CITY OF VANCOUVER

CITY CLERK'S DEPARTMENT
Access to Information & Privacy

File No.: 04-1000-20-2018-003

February 14, 2018

s.22(1)

Dear s.22(1)

Re: **Request for Access to Records under the Freedom of Information and Protection of Privacy Act (the "Act")**

I am responding to your request of January 2, 2018 for:

> **Any and all reports regarding the most-recent detailed structural and seismic inspections of the Georgia and Dunsmuir viaducts, including, but not limited to, the composition of the viaducts, the assessment and evaluation of materials and any scientific testing of the materials.**

All responsive records are attached. Some information in the records has been severed, (blacked out), under s.13 (1) of the Act. You can read or download this section here: http://www.bclaws.ca/EPLibraries/bclaws_new/document/ID/freeside/96165_00

Please note that instances of the record that did not relate to the request have been marked as "Not Responsive to Request."

Under section 52 of the Act you may ask the Information & Privacy Commissioner to review any matter related to the City's response to your request. The Act allows you 30 business days from the date you receive this notice to request a review by writing to: Office of the Information & Privacy Commissioner, info@oipc.bc.ca or by phoning 250-387-5629.

If you request a review, please provide the Commissioner's office with: 1) the request number assigned to your request (#04-1000-20-2018-003); 2) a copy of this letter; 3) a copy of your original request for information sent to the City of Vancouver; and 4) detailed reasons or grounds on which you are seeking the review.

Please do not hesitate to contact the Freedom of Information Office at foi@vancouver.ca if you have any questions.

Yours truly,

Barbara J. Van Fraassen, BA
Director, Access to Information & Privacy

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Encl.

:kt

COWI

City of Vancouver

Bridge Engineering Services

Task C1 - Detailed Visual Inspections

2016

2017 Jan 10 Our Ref: 2068-016-RPT-GEN-001-0

Prepared by:

Todd McCrimmon, P.Eng.

Reviewed by:

Darrel Gagnon, P.Eng.

ID #	Bridge
Not Responsive to Request	
D-8	Dunsmuir Viaduct
D-9	Georgia Viaduct
Not Responsive to Request	

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Revision Record Sheet					
Rev. No	**Date**	**Changes Implemented**	**Originated By**	**Verified By**	**Approved By**

COWI

Amendments Record Sheet

Executive Summary

Presented in this report are the results of eight detailed visual bridge condition inspections performed by COWI North America Ltd. (COWI) [formerly Buckland & Taylor Ltd.] for the City of Vancouver (CoV) as part of 2016 scope for *Task C1 – Detailed Visual Inspections* under Professional Services Agreement PS20130837. The Granville Bridge (steel) detailed inspection is the ninth inspection performed in 2016 but is provided under separate cover. This agreement is a five-year program which began with the development of a Bridge Condition Index (BCI) rating/ranking system, and through which all of the City's inventory of bridge, tunnel, underpass, and overpass structures are being inspected through to the end of 2017.

All inspections have been completed and documented in accordance with the *Bridge Condition Index (BCI) Implementation Manual and User Guide*. The updated inspection schedule for this contract is as follows:

Updated Annual Detailed Inspection Schedule Summary

2013 / 2014*	2015	2016	2017
AO-3 Hastings Viaduct	AO-1 Birch-Alder Overpass	D-1 Howe Viaduct	D-5 Cordova 3 Viaduct
AO-4 Marine Dr-Bdry Rd OP	AO-2 Deering Island Bridge	D-2 Canada Place 1 Viaduct	D-5a Thurlow Viaduct
D-10 Main Street OP - Dun	AO-5 New Brighton Rd OP	D-3 Cordova 1 Viaduct	D-7 Canada Place 2 Viaduct
D-11 Main Street OP - Geo	AO-6 Windermere Ped UP	D-4 Cordova 2 Viaduct	FC-2 Cambie Bridge
GC-1 Grandview Viaduct	AO-7 Granville Br SE Ped UP	D-6 Burrard Viaduct	
GC-2 Clark Drive Bridge	AO-8 Powell Street OP	D-8 Dunsmuir Viaduct	
GC-3 Woodland Drive	D-12 Chilco Ped Underpass	D-9 Georgia Viaduct	
GC-4 Commercial Drive	P-2 Gladstone Ped OP	D-13 Portal Park	
GC-5 Broadway Bridge	P-3 Knight St Ped Fishing Br		
GC-6 Victoria Drive Bridge	P-4 Hemlock St Ped OP		
GC-7 Lakewood Drive	P-5 Laurel Ped Land Bridge		
GC-8 Nanaimo St Bridge	P-6 Keefer St Ped OP		
P-1 Boundary Rd Ped OP	P-8 Trans Canada Trail Ped	**SEPARATE COVER**	
P-9 SEFC Ped (Canoe) Bridge	P-12 McCleery Ped Bridge	FC-3 Granville Bridge (steel)	
P-10 SEFC Weir Ped Bridge			
P-11 Still Creek Ped Bridge			
16 COMPLETED	**14 COMPLETED**	**9 NOW COMPLETE**	**4 PLANNED**

* submitted 2013 and 2014 detailed inspection findings in one report

This report summarizes the results of the first eight 2016 inspections. Detailed inspection reports for each bridge are contained in Appendix A. This report is accompanied by a DVD containing PDF versions of all reports and all photographs in high-resolution digital format.

Overall the bridges are generally in good to excellent (as new condition) with a number of localized deficiencies identified. Recommendations for repairs, rehabilitation, monitoring and maintenance activities are provided in this report.

Table of Contents

1 City of Vancouver Bridge Inventory & Location

1.1 Complete Structures List

A complete list of the structures that comprise the City of Vancouver's 2016 inventory is outlined in Table 1, which includes the year of construction, basic superstructure type and an overall structure count. The approximate location of all structures are shown in Figure 1 of Section 1.3 using the 'No.' (number) reference numbers.

Table 1: Complete List of City of Vancouver Bridges

ID #	BRIDGE	YEAR	STRUCTURE TYPE	No.
AO-1	Birch – Alder Overpass	1976	VEH – Concrete I-girders	1
AO-2	Deering Island Bridge	1989	VEH – Concrete box girders	2
AO-3	Hastings Viaduct	1978	VEH – Concrete box girders	3
AO-4	Marine Drive - Boundary Rd. Overpass	1980	VEH – Concrete box girders	4
AO-5	New Brighton Rd. Overpass	1998	VEH – Concrete box girders	5
AO-6	Windermere Pedestrian Underpass	1966	PED – Concrete slab	6
AO-7	Granville Br South End Ped Underpass	1954	PED – Concrete slab	7
AO-8	Powell Street Overpass	2014	VEH – Steel I-girders	8
D-1	Howe Viaduct	1983	VEH – Concrete I-girders	9
D-2	Canada Place 1 Viaduct	1983	VEH – Concrete I-girders	10
D-3	Cordova 1 Viaduct	1983	VEH – Concrete beams	11
D-4	Cordova 2 Viaduct	1989	VEH – Concrete beams	12
D-5	Cordova 3 Viaduct	2002	VEH – Concrete I-girders	13
D-5a	Thurlow Viaduct	2002	VEH – Concrete I-girders	14
D-6	Burrard Viaduct	1983	VEH – Concrete I-girders	15
D-7	Canada Place 2 Viaduct	2009	VEH – Concrete I-girders	16
D-8	Dunsmuir Viaduct	1969	VEH – Concrete I-girders	17
D-9	Georgia Viaduct	1969	VEH – Concrete I-girders	18
D-10	Main Street Overpass - Dunsmuir	1969	VEH – Concrete box girders	19
D-11	Main Street Overpass - Georgia	1969	VEH – Concrete box girders	20
D-12	Chilco Pedestrian Overpass	2002	VEH – Concrete slab	21
D-13	Portal Park	1985	PED – Steel beams	22
FC-1	Burrard Bridge	1930	VEH – Steel truss (main span)	23
FC-2	Cambie Bridge	1985	VEH – Concrete box girders	24

ID #	BRIDGE	YEAR	STRUCTURE TYPE	No.
FC-3	Granville Bridge	1954	VEH – Steel truss (main span)	25
G-1	Grandview (1st Ave) Viaduct	1937	VEH – Steel plate girders	26
G-2	Clark Drive Bridge	1993	VEH – Steel box girders	27
G-3	Woodland Drive Bridge	1991	VEH – Steel I-girders	28
G-4	Commercial Drive Bridge	1989	VEH – Concrete box girders	29
G-5	Broadway Bridge	1992	VEH – Concrete I-girders	30
G-6	Victoria Drive Bridge	1993	VEH – Concrete I-girders	31
G-7	Lakewood Drive Bridge	2001	VEH – Concrete I-girders	32
G-8	Nanaimo Street Bridge	2000	VEH – Concrete I-girders	33
P-1	Boundary Rd Pedestrian Overpass	1981	PED – Concrete box girder	34
P-2	Gladstone Pedestrian Overpass	1985	PED – Concrete box girder	35
P-3	Knight St. Pedestrian Fishing Bridge	1974	PED – Steel vierendeel truss	36
P-4	Hemlock St. Pedestrian Overpass	1986	PED – Concrete box girder	37
P-5	Laurel Pedestrian Land Bridge	1976	PED – Concrete slab	38
P-6	Keefer St. Pedestrian Overpass	1971	PED – Concrete double T-girder	39
~~P-7~~	~~Nanaimo Foot Bridge*~~ *(removed in 2014)	~~1968~~	~~PED – Steel truss~~	REMOVED
P-8	Trans Canada Trail Pedestrian Bridge	2003	PED – Steel truss	40
P-9	SEFC Pedestrian (Canoe) Bridge	2007	PED – Steel truss	41
P-10	SEFC Weir Pedestrian Bridge	2007	PED – Steel beam	42
P-11	Still Creek Ped Bridge (Nootka & 14th)	2009	PED – Timber beam	43
P-12	McCleery Pedestrian Bridge	1998	PED – Timber beam	44

1.2 Variances in Responsibility

All structures listed in Table 1 above are considered exclusively as the responsibility of the City of Vancouver, with the following exceptions:

- D4 – Cordova 2 Viaduct: The City of Vancouver is only responsible for the top surface (wearing surface including sidewalks). The bridge structure below is the responsibility of Translink.
- D12 – Chilco Ped Underpass: The City of Vancouver is only responsible for the underpass portion and top side asphalt (wearing surface). The bridge structure is the responsibility of BC MOTI.

1.3 Bridge Location Map

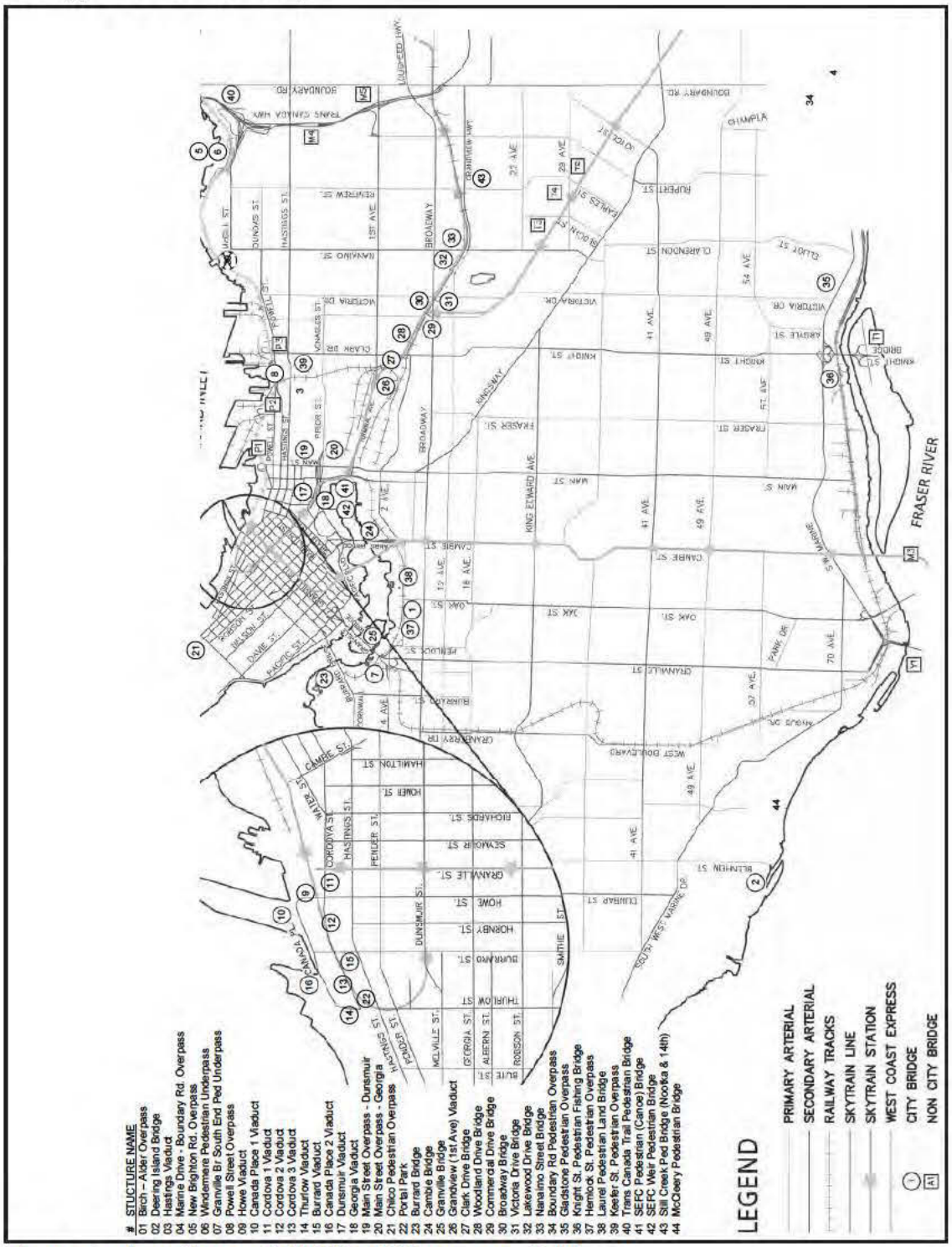

Figure 1: Locations of all City of Vancouver Bridges

1.4 Hansen Bridge ID Numbers

At the request of the CoV, Hansen Bridge identification numbers for each structure have been included in this report (see Table 2). These numbers represent asset ID's as part of a work order system currently being used for the bridge inventory.

As part of the system, the large bridges are typically broken down into their various structural components. For example, Burrard Bridge has five Hansen ID numbers: one for each set of concrete approaches (two total), one for each set of steel deck truss spans (two total), and one for the steel through truss marine (main) span. Granville Bridge has different numbers for the different on/off ramps etc. For convenience, only the main structure is included in the table below.

Table 2: Hansen Work Order System Bridge Identification Numbers

ID #	BRIDGE	H. ID
AO-1	Birch – Alder Crossing	189
AO-2	Deering Island Bridge	182
AO-3	Hastings Viaduct	140
AO-4	Marine Dr-Boundary Rd. Overpass	138
AO-5	New Brighton Rd. Overpass	174
AO-6	Windermere Pedestrian Underpass	144
AO-7	Granville Br. South End Ped UP	120
AO-8	Powell Street Overpass	unknown
D-1	Howe Viaduct	147
D-2	Canada Place 1 Viaduct	190
D-3	Cordova 1 Viaduct	173
D-4	Cordova 2 Viaduct	198
D-5	Cordova 3 Viaduct	202
D-5a	Thurlow Viaduct	137
D-6	Burrard Viaduct	161
D-7	Canada Place 2 Viaduct	128
D-8	Dunsmuir Viaduct	141
D-9	Georgia Viaduct	150
D-10	Main Street Overpass - Dunsmuir	123
D-11	Main Street Overpass - Georgia	130
D-12	Chilco Pedestrian Overpass	153
D-13	Portal Park	unknown
FC-1	Burrard Bridge (Main Span)	163
FC-2	Cambie Bridge (Main Span)	201
FC-3	Granville Bridge (Main Span)	210

ID #	BRIDGE	H. ID
G-1	Grandview (1st Ave) Viaduct	176
G-2	Clark Drive Bridge	167
G-3	Woodland Drive Bridge	193
G-4	Commercial Drive Bridge	178
G-5	Broadway Bridge	194
G-6	Victoria Drive Bridge	191
G-7	Lakewood Drive Bridge	186
G-8	Nanaimo Street Bridge	196
P-1	Boundary Rd Pedestrian Overpass	187
P-2	Gladstone Pedestrian Overpass	197
P-3	Knight St. Pedestrian Fishing Bridge	148
P-4	Hemlock St. Pedestrian Overpass	181
P-5	Laurel Pedestrian Land Bridge	169
P-6	Keefer St. Pedestrian Overpass	160
P-7	Nanaimo Foot Bridge* *(removed in 2014)	185
P-8	Trans Canada Trail Ped. Bridge	143
P-9	SEFC Pedestrian (Canoe) Bridge	129
P-10	SEFC Weir Pedestrian Bridge	136
P-11	Still Creek (Nootka & 14th)	174530
P-12	McCleery Pedestrian Bridge	unknown
other	Waterfront Rd Wharf (Burrard-Howe)	168
other	Waterfront Rd Wharf (East of Howe)	203
other	Slocan St. Bridge	170
other	Knight St. Bridge	192

The Hansen Bridge Identification numbers listed here are only for reference, and not used anywhere else in the report. Four additional structures are included as 'other' for completeness, but are not part of the inventory related to this inspection contract.

2 Introduction

2.1 Background

This report summarizes detailed bridge condition inspections performed by COWI North America Ltd. (COWI) for the City of Vancouver (CoV) as part of scope *Task C1 – Detailed Visual Inspections* under the Professional Services Agreement PS20130837.

The majority of the detailed bridge inspections took place between 2016 May 17 and 2016 May 26. The inspection of D-4 Cordova 2 Viaduct (surface only) was performed on 2016 June 28, and the D-13 Portal Park structure inspection was completed on 2016 December 22. Follow-up site visits to some structures were performed (on foot) as determined necessary to complete the reporting.

One structure was inspected for the first time: D-13 Portal Park (determined as CoV responsibility in late 2015).

The detailed inspection reports for each structure are included as Appendix A.

2.2 Objectives

The primary objectives for the 2016 detailed visual inspections were to:

i. Conduct a visual inspection to document the current condition and behaviour of structural components;

ii. Identify areas, if any, requiring a more detailed inspection or further study/investigation;

iii. Recommend and prioritize rehabilitation/repair measures based on inspection findings;

iv. Recommend and prioritize regular maintenance work items based on inspection findings; and

v. Develop budget cost estimates for recommended rehabilitation/repair and maintenance work.

2.3 List of Structures Inspected

Table 3 lists all structures that received a detailed visual inspection as part of this report, and describes the primary means of access used for the inspection.

Table 3: List of Structures Inspected and Means of Access

ID #	BRIDGE	MEANS OF ACCESS
Not Responsive to Request		
D-8	Dunsmuir Viaduct	Boom Lift with Traffic Control
D-9	Georgia Viaduct	Boom Lift with Traffic Control
Not Responsive to Request		

3 Inspection Methodology

3.1 Execution

The detailed inspections were primarily visual in nature. Non-destructive techniques such as hammer sounding and chain dragging were also used to identify deficiencies. The use of access equipment with the intent of gaining close proximity to all above ground bridge components over active railway and Skytrain tracks was discussed with the City, but was expected to be unnecessary due to the generally good condition of the structures. It was decided that any inaccessible areas of a structure that was suspected as being in poor condition based on observations made from the accessible areas would be flagged for future inspection after proper access and coordination with key stakeholders was achieved. Areas not accessible are typically documented in the individual reports.

3.2 Bridge Condition Rating and Inspection Forms

The detailed inspections were completed in accordance with the *CoV Bridge Condition Index Implementation Manual and User Guide* [herein referred to as the User Guide] prepared by COWI (B&T at the time) as part of 2014 scope, modified in 2015 to include the DRU rating system as requested by the CoV. Though not yet updated to include the DRU rating information, this document identifies the general forms to be used for the inspection, and the rating system by which to rate the condition of the individual bridge components.

The overall bridge condition rating, or Bridge Condition Index (BCI), has been calculated for each bridge in accordance with the User Guide. Work activities have also been documented and assigned a priority (urgency) in accordance with this guide. Standardized work activities (listed in Appendix C) have been used whenever possible for consistency.

3.3 Photographic Log

A *General Conditions Photo Log* has been prepared for all bridges to provide the general condition of all major components at the time of inspection. If significant repairs have been completed since the previous inspection they are likely to be included in this log. General Condition photos are given the precursor “G”.

A *Deficiencies Photo Log* has also been included for each bridge with observed defects. Photos are designated with the precursor "D" to denote it is associated with

a defect (e.g. D1) and cross-referenced in the inspection form. The intent is that each defect has at least one photo included in the log. Photos taken illustrate something of note (e.g. evidence of regular movement at an expansion bearing) have also been given the precursor "D".

3.4 5 Year Repair and Rehabilitation Plan

To assist the CoV with planning and budgeting work activities, a *5 Year Repair and Rehabilitation Plan* has been developed for each structure and is included as a part of the inspection reporting. Section 5.6 summarizes the rehabilitation program cost estimates organized per structure as well as per urgency category; these tables outline the costs only. Appendix B also provides a summary of the five-year rehabilitation program organized by urgency but includes the details of the individual repairs. Unit rates for standardized work activities are included in Appendix C. For non-standard work activities, engineering judgment has been used to develop a unit rate.

All unit rates represent an approximate base cost for that work activity only and are most relevant when performing large volumes of work related to that activity. Percentage mark-up for engineering design, supervision, traffic management, contractor mobilization, contingency, taxes and inflation are applied to the sum of the base costs, but will typically result in an under-estimation of the actual rehabilitation cost when considering small individual repairs.

When obvious discrepancies arise between a repair cost obtained from projecting a unit rate vs. what cost can be reasonably expected for actually performing the repair, the amount has been adjusted manually to a more appropriate estimation of cost.

For convenience, a Repair Completion Checklist that outlines all recommended repair and rehabilitation items for each structure has been included as Appendix D.

4 Inspection Report Format

Appendix A contains the individual inspection reports for each bridge. Each report consists of the following sections:

- Bridge Summary Sheet;
- Bridge Condition Inspection Form;
- General Arrangement Photo Log;
- Deficiencies Photo Log;
- Crack Maps/Sketches (if applicable);
- 5 Year Repair and Rehabilitation Plan; and
- Comment Sheet.

The majority of the Bridge Summary Sheets have been provided by the CoV and modified to include: Screening Level Seismic assessment priority and priority index, anticipated remaining service life, estimated replacement cost and the BCI (previous and current). Some of the inventory information provided by the CoV has been assumed correct by COWI and may not have been verified for accuracy.

Replacement cost estimates provided in the summary sheet for each structure are approximations based on a cost-per-square-foot unit rate of structure. The unit rate is selected to consider structure type, ease/difficulty of access, and influenced by the feature being crossed. The selected unit rates are consistent with those used in the summary sheets for the 2014 detailed inspections as general construction costs have not been observed to increase over the last few years. This trend may not continue in the long term but is considered relevant for the current assessments. CoV overhead, engineering fees, and a contingency are included in the estimated bridge replacement cost.

The Comment Sheet provided at the end of each subsection is intended to be blank and can be used to list comments or questions during review of the report.

Each individual report is also provided in PDF format on a writable DVD. Included on the DVD are high-resolution copies of all of the photographs used in the reports.

5 Results

5.1 Summary of Deficiencies

Table 4 provides a brief description of significant defects identified for each bridge at the time of inspection, ranging from the more critical issues to minor deficiencies.

These items include any structurally significant defects, major rehabilitation items, and any safety issue that requires repair. All items in this category are suggested for repairs as they are issues that are currently, or are expected to, affect long term durability or aesthetics of the structure. All items in this category are also assigned an Urgency (U) rating in accordance with the following system:

- Urgency = 1: Action required in 5 years or more (by 2022);
- Urgency = 2: Action required within 3 years (by 2020);
- Urgency = 3: Action required within 2 years (by 2019); and
- Urgency = 4: Action required as soon as possible (ASAP).

