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GLOBAL PERSPECTIVE.
LOCAL FOCUS.

Western Bridge Engineers

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Accelerated Bridge Construction – Fraser Heights Bridge

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CANADA'S BEST MANAGED COMPANIES

Outline

- Introduction
- Problem Statement
- Solution
- Seismic Design
- Construction
- Conclusion
- Acknowledgements

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Introduction

- Part of Port Mann Highway Project – a 37 km freeway widening: Vancouver – Langley, BC
- $2.5 Billion contract between the Province of BC and Design/Build Contractor Kiewit/Flatiron
- 450 m four-lane wetland crossing for the new South Fraser Perimeter Road
- *– Construction equipment prohibited in wetland*
- *– Total "footprint" restricted to 45 m^2*

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Problem Statement

- Wetland comprises highly compressible soils
- Challenging seismic performance requirement
- Construction schedule – limited to 12 months
- 4–5 m deck height results in stiff substructure
- Long segment lengths are desirable to minimize expansion joints and seismic interfaces, and improve vehicle ride quality
- – *Innovative solution required*

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Location

North Surrey, BC

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Solution

- Final design *very similar* to bid design
- Parallel 436 m and 472 m long, 11 m wide superstructures
- Typical span length 18 m – end spans 14 m
- Bents: two steel pipe piles per trestle supporting box-section steel cap beams
- 302 identical reversible full-depth 250 mm precast deck panels – 3 m long, 11 m wide
- 100 mm membrane and asphalt wear surface

