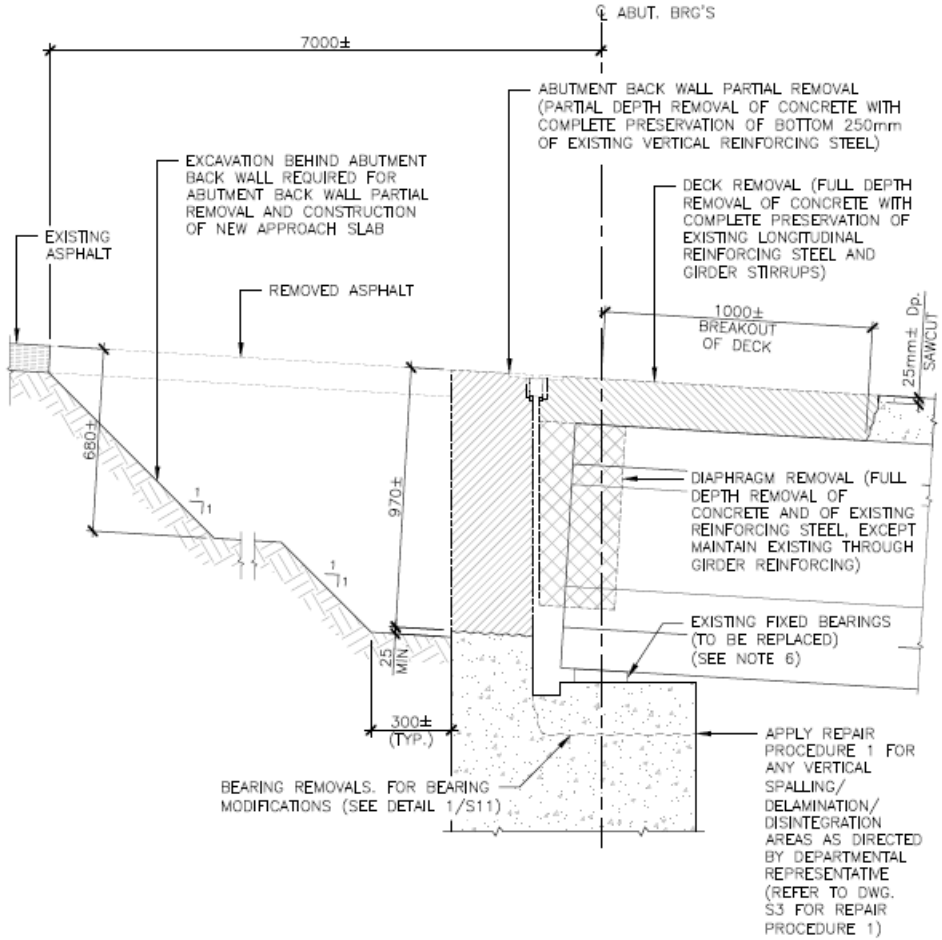
SEMI-INTEGRAL ABUTMENTS



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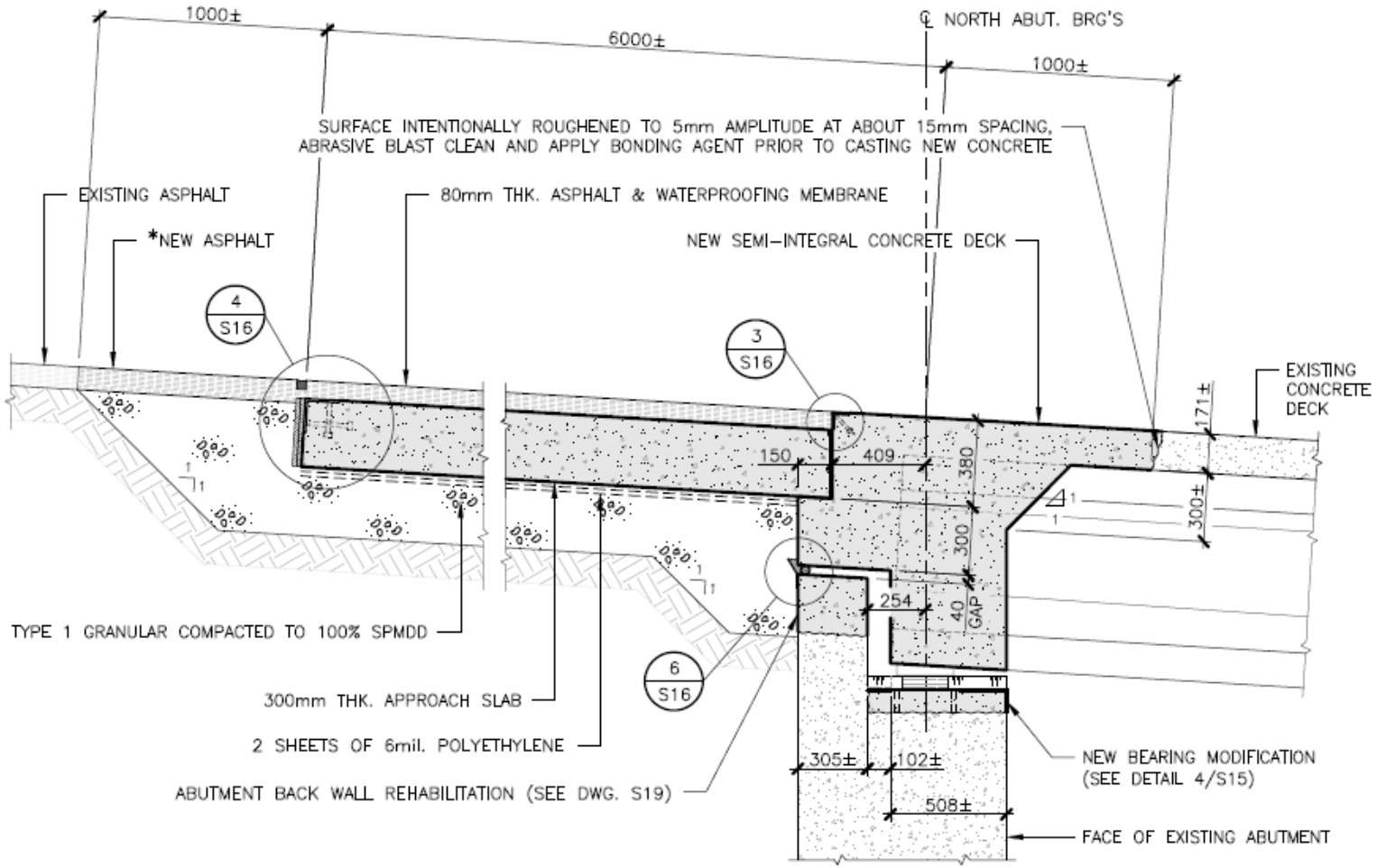
SEMI-INTEGRAL ABUTMENTS



TO THIS

PIER INTEGRATION & SEMI-INTEGRAL ABUTMENTS

- Eliminates need to jack and support girders during rehab
- Eliminates the need to replace existing bridge bearings
- Reduces quantity of girder repairs
- Eliminates LEAKING JOINTS
- Improves surface smoothness

PIER INTEGRATION & SEMI-INTEGRAL ABUTMENTS

- Will lead to a longer lasting repair (perhaps 40 years + with minimal maintenance)
- Minimal increase in cost

