Vehicle Repair Shop

Seismic Assessment and High Level Costing Model

2020 Labieux Road
Nanaimo, BC

January 19, 2018

RJC No. NAN.117803.0001

Prepared for:
City of Nanaimo
2020 Labieux Road
Nanaimo BC V9T 6J9

Attention: Art Groot

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PREFACE (INTRODUCTION TO CONCEPT)

The following report has been commissioned by the City of Nanaimo to quantify seismic risk; generate a design concept for upgrading of the base building structure; and provide initial order of magnitude costing based on the design concept. The analysis and upgrade scheme utilize the methodology of the Third Edition of the Seismic Retrofit Guidelines (SRG3) for BC School Buildings, herein referred to as "SRG3".

The evaluation of old structures to resist seismic forces by using current Codes and material standards presents many difficulties for engineers. The National Building Code of Canada (NBCC) therefore recommends that the "NRC Guidelines for Seismic Evaluation of Existing Buildings" be followed in this regard. This guideline was published in 1992 and has not been updated in over 20 years. In British Columbia, the Ministry of Education spearheaded a program to reduce seismic risk of public school buildings. In conjunction with the Engineers and Geoscientists of British Columbia (EGBC) and the University of British Columbia (UBC), the SRG3 method was developed. These guidelines, present a state-of-the-art approach to the seismic assessment and retrofit of low-rise buildings which complements the Building Code for new construction by providing a rational method for "Life Safe" and "Enhanced" retrofit levels.

Each retrofit level is based on the probability that the "design drift" would be exceeded given the occurrence of the maximum considered seismic event. Typically this represents an earthquake return period of 2475 years. The term "drift" describes the amount a building, or building element, can move sideways before experiencing a catastrophic failure. The value is expressed in terms of a percentage of the height between floor levels. The probability of drift exceedance (PDE) used to evaluate each retrofit level is as follows:

- 2% for "Life Safety" approach – Long term retrofit solution with an expected design life of 50 years.

- Approximately 1% for "Enhanced" approach – A more demanding long term retrofit solution similar to the Life Safety approach, with the additional expectation of post-seismic event functionality. Note that SRG3 imposes a drift criteria of approximately 1/2 the Life Safe drift criteria, which will be similar to a PDE = 1% for many structural configurations.

In general, the lower the PDE value selected, the more stringent the upgrade requirements become. The SRG3 analysis identifies the corresponding minimum strength levels for structural elements that are needed to achieve the targeted PDE. These structural elements would be designed or evaluated for these force levels according to current Design Standards.

This report uses the following abbreviations:

1. LDRS Prototype: Lateral Deformation Resisting System (LDRS) Prototype refers to the numbered analysis prototype embedded in the SRG3's Analyzer software which we have selected to describe the behavior of the element in question. For example, an"F-1" prototype is a wall foundation that is subject to sliding, before shear, bending, or rocking.

2. PDE: Probability of Drift Exceedance (PDE) represents the probability that the design drift limit would be exceeded over a 50 year period. This is extrapolated from the seismology of the region and the earthquake records used to complete the non-linear modeling of the LDRS Prototypes.

3. CDL: Collapse Prevention Drift Limit (CDL) represents the maximum compatible drift limit among the key building structural elements. For example, some LDRS elements are capable of sustaining large drifts without collapse, but the corresponding columns or walls that support floor loads may not be. Hence, a lower CDL needs to be set to ensure the Vertical Load Resisting System elements are not damaged as a result of excessive drift.

4. Ws: Seismic Weight (Ws) is an expression of the inertia force generated by each floor level. A LDRS element that provides adequate capacity, expressed as %Ws, will meet the selected DDL, based on the desired level of PDE.

5. Eccentric: In the context of the results, "eccentric" results indicate that the arrangement of the LDRS elements create an excessive strength based eccentricity. The geometric center of mass for a given floor level is mis-aligned with the geometric centre of LDRS element strength by more than 10% of the width of the floor, perpendicular to the direction of loading. This causes the results to fall outside the applicability of SRG3. The eccentricity must be corrected as part of the upgrading process by altering the geometric layout or strength of the structural elements.

Use of the SRG3 method requires that the subject building meet certain geometric and material criteria. If the subject building does not conform, a building code based linear static, or linear dynamic analysis would be completed in accordance with the British Columbia Building Code (BCBC). In these cases, the results will be addressed in the context of SRG3 where possible.

EXECUTIVE SUMMARY

RJC has completed a preliminary seismic upgrade scheme and cost model for the City of Nanaimo Public Works Vehicle Repair Shop at 2020 Labieux Rd, based on the SRG3 method. This is a non-building code approach utilizing proprietary software that assesses the performance of the building in terms of the probability of exceeding acceptable "drift" limits as a result of lateral earthquake forces. "Drift" describes the amount a building, or building element can move sideways before experiencing a catastrophic failure. The value is expressed in terms of a percentage of the height between floor levels.

We determined that the existing lateral deformation resisting system (LDRS) is deficient in both principal plan directions. The existing building configuration has additional weaknesses due to structural irregularities, including soft-storey conditions. Further, the existing building contains unreinforced masonry partition walls that have inadequate resistance to out-of-plane action that present a significant hazard in a seismic event.

The SRG3 method was used to develop a structural concept that provides sufficient lateral deformation resistance in both directions, while reducing the influence of the existing structural irregularities noted above. The seismic retrofit scheme targeted the "Life Safety" retrofit condition as defined in SRG3. The developed structural scheme includes the construction of new reinforced concrete shear walls and steel braces, upgrades to the foundation system including installation of minipiles, tying the new LDRS construction into the existing slabs and walls using steel plates and exposed anchors, upgrading the existing roof diaphragms. Reinforcing or replacing existing unreinforced masonry partition walls is also recommended. Proposed locations of the new preliminary lateral resisting elements and other structural modifications are provided in Appendix A.

The upgraded structure in accordance with the "Life Safety" retrofit defined in SRG3 will see a significant improvement in its expected performance under strong ground shaking compared to its existing configuration.

To assist in capital project planning for the implementation of any seismic upgrading at this facility, we obtained the services of a Professional Quantity Surveyor to review the developed scheme and to provide an order of magnitude probable cost. The probable cost for the proposed seismic upgrade is **$1,824,100 + GST as a single project, excluding additional architectural changes or facility upgrades that might be completed at the same time as the seismic retrofit.** See Appendix B for the cost model reports.

1.0 INTRODUCTION

At the request of City of Nanaimo, Read Jones Christoffersen Ltd. (RJC) has performed a seismic assessment of the existing building structure at 2020 Labieux Road in Nanaimo, BC, also known as Vehicle Repair Shop at the Public Works Site.

Our review was based on the following information:

- Structural drawing 3-1, prepared by H James White , and dated February 15, 1965.
- Structural drawing S-301, prepared by Croft Construction, and dated January 26, 1976.
- Architectural drawings A1.0 through A4.0 prepared by Herold Engineering Limited and dated July 22, 2002.
- Photos and information gathered through a Seismic Screening from the Manual of Seismic Screening of Existing Buildings for Seismic Investigation from the IRC/NRC Canada 1992 completed in April 2012.
- Photos and information gathered during a site visit completed on August 30, 2017.

In general, complete drawing information was not available for any of the construction phases. No drawing information was available for the two manufactured trailer additions.

2.0 BUILDING DESCRIPTION

The vehicle repair shop is primarily a reinforced concrete masonry building, 366 m^2 in plan, constructed in 1965 with a T&G wood deck spanning to glulam beams supported by steel gravity columns. The walls are supported by concrete foundation walls and the gravity columns are supported with spread footings. There are wood framed mezzanines on the east and west ends of the building.

The 1976 addition, 293 m^2 in plan, is constructed with a plywood roof deck spanning to wood joists and glulam beams supported by the reinforced concrete masonry walls atop strip footings. There is a wood framed mezzanine on the east side of the addition.

The 2002 addition, 150 m^2 in plan, is constructed with a plywood roof deck spanning to wood trusses supported by the reinforced concrete masonry walls atop strip footings.

Two manufactured trailers were also added at unknown dates to provide extra storage and office spaces. They are located to the east and south of the 1965 building. The trailers were placed on cribbing, but they were also integrated with the existing building through the creation of new doorways through abutting walls. We believe these units are wood framed construction.

