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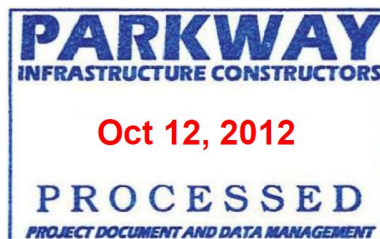
Design Consultant:		HMM
Date	Revision	Description
Sept. 17, 2012	0	Issued for Construction

Issued by: Yang Eileen Li
Name

Signature

Sept. 17, 2012
Date

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Appendix A – Design Documentation

1 Project Description

This submission contains design drawings and geotechnical recommendations associated with Tunnel 9 – Cousineau Tunnel. This is the Issued for Construction submission for the structure deliverables.

1.1 Name and location of tunnel

Tunnel 9 - Cousineau Tunnel is located along the below-grade section of Highway 401 from STA. 12+130.00 to STA. 12+300.00.

1.2 Permitted traffic speed (for a Tunnel give over and/or under)

Top of the tunnel carries Cousineau Road as well as landscaping area. Traffic for HWY401 is accommodated below the structure.

HWY401

Highway Classification:	UFD 120
Design Speed:	120 km/h
Posted Speed:	100 km/h
Lanes:	6 traffic lanes with 4 shoulders
Design Clearance:	Minimum 5.0 m vertical clearance
Bridge Design Vehicle:	CL-625-ONT

2 Tunnel Details

2.1 Basic layout (Number of lanes, length, etc.)

Cousineau Tunnel is 170 m long and 40.6m wide. The tunnel has one centre pier which follows HWY401 centerline between STA. 12+130.00 and STA. 12+300.00. The tunnel centerline is perpendicular to HWY401 centerline at STA. 12+215.00. The layout of HWY401 is summarized in the following table.

Basic Layout Summary

HWY401

Length	170 m
Clear Roadway Width	17.25 m minimum for westbound roadway; 17.25 m minimum for eastbound roadway
Alignment	Tangent
Lanes	3 – 3.75 m westbound lanes 3 – 3.75 m eastbound lanes
Shoulders	2 outside shoulders, each with a minimum width of 3.0 m 2 median shoulders, each with a minimum

	width of 3.0 m
Median Barrier	Along median
Road side Barrier	Along shoulders

2.2 Restrictions to traffic

Not applicable.

3 Brief Description of Tunnel, Traffic and Tunnel Geometry

3.1 Structural form of Tunnel

Cousineau Tunnel is a two-span deck-on-girder structure designed to accommodate Cousineau Road on top of tunnel and below-grade sections of Highway 401. The superstructure is divided into four segments by three deck expansion joints parallel to the girders, which are located 41.65 m, 83.49 m, and 125.33 m, respectively, from the structure's west limit. Girders are at 90 degrees to centerlines of abutments. The tables below provide summaries of the general arrangement.

Structure Summary

Structural Type:	Prestressed concrete modified NU girders and semi-integral abutments.
Span Arrangement:	<ul style="list-style-type: none"> Two span structure with modified NU girders spaced at 3.02m. Exterior deck overhang under parapet wall is 1.1m, while interior deck overhang under expansion joint is 1.29m. Span length is 20.3m for both north and south span.
Foundation Type:	
North Abutment	Semi-integral abutment supported on HP 310x110 steel piles
South Abutment	Semi-integral abutment supported on HP 310x110 steel piles
Piers	Pier footings supported on HP 310 x 110 steel piles
Span Articulation:	Semi-integral abutment support at two ends with intermediate pier supports; Three expansion joints parallel to girders are provided on the deck along length of the tunnel.
Deck:	235 mm deck comprising 90 mm precast panels and cast-in-place concrete topping; 30mm girder haunch; 1.8m tall parapet wall at the each side

