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Design Consultant:		HMM
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Issued by: Mohammad Majdabadi
Name

May 16, 2012
Date

Signature



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Appendix A – Design Documentation

1 Project Description

This submission contains the final submission – issued for construction design drawings and geotechnical recommendations for Labelle Tunnel T-2.

1.1 Name and location of tunnel

Labelle Tunnel is designed for the westbound and eastbound traffic along the below-grade section of Highway 401 from STA. 12+950 to STA. 13+190.

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

Highway Classification:	UFD 110
Design Speed:	110 km/h
Posted Speed:	90 km/h
Lanes:	Landscape and Labelle St./Hwy. 3 EBL(SR1) intersection over the structure 6 lanes under the structure for Hwy. 401
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.)

Labelle Tunnel is 239.5 m long with three 3.75 m westbound lanes and three 3.75 m eastbound lanes. 3.0 m wide shoulders are accommodated along the north and south side of the below-grade highway. Concrete barrier walls along the sides of pier columns divide the westbound and eastbound lanes.

Basic Layout Summary

Length	239.5 m
Lanes	3 – 3.75 m westbound lanes 3 – 3.75 m eastbound lanes
Outer Shoulder	3.0 m wide each side
Median Shoulder in Tunnel	2.88 m westbound lanes 1.88 m eastbound lanes
Median Barrier	Along sides of pier columns
Road side Barrier	None

2.2 Restrictions to traffic

Not applicable.

3 Brief Description of Tunnel, Traffic and Tunnel Geometry

3.1 Structural form of Tunnel

Labelle Tunnel is a two span deck-on-girder structure designed along the below-grade section of Highway 401. The pier and abutments are parallel to the Alignment of Hwy. 401.

The main bearing structure is composed of 80 lines of modified NU1600 girders of no skew angle with the abutments, each with two spans. The NU girders are precast prestressed concrete girders, transported and erected on-site, then connected together to make them continuous to bear SDL and live loads. Semi-integral abutments over driven deep HP steel piles with the top 5m having a 0.5m concrete collar are used; the central pier consists of a pier cap supported by circular columns over a concrete footing, which is in turn also supported by driven deep HP steel piles.

The 235mm thick concrete slab on top of the modified NU1600 girders is continuous over the entire width of the bridge with no expansion joint. The behaviour and response of the superstructure due to thermal expansion and contraction for temperature changes from -32°C to +20°C if the construction temperature is set to 15°C, as well as shrinkage and creep effects, is studied in detail by 3D finite element modeling and analysing the superstructure.

In addition, a utility corridor with a watermain, MNSI and a power distribution assembly are located at the east side of the tunnel, close to the east side parapet wall.

See summary below for general arrangement.

Structure Summary

Structural Type:	Prestressed concrete modified NU1600 girders and semi-integral abutments.
Span Arrangement:	Two span structure comprising NU girders spaced at 3.0 m. Span lengths are 25.5-26.5m perpendicular to Highway 401 alignment.
Foundation Type:	
North Abutment	Semi-integral abutment supported on HP 310x110 steel piles with 7 expansion joints at 30m spacing. The top 5m of piles have a 500mm diameter collar section (CPS pipe filled with concrete around the pile shaft).
South Abutment	Semi-integral abutment supported on HP 310x110 steel piles with 7 expansion joints at 30m spacing. The top 5m of piles have a 500mm diameter collar section (CPS pipe filled with concrete around the pile shaft).

Pier	Pier cap beam supported by cylindrical concrete columns found on footing with HP 310x110 steel piles. The pier cap and footing are split into 8 segments with 7 expansion joints at 30m spacing.
Span Articulation:	Semi-integral support at abutments. Semi-integral support at abutments, concrete footing for central piers. Girders are supported by laminated elastomeric bearings.
Deck:	235 mm deck comprising 90 mm precast panels and cast-in-place concrete topping. 1.8m parapet wall at each sides.

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: spiral-to-curve (R=1200) at STA. 12+383.147 follow by curve (R=1200)-to-spiral at STA. 13+145.191 follow by spiral-to-tangent at STA. 13+238.712

Vertical alignment: -0.5% grade to the west followed by a K=200 sag curve along the tunnel structure and a +0.5% grade to the east

BVC 12+934.530 EL. 173.700

VPI 13+034.530 EL. 173.200

EVC 13+134.530 EL. 173.700

3.3.2 Cross-section

Tunnel satisfied 5.0 m minimum vertical clearance. 5.075 m vertical clearance is provided.

3.3.3 Standards used

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 shown on the drawings.

3.3.5 Minimum headroom, horizontal clearances

Minimum headroom is 5.0 m. Horizontal clearance from outside of shoulder-to-shoulder is 17.25 m.

3.4 Proposed arrangements for inspection and maintenance

Minimum 1.0 m benches are provided at top of embankment slopes to provide access to abutments for inspection. Minimum height of 150 mm is provided to allow for jacking and bearing replacement.