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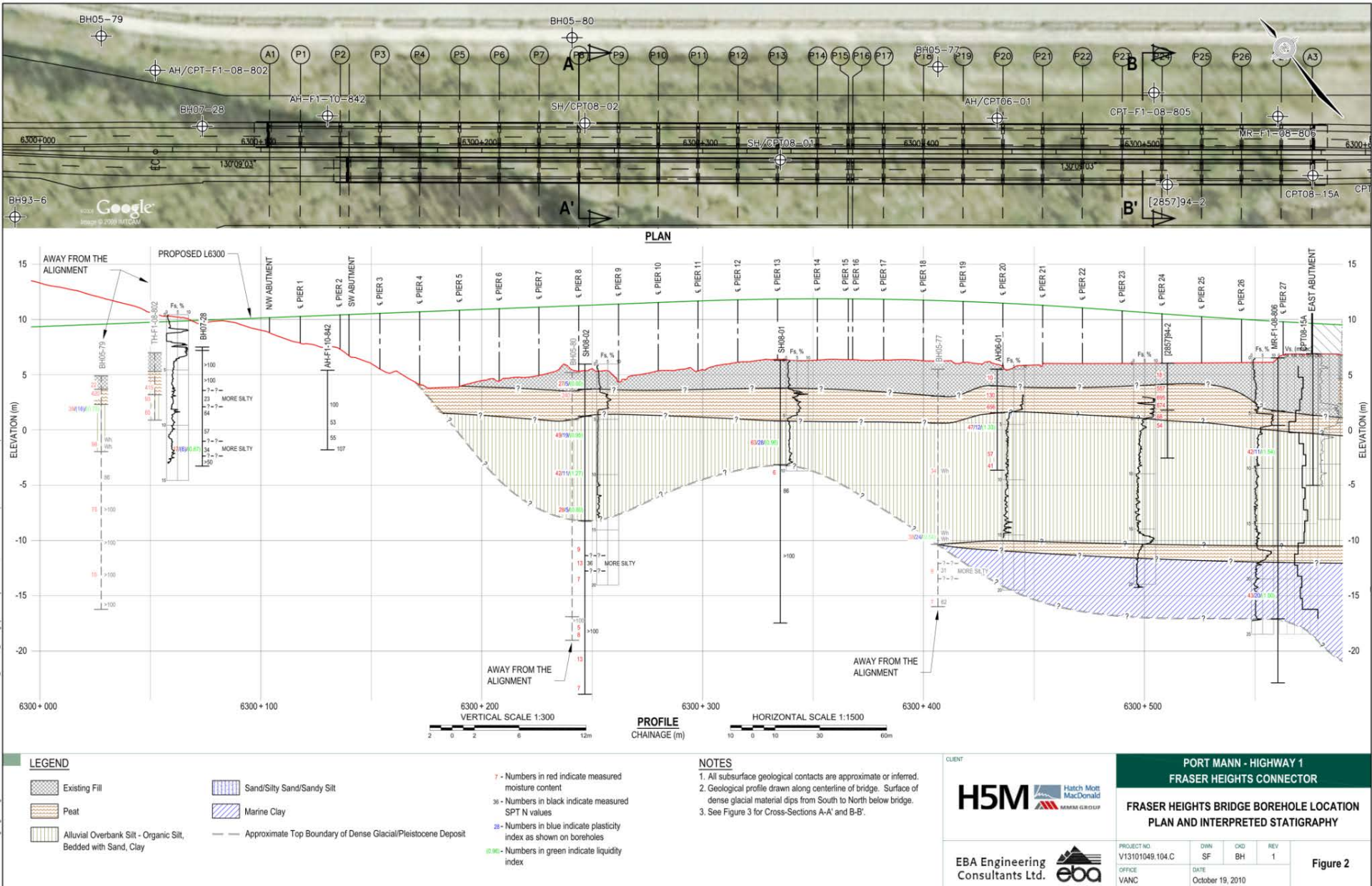
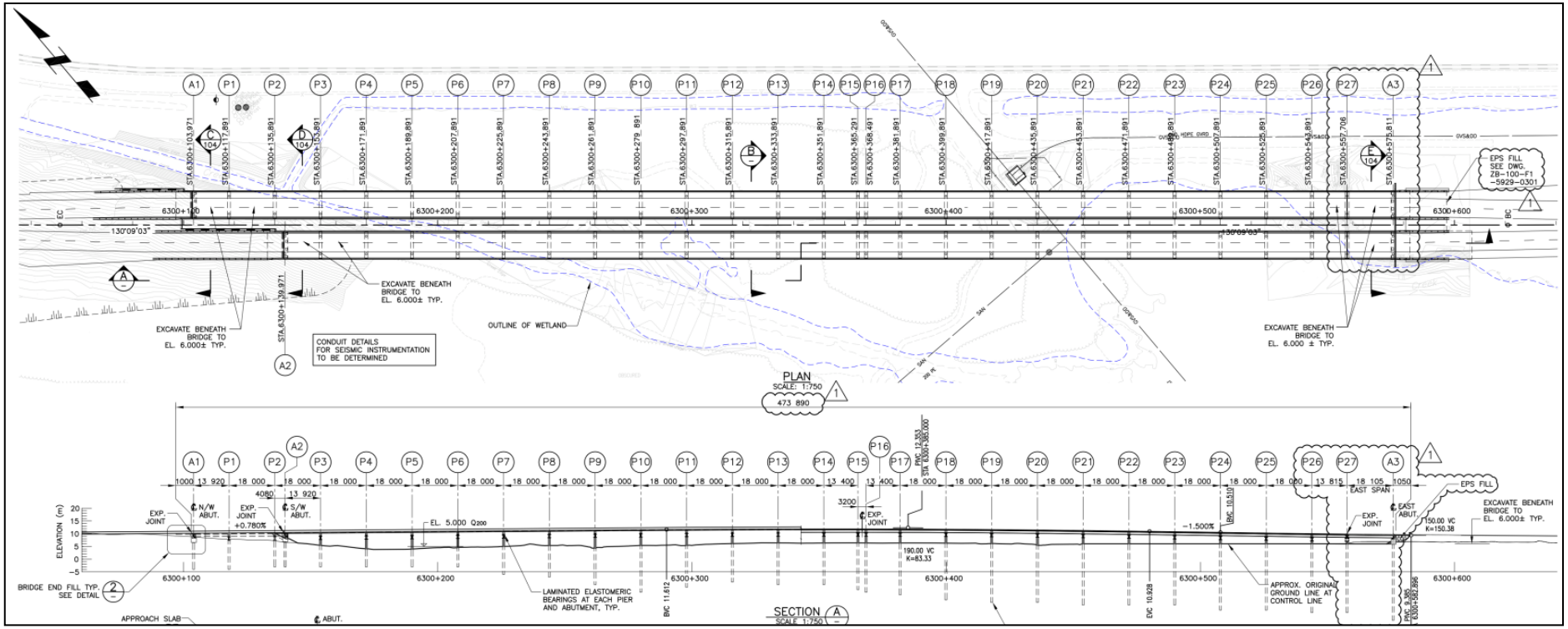
Wetlands and soil profiles