2.1 Vertical Load Bearing Support (VLS)

The building generally consists of reinforced concrete masonry construction with some steel gravity columns in the original building construction. In the additions to the building the concrete masonry walls are described as described as reinforced. However, other concrete block masonry walls appear to be non-bearing partitions and it is not clear from available information if these concrete block masonry walls are reinforced beyond that which is called up around openings. The manufactured trailers are assumed to be wood stud wall construction.

Given the above, the collapse prevention drift limit (CDL) for the VLS is 1.25% in accordance with SRG3.

2.2 Existing Lateral Deformation Resisting System (LDRS)

There are four (4) LDRS prototypes that describe the behavior and potential failure mode of the existing LDRS.

PROTOTYPE	LIFE SAFETY MAX CDL	YIELD DRIFT
M-1: Concrete Masonry Wall Sliding at Base	2.0%	0.1%
M-2: Unreinforced Masonry Wall	1.5%	0.1%
M-3: Reinforced Concrete Masonry Wall	2.0%	0.25%
F-1: Sliding Foundation	5.0%	0.25%

Given the above, and the limit of the VLS, the CDL for the LDRS is selected to be 1.25%.

3.0 SEISMIC REVIEW

The seismic review established the strength of the existing LDRS elements by using the appropriate material design standards. The performance of the elements were analyzed using a web-based software tool called "Seismic Performance Analyzer", which is part of the SRG3 approach. This software provides a large database of non-linear dynamic analysis results for a wide range of structural element types from which representative performance of the LRDS elements in the Vehicle Repair Shop can be extrapolated.

3.1 Design Assumptions

The seismic review and subsequent structural scheme were developed based on available drawings and visual observation at the site. This necessitated a number of assumptions that should be confirmed during any detailed design phase for this project. These assumptions and judgements are as follows:

DESIGN PARAMETER	INFORMATION SOURCE	VALUE/ASSUMPTION
Analysis Method	SRG3 OR BCBC	SRG3 based on building geometry and height.
Number of Analysis Blocks	Existing Drawing Review	3 + trailers
Site Class	Geotechnical Desktop Study	C
Foundation bearing pressure	Geotechnical Desktop Study	400 kPa Report suggests no issues with abandoned mine workings based on desktop study only.
Deep Foundations	Previous project application	18 Dywidag GEWI minipiles with tension/compression capacities of 270 kips (1200 kN) each.
Liquefaction Potential	Geotechnical Desktop Study	No
Geometric Assumptions /Simplifications	Engineering Judgement	The mezzanines in the building were modelled as parts and portions of the building due to their relative size. The trailer structures were not quantitatively analysed. We treated them as a fixtures and believe the required a new foundation element. Wood species was assumed to be D-Fir. Existing tongue and grove deck assumed to be 6" boards.

3.2 Results

The original building was constructed in 1965. In the decades since, it has undergone two expansions to create more office space, in 1976 and 2002. See Figure 1 for a site plan.

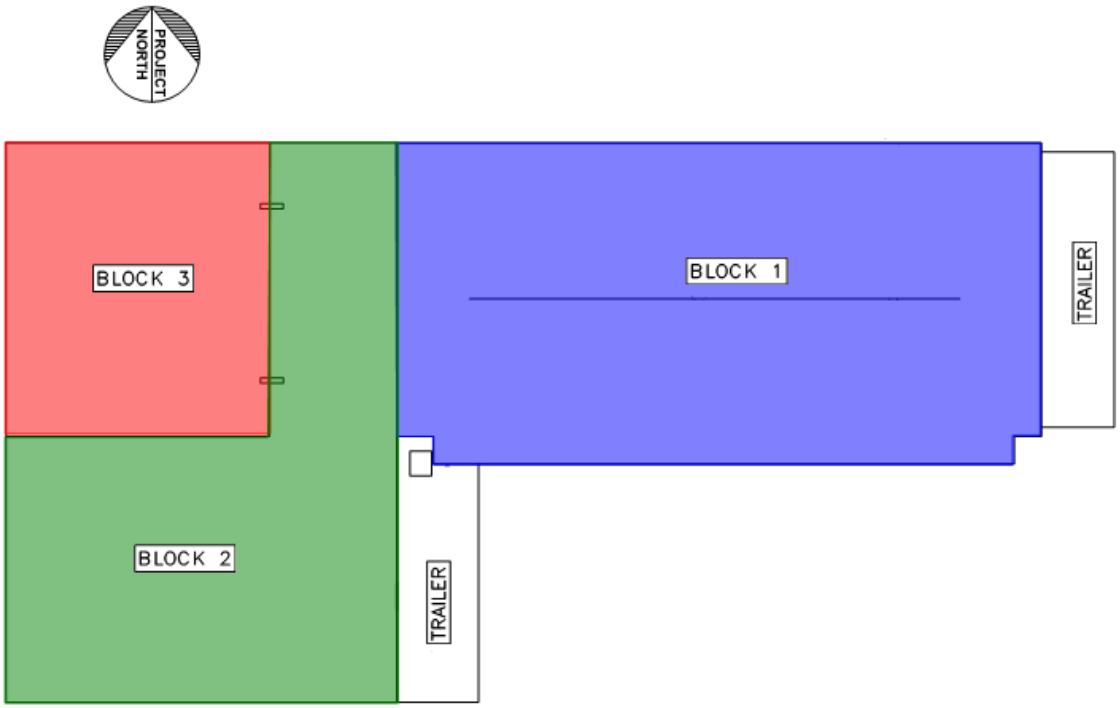


Figure 1: Block Definition

The building was divided up into three (3) different analysis "Blocks" for the purpose of performing the SRG analysis. Block definition is generally based on location, year of construction or upgrade, alignment of floor levels, number of stories and construction type.

Block 1 – Original Building

The original repair shop was built in 1965. The design code in effect at the time was NBC 1960. Seismic provisions at the time were limited, so it was likely that the building was not explicitly engineered to resist seismic forces.

Block 1 is 366 m^2 in plan, constructed with a T&G wood deck spanning to glulam beams supported by steel gravity columns and perimeter concrete masonry walls. The walls are supported by concrete foundation "walls", which do not appear to have a strip footing. The gravity columns are supported with spread footings. There are wood framed mezzanines on the east and west ends of the building supported by the concrete masonry walls. There are several large bay door openings in the south side of the building and strip windows in the north side, severely limiting the capacity of the LDRS in the east west direction.

Based on the SRG3 analysis, the following deficiencies were observed:

- The LDRS in both the NS and EW directions is inadequate. The NS direction performs better due the presence of several masonry walls, and deemed a Medium Risk. The placement and size of openings result in the EW direction being High Risk. There is only incidental reinforcing in the walls to frame around these openings, and their capacity does not provide any additional strength.
- The diaphragm has inadequate capacity due to the large span and type of construction.

TABLE 1 - BLOCK 1 RISK RESULTS				
LDRS				
	SRG3 prototype	**Collapse Prevention Drift Limit (CDL) (%)**	**Probability of Drift Exceedance (PDE) (%)**	**Seismic Risk**
NS Direction	F1-Foundation Sliding	1.25	4.2	Medium
EW Direction	M-2 – Unreinforced Wall	1.25	7.7	High
Diaphragm				
	SRG3 prototype	**Collapse Prevention Drift Limit (CDL) (%)**	**Probability of Strain Exceedance (PSE) (%)**	**Seismic Risk**
Roof	D3- Horizontal Boards	N/A	>20%	High

Block 2 – 1976 Addition

The design code in effect at the time was NBCC 1975.

Block 2 is a single high storey building. It is constructed with a plywood roof deck spanning to wood joists and glulam beams supported by the reinforced concrete masonry walls atop strip footings. There is a wood framed mezzanine on the east side of the addition.

Based on the SRG analysis, the following deficiencies were observed:

- The LDRS in both the NS and EW directions is inadequate.
- The diaphragm has inadequate capacity due to the large span and type of construction. The placement and size of openings result in the EW direction being Medium Risk. The poor reinforcing for this construction does not provide adequate capacity.

TABLE 2 - BLOCK 2 RISK RESULTS				
LDRS				
	SRG3 prototype	**Collapse Prevention Drift Limit (CDL) (%)**	**Probability of Drift Exceedance (PDE) (%)**	**Seismic Risk**
NS Direction	F1-Foundation Sliding	1.25	3.2	Medium
EW Direction	M2-Unreinforced Wall	1.25	3.1	Medium
Diaphragm				
	SRG3 prototype	**Collapse Prevention Drift Limit (DDL) (%)**	**Probability of Strain Exceedance (PSE) (%)**	**Seismic Risk**
Roof	D2 – Unblocked Plywood	N/A	5.3	High

Block 3 – 2002 Addition

The design code in effect at the time was BCBC 1998.

