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Screening of Buildings for Seismic Considerations

Screening Tool Based on 2005 and 2010 NBCC

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NRC-Seismic Screening Manual for Buildings in Canada

- NRC developed the Canadian seismic screening manual in 1992 by modifying the ATC-21 document dated 1989.
- It was adopted to the Canadian seismicity and building practices on the basis of the NBCC-1990.
- It was further modified to include the inspection of buildings not only from outside (walk down survey), but also from inside, as well as the inspection of drawings.

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NRC-Seismic Screening Manual for Buildings in Canada

- The method used in the Screening Manual is based on the computation of seismic priority index as the product of factors that affect building performance during earthquakes.
- These factors are relate to the seismic requirements of the NBCC-1990, which reflect the Canadian seismicity incorporated into the NBCC-1985. The 1985 seismic hazard map was expressed in terms of Seismic Zones

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Seismic Priority Index

Structural Index, SI:

$$SI = A * B * C * D * E$$

Non-Structural Index, NSI:

$$NSI = B * E * F$$

Seismic Priority Index, SPI:

$$SPI = SI + NSI$$

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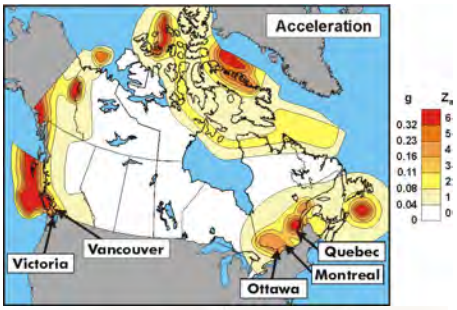
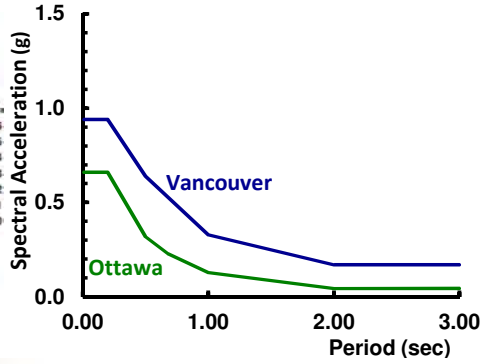
Seismic Hazard



Hazard Map by GSC

In 1990 NBCC, hazard is expressed in terms of Seismic Zones



In 2005 and 2010 NBCC, hazard is expressed in terms of UHS

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Seismicity Index – A

Province : Ontario
City : Ottawa

NBC-95	
Za =	4
Zv =	2
v =	0.10

NBC-2005	
Sa(0.2) =	0.66
Sa(0.5) =	0.32
Sa(1.0) =	0.13
Sa(2.0) =	0.044

Seismicity (A)

Period(sec)	Frame Category	Design NBC Pre-65	65-84	85-05	Post-05
Ta <= 1.0	All Frame	2.3	1.5	1.5	1.0
1.0 < Ta < 2.0	All Frame	1.3	0.9	0.9	1.0
2.0 <= Ta	MRF	0.6	0.4	0.4	1.0
	BRF	0.8	0.5	0.5	1.0
	SWF	1.3	0.9	0.9	1.0

For buildings with T<= 0.5 sec designed prior to 2005, Factor A may be multiplied by 2/3 if the building has some ductility (Rd >=1.5 as per NBCC-2005).

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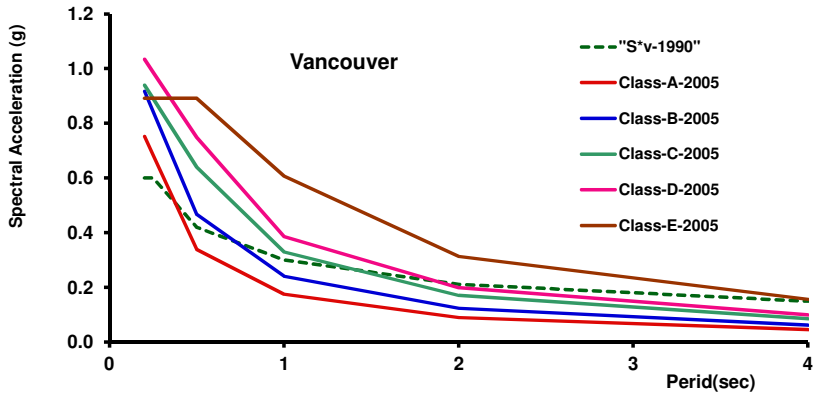
Effect of Soil Conditions - B



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Effect of Soil Conditions - B

NBCC-2005		NBCC-1990	
Site Class	Soil Profile Name	Categories	Type and Depth of Soil*
A	Hard Rock	1	Rock, dense and very dense coarse-grained soils, less than 15 m deep
B	Rock		
C	Very Dense Soil and Soft Rock	2	Compact coarse-grained soils, less than 15 mm deep.
D	Stiff Soil	3	Very loose and loose coarse grained soils greater than 15 m in depth
E	Soft Soil	4	Very soft and soft fine-grained soils greater than 15 m in depth.

$$B_{(65-05)} = B_{(Post\,65)} \frac{R_a or\ R_v}{F_{(1990)}}$$

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Effect of Soil Conditions - B (Ottawa)

Soil Conditions (B)

Period(sec)	Soil Category	Design NBC Pre-65	65-84	85-05	Post-05
Ta <= 0.2	Class A	0.8	0.8	0.8	1.0
	Class B	0.9	0.9	0.9	1.0
	Class C	1.0	0.8	0.8	1.0
	Class D	1.1	0.8	0.8	1.0
	Class E	1.2	0.9	0.9	1.5
Ta = 0.5	Class A	0.5	0.5	0.5	1.0
	Class B	0.6	0.6	0.6	1.0
	Class C	1.0	0.8	0.8	1.0
	Class D	1.4	0.9	0.9	1.0
	Class E	2.1	1.6	1.6	1.5
1.0 <=Ta	Class A	0.5	0.5	0.5	1.0
	Class B	0.6	0.6	0.6	1.0
	Class C	1.0	0.8	0.8	1.0
	Class D	1.4	0.9	0.9	1.0
	Class E	2.1	1.6	1.6	1.5

For all other soils, site-specific evaluation is required.