Bridge Configuration



Eastbound: 436 m long – 26 spans
Westbound: 472 m long – 28 spans

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Underside of Superstructure

Piles, caps, girders, precast deck panels installed

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Seismic Design

Performance Criteria

- Minimal damage and immediate use by emergency vehicles for 475-year RP event
- Significant damage, return to full service following repairs for 975-year RP event
- No collapse, non-repairable damage acceptable, for 2475-year RP or Cascadia subduction events
- *Criteria readily achieved by design selected*

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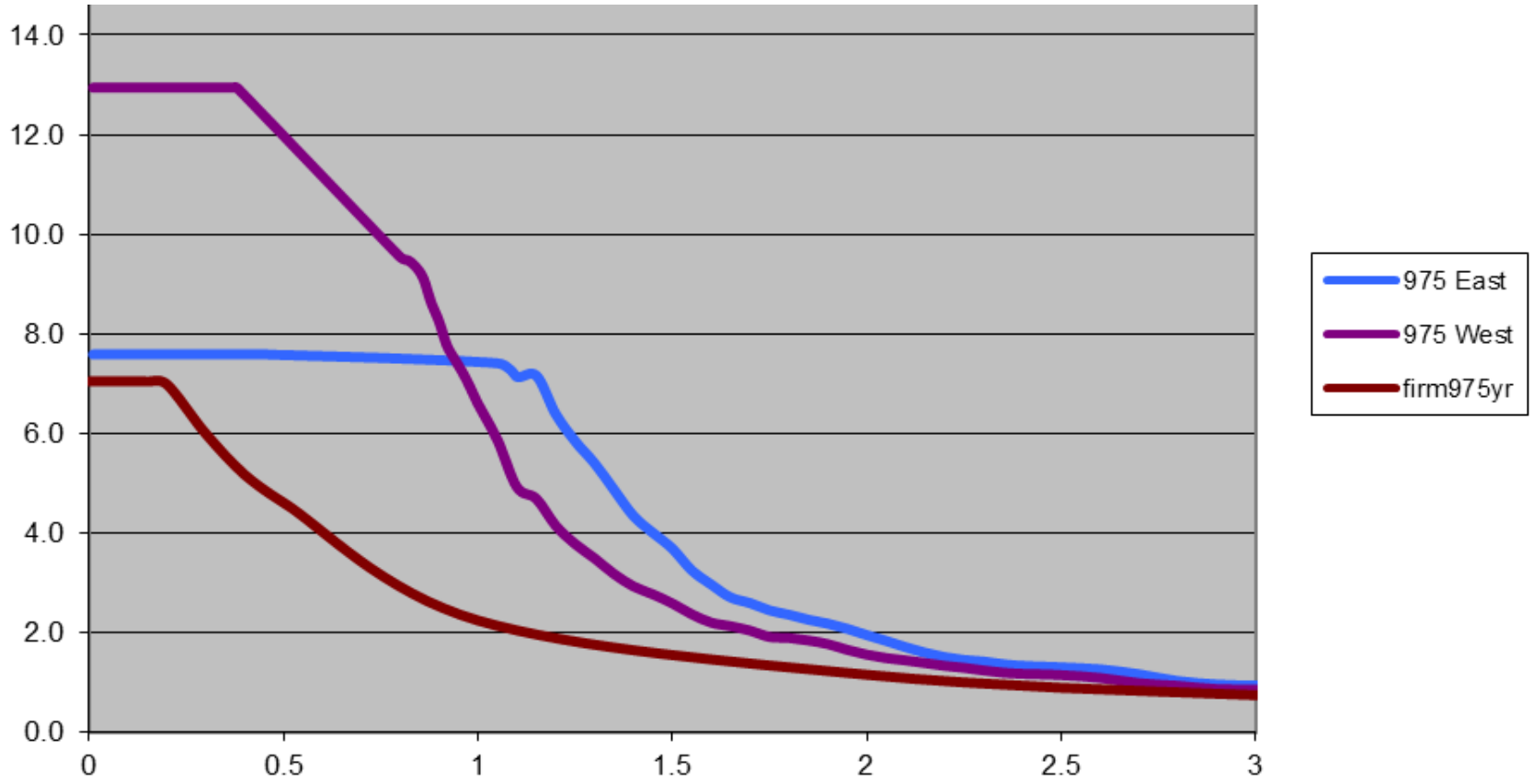
Seismic Design