Northwest Arm Drive Bridges HFX244A & HFX244B

Analysis

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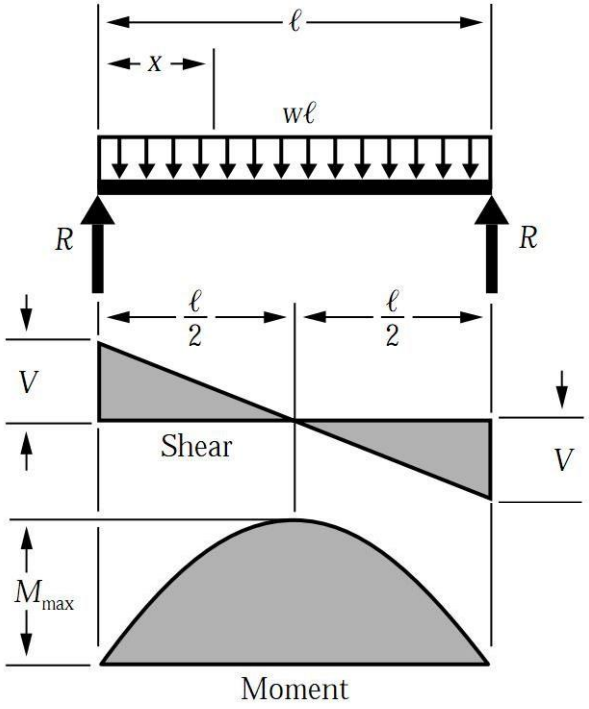
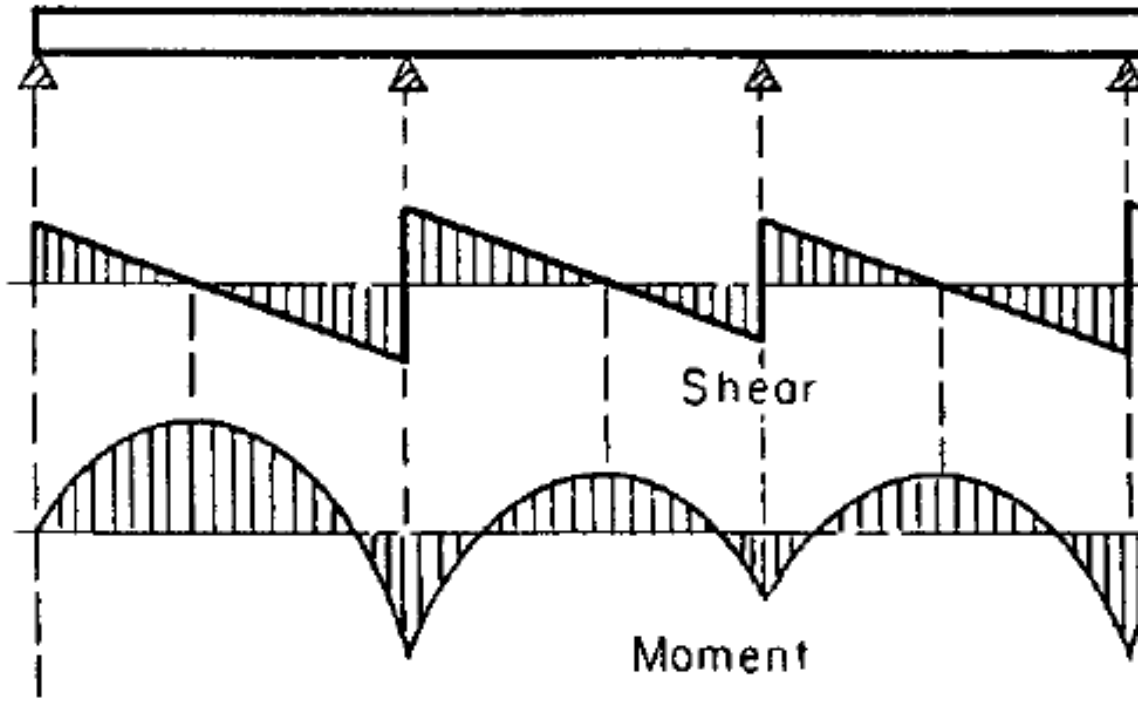
Analysis Approach

- Analysis Scope
  - To assess the feasibility of joining (integrating) the pier cap with the girders to form a fully continuous bridge
    - 16.3 m becomes 83 m+
    - Temperature effects become very important
  - To determine the load effects on all structures in the bridge as well as their resistances upon integration

Analysis Approach

- Finite Element (FE) Model: Simple vs Continuous Span



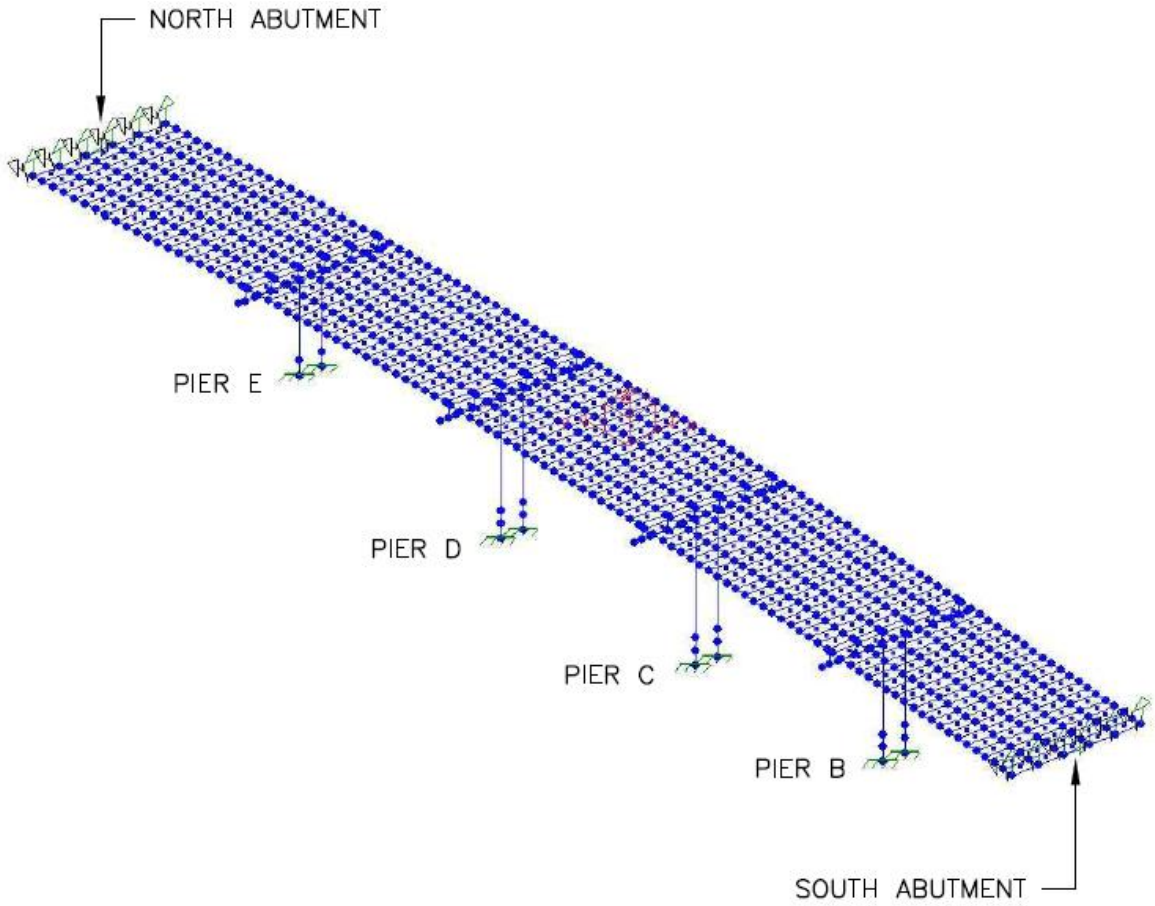


Analysis Approach

- Finite Element (FE) Models:
  - Beam and shell models in SFrame
    - Simple span model
      - Uncracked properties, Dead Loads
    - Continuous span model
      - Uncracked properties, SLS Cracking check
    - Continuous span model
      - Cracked properties over pier, Full assessment of load effects
  - Pier and footing models – shell models
    - Capture settlement effects and new shear and bending effects
- Tangent girders with curved deck