Refer to individual inspection reports contained in Appendix A for the complete list, description, location, and urgency rating of all deficiencies and recommended repairs for each bridge. The following tables may include recommendations for areas of a structure under a different jurisdiction; see Section 1.2 for variances in responsibility.

Table 4: Summary of Identified Bridge Deficiencies

ID #	Bridge	Deficiencies / Repairs
Not Responsive to Request		
D-8	Dunsmuir Viaduct	• None
D-9	Georgia Viaduct	• Deck Joints: remove sharp edge. • Deck Joints: remove trip hazard.
Not Responsive to Request		

5.2 Monitoring Items

Table 5 summarizes components or specific deficiencies that should be monitored on an ongoing basis in future detailed and annual monitoring inspections. These items are often defects that do not require immediate repair, but should be monitored as their condition may deteriorate. Monitoring items from previous inspection reports are always re-evaluated during each new inspection to compare the condition of the defect and assess if the issue is static or continuing to deteriorate. Monitoring items generally remain on the watch list even if the identified issues appear dormant. Only when repairs are made to the defect should the item be removed from the list.

These items are sometimes specifically listed under General Inspection Notes (Monitoring Notes) in the inspection form. These are all identified in the individual inspection reports by designating the deficiency with an Urgency (U) rating of "M".

Table 5: Summary of Monitoring Items

ID #	Bridge	Monitoring Items
Not Responsive to Request		

ID #	Bridge	Monitoring Items
Not Responsive to Request		
D-8	Dunsmuir Viaduct	• Foundation Movement: settlement of approach slab at on-ramp abutment. • Retaining Wall: undermining of abutment footings due to slope creep. • Caps: small concrete spall over skatepark. • Sub Deck: concrete spalls x 2 locations. • Deck Joints: deteriorated joint components. • Parapets: loose concrete at existing spalls.
D-9	Georgia Viaduct	• Foundation Movement: settlement of approach slab at off-ramp abutment. • Retaining Wall: undermining of abutment footings due to slope creep. • Sub Deck: concrete spalls over sidewalk. • Deck Joints: deteriorated joint components. • Deck Joints: vibrations of steel with passing live load.
Not Responsive to Request		

5.3 Routine Maintenance Activities

Table 6 lists specific routine maintenance activities that were identified as necessary at the time of inspection. These have been identified in the individual inspection reports by designating the deficiency with an Urgency (U) rating of "R". Routine maintenance activities are those work activities that can be undertaken with minimal planning and preparation and should be completed by the CoV on a routine basis (typically annual at minimum).

Examples of typical routine maintenance activities include:

- trash/debris removal;
- brushing (clearing of obstructive & intrusive vegetation);
- bird/insect nest removal;
- power-washing and graffiti removal;
- identifying tripping hazards, sharp edges and/or snags;
- replace lights no longer effective/operational;
- tightening of fasteners;
- selective fastener replacements (rivet and bolt);
- localized paint touch-ups;
- gutter and drainage system clean-out/repair/replacement;
- bearing and bearing shelf flushing/clean-up; and
- deck joint compression seal flushing/clean-out.

Table 6: Identified Routine Maintenance Activities

ID #	Bridge	Routine Maintenance Activities
Not Responsive to Request		

ID #	Bridge	Routine Maintenance Activities
Not Responsive to Request		
D-8	Dunsmuir Viaduct	• Abutments: repairs to fencing of enclosure. • Drains: clear blockage of drain basin. • Signage: repair hazard sign at bike lane taper.
D-9	Georgia Viaduct	• Bearings: clean debris from around bearings. • Drains: clear blockage of drain basin. • Lighting: secure loose hand hole cover plate.
Not Responsive to Request		

5.4 Make Safe Deficiencies

Table 7 lists the identified deficiency, monitoring, and routine maintenance items that are considered as requiring 'make safe' ('MS') repairs. These items may or may not affect the structural integrity of the structure, however, they should be addressed as soon as possible as they are currently, or may soon become, safety hazards to the users of the structures.

Deficiencies identified as a safety related item but are not currently posing a threat to bridge users, and as such not being recommended for immediate repair are marked as 'S' in the inspection reports but have not been included in this list.

Table 7: Identified Make Safe Deficiencies

ID #	Bridge	Make Safe Deficiencies
Not Responsive to Request		
D-8	Dunsmuir Viaduct	• None

ID #	Bridge	Make Safe Deficiencies
D-9	Georgia Viaduct	• Deck Joints: remove sharp edge. • Deck Joints: remove trip hazard.

Not Responsive to Request

5.5 Bridge Condition Indices

The details of the BCI calculations are outlined in the *User Guide* (see Section 3.2 for more details), but in short: The BMIS methodology calculates a BCI for each structure based upon a weighted average of the condition ratings for inspected bridge components. In general, the following condition states are used as baselines for a BCI rating: Excellent = 1, Good = 2, Fair = 3, Poor = 4 and Very Poor = 5.

Table 8 summarizes the bridge condition index (BCI) for each bridge. The previous BCI was calculated from information from past inspection reports that have been converted into the condition index format as described in the *User Guide*. For new structures not known to have been previously inspected (e.g. Portal Park) the Previous BCI value was taken to be equal to 1.00. The new BCI values have been calculated based on the results of the 2016 detailed inspections.

Table 8: Summary of Bridge Condition Indices

ID #	Bridge	Previous BCI	New BCI	Variation
Not Responsive to Request				
D-8	Dunsmuir Viaduct	1.44	2.06	0.62
D-9	Georgia Viaduct	1.43	2.00	0.57
Not Responsive to Request				

For a typical five-year inspection cycle the BCI can be expected to increase by 0.1 to 0.2 for normal deterioration, assuming no major repairs have been undertaken. As shown in the variation column of Table 8, seven of the eight bridges have seen their BCI values increase by 0.5 or more. There are a number of contributing factors to the larger overall variances, including:

- New deficiencies have been discovered, predominantly new concrete spalls.
- The differences between the current inspection system and the system in place during previous inspections of these structures, including the way the bridge

components are defined and measured. Although efforts were made to minimize discrepancies during the system conversion, some could not be avoided;

- The timing of previous inspections. Of the seven structures previously inspected, all two were last inspected in 2009, over seven years ago – slightly longer than the typical five year inspection cycle; and
- An overall shift from the 'Excellent' (as new) ratings used in previous inspection assessments on the older structures to 'Good' (normal wear, not requiring repairs) ratings for many components. This had the most significant impact on the overall BCI ratings.

For all of the structures inspected this year, the most significant contributing factor to the larger variances in the BCI values was the general shift in component condition ratings from 'Excellent' (as new) to 'Good' (normal wear, not requiring repairs). When considering the components that are applicable for the structures inspected this year, a complete shift from 'Excellent' to 'Good' results in an overall increase of the BCI by 0.93. The reason that none of the shifts in BCI values are this large is because several components were previously assigned 'Good' ratings for portions of (or all of) their condition. This year's inspections have moved any remaining 'Excellent' (as new) condition ratings to 'Good' as the structures are now 30 to 40 years old and all exhibit expected normal wear.

The largest depreciation of health was observed for D-13 Portal Park in which the BCI rose 0.70 points from 1.00 to 1.70. However, this is a result of the structure being recently added to the City's inventory and has no previous inspection records. As such it was assigned a 1.00 (excellent/as new) entry condition BCI rating (refer to Section 4.1 of the *User Guide*) despite being over 25 years old.

Overall the bridges inspected this year are generally in Good (normal wear, not requiring repairs) condition. Though there are a number of localized deficiencies identified, these are typically considered as small and, with few exceptions, inconsequential to user safety or the structural capacity of the structure. Most recommended repairs are included to improve the long-term durability of the structures to best ensure that the design lives of the structures remain achievable.

5.6 Repair and Rehabilitation Projections

Table 9 lists the total estimated cost of carrying out the recommended repair and rehabilitation works outlined in the individual 5 Year Repair and Rehabilitation Plans

generated for each bridge. The cost breakdown for the rehabilitation work organized per urgency rating is detailed in Table 10, and further elaborated in Appendix B.

The repair and maintenance costs are obtained from considering the size of the deficiency observed during the inspection and the unit rate for the applicable standardized work activity (see Appendix C) required to perform the repair. Table 9 is the summation of all Urgency 1 through Urgency 4 deficiencies (see Section 5.1) and all of the Routine Maintenance items (see Section 5.3). Monitoring items are not included as repairs for these deficiencies are not recommended at this time.

Costs are rounded up to the nearest $1,000. This is performed at different times for each table which results in small discrepancies when comparing totals. See Section 3.4 for qualifications regarding cost estimates.

Table 9: 5 Yr. Repair and Rehab Cost Projection Estimates per Structure

ID #	Bridge	Total Repair & Maintenance Costs
Not Responsive to Request		
D-8	Dunsmuir Viaduct	$ 2,000
D-9	Georgia Viaduct	$ 3,000
Not Responsive to Request		
	TOTAL	**$ 42,000**

Table 10: 5 Yr. Repair and Rehab Cost Projections per Urgency Rating

ID #	BRIDGE	U4	U3	U2	U1	R	SUB-TOTALS
Not Responsive to Request							
D-8	Dunsmuir Viaduct	0	0	0	0	$ 750	$ 750
D-9	Georgia Viaduct	$ 500	0	0	0	$ 1,050	$ 1,550
Not Responsive to Request							
	Base Cost Total	$ 750	$ 2,000	$ 4,800	$ 2,000	$ 14,800	$ 24,350
	Engineering Design and Supervision (15%)	$ 113	$ 300	$ 720	$ 300	$ 2,220	$ 3,653
	Traffic Mgmt and Site Establishment (20%)	$ 150	$ 400	$ 960	$ 400	$ 2,960	$ 4,870
	SUB-TOTAL	$ 1,013	$ 2,700	$ 6,480	$ 2,700	$ 19,980	$ 32,873
	Contingency and Inflation (15%)	$ 152	$ 405	$ 1,023	$ 405	$ 2,997	$ 4,931
	TOTALS	$ 1,200	$ 3,200	$ 7,500	$ 3,200	$ 23,000	~ $ 38,000

Appendix A
Detailed Condition Inspection Reports

INCLUDES

Not Responsive to Request	**11 pages**
	15 pages
	11 pages
	10 pages
	12 pages
D-8: Dunsmuir Viaduct	**12 pages**
D-9: Georgia Viaduct	**13 pages**
Not Responsive to Request	**09 pages**

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Bridge No. D-8

Dunsmuir Viaduct

between Beatty St. & Main St.

Construction Date and Orientation:	Built in 1969	Bridge Orientation: East-West
Feature Supported:	Dunsmuir Street – three lanes [2 westbound and 1 bike lane].	
Feature Crossed:	Quebec St., Expo Blvd., Carrall St., Pat Quinn Way (Abbott St.).	
Substructure:	Concrete pier on concrete footing with concrete (or timber) piles.	
Superstructure:	Precast concrete I-girders (prestressed & post tensioned) with a 200 mm thick reinforced cast-in-place concrete deck.	
Wearing Surface:	Concrete.	
Approaches:	Asphalt roadway.	
Dimensions:	*No. of Spans:*	21
	Deck Area:	848.4 m [long] x 13.9 m [wide] = 11,793 m^2
	Skew Angle:	0º
	Sidewalks:	North side only [1.22 m wide]
General:	*Bearings:*	Reinforced Neoprene Pads (abutments only)
	Bank/Pier Protection:	None
	Guardrail:	Precast Concrete
	Curb:	None
	Utilities:	Unknown
	Clearance:	Unknown (and varies)
	Posted Speed Limit:	50 km/h
	Sign Posting:	None
	Design Load:	AASHTO HS-25

Major Future Improvements Needed:	Detailed seismic assessment and retrofit design.			
Anticipated Remaining Service Life:	15 –20 years			
Estimated Bridge Replacement Cost:	$52,679,000			
Screening Level Seismic Assessment:	Priority:	High	Priority Index:	80
Bridge Condition Index [BCI] Rating:	Previous BCI:	1.44	Current BCI:	2.06

Updated: 2016 June

BRIDGE CONDITION INSPECTION

CITY OF VANCOUVER

Structure Number	D-8	Structure Name	Dunsmuir Viaduct	Inspection Date (yyyy/mm/dd)	2016 May 18

COMPONENT — **PERCENT CONDITION RATING** (Enter % in each condition. See CoV User Guide)

		E	G	F	P	V	X	N
	CHANNEL							
1	Debris Risk							100
2	Bank/Bed							100
3	Dolphins/Fenders							100
	SUBSTRUCTURE							
4	Foundat'n Movement		98	2				
5	Abutments		100					
6	Wing/Retaining Wall		25	50			25	
7	Footings/Piling							100
8	Piers/Columns		100					
9	Bearings		100					
10	Caps		100					
11	Corbels							100
	SUPERSTRUCTURE							
12	Floorbeams							100
13	Stringers							100
14	Girders		100					
15	Portals							100
16	Bracing/Diaphragms							100
17	Truss Chords/Arch							100
18	Arch Ties							100
19	Truss Diagonals							100
20	Truss Rods/Verticals							100
21	Cables							100
22	Panels							100
23	Pins/Bolts/Rivets							100
24	Camber/Sag		100					
25	Live Load Vibration		100					
26	Coating (structure)							100
	DECK							
27	Sub Deck/Cross Ties		98	2				
28	Wearing Surface		100					
29	Deck Joints				100			
30	Curbs/Wheelguards							100
31	Sidewa k(s)		100					
32	Railings/Parapets		60	40				
33	Median Barrier		100					
34	Drains/Pipes		98	2				
35	Coating (Railings)							100
	APPROACHES							
36	Signing/Lighting		99	1				
37	Roadway		100					
38	Roadway Flares							100

INSPECTION NOTES BY COMPONENT

All poor or very poor conditions should be explained with notes and documented by photos. Label explanation(s) with component no.'s.

4. Foundation Movement: Settlement of approach structure at east end of on-ramp abutment (DM2) measured at 89 mm.

5. Abutments: Restrictive enclosure fencing on north side of on-ramp abutment (DM2) compromised in a 1m^2 area, possibly with assistance of a fire [Photo D1].

6. Retaining Wall: Failure of retaining wall at base of east abutment (D2) has permitted slope creep of hillslope resulting in the moderate undermining of approach structure elements. Footing on each side approach undercut for appx. 1500 mm. Issue has been known for a long period; no structural concerns observed.

9. Bearings: One bearing pad at west abutment (D23) overhung the bearing seat by 5 mm. Not a concern given the size of the pads [Photo D2].

10. Caps: Small spall with exposed rebar on south overhang soffit of Pier DM5 (above skate park) [Photo D3].

27. Sub Deck: Transverse cracks with efflorescence consistent along north and south overhangs of on-ramp approach [Photo D4].

27. Sub Deck: Large spall of deck overhang at base of north barrier in two locations of on-ramp approach (DM1 -DM2). Surrounding concrete appears sound [Photo D5].

Continued on next page (if necessary)

General Inspection Notes (Monitoring Notes):

Access to southern half of bearings at the west abutment not accessible due to limitations in reach of equipment.

Utility Concern Notes (Contact Utility Owner):

Condition Codes			
E	Excellent	V	Very Poor
G	Good	X	Not Insp.
F	Fair	N	n/a
P	Poor		

For Condition Guidelines see CoV User Guide

Temperature
+ 14 °C
Weather
Partly Cloudy
Time of Day
7:30 am

Todd McCrimmon, P.Eng. / Aaron Pettis, P.E. – COWI North America

Lead Inspector / Inspector - Firm (please type or print)

Signature (Lead)

Inspection Notes by Component (continued):

27. Sub Deck: Black soot stains on deck soffit and surrounding members due to fire lit beneath north side of abutment [Photo D6].

27. Sub Deck: Transverse deck soffit cracks with efflorescence observed periodically throughout structure. No evidence of spalling or corrosion staining [Photo D7].

27. Sub Deck: Large deck soffit spall with exposed reinforcement on east side of Pier D6 at transition with off-ramp (above skate park). All loose material removed exposing new 200 mm x 200 mm area with (uncoated) corroded reinforcement [Photo D8].

27. Sub Deck: Exhaust staining and transverse cracks with efflorescence typical in Span D7-D8 above Skytrain tracks.

27. Sub Deck: No change since previous inspection report to timber formwork (appx. 400 mm x 300 mm) from through-deck repair still in place in Span D17-D18. Appears securely fastened. Similar formwork (appx. 200 mm x 400 x mm) in place in Span D22-D23.

27. Sub Deck: Several locations of deck soffit (and Piers) in Span D17-D18 have been mapped for embedded steel to avoid conflict when mounting decorative lighting for Rogers Arena Plaza [Photo D9].

27. Sub Deck: Removed loose mortar and confirmed soundness of three small patches on soffit overhang on south side of Span D18-D19 (over Rogers Arena Plaza) [Photo D10], and four small patches on soffit overhang on south side of Span D19-D20 (over Costco sidewalk) [Photo D11]. Two of the patches in Span D19-D20 are delaminated but could not be removed by hand [Photo D12].

27. Sub Deck: Confirmed soundness of spalled concrete areas over 3.5 m long with exposed reinforcement on north overhang of Span D20-D21 [Photo D13].

29. Deck Joints: Surface corrosion on all deck joint steel typical at deck joint overhangs [Photo D14].

29. Deck Joints: All deck joint seals are in poor condition. Most seals are visibly torn or recessed and filled with debris [Photo D15].

32. Parapets: Damage to top rail of barrier on south side of on-ramp approach entrance. No risk of fall at this location [Photo D16].

32. Parapets: Spalling on outside face of barrier observed at ten locations along south side of on-ramp approach.

32. Parapets: Loose concrete removed from 9 existing spalls on outside face south barriers, and one failed deck soffit patch in Span D14-D15 over parking lot. Four locations in Span D15-D16 and 5 locations over Abbott St. not worked on due to cars below [Photo D17].

32. Parapets: Shallow surface spalling with exposed reinforcement on south face of north parapet typical on 185 of 464 panels throughout length of structure. Majority of bars are coated with zinc-rich paint but have continued to corrode [Photo D18].

33. Median Barrier: Slight misalignment of barrier between vehicle traffic and bike lane around Pier D15 [Photo D19].

34. Drains/Pipes: Drain basin at DM5 filled with debris and vegetation [Photo D20].

36. Signing: Broken hazard sign at beginning of eastbound bike lane taper at top of on-ramp [Photo D21].

39. Utilities: Concrete utilities access box below roadway on north side of Pier D9 has corrosion stains and efflorescence. Concrete condition appears sound [Photo D22].

Inspection Photos

See attached photo log.

Structure Number	D-8	Structure Name	Dunsmuir Viaduct	Inspection Date (yyyy/mm/dd)	2016 May 18

Remedial Work Activity List

Component	Location	Activity Description	Qty.	Unit	D	%	R	U	S	Photo #
4. Foundation Movement	DM2	Monitor – Settlement of approach structure at east end of abutment.	89	mm	1	100	1	M		
5. Abutments	DM2-N	Determine if repairs to the fencing is necessary.	1	m^2	3	5	1	R		D1
6. Retaining Wall	D2	Monitor – Undermining of east abutment and approach structures due to loss of soil.	1	ea.	1	100	1	M		
10. Caps	DM5-S	Monitor – Existing spall (with exposed rebar) which will fall onto skate park if future spalling occurs.	0.01	m^2	1	1	1	M		D3
27. Sub Deck	D6	Monitor – Existing spall (with exposed rebar) which will fall onto skate park if future spalling occurs.	0.2	m^2	2	1	2	M		D8
27. Sub Deck	D19-D20 South	Monitor – Two 200 mm x 200 mm delaminations of previous patch repairs in deck overhang above sidewalk outside Costco.	0.1	m^2	1	1	2	M		D11 D12
29. Deck Joints	All	Monitor – Condition of all expansion joint seals is poor. Ensure seals are not protruding above roadway surface or resulting in other hazard for bridge users.	8	ea.	4	100	1	M		D15
32. Parapets	D15-D17 South	Monitor – Nine spall locations were not assessed for loose concrete due to vehicles below. Based on condition of nearby spalls, current threat of loose material assumed to be low.	9	ea.	2	1	2	M		D17
34. Drains	DM5	Clear catch basin blockage.	1	ea.	3	1	1	R		D20
36. Signing	DM5	Repair hazard sign for bike lane taper.	1	ea.	1	1	1	R		D21

Location Legend: DM = On-Ramp Pier S = South
D = Mainline Pier
N = North

Rating System Legend:

Rating		Rating "D" – Degree of Condition		Rating "R" – Relevancy		Rating "U" – Urgency		Rating
		Degree of Severity of Defect		Structural Integrity and Safety of User		Maintenance Priority and Urgency of Repair	Monitor	M
E	E	Excellent	No defects, as new condition.	No defects, as new condition.		Routine maintenance work.	Routine	R
G	1	Good	Normal wear and deterioration not requiring maintenance/repair.	Minimum Relevancy	No structural integrity or safety issues.	Work not required before next detailed inspection.	≥ 5 yrs.	1
F	2	Fair	Functioning as intended. Minor maintenance/repair required.	Moderate Relevancy	Minor impact on structural integrity or safety issue.	Work required within specified time period.	< 3 yrs.	2
P	3	Poor	Not functioning as intended. More extensive repair required.	Major Relevancy	Structural integrity or safety issue compromised.	Work required within specified time period.	< 2 yrs.	3
V	4	Very Poor	Not functioning as intended. Major repair required.	Maximum Relevancy	Structural integrity and safety severely compromised. Collapse imminent and/or danger to users.	Immediate repair required.	ASAP	4

X – not inspected; N – not applicable; % – percentage of component with rating "D".
Safety Column [S]: S – Safety related defect; MS – Make safe a "S" related defect; ST – Make safe a structural integrity related defect. Otherwise left blank.

General Conditions Photo Log

COWI

Structure: D-8 Dunsmuir Viaduct

Date: 2016 May 18

G1. View west along on-ramp approach from Main Street.

G2. Typical bearing condition at on-ramp abutment (DM2).

G3. View of on-ramp span DM4-DM5 over Quebec St.

G4. General view of east abutment at D2.

G5. Typical bearing condition at east abutment (D2).

G6. On-ramp junction with mainline at Pier D6.

General Conditions Photo Log

COWI

Structure: D-8 Dunsmuir Viaduct

Date: 2016 May 18

G7. General view looking west from Pier D8.

G8. Gap between piers at expansion joint; Pier DM5 shown.

G9. General view of deck looking west from D14.

G10. East face of Pier D21 north of the Costco building.

G11. General view of west abutment at D23.

G12. Deck joint at west abutment (D23).

2016 Deficiency Photo Log

COWI

Structure: D-8 Dunsmuir Viaduct

Date: 2016 May 18

D1. Damaged fencing at on-ramp abutment enclosure (DM2).

D2. Slight overhang of bearing pad at west abutment (D23).

D3. Pier cap soffit spall with exposed rebar at Pier DM5.

D4. Cracks on deck overhang along on-ramp approach.

D5. Deck overhang spall on on-ramp approach.

D6. Staining of deck soffit from fire at on-ramp abutment.

2016 Deficiency Photo Log

COWI

Structure: D-8 Dunsmuir Viaduct

Date: 2016 May 18

D7. Deck soffit cracks of on-ramp span between DM4-DM5.

D8. Deck soffit spall with exposed rebar at Pier D6.

D9. Steel mapping outlines on pier and deck soffit D17-D18,

D10. Deck soffit spall at south overhang in span D18-D19.

D11. Deck soffit spall at south overhang in span D19-D20.

D12. Deck soffit spall at south overhang in span D19-D20.

2016 Deficiency Photo Log

COWI

Structure: D-8 Dunsmuir Viaduct Date: 2016 May 18

D13. Spalled concrete on north deck overhang span D20-D21.