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Condominium in Concepcion

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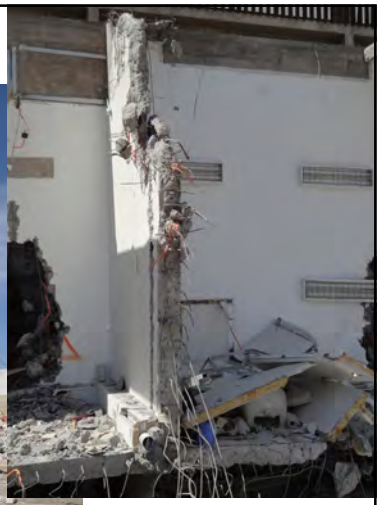
Shear wall detailing



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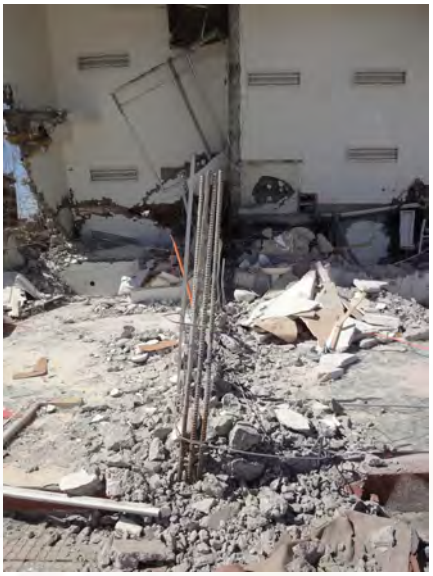

Splice Failure

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Type of Structure - C

- Factor for Type of Structure reflects the toughness of the structure. A low value indicates the structure has sufficient strength and deformability to absorb seismic induced energy.
- Inelastic deformability was reflected in earlier codes through coefficient K and then by coefficient R.
- NBCC-2005/2010 uses $R_d R_o$ product to reduce elastic force levels in exchange of seismic design and detailing of individual elements. This product can be perceived to be approximately equal to the R/U used in NBCC-1990.

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Type of Structure - C

- R_d and R_o values corresponding to full ductility, moderate ductility and conventional construction were used when $S_a(0.2) > 0.75$; $0.2 \leq Sa(0.2) \leq 0.75$ and $S_a(0.2) < 0.2$, respectively.

Type of Structure (C)
(For construction type and abbreviations please see Help)

Design	Wood		Steel				Concrete		Precast		Masonry(Infill)	Masonry	
NBC	WLF	WPB	SLF	SMF	SBF	SCW	CMF	CSW	PCF	PCW	SIW,CIW	IRML,RMC	URM
Pre-70	1.4	1.6	1.0	1.6	2.0	2.0	2.5	2.0	4.3	3.4	3.3	2.8	3.5
70-BM	1.4	1.6	1.0	1.6	2.0	1.5	1.5	1.5	3.1	2.6	2.2	1.7	3.5
BM-05	1.2	1.3	1.0	1.3	1.3	1.0	1.0	1.0	1.7	1.7	1.1	1.1	****
Post-05	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	****

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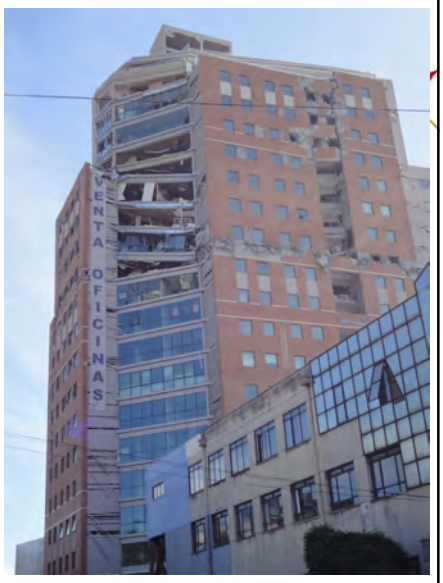

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Building Irregularities - D

- Vertical Irregularities
- Horizontal Irregularities
- Short Concrete Columns
- Soft Storey
- Pounding
- Modification
- Deterioration

Building Irregularities (D)

(D = product of applicable irregularity factors; not to exceed 4.0)

Design NBC	Vertical	Horizontal	Short Concrete Columns	Soft-Storey	Pounding	Modification	Deterioration	None
Pre-70	1.3	1.5	1.5	2.0	1.3	1.3	1.3	1.0
Post-70	1.3	1.5	1.5	1.5	1.3	1.0	1.3	1.0

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Building Importance - E

Post Disaster	Special Operational Req.	Others

N = Occupied Area x Occupancy Density x Duration Factor

- Low occupancy: N<10
- Normal occupancy: N= 10 to 300
- School or high occupancy: N= 301 – 3000
- Post disaster or very high occupancy: N> 3000
- Special operational requirements

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Building Importance - E

Parameters of "N"

Primary Use	Occupancy Density (persons/m^2)	Average Weekly Hours of Human Occupancy
Assembly	1	5 – 50
Mercantile, Personal service	0.2	50 – 80
Offices, Institutional, Manufacturing	0.1	50 – 60
Residential	0.05	100
Storage	0.01 – 0.02	100

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Building Importance - E

Building Importance (E)

(For computation of N in the Table, please see Help)

Design NBC	Low Occupancy N < 10	Normal Occupancy N=10 - 300	High Occupancy N = 301 - 3000	Post Disaster, or Very High Occup. N > 3000	Special Operational Requirements
Pre-70	0.7	1.0	1.5	2.0	3.0
Post-70	0.7	1.0	1.2	1.5	2.0

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Non-Structural Hazard - F

- Falling hazards
- Hazards to vital operations

Non-Structural Hazards (F) {F= Max (F1,F2) }

				None	Yes	Yes*
F1	Falling Hazards to Life	Pre-70	NBC	1.0	3.0	6.0
		Post-70	NBC	1.0	2.0	3.0
F2	Hazards to Vital Operations	Any Year		1.0	3.0	6.0

* Only if one or more of the following types of structure and/or building irregularity apply.
SMF, CMF, Soft-Storey, Horizontal Irregularity