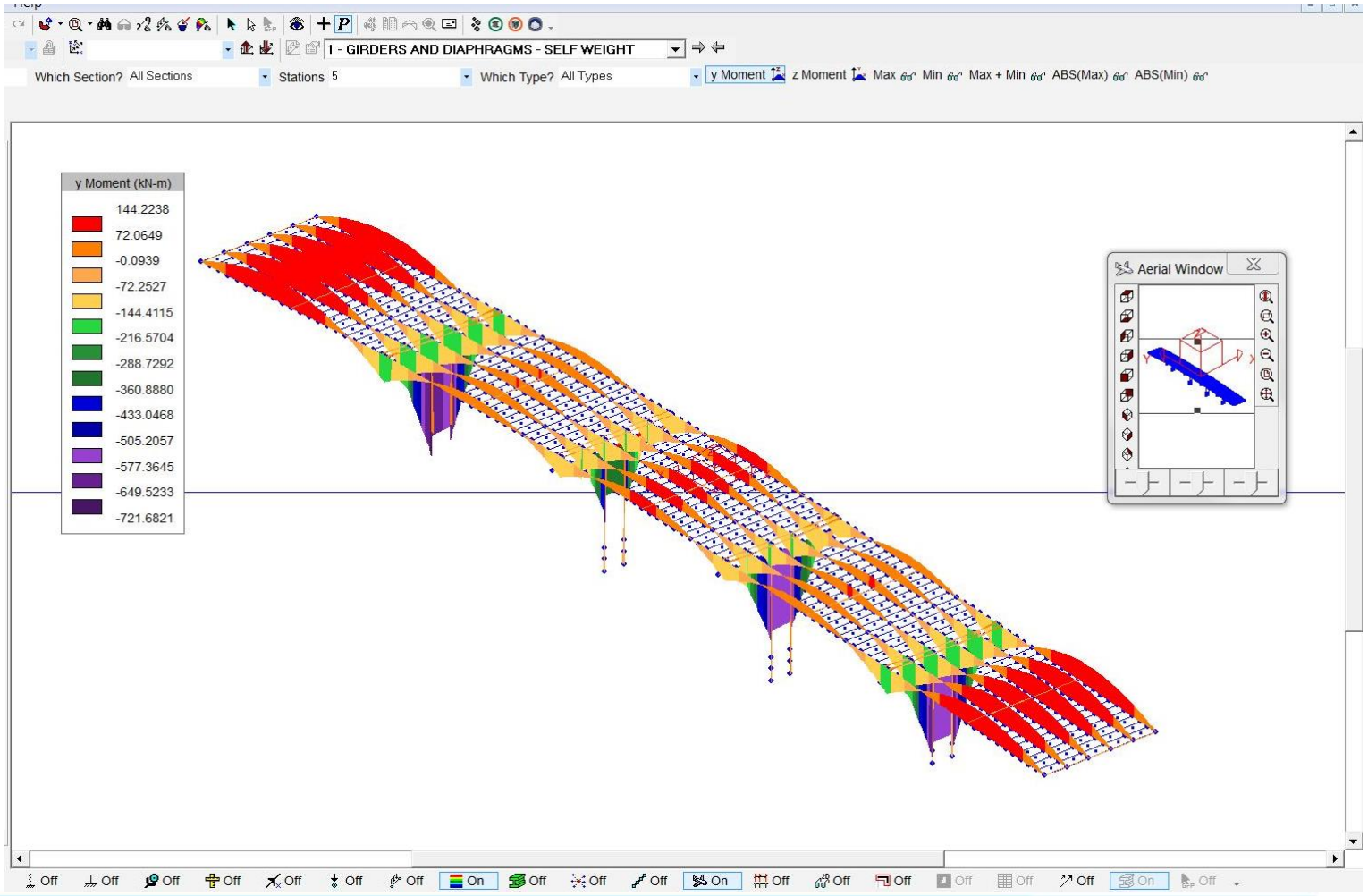
Analysis Approach

- Finite Element (FE) Model:



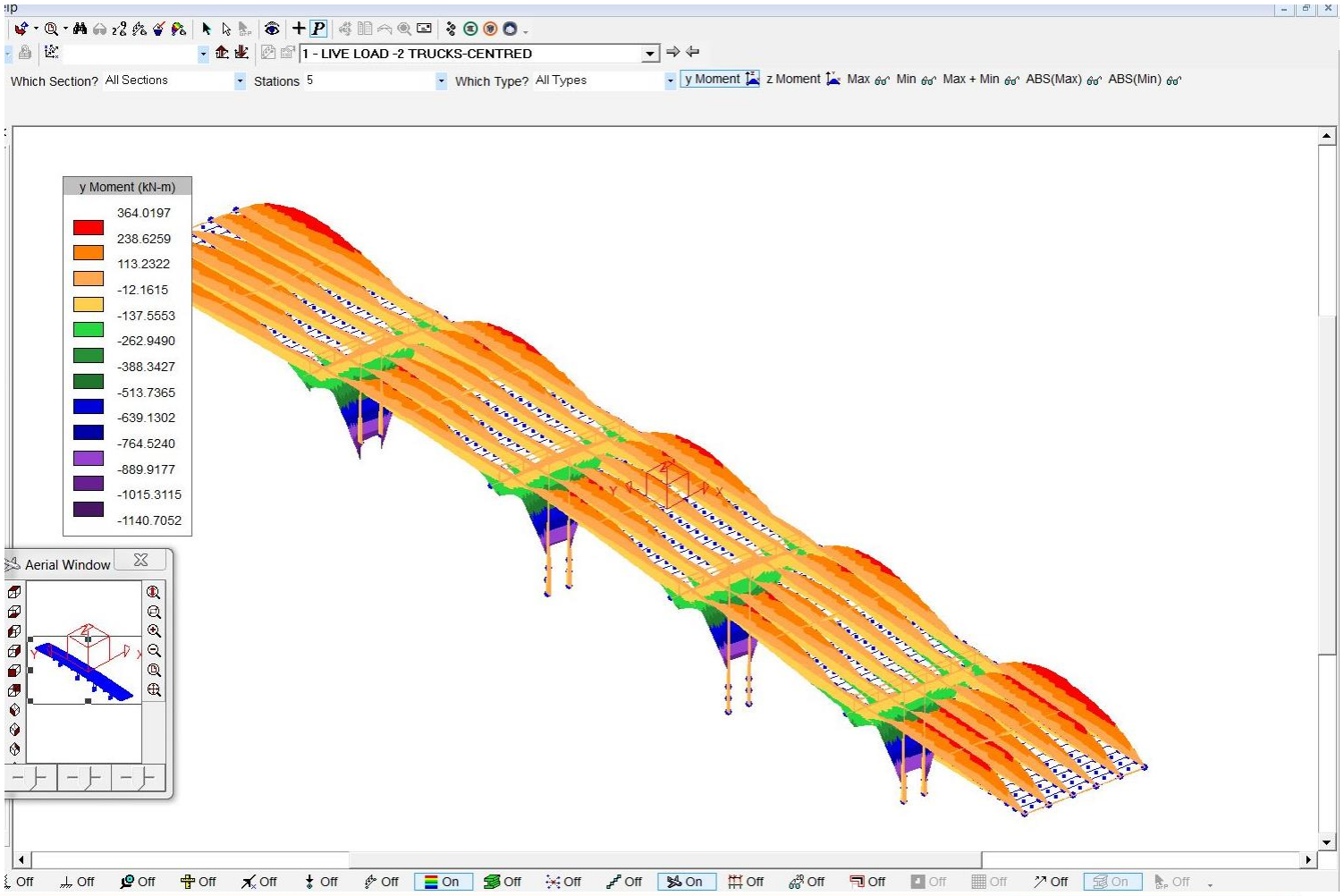
Analysis Approach

- Finite Element (FE) Model: Concrete Dead Load (Continuous)



