GEOLOGICAL SURVEY OF CANADA
OPEN FILE 7345

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Hazard Mitigation & Disaster Management Research Center

Centre de recherche en atténuation des risques et gestion des catastrophes

uOttawa

DESKTOP/MOBILE GIS APP

M. SAWADA, S.K. PLOEGER, A. ELSABBAGH, M. SAATCIOGLU, E. ROSETTI & M. NASTEV

A software system has been developed that seamlessly integrates desktop GIS, Google APIs and the mobile Android SDK for the purpose of collecting HAZUS related variables for building stock. The report outlines the software and provides a user-guide.

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SUMMARY

A software system has been developed that seamlessly integrates desktop GIS, Google APIs and the mobile Android SDK. This system programmed within the .NET environment integrates Google StreetView within desktop ArcGIS for an in-lab virtual assessment and visual data assessment of buildings. For on-site assessment, the Android SDK has been used to create a custom app that provides seamless communication between the app and add-in via a common JSON or schema or via CSV files. This system substantially increases the efficiency of data collection and allows future HAZUS users to collect structural information on thousands of buildings within a very small time-span when compared to manual sidewalk survey methods. The system architecture has been validated using the existing building stock in Ottawa. The software will be made available on the projects web site for other HAZUS users.

BACKGROUND

Canadian municipalities and other levels of government face a pressing need to perform an all-hazard risk assessment in order to meet regulatory requirements and inform planning and mitigation decisions. The ongoing ESS Public Safety Geoscience Program - Risk Assessment Project will provide knowledge, methods and products to develop and update a quantitative best-practices approach for risk assessment from natural hazards.

In order to assess and mitigate potential impacts of natural hazards such as an earthquake, it is necessary to have not only an understanding of the potential seismic event but also of the characteristics of the built environment that may be impacted. The present research tool aims to contribute to the adaptation of an existing standardized tool, FEMA-HAZUS, for seismic risk assessment of Canadian urban centers by providing software for rapid building inventory creation - Integrated desktop/mobile GIS application for inventory of the existing built environment.

The tool described herein operates in ArcGIS 10.x and Google Android and is designed specifically for the collection of building inventory data and so contributes to the adaptation of an existing standardized tool, FEMA-HAZUS, for seismic risk assessment of Canadian municipalities. HAZUS uses standardized classification tables for general building stock and consists of building type and occupancy. There are four major building material types (wood, steel, concrete, and masonry) divided further into 36 building classes according to the structural system and height. A given model building type can be designed to pre-, low-, moderate-, or high-code seismic standards. The occupancy classification of the general building stock is broken into seven general occupancy groups, for a total of 33 specific occupancy classes. The tool herein allows for the collection of parameters based on FEMA 154 and FEMA 310 that can be used for both tier-1 and tier-2 evaluations, and is compatible with earthquake loss estimation programs such as HAZUS-MH.

URBAN RAPID ASSESSMENT TOOLS (URAT) TOOLS

The tool described herein is a number of pieces of software that work together to facilitate the rapid and intense data collection of advanced engineering parameters geared towards earthquake loss estimation research. The toolset is collectively referred to as “Urban RAT” and contains two applications, one that works with ESRI ArcGIS 10.x “Urban RAT Lab” and the other works on the Google Android operating

system “Urban RAT Mobile”. Urban RAT encompasses both in-lab and on-site data collection applications. This suite allows (1) in-lab / virtual site assessment data collection using a customized Add-in for ArcGIS 10.x integrated with a Google Street View API, (2) in-field / on-site data collection using an Android-platform application, and (3) a seamless synchronization between ArcGIS-Google-Android by using a common JSON schema or via comma separated values files.

From a structural engineer’s perspective, when large numbers of structures need to be visually assessed, detailed imagery available from Google Inc., such as Google Street View, introduces the possibility of conducting rapid assessment ‘virtually’ and characterizing large numbers of structures and their relationships with each other in a virtual urban landscape

Again, Urban RAT collects parameters based on FEMA 154 and FEMA 310 that can be used for both tier-1 and tier-2 evaluations, and are compatible with earthquake loss estimation programs such as HAZUS-MH. The URAT suite’s framework is designed to incorporate over 40 structural parameters, refer to Table 1 (**See Appendix A for variable descriptions**).

With reference to Table 1, information collected within Urban RAT includes: [1] General information appropriate for tier-1 evaluations and the basic information for the given structural system. [2] and [3] are the major endogenic themes involving advanced engineering parameters regarding building vulnerability, and [4] incorporates an imperative exogenic factor to the structural system during earthquake ground shaking. The full set of variables listed in [1]-[4] are required for high resolution (tier-2 and above) earthquake loss estimation studies.

TABLE 1: VARIABLES COLLECTED TO SUPPORT HAZUS DATA COLLECTION IN THE URBAN RAT SUITE. SEE APPENDIX A FOR DESCRIPTIONS OF VARIABLES.

[1] General	
Building Type	Year of Construction
Address	Number of Stories
Name of Building	Occupancy Class
Vertical irregularity	Occupancy
Plan irregularity	Economic Impact
Construction Quality	Design Quality
[2] Increase in Demand	
Structural Walls	Weak Column-Strong Beam
Redundancy	
Plan Irregularity	
Diaphragm Continuity	Torsional Irregularity
Re-Entrant Corners	
Vertical Irregularity	
Short Column Effect (Captivated Column)	Soft Story Weak Story
[3] Decrease in Resistance	
Deterioration (e.g. Corrosion)	Code Enforcement
Damaged from Previous Earthquake	
[4] Issues with Adjacency	
Floor Elevation	Spacing Between Adjacent Buildings

URBAN RAT TOOL

URAT is an ArcGIS-Google-Android system that contains two components: an in-lab application built within ArcGIS 10.x and the .Net framework (ArcGIS and Google API) and second, an on-site (Google Android) app that collects positional and visual information in addition to inputs that contain the same structural inventory data. The on-site application can be synchronized with the desktop software.

IN-LAB / VIRTUAL SITE ASSESSMENT

The novelty of the system is found in a tight integration with a professional desktop GIS system, ArcGIS 10.x, that has an application programming interface (API) that is customizable within the Microsoft .NET integrated development environment and any programming language supported therein – C# and VB are the most popular (Figure 1). The availability of a complex and complete API encourages quick development of custom Graphical User Interfaces (GUI) that runs natively within the ArcGIS system. Additionally, all of the mapping functionality required by the user is handled by API and therefore development in this manner encompasses all the benefits of object oriented systems which reduces development time, cost and modification. From a data collection perspective, entering data directly into the GIS via user GUI's minimizes error through form-based validation. Secondly, behind the user GUI, the programming that is done in the .NET environment takes advantage of the ArcGIS API (ArcObjects) to create spatial data points where buildings are geographically located as well as adding the data

supplied by the GUI directly into the spatial data tables. In addition, by using the exposed objects in the ArcGIS API, efficiency is enhanced with layers of ancillary information. For example if the building footprint is available, the user can select it for an automatic query, including its area and centroid which can be added to the user form and entered into the structural database for each building. When the user submits the form for the assessment, the program automatically centers the newly created assessment point at the building footprint center (the user has the choice of having that done automatically or manually placing the point should building footprints be unavailable for a particular area).