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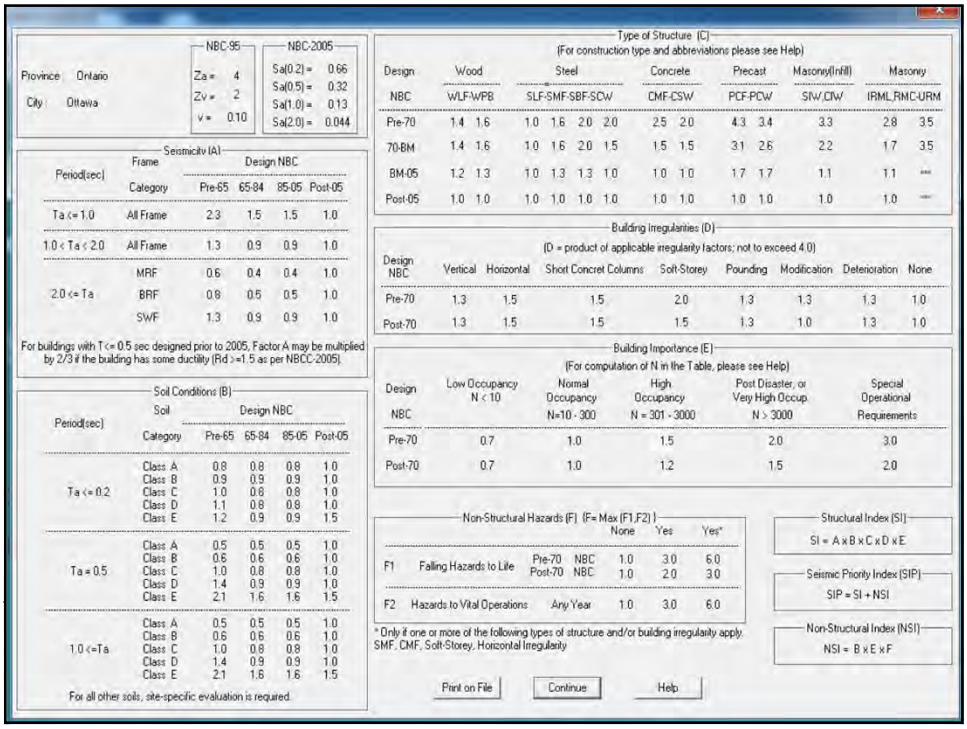
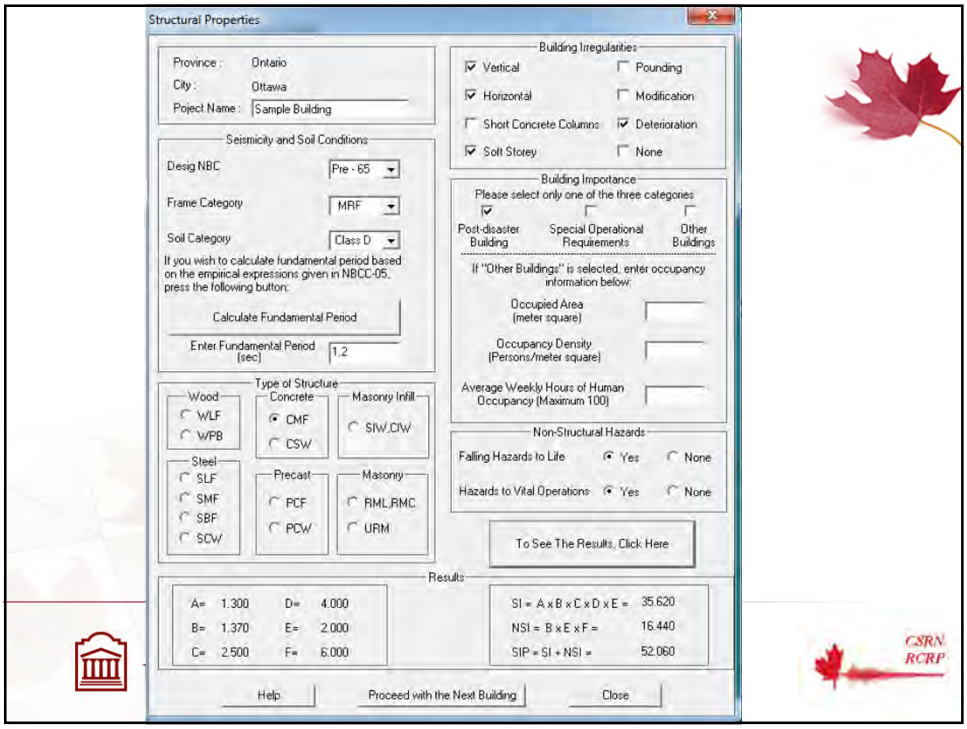

Province Ontario
City Ottawa
NBC-95
Za = 4
Zv = 2
v = 0.10
NBC-2005
Sa(0.2) = 0.66
Sa(0.5) = 0.32
Sa(1.0) = 0.13
Sa(2.0) = 0.044
Seismicity (A)
Soil Conditions (B)
Type of Structure (C)
(For construction type and abbreviations please see Help)
Building Irregularities (D)
(D = product of applicable irregularity factors; not to exceed 4.0)
Building Importance (E)
(For computation of N in the Table, please see Help)
Non-Structural Hazards (F) (F= Max (F1,F2))
Structural Index (SI)
SI = A x B x C x D x E
Seismic Priority Index (SIP)
SIP = SI + NSI
Non-Structural Index (NSI)
NSI = B x E x F
* Only if one or more of the following types of structure and/or building irregularity apply: SMF, CMF, Soft-Storey, Horizontal Irregularity
Print on File
Continue
Help


Structural Properties
Province : Ontario
City : Ottawa
Poject Name : Sample Building
Seismicity and Soil Conditions
Desig NBC
Pre - 65
Frame Category
MRF
Soil Category
Class D
If you wish to calculate fundamental period based on the empirical expressions given in NBCC-05, press the following button:
Calculate Fundamental Period
Enter Fundamental Period (sec)
1.2
Type of Structure
Wood
WLF
WPB
Concrete
CMF
CSW
Masonry Infill
SIW,CIW
Steel
SLF
SMF
SBF
SCW
Precast
PCF
PCW
Masonry
RML,RMC
URM
Building Irregularities
Vertical
Horizontal
Short Concrete Columns
Soft Storey
Pounding
Modification
Deterioration
None
Building Importance
Please select only one of the three categories
Post-disaster Building
Special Operational Requirements
Other Buildings
If "Other Buildings" is selected, enter occupancy information below:
Occupied Area (meter square)
Occupancy Density (Persons/meter square)
Average Weekly Hours of Human Occupancy (Maximum 100)
Non-Structural Hazards
Falling Hazards to Life
Yes
None
Hazards to Vital Operations
Yes
None
To See The Results, Click Here
Results
A= 1.300
B= 1.370
C= 2.500
D= 4.000
E= 2.000
F= 6.000
SI = A x B x C x D x E = 35.620
NSI = B x E x F = 16.440
SIP = SI + NSI = 52.060
Help
Proceed with the Next Building
Close
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Ranking of Screening Indices

- Higher scores in screening indices indicate higher priority for further evaluation
- It is difficult to define the level of “acceptable score”
- SI or NSI score of 1.0 to 2.0 indicate compliance with NBCC-2005 and NBCC-2010
- SPI < 10 indicates low priority
- SPI of 10 to 20 indicates medium priority
- SPI > 20 indicates high priority
- SPI > 30 can be considered potentially hazardous

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EXAMPLES AND USE OF “SCREEN”

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Seismic Risk Assessment of Concrete Structures in Ottawa

Dr. M. Saatcioglu, Civil Engineering, uOttawa
Dr. S. Tesfamariam, Civil Engineering, UBC
Dr. M. Sawada, Geography, uOttawa
Ms. Kate Ploeger, Geography, uOttawa
Mr. Amid Elsabbagh, Civil Engineering, uOttawa
Mr. Erik Selin, Mathematics/Computer Science, uOttawa