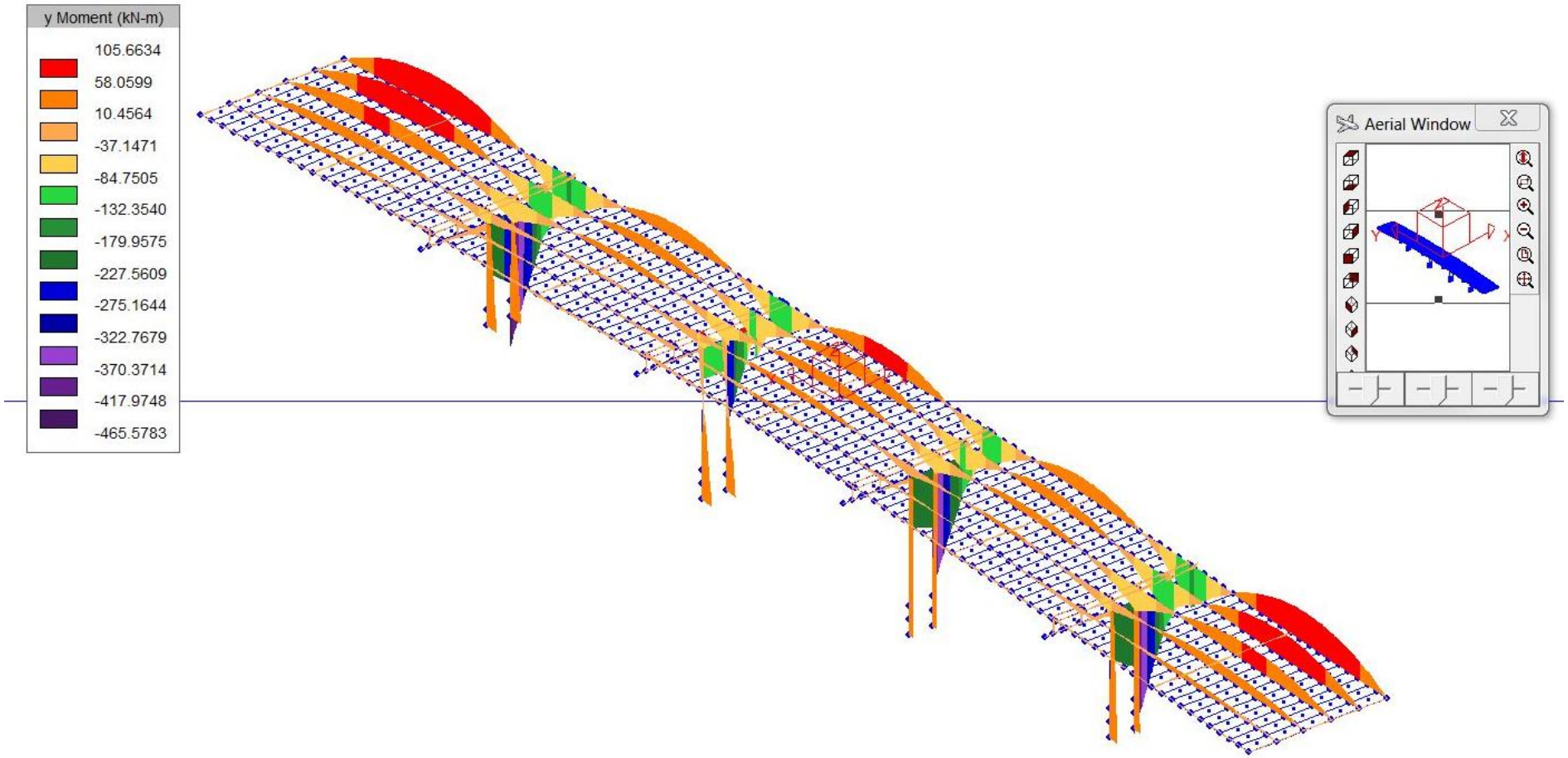
Analysis Approach

- Finite Element (FE) Model: Live Load Truck



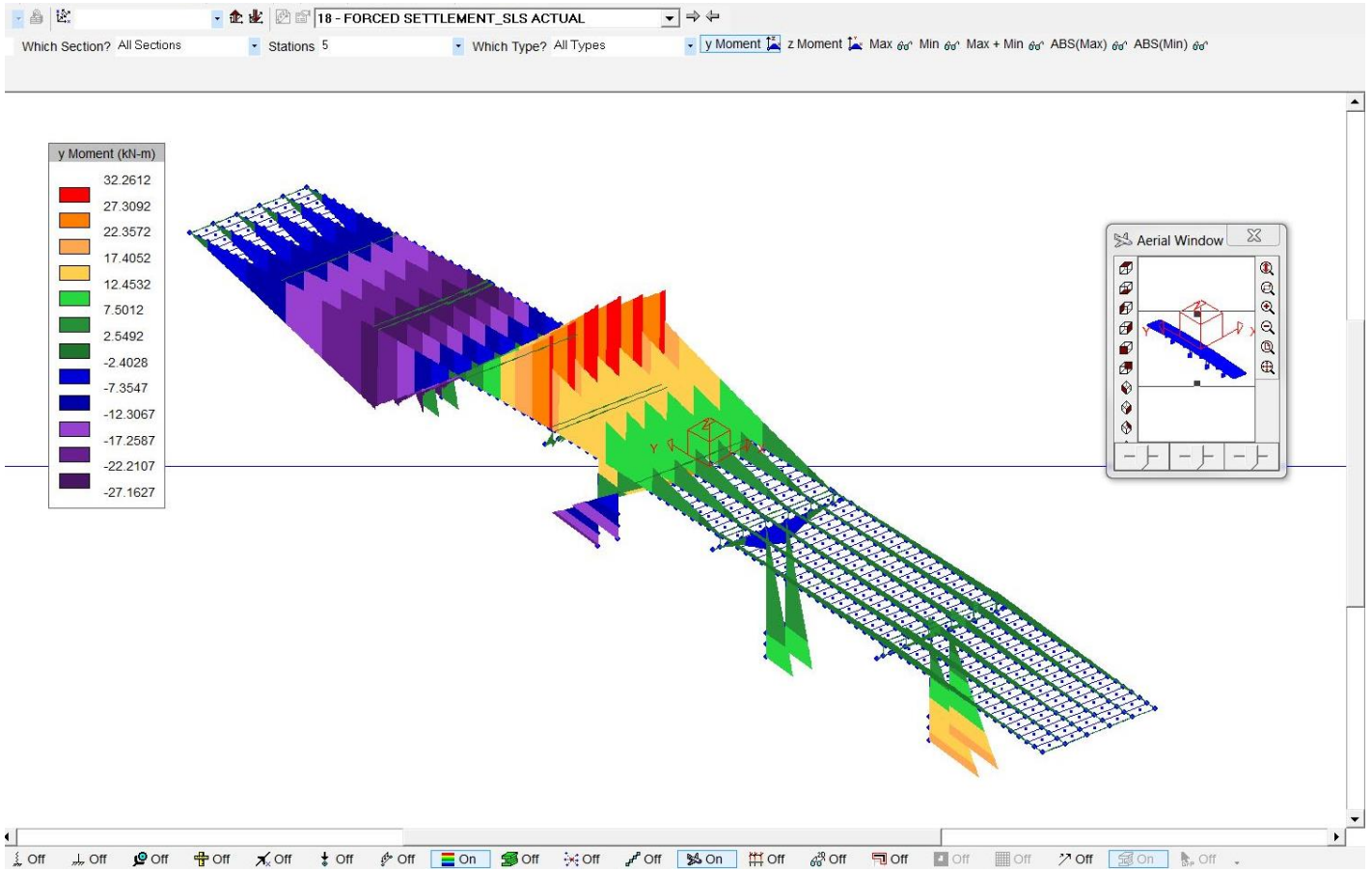
Analysis Approach

- Finite Element (FE) Model: Transverse Wind Load Bending



Analysis Approach

- Finite Element (FE) Model: Forced Settlement of Piers on Different Soils



Northwest Arm Drive Bridges HFX244A & HFX244B

Tendering

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Tendering

- Major effort was put into defining the scope of the work and detailing it:
  - 23 detailed drawings
  - Full procedures for all repairs
  - Extents and boundaries for all key repairs
  - First application, so contractors not familiar with new approach

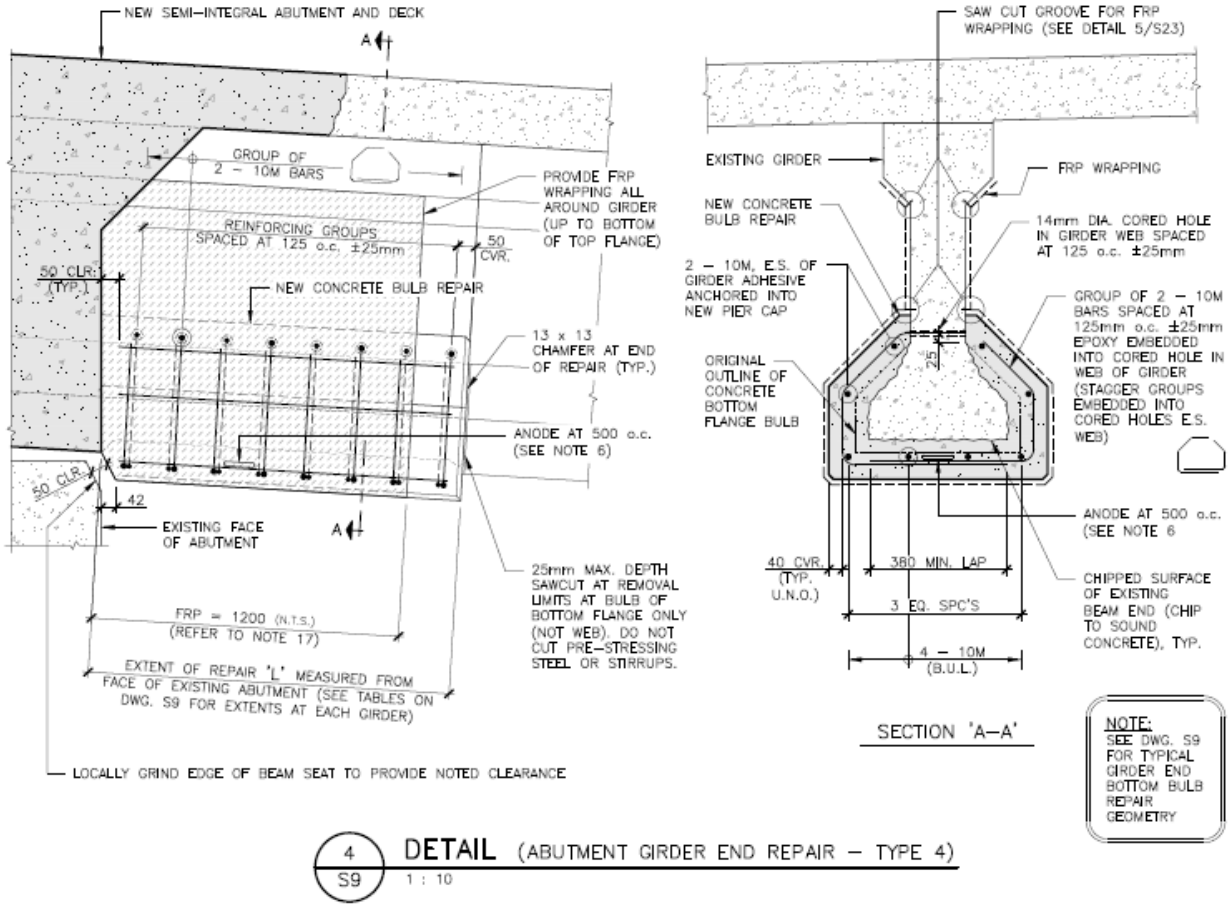
Tendering

- Example of Girder End Repair level of detail:

HFX 244A – SOUTHBOUND BRIDGE GIRDER REPAIRS											