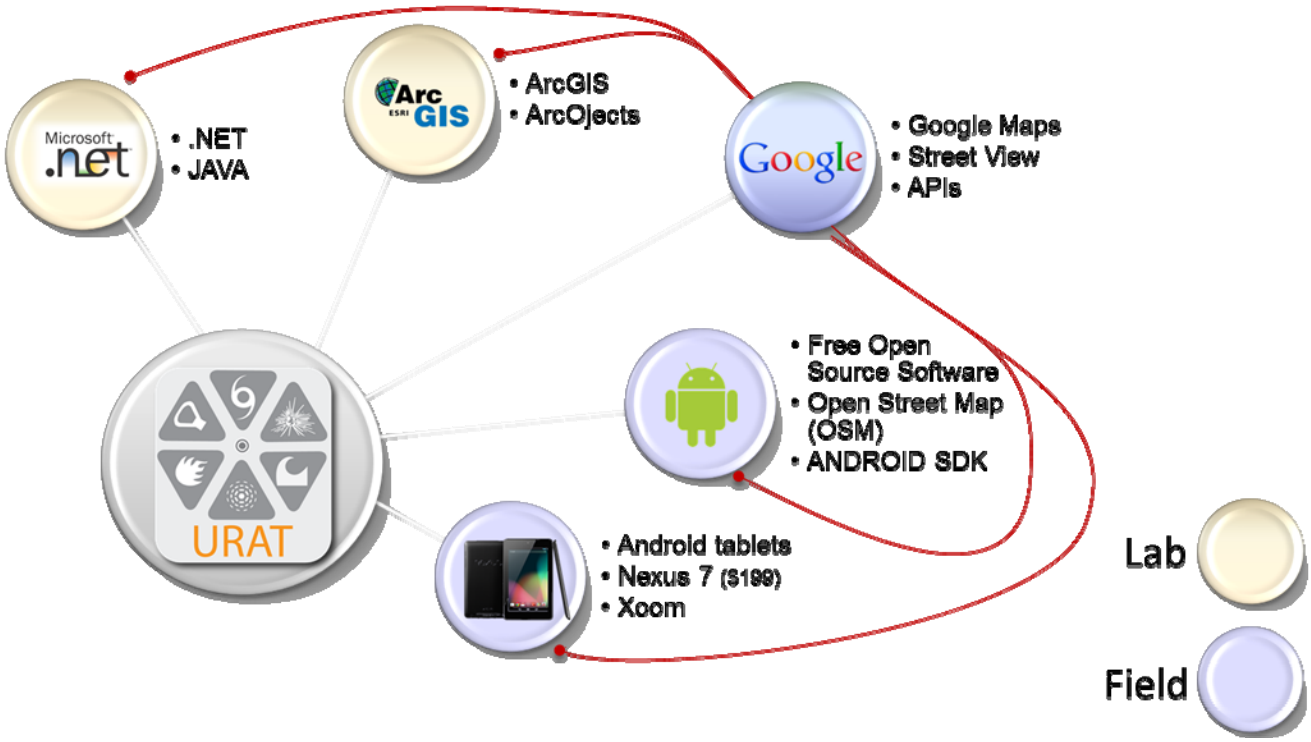


FIGURE 1: URBAN RAT SCHEMATIC

Google has a number of APIs that are available for public consumption that are housed under the company's http://code.google.com/ site. In particular for this project, the Google Maps JavaScript V3 Services API is used for accessing Google Street View from within the ArcGIS custom assessment form. The Google Maps JavaScript API provides the mechanisms used to retrieve and manipulate the imagery stored within the Google StreetView for the City of Ottawa, however, this functionality will work anywhere StreetView is available. Within the .Net program that was created using ArcObjects and the Google API, within ArcGIS, the user first clicks on a property building footprint to assess and then a standard Windows-form opens together with a separate full-screen window that shows that property from Google Street View. The assessor can then interact with the Street View window that is showing the precise location of the building(s) that require assessment. The user can change angles, zoom-in-out or take a different vantage point. This integration was achieved in .NET by using the Google Maps JavaScript V3 Services API and sending it the coordinates from the ArcGIS ArcObjects API acquired when the user clicked on a property. The Google Maps JavaScript V3 API also provides the coordinates to reverse-geocode and automatically acquires an alphanumeric address that is entered

into the database for each assessment. The added benefit of reverse-geocoding extends beyond the realms of structural engineering and into emergency management and response as the identification on the building via its address is essential for the identification of vulnerable buildings for retrofit programs and as geographic 'hotspots' that can experience exceptional seismically-induced damage (hence the deployment of response teams to that address). In addition to the aforementioned benefits, this level of integration drastically reduces the time required to assess a building visually. A noted challenge while building this system, was that the assessor had to manually orient themselves on Google maps and then open Street View and re-orient again to the building of interest. That time consuming process was the impetus for integrating the ArcGIS API with the Google Street View API to provide instant orientation to the assessor.

IN-FIELD / ON-SITE SITE ASSESSMENT

In many cases, the engineer must undertake a site visit to confirm any ambiguous variables. A mobile platform version of the virtual site assessment software was created for a mobile data collection, in this case the Motorola Xoom, Google Nexus 7 and Nexus 10 tablets were used. A further advantage of the mobile application is cross-platform compatibility; it will run on any Android device. The Motorola Xoom and Google Nexus devices were chosen for two reasons: first, they are inexpensive 7 and 10-inch tablets ($199 & $399 respectively) with a full sensor array, that allows for numerous input fields to be placed on a single screen; this avoids the need to swipe across multiple screens in order to enter all of the data for a particular building. Secondly, these tablets are developer devices, receiving new operating systems directly from Google Inc. when they are released, and as such, they contain no vendor specific software running on top of the Android OS (so called 'skins'). These are preferred devices for developing on the Android OS.

The Xoom and Nexus devices employ the Android software development kit (SDK). Unlike .NET integrated development environment (IDE) by Microsoft, the Android SDK is an open source set of tools and software that uses the open IDE called ECLIPSE (which is also packaged with the SDK). The Android SDK has all of the tools necessary for developing mobile 'apps' and uses a subset of the Java programming language that runs on top of Android which is a Linux kernel operating system. Android is developed by the Open Handset Alliance (OHA) which is led by Google Inc.