The expansion joints in tunnel deck are required because the tunnel superstructure is expected to expand and/or contract immediately after construction and during its service life due to creep, shrinkage and thermal movement. Dividing the tunnel superstructure into segments using expansion joints significantly reduces the demand on the bearings caused by these movements, and reduces bending demand on piles perpendicular to the girder center lines, thus resulting in a more efficient design. Most of the strip seals are to be installed 1.0 m below backfill. They are also covered by a protective material further resistance to vertical live load/impact. The expansion joints are not expected to require frequent maintenance. Inspection (e.g. for signs of leakage) can be undertaken from beneath the deck using a lifting platform or similar. The replacement procedure for expansion joints is expected to be similar to that of replacing buried utilities on top of tunnels. For joints exposed to traffic, appropriate standard joints have been specified with input from suppliers.

3.2 Structural form of portal structures

Not applicable.

3.3 Traffic and geometry

3.3.1 Horizontal and vertical alignment of Tunnel and Tunnel approaches

Tunnel:

Horizontal alignment: Tangent from STA. 12+130.00 to STA. 12+300.00 of Highway 401

Vertical alignment: Vertical curve from STA. 12+130.00 to 12+223.27 of Highway 401; -0.5% slope from STA. 12+223.27 to STA. 12+300.00 of Highway 401

Above Tunnel: Cousineau Road

3.3.2 Cross-section (include spare provided for any mechanical and electrical equipment)

Tunnel satisfies 5.00 m minimum vertical clearance by providing a minimum of 5.084 m vertical clearance.

3.3.3 Standards used (include design traffic flows and speeds and any proposed departures from standards)

Design Criteria in accordance with Part 2 of Project Agreement – Schedule 15-2:

Article 1 – Highway Geometrics Design Criteria

Article 3 – Structural Design Criteria

Article 4 – Tunnel Design Criteria

Article 5 – Geotechnical and Foundation Design Criteria

Referenced Documents as specified in these Articles following the order of precedence as instructed.

No deviation from the standards used including design traffic flows and speeds.

3.3.4 Accommodation of mechanical and electrical services in Tunnel

Mechanical and electrical arrangements are as shown on drawings.

3.3.5 Minimum headroom, horizontal clearances

Minimum headroom provided is 5.084 m. Minimum horizontal clearance provided between the traffic carriageway and the face of the structure is 4.135m along outside shoulders and 2.8m along median shoulders for both westbound and eastbound roadway.

3.4 Proposed arrangements for inspection and maintenance

All exposed features are inspectable through the use of an inspection platform.

3.5 Provision to be made in the Tunnel layout for emergency communication and escape facilities, fire, etc.

Emergency communication details are shown on ATMS New Construction drawings which is not included in this submission.

No escape facilities will be provided.

3.6 Landscaping above Tunnel and protection of Tunnel Roof

Landscaping above tunnel is shown on Landscape Construction drawings which is not included in this submission. Tunnel has been designed with 0.85 m soil layer on top deck to accommodate the requirement for drainage and landscaping.

3.7 Finishes

Concrete finishes on exterior of the parapet wall will have grassland pattern. All remaining finishing is specified in the General Notes, Doc No. 285380-03-060-SEG1-2902.

4 Design Assessment Criteria

4.1 Live Loading

4.1.1 Loading relating to normal traffic under applicable code loading and regulation

Cousineau tunnel carries Cousineau Road and landscaped area on top of the structure. For the roadway area, the tunnel is designed for traffic load per CSA S6-06 and S6S1-10 (Canadian Highway Bridge Design Code 2006 and Supplement 2010). For the landscaped area, the tunnel is designed for pedestrian load per CSA S6-06 and S6S1-10, or a vehicle load equivalent to one individual CL-625-ONT truck placed anywhere on the fill area.

4.1.2 Design vehicle

The tunnel is designed to carry multiple CL-625-ONT trucks for the roadway area, and one single CL-625-ONT truck for the landscaped area placed anywhere on the soil fill.

4.1.3 Provision for exceptional abnormal loads

Not applicable.

4.1.4 Any special loading not covered above

Not applicable.

4.1.5 Heavy or high load route requirements and arrangements being made to preserve the route and any provisions for future heavier loads or future widening

Not applicable.