Response Spectra



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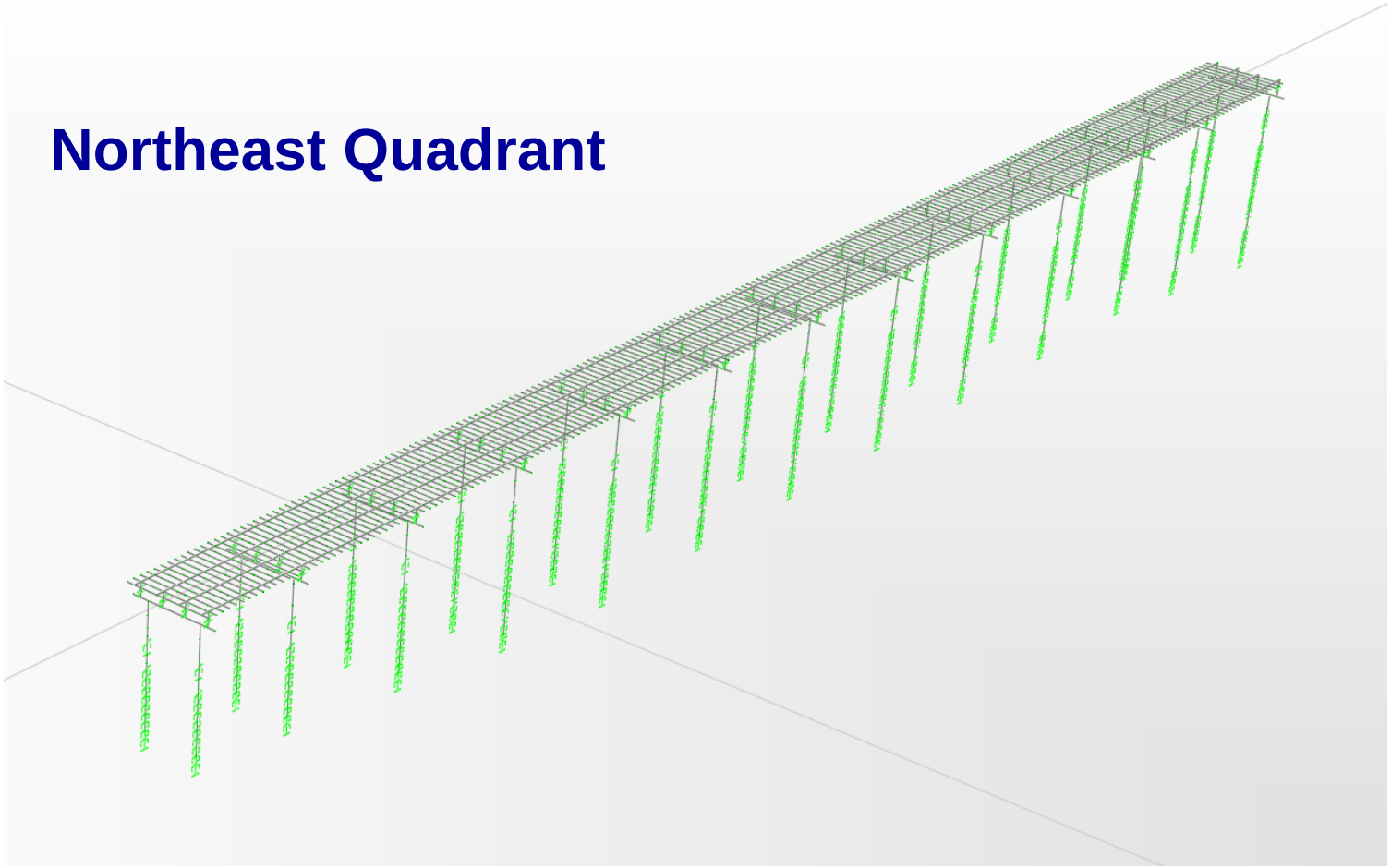
Seismic Design – SAP Model