Block 3 is a single high storey building. It is constructed with a plywood roof deck spanning to wood trusses supported by the reinforced concrete masonry walls atop strip footings.

Based on the SRG analysis, the following deficiencies were observed:

- The LDRS in both the NS and EW directions is inadequate due to foundation sliding. The reinforced walls themselves appear to be adequate.
- The diaphragm has inadequate capacity due to visual observations that suggest the existing plywood is unblocked.

TABLE 3 - BLOCK 3 RISK RESULTS				
LDRS				
	SRG3 prototype	**Collapse Prevention Drift Limit (CDL) (%)**	**Probability of Drift Exceedance (PDE) (%)**	**Seismic Risk**
NS Direction	F1-Foundation Sliding	1.25	3.0	Medium
EW Direction	F1-Foundation Sliding	1.25	7.7	High
Diaphragm				
	SRG3 prototype	**Collapse Prevention Drift Limit (CDL) (%)**	**Probability of Strain Exceedance (PSE) (%)**	**Seismic Risk**
Roof	D2 – Unblocked Plywood	N/A	3.7	Medium

Out of Plane Effects

There are out of plane concerns with the unreinforced masonry partition walls that are in Block 1 which will be addressed as part of our upgrade scope.

Upon review of the load bearing masonry, we believe the walls are capable of spanning horizontally between the reinforced masonry columns that support the roof structure.

4.0 SEISMIC RETROFIT

To mitigate the seismic deficiencies determined through our assessment, a concept was developed based on strength analysis in accordance with SRG3. The retrofit scheme requires the enhancement of existing LDRS elements as well as the addition of new LDRS elements positioned to balance the demands of the existing members relative to the configuration of the LDRS as a whole. Locations for new LDRS elements were selected in relation to the existing functional layout of the repair shop. Significant strengthening of the foundation system for seismic force demands is also required.

The demand to capacity ratios for all LRDS elements will be below 1.0 for seismic excitation corresponding to the "Life Safety" guidelines in SRG3. While using a different design philosophy than NBCC2015, the structure is expected to meet performance criteria that is similar to a structure designated as "Normal Importance" in NBCC2015.

4.1 Proposed Seismic Retrofit Concept

1. Upgrade the EW direction by providing a new reinforced concrete shear wall from foundation to roof along the south west side of the building, approximately 6.6m high as a structural overlay to an existing reinforced masonry wall at the ground floor level. The height of the wall requires a minimum thickness of 500mm to maintain required height to thickness ratios.

2. Upgrade NS direction by providing steel braced frames and corresponding footings in the shop area. The installation of these frames will require removing existing reinforced masonry walls and slab on grade. Additional steel frames are to be installed to support the mezzanines that the masonry walls were originally supporting. We opted for steel braced frames as we did not believe it would be practical to upgrade the existing non-load bearing masonry given that the walls were 6.6m high.

3. Add reinforced concrete overlays to along north foundation wall to tie blocks together to resist foundation sliding.

4. Remove existing reinforced slab on grade adjacent to west wall of 1976 addition and replace with reinforced slab anchored into existing masonry wall to increase sliding resistance of the building.

5. Provide reinforced concrete slab on grade foundations and curbs to support the trailers at the south and west ends of the building. These trailers will also be seismically separated from the remainder of the building. Note, we have not performed a quantitative analysis on the trailer

structures. We believe the structures themselves are small and light enough that they represent a low risk once they have an adequate permanent foundation.

6. Provide new footings and pile caps integrated with existing footings below new and upgraded LDRS elements. Tension and compression minipiles as per layout in Appendix A.

7. Provide new plywood overlay diaphragms at the roof level and enhance the connections with the LDRS elements with new chord elements and additional anchors.

8. Enhance the connections between the mezzanine floors and the adjacent LRDS elements.

9. Provide drag struts at the roof level to transfer the diaphragm load into the LDRS elements.

10. Retrofit existing unreinforced masonry walls as described in Section 4.2. Masonry partition walls are to be reinforced to span horizontally to adjacent concrete walls.

4.2 Additional Upgrade Considerations

1. Verify concrete block masonry reinforcing. Existing masonry walls are provided as partition walls on the ground floor and mezzanine level. Available drawings do not indicate the presence of sufficient reinforcement in these walls. This can be verified on site through localized testing. If reinforcement is present then additional reinforcement is not required. To reinforce the walls in place, the face shells can be saw-cut with new reinforcing steel and grout introduced.

2. It is also noted that completion of the foundation work may require partial/complete repaving of exterior spaces on the west side of the building. These constraints should be evaluated during a detailed design phase.

4.3 Incremental (Staged) Upgrading

Unlike the building code approach to design, the SRG3 method is less quantitative in terms of identifying what percentage you can improve a multi storey building if you were to upgrade incrementally. The SRG3 method generates an upgrade scheme that is designed to prevent collapse only when fully implemented, and the capacity demand ratios are calculated for each floor level, not for the building as a whole. However, judicious partial implementation could help improve the building's performance, even if the amount of improvement is difficult to express numerically.

The full seismic retrofit requirements identified in Sections 4.1 and 4.2 presents several discrete construction activities that could be performed incrementally. Construction activities to complete in each increment should normally be sequenced to retrofit the structural elements that have the highest seismic risk classifications. Items in each increment must also be selected so that a partial-retrofit does not result in the creation of new or amplified structural irregularities.

Our review identified that the seismic structural deficiencies at the Vehicle Repair Shop are widespread. The risk rating would not be decreased significantly until all items are completed. However, completion of the new concrete shear wall on the south elevation of the 1965 building, along

with the steel diaphragm tie on the north wall, would provide a significant qualitative improvement to the performance of the building. This work should be followed by upgrading of the roof diaphragm; and the addition of the new steel braces in the 1965 building. Completion of all of the components should reduce the global risk to medium.

We note that these incremental upgrades would not individually reduce the global risk level of the building. As such, the costing model presented does not separate the incremental items into separate projects.

4.4 Probable Cost Projection

We retained the services of James Bush and Associates (JBA) to review the proposed schematic plan for the seismic retrofit. The work completed by JBA is intended to provide an order of magnitude cost to address adding new LDRS elements indicated in Appendix A. The report from JBA has been included in Appendix B, which outlines the order of magnitude cost of the upgrade when completed as a single project or as phases. These are noted by JBA as Class D+ Estimates.

As a single project, the order of magnitude cost is **$1,824,100 + GST**.

Architectural and occupant disruption issues have not been explicitly addressed in the estimates from JBA. These issues include the following:

1. The level of architectural finish replacement has not been explicitly addressed. Allowances have been made for generic architectural finishing, but no specific requirements or interior design considerations have been addressed at this time.

2. We have assumed that the building will not be occupied during the work. There are considerable cost implications related to completing this type of work within an occupied space. If occupancy needs to be maintained, we would need to review the appropriate work sequence in detail.

The order of magnitude costing includes a design contingency of 16%. The construction contingency and contractor overhead figures of 15% and 18%, respectively, are based on the projected construction cost. The allowance for consulting fees and project management represents 16% of the projected construction cost, including the contingency and contractor overhead amounts.

5.0 LIMITS OF COMMISSION

The Client recognizes that special risks occur whenever engineering or related disciplines are applied to identify hidden elements or portions of a building. Even a comprehensive sampling and testing program, implemented with the appropriate equipment and experienced personnel, under the direction of a trained professional who functions in accordance with a professional standard of practice, may fail to detect certain conditions. This is because these conditions are hidden and therefore cannot be considered in the development of a repair program. For similar reasons, actual conditions that the design professional properly inferred to exist between examined conditions may differ significantly from those that actually exist.

The Client realizes that nothing can be done to eliminate these risks altogether. As a result, we cannot guarantee the accuracy of opinions of probable cost and can assume no liability where the probable costs are exceeded.

The Client recognizes that RJC does not have expertise in the identification of, or health risks associated with, mould, mildew or other fungi and therefore cannot provide an opinion as to the extent to which these substances exist in the building(s) or the associated potential health risks to building occupants.

This report was prepared for the City of Nanaimo. It is not for the use or benefit of, nor may it be relied upon, by any other person or entity, without written permission of Read Jones Christoffersen Ltd.

6.0 CLOSING REMARKS

If you wish to pursue any of the recommended upgrades or further refinement of the analysis and upgrade scheme we will be pleased to meet with you to discuss this in more detail at your convenience.