4.1.6 Authorities consulted or any special conditions required

Not applicable.

5 Structural Analysis

5.1 Methods of analysis proposed

T9 has been analysed in accordance with CSA S6-06 and S6S1-10 (Canadian Highway Bridge Design Code 2006 and Supplement 2010). Software design aids include RM Bridge V8i version 08.09.90.01, STAAD Pro 2007 version 20.07.02.15, Response 2000 version 1.0.5, pcaColumns version 3.60 and Microsoft Office Excel 2007.

5.2 Assumptions of structural elements (strength, stiffness, etc)**5.2.1 Cast-In-Place Concrete**

Minimum compressive strength at 28 days: 30MPa (substructure)

Minimum compressive strength at 28 days: 40MPa (deck)

5.2.2 Precast Prestressed Concrete

Minimum compressive strength at transfer: 42MPa (girders)

Minimum compressive strength at 28 days: 60MPa (girders)

Minimum compressive strength at transfer: 24MPa (deck panels)

Minimum compressive strength at 28 days: 40MPa (deck panels)

5.2.3 Reinforcing Steel

Plain and coated reinforcing steel bars: CAN/CSA G30.18-M92; Grade 500W for columns only, and Grade 400W for all other elements

Stainless steel reinforcing bars: Type 316LN or Duplex 2205 or Type XM-28;
Grade 500

5.2.4 Prestressing Steel

Strands shall be low-relaxation, size designation 11 in precast panels and size designation 15 in precast girders, Grade 1860 in accordance with CSA Standard G279.

5.2.5 Structural Stiffness

Structural stiffness is calculated according to CAN/CSA S6-06.

5.3 Proposed earth pressure coefficient (K_a , K_o , or K_p)

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012.

5.4 Proposed fire design including protection of structure and cable

For proposed fire design refer to the following fire protection documents:

- Tunnel Structural Fire Assessment, Doc. No. 285380-03-126-0045;
- Tunnel Structural Fire Assessment – Deck Slab, Doc. No. 285380-03-126-0049;
- Tunnel Fire Design Criteria, Doc. No. 285380-03-109-0004.

Only non-combustible materials are used in tunnel for electrical and ATMS works.

6 Ground Conditions

6.1 Ground Conditions

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012.

6.2 Geotechnical Design Parameters

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012.

6.3 Differential Settlement

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012.

6.4 Anticipated Ground Movements or Settlement

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012.

6.5 Groundwater Conditions and Mitigative Measures

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012.

6.6 Variance from Geotechnical Memo Recommendations

Not applicable.

7 Drainage and Waterproofing

7.1 Details of proposed/existing drainage

Refer to Highway and Roadway Drainage Design Report, Doc No. 285380-70-119-0001 for Phase 1 and Phase 2.

7.1.1 Ground water seepage and run off

Refer to Highway and Roadway Drainage Design Report, Doc No. 285380-70-119-0001 for Phase 1 and Phase 2.

7.1.2 Accidental spillage, water carried in by vehicles

Drainage structures have been placed along the tunnel to collect runoff from vehicles and any accidental spills. These liquids would then be conveyed to the spill containment units located upstream of each pumping station. See Highway New Construction Drawings for more details.

7.1.3 Fire main burst

The runoff from a fire main burst would be less than the 100yr storm flow, which the storm system is designer for. The flow would be collected within two or three inlets. Watermains crossing Highway 401 and Highway 3 will be installed in steel casings per MTO requirements. Casing material will be stronger than the watermain material to be used. Additionally, the casing void (area between outside of watermain pipe and casing pipe) will be fill with cement based grout. Grouting the void area will provide added strength to the pipe system crossing the Highways, and minimize the potential for watermain breaks underneath a travel lane. Should a break occur under the travelled portion of the Highway, the casing will direct water flow to the shoulder areas where the subdrains and catchbasins will direct the water into the storm system. Water valves are placed along the watermain along Highway 401. This will permit the watermain to be isolated in the area of a break. Once the valves are closed, the water flow will be shut off.