D14. Typical corrosion staining at expansion joint locations.

D15. Typical condition of deck joints; torn seals and debris.

D16. Damage to barrier concrete of on-ramp approach (DM1).

D17. Loose concrete at existing parapet spalls D14-D15.

D18. Typical spalls on south face of north parapets.

2016 Deficiency Photo Log

COWI

Structure: D-8 Dunsmuir Viaduct Date: 2016 May 18

D19. Slight misalignment of traffic barrier near Pier D15.

D20. Drain basin filled with debris and vegetation at DM5.

D21. Broken hazard sign at on-ramp bike lane taper.

D22. Staining of concrete at base of utility box at Pier D9.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

Structure #: D-8 Inspection Date: 2016 May 18

5 Year Repair, Rehabilitation and Maintenance Plan

Structure Name: Dunsmuir Viaduct

	Component	Location	Activity Description	Qty.	Unit	Unit Rate		Base Cost+	D	%	R	U	S	Photos
5	Abutments	DM2-N	Determine if repairs to enclosure fencing is necessary.	1	m^2	$250	=	$250	3	5	1	R		D1
34	Drains	DM5	Clear catch basin blockage.	1	ea.	$250	=	$250	3	1	1	R		D20
36	Signage	DM5	Repair hazard sign for bike lane taper.	1	ea.	$250	=	$250	1	1	1	R		D21
						Routine Maintenance Sub-Total		**$750**	**(by 2017)**					

Total of Base Costs	$750
Engineering Design and Supervision (15%)	$113
Traffic Management and Site Establishment (20%)	$150
Sub-Total	$1,013
Contingency and Inflation (15%)	$152
Bridge Total Rounded Up (nearest $1,000)	**$2,000**

+ Base cost shown is best estimate and may deviate from unit rate projection when projection is deemed an unrealsitic estimate of expected repair cost.

Location Legend: DM = On-Ramp Pier

N = North

Bridge No. D-8

Dunsmuir Viaduct

between
Beatty St. & Main St.

Notes:

Bridge No. D-9

Georgia Viaduct

between Beatty St. & Main St.

Construction Date and Orientation:	Built in 1969	Bridge Orientation: East-West
Feature Supported:	Georgia Street – three lanes [eastbound].	
Feature Crossed:	Quebec St., Expo Blvd., Carrall St., Pat Quinn Way (Abbott St.).	
Substructure:	Concrete pier on concrete footing with concrete (or timber) piles.	
Superstructure:	Precast concrete I-girders (prestressed & post tensioned) with a 200 mm thick reinforced cast-in-place concrete deck.	
Wearing Surface:	Concrete.	
Approaches:	Asphalt roadway.	
Dimensions:	*No. of Spans:*	25
	Deck Area:	944.2 m [long] x 13.9 m [wide] = 13,124 m^2
	Skew Angle:	0º
	Sidewalks:	South side only [1.22 m wide]
General:	*Bearings:*	Reinforced Neoprene Pads (abutments only)
	Bank/Pier Protection:	None
	Guardrail:	Precast Concrete
	Curb:	None
	Utilities:	None
	Clearance:	Unknown
	Posted Speed Limit:	50 km/h
	Sign Posting:	None
	Design Load:	AASHTO HS-25

Major Future Improvements Needed:	Detailed seismic assessment and retrofit design.			
Anticipated Remaining Service Life:	15 – 20 years			
Estimated Bridge Replacement Cost:	$59,740,000			
Screening Level Seismic Assessment:	Priority:	High	Priority Index:	80
Bridge Condition Index [BCI] Rating:	Previous BCI:	1.43	Current BCI:	2.00

Updated: 2016 June

BRIDGE CONDITION INSPECTION

CITY OF VANCOUVER

Structure Number	D-9	Structure Name	Georgia Viaduct	Inspection Date (yyyy/mm/dd)	2016 May 17

	COMPONENT	PERCENT CONDITION RATING (Enter % in each condition. See CoV User Guide) E	G	F	P	V	X	N
	CHANNEL							
1	Debris Risk							100
2	Bank/Bed							100
3	Dolphins/Fenders							100
	SUBSTRUCTURE							
4	Foundat'n Movement		97	3				
5	Abutments		100					
6	Wing/Retaining Wall			50			50	
7	Footings/Piling						100	
8	Piers/Columns		100					
9	Bearings		100					
10	Caps		100					
11	Corbels							100
	SUPERSTRUCTURE							
12	Floorbeams							100
13	Stringers							100
14	Girders		100					
15	Portals							100
16	Bracing/Diaphragms							100
17	Truss Chords/Arch							100
18	Arch Ties							100
19	Truss Diagonals							100
20	Truss Rods/Verticals							100
21	Cables							100
22	Panels							100
23	Pins/Bolts/Rivets							100
24	Camber/Sag		100					
25	Live Load Vibration		100					
26	Coating (structure)							100
	DECK							
27	Sub Deck/Cross Ties		98	2				
28	Wearing Surface		100					
29	Deck Joints				100			
30	Curbs/Wheelguards							100
31	Sidewa k(s)		100					
32	Railings/Parapets		100					
33	Median Barrier		75	25				
34	Drains/Pipes		98	2				
35	Coating (Railings)							100
	APPROACHES							
36	Signing/Lighting		100					
37	Roadway		100					
38	Roadway Flares							100

INSPECTION NOTES BY COMPONENT

All poor or very poor conditions should be explained with notes and documented by photos. Label explanation(s) with component no.'s.

4. Foundation Movement: Settlement of approach structure at east end of off-ramp abutment (GM2) measured at 127 mm [Photo D1].

6. Retaining Wall: Failure of retaining wall at base of east abutment (G2) has permitted slope creep of hillslope resulting in the moderate undermining of approach structure elements. Footing on each side approach undercut for appx. 1700 mm. Issue has been known for a long period; no current structural concerns observed [Photos D2 & D3].

8. Piers: No change to repair at base of Pier G10 identified in previous inspection report [Photo D4].

8. Piers: Minor spalling at base of Pier G26 on west face [Photo D5].

9. Bearings: North bearing at east abutment (G2) surrounded by large amount of bird droppings [Photo D6].

14. Girders: Diagonal hairline cracks in webs of several girders throughout structure observed to be typical and considered normal wear and deterioration.

27. Sub Deck: Large spalls on off-ramp (GM1-GM2) at base of barriers at edge of deck: two on north side, one on south side. Overhang is just above ground level, there is no significant risk associated with falling debris [Photo D7].

Continued on next page (if necessary)

General Inspection Notes (Monitoring Notes):

Piers G18 to G20 are fully within construction site adjacent to Rogers Arena. Assessed from ground and arena stairs. Access to west abutment not available due to locked gates.

Utility Concern Notes (Contact Utility Owner):

Condition Codes			
E	Excellent	V	Very Poor
G	Good	X	Not Insp.
F	Fair	N	n/a
P	Poor		

For Condition Guidelines see CoV User Guide

Temperature
+ 12 °C
Weather
Clear Sky
Time of Day
7:30 am

Todd McCrimmon, P.Eng. / Aaron Pettis, P.E. – COWI North America

Lead Inspector / Inspector - Firm (please type or print)

Signature (Lead)

Inspection Notes by Component (continued):

27. Sub Deck: No major change to large deck overhang cracking (750 mm x 800 mm) and long opening (1200 mm) below edge barrier (with edge barrier spalling) on north side of off-ramp at end of approach (near GM2) [Photo D8].

27. Sub Deck: Large deck soffit spall 1600 mm x 700 mm with exposed reinforcement on east side of Pier G6 at transition with off-ramp. All loose material removed, and exposed rebar has already been coated with zinc-rich paint - however a 300 mm x 500 mm delamination remains adjacent to spall [Photo D9].

27. Sub Deck: Exhaust staining typical in Span G6-G7 above Skytrain tracks [Photo D10], and Span G22-G23 above equipment parked at BC Place stadium [Photo D11].

27. Sub Deck: Two overhang spalls 600 mm long with exposed reinforcement on south side of span between Pier G7 and G8 [Photo D12].

27. Sub Deck: Several small concrete spalls on south overhang between Pier G24 and G26 [Photo D13].

27. Sub Deck: Transverse deck soffit cracks with efflorescence observed periodically throughout structure. No evidence of spalling or corrosion staining [Photo D14].

28. Wearing Surface: Vehicles have tracked asphalt tar from new pavement at Beatty St. and deposited it on entire viaduct roadway. Most predominantly at east end of off-ramp where vehicles are often forced to come to a stop due to traffic light [Photos G1 & D15].

28. Wearing Surface: Transverse cracks in roadway at transition between off-ramp abutment and approach. No current hazards for motorists [Photo D16].

28. Wearing Surface: Deck patches in Span G13-G14 appear to be in good condition [Photo D17].

29. Deck Joints: Surface corrosion on all deck joint steel typical at deck joint overhangs [Photo D18].

29. Deck Joints: All deck joint seals are in poor condition. Most seals are visibly torn or recessed and filled with debris [Photo D19].

29. Deck Joints: Expansion joint at Pier G16 rattles with live load [Photo D20].

29. Deck Joints: Steel cover plate of longitudinal deck joint at north east corner of intersection with Citadel Parade has been bent revealing a very sharp edge that could be considered a hazard to pedestrians [Photo D21].

29. Deck Joints: Steel cover plate of longitudinal deck joint 9 m east of intersection with Citadel Parade is missing some fasteners and has an elevated corner that could be considered a hazard to pedestrians [Photo D22].

32. Parapets: Moderate spalling typical in barriers where settlement has occurred across transition between off-ramp abutment and approach [Photo D23].

33. Median Barrier: Shallow surface spalling with exposed reinforcement on south face of barriers (which separate roadway from sidewalk) typical on 126 of 517 panels throughout length of structure. Majority of bars are coated with zinc-rich paint but have continued to corrode [Photo D24].

34. Drains: Roadway drain grate blockage observed at Pier G9 and G13 [Photo D25].

36. Lighting: Loose hand hole cover plate at base of luminaire in Span G18-G19 [Photo D26].

39. Utilities: Concrete utilities access box below roadway on north side of Pier G7 has a transverse crack in the wall with corrosion stains and efflorescence. Concrete condition appears sound [Photo D27].

39. Utilities: Defunct utility drip tray with corroded base at north end of Pier G13 still secured to the girder soffit [Photo D28].

Inspection Photos

See attached photo log.

Structure Number	D-9	Structure Name	Georgia Viaduct	Inspection Date (yyyy/mm/dd)	2016 May 17

Remedial Work Activity List

Component	Location	Activity Description	Qty.	Unit	D	%	R	U	S	Photo #
4. Foundation Movement	GM2	Monitor – Settlement of approach structure at east end of abutment.	127	mm	1	100	1	M		D1
6. Retaining Wall	G2	Monitor – Undermining of east abutment and approach structures due to loss of soil.	1	ea.	1	100	1	M		D2 D3
9. Bearings	G2	Clean pier cap tops of excessive amounts of dirt and nesting debris.	3	m^2	1	20	1	R		D6
27. Sub Deck	G6-E	Monitor – Existing delamination (adjacent to large spall) which may fall onto sidewa k if spalls from deck soffit.	0.2	m^2	2	1	2	M		D9
29. Deck Joints	All	Monitor – Condition of all expansion joint seals is poor. Ensure seals are not protruding above roadway surface or resulting in other hazard for bridge users.	9	ea.	4	100	1	M		D19
29. Deck Joints	G16	Monitor – Deck joint plates rattle with passing of live load indicating that elements are loose.	1	ea.	3	100	1	M		D20
29. Deck Joints	Citadel Parade	Remove sharp edge in sidewalk deck plate.	1	ea.	2	1	3	4	MS	D21
29. Deck Joints	G26-N	Secure sidewalk deck plate to remove sharp edges.	1	ea.	2	1	3	4	MS	D22
34. Drains	G9 & G13	Clear catch basin blockage.	2	ea.	2	1	1	R		D25
36. Lighting	G18-G19	Secure loose hand hole cover plate at base of luminaire.	1	ea.	2	1	1	R		D26

Location Legend: GM = Off-Ramp Pier N = North
G = Mainline Pier
E = East

Rating System Legend:

Rating		Rating "D" – Degree of Condition		Rating "R" – Relevancy		Rating "U" – Urgency		Rating
		Degree of Severity of Defect		Structural Integrity and Safety of User		Maintenance Priority and Urgency of Repair	Monitor	M
E	E	Excellent	No defects, as new condition.	No defects, as new condition.		Routine maintenance work.	Routine	R
G	1	Good	Normal wear and deterioration not requiring maintenance/repair.	Minimum Relevancy	No structural integrity or safety issues.	Work not required before next detailed inspection.	≥ 5 yrs.	1
F	2	Fair	Functioning as intended. Minor maintenance/repair required.	Moderate Relevancy	Minor impact on structural integrity or safety issue.	Work required within specified time period.	< 3 yrs.	2
P	3	Poor	Not functioning as intended. More extensive repair required.	Major Relevancy	Structural integrity or safety issue compromised.	Work required within specified time period.	< 2 yrs.	3
V	4	Very Poor	Not functioning as intended. Major repair required.	Maximum Relevancy	Structural integrity and safety severely compromised. Collapse imminent and/or danger to users.	Immediate repair required.	ASAP	4
X – not inspected; N – not applicable; % – percentage of component with rating "D". Safety Column [S]: S – Safety related defect; MS – Make safe a "S" related defect; ST – Make safe a structural integrity related defect. Otherwise left blank.								

General Conditions Photo Log

COWI

Structure: D-9 Georgia Viaduct

Date: 2016 May 17

G1. View west along off-ramp approach from Main Street.

G2. General view of off-ramp abutment at GM2.

G3. View west near off-ramp junction with mainline.

G4. General view of east abutment at G2.

G5. Typical bearing condition at east abutment (G2).

G6. Off-ramp junction with mainline at Pier G6.

General Conditions Photo Log

COWI

Structure: D-9 Georgia Viaduct

Date: 2016 May 17

G7. General view looking west from Pier G13.

G8. General view of south parapet.

G9. Pier G19 fenced off due to construction activities.

G10. Pier G21 between Rogers Arena and BC Place Stadium.

G11. General view of west abutment at G27.

G12. South end of west abutment at G27.

2016 Deficiency Photo Log

COWI

Structure: D-9 Georgia Viaduct Date: 2016 May 17

D1. Settlement observed at GM2 east abutment of off-ramp.

D2. Failure of retaining wall at base of G2 east abutment.

D3. Undercut approach slab south end of G2 east abutment.

D4. Pier base repair at G10.

D5. Surface spalling on base of west face of Pier G26.

D6. Debris on bearing shelf at G2 east abutment.

2016 Deficiency Photo Log

COWI

Structure: D-9 Georgia Viaduct Date: 2016 May 17

D7. Spalls at deck overhang of off-ramp approach GM1-GM2.

D8. Deck overhang cracking near off-ramp abutment (GM2).

D9. Deck soffit spall with exposed rebar at Pier G6.

D10. Deck soffit staining above Skytrain in Span G6-G7.

D11. Deck soffit staining above equipment storage G22-G23.

D12. Deck overhang spalls south side of Span G7-G8.

2016 Deficiency Photo Log

COWI

Structure: D-9 Georgia Viaduct Date: 2016 May 17

D13. Deck overhang spalls south side near Pier G25.

D14. Deck soffit cracks as seen throughout structure.

D15. Tar deposits on off-ramp from new Beatty St pavement.

D16. Transverse cracks in roadway at off-ramp approach slab.

D17. Previous defect repairs sound, in Span G13-G14.

D18. Typical deck soffit corrosion at expansion joint locations.

2016 Deficiency Photo Log

COWI

Structure: D-9 Georgia Viaduct Date: 2016 May 17

D19. Typical condition of deck joints; torn seals and debris.

D20. Deck joint steel at Pier G20 which rattles with live load.

D21. Deck joint cover plate with sharp edge near Pier G26.

D22. Lifted deck joint cover plate near Pier G26.

D23. Spalling of parapets at approach slab transition (GM2).

D24. Typical spalls on south face of sidewalk barriers.

2016 Deficiency Photo Log

COWI

Structure: D-9 Georgia Viaduct Date: 2016 May 17

D25. Drain basin filled with debris at Pier G9.

D26. Luminaire with loose hand hole cover plate G18-G19.

D27. Staining of concrete at base of utility box at Pier G7.

D28. Corroded drip tray below utilities at Pier G13.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

Structure #: D-9 Inspection Date: 2016 May 17

5 Year Repair, Rehabilitation and Maintenance Plan

Structure Name: Georgia Viaduct

Component	Location	Activity Description	Qty.	Unit	Unit Rate		Base Cost+	D	%	R	U	S	Photos
29 Deck Joints	G26-N	Remove sharp edge in sidewalk deck plate.	1	ea.	$250	=	$250	2	1	3	4	MS	D21
29 Deck Joints	G26-N	Secure sidewalk deck plate to remove sharp edges.	1	ea.	$250	=	$250	2	1	3	4	MS	D22
					Urgency 4 Sub-Total		**$500**	**(ASAP)**					
9 Bearings	G2	Clean debris from around bearings.	0.5	m^2	$1,000	=	$500	1	20	1	R		D6
34 Drains	G9 & G13	Clear catch basin blockage.	2	ea.	$250	=	$500	2	1	1	R		D25
36 Lighting	G18-G19	Secure loose hand hole cover plate at base of luminaire.	1	ea.	$50	=	$50	2	1	1	R		D26
					Routine Maintenance Sub-Total		**$1,050**	**(by 2017)**					

Total of Base Costs	$1,550
Engineering Design and Supervision (15%)	$233
Traffic Management and Site Establishment (20%)	$310
Sub-Total	$2,093
Contingency and Inflation (15%)	$314
Bridge Total Rounded Up (nearest $1,000)	**$3,000**

+ Base cost shown is best estimate and may deviate from unit rate projection when projection is deemed an unrealsitic estimate of expected repair cost.

Location Legend:

N = North

S = South

E = East

CITY OF VANCOUVER

Bridge No. D-9

Georgia Viaduct

between
Beatty St. & Main St.

Notes:

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Appendix B
5 Year Repair, Rehabilitation and Maintenance Plan - By Urgency

INCLUDES

U4 Urgency Rating Summary (ASAP)	**1 page**
U3 Urgency Rating Summary (by 2019)	**1 page**
U2 Urgency Rating Summary (by 2020)	**1 page**
U1 Urgency Rating Summary (by 2022)	**1 page**
Routine Maintenance Items Summary (by 2017)	**1 page**
All Rehab Items – Overall DRU Score Ranking	**1 page**

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

5 Year Repair, Rehabilitation and Maintenance Plan - Urgency Rating (U4) Summary

Reported: 2016 Jun Complete Before: ASAP

No.	ID #	Bridge	Component	Location	Activity Description	Qty.	Unit	Unit Rate		Base Cost+	D	%	R	U	S	Photos
Not Responsive to Request																
2	D-9	Georgia Viaduct	29 Deck Joints	G26-N	Remove sharp edge in sidewalk deck plate.	1	ea.	$250	=	$250	2	1	3	4	MS	D21
3	D-9	Georgia Viaduct	29 Deck Joints	G26-N	Secure sidewalk deck plate to remove sharp edges.	1	ea.	$250	=	$250	2	1	3	4	MS	D22

Total of Base Costs	$750
Engineering Design and Supervision (15%)	$113
Traffic Management and Site Establishment (20%)	$150
Sub-Total	$1,013
Contingency and Inflation (15%)	$152
Bridge Total Rounded Up (nearest $1000)	**$2,000**

+ Base cost may be adjusted when unit rate projection is deemed an unrealsitic estimate of expected repair cost.

* Urgency Note 4* urgency given to indicate that action should be taken before construction warranty period of structure expires.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

5 Year Repair, Rehabilitation and Maintenance Plan - Urgency Rating (U3) Summary

Reported: 2016 Jun Complete Before: 2019

No.	ID #	Bridge	Component	Location	Activity Description	Qty.	Unit	Unit Rate	Base Cost+	D	%	R	U	S	Photos
Not Responsive to Request															

Total of Base Costs	$2,000
Engineering Design and Supervision (15%)	$300
Traffic Management and Site Establishment (20%)	$400
Sub-Total	$2,700
Contingency and Inflation (15%)	$405
Bridge Total Rounded Up (nearest $1000)	**$4,000**

+ Base cost may be adjusted when unit rate projection is deemed an unrealsitic estimate of expected repair cost.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

5 Year Repair, Rehabilitation and Maintenance Plan - Urgency Rating (U2) Summary

Reported: 2016 Jun Complete Before: 2020

No.	ID #	Bridge	Component	Location	Activity Description	Qty.	Unit	Unit Rate	Base Cost+	D	%	R	U	S	Photos

Not Responsive to Request

Total of Base Costs	$4,800
Engineering Design and Supervision (15%)	$720
Traffic Management and Site Establishment (20%)	$960
Sub-Total	$6,480
Contingency and Inflation (15%)	$972
Bridge Total Rounded Up (nearest $1000)	**$8,000**

+ Base cost may be adjusted when unit rate projection is deemed an unrealsitic estimate of expected repair cost.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

5 Year Repair, Rehabilitation and Maintenance Plan - Urgency Rating (U1) Summary

Reported: 2016 Jun Complete Before: 2022

No.	ID #	Bridge	Component	Location	Activity Description	Qty.	Unit	Unit Rate	Base Cost+	D	%	R	U	S	Photos

Not Responsive to Request

Total of Base Costs	$2,000
Engineering Design and Supervision (15%)	$300
Traffic Management and Site Establishment (20%)	$400
Sub-Total	$2,700
Contingency and Inflation (15%)	$405
Bridge Total Rounded Up (nearest $1000)	**$4,000**

+ Base cost may be adjusted when unit rate projection is deemed an unrealsitic estimate of expected repair cost.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

5 Year Repair, Rehabilitation and Maintenance Plan - Routine Maintenance Items Summary

Reported: 2016 Jun Complete Before: 2017

No.	ID #	Bridge	Component	Location	Activity Description	Qty.	Unit	Unit Rate		Base Cost+	D	%	R	U	S	Photos
Not Responsive to Request																
5	D-8	Dunsmuir Viaduct	5 Abutments	DM2-N	Determine if repairs to the fencing is necessary.	1	m^2	$250	=	$250	3	5	1	R		D1
6	D-8	Dunsmuir Viaduct	34 Drains	DM5	Clear catch basin blockage.	1	ea.	$250	=	$250	3	1	1	R		D20
Not Responsive to Request																
15	D-9	Georgia Viaduct	34 Drains	G9 & G13	Clear catch basin blockage.	2	ea.	$250	=	$500	2	1	1	R		D25
16	D-9	Georgia Viaduct	36 Lighting	G18-G19	Secure loose hand hole cover plate at base of luminaire.	1	ea.	$50	=	$50	2	1	1	R		D26
Not Responsive to Request																
20	D-8	Dunsmuir Viaduct	36 Signage	DM5	Repair hazard sign for bike lane taper.	1	ea.	$250	=	$250	1	1	1	R		D21
21	D-9	Georgia Viaduct	9 Bearings	G2	Clean debris from around bearings.	0.5	m^2	$1,000	=	$500	1	20	1	R		D6

Total of Base Costs	$14,800
Engineering Design and Supervision (15%)	$2,220
Traffic Management and Site Establishment (20%)	$2,960
Sub-Total	$19,980
Contingency and Inflation (15%)	$2,997
Bridge Total Rounded Up (nearest $1000)	**$23,000**

+ Base cost may be adjusted when unit rate projection is deemed an unrealsitic estimate of expected repair cost.

* Urgency Note 4* urgency given to indicate that action should be taken before construction warranty period of structure expires.

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI.