There is no need to have an active wireless internet connection (Wi-Fi, 3G, 4G or otherwise) with URAT-mobile in order to utilize it in the field and make full use of the sensor array. The GPS functions regardless of the data connection because Google certified Android devices have actual GPS receiver chips within their housing. However, an active data connection will improve the speed at which the GPS chip in the device can acquire a location using assisted GPS which uses Wi-Fi triangulation to acquire an initial position. For this Android application, all data is stored locally on the device as XML and CSV files which can be easily uploaded to the main ArcGIS program when the user returns to the desktop.

URBAN RAT DESKTOP

The in-lab or desktop requirements to run URAT are the following:

1. ArcGIS 10 (SP 2) or 10.1 (SP 1)
2. A live internet connection, preferably broadband wired or 802.11n wireless, or 3G or 4G connection.

3. The ArcGIS 10.x add-in called “Urban RATData” which includes three files, all of which must be in the same folder:
    a. Urban RATData.dll
    b. Urban RATData.esriAddIn
    c. Urban RATData.pdb

    These three files together are an ArcGIS 10.x add-in.

4. The shapefile called TierIIBuildings which is composed of the following four files:
    a. TierIIBuildings.shp
    b. TierIIBuildings.shx
    c. TierIIBuildings.dbf
    d. TierIIBuildings.prj

    This shapefile is of type “POINT” and contains the necessary fields (attributes) that are required for the add-in to work correctly and save each building assessment within the ArcGIS ArcMap environment.

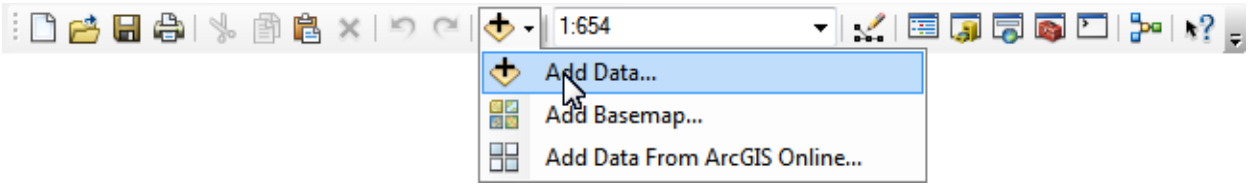
5. **OPTIONAL**: a shapefile called “buildings” which contains building footprints as polygons. The user must supply this file as it would be specific to a particular urban environment. This file is not required for the use of the in-lab assessment tool.

The above files described in requirements 2 and 3 are distributed as a single zip-file called URBAN RAT.ZIP.

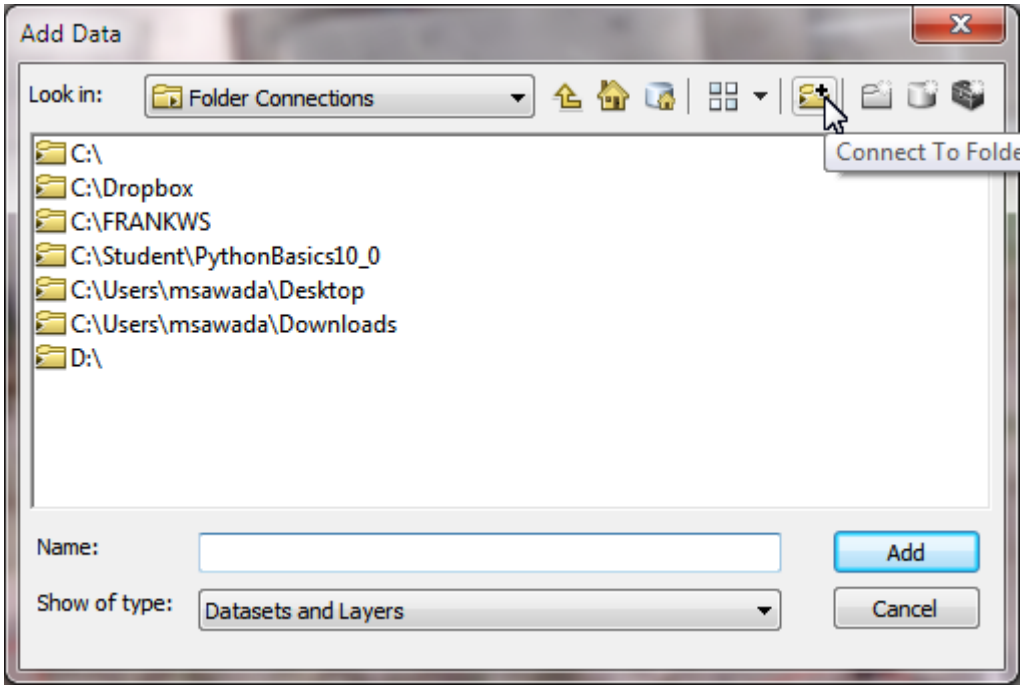
Stage 1: Setting up ArcMap for the URBAN RAT data collection

This stage contains 12 steps that must be followed in order to set-up your ArcMap environment with the data necessary to use the URBAN RAT ArcGIS Add-in for collecting building structural information.

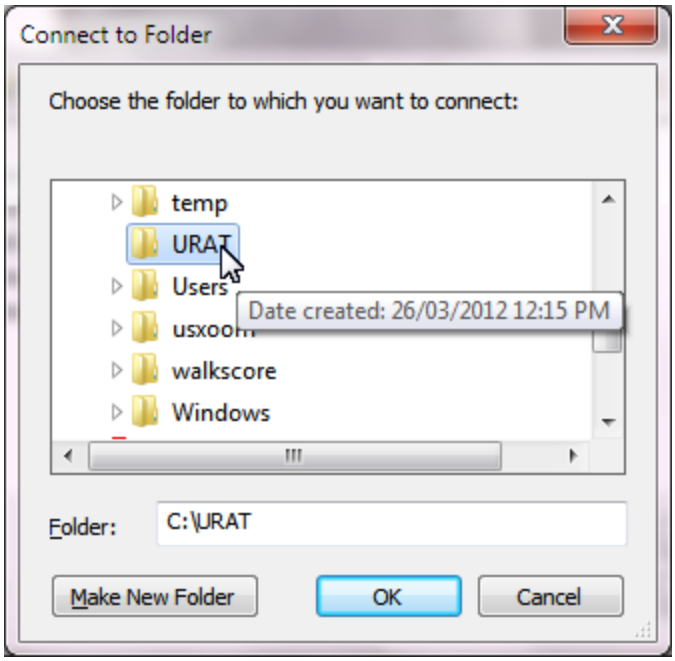
1. Create a folder on your local hard-drive called “URBAN RAT” (You can choose to create a folder by a different name)
2. Download the file URBAN RAT.zip and unzip this into your folder created in Step 1.
3. Open ArcMAP 10.x.
4. Click on the the “Add Data” button:



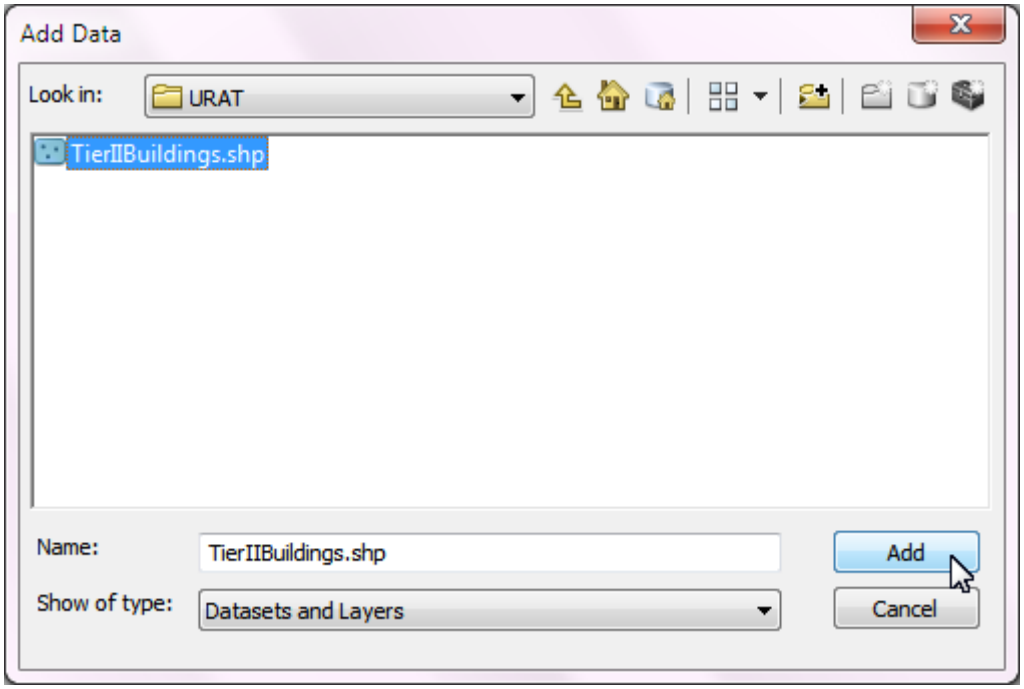
5. In the ‘Add Data’ dialog, click on the “Connect to Folder” button:



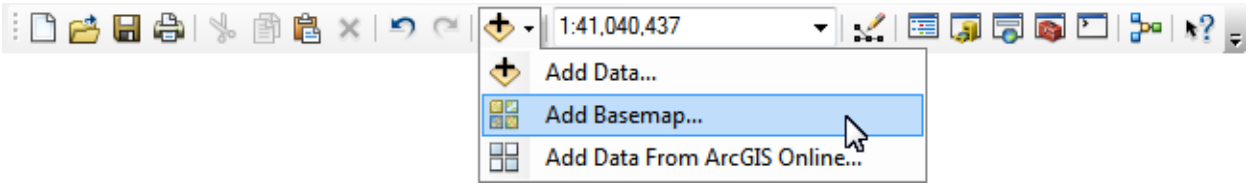
6. In the “Connect to Folder” dialog box, navigate to where you created the “URBAN RAT” folder in Step 1 above. Click on the folder URBAN RAT and click OK.



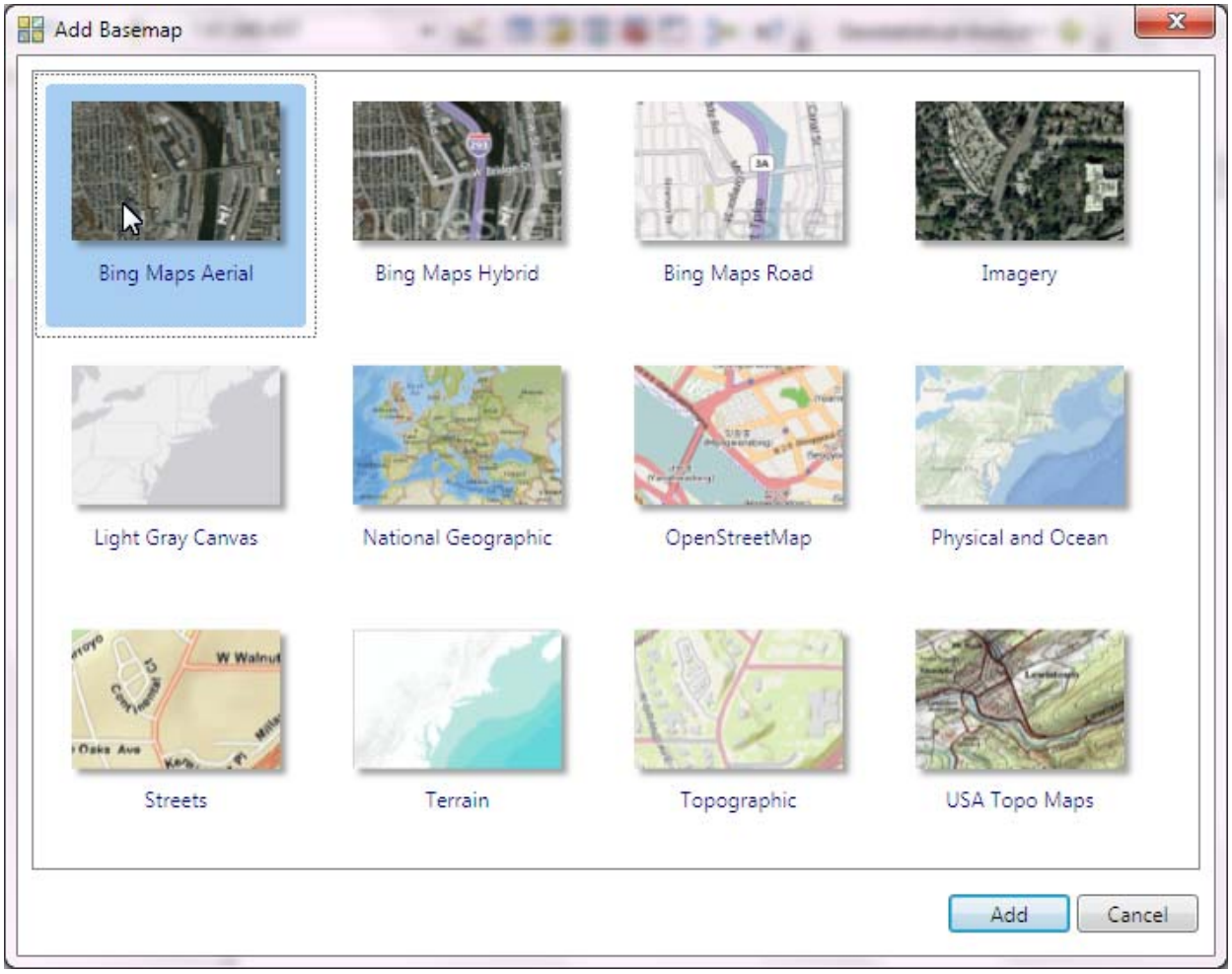
7. You will now see the shapefile called “TierIIBuildings”. Select that file and click the ‘Add’ button.