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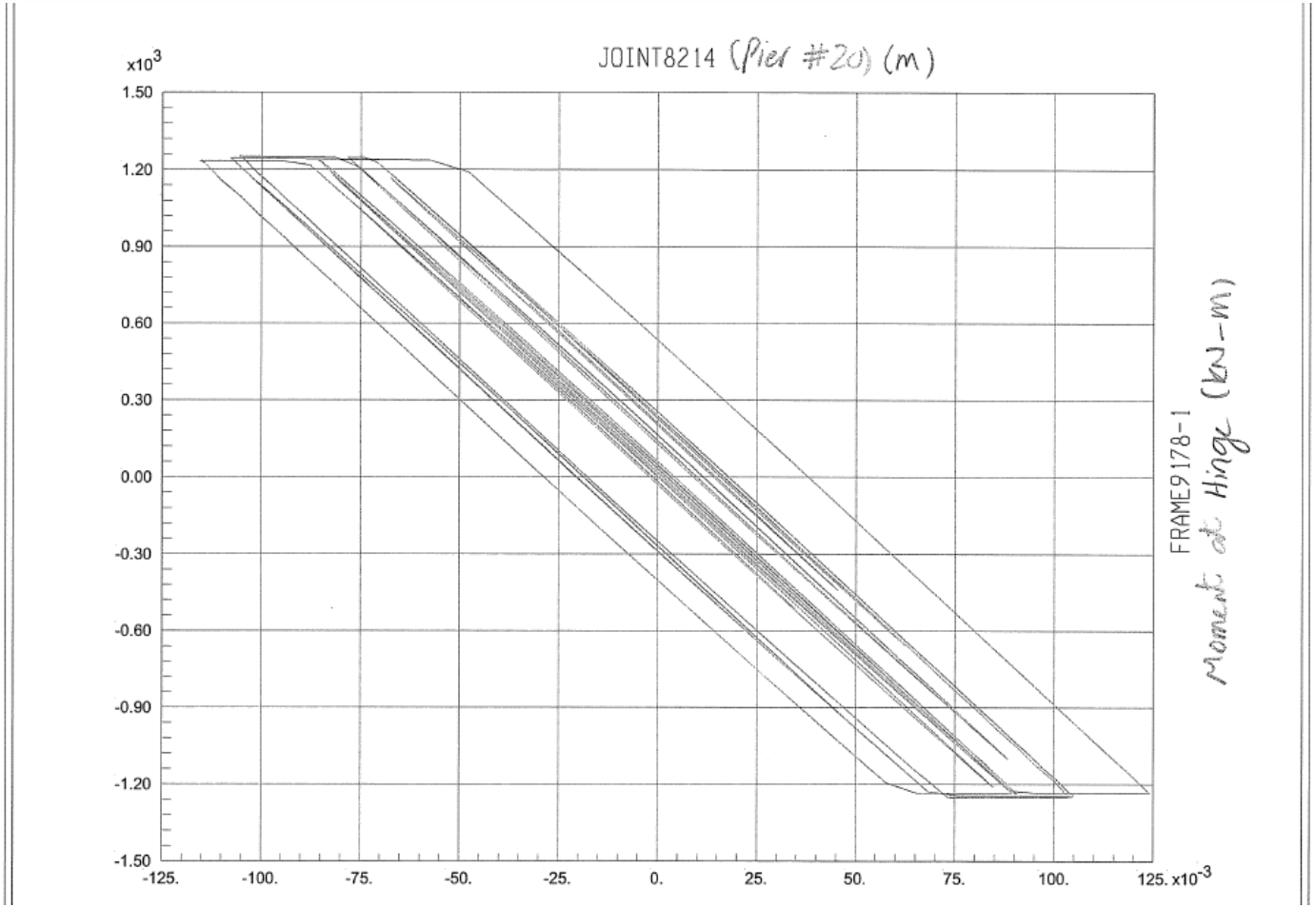
Seismic Design – Plastic Hinges