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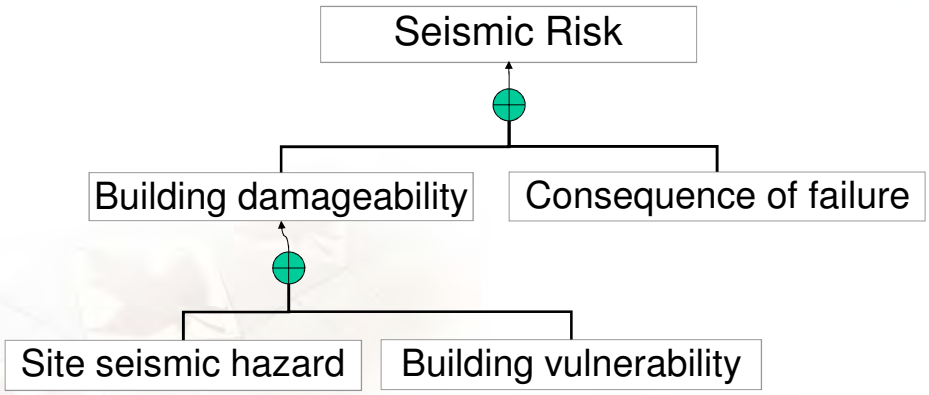
Seismic Risk

Risk = Building damageability x Consequence of failure



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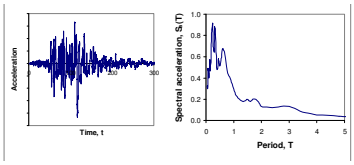
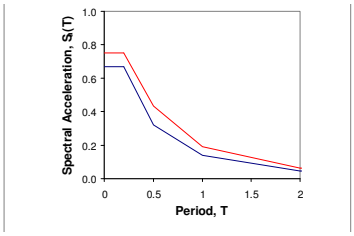
Site Seismic Hazard

- Canadian seismicity is expressed in the National Building Code of Canada in terms of Uniform Hazard Spectra (UHS)
- UHS compatible synthetic ground motion records have been generated
- Soil amplification effects can be considered as per NBCC
- Seismic microzonation is available for various cities in Canada, including the City of Ottawa, providing the basis for site-specific risk analysis

Site specific earthquake record



Site specific design response spectrum



Compute spectral acceleration (S_a)

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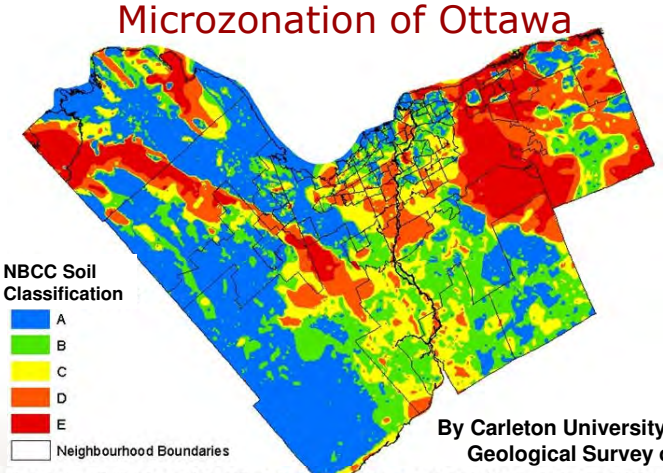
Microzonation of Ottawa



By Carleton University and NRCan, Geological Survey of Canada

J.A. Hunter, D. Motazedian & K. Kaheshi-Banab, G.R. Brooks, M. Lamontagne, H. Crow, T. Cartwright, A. Pugin, M. Pyne. DATA COLLECTION FOR EARTHQUAKE HAZARD MAPPING IN THE OTTAWA AREA. In : J. Locat, D. Perret, D. Turmel, D. Demers et S. Leroueil, (2008). *Comptes rendus de la 4e Conférence canadienne sur les géorisques: des causes à la gestion. Proceedings of the 4th Canadian Conference on Geohazards : From Causes to Management.* Presse de l'Université Laval, Québec, 594 p.

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Building Vulnerability

Can be assessed in three different levels of complexity and accuracy:

- Tier I – Screening based on walk-down survey
- Tier II – Detailed evaluation using simple computations
- Tier III – Dynamic Response History Analysis

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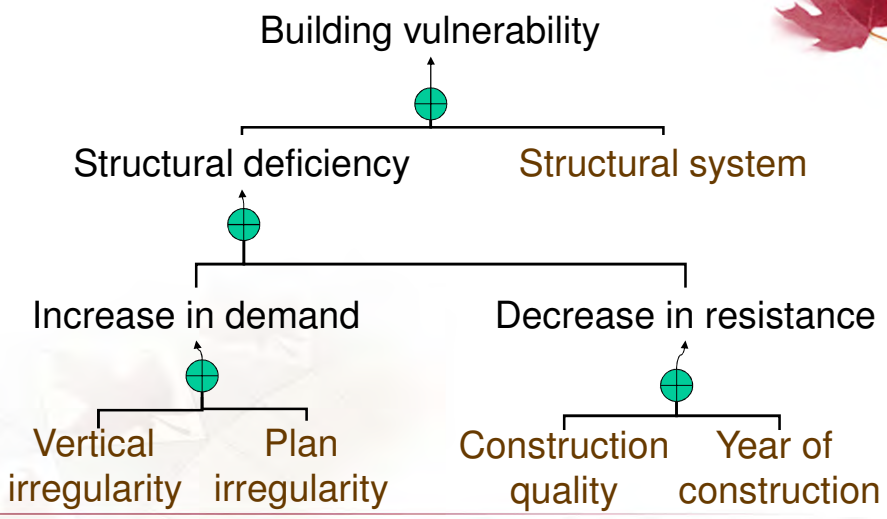
Tier – I Evaluation



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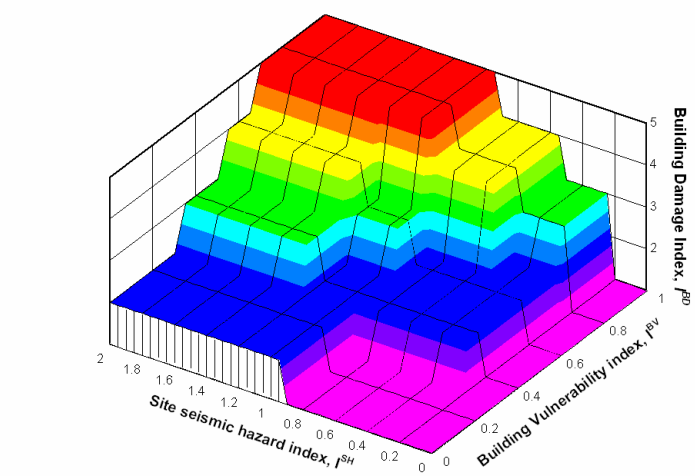
Building Damageability