5 Year Repair, Rehabilitation and Maintenance Plan - Overall DRU Score Ranking (Most to Less Critical)

Reported: 2016 Jun

No.	ID #	Bridge	Component	Location	Activity Description	Qty.	Unit	Unit Rate		Base Cost+	D	%	R	U	S	Photos
Not Responsive to Request																
2	D-9	Georgia Viaduct	29 Deck Joints	G26-N	Remove sharp edge in sidewalk deck plate.	1	ea.	$250	=	$250	2	1	3	4	MS	D21
3	D-9	Georgia Viaduct	29 Deck Joints	G26-N	Secure sidewalk deck plate to remove sharp edges.	1	ea.	$250	=	$250	2	1	3	4	MS	D22
Not Responsive to Request																
11	D-8	Dunsmuir Viaduct	5 Abutments	DM2-N	Determine if repairs to the fencing is necessary.	1	m^2	$250	=	$250	3	5	1	R		D1
12	D-8	Dunsmuir Viaduct	34 Drains	DM5	Clear catch basin blockage.	1	ea.	$250	=	$250	3	1	1	R		D20
Not Responsive to Request																
24	D-9	Georgia Viaduct	34 Drains	G9 & G13	Clear catch basin blockage.	2	ea.	$250	=	$500	2	1	1	R		D25
25	D-9	Georgia Viaduct	36 Lighting	G18-G19	Secure loose hand hole cover plate at base of luminaire.	1	ea.	$50	=	$50	2	1	1	R		D26
Not Responsive to Request																
29	D-8	Dunsmuir Viaduct	36 Signage	DM5	Repair hazard sign for bike lane taper.	1	ea.	$250	=	$250	1	1	1	R		D21
30	D-9	Georgia Viaduct	9 Bearings	G2	Clean debris from around bearings.	0.5	m^2	$1,000	=	$500	1	20	1	R		D6

Total of Base Costs	$24,350
Engineering Design and Supervision (15%)	$3,653
Traffic Management and Site Establishment (20%)	$4,870
Sub-Total	$32,873
Contingency and Inflation (15%)	$4,931
Bridge Total Rounded Up (nearest $1000)	**$38,000**

+ Base cost may be adjusted when unit rate projection is deemed an unrealsitic estimate of expected repair cost.

Appendix C
Standard Remedial Activities and Applicable Unit Rates

INCLUDES

Repair Item Unit Rates **6 pages**

ID#	Insp. Item	Repair Item	Unit	Cost
1	Debris Risk			
	1.1	Re-profile channel bed	LS	0.99
	1.2	Freeboard - monitor	LS	0
	1.3	Channel - local hydraulic assessment	LS	0.99
	1.4	River gravel - remove	m^3	100
	1.5	Debris - remove	m^2	200
2	Bank/Bed			
	2.1	Planting, approach slope protection	m^2	10
	2.2	Seed grass, approach slope protection	m^2	5
	2.3	Vegetation, remove/trim	m^2	100
	2.4	Regrade slope	m^3	50
	2.5	Riprap - install	m^3	75
	2.6	Riprap - reshape	m^2	25
	2.7	Shotcrete	m^2	25
	2.8	Tree removal < 0.3 m dia.	ea.	500
	2.9	Tree removal > 0.3 m dia.	ea.	1200
	2.10	Tree removal > 0.6 m dia.	ea.	2000
	2.11	Gabion Baskets - new	m^3	300
	2.12	Channel - waterway hydraulic assessment	LS	50
3	Dolphins/Fenders			
	3.1	Fender Planks - replace	m^2	200
	3.2	Fender - new	m^2	500
4	Foundation Movement			
	4.1	Concrete spall repair, spread footing	m^3	10000
	4.2	Timber Pile band, abutment foundation	ea.	150
	4.3	Timber Pile replace, abutment foundation	ea.	10000
	4.4	Undermining of spread footing - pump grout	m^3	2000
	4.5	Reinstate stability, foundation	LS	0.99
	4.6	Settlement/rotation, foundation - monitoring	LS	0
5	Abutments			
	5.1	Clear debris, bearing seat	m^3	1000
	5.2	Concrete cracks < 0.3 mm - monitor	m	0
	5.3	Concrete cracks > 0.3 mm - epoxy injection	m	230
	5.4	Concrete cracks > 12 mm - grout injection	m	200
	5.5	Concrete spall repair	m^3	10000
	5.6	Graffiti removal	m^2	25
	5.7	Timber Planking - replace	m^2	200
6	Wing/Retaining Walls			
	6.1	Concrete cracks < 0.3 mm - monitor	m	0
	6.2	Concrete cracks > 0.3 mm - epoxy injection	m	230
	6.3	Concrete cracks > 12 mm - grout injection	m	200
	6.4	Concrete spall repair	m^3	10000
	6.5	Graffiti removal	m^2	25
	6.6	Stability - reinstate, wing/retaining wall	ea.	0.99
	6.7	Undermining of wing/retaining wall - pump grout	m^3	2000
	6.8	Monitor rotation, wing/retaining wall	LS	0
	6.9	Timber crib / plank wall - new	m^2	300
	6.10	Lock block - new	m^2	300
	6.11	Retaining wall remove and regrade slope	m^2	150

ID#	Insp. Item	Repair Item	Unit	Cost
7	Footings/Piling			
	7.1	Concrete spall repair, spread footing, pier	m^3	1000
	7.2	Timber Pile replace, pier foundation	ea.	0.99
	7.3	Undermining of spread footing - pump grout, pier	m^3	1200
8	Pier			
	8.1	Concrete cracks < 0.3 mm - monitor, pier	m	0
	8.2	Concrete cracks > 0.3 mm - epoxy injection, pier	m	230
	8.3	Concrete cracks > 0.3 mm - install telltale for monitoring	ea.	150
	8.4	Concrete spall repair, pier	m^3	10000
	8.5	Graffiti removal	m^2	25
	8.6	Pier Bent - replace with H piles and W beam cap	ea.	0.99
	8.7	Timber bearing pile - replace	ea.	10000
	8.8	Timber fender pile - install/replace flashing to top	ea.	25
	8.9	Timber fender pile - replace	ea.	6000
	8.10	Timber pile - band	ea.	150
	8.11	Timber pile - post and splice	ea.	1200
9	Bearings			
	9.1	Bearing Anchor Bolts - monitor deflection	LS	0
	9.2	Bearing Anchor Bolts - replace bolts	ea.	750
	9.3	Bearing Anchor Bolts - replace nuts	ea.	50
	9.4	Bearing Anchor Bolts - tighten/loosen nuts	ea.	10
	9.5	Coating - localized wire brush and touch up - bearings	ea.	200
	9.6	Coating - localized wire brush and touch up - bearings	ea.	250
	9.7	Concrete spall repair, bearing plinth	m^3	10000
	9.8	Jack bridge for Bearing Replacement	LS	0.99
	9.9	Jack bridge to re-set bearing	LS	0.99
	9.10	Monitor Bearing movement	LS	0
	9.11	Replace bearing - elastomeric	ea.	500
	9.12	Replace bearing - sliding	ea.	5000
	9.13	Replace bearing - steel pot	ea.	5000
	9.14	Re-set bearings	ea.	1000
10 + 11	Caps and Corbels			
	10.1	Concrete cracks < 0.3 mm - monitor, pier column	m	0
	10.2	Concrete cracks > 0.3 mm - epoxy injection, pier column	m	230
	10.3	Concrete cracks > 0.3 mm - install telltale for monitoring	ea.	150
	10.4	Concrete spall repair, pier column	m^3	10000
	10.5	Timber pier cap - install steel straps	ea.	150
	10.6	Timber pier cap - replace	ea.	0.99
	10.7	Graffiti removal	m^2	25
	10.8	Clear debris, bearing seat - piers	m^3	1000
12	Floorbeams/Transoms			
	12.1	Coating - localized wire brush and touch up, tranv. < 2 m^2	m^2	2000
	12.2	Concrete cracks < 0.3 mm - monitor, tranv. member	m	0
	12.3	Concrete cracks > 0.3 mm - epoxy injection, tranv. member	m	230
	12.4	Concrete cracks > 0.3 mm - install telltale, tranv. member	ea.	150
	12.5	Concrete spall repair, tranv. member	m^3	15000
	12.6	Diaphragm Connection - tighten bolts	ea.	50
	12.7	Floorbeam/Transom - replace	ea.	0.99

ID#	Insp. Item	Repair Item	Unit	Cost
13 + 14	Stringers and Girders			
	14.1	Coating - localized wire brush and touch up, ext. long. < 2 m^2	m^2	2000
	14.2	Concrete cracks < 0.3 mm - monitor, stringer/girder	m	0
	14.3	Concrete cracks > 0.3 mm - epoxy injection, stringer/girder	m	230
	14.4	Concrete cracks > 0.3 mm - install telltale, stringer/girder	ea.	150
	14.5	Concrete spall repair, stringer/girder	m^3	15000
	14.6	Deflection - monitor, stringer/girder	LS	0.99
	14.7	Stringer - replace	ea.	0.99
	14.8	Girder - replace	ea.	0.99
19	Truss Diagonals			
	19.1	Diagonal Member - tighten/replace bolts	ea.	50
	19.2	Steel Diagonal Member - replace	ea.	0.99
	19.3	Steel Diagonal Member - warped/deflected - monitor	LS	0
26	Coatings (structure)			
	26.1	Coating - field prep & recoat to specification, full containment	m^2	250
	26.2	Coating - field prep & recoat to specification, minimal containment	m^2	150
	26.3	Coating - localized wire brush and touch up > 2 m^2	m^2	1500
27	Sub Deck / Cross Ties			
	27.1	Concrete cracks < 0.3 mm - monitor, deck soffit	m	0
	27.2	Concrete cracks > 0.3 mm - epoxy injection, deck soffit	m	230
	27.3	Concrete cracks > 0.3 mm - install telltale for monitoring, deck soffit	ea.	150
	27.4	Concrete spall repair, deck soffit	m^3	10000
	27.5	Graffiti removal	m^2	25
28	Wearing Surface			
	28.1	Asphalt Cracks - seal with bitumen mastic, on span	m	15
	28.2	Asphalt Overlay - mill and place 50 mm lift, on span	m^2	50
	28.3	Asphalt Overlay - mill existing and place new full depth, on span	m^2	40
	28.4	Asphalt Patch Repair, on span	m^2	50
	28.5	Concrete cracks > 0.3 mm - epoxy injection, deck top	m	230
	28.6	Concrete Deck Repair - full depth	m^2	1500
	28.7	Concrete Deck Repair - partial depth	m^2	500
	28.8	Cracks seal - concrete wearing surface	m	100
	28.9	Debris remove, wearing surface	m^2	20
	28.10	Linemarking	m	20
	28.11	Reflective Line Marking - replace	ea.	50
	28.12	Timber deck planks - replace	m^2	250
	28.13	Timber running planks - replace	m^2	150
	28.14	Unreinforced concrete overlay - full depth repair/replace	m^2	900
	28.15	Unreinforced concrete overlay - patch repair	m^2	400
29	Deck Joints			
	29.1	Clear/flush debris, expansion joint	m	25
	29.2	Concrete nosing - breakout and replace	m	200
	29.3	Concrete nosing - localized patch repair	m	200
	29.4	Investigate Articulation Modification	LS	0.99
	29.5	Joint locked closed - investigate	LS	0
	29.6	Leaking evident - investigate	LS	0
	29.7	New Buried Joint	m	3000
	29.8	New Compression Seal	m	250
	29.9	New Compression Seal plus Armour	m	4000
	29.10	New Compression Seal plus Armour, Asbestos AC	m	5500

ID#	Insp. Item	Repair Item	Unit	Cost
	29.11	New Finger Plate Joint	m	9500
	29.12	New Modular Joint - 2 cells	m	7500
	29.13	New Modular Joint - 3 cells	m	12500
	29.14	New Modular Joint - 4 cells	m	15000
	29.15	New Strip Seal only	m	1000
	29.16	New Strip Seal plus Armour	m	4500
	29.17	New Strip Seal plus Armour, Asbestos AC	m	6000
	29.18	Pourable seal - repair	m	500
	29.19	Repair cover plate	m	250
	29.2	Replace cover plate	m	500
	29.21	Steel nosing - breakout and replace	m	3500
	29.22	Steel nosing - localized repair	m	300
30	Curbs/Wheelguards			
	30.1	Cats eyes - new, curb on span	ea.	100
	30.2	Concrete curb - replace, on span	m	80
	30.3	Concrete spall repair, curb on span	m^3	10000
	30.4	Remove debris, curb on span	m^3	200
31	Sidewalk(s)			
	31.1	Concrete cracks < 0.3 mm - monitor, sidewalk	m	0
	31.2	Concrete cracks > 0.3 mm - monitor, sidewalk	m	0
	31.3	Concrete cracks > 0.3 mm - epoxy injection, sidewalk	m	230
	31.4	Concrete cracks > 12 mm - grout injection, sidewalk	m	200
	31.5	Concrete spall repair, sidewalk	m^3	10000
	31.6	Place concrete to remove triping hazard	m^3	2000
	31.7	Asphalt Cracks - seal with bitumen mastic, sidewalk	m	15
	31.8	Asphalt Overlay - mill and place 50 mm lift, sidewalk	m^2	50
32 + 35	Railings/Parapets (incl. coatings)			
	32.1	Bolts Replace	ea.	25
	32.2	Coating - localized wire brush and touch up, parapets < 2 m^2	m^2	1500
	32.3	Concrete cracks < 0.3 mm - monitor, parapet or plinth	m	0
	32.4	Concrete cracks > 0.3 mm - epoxy injection, parapet or plinth	m	230
	32.5	Concrete cracks > 0.3 mm - monitor, parapet or plinth	m	0
	32.6	Concrete cracks > 12 mm - grout injection, parapet or plinth	m	200
	32.7	Concrete spall repair, parapet or plinth	m^3	10000
	32.8	Galvanized coating - field apply	m^2	1200
	32.9	New Bicycle Railing	m	150
	32.10	New Concrete Barrier - precast PL-2	ea.	400
	32.11	New Steel Barrier - PL-2	m	300
	32.12	Parapet/Barrier Connection upgrade/replace	ea.	500
	32.13	Pedestrian Railing - replace	m	150
	32.14	Infill Mesh Repair	m^2	50
	32.15	Infill Mesh Replace	m^2	300
	32.16	Timber Post - replace	ea.	150
	32.17	Timber Rail - replace	m	50
33	Median Barrier			
	33.1	Concrete cracks < 0.3 mm - monitor, median	m	0
	33.2	Concrete cracks > 0.3 mm - monitor, median	m	0
	33.3	Concrete cracks > 0.3 mm - epoxy injection, median	m	230
	33.4	Concrete cracks > 12 mm - grout injection, median	m	200

ID#	Insp. Item	Repair Item	Unit	Cost
	33.5	Concrete spall repair, median	m^3	10000
	33.6	Concrete spall repair, median curb	m^3	10000
	33.7	Concrete Barrier new - precast concrete barrier (jersey)	ea.	400
	33.8	Repair/replace damaged precast concrete barrier	ea.	1200
34	Drains/Pipes			
	34.1	Catch basin - clear debris	ea.	250
	34.2	Catch basin - install	ea.	6500
	34.3	Catch basin - replace cover	ea.	250
	34.4	Construct open channel drain	m	125
	34.5	Deck drain - clear debris	ea.	250
	34.6	Deck drain pipe - extend (steel)	ea.	750
	34.7	Deck drain pipe - extend (3" pvc)	m	10
	34.8	Grade gravel road for drainage	m^2	30
	34.9	Install drip groove to concrete soffit - silicon bead	m	15
	34.10	Weep hole - clear blockage	ea.	20
	34.11	Weep hole - install	ea.	150
36	Signing / Lighting			
	36.1	Coating - localized wire brush and touch up, lights < 2 m^2	m^2	1500
	36.2	Lamp Standard - new bulb	ea.	250
	36.3	Lamp Standard - replace	ea.	350
	36.4	Lamp Standard - replace connection bolts	ea.	50
	36.5	Misc. Sign - clean	ea.	250
	36.6	Misc. Sign - new	ea.	250
	36.7	Misc. Sign - relocate or reinstate	ea.	250
	36.8	Width hazard marker - clean	ea.	20
	36.9	Width hazard marker - new	ea.	150
	36.10	Width hazard marker - relocate or reinstate	ea.	75
37	Roadway			
	37.1	Asphalt Cracks - seal with bitumen mastic, on approach	m	15
	37.2	Asphalt Overlay - mill and place 50 mm lift, on approach	m^2	50
	37.3	Asphalt Overlay - place additional for settlement, on approach	m^2	50
	37.4	Asphalt Patch Repair on approach	m^2	50
	37.5	Asphalt Pavement - full depth reconstruction, on approach	m^2	400
	37.6	Concrete cracks < 0.3 mm - monitor, approach slab	m	0
	37.7	Concrete cracks > 0.3 mm - epoxy injection, approach slab	m	230
	37.8	Concrete cracks > 12 mm - grout injection, approach slab	m	200
	37.9	Debris remove, approach wearing surface	m^2	20
	37.10	Granular Pavement - add gravel and grade	m^2	100
	37.11	Lift Slab - grout injection	ea.	0.99
38	Roadway Flares			
	38.1	Approach Barrier new - precast concrete barrier (jersey)	ea.	400
	38.2	Approach Barrier new - precast concrete barrier transition	ea.	400
	38.3	Approach Barrier new - steel pedestrian railing	m	100
	38.4	Approach Barrier new - steel w-beam guradrail end treatment	ea.	3500
	38.5	Approach Barrier new - steel w-beam guradrail fishtail/shoe	ea.	150
	38.6	Approach Barrier new - steel w-beam guradrail post	ea.	50
	38.7	Approach Barrier new - w-beam guradrail	m	100
	38.8	Approach Barrier repair/replace damaged - chainlink fence	m	30
	38.9	Approach Barrier repair/replace damaged - precast concrete barrier	ea.	1200

ID#	Insp. Item	Repair Item	Unit	Cost
	38.10	Approach Barrier repair/replace damaged - steel pedestrian railing	m	25
	38.11	Approach Barrier repair/replace damaged - steel w-beam guradrail	m	200
	38.12	Approach Barrier/Parapet Connection - new	ea.	800
	38.13	Concrete cracks < 0.3 mm - monitor, approach median	m	0
	38.14	Concrete cracks > 0.3 mm - epoxy injection, approach median	m	230
	38.15	Concrete cracks > 12 mm - grout injection, approach median	m	200
	38.16	Concrete Curb - replace	m	
	38.17	Concrete spall repair	m^3	10000
	38.18	Revegetate	m^2	30
	38.19	Tree remove	ea.	500
	38.20	Vegetation - remove	m^2	50
39	Utilities			
	39.1	Coating - localized wire brush and touch up, utility < 2 m^2	m^2	1500
	39.2	Protective insulation - local repair	m	150
	39.3	Protective insulation - replace	m	250
	39.4	Utility - replace	m	0.99
	39.5	Utility Cover replace - Plastic	ea.	50
	39.6	Utility Cover replace - Steel/cast iron heavy duty	ea.	250
	39.7	Utility Cover replace - Steel/cast iron light duty	ea.	200
	39.8	Utility Support - replace	ea.	500

Appendix D
Repair Completion Checklists

INCLUDES

Not Responsive to Request

D-8: Dunsmuir Viaduct **1 page**

D-9: Georgia Viaduct **1 page**

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Not Responsive to Request

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI

Inspection Date: 2016 May 18

Repair, Rehabilitation and Maintenance Plan - Completion Checklist

Structure: D-8 Dunsmuir Viaduct

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
5 Abutments	DM2-N	Determine if repairs to enclosure fencing is necessary.	3	5	1	R			

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 250			

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
34 Drains	DM5	Clear catch basin blockage.	3	1	1	R			

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 250			

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
36 Signage	DM5	Repair hazard sign for bike lane taper.	1	1	1	R			

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 250			

Location Legend: DM = On-Ramp Pier
N = North

Detailed Inspection Results for the City of Vancouver - 2016 Inspections by COWI

Inspection Date: 2016 May 17

Repair, Rehabilitation and Maintenance Plan - Completion Checklist

Structure: D-9 Georgia Viaduct

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
29 Deck Joints	G26-N	Remove sharp edge in sidewalk deck plate.	2	1	3	4	MS		

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 250			

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
29 Deck Joints	G26-N	Secure sidewalk deck plate to remove sharp edges.	2	1	3	4	MS		

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 250			

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
9 Bearings	G2	Clean debris from around bearings.	1	20	1	R			

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 500			

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
34 Drains	G9 & G13	Clear catch basin blockage.	2	1	1	R			

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 500			

Component	Location	Activity Description	D	%	R	U	MS	Recon. Date	Recon. Notes
36 Lighting	G18-G19	Secure loose hand hole cover plate at base of luminaire.	2	1	1	R			

Personnel	Equipment / Materials Used	Cost Estimate / Actual Cost	Completion Date	Follow Up Required?	Rehab. Notes
		$ 50			

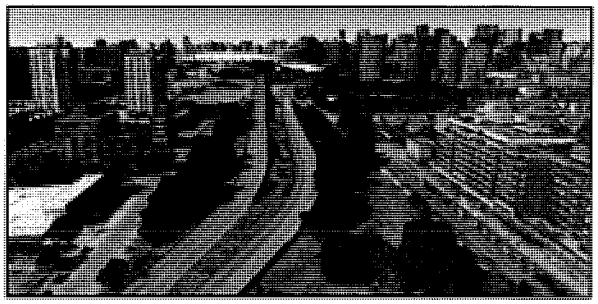
Location Legend: N = North
S = South
E = East

Not Responsive to Request

End of Report

SURE Hazmat and Testing

May 29, 2017



Thurber Engineering Ltd
#900 – 1281 West Georgia Street,
Vancouver, BC
V6E 3J7

Attention: **Andrew Sorenson, *Senior Environmental Engineer***

Reference: **Asphalt Core Sampling**
Georgia & Dunsmuir Viaducts, Vancouver, BC

Sure Hazmat and Testing has, in accordance with your request, completed asphalt core sampling as part of the planned demolition of the Georgia & Dunsmuir Viaducts in Vancouver, BC. The scope of work was outlined by the client in the site plan and included both viaducts and on/off ramps from the East intersection of Gore Avenue to the West intersection of Citadel Parade. Core sampling was conducted to include all layers of asphalt and any other accessible suspect materials were also included.

Sampling Methodology

Prior to the start of fieldwork all required documentation was obtained including City of Vancouver Street Use Permit, Test Hole Permit, Noise Variance Permit and BC One Call notification. Traffic control with approved traffic management plans was provided by Traffic Pro Services during fieldwork activities.

On May 1st & 2nd 2017, Urban Sawing and Scanning conducted wet core sampling at the designated sample locations. Sampling was conducted following moderate risk work procedures including half face respirator and disposable coveralls. A total of twenty eight (28) samples of asphalt and suspect caulking were collected and submitted for asbestos analysis. A total of three (3) samples of suspect lead-based paint were collected and submitted for lead content analysis.

Analytical Methodology

Asbestos

Samples were analyzed at the in-house laboratory of Sure Hazmat and Testing in accordance with the NIOSH 9002 PLM Bulk Sampling Analytical Method using polarized light microscopy and dispersion staining techniques. The detection limit of this method is listed as <1%. A copy of our Asbestos Bulk Results spreadsheet is attached to this report for your information and records. All records should be retained for a period of ten years as required by WorkSafe BC.

Samples will be stored at our laboratory for two months before being disposed of. Should you wish to keep these samples beyond this, please notify us within this period.

Lead-Based Finishes

Suspect leaded paint finishes were submitted to Maxxam Analytics for analysis of lead content. For leaded paint finishes, samples were digested using nitric acid/hydrogen peroxide followed by analysis using Inductively Coupled Plasma Spectroscopy (ICAP) and/or Inductively Coupled Plasma/Mass Spectroscopy (ICPMS).