Hysteresis in piles

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Seismic Design

Isolated Superstructure

- Base isolation accommodated thermal strains
- Segment lengths up to 250 m
- 224 bearings – only two types required
- Bearings: height – 144 mm; rubber thickness – 126 mm
- 975 year event displacement (non-linear time history analysis) – 109 mm max

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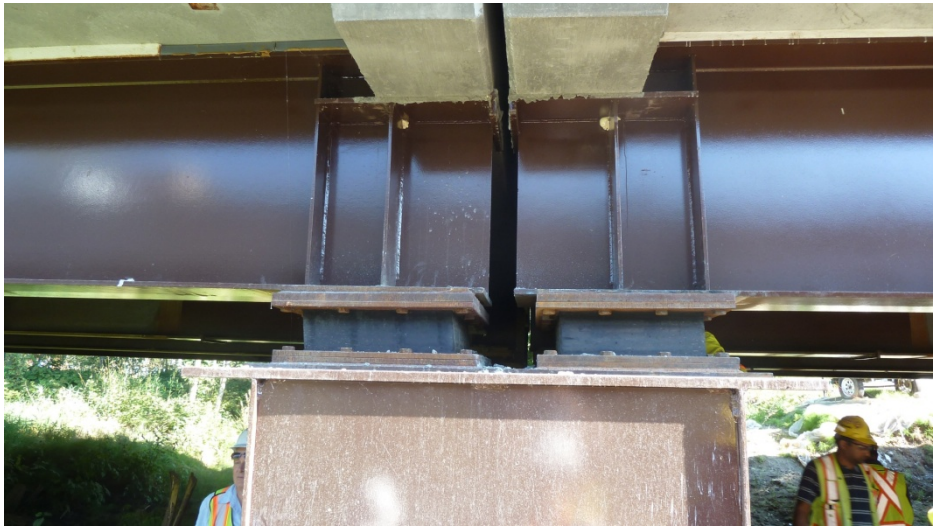
Isolation Bearings

Typical single-bearing support



Double-bearing support – west end-span

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Seismic Response – Periods

Mode	Natural Period (sec)	
	Westbound Bridge	Eastbound Bridge
Longitudinal	1.7	2.18
Transverse 1	1.49	1.67
Transverse 2	1.33	1.58

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Seismic Response – Displacement

Hazard	Displacement (mm) max.	W/B Bridge	E/B Bridge	Expected Yielding
10% in 50 years	Transverse	154	165	None
	Longitudinal	109	146	
5% in 50 years	Transverse	212	227	Several cap/pile joints
	Longitudinal	154	211	
2% in 50 years	Transverse	341	363	Several cap/pile joints Several piles (minor)
	Longitudinal	253	325	