7.1.4 Tunnel washing

The runoff from tunnel washing would be less than the 100yr storm flow, which the storm system is designer for. The flow would be collected within two or three inlets. Watermains crossing Highway 401 and Highway 3 will be installed in steel casings per MTO requirements. Casing material will be stronger than the

watermain material to be used. Additionally, the casing void (area between outside of watermain pipe and casing pipe) will be fill with cement based grout. Grouting the void area will provide added strength to the pipe system crossing the Highways, and minimize the potential for watermain breaks underneath a travel lane. Should a break occur under the travelled portion of the Highway, the casing will direct water flow to the shoulder areas where the subdrains and catchbasins will direct the water into the storm system. Water valves are placed along the watermain along Highway 401. This will permit the watermain to be isolated in the area of a break. Once the valves are closed, the water flow will be shut off.

7.2 Details of proposed waterproofing

Refer to Tunnel Watertightness REV E, Doc No. 285380-03-126-0039.

7.3 List special requirements of local drainage authority

None.

8 Tunnel Support System and Method of Construction

8.1 Give details of predicted settlements on adjacent structures

Structural form as described on Section 3.1 is one of the effective support system commonly used to carry roadway above for highway underpass. This support system is also cable of satisfying the design requirements for permanent conditions of the WEP tunnels.

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012 for the basis of permanent ground treatment design.

Design for temporary conditions is not addressed in this submission.

8.2 State methods to be adopted to monitor and control the effects of tunnel construction to ensure compliance with any criteria imposed to limit surface movements or vibration (if applicable)

Permanent design is based on the Construction Sequence provided on the Foundation Plan, Abutment Layout and Ground Improvements Plan. (Construction methodology, staging and temporary works design are not addressed in this submission.)

8.3 Give details of predicted settlements on adjacent structures

Refer to Geotechnical Investigation and Design Report prepared by AMEC Earth and Environmental, dated September 2012 for anticipated deformation of the ground around the structure.

8.4 State methods to be adopted to monitor and control the effects of Tunnel construction to ensure compliance with any criteria imposed to limit surface movements or vibration (if applicable).

A program of site instrumentation and monitoring will be developed and implemented during construction, but is not part of this submission.

9 Checking**9.1 Independent Check**

Independent check is required as per Project Agreement – Schedule 15-2, Part 2, Article 3 3.2 (c) (i).

Independent Checking Team: INTERNATIONAL BRIDGE TECHNOLOGIES.

9.2 Responsible Design Personnel

Originator: Yang Eileen Li

Checker: Matthias Yu, MStructE, C.Eng., P.Eng.

Reviewer: Biljana Rajlic, P.Eng.

10 Drawings and Documents**10.1 List of Drawings (included in this submission):**

Drawing No.	Revision	Drawing Name
285380-03-060-SEG 1-2900	0	Cover Sheet, Site Plan and Key Plan
285380-03-060-SEG 1-2901	0	General Arrangement
285380-03-060-SEG 1-2902	0	General Notes
285380-04-090-SEG 1-2903	0	Borehole Locations & Soil Strata
285380-04-091-SEG 1-2904	0	Soil Stratigraphy
285380-03-061-SEG 1-2905	0	Foundation Layout
285380-03-061-SEG 1-2906	0	Foundation Details
285380-03-060-SEG 1-2907	0	Ground Improvements - Plan