The federal *Hazardous Products Act* (HPA) under Surface Coating Materials regulation defines leaded paint or lead-based surface coating materials with a total lead concentration of 0.009% or 90 µg/g. This is the current accepted standard by WorkSafe BC for identification of lead-based paint. Paint finishes that contain lead equal to or greater than 90 µg/g are considered to present a risk to pregnant women & children and a risk assessment must be conducted by a qualified person prior to the performance of any work that impacts lead-based paint finishes in work areas with high risk individuals in adjacent occupied areas.

Asbestos-Containing Material Results

Asbestos-containing asphalt has been identified on the Georgia Viaduct including the off ramp to Main Street. Samples were observed as a homogenous single phase with no distinguishable layers. Asphalt core samples average depth was 3" to concrete deck.

Non-Asbestos Material Results

All asphalt samples collected from the Dunsmuir Viaduct including the on ramp from Main Street were determined to be non-asbestos.

Seven (7) samples of caulking were collected from both Georgia & Dunsmuir Viaducts and were determined to be non-asbestos.

Please refer to the attached laboratory results sheet and sample location plan for detailed sample location information.

Lead-Based Finish Results

Sampling of suspect paint finishes was conducted within the work area. Table 1 shows the concentration of lead in paint for the samples collected:

Table 1 – Paint Sample Results

Sample #	Sample Location	Lead Concentration (µg/g)	HPA Standard Level (µg/g)
11387-LP01	Road Marking - White	6.7	90
11387-LP02	Road Marking - Yellow	**381**	90
11387-LP03	Lamp Post - Silver/Grey	**49,700**	90

Note: Bold values exceed standard level

The concentration of lead was above the HPA standard level of 90 µg/g for both the yellow painted road marking and the silver/grey painted lamp posts. A metal railing along the outside of the viaducts is galvanised and is assumed to be lead-containing.

Conclusions and Recommendations

Asbestos

Asbestos containing asphalt must be removed to concrete base by a qualified hazardous materials contractor using appropriate work procedures as defined by WorkSafe BC.

It should be noted that suspect asbestos-containing drainage piping may be present concealed below grade, however no asbestos cement piping was visible during this investigation.

Inaccessible PVC piping was observed on the underside of the viaducts. Suspect mastic was observed at joints and should be sampled prior to disturbance.

Lead

The presence of lead based paint finishes does not pose an immediate hazard when present in good condition and left undisturbed. Abrasion of leaded paint surfaces can create hazardous lead dust and paint chips. Removal of lead-based painted yellow road markings will be conducted as part of the asphalt asbestos removal following Moderate Risk asbestos safe work procedures.

Lamp posts with lead-based paint will need to be handled following lead safe work procedures depending on the method of removal and disposal. A qualified person should conduct a Risk Assessment when the method of removal has been determined.

WorkSafe-BC Requirements

This section is intended to aid in compliance with WorkSafe BC regulations, and is not intended to replace a Risk Assessment conducted on site by a qualified person prior to the start of asbestos abatement work.

Prior to the performance of any work that impacts asbestos-containing materials, it is a regulatory requirement that a qualified person perform a Risk Assessment. This requirement is in compliance with the WorkSafe-BC Occupational Health & Safety (OH&S) Regulation *Part 6 "Substance Specific Requirements";* specifically Section 6.6 subsections (1), (2), (3) and (4).

During the removal of asbestos-containing asphalt, **Moderate Risk** asbestos safe work procedures must be followed, including the following at a minimum:

- Supply appropriate notification to WorkSafeBC,
- Personal Protective Equipment must include tight-fitting half face piece respiratory protection fitted with P100 filters and approved disposable coveralls with head and foot covers,
- Application of amended water to the asbestos materials being disturbed such as water cannon,
- Complete isolation of the work area during removal activities including fence barriers and privacy curtains at the perimeter of the work area,
- Use of asbestos barrier tape and warning signs around the perimeter of the work area,
- HEPA-equipped vacuum for local exhaust ventilation and to ensure removal of all asbestos materials,
- Hand and face wash station,
- Air monitoring.

To comply with Part 6 of the WorkSafe-BC OH&S Regulation, specifically Section 6.32 relating to documentation, the client should acquire copies of the asbestos abatement contractor's Notice of Project (NOP), abatement procedures, air monitoring results and any documentation issued to WorkSafe-BC. These documents are required to be stored and held for 10 years.

Limitations

This report is intended for the exclusive use of the client to determine the locations of asbestos and lead containing materials prior to the demolition of the viaducts. Should a suspect material be encountered during demolition or excavation, all work must be stopped and Sure Hazmat will investigate immediately. Hazardous materials investigation does not include investigation for the presence of subsurface contamination or underground storage tanks.

If further clarification is required, please contact our office. Thankyou for having Sure Hazmat and Testing perform this work for you.

Sincerely,

Damien Fitzpatrick, B. Sc.*Project Manager*
Sure Hazmat and Testing

Reviewed by:

John Shaw, CTech, *Principal*
Sure Hazmat and Testing

Encl. Photographs
Laboratory Bulk Asbestos Report
Laboratory Lead Report
Sample Locations Plan

Ref: 11387-R01

Photos:

Photo 1 – Asbestos-containing asphalt – Core sample Approx 3" Depth

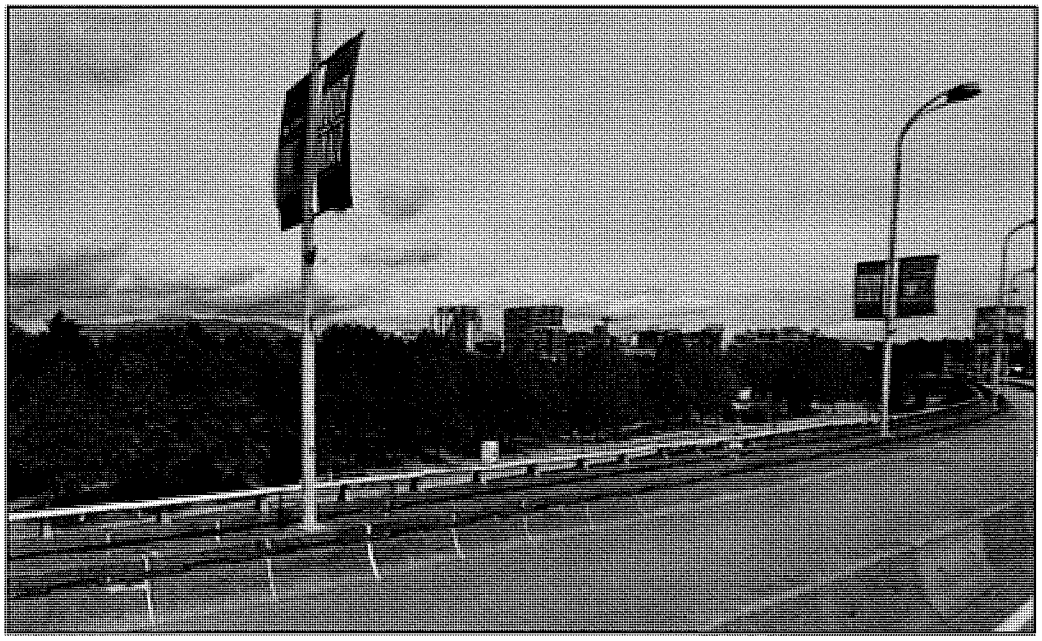


Photo 2 – Lead-based painted lamp post& galvanised railing

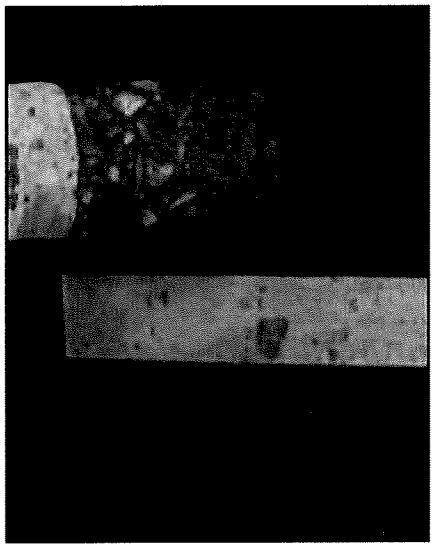


Photo 3 – Asbestos-containing asphalt core sample

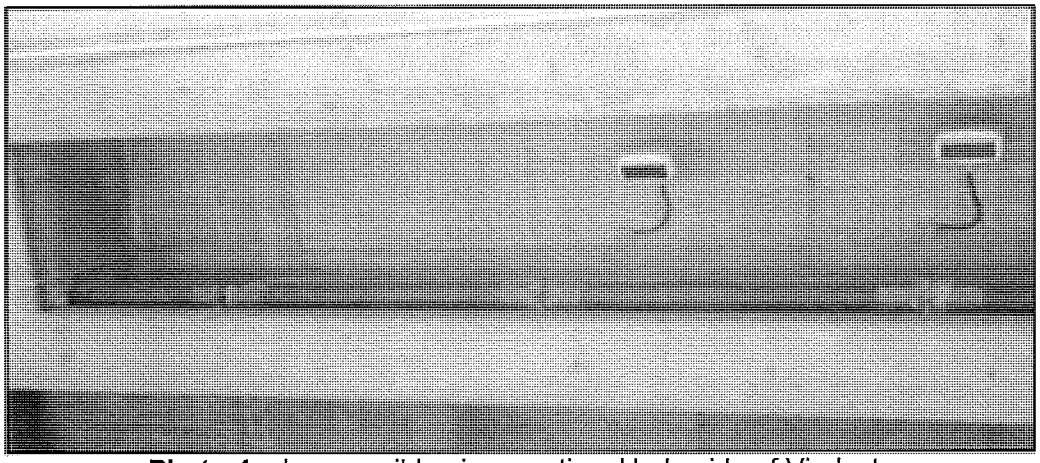


Photo 4 – Inaccessible pipe mastic – Underside of Viaducts

101-4268 Lozells Avenue
Burnaby, B.C.
Tel: 604.444.0204

SURE Hazmat and Testing

Bulk Asbestos Results

Client: 11387 - Thurber Engineering Ltd **Sampled By/ Date: D. Fitzpatrick/ 1st & 2nd May, 2017**

Reference: Georgia & Dunsmuir Viaducts Asphalt Sampling - Vancouver, BC

Sample #	Date Analyzed	Analyst	Sample Location	Material Type	Other Materials glass, synthetics, cellulose	Asbestos Type & Amount
11387-01	09-May-17	DF	Loc. 1 Dunsmuir - 2m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-02	09-May-17	DF	Loc. 2 Dunsmuir- 100m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-03	09-May-17	DF	Loc. 3 Dunsmuir - 250m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-04	09-May-17	DF	Loc. 4 Dunsmuir - 400m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-05	09-May-17	DF	Loc. 5 Dunsmuir - 500m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-06	09-May-17	DF	Loc. 6 Dunsmuir - 650m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-07	09-May-17	DF	Loc. 7 Dunsmuir - 800m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-08	09-May-17	DF	Loc. 8 Dunsmuir- 1000m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-09	09-May-17	DF	Loc. 9 Georgia - 1000m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-10	09-May-17	DF	Loc. 10 Georgia - 800m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**

Note* Chrysotile is part of the Serpentine Asbestos Mineral Group

101-4268 Lozells Avenue
Burnaby, B.C.
Tel: 604.444.0204

SURE Hazmat and Testing

Bulk Asbestos Results

Client: 11387 - Thurber Engineering Ltd **Sampled By/ Date: D. Fitzpatrick/ 1st & 2nd May, 2017**

Reference: Georgia & Dunsmuir Viaducts Asphalt Sampling - Vancouver, BC

Sample #	Date Analyzed	Analyst	Sample Location	Material Type	Other Materials glass, synthetics, cellulose	Asbestos Type & Amount
11387-11	09-May-17	DF	Loc. 11 Georgia - 650m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-12	09-May-17	DF	Loc. 12 Georgia - 500m West from Gore Ave south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-13	09-May-17	DF	Loc. 13 Georgia - 400m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-14	09-May-17	DF	Loc. 14 Georgia - 250m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-15	09-May-17	DF	Loc. 15 Georgia - 100m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-16	09-May-17	DF	Loc. 16 Georgia - 2m West from Gore Ave north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-17	09-May-17	DF	Loc. 17 Georgia Off Ramp - 200m West from Main St south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-18	09-May-17	DF	Loc. 18 Georgia Off Ramp - 100m West from Main St south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-19	09-May-17	DF	Loc. 19 Georgia Off Ramp - 2m West from Main St south lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	**Chrysotile 0.5-5%**
11387-20	09-May-17	DF	Loc. 20 Dunsmuir On Ramp - 2m West from Main St north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected

Note* Chrysotile is part of the Serpentine Asbestos Mineral Group

101-4268 Lozells Avenue
Burnaby, B.C.
Tel: 604.444.0204

SURE Hazmat and Testing

Bulk Asbestos Results

Client: 11387 - Thurber Engineering Ltd

Sampled By/ Date: D. Fitzpatrick/ 1st & 2nd May, 2017

Reference: Georgia & Dunsmuir Viaducts Asphalt Sampling - Vancouver, BC

Sample #	Date Analyzed	Analyst	Sample Location	Material Type	Other Materials glass, synthetics, cellulose	Asbestos Type & Amount
11387-21	09-May-17	DF	Loc. 21 Dunsmuir On Ramp - 15m West from Main St north lane	Asphalt	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-22	09-May-17	DF	Loc. 1 Dunsmuir Viaduct - Concrete Barrier	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-23	09-May-17	DF	Loc. 4 Dunsmuir Viaduct - Concrete Barrier	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-24	09-May-17	DF	Loc. 7 Dunsmuir Viaduct - Concrete Barrier	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-25	09-May-17	DF	Loc. 9 Georgia Viaduct - Concrete Barrier	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-26	09-May-17	DF	Loc. 11 Georgia Viaduct - Concrete Barrier	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-27	09-May-17	DF	Loc. 13 Georgia Viaduct - Concrete Barrier	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected
11387-28	09-May-17	DF	Loc. 15 Georgia Viaduct - Curbs	Caulking	Non-Fibrous 95% Other Fibres <5%	Non-Detected

AIHA Proficiency Analytical Testing Programs, LLC Lab #193144

*Samples analyzed in accordance with NIOSH 9002 PLM Bulk Sampling Method

Sure Hazmat and Testing is an active participant of the American Industrial Hygiene Association (AIHA) Bulk Asbestos Proficiency Analytical Testing (BAPAT)

Maxxam
A Bureau Veritas Group Company

Success Through Science®

Your Project #: 11387
Site Location: GEORGIA + DUNSMIUR VIADUCTS
Your C.O.C. #: 502225-183-01

Attention:Damien Fitzpatrick

Sure Hazmat & Testing
101-4268 Lozells Avenue
BURNABY, BC
CANADA V5A 0C6

Report Date: 2017/05/16
Report #: R2383657
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B735506
Received: 2017/05/10, 13:45

Sample Matrix: PAINT
Samples Received: 3

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICP-AES (acid extr. solid)	3	2017/05/16	2017/05/16	BBY7SOP-00018	EPA 6010c R3 m

Remarks:

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Encryption Key

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Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Graham Rudkin, Project Manager, Environmental
Email: GRudkin@maxxam.ca
Phone# (604)638-5926 Ext:5926

==========

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Maxxam Job #: B735506
Report Date: 2017/05/16

Sure Hazmat & Testing
Client Project #: 11387
Site Location: GEORGIA + DUNSMIUR VIADUCTS
Sampler Initials: DF

LEAD IN PAINT CHIPS (PAINT)

Maxxam ID		RA5382	RA5383	RA5384		
Sampling Date		2017/05/02	2017/05/02	2017/05/02		
COC Number		502225-183-01	502225-183-01	502225-183-01		
	UNITS	11387-LP01 ROAD MARKING-WHITE	11387-LP02 ROAD MARKING-YELLOW	11387-LP03 LAMPPOST-SILVER/GREY	RDL	QC Batch
Total Metals by ICP						
Total Lead (Pb)	mg/kg	6.7	381	49700	3.0	8630964
RDL = Reportable Detection Limit						

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Maxxam Job #: B735506
Report Date: 2017/05/16

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Client Project #: 11387
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GENERAL COMMENTS

Results relate only to the items tested.

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Maxxam Job #: B735506
Report Date: 2017/05/16

QUALITY ASSURANCE REPORT

Sure Hazmat & Testing
Client Project #: 11387
Site Location: GEORGIA + DUNSMIUR VIADUCTS
Sampler Initials: DF

			Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	Value	UNITS	Value (%)	QC Limits	% Recovery	QC Limits
8630964	Total Lead (Pb)	2017/05/16	<3.0	mg/kg	7.6	35	89	80 - 120

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

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Chain Of C

B735506_COC

INVOICE TO:		Report Information		Project Information	
Company Name	#4212 Sure Hazmat & Testing	Company Name		Quotation #	B01683
Contact Name	Karen Smith	Contact Name	Damien	P.O. #	
Address	101-4256 Lozells Avenue	Address		Project #	
	BURNABY BC V5A 0C6		604-562-9656	Project Name	11387.
Phone	(604) 444-0204 Fax (604) 420-9559	Phone	Fax:	Site #	Georgia + Dunsmuir Viaducts
Email	ksmith@surehazmat.com	Email	dfitzpatrick@surehazmat.com	Sampled By	D. Fitzpatrick

C#602225-183-01

Regulatory Criteria
- [ ] CSR
- [ ] CCME
- [ ] BC Water Quality
- [ ] Other _____

Special Instructions

SAMPLES MUST BE KEPT COOL (< 10°C) FROM TIME OF SAMPLING UNTIL DELIVERY TO MAXXAM

ANALYSIS REQUESTED (PLEASE BE SPECIFIC)

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Metals Field Filtered ? (Y / N)	Lead (in Paint)	Lead (in Glazing/Tile/Other Solid)	TCLP Lead Leachate	Lead (in Swab)	Lead (in Air)	PCBs in Oil	Respirable Silica (Quartz)	# of Bottles	Comments
1	11387 - LP01			24/5/17.	Paint		✓								Road Marking - white
2	11387 - LP02			↓	"		✓								Road Marking - yellow.
3	11387 - LP03			↓	"		✓								Lamppost - silver/grey.
4															
5															
6															
7															
8															
9															
10															

Turnaround Time (TAT) Required

Please provide advance notice for rush projects

Regular (Standard) TAT: [X]
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
1 DAY [ ] 2 Day [ ] 3 Day [ ] Date Required _____ [ ]
Rush Confirmation Number _____ (call lab for #)

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
D Fitzpatrick	17/05/10	1:45	Maxxam Receiver	2017/05/10	13:45	

Lab Use Only

Time Sensitive	Temperature (°C) on Receipt	Custody Seal Intact on Cooler?
[ ]	NA	[ ] Yes [ ] No

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

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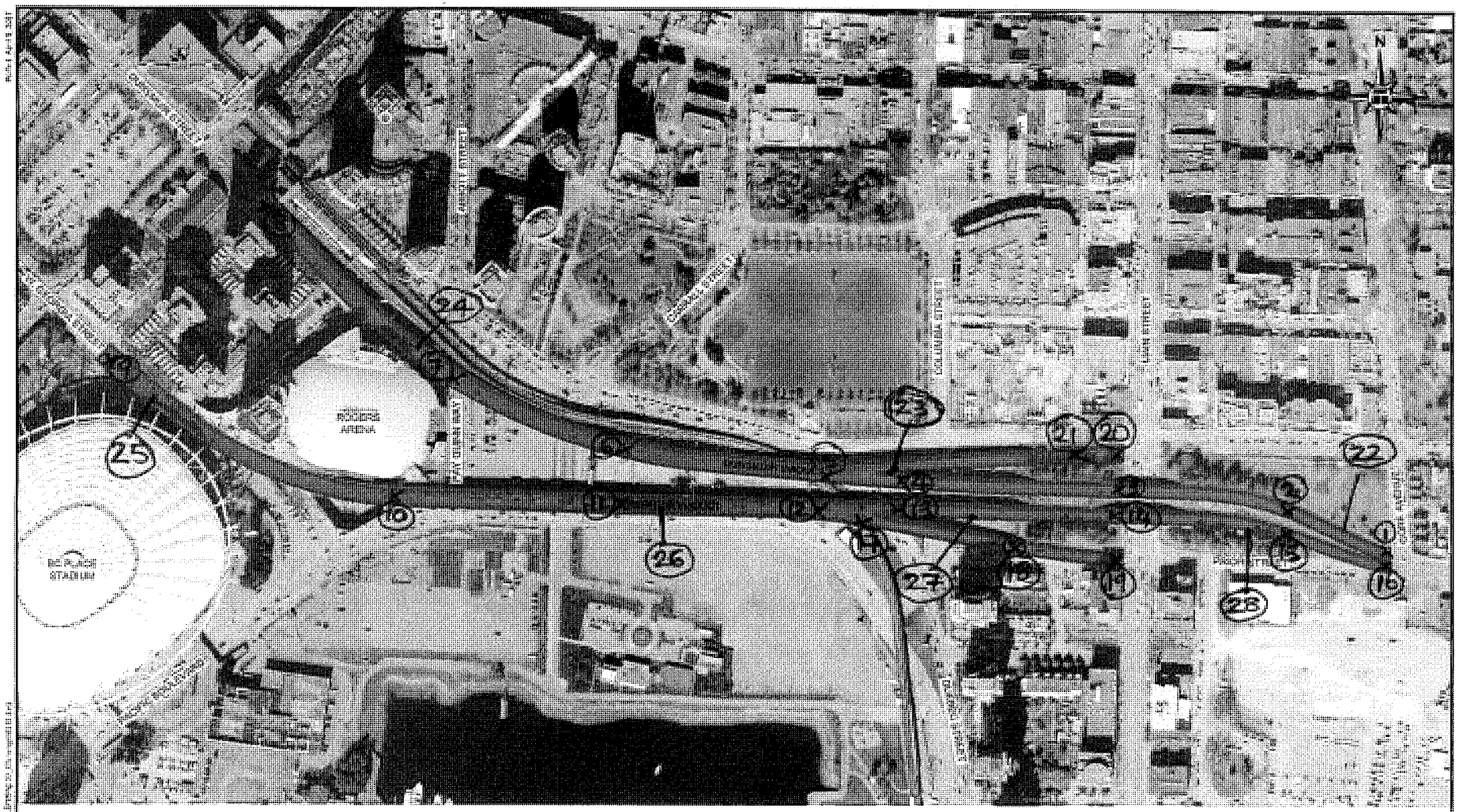


LEGEND

(1) Asbestos Sample Location

NOTES

1. BASE PLAN TAKEN FROM THE CITY OF VANCOUVER'S OPEN DATA CATALOGUE (2015 AERIAL IMAGE)

THURBER ENGINEERING LTD

CITY OF VANCOUVER as NMM GROUP LTD

VIADUCT ASPHALT OUTLINE
SITE PLAN

NORTHEAST FALSE CREEK (URPC)

VANCOUVER, BC

ARE	NAK	ARE
06/04/17		1:2000
19515	1	0

Detailed Design of Road & Utilities in the Northeast False Creek Project

17M-00475-01 | PS20161278

DUNSMUIR VIADUCT

Condition Assessment Report

NEFCAP-MMM-S-RPT-003_0

Rev 0 | Sep 20, 2017

REVISION HISTORY:

Revision	Date	Description	Author	Reviewer
0	Sep 20, 2017	Re-issued as Rev. 0	RS	MK
C	Sep 20, 2017	Revised as per City Comments	RS	MK
B	Aug 30, 2017	Revised as per City Comments	RS	CC
A	June 16, 2017	Draft Submission	RS	MK

TABLE OF CONTENTS

APPENDICES:

- Appendix A: General Arrangement Drawings
- Appendix B: Past Condition Inspection Reports

EXECUTIVE SUMMARY

At the request of the City of Vancouver (the City) and as a component of the "Detailed Design of Roads and Utilities in the Northeast False Creek (RFP No. PS20161278)", WSP have completed a bridge inspection for a six span segment of the Dunsmuir Viaduct between the west abutment (D23) and Pat Quinn Way (pier D17) in Vancouver, BC. Engineers from WSP visited the bridge site and performed detailed visual inspections of the viaduct on February 2 and March 30, 2017. WSP were also retained to complete the detailed deck condition survey and material testing.