All exposed structure elements will be accessible for inspection and maintenance. Some elements may require 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 above deck, and 1.0m soil layer within utility corridor above tunnel deck.

3.7 Finishes

Concrete finishes of the parapet wall will be grassland pattern for the exterior face and smooth finish for the interior face for snake protection. Concrete finishes of all other cast-in-place surfaces will be as specified in the general notes Doc. No. 285380-03-060-SEG2-2202.

4 Design Assessment Criteria

4.1 Live Loading

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

Truck load of CL-625-ONT and pedestrian load used in the design of T2 is as per the Canadian Highway and Bridge Design Code (CHBDC) S6-06.

4.1.2 Design vehicle

CL-625-ONT live loading was used in the design for the roadway portion of T2. There are no vehicular traffic lanes over the trail portion, therefore, only one CL-625-ONT truck was used in the design.

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

T2 has been analysed in accordance with Canadian Highway Bridge Design Code and S6S1-10 (Supplement No. 1 to CAN/CSA-S6-06). Software design aids including SAP2000 version 14.1.0 and Microsoft Office Excel 2007 were used. The crossing of Labelle-Hwy 3 on Tunnel T2 is almost 45 degrees skewed to the girders. Therefore, a 3D FE model has been developed to analyse the effect of live loads on the bridge girders.

The deck is continuous along the entire 239.5m width of the bridge with no expansion joints, whereas the substructure is split into 8 segments by 7 expansion joints at 30m spacing. In order to study the superstructure response to the effects of temperature rise and drop, shrinkage and creep of the prestressed NU girders, a 3D finite element model was built by using SAP2000 shell (deck panels and pier/abutment diaphragms) and frame (girders) elements. The boundary conditions of the model included vertical restraint and horizontal springs proportional to the shear rating of the elastomeric bearings.

The substructure units (pier and abutments) were also modeled using shell (pile caps) and frame elements (pier cap/columns and piles) and their response to the superstructure loads, as well as the temperature and shrinkage effects of the substructure, were studied.

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 28 days: 40MPa (deck panels)

5.2.3 Reinforcing Steel

Plain and coated reinforcing steel bars: CAN/CSA G30.18-M92; Grade 400W,
unless noted otherwise on drawings.

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 15, 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 Tunnel T-2 (Sta. 12+800W to
Sta. 13+300W), Doc No. 285380-04-119-0023 prepared by AMEC Earth and
Environmental, dated March 2012.

5.4 Proposed fire protection design

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 Tunnel T-2 (Sta. 12+800W to
Sta. 13+300W), Doc No. 285380-04-119-0023 prepared by AMEC Earth and
Environmental, dated March 2012.

6.2 Geotechnical Design Parameters

Refer to Geotechnical Investigation and Design Report Tunnel T-2 (Sta. 12+800W to Sta. 13+300W), Doc No. 285380-04-119-0023 prepared by AMEC Earth and Environmental, dated March 2012.

6.3 Differential Settlement

Refer to Geotechnical Investigation and Design Report Tunnel T-2 (Sta. 12+800W to Sta. 13+300W), Doc No. 285380-04-119-0023 prepared by AMEC Earth and Environmental, dated March 2012.

6.4 Anticipated Ground Movements or Settlement

Refer to Geotechnical Investigation and Design Report Tunnel T-2 (Sta. 12+800W to Sta. 13+300W), Doc No. 285380-04-119-0023 prepared by AMEC Earth and Environmental, dated March 2012.

6.5 Groundwater Conditions and Mitigative Measures

Refer to Geotechnical Investigation and Design Report Tunnel T-2 (Sta. 12+800W to Sta. 13+300W), Doc No. 285380-04-119-0023 prepared by AMEC Earth and Environmental, dated March 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 filled 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 a burst watermain/fire main 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 filled 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 D, 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 Basis of the design of the Tunnel support system for temporary and permanent conditions and any proposals for ground treatment

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

Refer to Geotechnical Investigation and Design Report Tunnel T-2 (Sta. 12+800W to Sta. 13+300W), Doc No. 285380-04-119-0023 for the basis of permanent ground treatment design.

Design for temporary conditions is not addressed in this submission.