We trust the above meets with your current requirements. Should you have any questions, please do not hesitate to contact the undersigned.

Yours truly,

READ JONES CHRISTOFFERSEN LTD.

Julia Halipchuk

Julia Halipchuk, EIT
Design Engineer

Reviewed by:

D. S. GAM #27413 PROFESSIONAL ENGINEER PROVINCE OF BRITISH COLUMBIA

Jan 19/18

Dennis Gam, M.Eng., P.Eng.
Principal

JMH/km

Encl.: Appendix A – Drawings
Appendix B – Costing Report

Appendix A Drawings

LIST OF STRUCTURAL SKETCHES

SK - 0.0	-	GENERAL NOTES
SK - 1.1	-	GROUND FLOOR PLAN
SK - 1.2	-	MEZZANINE FLOOR PLAN
SK - 1.3	-	ROOF PLAN
SK - 2.1	-	DETAILS

GENERAL

1. SECTION MARK SHOWN THUS 

MEANS SECTION #4 ON DRAWING S - 3

CONCRETE WORK

2. SHALL CONFORM TO CAN / CSA - A23.1, CAN / CSA - A23.2, CAN / CSA - A23.3 AND REFERENCED DOCUMENTS.

STRUCTURAL STEEL WORK

3. SHALL CONFORM TO CAN / CSA - S16 AND ITS REFERENCED DOCUMENTS.

MASONRY WORK

4. SHALL CONFORM TO CAN / CSA - S304.1 AND ITS REFERENCED DOCUMENTS.

WOOD WORK

5. SHALL CONFORM TO CAN / CSA - O86 AND ITS REFERENCED DOCUMENTS.

ANALYSIS & DESIGN CRITERIA

1. THE INDICATIVE STRUCTURAL RETROFIT CONCEPT SHOWN ON THESE SKETCHES TARGETS THE "LIFE SAFETY" DESIGN CRITERIA PER THE STRUCTURAL ENGINEERING GUIDELINES FOR THE PERFORMANCE - BASED SEISMIC ASSESSMENT AND RETROFIT OF LOW - RISE BRITISH COLUMBIA SCHOOL BUILDINGS, 3RD EDITION PUBLISHED JUNE 2017.

2. ANALYSIS COMPLETED USING SEISMIC PERFORMANCE ANALYZER I (VERSION 3.1) WITH THE FOLLOWING PARAMETERS:

   A) LOCATION = NANAIMO

   B) DESIGN PROBABILITY OF DRIFT EXCEEDENCE (PDE) FOR ASSESSMENT AND DESIGN: BUILDING: 2% IN 50 YEARS (LIFE SAFE)

3. C) SOIL TYPE = SITE CLASS C (PER GEOTECHNICAL REPORT)

4. SNOW LOADING DESIGN CRITERIA HAS BEEN DEVELOPED IN SUBSTANTIAL ACCORDANCE WITH THE NATIONAL BUILDING CODE OF CANADA 2015.

   SCOPE OF EVALUATION WAS LIMITED TO THE LATERAL DEFORMATION RESISTING SYSTEM ELEMENTS UNDER SEISMIC LOAD CASE ONLY.

No.	Revision	Date	By
.	ISSUED FOR PRICING	SEPT/7/17	DSG

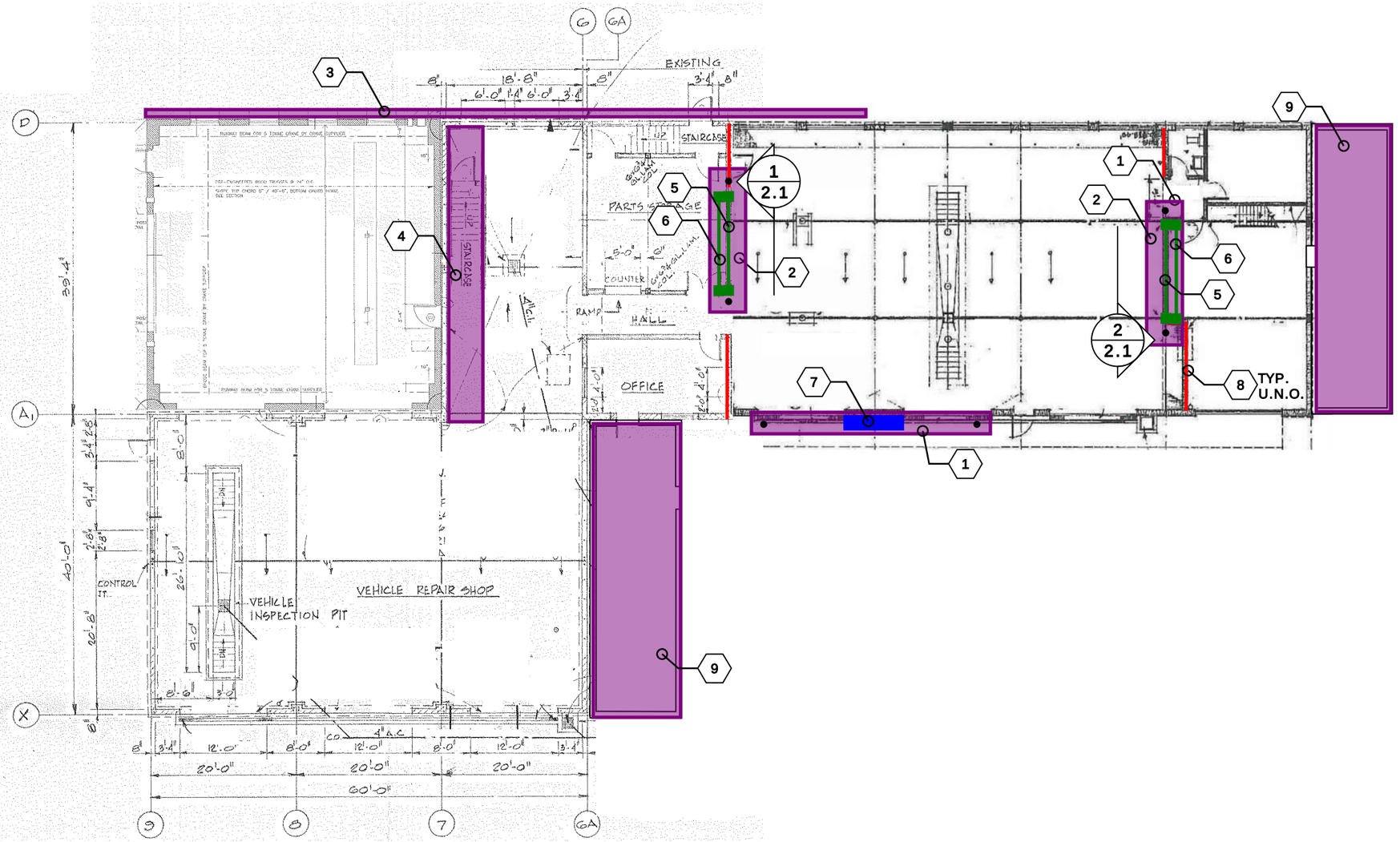
rjc Engineers

Project Name
CON PUBLIC WORKS VEHICLE REPAIR SHOP
2020 LABIEUX ROAD SPIR ASSESSMENT
Sketch Title
GENERAL NOTES

Drawn By	**JMH**
Scale	**N.T.S.**
Date	**SEPTEMBER 6, 2017**
Project No.	**NAN.117803.0001**
Sketch Number	Rev.
SK-0.0	.