The inspection was carried out using both boom lift and foot access and included a thorough visual examination of accessible bridge components and evaluation of visible defects for the purpose of assessing the current bridge condition, stability, and safety.

All expansion joints were leaking, resulting in efflorescence and corrosion stains on the split pier caps and columns below. While the surface concrete of these elements appears to be in good condition, prolonged exposure to moisture and chlorides is likely to lead to rebar corrosion, spalling of concrete cover, and loss of structural strength. We recommend replacing these expansion joints with link slabs at piers D19 and D21 and strip seal expansion joints at pier D17 and abutment D23. This is estimated to cost $94,000 for the link slabs and $43,000 for the expansion joint at D23. The cost of expansion joint at D17 can be considered part of the adjacent Dunsmuir Elevated Park.

We recommended conducting a detailed deck condition evaluation if the structure is to be retained.

Also, a few minor defects were noted, for which we recommend the following repairs:

- Deck: Repair spalling in south overhang in span D18-D19.
- Joint at Costco building: Repair spalling concrete
- Drainage: Replace seal at leaking PVC pipe connection near D19. Replace waterproofing membrane in catch basin at pier D17.

These repairs are estimated to cost $35,000.

The spalling infill concrete along the deck soffit at the longitudinal joint between the viaduct and the Costco building presents a potential safety hazard to pedestrians below. We recommend removing any unbonded concrete be considered a high priority.

The total cost of all repairs is estimated to be $172,000. Contingencies (10%) and contract administration (10%) will increase this to approximately $210,000.

1. INTRODUCTION

At the request of the City of Vancouver (the City) and as a component of the "Detailed Design of Roads and Utilities in the Northeast False Creek" (RFP No. PS20161278), WSP have completed a bridge inspection for a six span segment of the Dunsmuir Viaduct between Citadel Parade (abutment D23) and Pat Quinn Way (pier D17) in downtown Vancouver, BC. The required scope elements are itemized in the City's Request for Proposals dated October 14, 2016, and our Technical Proposal dated November 21, 2016, and include the following:

- Perform an independent condition assessment of the bridge, including a detailed deck assessment.
- Identify areas of material defects and structural performance deficiencies;
- Identify structural improvements to address existing deficiencies for the basis of the rehabilitation works; and
- Provide cost estimates for all recommended improvements and repairs.

1.1. Bridge Location

Figure 1 shows the bridge location.

Figure 1. Bridge location (west abutment D23 to pier D17), Downtown Vancouver

1.2. Review of Existing Information

Prior to conducting the inspection, the following information received from the City was reviewed in detail:

- Original record drawings dated 1969 to 1973
- Previous condition inspection reports:
  - Associated Engineering (2009): Inspected on July 23, 2009
  - COWI (2016): Inspected on May 18, 2016

The details of these references can be found in Section 6.

1.3. Bridge Configuration

The Dunsmuir Viaduct was built in 1970-1971. The 1.0 km long structure starts at Gore Avenue in the east, spans over Main Street, Quebec Street, Expo Boulevard and Pat Quinn Way, and ends at Citadel Parade in the west. The portion from the west abutment D23 (at Citadel Parade) to pier D17 (at Pat Quinn Way) is proposed to be retained (Figure 2), while the remaining portions east of D17 will be demolished and replaced with the new Dunsmuir Elevated Park.

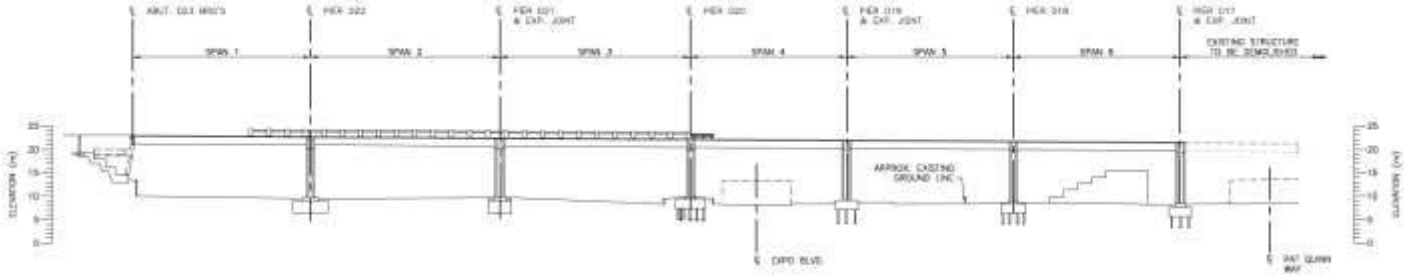


Figure 2. Bridge elevation, looking north

The six spans proposed to be retained consist of three two-span continuous frames, namely D17 to D19, D19 to D21, and D21 to D23. Each two-span continuous frame is made up of a superstructure integral with the piers. The superstructure consists of a 203 mm thick cast-in-place concrete deck with a 90 mm thick asphalt overlay on 1,600 mm deep pre-tensioned and post-tensioned concrete girders. Piers D17 to D22 comprise of concrete pier caps on concrete columns, supported on piled and/or spread footings. Abutment D23 comprises large retaining walls on spread footings. The drawings in Appendix A illustrate the span arrangement and typical sections of the existing viaduct for these spans. Figure 3 and Figure 4 show typical cross-sections. The general configuration of the structure is summarized in Table 1.

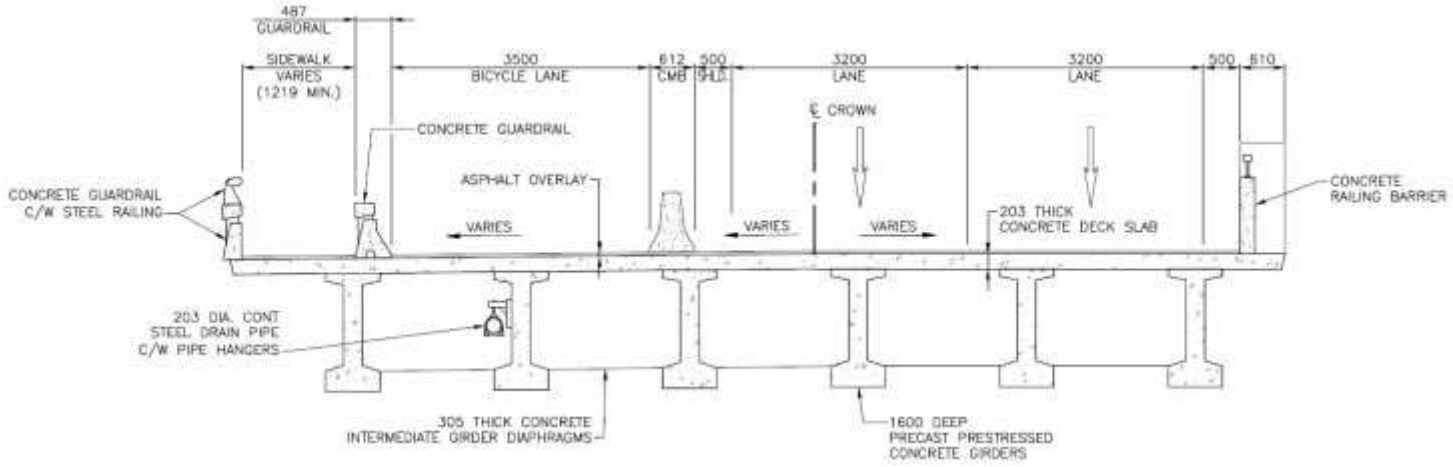


Figure 3. Typical superstructure section, looking east

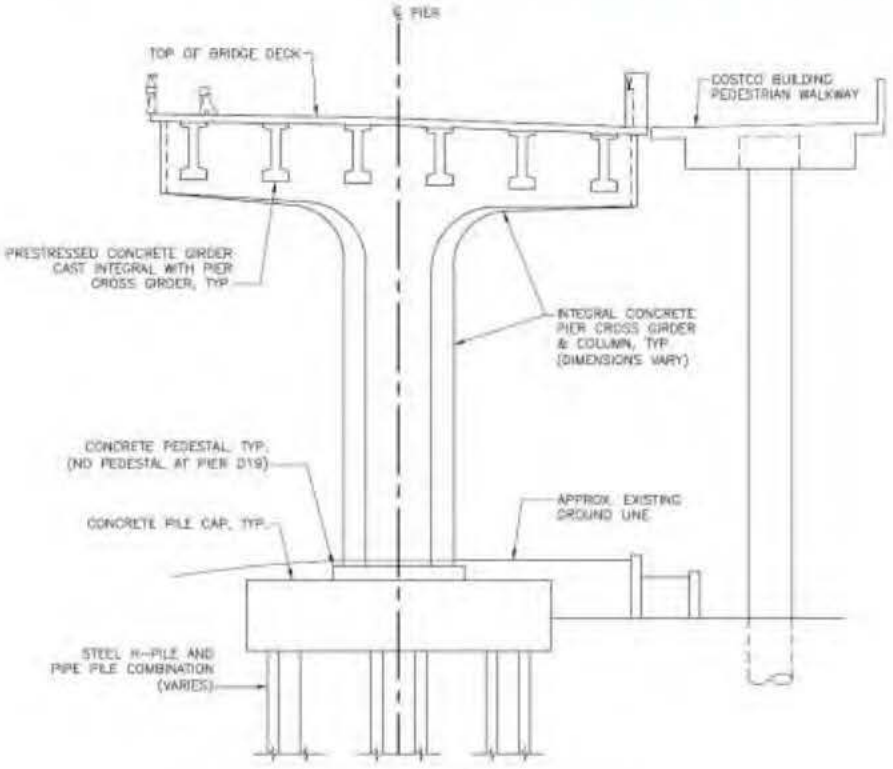


Figure 4. Cross-section at pier D20, looking east

Table 1: Bridge Configuration Summary

Element	Configuration & Material
Construction Date	1970-1971
Span Arrangement	▶ D17-D19: 35.8 m, 35.8 m ▶ D19-D21: 33.5 m, 40.9 m ▶ D21-D23: 40.7 m, 38.1 m All span lengths noted are between centrelines of supporting piers / abutment bearings.
Lane Configuration	From south to north: Shoulder (~0.76 m), two westbound vehicle lanes (~3.65 m each), bi-directional cycling lane (~3.04 m clear), pedestrian walkway (1.22 m clear min.)
Piers (D17 to D22)	Cast-in-place concrete piers founded on expanded base piles at D17, D18, D19, H-piles and expanded base piles at D20, and spread footings at D21, D22
Abutment (D23)	Cast-in-place concrete abutment wall and wing walls founded on spread footings
Girders	1600 mm deep prestressed concrete I-girders integral with piers
Bearings	Laminated elastomeric bearings at abutment D23
Deck	▶ 203 mm cast-in-place concrete deck ▶ 90 mm (estimated) asphalt overlay
Joints	Neoprene compression seals with steel armouring at abutment D23 and piers D21, D19 and D17 Neoprene compression seal at longitudinal joint above Costco building
Barriers	▶ Guardrails: 749 mm high precast concrete, at south edge of deck and south edge of sidewalk

Element	Configuration & Material
	▶ Handrails: 749 mm high precast concrete + 400 mm high aluminum railing, at north edge of deck ▶ Guardrails and handrails are anchored into deck, and have sealant between segments ▶ BC MoTI standard precast concrete median barrier (CMB) separating bicycle lanes from vehicle lanes
Drains	Immediately west of joints D23 through D17, south of north guardrails: ▶ Inlets with 641 mm x 375 mm steel gratings ▶ Inlets feed into concrete catch basins with manholes between two northern-most girders ▶ Catch basins connected via 203 mm dia. PVC drain pipes
Utilities	Lighting on the bridge: ▶ Luminaires mounted on north guardrails, with power supply running through ducts encased in the guardrail Lighting under the bridge: ▶ Surface-mounted to various piers ▶ Spans D17 to D19: Under south edge of deck and two northernmost girders ▶ Spans D20 to D23: Under various girders and two northernmost girders

1.4. Inspection Methodology

Observations from previous inspections were reviewed before visiting the site to become familiar with the condition of the structure and to identify areas of concern where deterioration may have progressed since the last inspection. Previous inspection reports are provided in Appendix B.

This inspection was completed on February 2 and March 30, 2017. Reza Saiedi, P.Eng., Charles Chataway, P.Eng., and Henry Leung, P.Eng. conducted the field inspection and condition assessment. Conditions were clear with daytime high temperature of 6°C and 12°C on the first and second days, respectively.

The inspection included a thorough visual examination of accessible components of the bridge and general evaluation of visible defects for the purpose of assessing the current bridge condition, stability and safety. Superstructure components above the deck were reviewed from the sidewalks. Lane closures were deemed disruptive and unnecessary. An all-terrain boom lift with an 80 ft (24.4 m) reach was used to inspect the west abutment, pier caps, columns, deck soffit, prestressed concrete girders, and girder diaphragms.

2. BRIDGE INSPECTION

2.1. West Abutment

2.1.1. Abutment Walls

The west abutment has sloping front and side walls and is supported on spread footings (Figure 5, Figure 6, Figure 7). The front wall is approximately 13.0 m high. A closed series of tie beams near the top of the abutment connects the front and side walls and helps resist lateral earth pressure forces.

Figure 5. West abutment: Front wall

Figure 6. West abutment: North wall

Figure 7. West abutment: South wall

The northern half of the east wall and the east end of the north wall were accessible with the boom lift platform and were inspected at close range. The features inspected appeared to be typical and representative of other parts of the abutment which were inaccessible. The south wall was inspected from ground level (Figure 7).

A vertical concrete wall attached to the Stadium-Chinatown SkyTrain station butts against the vertical face of the north abutment wall (Figure 8, Figure 9).

Figure 8. West abutment: Wall connecting to Stadium-Chinatown SkyTrain station

Figure 9. West abutment: North wall: Vertical face and cheek wall

Three vertical cracks were observed in the abutment wall under and just north of the bearing for girder C (third girder from the north) (Figure 10). These cracks are considered to be minor in nature and apart from ongoing monitoring during inspections, no rehabilitation work is deemed necessary.

Figure 10. West abutment: Cracks under Girder C bearing

No other visible defects were found on the abutment walls, and sounding of the concrete by hammer did not reveal any delamination.

2.2. Bearings and Shear Key

The only bearings in the retained portion of the viaduct are at the west abutment (D23). Girders are integral with the substructure elsewhere (piers D22 to D17). The bearings are 686 mm wide x 356 mm long x 125 mm thick reinforced elastomeric (vulcanized neoprene) pads with six reinforcing plates. Figure 11 shows the layout for the span adjacent to the abutment and the alphabetical names assigned to each girder.

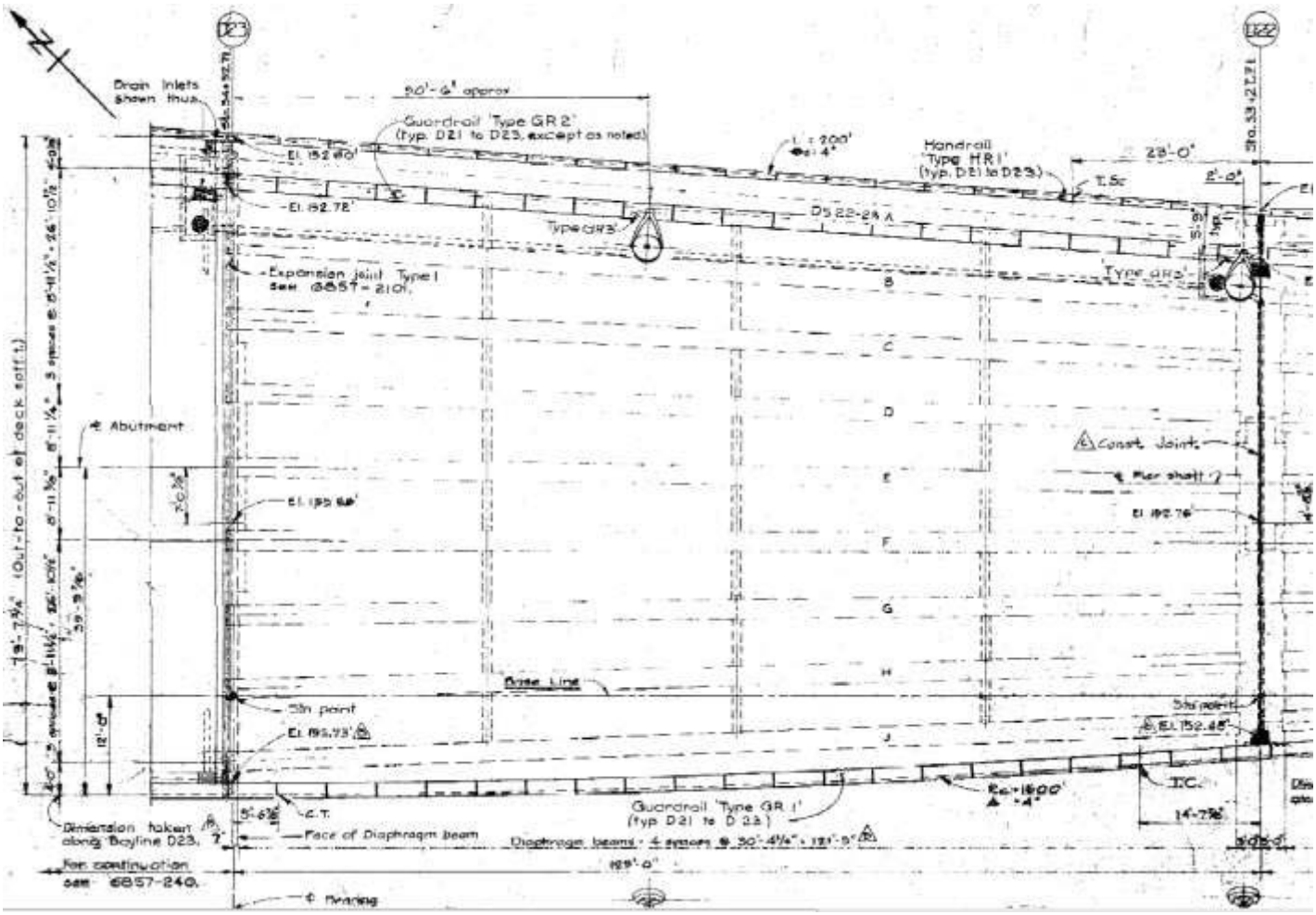


Figure 11. Span D23-D22 layout

Bearings for girders A through F were observed up-close (Figure 12). Bearings for girders G, H, and J were observed from a distance (Figure 13), and no obvious severe defects were observed.

Figure 12. Bearings for girders A, B, C

Figure 13. Bearings for girders G, H, J

The bearings had typical outward bulging between reinforcing plates (Figure 14), as expected under vertical loading. Slight transverse deformation (10 to 15 mm) towards the south was observed in some bearings (Figure 15), but this is well within the pad's

shear deformation capacity of 48 mm (based on CAN/CSA S6-14 §11.6.6.4: "Deformation and rotation"). The bearing at girder A had what appeared to be a fine vertical slice on its east face. This was likely made during manufacture or installation, does not appear to be associated with any structural distress, and is not expected to affect the bearing's performance. We recommend monitoring this bearing in future inspections.

Figure 14. Chalk lines outlining bulging of bearings between reinforcing plates (girder B bearing shown)

Figure 15. Slight transverse deformation of bearings (girder A bearing shown)

In an earthquake, the longitudinal movement of the superstructure could result in loss of support for girders at bearings. A preliminary calculation based on CAN/CSA S6-14 Cl. 4.4.10.5 ("Minimum support length requirements for displacements") indicates all but girders D, E and F have insufficient bearing seat length, which could lead to span D23-D22 collapsing during a seismic event. To rectify this deficiency, one of the following retrofit measures can be adopted:

- Extend the seat length at these girders by at least 300 mm. This can be accomplished by building a corbel at bearing seat level and dowelling it into the abutment front wall.
- Install longitudinal restrainers between the girders and abutment front wall.

Bearing seats for girders D, E, F are 305 mm longer and may not require a retrofit.

The concrete shear key between the bottom flanges of girders E and F was in good condition with no signs of cracking or damage (Figure 16). The gaps between the shear key and the bottom flanges of adjacent girders E (north of shear key) and F (south of shear key) were 15 and 30 mm, respectively. If the girders were equidistant from the shear key at time of installation, they have moved 7.5 mm to the south. This is consistent with the southwards deformation of the bearings mentioned above. There was no distress observed as a result of this transverse displacement.

Figure 16. Shear key at interface with girder F (sixth girder from north)

2.3. Piers

There are two types of piers in the viaduct:

- "Full" piers, located in the middle of two-span continuous segments (Figure 17), i.e. at D18, D20, and D22. These are integral with both spans.
- "Split" piers, which consist of two symmetrical halves with a gap in between (Figure 18 and Figure 19). These piers are located at the ends of two-span continuous segments, at expansion joints, i.e. at D17, D19, and D21. Each half is integral with one span only.

Figure 17. Pier D22 : Typical full pier

Figure 18. Pier D17: Split columns

Figure 19. Pier D17: Split pier caps

2.3.1. General

Horizontal construction joints were observed on all columns (Figure 18, Figure 20), which are attributed to staged pours during construction. Localized concrete repairs were noted on the margins of these joints where previous delamination, spalling and forming defects were previously addressed.

Bird's nests were observed above some lamps mounted on piers (Figure 21). This is considered a fire hazard and should be removed. We recommend installing bird spikes or other deterrent devices above these lamps to discourage nesting.

Figure 20. Pier D18 : Typical diagonal construction joint

Figure 21. Bird's nest at pier D17

2.3.2. Split Piers

The piers at expansion joints D21, D19 and D17 are "split" piers (Figure 22 and Figure 23). Each split pier supports one side of the expansion joint. The split piers share the same foundation (spread footing or pile cap). The gap between split piers accommodates longitudinal movements of the superstructure due to temperature changes, creep of the prestressed concrete girders, and shrinkage of the concrete girders and deck.

Figure 22. Pier D21: Typical split pier

Figure 23. Pier D17: Typical split pier foundation

The defects observed in split piers are a direct result of failure of the expansion joints above them. Therefore, these defects are outlined in Section 2.4.3.

2.4. Superstructure

2.4.1. Barriers

Figure 24 through Figure 28 show the precast guardrails, handrails and median barriers on the bridge. Past inspection reports have highlighted extensive spalling and rebar corrosion in the existing handrails and guardrails. Our inspection identified consistent defects in the handrails and guardrails.

The south side of the south guardrail appears been patched (Figure 29) around the entrance to Rogers Arena. Sounding by hammer of the concrete on the exterior faces of the south guardrail and north handrail did not reveal any delamination. Therefore, these barriers do not pose a safety threat to pedestrians below the bridge.

Once the new Georgia Ramp is completed, spans D17 to D23 of the Dunsmuir Viaduct will either be rehabilitated or demolished. If the City of Vancouver decides to rehabilitate them, as part of the general rehabilitation design and for compatibility with the New Dunsmuir Elevated Park, all existing barriers would be removed and replaced with new pedestrian / bicycle barriers. Given the short remaining functional life of these barriers, we do not recommend any repairs.

Figure 24. Looking west: Precast guardrails (left), and railing on precast handrails (right)

Figure 25. Precast north handrails: Concrete spalling and rebar corrosion on south face

Figure 26. Looking east: North handrails (left) in poor condition, North guardrails (right) in fair condition

Figure 27. Looking east: North guardrails (left) and median barriers (right) in fair condition

Figure 28. Looking west: South guardrail, span D20-D21: Algae growth

Figure 29. Looking east: South guardrail, span D18-D19: Previous patches are visible.

2.4.2. Deck

The 203 mm thick reinforced concrete deck is topped with an asphalt overlay (Figure 30) everywhere except on the sidewalk on spans D17 to D21.