GIRDER END	EXTENT OF REPAIR 'L' (mm)	REPAIR TYPE	DETAIL	GIRDER END	EXTENT OF REPAIR 'L' (mm)	REPAIR TYPE	DETAIL	GIRDER END	EXTENT OF REPAIR 'L' (mm)	REPAIR TYPE	DETAIL
A1	1500	4	4/S23	C4	500	2	2/S23	E1	1700	2	2/S23
A2	300	3	3/S23	C5	700	2	2/S23	E2	800	1	1/S23
A3	N/A			C6	300	1	1/S23	E3	600	1	1/S23
A4	N/A			C7	N/A			E4	1000	1	1/S23
A5	N/A			C8	N/A			E5	1800	1	1/S23
A6	N/A			C9	N/A			E6	300	1	1/S23
B1	500	1	1/S23	C10	N/A			E7	N/A		
B2	N/A			C11	N/A			E8	N/A		
B3	1000	1	1/S23	C12	N/A			E9	N/A		
B4	1200	1	1/S23	D1	3100	2	2/S23	E10	N/A		
B5	2100	1	1/S23	D2	1000	2	2/S23	E11	N/A		
B6	N/A			D3	800	1	1/S23	E12	N/A		
B7	600	1	1/S23	D4	800	1	1/S23	F1	800	3	3/S23
B8	N/A			D5	900	1	1/S23	F2	1100	4	4/S23
B9	N/A			D6	N/A			F3	500	3	3/S23
B10	N/A			D7	1400	2	2/S23	F4	N/A		
B11	N/A			D8	N/A			F5	N/A		
B12	N/A			D9	300	1	1/S23	F6	N/A		
C1	1400	1	1/S23	D10	N/A			LEGEND:			
C2	N/A			D11	N/A			N/A – NO GIRDER END REPAIRS REQUIRED			