UPGRADE LEGEND	
SYMBOL	DESCRIPTION
	FOOTING
	SOIL ANCHOR
	STEEL BRACED FRAMES
	WOOD SHEAR WALL
	CONCRETE SHEAR WALL
	MASONRY WALL
	STEEL MEMBERS
	DRAG STRUT
	WOOD DIAPHRAGM
	STEEL DECK DIAPHRAGM
	CONCRETE DIAPHRAGM

NORTH PROJECT



GROUND FLOOR KEY NOTES

1. NEW 10000mm x 900 mm x1800 mm DP REINFORCED CONCRETE FOUNDATION C/W 1 -#18 DYWIDAG SOIL ANCHOR WITH AXIAL CAPACITY IN TENSION OF 1200 kN (270 kips) AT EA. END (2 TOTAL). UDREPIN 600mm DP FOUNDATION UNDER EXISTING 1200mm DP FOUNDATION WALL.
2. NEW 6000mm x 1500 mm x1000 mm DP REINFORCED CONCRETE FOUNDATION C/W 1 -#18 DYWIDAG SOIL ANCHOR WITH AXIAL CAPACITY IN TENSION OF 1200 kN (270 kips) AT EA. END (2 TOTAL). INSTALL ON EITHER SIDE OF EXISTING 1200mm FOUNDATION WALL AND DOWEL THROUGH.
3. NEW 30000mm x 300 x 600 DP FOUNDATION WALL C/W 20M @ 800 EMBED INTO EXISTING WALL WITH HILTI RE 500V3 AND 8 - 15M @ LONG WAY.
4. REMOVE 1330mm WIDE SECTION OF EXISTING SLAB ON GRADE NEXT TO WALL AND REPLACE WITH 150 THICK S.O.G. C/W 20M0922 @ 800 EMBED INTO EXISTING WALL WITH HILTI RE 500 V3 AND S.O.G. 150 AND 2 - 15M @ LONG WAY.
5. REMOVE EXISTING BLOCK WALL AND INSTALL NEW STEEL BRACED FRAME C/W 2 - HSS 203x203x6.4 COLUMNS @ 4000 O/C AND HSS 102x102x6.4 BRACES AND W310 HEADER BEAM (6600mm HIGH).
6. INSTALL STEEL FRAME TO SUPPORT MEZZANINE FLOOR FRAMING C/W 2 - HSS 152x152x6.4 COLUMNS @ 4000 O/C AND W200x27 BEAM.
7. NEW 2400 x 500 THICK CONCRETE SHEAR WALL TO ROOF (6600mm HIGH).
8. CUT IN 20M VERTICAL REINFORCING @ 1200 O/C.
9. REMOVE TRAILER AND PROVIDE 125mm THICK REINFORCED SLAB ON GRADE WITH A 450mm DP THICKENING AT EDGES. INCLUDE 200mmx 450mm HIGH CURB AROUND PERIMETER TO SUPPORT TRAILER.

No.	Revision	Date	By

rjc Engineers

Project Name
CON PUBLIC WORKS VEHICLE REPAIR SHOP
2020 LABIEUX ROAD SPIR ASSESSMENT
Sketch Title
GROUND FLOOR PLAN

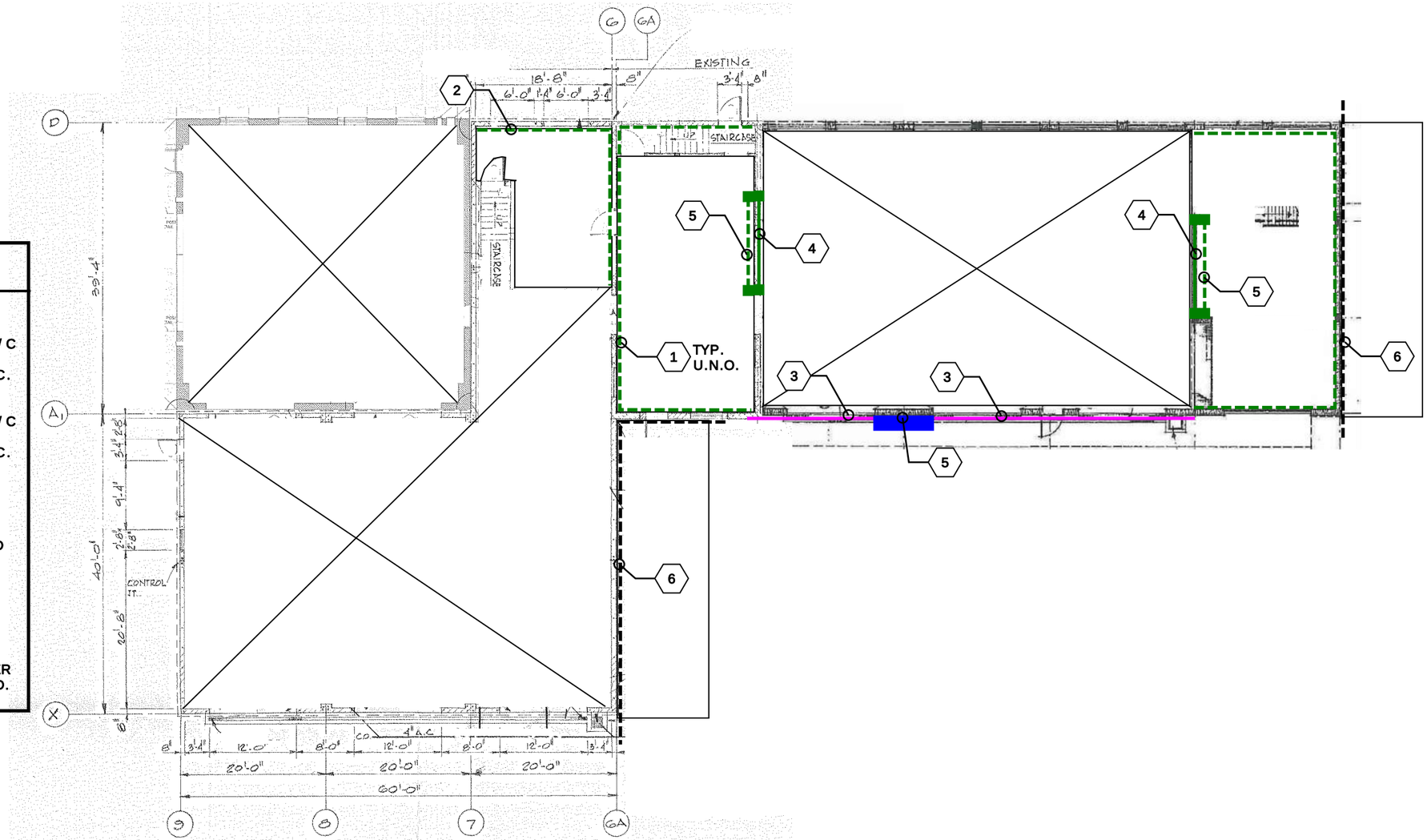
Drawn By	**JMH**
Scale	**1:200**
Date	**SEPTEMBER 6, 2017**
Project No.	**NAN.117803.0001**
Sketch Number	Rev.
SK-1.1	.

UPGRADE LEGEND	
SYMBOL	DESCRIPTION
	FOOTING
	SOIL ANCHOR
	STEEL BRACED FRAMES
	WOOD SHEAR WALL
	CONCRETE SHEAR WALL
	MASONRY WALL
	STEEL MEMBERS
	DRAG STRUT
	WOOD DIAPHRAGM
	STEEL DECK DIAPHRAGM
	CONCRETE DIAPHRAGM

PROJECT NORTH

MEZZANINE KEY NOTES

1. ANCHOR EXISTING MEZZANINE FLOOR TO EXISTING MASONRY WALL WITH L76x76x4.8 C/W 19mm DIA ANCHORS @ 200 O/C INTO EXISTING MASONRY WALL AND NAIL TO EXISTING MEZZANINE DIAPHRAGM WITH TWO ROWS OF NAILS @ 76 O/C.
2. ANCHOR EXISTING MEZZANINE FLOOR TO EXISTING MASONRY WALL WITH L76x76x4.8 C/W 19mm DIA ANCHORS @ 800 O/C INTO EXISTING MASONRY WALL AND NAIL TO EXISTING MEZZANINE DIAPHRAGM WITH TWO ROWS OF NAILS @ 76 O/C.
3. INSTALL PL 76x6.4 DRAG STRUT C/W 19MM DIA ANCHORS INSTALL WITH HILTI HY 70 @ 200 O/C.
4. NEW STEEL BRACED FRAME C/W 2-HSS 178x178x6.4 COLUMNS @ 4000 O/C AND HSS 102x102x6.4 BRACES AND W200 HEADER BEAM (6600mm HIGH).
5. NEW 2400 x 500 THICK CONCRETE SHEAR WALL TO ROOF (6600mm HIGH).
6. STEEL BRACE FRAME SUPPORTING MEZZANINE UNDERNEATH.
7. PROVIDE 150mm WIDE GAP BETWEEN TRAILER AND REMAINDER OF BUILDING. FINISH GAP WITH FLASHING DETAIL ALL AROUND.