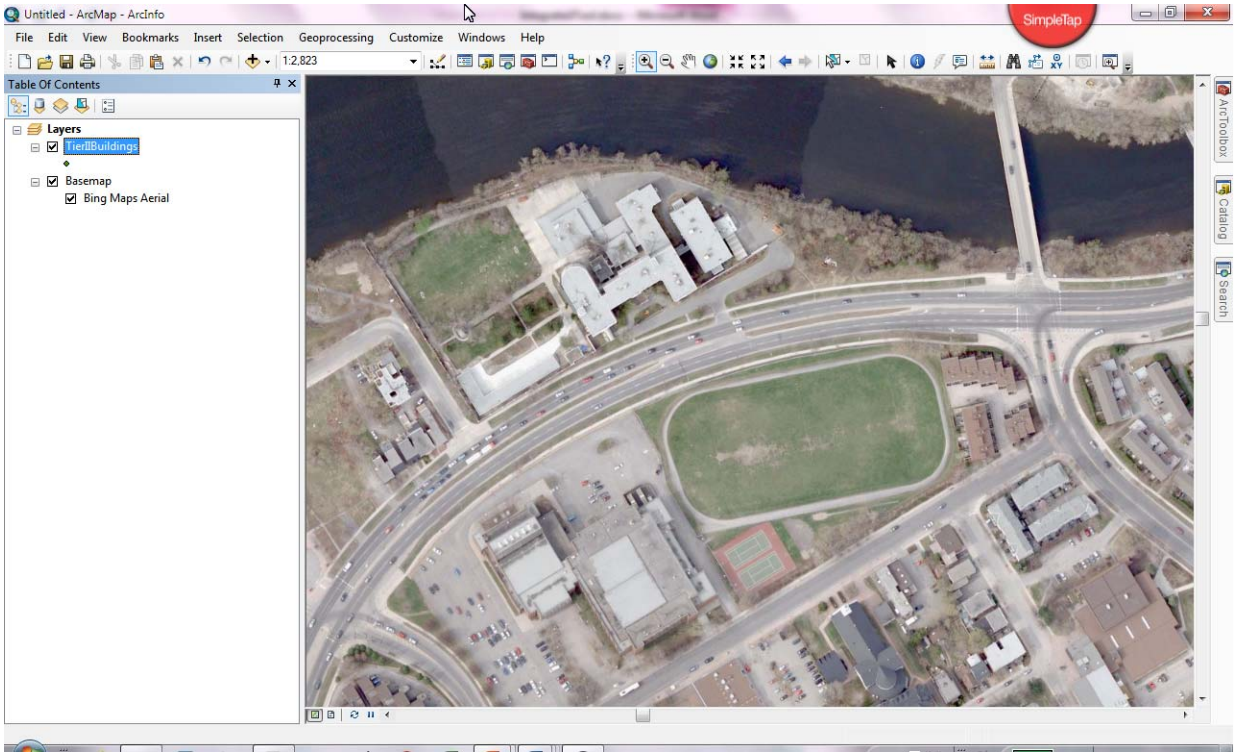
8. You will now have a single layer within the ArcMap table of contents called “TierIIBuildings”. This layer contains the schema (field names and definitions) that will be populated as you collect the data using the Urban RAT Data Add-in that you will load in the next stage.
9. ArcGIS 10.x allows for native integration of Bing Satellite Imagery as a background. This is very useful for identifying individual structures that will be virtually assessed. Load the Bing satellite imagery backdrop for your area of interest. To do so, click on the ‘Add Data’ button and choose “Add Basemap…”



10. Choose “Bing Maps Aerial” (or other suitable basemap for your purposes of identifying individual structures).



11. Use the standard tools to zoom into your area of interest that contains the building(s) that you wish to assess. Your ArcMap window should now contain two layers, “TierIIBuildings” and “Bing Maps Aerial”.



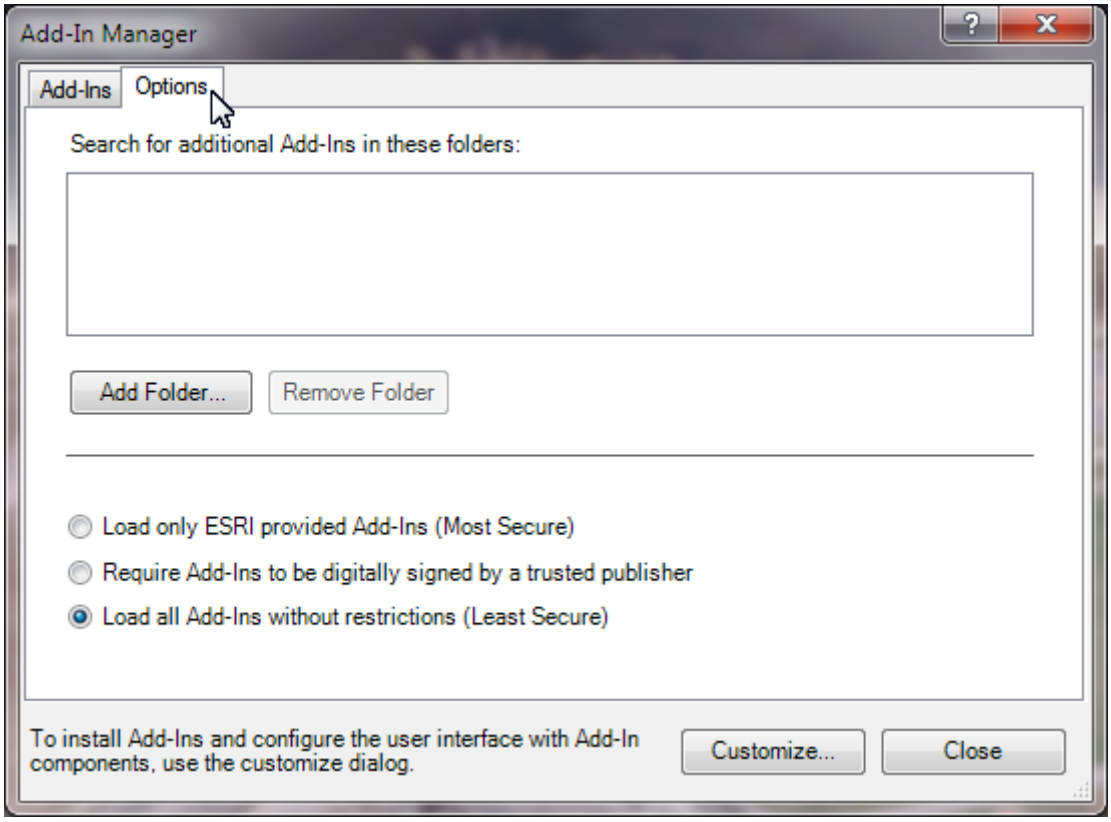
12. OPTIONAL: If you have a layer that contains building footprints that you wish to overlay on the BaseMap Bing Maps Aerial, then you can add it now, otherwise proceed to the next stage – Loading the Add-in.