Figure 30. Asphalt wearing surface at D19

Algal growth and wetness was observed on both the vertical edges of the deck along the entire viaduct (Figure 31). This points to water seepage through the grouted horizontal joint between the precast barriers and the top of the deck. The drip grooves have mostly prevented this water from running down the deck soffit towards the exterior girders (Figure 32).

Figure 31. Seepage, efflorescence, and algal growth on outside edge of deck

Figure 32. Drip groove prevented water from running down deck soffit towards exterior girder

Previous patch repairs and new concrete spalls were found in the deck soffit of the south overhang in span D18-D19 (Figure 33, Figure 34). The concrete in these areas appeared to be robust when struck with a hammer, and there were no signs of deterioration around them. We recommend the new spall be repaired using a repair mortar (e.g. SikaTop 123) for aesthetic reasons.

Figure 33. Deck soffit in south overhang, span D18-D19: Past patch repairs

Figure 34. Deck soffit in south overhang, span D18-D19: Concrete spall

There were no defects observed on the deck soffit between girders that would suggest conditions of structural distress or other deterioration mechanisms (Figure 35). A previous full-depth patch repair, identifiable by the stay-in-place soffit formwork (Figure 36), was found to be stable with no evidence of leaking or other instability that would warrant concern or require further remediation.

Figure 35. Deck soffit between girders, span D20-D21

Figure 36. Deck soffit between girders, span D22-D23: Past patch repair

We recommend conducting a detailed deck condition evaluation if the structure is to be retained.

2.4.3. Expansion Joints

The expansion joints at piers D17, D19, D21, and D23 are neoprene compression seals with steel armouring anchored into the concrete deck. The original joints were modified when the asphalt overlay was installed, circa 1988, as shown in Figure 37. The joints at piers D17, D19 and D21 are modular and comprise two seals with an intermediate steel beam supported by a series of longitudinal support bars. The joint at abutment D23 consists of a single seal. At the edges of deck, the seals are turned up to contain runoff on the deck and covered with an end cover plate. The joint cover plates are fabricated of steel checkered plate on the sidewalk to reduce the tripping hazard and improve traction (Figure 38).

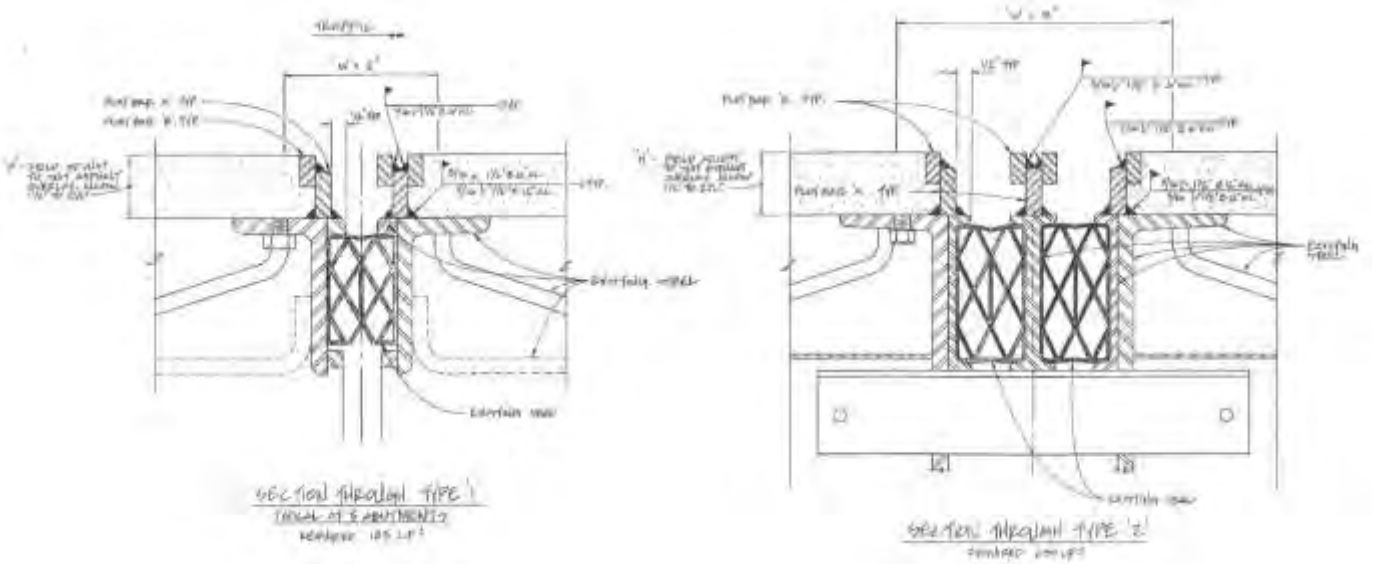


Figure 37. Expansion joint details

Figure 38. Joint at D21: Checkered cover plate on sidewalk and end cover plate at edge of deck

From above, the joints were inspected from the north sidewalk, as lane closures were impractical. All joints were filled with debris, so the seals were hidden from view. The seal at joint D19 was torn in places, while the seal at joint D21 seemed to be missing.

Figure 39. Joint at D17: Filled with debris

Figure 40. Joint at D19: Filled with debris

Figure 41. Joint at D21: Filled with debris, seal seems to be missing

Figure 42. Joint at west abutment D23: Filled with debris

Joints at piers D17, D19, and D21 were leaking. This had led to water and chlorides entering the gap between split piers. The north side of joint D19 had a filter fabric covering the vertical edges of pier caps and part of the underside (Figure 43). On the south side of joint D19, the ingress of chloride-laden water had caused wetness, efflorescence and corrosion stains on pier caps (Figure 44, Figure 45) and columns (Figure 46). A similar pattern was observed on piers D17 (Figure 47) and D21 (Figure 48).

Areas of suspect concrete were hammer-sounded to detect delaminations which would indicate rebar corrosion due to prolonged exposure to water and chlorides. No such areas were found, but continued exposure could lead to concrete deterioration. Therefore, it is recommended that the joints be rehabilitated.

Figure 43. Joint at D19: North side

Figure 44. Joint at D19, south side, pier caps

Figure 45. Joint at D19, south side, pier caps

Figure 46. Joint at D19, south side, columns

Figure 47. Joint at D17, pier caps and columns

Figure 48. Leaking joint at D21

At the west abutment (D23) expansion joint, corrosion staining and spalling of the north overhang soffit was observed (Figure 49). The expansion joint between the exterior girders could not be inspected, as the girder end diaphragm prevents access. The bearing seats were generally dry, with some efflorescence and corrosion staining.

Figure 49. Joint at west abutment (D23): Corrosion stains

We recommend replacing existing expansion joints and armouring at D19 and D21 with link slabs to prevent further deterioration of deck, pier caps and columns at split piers. We recommend replacing the existing expansion joints and armouring at D17 and D23 with strip seal expansion joints. This is consistent with the City's intent as outlined in the project RFP. Any deteriorated deck concrete should be replaced during this process.

In general, link slabs are preferred over strip seal expansion joints, because (a) expansion joints introduce ongoing maintenance issues, and (b) the surface of expansion joints is not ideal for pedestrian and bike use. However, expansion joints are required at D17 and D23 to allow thermal movement of the six retained spans. Replacement of existing expansion joints at D19 and D21 with link slabs changes the bridge articulation and load paths during thermal movement and seismic excitations. These effects have been investigated and are discussed in detail in the Seismic Retrofit Strategy Report (NEFCAP-MMM-S-RPT-017). The proposed retrofit strategy was found to have satisfactory seismic and in-service performance.

2.4.4. Longitudinal Joint

There is a longitudinal joint at deck level along the south edge of the viaduct, beginning at the west end of the south wall of the west abutment D23 (Figure 50), continuing along the roof of the adjacent Costco building (which also serves as the sidewalk south of the viaduct) (Figure 51 and Figure 52), and ending close to pier D20 on the pedestrian bridge connecting the sidewalk to Rogers Arena. East of this point, the Dunsmuir Viaduct deck and pedestrian bridge separate and start to diverge vertically (Figure 53).

Figure 50. Longitudinal joint between viaduct (span D22-D23, right) and sidewalk (left), looking west

Figure 51. Longitudinal joint between viaduct (span D22-D23, left) and sidewalk (right), looking east

Figure 52. Longitudinal joint between viaduct (spans D21 to D23) and Costco building, looking east

Figure 53. Longitudinal joint between viaduct (span D19-D20, right) and pedestrian bridge connecting sidewalk to Rogers Arena (left), looking east

The expansion joint is a compression seal with no armouring and a checkered steel cover plate to reduce the tripping hazard (Figure 54). A 125-150 mm wide concrete infill was poured against the south of the bridge deck to close the gap and minimize joint width (75 mm) (Figure 55). The joint is leaking in some areas (Figure 55) and performing well in other areas (Figure 56).

There is a long spall in the concrete infill at the south end of span D20-D21 (Figure 57). This likely occurred because the concrete infill was not attached to the bridge deck using dowels. This spalled concrete should be re-cast and attached to the existing bridge deck using dowels. Hammer-sounding of the remaining concrete infill showed no sign of delamination.

The City has informed WPS that the longitudinal expansion joint is itemized in an encroachment agreement and the maintenance, upkeep, and replacement of the joint are the responsibility of the owners of the adjacent Spectrum development site.

Figure 54. End of longitudinal joint near pier D20, looking west: Compression seal and cover plate

Figure 55. Longitudinal joint, span D20-D21, looking west: Joint leaking. Concrete infill to the right of joint.

Figure 56. Longitudinal joint, pier D21, looking east: Joint performing well; concrete is dry.

Figure 57. Longitudinal joint, span D20-D21, looking east: Spall in concrete infill. Joint is leaking; concrete is moist.

The existing gap at this expansion joint is 75 mm wide. In a seismic event, transverse movement of the Dunsmuir Viaduct and the adjacent building and pedestrian bridge may result in pounding between these structures. This can lead to structural damage at the contact surfaces and elsewhere in these structures. To prevent this, our seismic retrofit design will consider the use of a wider joint. This joint will be designed during detailed design. This matter is discussed in detail in the Seismic Retrofit Strategy Report (NEFCAP-MMM-S-RPT-017).

2.4.5. Drainage

The deck has varying super-elevation and a 0.65% grade from west to east. Rainwater that falls on the deck runs eastward along the edges of the guardrails and handrail before entering storm drains at piers D17 through D23. Drains on the roadway and sidewalk are covered with steel gratings (Figure 58, Figure 59).

Figure 58. D21: From left to right: Catch basin manhole and roadway drain, wide sidewalk drain

Figure 59. D19: From left to right: Catch basin manhole, drain on roadway, small sidewalk drain

These inlets feed into cast-in-place concrete catch basins with manholes supported between the girders A and B (Figure 60). 203 mm dia. PVC drain pipes connect catch basins between adjacent spans. The drain pipes hang from inserts cast into the girder webs and pass through holes in the diaphragms (Figure 61) and abutment back wall (Figure 62).

The catch basin at D17 has corrosion stains along its south edge (Figure 60). This may be due to failure of waterproofing membrane. Early signs of similar deterioration were observed at other catch basins. We recommend the waterproofing membrane at D17 be replaced to prevent further deterioration. Access would be from the manhole above.

The PVC pipe was leaking at some connections (Figure 63). We recommend the seals on these connections be replaced.

Figure 60. Catch basin at D17

Figure 61. PVC pipes connect catch basins between spans

Figure 62. PVC pipe passes through west abutment back wall.

Figure 63. Water stains under PVC pipe fitting, girder B, east of D19

2.4.6. Prestressed Concrete Girders

The deck is supported on 1,600 mm deep prestressed concrete girders. Spans D17 through D21 have constant deck width and six girders with equal spacing. Spans D21 to D23 increase in width from east to west, and have nine girders that fan out accordingly.

Girders were made of precast prestressed concrete. During installation, the precast girders were cast integral with the pier caps. The tops of girders were then post-tensioned across the middle piers at D18, D20 and D22, and on both sides of expansion joints at D17, D19, D21, and D23. The resulting compression exerted in the tops of girders served to induce positive bending moment in these negative bending moment regions, and enhance shear resistance as well.

The west side of span D19-D20 is above Expo Blvd which was not closed to traffic, and therefore not inspected from the boom lift. The girders in this section were inspected visually from ground level.

North girders (A) had water stains along north edge of bottom flange (Figure 64). This is likely the result of both (a) water seeping under precast barriers, and (b) degradation due to prolonged exposure to rain, which can be slightly acidic. This defect is not of concern at this time because the girders are uncracked.

Figure 64. Span D20-D21, north girder

Parallel diagonal cracks were observed on all girders on both sides of pier D22 at a distance of 4 to 5 m from the girder ends (Figure 65). These cracks were typically on an approximate 30° angle from the horizontal down towards the pier, and extended from 300 to 600 mm from top of web. Similar cracks were seen on the west side of full pier D20 (the east side was not inspected). Associated (2009) also spotted these cracks and attributed them to post-tensioning details. The crack locations near pier D22 coincide with loop anchors for post-tensioning tendons at centre piers (Figure 66).

Figure 65. Diagonal cracks at top of web, east of D22

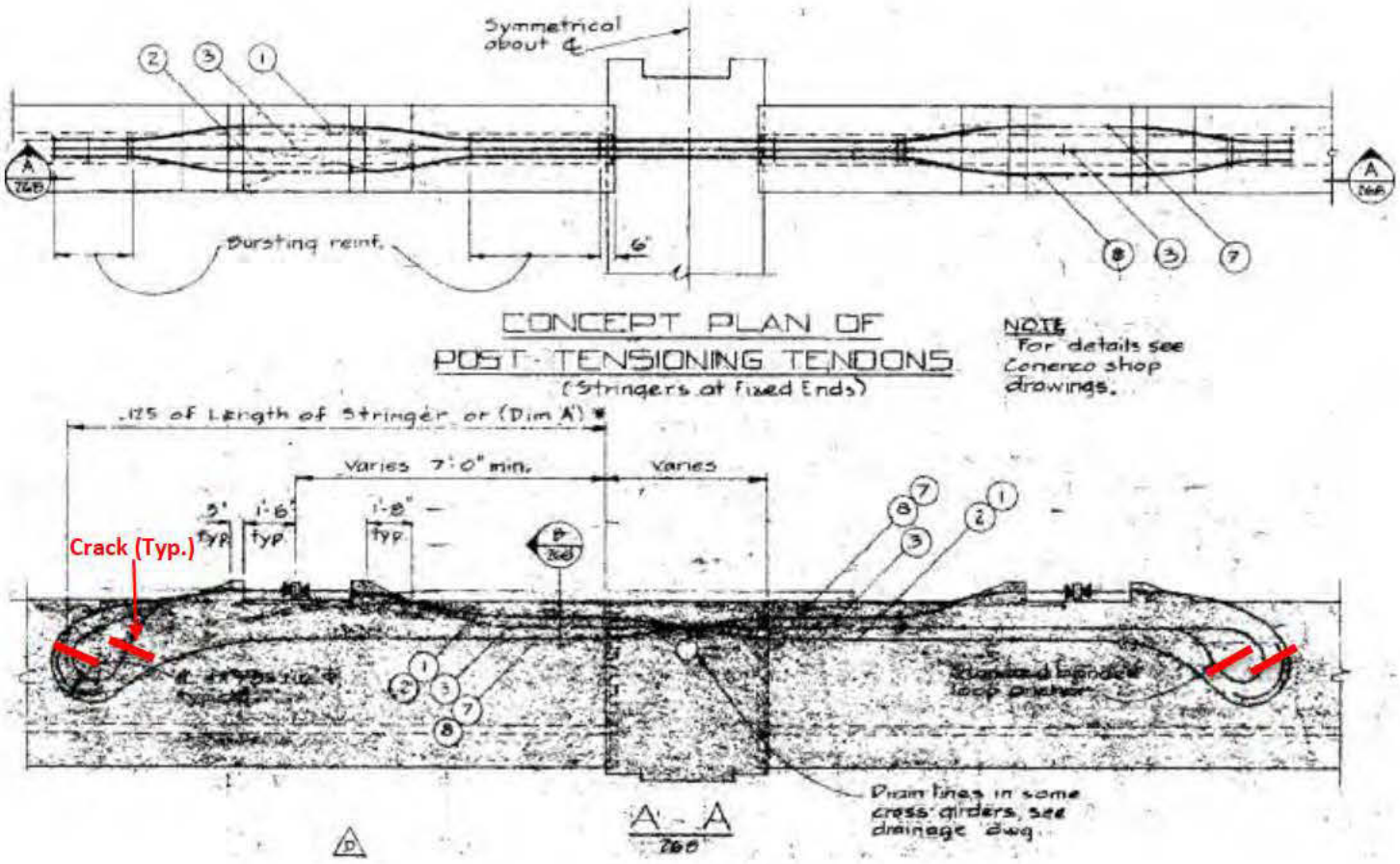


Figure 66. Approximate crack locations relative to post-tensioning tendons at full piers

These loops carry large post-tensioning forces (2,335 kN design force) over a very tight radius (157 mm). High stresses are generated around the tendon anchor loop as the force spreads out into the concrete section. The local tensile stresses generated can cause cracking in the concrete. These cracks are controlled by bursting reinforcement arranged to counter the tensile stresses. Small cracks in the bursting region are acceptable provided their width is within acceptable design limits (Hewson, 2003). The cracks observed near piers D20 and D22 were small, and are thus not cause for concern.

Diagonal cracks were observed at split piers on the east side of D18 and D21 between 0.5 to 1 m from girder ends (Figure 67). Cracks were typically on a 30° angle from the horizon down towards the pier, and extended from 0 to 300 mm from top of web.

Figure 67. Diagonal crack at top of web, east of D21, typical for all girders

Figure 68. Diagonal crack at top of web, east of D18, typical for all girders

These are not shear cracks, as they are closer than the girder depth from the support point (face of pier cap). They may be due to post-tensioning at top of girders at these locations. These cracks are small, stable and not exposed to road spray, and are therefore not of concern. We recommend these cracks be monitored in future inspections, with no remedial action required at this time.

2.4.7. Diaphragms

The diaphragms are made of cast-in-place concrete, connect to the deck via vertical stirrups, and join the girders transversely via dowels protruding from girder webs. Figure 69 and Figure 70 show typical diaphragms. Spans D17 to D19 have two intermediate diaphragms. Spans D20 to D22 have three intermediate diaphragms. Span D23-D22 has three intermediate diaphragms and an end diaphragm at the west abutment (D23).

All diaphragms inspected were in good condition, with no repairs required.

Figure 69. Diaphragms in span D20-D21

Figure 70. Typical diaphragm

3. DISCUSSION

3.1. Remaining Service Life Estimates

As of 2017, the bridge has been in service for approximately 44 years. The remaining service life estimates for major structural elements are presented in Table 2. These estimates are based on the findings of this inspection and can be used to allocate resources accordingly. These estimates are contingent on the bridge receiving regular maintenance. Most defects can be attributed to the failed expansion joints.

Based on our observations, we expect the remaining service life of the bridge to be at least 35 years under its current service level, possibly up to 50 years with regular preventative maintenance, and potentially longer with more investment. We recommend conducting a detailed deck condition evaluation if the structure is to be retained to confirm this remaining service life estimate.

The integral connections between the girders and pier caps protects the girders against exposure to moisture. The concrete-filled steel jackets on columns will protect the full and split piers from the elements. Replacing the expansion joints with link slabs will halt the ingress of water and chlorides between split piers.

Table 2. Estimated Remaining Service Life

Component	Percentage in Poor Condition	Estimated Remaining Service Life	Estimated Age	Comments
West Abutment	0%	50 years	44 years	Good condition
Bearings	0%	50 years	44 years	Good condition
Piers	10%	50 years	44 years	Wetness, efflorescence and corrosion stains at split pier caps and columns due to leaking expansion joints
Barriers	60%	25 years	44 years	North handrail: Concrete spalls, rebar corrosion
	10%	50 years	44 years	Guardrails
	5%	50 years	44 years	Median barriers
Deck	10%	50 years	44 years	Spalls on south overhang soffit at D18-D19 Algae on vertical edges throughout viaduct
Expansion Joints	100%	0 years	44 years	Joints filled with debris. Seals torn or missing Leaking joints resulted in wetness, corrosion stains, and efflorescence on split pier caps and columns.
Longitudinal Joint	20%	10 years	44 years	Leaking in some places Spalling infill concrete
Drainage	10%	50 years	44 years	Some PVC pipe connections are leaking. Catch basin at D17 has corrosion stains.
Diaphragms	0%	50 years	44 years	Good condition

3.2. Rehabilitation Needs

Table 3 summarizes the rehabilitation needs identified during the inspection. All repairs have been recommended to help the City maintain the existing structure for an additional 50 years of service. As per the RFP, proposed repairs meet expected industry service life.

As per the report objectives (Section 1), these repairs address material defects and structural performance deficiencies only. As such, they do not rectify seismic deficiencies or include functional improvements that may be required to prepare the viaduct for its intended use as an elevated park and active transportation bridge. These items are included in the Seismic Retrofit Strategy Report (NEFCAP-MMM-S-RPT-017).

The infill concrete along the deck soffit between the viaduct and the Costco building appears unstable with evidence of delamination and spalling. As this joint is located directly over a pedestrian area, there is a potential hazard to pedestrians from falling concrete. We recommend removal of any unbonded or otherwise potentially hazardous concrete be considered a high priority.

Table 3. Rehabilitation needs

Component	Activity	Quantity	Unit Cost	Total Cost
West Abutment	None	N/A	N/A	N/A
Bearings	None	N/A	N/A	N/A
Piers	None	N/A	N/A	N/A
Barriers	None	N/A	N/A	N/A
Deck	Pending deck concrete investigation	Pending	Pending	Pending
	Repair spalls in south overhang in span D18-D19	0.3 m2	L.S.	$5,000
Expansion Joints	Replace with link slabs at D19 and D21	28 m	L.S.	$94,000
	Replace with strip seal expansion joints at D17 and D23. (Cost of strip seal expansion joint at D17 can be considered part of new Dunsmuir Elevated Park.)	24 m	$1,800	$43,000
Longitudinal Joint	Repair spalling infill concrete	15 m	L.S.	$20,000
Drainage	Replace seal on leaking PVC pipe connection near pier D19	1 seal	L.S.	$5,000
	Replace waterproofing membrane in catch basin at pier D17	6 m^2	L.S.	$5,000
Girders	None	N/A	N/A	N/A
Diaphragms	None	N/A	N/A	N/A

N/A: Not Applicable

4. CONCLUSION

All expansion joints were leaking, resulting in efflorescence and corrosion stains on the split pier caps and columns below. While the surface concrete of these elements appears to be in good condition, prolonged exposure to moisture and chlorides is likely to lead to rebar corrosion, spalling of concrete cover, and loss of structural strength. We recommend replacing the existing joints with link slabs at D19 and D21 and strip seal expansion joints at D17 and D23. This work will cost roughly $94,000 for link slabs and $43,000 for the expansion joint at D23. The cost of expansion joint at D17 can be considered part of the adjacent Dunsmuir Elevated Park.

We recommend conducting a detailed deck condition evaluation if the structure is to be retained.

Other recommended repairs are minor and are listed in Table 3. The cost of these repairs is estimated at $35,000.

The total cost of all repairs is $172,000. Contingencies (10%) and contract administration (10%) will increase this to approximately $210,000.

5. CLOSURE

Please contact the undersigned should you have any questions or comments regarding the information provided herein.

Prepared By:

20 Sep 2017

Reza Saiedi, M.A.Sc., P.Eng.