No.	Revision	Date	By

Engineers

Project Name
CON PUBLIC WORKS VEHICLE REPAIR SHOP
2020 LABIEUX ROAD SPIR ASSESSMENT
Sketch Title
MEZZANINE FLOOR PLAN

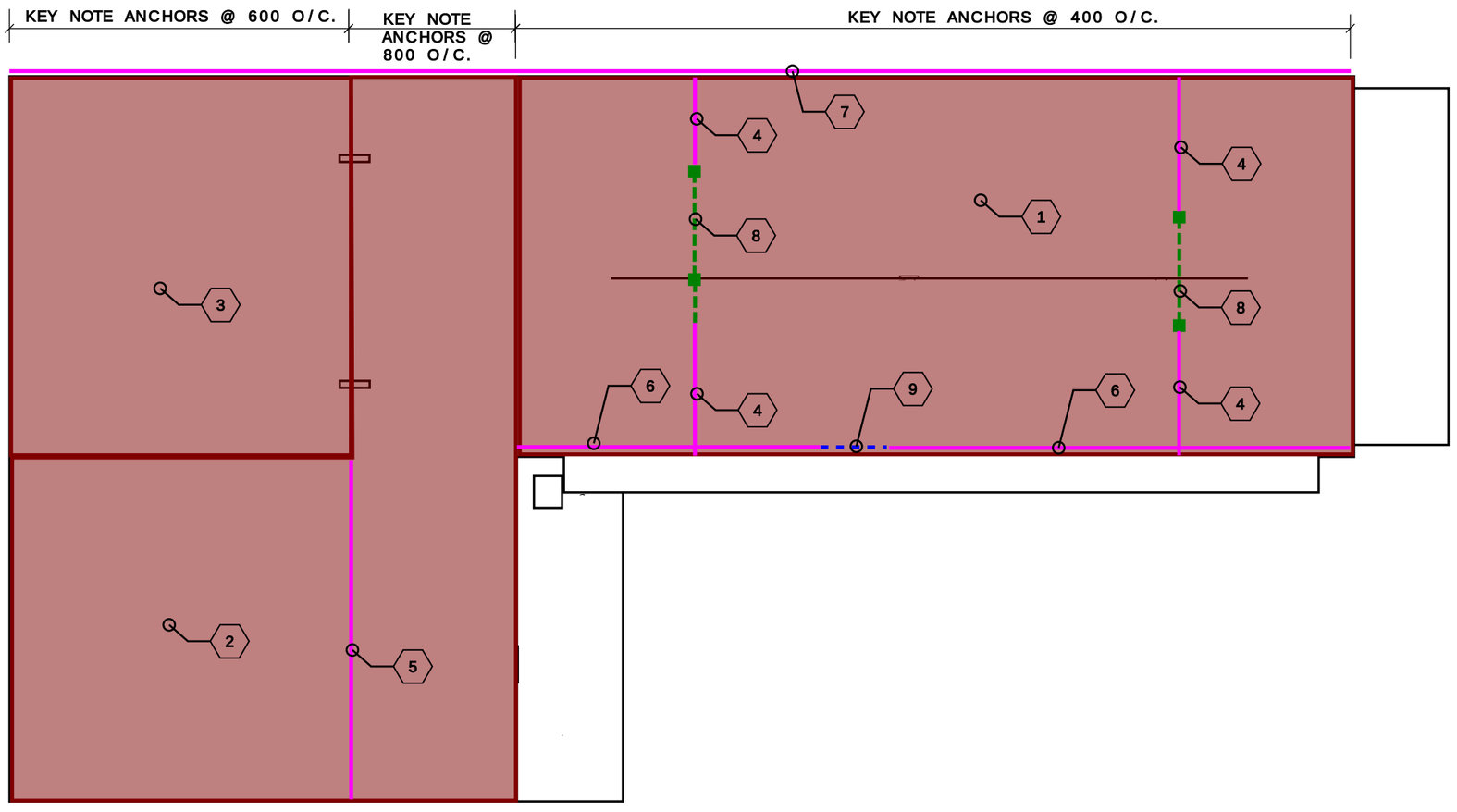
Drawn By	**JMH**
Scale	**1:200**
Date	**SEPTEMBER 6, 2017**
Project No.	**NAN.117803.0001**
Sketch Number	Rev.
SK-1.2	**.**

UPGRADE LEGEND	
SYMBOL	DESCRIPTION
	FOOTING
	SOIL ANCHOR
	STEEL BRACED FRAMES
	WOOD SHEAR WALL
	CONCRETE SHEAR WALL
	MASONRY WALL
	STEEL MEMBERS
	DRAG STRUT
	WOOD DIAPHRAGM
	STEEL DECK DIAPHRAGM
	CONCRETE DIAPHRAGM

NORTH PROJECT

ROOF KEY NOTES

1. INSTALL NEW 15.5mm PLYWOOD DECK DIAPHRAGM. ENHANCE CONNECTION TO LDRS WITH NEW L102x102x6.4 STEEL CHORDS ANCHORED TO EXISTING MASONRY WALL WITH 19mm DIA ANCHOR AND HILTI HY 70 @ 200 O/C.
2. INSTALL NEW 15.5mm PLYWOOD DECK DIAPHRAGM. ENHANCE CONNECTION TO LDRS WITH NEW L102x102x6.4 STEEL CHORDS ANCHORED TO EXISTING MASONRY WALL WITH 19mm DIA ANCHOR AND HILTI HY 70 INTO EXISTING GROUTED CELLS @ 800 O/C.
3. INSTALL NEW 15.5mm PLYWOOD DECK DIAPHRAGM. ENHANCE CONNECTION TO LDRS WITH NEW L76x76x4.8 STEEL CHORDS ANCHORED TO EXISTING MASONRY WALL WITH 19mm DIA ANCHOR AND HILTI HY 70 INTO EXISTING GROUTED CELLS @ 600 O/C.
4. INSTALL DRAG STRUT TO UNDERSIDE OF EXISTING ROOF (As=1100mm2)
5. INSTALL DRAG STRUT TO UNDERSIDE OF EXISTING ROOF (As=3000mm2)
6. INSTALL DRAG STRUT TO UNDERSIDE OF EXISTING ROOF (As=1870mm2)
7. INSTALL PL 6.4x400X48000 LG C/W 2 ROWS OF 19mm DIA ANCHORS EMBEDDED INTO EXISTING MASONRY WALL. INSTALL @ 5400 ABOVE GRADE. REFER TO PLAN FOR ANCHOR SPACING.
8. NEW STEEL BRACED FRAME BELOW.
9. NEW CONCRETE SHEAR WALL BELOW.

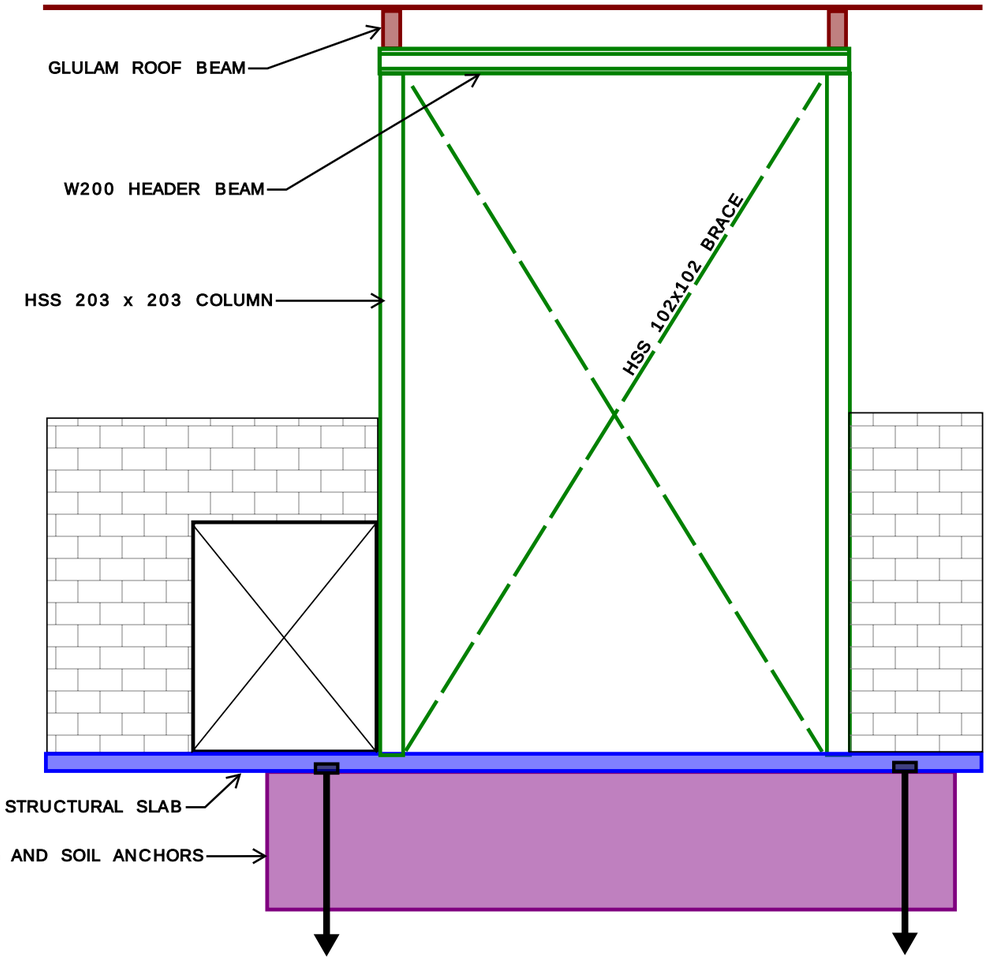


No.	Revision	Date	By

rjc Engineers

Project Name
CON PUBLIC WORKS VEHICLE REPAIR SHOP
2020 LABIEUX ROAD SPIR ASSESSMENT
Sketch Title
ROOF PLAN