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Construction

Top-down construction method

- 250 tonne erection crane
- Two movable work platforms on WB trestle
- Crane drives piles, installs pilecaps, places concrete in piles and cap joints, erects girders, and installs deck panels
- Materials delivered over EB and WB trestles
- Girders and panels acting non-compositely designed for one lane of highway loading

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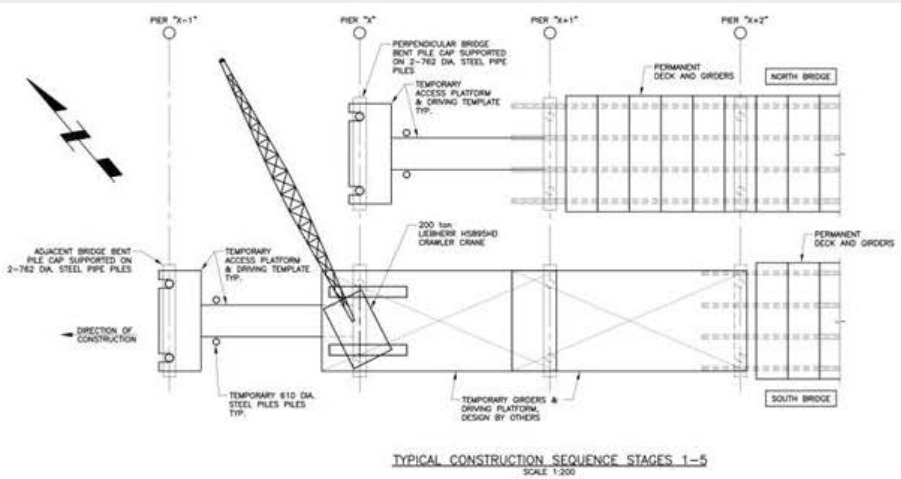
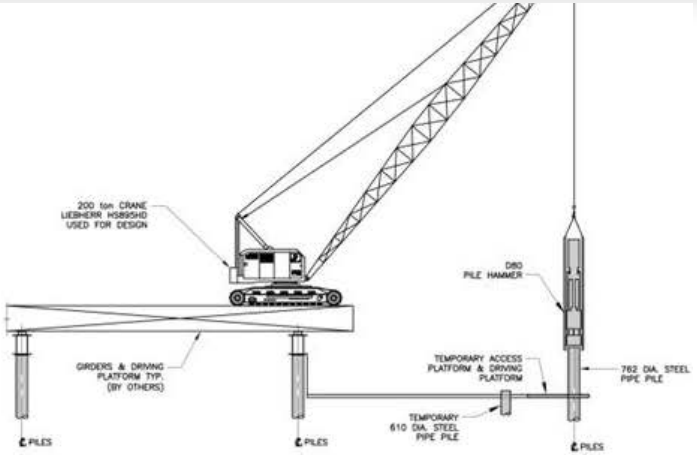
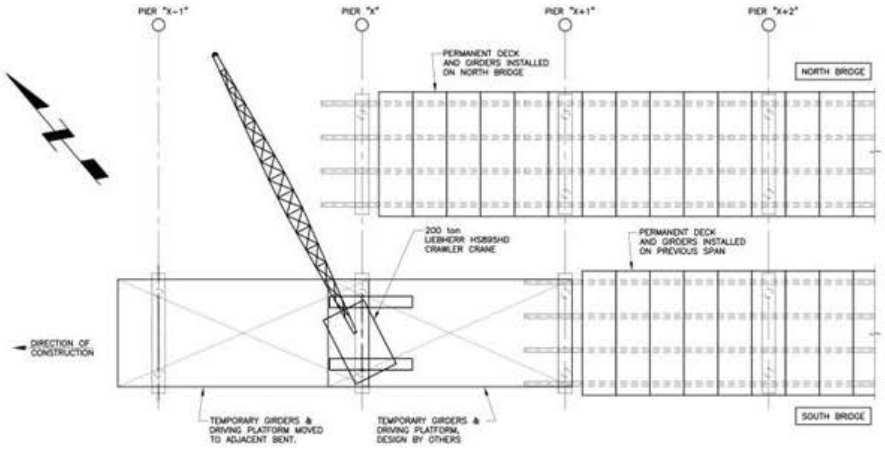
Top-down construction method