Stage 2: Loading URAT ArcGIS Add-in in ArcMap

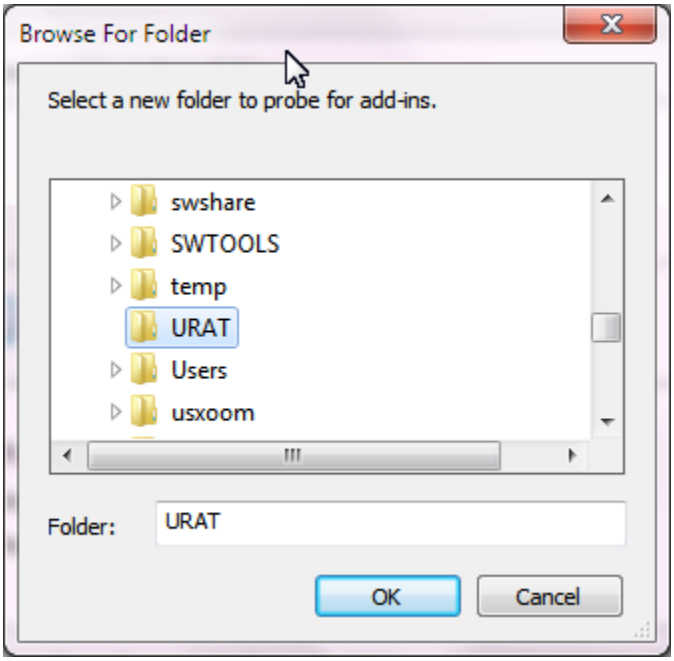
This stage contains X steps that must be followed in order to load the URBAN RAT ArcMap Add-in for data collection.

1. If you have not undertaken Stage 1 (above) then do it now.
2. Click on Customize->Add-In Manager in the main menubar of ArcMap:

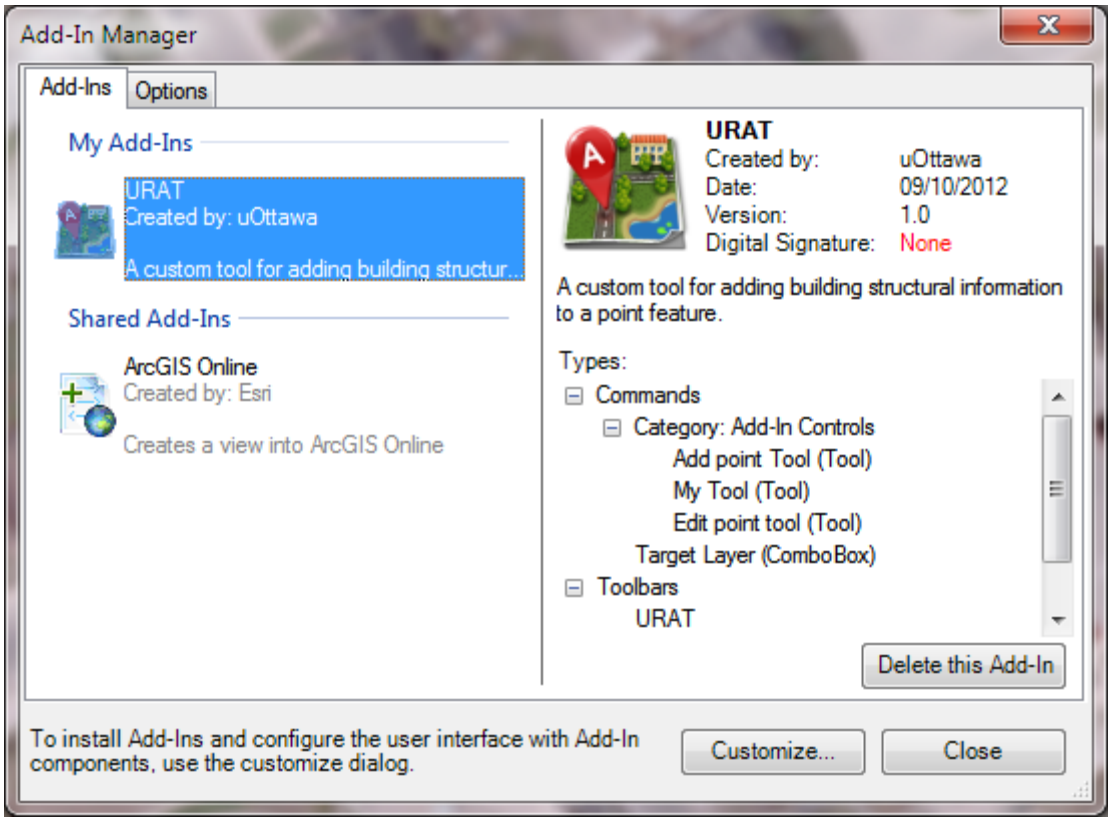
3. In the Add-in Manager Dialogbox, click on the 'Options' tab at the top and ensure that you click on the "Load all add-ins without restrictions (Least Secure)" radio button at the bottom of the dialog:



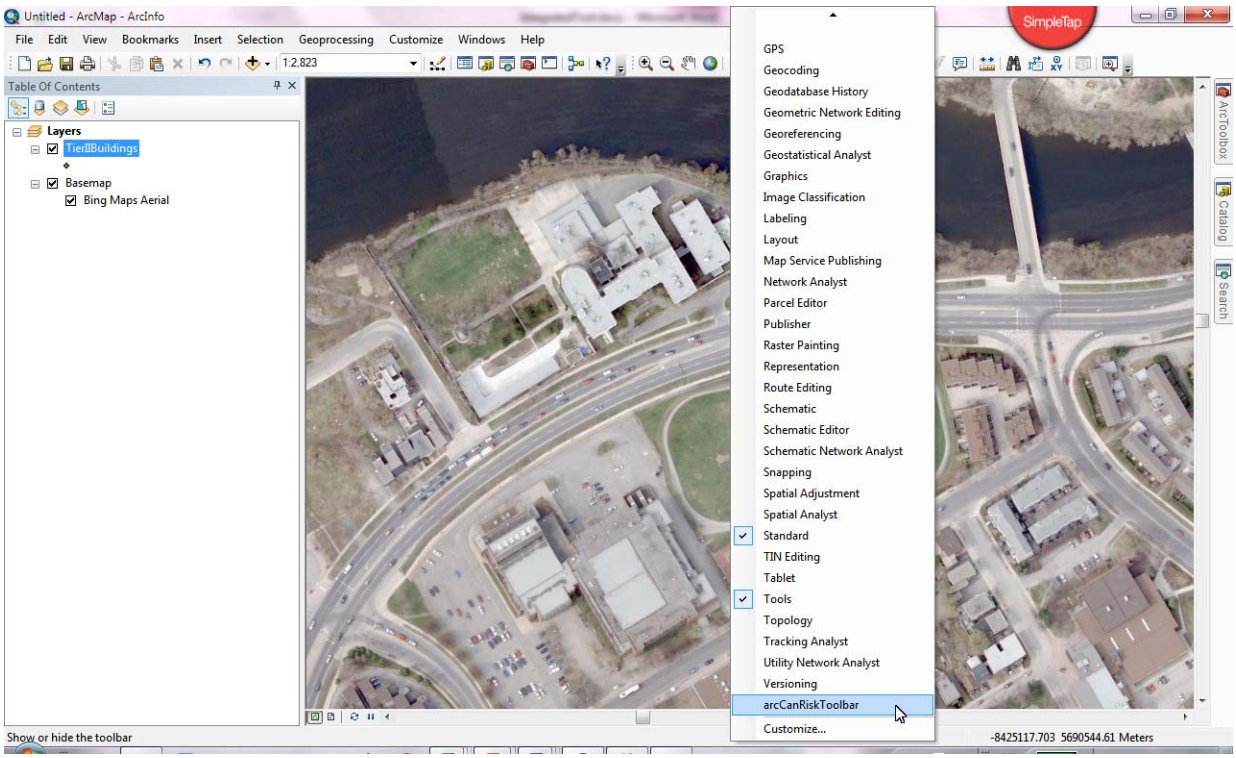
4. Now, click on the “Add Folder…” button and navigate to the folder you created in Stage 1: Step 1, and click OK:



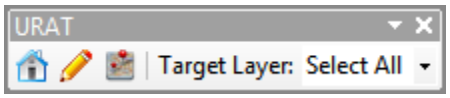
5. Now you will be back in the Add-ins dialog box and click on the Add-Ins tab and you will see the Urban RAT Add-In. Now click the Close button to return to ArcMap:



6. Next, load the Urban RATToolbar by right clicking on any gray area of the menubar, scrolling down and choosing the Urban RATToolbar item:



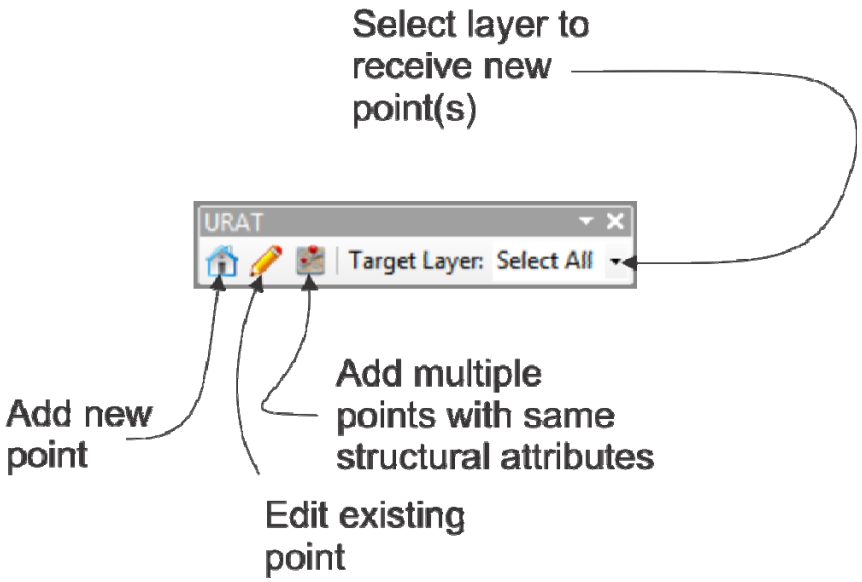
7. You will now see the Urban RAT toolbar with two tools available:



8. You are now ready to use the Urban RAT toolbar to add building points and collect structural information that is used by HAZUS.
9. Move to Stage 3.

Stage 3: Adding a new building point Using the Urban RAT Add-in

This stage is quite intuitive. For reference, the following diagram provides the function of each tool in the toolbar:



The result of this stage is a record in the attribute table of "TierIIBuildings" that is permanent.

1. In the Target Layer: dropdown, choose the layer that will accept the new building point and attributes. This should be the "TierIIBuildings" layer or a copy of this layer with the same attribute schema.
2. Click on the "Add new point" tool - the tool that looks like a house.
3. Click on a building structure in your map window.
4. Two windows will open, the form for structural information and a window containing the Google StreetView and Google Map for the building. You can move between the StreetView and the data entry form as needed. If the current structure is the same as the previous one assessed, then click on the "Copy Last" button, and modify the parameters appropriately. Once you have filled in the data click the OK button:

Building Type

W1
W2
S1L
S1M
S1H
S2L
S2M
S2H
S3
S4L
S4M
S4H
S5L
S5M
S5H
C1L
C1M
C1H
C2L
C2M
C2H
C3L
C3M
C3H
PC1
PC2L
PC2M
PC2H
RM1L
RM2M
RM2L
RM2M
RM2H
URML
URMM
MH

Occupancy Class

Single Family Dwelling
Mobile Home
Multi-Family Dwellings: Duplex
Multi-Family Dwellings: 3 - 4 units
Multi-Family Dwellings: 5 - 9 units
Multi-Family Dwellings: 10 – 19 units
Multi-Family Dwellings: 20 – 49 units
Multi-Family Dwellings: 50+ units
Temporary Lodging (Hotel/Motel)
Institutional Dormitories (Group Housing/Jails)
Nursing Homes
Retail Trade (Stores)
Wholesale Trade (Warehouses)
Personal/Repair Services (Service Station/S
Professional/Technical Services (Offices)
Banks
Hospital
Medical Office/Clinics
Entertainment & Recreation (Restaurants/Ba
Theaters
Parking (Garages)
Heavy Industrial
Light Industrial
Food/Drugs/ Chemicals
Metals/Mineral Processing
High Technology
Construction (Offices)
Agriculture
Church/Non-Profit
Government General Services (Office)
Government Emergency Response (Police,Fi
Grade Schools
Colleges/Universities