Drawn By	**JMH**
Scale	**1:200**
Date	**SEPTEMBER 6, 2017**
Project No.	**NAN.117803.0001**
Sketch Number	Rev.
SK-1.3	.



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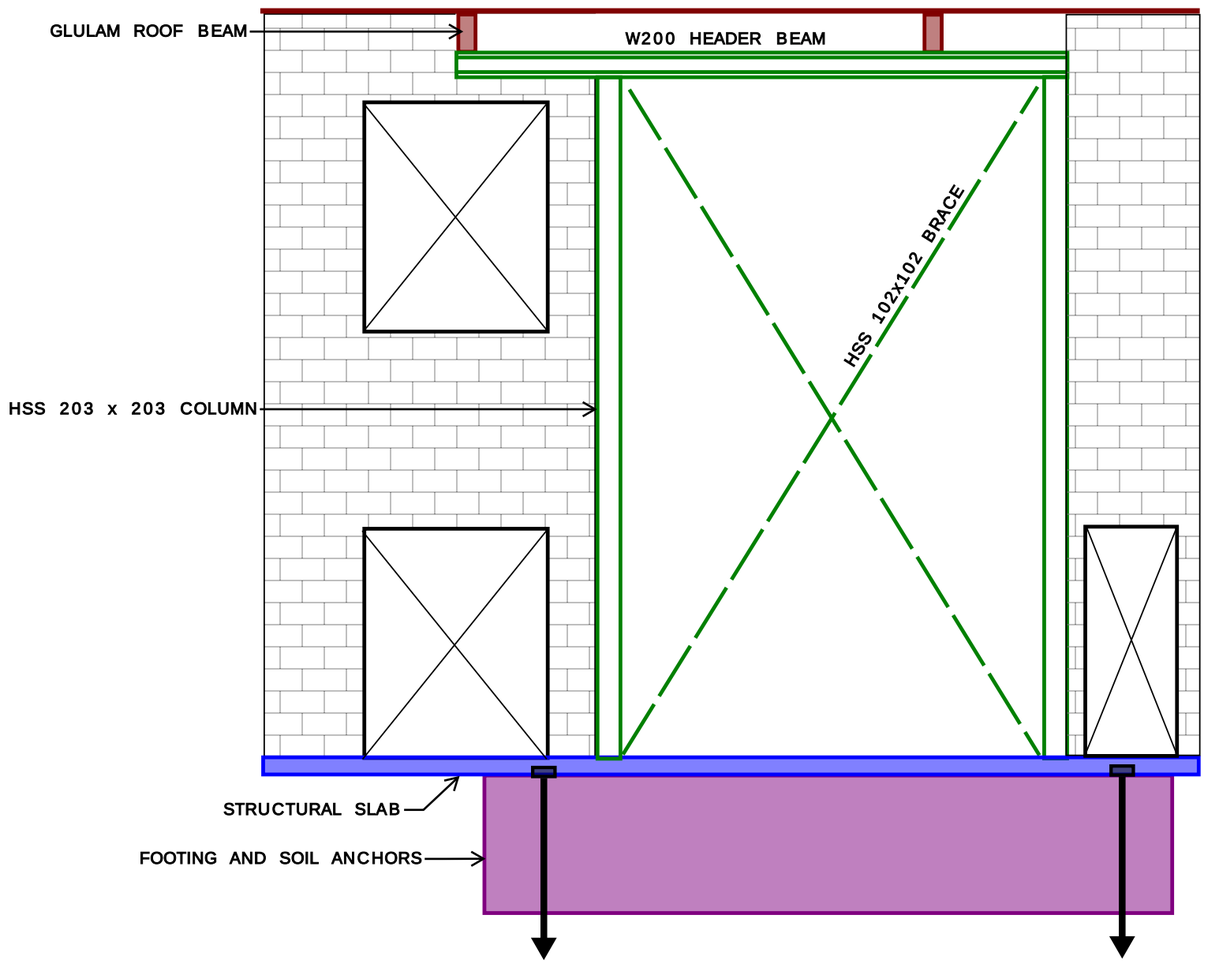

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No.	Revision	Date	By

rjc Engineers

Project Name
CON PUBLIC WORKS VEHICLE REPAIR SHOP
2020 LABIEUX ROAD SPIR ASSESSMENT
Sketch Title
DETAILS

Drawn By	**JMH**
Scale	**1:200**
Date	**SEPTEMBER 6, 2017**
Project No.	**NAN.117803.0001**
Sketch Number	Rev.
SK-2.1	.

Appendix B Costing Report

CITY of NANAIO SRG ASSESSMENT
PUBLIC WORKS VEHICLE REPAIR SHOP
Seismic Project Identification Report (SPIR)
Seismic Assessment prepared by: READ JONES CHRISTOFFERSEN ENGINEERS

October 17, 2017

SEISMIC RETROFIT ESTIMATE SUMMARY

	LIFE SAFETY RETROFIT VEHICLE REPAIR SHOP & TRAILERS	
Gross Floor Area (m2)	1,015 m2	
CONSTRUCTION COST ESTIMATE		
SEISMIC RETROFIT		
Site Work	63,900	
Selective Demolition:	60,100	
Earthwork	37,600	
Concrete Work	121,400	
Soils Anchors	43,200	
URM Upgrade	29,600	
Drag Struts & Steel Brace Frame	98,800	
Diaphragm Upgrades & Connections	92,600	
Other	0	
Roofing	257,100	
Exterior Wall Cladding, Windows & Doors	14,600	
Partitions & Doors	0	
Finishes	11,200	
Millwork, Specialties	0	
Electrical Work	70,000	
Mechanical Work	75,900	
Asbestos & Lead Paint Remediation	35,500	
Contractor Site Overheads & Markup	177,000	
Design Contingency & Unspecified Risk 15%	178,400	
SEISMIC RETROFIT	$1,346.70	**$1,366,900**
LIQUEFACTION RETROFIT		
Non-Structural SEISMIC RESTRAINT		**Not Included**
Site Specific PHASING COSTS		**Not Included**
Required CODE Upgrades		**Not Included**
CONSTRUCTION (excl Taxes)		**$1,366,900**
SOFT COSTS		
Temporary Accommodation, Portables, Phased Construction		Not Included
Building Permits, Inspections ($7.00/$1000 plus 15% insp/fees/deposit)		$14,500
Design & Engineering Fees (16%)		$218,700
Construction Contingency, change orders/extg condition (10%)		$136,700
Soft Costs, Owner's Project Management (allow 5%)		$87,300
GST - assumed fully refunded		$0
TOTAL PROJECT COST		**$1,824,100**

CITY of VANCOUVER SRG ASSESSMENT
PUBLIC WORKS VEHICLE REPAIR SHOP
Seismic Project Identification Report (SPIR)
Seismic Assessment prepared by: READ JONES CHRISTOFFERSEN ENGINEERS