TYPICAL CONSTRUCTION SEQUENCE STAGES 1–5
SCALE 1:200



CONSTRUCTION SCHEMATIC
SCALE 1:150



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Crane – Work Platform

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Construction – Piles

- 112 open-ended steel pile piles
- 762 mm diameter x 19 mm wall thickness
- SLS – 2100 kN; ULS – 2700 kN
- Required geotechnical capacity – 5400 kN
- APE D80 hammer: 268 kNm; 31.4 tonnes
- Top 11.5 m concrete-filled; reinforcing ratio: 2.6%
- Rebar cage penetrates into joint in pile cap
- Rebar flexural yielding capacity-protects pile cap

Crane – Pile Driving

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Steel Pilecap Installation

Joint formwork in place

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Pilecap Joint

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Pilecap Joint

Pile rebar cage projects into pilecap joint

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Accelerated Bridge Construction

Time frame

- 52 weeks available for construction
- Virtually all components critical path
- Span cycle:
  - Advance work platform and crane
  - Drive piles – clean out, fill with concrete
  - Place steel pier cap and cast pile/cap joints
  - Install bearings, girders and precast panels
- ***10-day average span-cycle achieved***

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Challenges – Pile Installation

- East abutment piles 45 m long (35 m anticipated)
- Several piles encountered boulders:
  - Full-height HP 360x174 driven inside pipe to by-pass boulder (3 piles)
  - Shallow boulder excavated (west end)
- Six west-end piles drilled-in from outside wetland to achieve required embedment
- Final total pile length: 2306 m (108% of estimate)
- ***All 112 piles successfully installed***

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Challenges – Pile Installation

Pile tip damage

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Girder Erection

Girders lifted in braced pairs

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Deck Panels

All panels identical and reversible

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Deck Panel Joints

- ***350 mm wide joints***
- ***Suspended forms***

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Deck Panels – Pockets

Clusters of thirteen 22 mm studs

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Watercourse Crossing

Bridge design accommodates existing wetland drainage

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Completed Bridge

- ***Minimal impact on wetland***
- ***Open median reduces deck shadow effect***

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West Abutments

Wire-faced MSE median wall

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Deck Paving

Installation of Protecto Wrap preformed waterproof membrane

Surfacing: 40 mm Open Graded Friction Course over 60 mm Hot Mix Asphalt

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Finished Deck Surface

Looking west from East Abutment

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Conclusion

- **Value achieved by:**
  - Maximizing deck segment lengths and work repetition
  - All 112 pile sections were identical
  - Constant girder section – no butt welds
  - All 302 precast full-depth deck panels were identical
  - Non-composite bridge carries materials delivery trucks
  - Building tolerance on support location into design – *no corrective action required*

Summary

- A custom solution was developed to solve a challenging bridging problem
- Bridging solution developed for bid design envisaged top-down, Accelerated Bridge Construction techniques
- Identical layout used for final design
- Work platform added to avoid 250 tonne crane loading on superstructure
- ***Contractor estimated cost at $25 Million: $2500 per m^2***

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Acknowledgements

- ***Owner:*** BC Ministry of Transportation and Infrastructure
- ***Design-Build Contractor:*** A joint venture of Peter Kiewit Sons Co. and Flatiron Constructors Canada Limited
- ***Onshore Design:*** H5M – a joint venture of Hatch Mott MacDonald and MMM Group Limited.
- ***Bridge Designer:*** Brybil Projects, a subsidiary of Associated Engineering Group Ltd.
- ***Geotechnical Engineer:*** EBA Engineering Consultants Ltd.
- ***Bridge Installation Contractor:*** Gateway Infrastructure Group GP

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Thank You

- for your attention

Questions?

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