- 8.2 Show how the proposed method of construction, i.e. excavation and applicable ground support, will ensure the continued safe use of the Parkway and prevent structural failure

Permanent design is based on the assumed 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 Tunnel T-2 (Sta. 12+800W to Sta. 13+300W), Doc No. 285380-04-119-0023 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: Patrick Chan

Checker: Mohammad Majdabadi

Reviewer: Rick Krutzler

10 Drawings and Documents

10.1 List of Drawings (included in this submission):

Drawing No.	Revision	Drawing Name
285380-03-060-SEG2-2200	0	COVER SHEET, SITE PLAN AND KEY PLAN
285380-03-060-SEG2-2201	0	GENERAL ARRANGEMENT
285380-03-060-SEG2-2202	0	GENERAL NOTES
285380-04-090-SEG2-2203	0	BOREHOLE LOCATION AND SOIL STRATA
285380-04-091-SEG2-2204	0	SOIL STRATIGRAPHY
285380-03-061-SEG2-2205	0	FOUNDATION LAYOUT
285380-03-061-SEG2-2206	0	FOUNDATION DETAILS
285380-03-060-SEG2-2207	0	GROUND IMPROVEMENTS - PLAN
285380-03-061-SEG2-2208	0	ABUTMENT LAYOUT I
285380-03-061-SEG2-2209	0	ABUTMENT LAYOUT II
285380-03-061-SEG2-2210	0	ABUTMENT REINFORCEMENT
285380-03-061-SEG2-2211	0	WINGWALL DETAILS
285380-03-061-SEG2-2212	0	RSS WALLS LAYOUT
285380-03-061-SEG2-2213	0	RSS WALLS DETAILS
285380-03-061-SEG2-2214	0	PIER LAYOUT
285380-03-061-SEG2-2215	0	PIER REINFORCEMENT
285380-03-062-SEG2-2216	0	BEARINGS LAYOUT AND DETAILS
285380-03-063-SEG2-2217	0	PRESTRESSED GIRDERS I
285380-03-063-SEG2-2218	0	PRESTRESSED GIRDERS II
285380-03-063-SEG2-2219	0	PRESTRESSED GIRDERS III
285380-03-063-SEG2-2220	0	PRESTRESSED GIRDERS IV
285380-03-064-SEG2-2221	0	PRECAST DECK PANELS FOR CONC. GIRDERS
285380-03-064-SEG2-2222	0	DECK LAYOUT AND SCREED ELEVATIONS
285380-03-064-SEG2-2223	0	DECK LAYOUT AND REINFORCEMENT
285380-03-064-SEG2-2224	0	ABUTMENT DIAPHRAGM LAYOUT AND REINF.
285380-03-065-SEG2-2225	0	PIER DIAPHRAGM LAYOUT AND REINF.
285380-03-065-SEG2-2226	0	PARAPET WALL FINISH (GRASSLAND PATTERN)
285380-03-065-SEG2-2227	0	6000MM APPROACH SLAB
285380-03-065-SEG2-2228	0	FENCE DETAILS
285380-03-065-SEG2-2229	0	DETAILS OF CONCRETE SLOPE PAVING
285380-03-066-SEG2-2230	0	STANDARD DETAILS
285380-07-444-SEG2-2231	0	EMBEDDED ELECTRICAL WORK I
285380-07-444-SEG2-2232	0	EMBEDDED ELECTRICAL WORK II
285380-07-444-SEG2-2233	0	EMBEDDED ELECTRICAL WORK III
285380-07-444-SEG2-2234	0	EMBEDDED ELECTRICAL WORK IV
285380-03-061-SEG2-2240	0	LIGHT/SIGNAL/COMMUNICATIONS FOUNDATION
285380-03-060-SEG2-2236	0	GROUND IMPROVEMENTS – SECTIONS I
285380-03-060-SEG2-2247	0	GROUND IMPROVEMENTS – SECTIONS II
285380-03-060-SEG2-2248	0	GROUND IMPROVEMENTS – SECTIONS III

285380-04-094-SEG2-2237	0	CONSTRUCTION NOTES – BACKFILL AT STRUCTURES
285380-04-094-SEG2-2238	0	CONSTRUCTION NOTES – LIGHTWEIGHT FILL MATERIAL
285380-04-094-SEG2-2239	0	CONSTRUCTION NOTES – EXPANDED POLYSTYRENE
285380-03-080-SEG2-2241	0	FIRE SUPPRESSION PLAN
285380-03-080-SEG2-2242	0	FIRE SUPPRESSION PROFILE
285380-03-080-SEG2-2243	0	FIRE SUPPRESSION DETAILS
285380-07-067-SEG2-2244	0	LUMINAIRE STRUCTURAL SUPPORT OPTION 1
285380-07-067-SEG2-2245	0	LUMINAIRE STRUCTURAL SUPPORT OPTION 2
285380-07-067-SEG2-2246	0	WIREWAY STRUCTURAL SUPPORT

10.2 List of Documents (included in this submission):

Document No.	Revision	Document Name
285380-03-127-0016	0	Technical Appraisal Form
285380-04-119-0023	0	Geotechnical Investigation and Design Report Tunnel T-2 (Sta 12+800W to Sta 13+300W)
285380-03-126-0039	D	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: May 16, 2012

Professional Registration Number: 100041385

Affix Professional Seal



Signed: *Enrico Casso*

Project Co Representative

Name: *Enrico Casso*

Date: *July 23rd, 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
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	A	Tunnel Structural Fire Assessment – Deck Slab
285380-03-109-0004	0	Tunnel Fire Design Criteria