Tendering

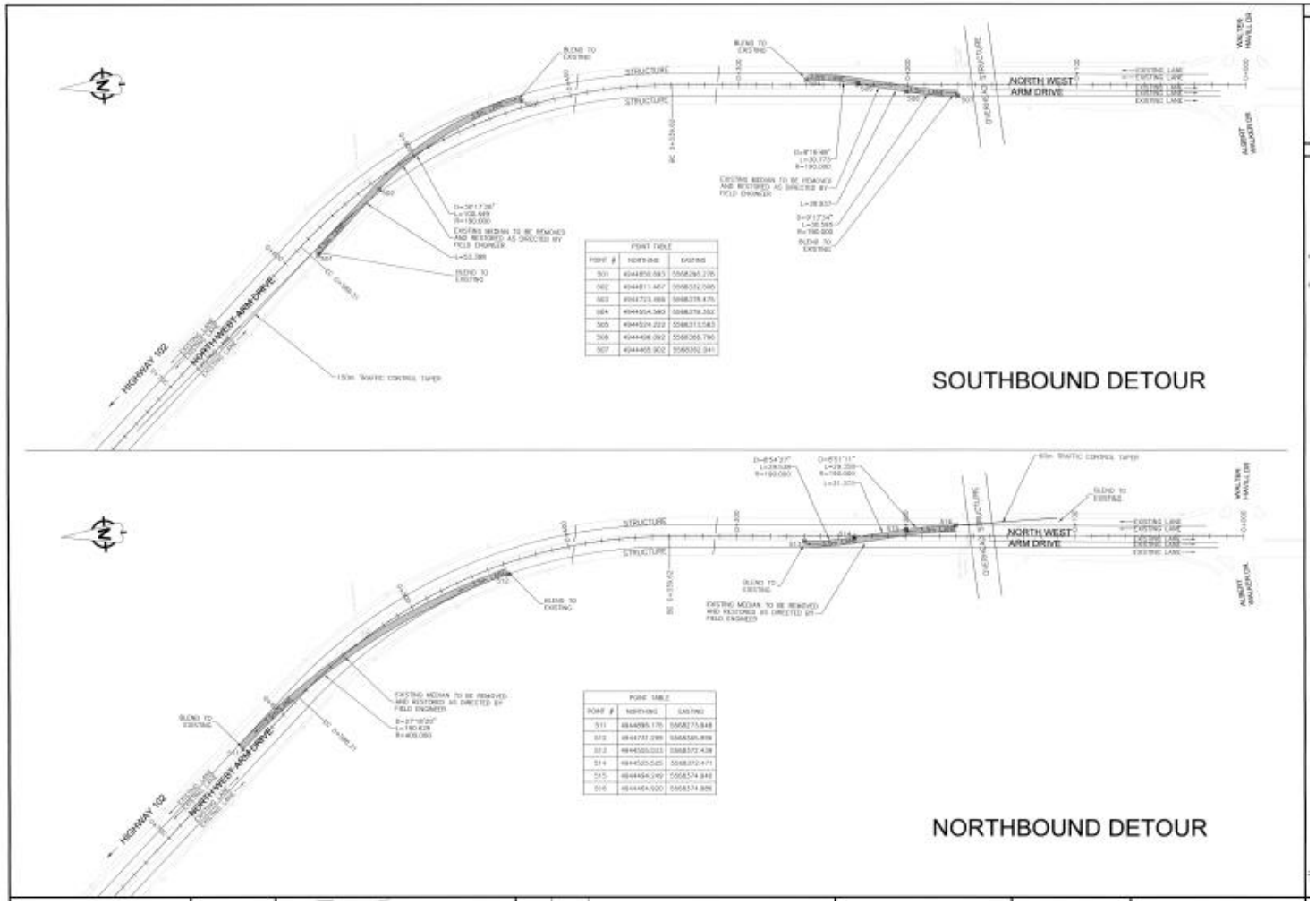
- Example of Girder End Repairs outside integration