October 17, 2017

LIFE SAFETY RETROFIT

SEISMIC RETROFIT ESTIMATE	VEHICLE REPAIR SHOP & TRAILERS				
Overview Description of Work	Upgrade existing foundation with new concrete foundation & soils anchors. New concrete shearwall and steel brace frames. Upgrade mezzanie with dragstruts. Upgrade roof diaphragm with plywood from above and add drag struts requiring re-roofing. Temp. replocate trailers and install new foundation pad				
SEISMIC RETROFIT CONSTRUCTION ESTIMATE					
	Main Floor			841.0	m2
	Mezzanines			174.0	m2
	GROSS FLOOR AREA			1,015.0	m2
Site Work & Trailers				**63,900**	
Demolish paving, landscape etc, for foundations	138	m2	45.00	6,200	
Make good pavings	54	m2	105.00	5,700	
Footing drains - rework due to foundations	80	m	300.00	24,000	
Make good landscaping etc			Item	3,000	
Disconnect, jack and temp move trailer for new foundation pad	2	No.	4,500.00	9,000	
Reinstall trailer on new foundation pad	2	No.	8,000.00	16,000	
Selective Demolition:				**60,100**	
Remove shop equipment and sundries for access to work area	1,015	m2	12.00	12,200	
Sawcut demolsh slab for foundation & slab on grade replacement	47	m2	185.00	8,700	
Demolish full height masonry wall for Brace Bays, cut verticals	12	m	747.50	9,000	
Temporary Shoring	12	m	250.00	3,000	
Prepare existing finishes/structure for new steel dragstruts/ties	191	m	18.00	3,400	
Remove stair, hold for reuse				2,500	
Remove finishes from URM walls to be upgraded with corefill	51	m2	25.00	1,300	
Remove wall mounted specialties, millwork etc for wall upgrade	120	hrs	58.00	7,000	
Demol work in Washrooms			Item	1,500	
Miscell demolition and removals			Item	6,500	
Cleanup, disposal off site			Item	5,000	
Earthwork				**37,600**	
Exterior detailed excavation for foundation	30	m3	185.00	5,500	
Interior detailed excavation for foundation incl. deep	34	m3	265.00	9,000	
Underpinning excavation under existing footings	33	m3	350.00	11,600	
Site prep slab area for Trailer pad	84	m2	45.00	3,800	
Backfilling	32	m3	85.00	2,700	
Disposal of excavated materials, cleanup			Item	5,000	
Concrete Work- Foundations & shearwalls				**121,400**	
Foundations					
Concrete footing (exterior)	23	m3	900.00	20,500	
Concrete footing (interior)	19	m3	1,100.00	20,800	
Drilled and epoxy grouted anchors - extg foundation	150	No.	39.00	5,900	
Slab on grade infil - foundation work	28	m2	165.00	4,600	
Drilled and epoxy grouted anchors - perimeter	200	No.	28.00	5,600	
Slab on Grade Replacement					
New slab on grade -150mm	19	m2	222.75	4,300	
Drilled and epoxy grouted anchors - perimeter	93	No.	28.00	2,600	
Reinstall stair			Item	4,800	
Foundation Pad for Trailers (2No.)					
New slab on grade -125mm with perimeter thickening 450mm dp	17	m3	950.00	16,600	
200mm x 450mm high curb to perimeter	62	m	151.88	9,400	
Concrete walls -500mm concrete walls	16	m2	1,029.04		
Formwork (two sides)	38	m2	185.00	7,100	
Rebar	1,089	kg	2.50	2,700	
cored holes for steel/pours					
Drilled and epoxy starters	40	No.	28.00	1,100	
Concrete supply	9	m3	215.00	1,900	
Concrete placing, pumping	35	hrs	58.00	2,000	
Strip forms	19	hrs	58.00	1,100	
Finishing, ginding, patching	19	m2	19.00	400	
Miscellaneous Concrete Allowance			Allow	10,000	

JBA QS

SEISMIC RETROFIT ESTIMATE		VEHICLE REPAIR SHOP & TRAILERS				
Soils Anchors						**43,200**
Dywidag soils anchors - #18 dia - exterior			No.	8,500.00	0	
Dywidag soils anchors - #18 dia - interior		4	No.	10,800.00	43,200	
URM Upgrade						**29,600**
Corefil existing walls		51	m2	582.45		
Exterior walls		0	No.	1,280.00	0	
Interior Walls - full height	12	14	No.	2,100.00	29,600	
Drag Struts & Steel Brace Frame						**98,800**
Horrizontal Drag struts & Anchor Mezzanine		73	m	165.75		
PL 76x6.4 supply/fab		126	Kg	3.75	500	
L 76x76x4.8 supply/fab		986	Kg	3.75	3,700	
Labour install		14	hrs	75.00	1,100	
Connection to new concrete		2	No.		200	
Drilled and epoxy grouted anchors into conc/masonry at 200c/s		365	No.	18.00	6,600	
Brace Frames		2	No.	16,350.00		
HSS 203x203x6.4 supply/fab, incl. baseplates		1,918	Kg	4.80	9,200	
HSS 102x102 diagonal brace - supply/fab		635	Kg	6.00	3,800	
W200 Header		552	kg	3.75	2,100	
Labour install		128	hrs	75.00	9,600	
Hoisting				Item	3,500	
Work W200 header into existing masonry,I ncl. grouting etc		12	m	300.00	3,600	
Connections to slab - drilled epoxy anchors 4ea		4	No.	140.00	600	
Connections to Glulam roof beams		4	No.	80.00	300	
Horrizontal Drag struts (Exterior Wall)		48	m	452.08		
PL 400x6.4 supply/fab	Note 7	1,507	Kg	3.75	5,700	
Labour install		53	Hrs	75.00	4,000	
Drilled and epoxy starters		320	No.	28.00	9,000	
Hoisting and manlifts				Item	3,000	
Horrizontal Drag struts (Underside of ROOF)		58	m	556.90		
PL 200x6.4 supply/fab	Note 4	251	Kg	3.75	900	
PL 300x10 supply/fab	Note 5	287	Kg	3.75	1,100	
PL 300x6.4 supply/fab	Note 6	707	Kg	3.75	2,600	
Labour install		116	Hrs	75.00	8,700	
Drilled and epoxy starters		320	No.	28.00	9,000	
Fasten to roof steel with screws at 200cc/2 rows		580	No.	6.00	3,500	
Hoisting and manlifts				Item	6,500	
Diaphragm Upgrades & Connections						**92,600**
Floor Diaphragm Upgrade						
Roof Diaphragm Upgrade		841	m2	110.11		
New plywood overlay existing roof		841	m2	68.00	57,200	
L 102x102x6.4 supply/fab	160m	2,880	Kg	3.75	10,800	
Labour install		136	Hrs	75.00	10,200	
Drilled and epoxy starters tomasonry at 200cs		800	No.	18.00	14,400	
Exterior Building Envelope Work						**271,700**
Roofing						
Remove roofing		841	m2	28.00	23,500	
Reroofing - SBS roofing, insulation		841	m2	218.00	183,300	
Reroofing - re/re mechanical equip/vents/stacks etc					incl.	
Rebuild perimeter parapet/roof edge with blocking/cant etc		148	m	125.00	18,500	
Perimeter fascia/flashing		148	m	215.00	31,800	
Exterior Cladding						
Seal exterior concrete wall, caulking to perimeter		19	m2	85.00	1,600	
Flashing head of wall		3	m	170.00	500	
Flashing horizontal dragstrut on wall		48	m	135.00	6,500	
Flashing at trailer roof to wall - expansion 150mm gap		25	m	240.00	6,000	

SEISMIC RETROFIT ESTIMATE	VEHICLE REPAIR SHOP & TRAILERS			
Interior Work - Finishes				**11,200**
Painting exposed steel			Item 1,800	
Paint Walls	102	m2	15.00 1,500	
Re/re finishes disturbed, make good, patching etc			Item 5,000	
Reinstrate finishes in washrooms			Item 2,000	
Reinstate Millwork, Specialties, Wall Mtd Specialties	16	Hrs	58.00 900	
Electrical Work				**70,000**
Nominal Elec work - re/re services on walls	1,015	m2	48.00 48,700	
Work around exisitng lighting and ceiling electrical	1,015	m2	21.00 21,300	
Mechanical Work				**75,900**
Plumbing - re/re plumbing fixtures			10,000	
Re/re fuel/oil/exhaust systems impacted by ceiling/wall work	1,015	m2	21.00 21,300	
Sprinklers - remove/replace as impacted by work	1,015	m2	9.00 9,100	
HVAC - re/re heating pipework, heaters, ducts etc	1,015	m2	35.00 35,500	
Asbestos & Lead Paint Remediation	1,015	m2	35.00	**35,500**
Contractor Site Overheads & Markup			17.5%	**177,000**
Design Contingency & Unspecified Risk (incl. on site)			15%	**178,400**
TOTAL - SEISMIC RETROFIT CONSTRUCTION ESTIMATE				**$1,366,900**