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Consequence of Failure

Building importance/ exposure

Functional use Occupancy Economic impact

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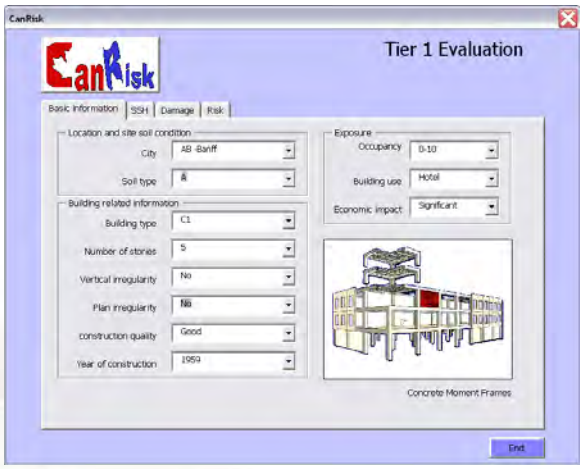
Risk Assessment Tool



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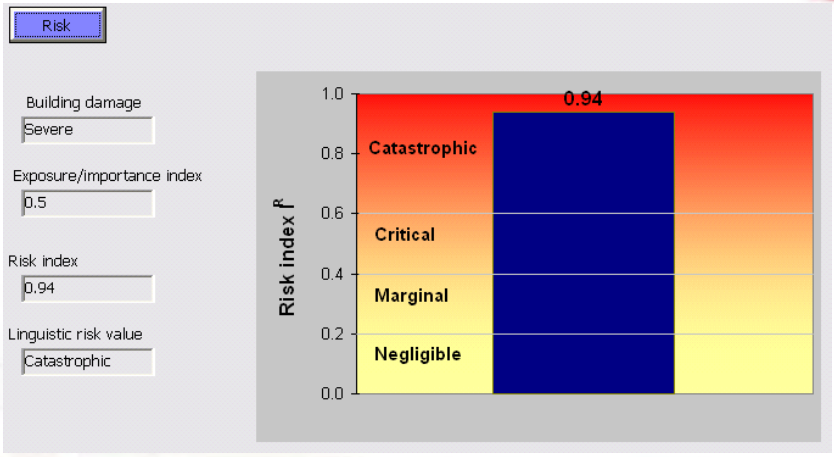
Risk Assessment Tool



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Tier – II Evaluation

However, the parameters that contribute to Building Vulnerability are far too complex

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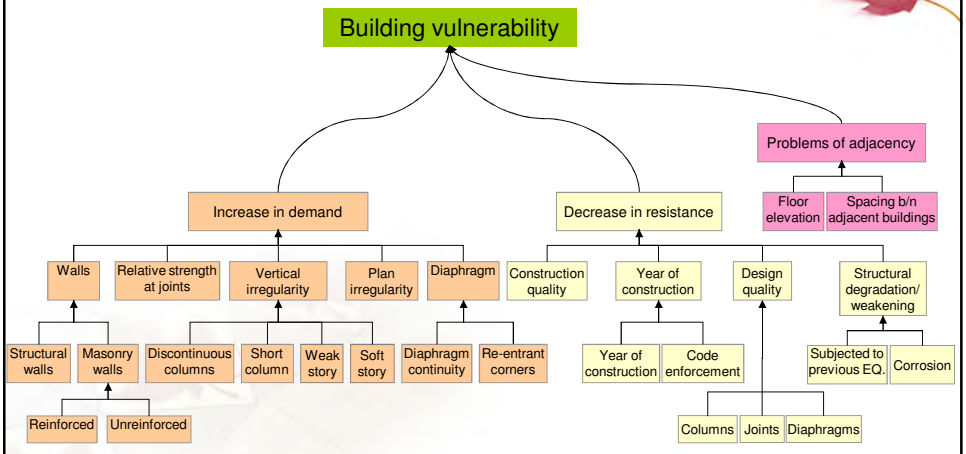
Tier – II Evaluation



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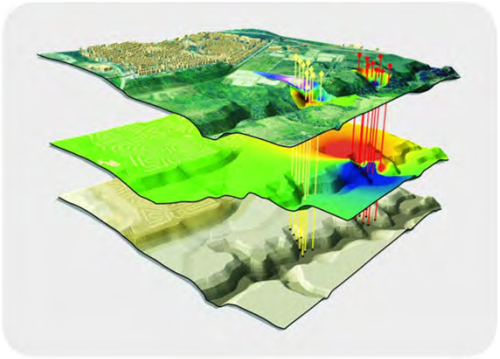
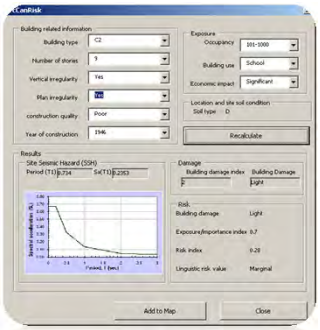


•arcCanRisk



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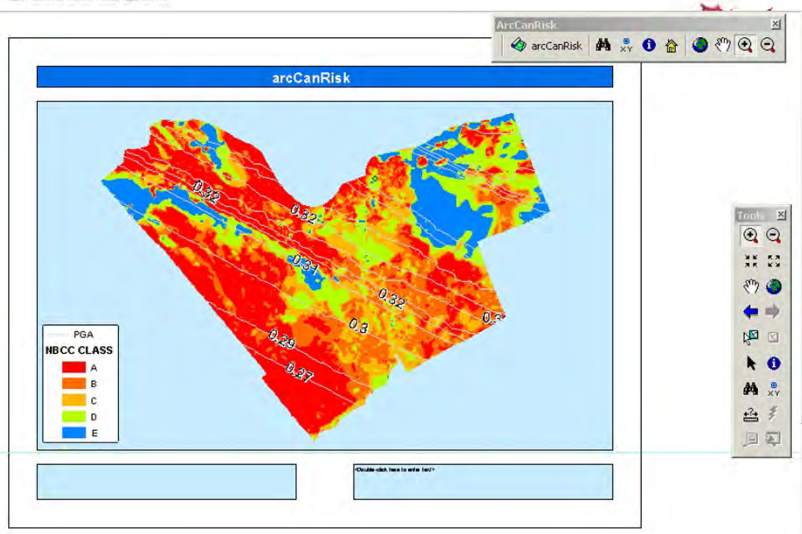
arcCanRisk



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arcCanRisk – Future directions

- Addition of other structures for assessment
- Incorporation of OFCs
- Incorporation of Tier 3 analysis
- ArcGIS 10 add-on integration
- Web-based analysis
- Area based assessments.
- Incorporation of Social Consequences/Casualties Module
- Incorporation of Economic Consequences Module
- Emergency Response Tool (first 72 hours)