Northwest Arm Drive Bridges HFX244A & HFX244B

Construction

Crossovers

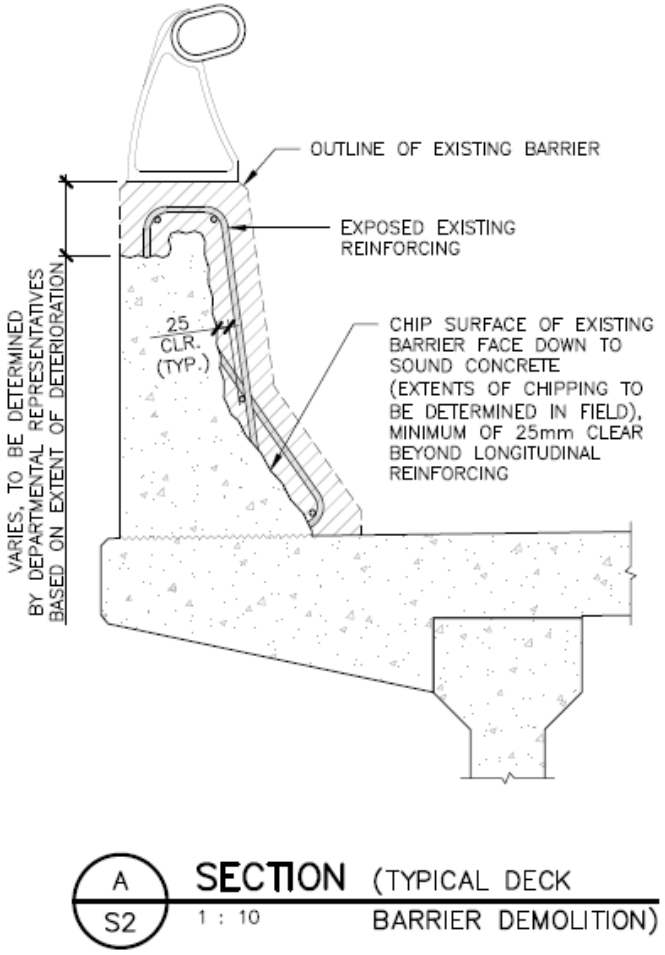

SOUTHBOUND DETOUR
NORTHBOUND DETOUR
NORTH WEST ARM DRIVE
HIGHWAY 102
STRUCTURE

Concrete Removal

Concrete Removal

Concrete Removal

Barrier Refacing



Barrier Refacing

Barrier Refacing

Deck Repairs

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Crack Injection

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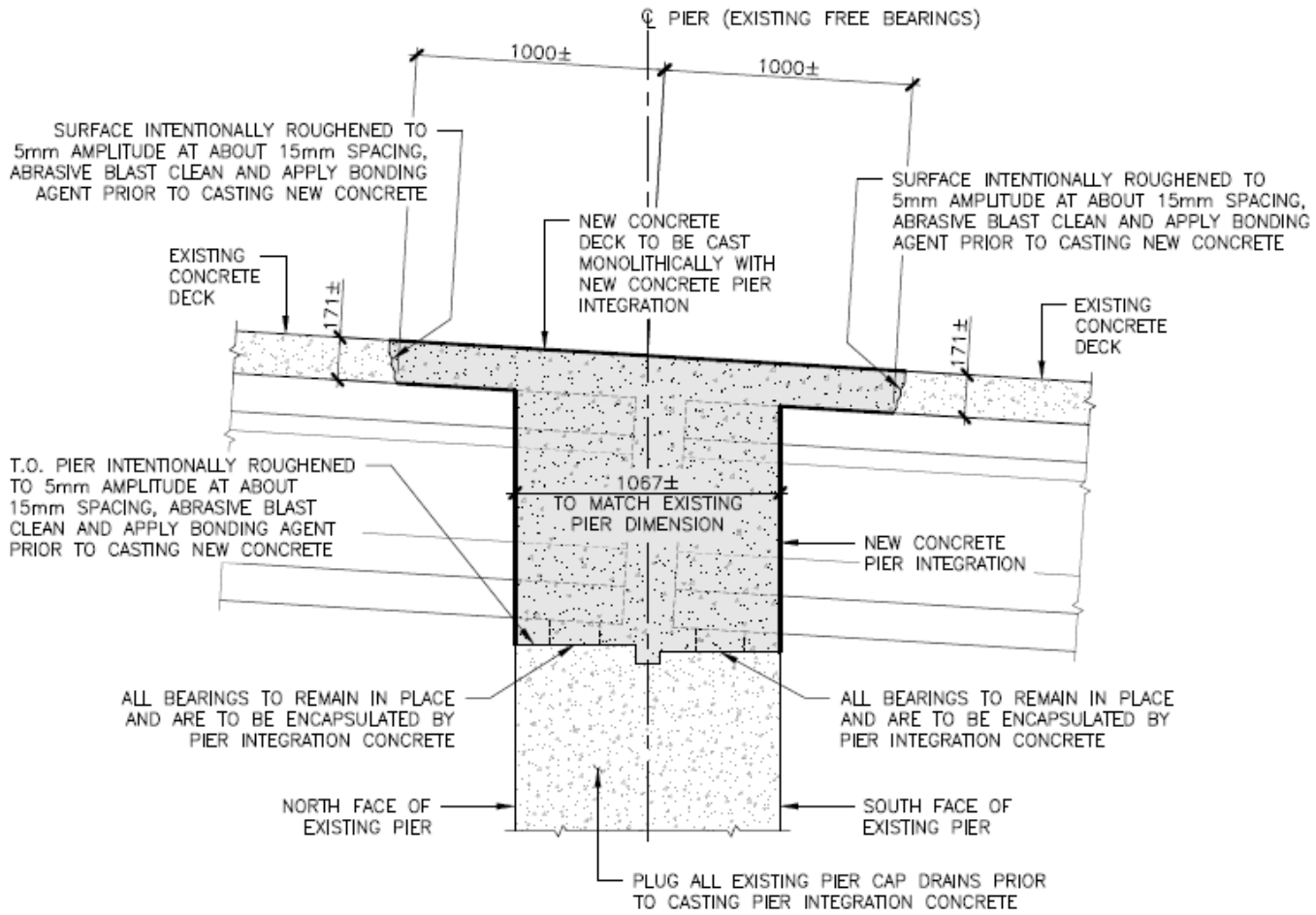
PIER INTEGRATION



AT NORTHBOUND PIER 'C' & NORTHBOUND/SOUTHBOUND PIER 'E'

PIER INTEGRATION

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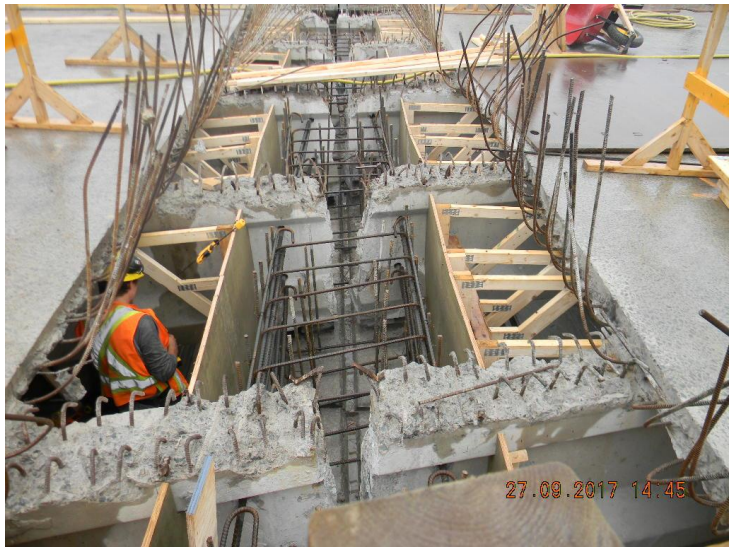
PIER INTEGRATION