Checked By:

Monty Kwan
for Charles Chataway, P.Eng.
Sept. 20/17

6. REFERENCES

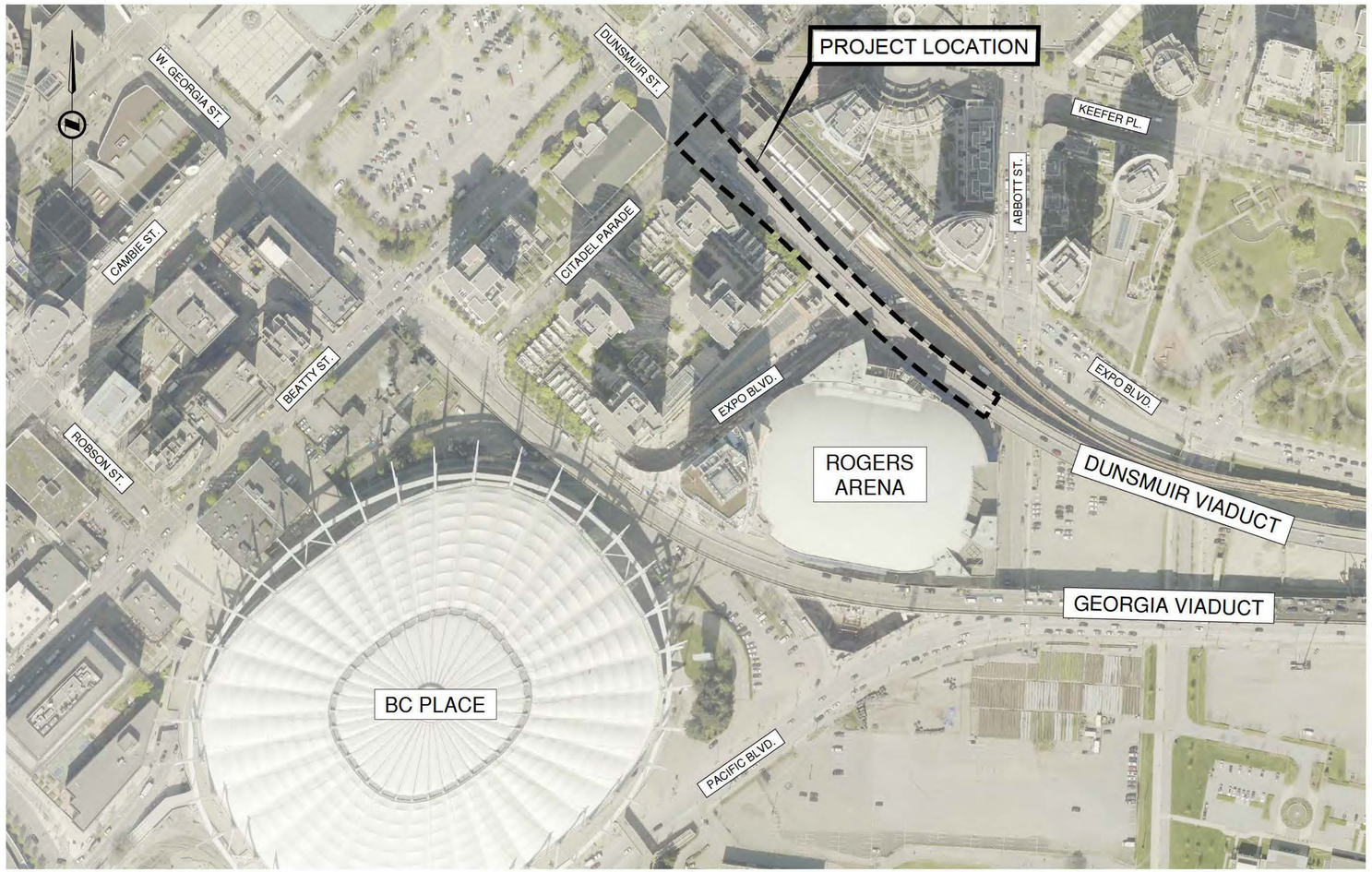
1. Associated Engineering (2009). "*City of Vancouver, 2009 Detailed Bridge Inspection Program*", Appendix D: Individual Bridge Summary, D-8 – Dunsmuir Viaduct
2. City of Vancouver (1969-1973). "*Georgia Viaduct Replacement, Contract No. 2*", Drawings 6857-200 to 299, 2100 to 2109, 801 to 805
3. COWI (2016). "*Bridge Engineering Services, Task C1 - Detailed Visual Inspections, 2016*". Appendix A: D–8 Dunsmuir Viaduct
4. COWI (2015). "*2015 Monitoring Inspection Report, D8 Dunsmuir Viaduct*".
5. Hewson, N. R. (2003). "*Prestressed Concrete Bridges: Design and Construction*", Thomas Telford Publishing, London, p317-318.
6. WSP (2017). "NEFCAP-MMM-S-RPT-017, Dunsmuir Viaduct, Seismic Retrofit Strategy Report"

APPENDIX A

General Arrangement Drawings

CITY OF VANCOUVER
DETAILED DESIGN OF ROAD & UTILITIES IN THE NORTHEAST FALSE CREEK PROJECT

DUNSMUIR VIADUCT REHABILITATION



PROJECT PLAN

KEY PLAN

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NEFCAP-MMM-S-PLN-N-300-004	A	GENERAL ARRANGEMENT - SHEET 1
NEFCAP-MMM-S-PLN-N-300-005	A	GENERAL ARRANGEMENT - SHEET 2
NEFCAP-MMM-S-PLN-N-300-006	A	GENERAL ARRANGEMENT - SHEET 3
NEFCAP-MMM-S-PLN-N-300-007	A	GENERAL ARRANGEMENT - SHEET 4

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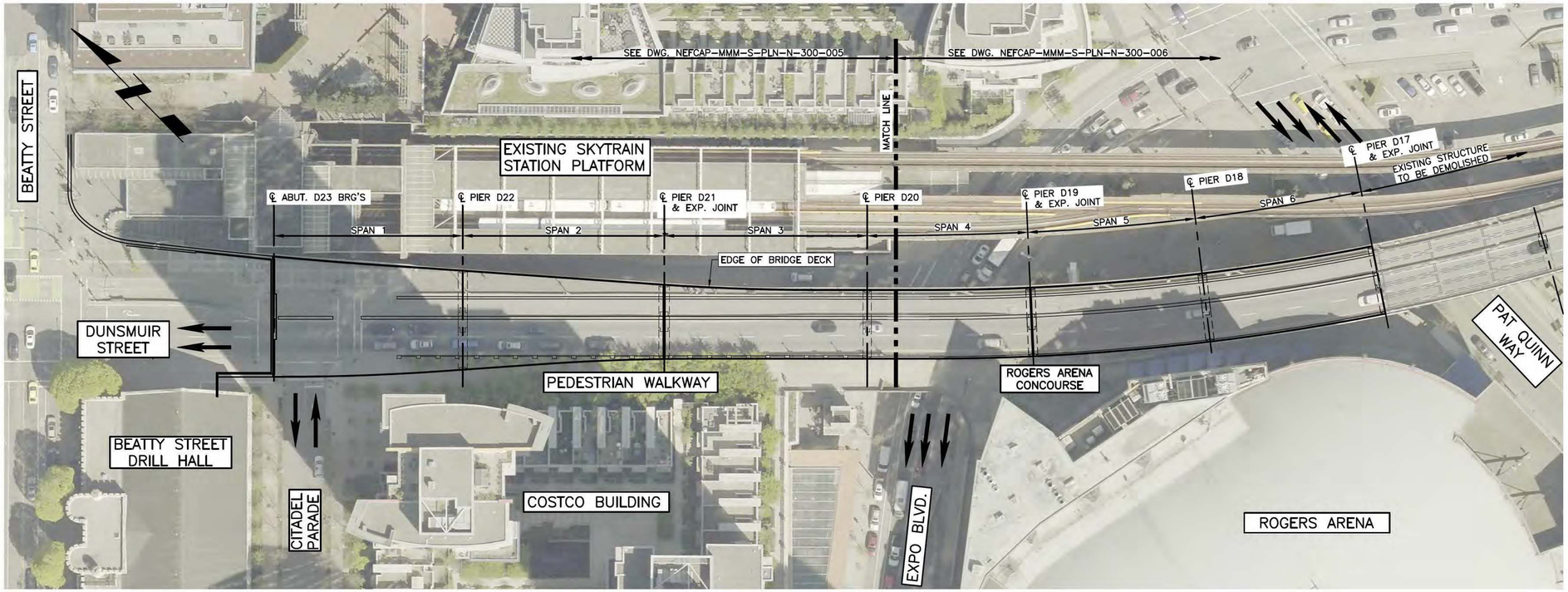
2017-03-30



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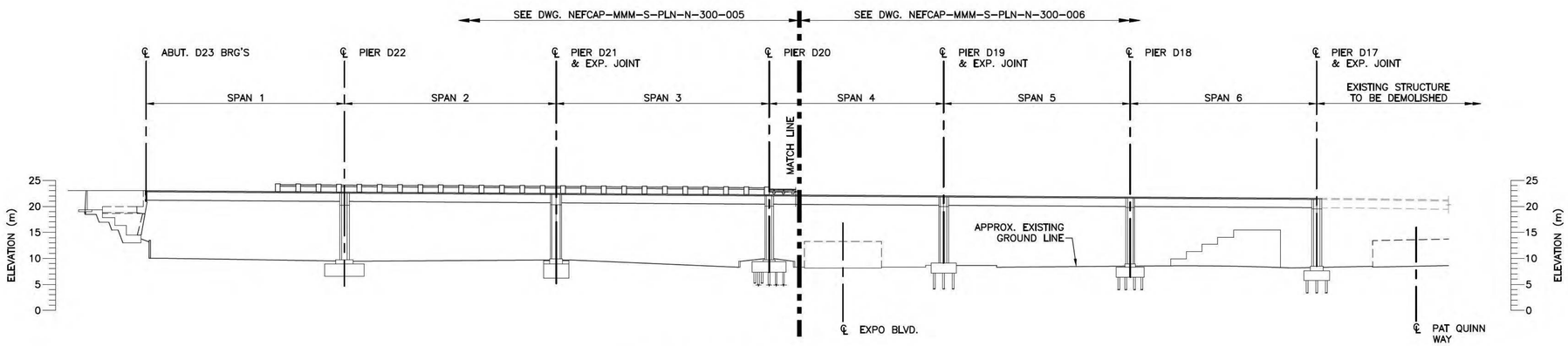

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NORTH EAST FALSE CREEK
DUNSMUIR VIADUCT REHABILITATION
GENERAL ARRANGEMENT
SHEET 1

Drawing Sheet of

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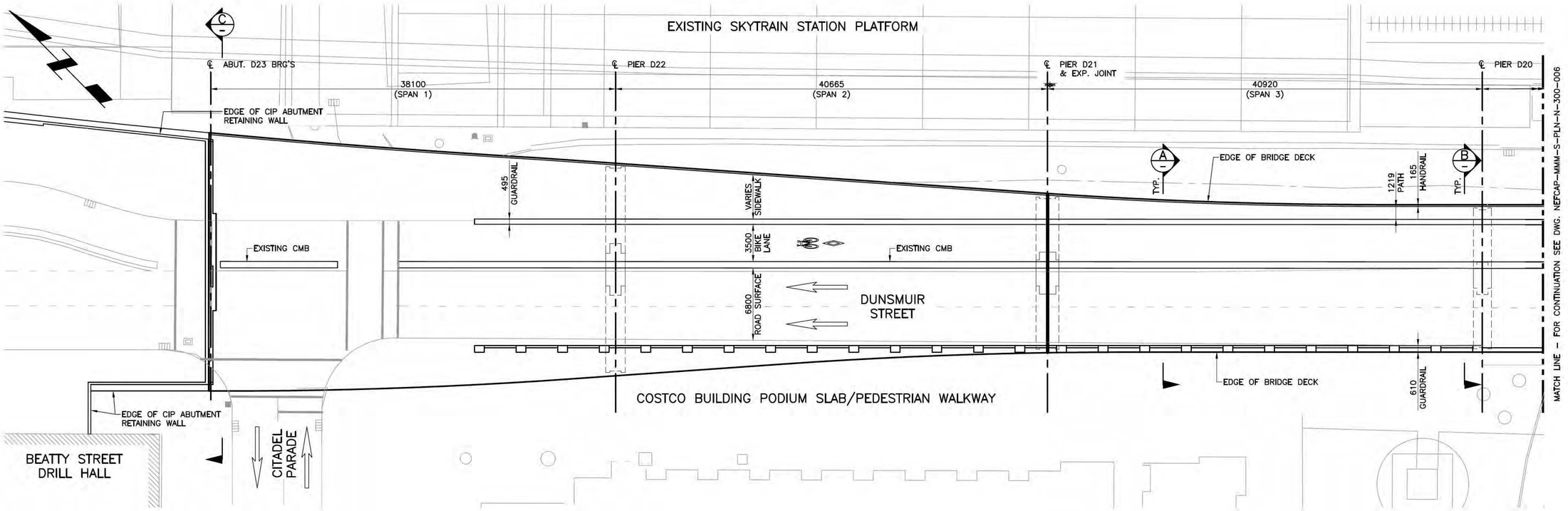
Revision: A



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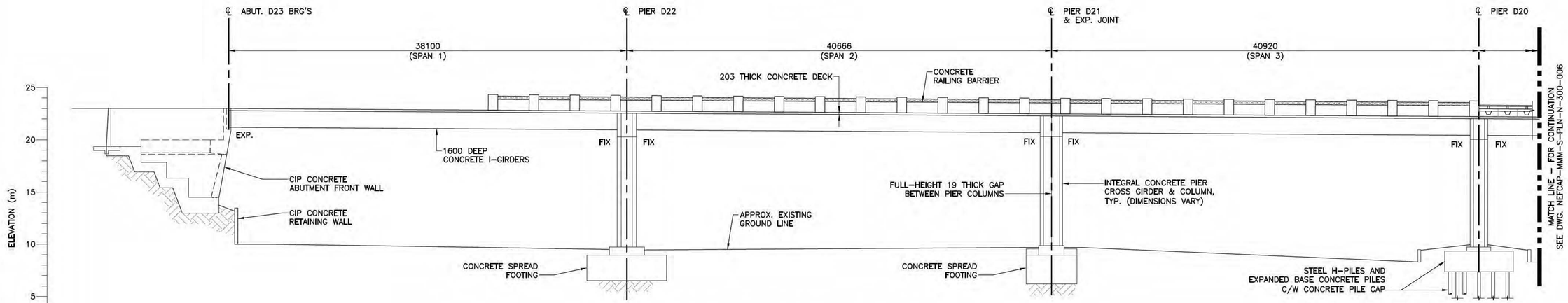

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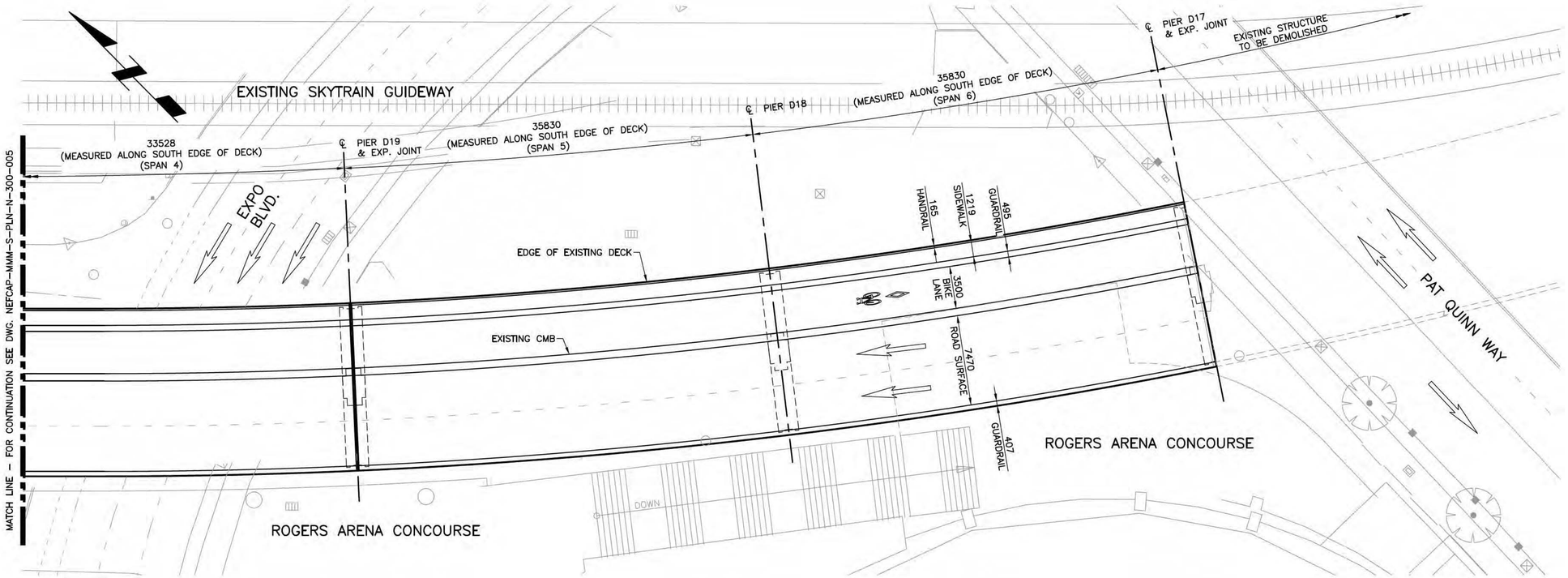

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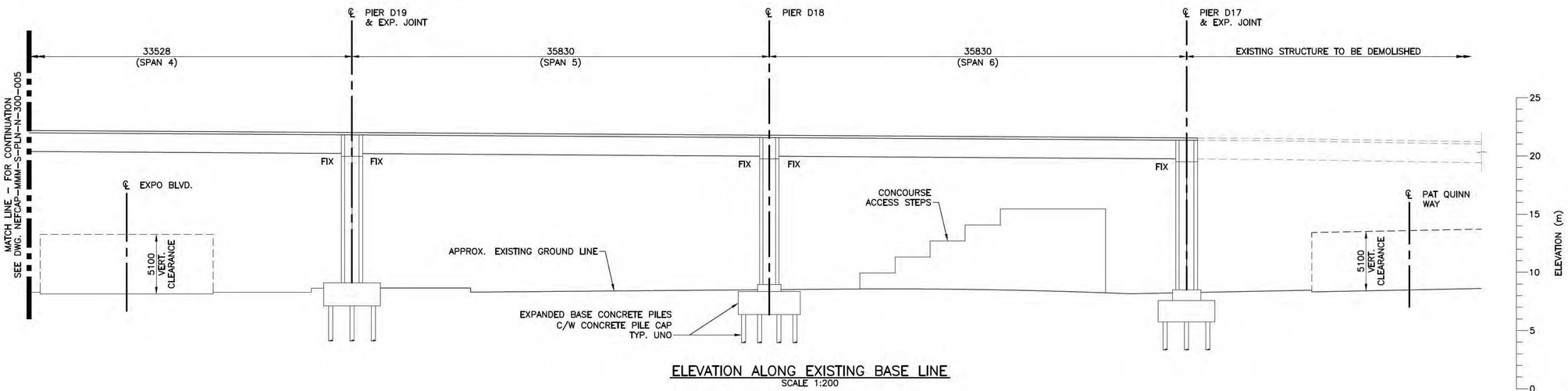

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DUNSMUIR VIADUCT REHABILITATION
GENERAL ARRANGEMENT
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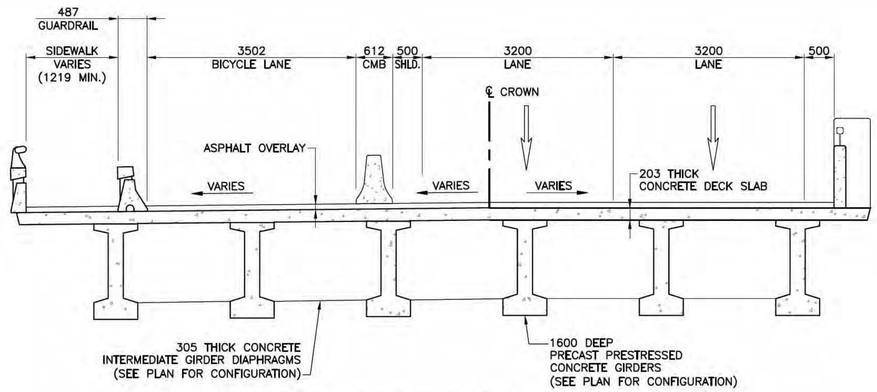

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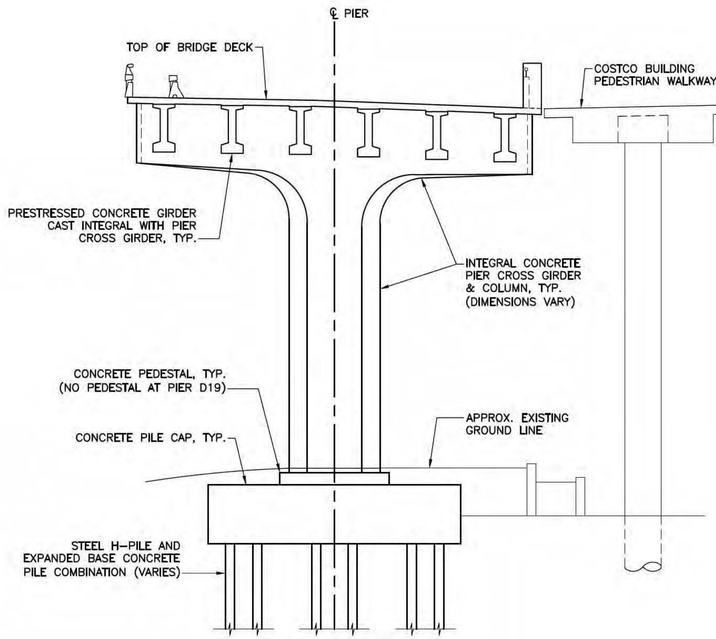

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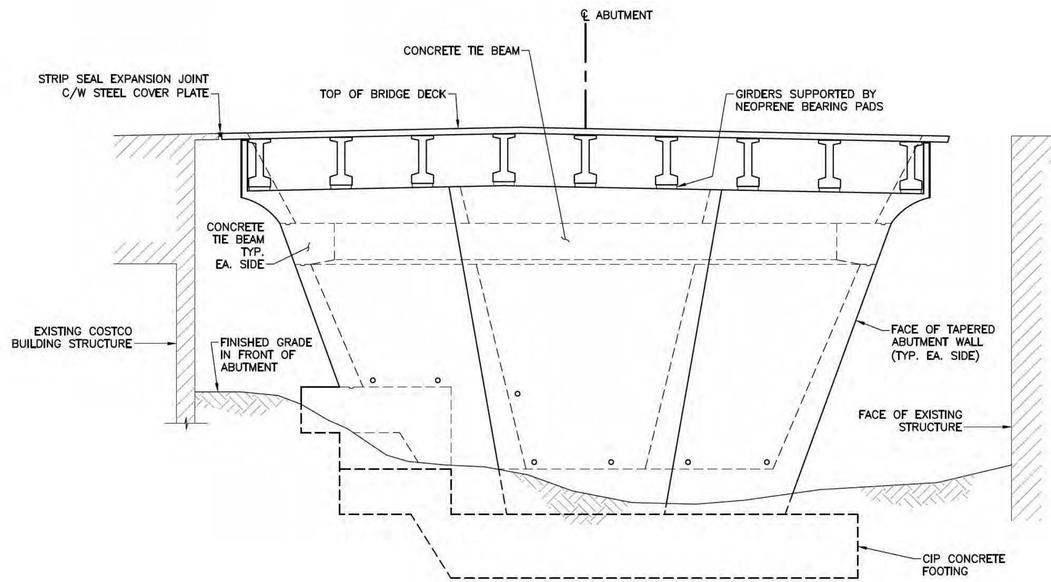

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Approved by	-	-

NORTH EAST FALSE CREEK
DUNSMUIR VIADUCT REHABILITATION
GENERAL ARRANGEMENT
SHEET 4

Drawing Sheet of

Drawing Number: NEFCAP-MMM-S-PLN-N-300-007

Revision: A