285380-03-061-SEG 1-2908	0	Abutment Layout
285380-03-061-SEG 1-2909	0	Abutment Details
285380-03-061-SEG 1-2910	0	Abutment Reinforcement
285380-03-061-SEG 1-2911	0	RSS Wall Layout
285380-03-061-SEG 1-2912	0	RSS Wall Details
285380-03-061-SEG 1-2913	0	Pier Layout and Details
285380-03-061-SEG 1-2914	0	Pier Reinforcement
285380-03-062-SEG 1-2915	0	Bearing Layout
285380-03-062-SEG 1-2916	0	Bearing Details
285380-03-063-SEG 1-2917	0	Prestressed Girder Layout
285380-03-063-SEG 1-2918	0	Prestressed Girder Details
285380-03-064-SEG 1-2919	0	Abutment Diaphragm Layout and Reinforcement
285380-03-064-SEG 1-2920	0	Pier Diaphragm Layout and Reinforcement
285380-03-064-SEG 1-2921	0	Interior Precast Deck Panels
285380-03-064-SEG 1-2922	0	Expansion Joint Precast Panels
285380-03-064-SEG 1-2923	0	Deck Layout and Reinforcement
285380-03-064-SEG 1-2924	0	Deck Details
285380-03-065-SEG 1-2925	0	Parapet Wall Finish (Grassland Pattern)
285380-03-065-SEG 1-2926	0	6000mm Approach Slab
285380-03-065-SEG 1-2927	0	Fence Details
285380-03-065-SEG 1-2928	0	Details of Concrete Slope Paving
285380-03-066-SEG 1-2929	0	Standard Details
285380-07-444-SEG 1-2930	0	Embedded Electrical Work I
285380-07-444-SEG 1-2931	0	Embedded Electrical Work II
285380-07-444-SEG 1-2932	0	Embedded Electrical Work III
285380-07-444-SEG 1-2933	0	Embedded Electrical Work IV
285380-03-060-SEG 1-2948	0	Ground Improvements - Sections IV
285380-03-060-SEG 1-2935	0	Ground Improvements - Sections I
285380-03-060-SEG 1-2936	0	Ground Improvements - Sections II
285380-03-060-SEG 1-2937	0	Ground Improvements - Sections III
285380-04-094-SEG 1-2938	0	Construction Notes - Backfill at Structures
285380-04-094-SEG 1-2939	0	Construction Notes - Lightweight Fill Material
285380-04-094-SEG 1-2940	0	Construction Notes - Expanded Polystyrene
285380-03-061-SEG 1-2941	0	Lighting/Signal/Communications Foundation
285380-03-080-SEG 1-2942	0	Fire Suppression - Plan
285380-03-080-SEG 1-2943	0	Fire Suppression - Profile
285380-03-080-SEG 1-2944	0	Fire Suppression - Details
285380-07-067-SEG 1-2945	0	Luminaire Structural Support Option I
285380-07-067-SEG 1-2946	0	Luminaire Structural Support Option II

285380-07-067-SEG 1-2947	0	Wireway Structural Support
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10.2 List of Documents (included in this submission):

Document No.	Revision	Document Name
285380-04-119-0050	0	Geotechnical Investigation and Design Report
285380-03-127-0023	0	Technical Appraisal Form
285380-03-126-0039	E	Tunnel Watertightness Technical Memorandum

10.3 List of Reference Drawings and Documents (not included in this submission)

See Appendix A.

The above design and construction proposals are submitted for review

Signed: *Biljana Rajlic*

Design Manager

Name: Biljana Rajlic

Engineering Qualifications: P. Eng.

Date: September 17, 2012

Professional Registration Number: 100041385

Affix Professional Seal



Signed: *James L...*

Project Co-Representative

Name: *James L...*

Date: *Oct 11, 2012*

Professional Registration Number:

Affix Professional Seal

Appendix A – Referenced Drawings and Documents

Referenced Drawing(s)

Drawing No.	Revision	Drawing Name

Certificate(s)

Certificate No.	Revision	Certificate Name

Special Provision(s)

Document No.	Revision	Document Name
285380-70-119-0001	C	Highway and Roadway Drainage Design Report for Phase 1 and Phase 2
285380-83-119-0013	B	Tunnel Top Soil – Proposed Soil Profiles and Corresponding Unit Weight
285380-03-126-0045	D	Tunnel Structural Fire Assessment
285380-03-126-0049	B	Tunnel Structural Fire Assessment – Deck Slab
285380-03-109-0004	3	Tunnel Fire Design Criteria