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DEMONSTRATION OF A WEB-BASED SEISMIC RISK ASSESMENT TOOL

CanRisk Google

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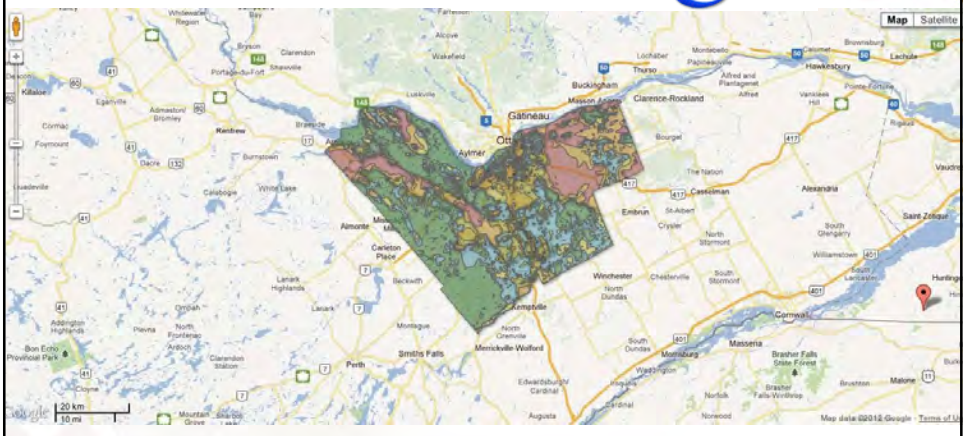
CanRisk Google



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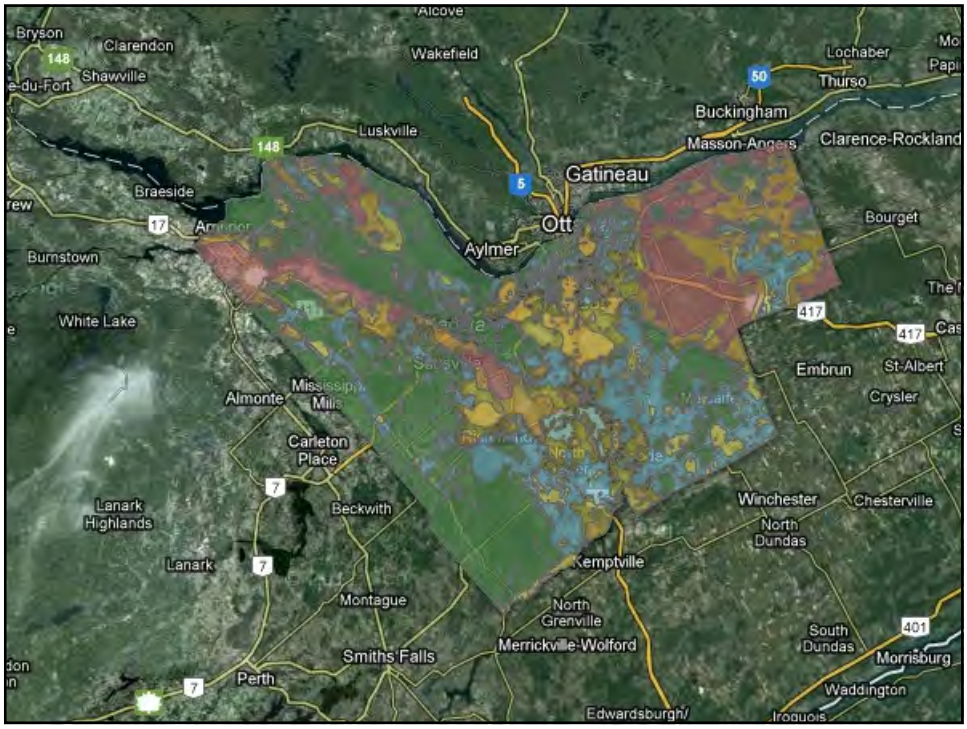
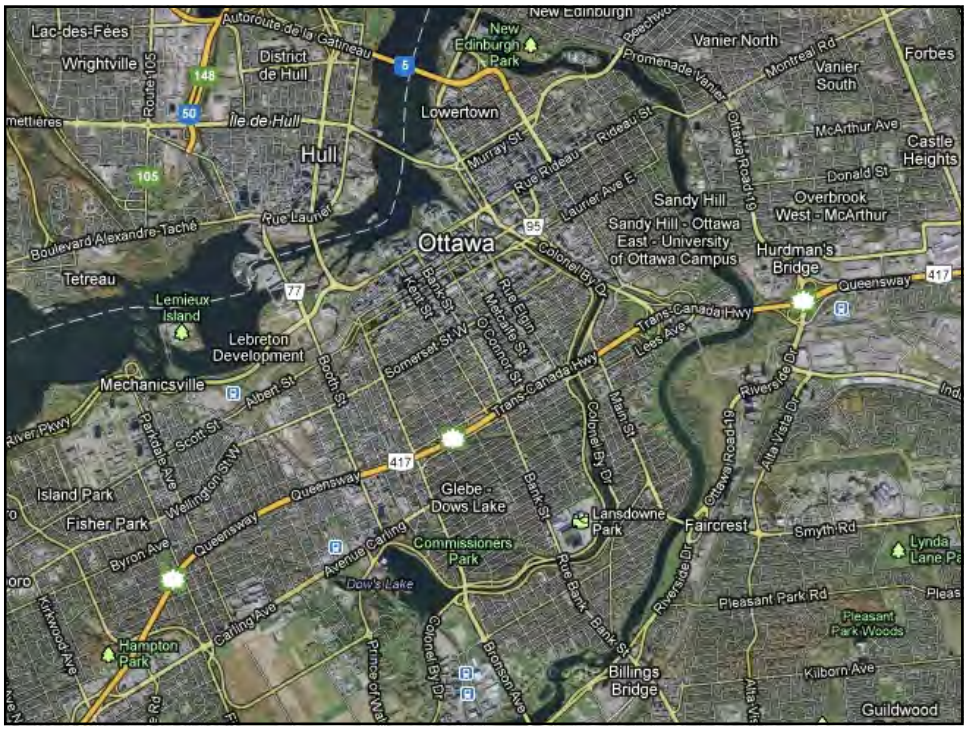
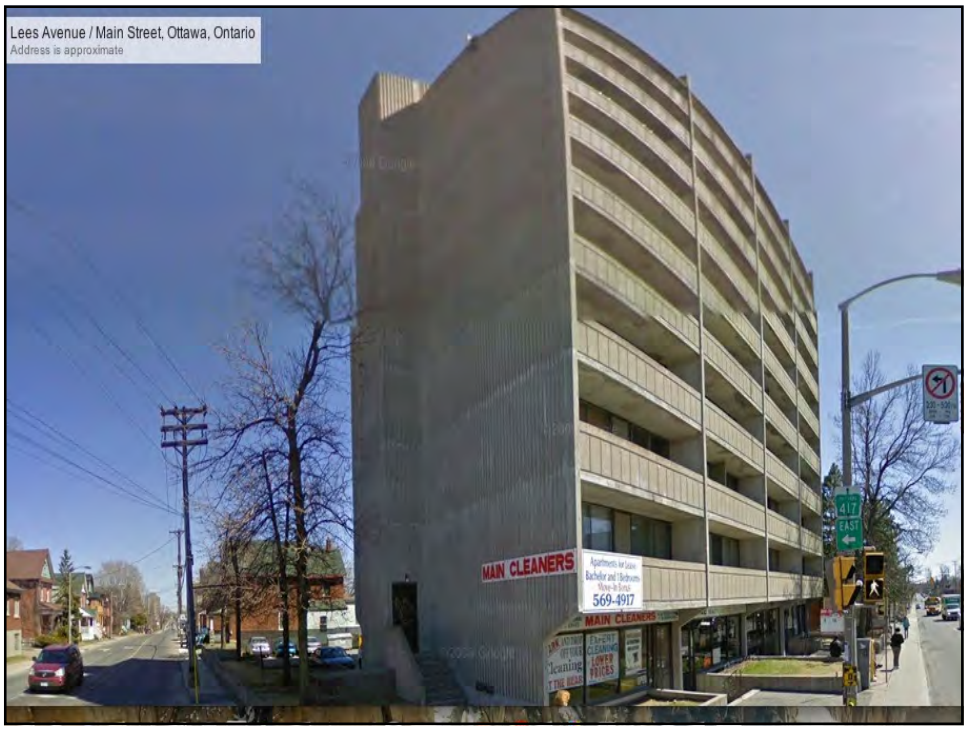
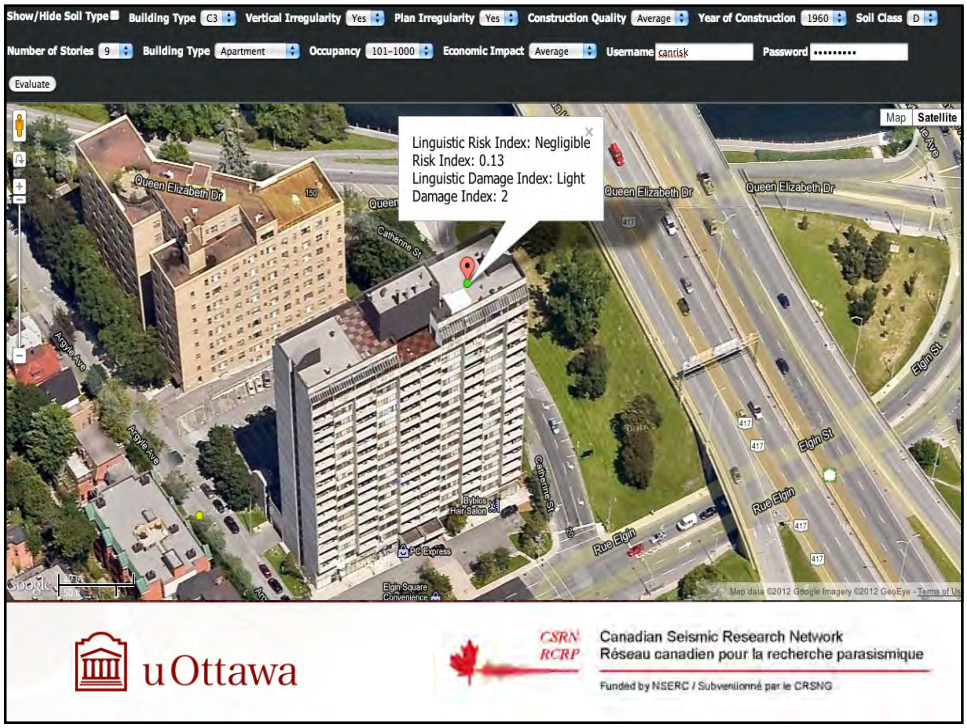