NOVA SCOTIA

PIER INTEGRATION

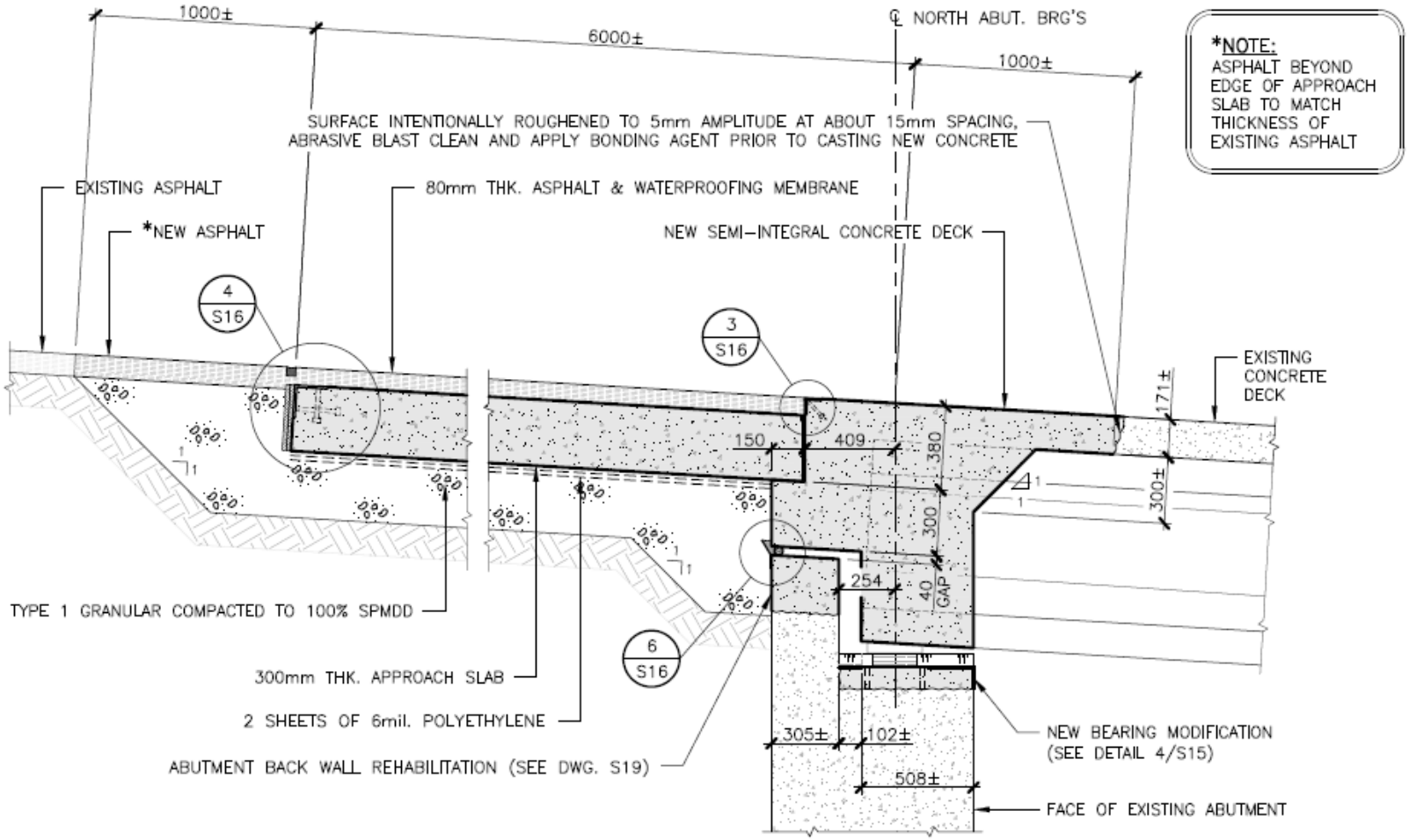
PIER INTEGRATION



PIER INTEGRATION

PIER INTEGRATION

SEMI-INTEGRAL ABUTMENTS



SEMI-INTEGRAL ABUTMENTS

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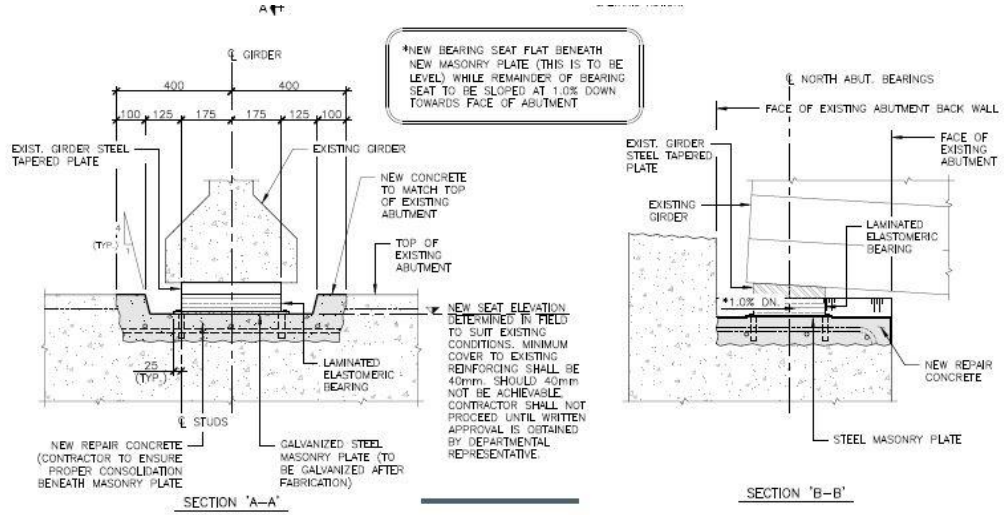

SEMI-INTEGRAL ABUTMENTS

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SEMI-INTEGRAL ABUTMENTS

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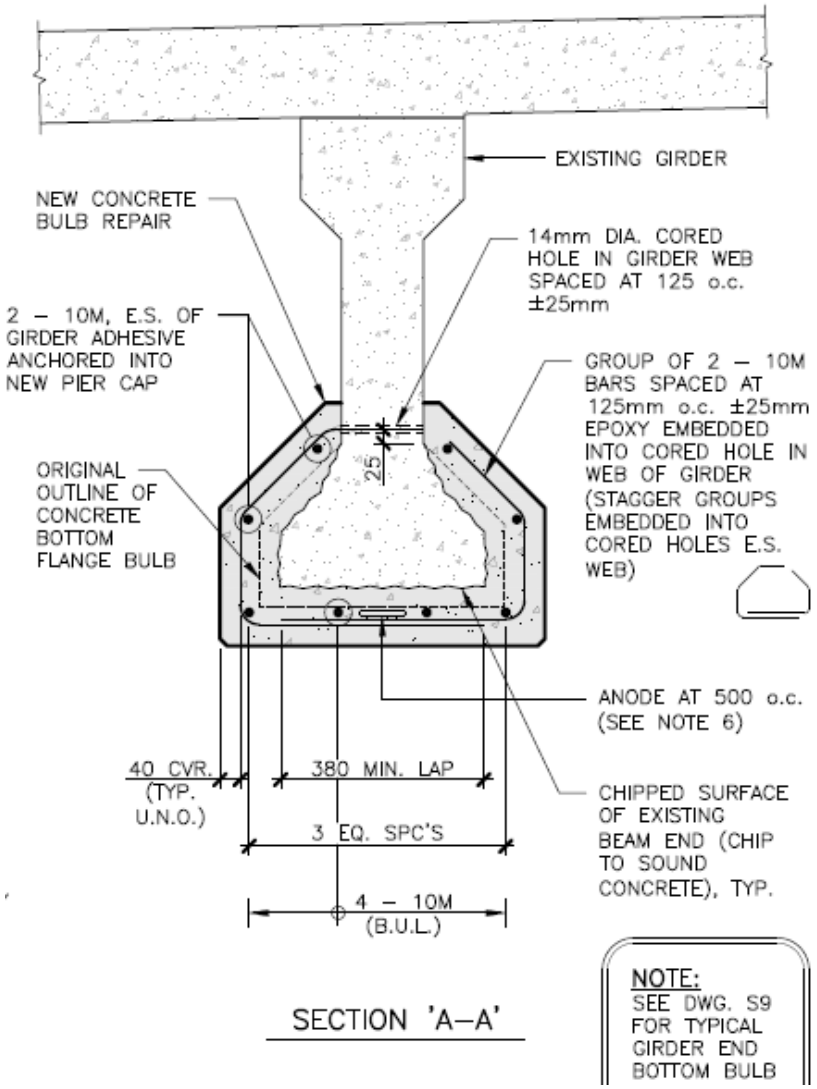
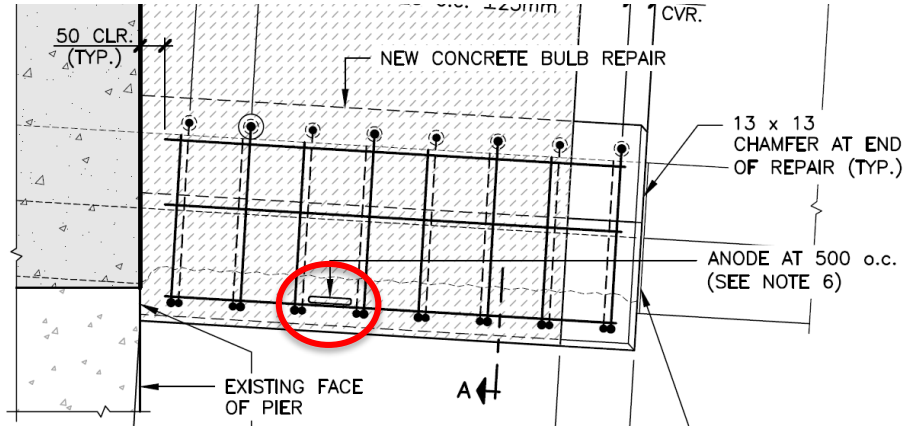
Girder Repairs



Girder Repairs



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Girder Repairs

Northwest Arm Drive Bridges HFX244A & HFX244B

Finished Condition Comparison
December 2018

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Girder Repairs + Wrapping

From This:

To This:

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Pier Repairs

From This:

To This:

Semi-Integral Abutments

From This:

To This:

Barrier Repairs

From This:

To This:

Resurfacing

From This:

To This:

So why not use this everywhere?

- This procedure is broadly applicable
- Applications will need to be carefully chosen
  - Traffic maintained in workzone?
  - Continuous conversion does not favour lane-by-lane construction
  - Design effort is more extensive and complex

Summary - Life Cycle Cost

- Low bid was Cdn$2.1Million (US$1.6Million) for both bridges
- Significant life cycle cost savings
- Significantly less impact on the public over the remaining life of the structure

Questions?

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