Alcove
Bryson
Clarendon
Wakefield
Lochaber
Thurso
Shawville
Buckingham
Luskville
Masson-Angers
Clarence-Rockland
Gatineau
Braeside
Ott
Aylmer
Bourget
Burnstown
White Lake
Embrun
St-Albert
Crysler
Almonte
Carleton Place
Lanark Highlands
Beckwith
Winchester
Chesterville
North Dundas
Lanark
Kemptville
Montague
North Grenville
South Dundas
Merrickville-Wolford
Smiths Falls
Morrisburg
Perth
Waddington
Edwardsburgh/


Lac-des-Fées
Wrightville
District de Hull
New Edinburgh Park
Vanier North
Forbes
Vanier South
Lowertown
Île de Hull
Hull
McArthur Ave
Castle Heights
Donald St
Overbrook
West - McArthur
Sandy Hill
Sandy Hill - Ottawa East - University of Ottawa Campus
Ottawa
Hurdman's Bridge
Tetreau
Lemieux Island
Lebreton Development
Mechanicsville
Island Park
Fisher Park
Glebe - Dows Lake
Lansdowne Park
Faircrest
Smyth Rd
Commissioners Park
Dow's Lake
Pleasant Park Rd
Pleasant Park Woods
Hampton Park
Billings Bridge
Kilborn Ave
Guildwood


The Clock Tower
Peace Latvian Ev Lutheran Church
Lees Ave
Main Haircutters
Lady Evelyn Alternative School
Riverside Montessori Pre-School
New Testament Assembly


Lees Avenue / Main Street, Ottawa, Ontario
Address is approximate
MAIN CLEANERS
569-4917
MAIN CLEANERS
417
EAST


Show/Hide Soil Type
Building Type C3
Vertical Irregularity Yes
Plan Irregularity Yes
Construction Quality Average
Year of Construction 1960
Soil Class D
Number of Stories 9
Building Type Apartment
Occupancy 101-1000
Economic Impact Average
Username canrisk
Password
Evaluate
Linguistic Risk Index: Negligible
Risk Index: 0.13
Linguistic Damage Index: Light
Damage Index: 2
Map
Satellite
Queen Elizabeth Dr
Catherine St
Argyle Ave
Elgin St
Rue Elgin
Rue Elgin
Elgin Square Convenience
Map data ©2012 Google Imagery ©2012 GeoEye - Terms of Use
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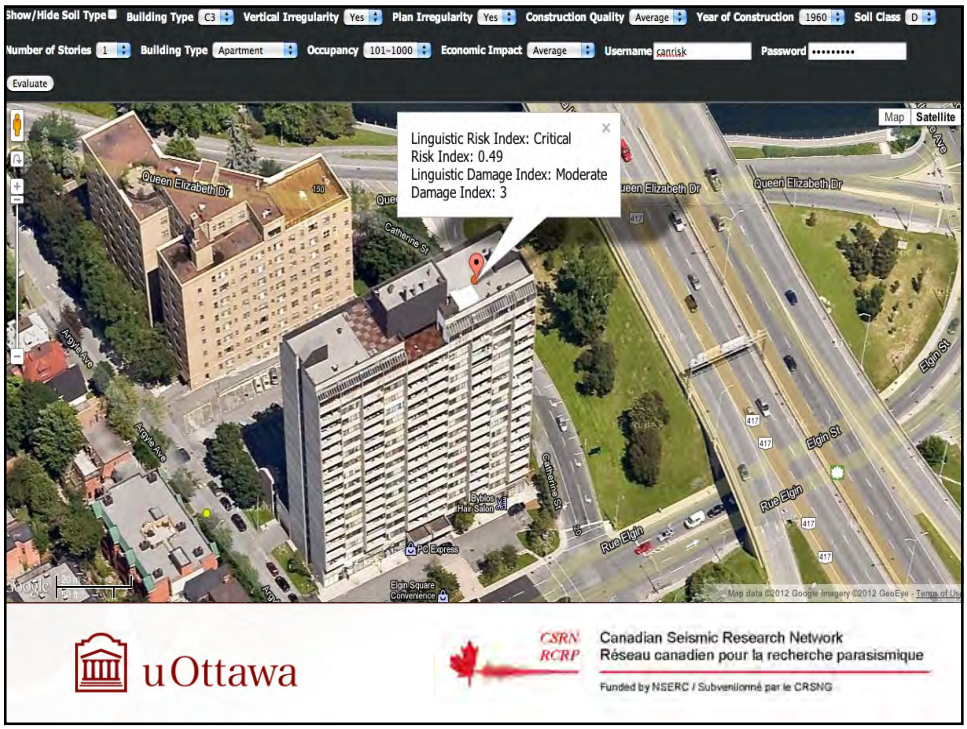
Show/Hide Soil Type
Building Type C3
Vertical Irregularity Yes
Plan Irregularity Yes
Construction Quality Average
Year of Construction 1960
Soil Class D
Number of Stories 1
Building Type Apartment
Occupancy 101-1000
Economic Impact Average
Username canrisk
Password
Evaluate
Linguistic Risk Index: Critical
Risk Index: 0.49
Linguistic Damage Index: Moderate
Damage Index: 3
Map
Satellite
Queen Elizabeth Dr
Catherine St
Argyle Ave
Elgin St
Rue Elgin
Rue Elgin
Elgin Square Convenience
Map data ©2012 Google Imagery ©2012 GeoEye - Terms of Use
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Data Collection for City of Ottawa

- Google Earth
- Street view
- Bing Maps
- ArcGIS
- ArcObjects
  - Visual Studio.Net
- Android Tablet/Smartphone Technology
  - App Inventor
  - Eclipse Android SDK (Java)

- GIS layers
- Field Data Collection
- Lab Data Collection

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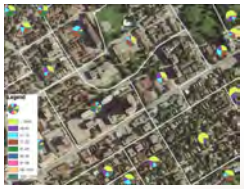
Data Collection for City of Ottawa



- Footprints
- Statistics Canada
- Zoning Data

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Data Collection – City of Ottawa

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City of Ottawa

- A total of 6233 buildings have been surveyed to date.
- Of this number, 5105 are single family, multi-family/duplex dwellings.
- The remaining (1128) are multi-story buildings of different use and occupancy categories.

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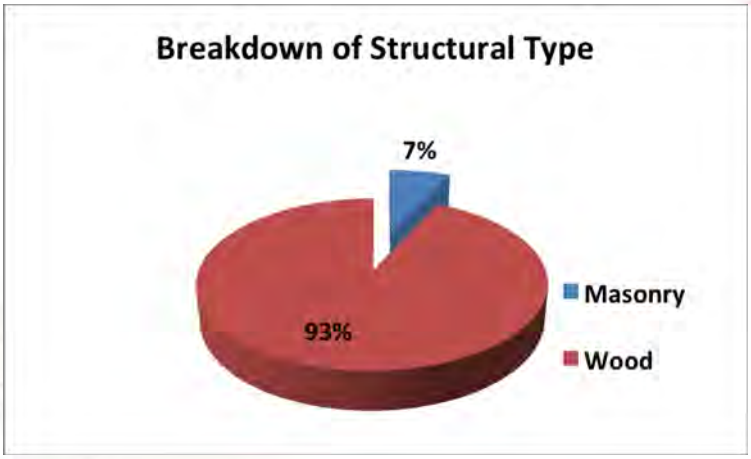
City of Ottawa

Single-family, Multi-family/duplex Dwellings



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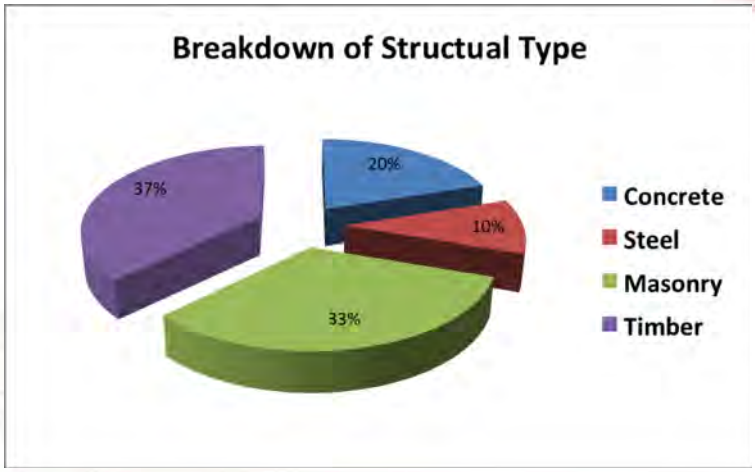
City of Ottawa

Multi-story buildings



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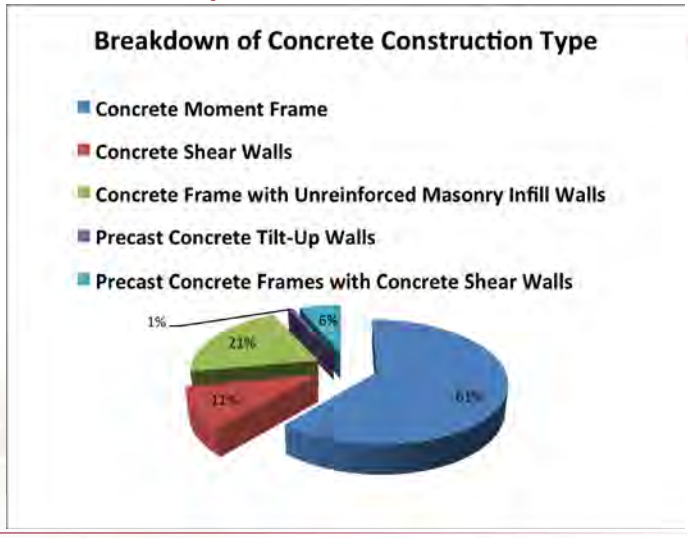
City of Ottawa



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Thank You….

Questions and Comments?

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