Address: 511-515 St Patrick St, Ottawa, ON K1N 5H3, Canac

Building Name:

Standard Information

Year of Construction: 1950

Number of Stories: 1

Building Area sq.m: 0

Occupancy
0-10
11-100
101-1000
>1000

Economic Impact
Negligable
Average
Significant

Problems Adjacency

Floor Elevation
Same level
Slightly different
Mid-height

Space btwn Adj Bldg
Very far apart
Far apart
Moderate
Close

Construction/Design

Construction Quality
Extremely poor
Poor
Average
Good
Extremely good

Design Quality
Extremely poor
Poor
Moderate
Good
Extremely good

Increase in Demand
Structural Walls
Bare frame
Lightly reinforced mas
Heavily reinforced ma
Lightly reinforced shea
Heavily reinforced she

Redundancy
Poor (nrr < 0.5)
Average (1.0 > nrr > 0
Good (nrr > 1.0)

Wek-Colmn Strng-Bem
Not Applicable
Negligible
Low
Moderate
High
Significantly high

Vertical Irregularity: No

Plan Irregularity: No

Dcrease in Rsistnce
Deterioration
Extremely severe
Severe
Moderate
Good
Extremely good

Prvious Quake Damge
Extremely severe
Severe
Moderate
Negligible

Code Enforcement
High - Code
Moderate – Code
Low – Code
Special High - Coc
Special Moderate

Copy Last

Cancel

OK

Notes:

Multiple Units

Stage 4: Editing parameters of an existing building point Using the Urban RAT Add-in

This stage allows you to edit an existing building point within the attribute table of “TierIIBuildings” that is permanent.

1. If you have not done so, in the Target Layer: dropdown, choose the layer that will accept the new building point and attributes. This should be the “TierIIBuildings” layer or a copy of this layer with the same attribute schema.
2. Ensure Clicking on the “Edit existing point” tool – the tool that looks like a pencil tool in the Urban RAT toolbar - which allows you to select and existing building point by clicking on an existing point with the active tool. The attribute values for that building will be brought up in the data entry form. Modify as appropriate and click OK.

Stage 5: Adding multiple building points Using the Urban RAT Add-in

This stage allows you to edit an existing building point within the attribute table of “TierIIBuildings” that is permanent.

1. If you have not done so, in the Target Layer: dropdown, choose the layer that will accept the new building point and attributes. This should be the “TierIIBuildings” layer or a copy of this layer with the same attribute schema.
2. Clicking on the “Add multiple building points” tool in the Urban RAT toolbar which allows you to click on multiple locations, each time, creating a point at the location of the click.
3. When you have clicked on the multiple locations hit any key on the keyboard and you will be asked whether or not you wish to keep the points you have clicked on.
4. Follow steps 4 of Stage 3 above to enter structural attribute information.
5. Click OK to save your information and that information will be copied to each point you had selected in Step 2 above.

URBAN RAT MOBILE

The requirements for using the Android Application are:

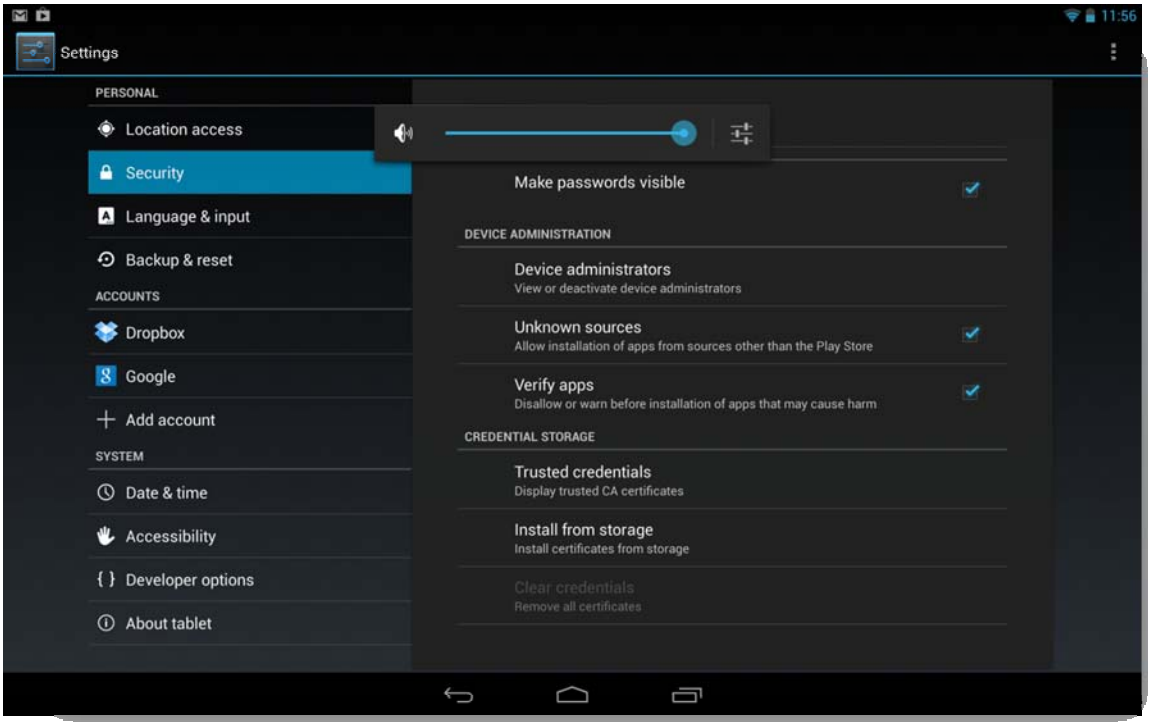
1. Android OS 3.2 (Honeycomb) or higher (Ice Cream Sandwich, Jelly Bean).
2. An android tablet. The app is designed for a 10 inch or 7 inch screen footprint. The app has not been tested in a smartphone footprint.

Should a site visit be required, the same variables were incorporated into an Android App that runs on a Motorola Xoom tablet (**Erreur ! Source du renvoi introuvable.**). However, this application will run on any tablet that has Android version 3.2 or later. The Android application automatically collects the geographic position of the building under assessment and can store a photo of the building for reference purposes.

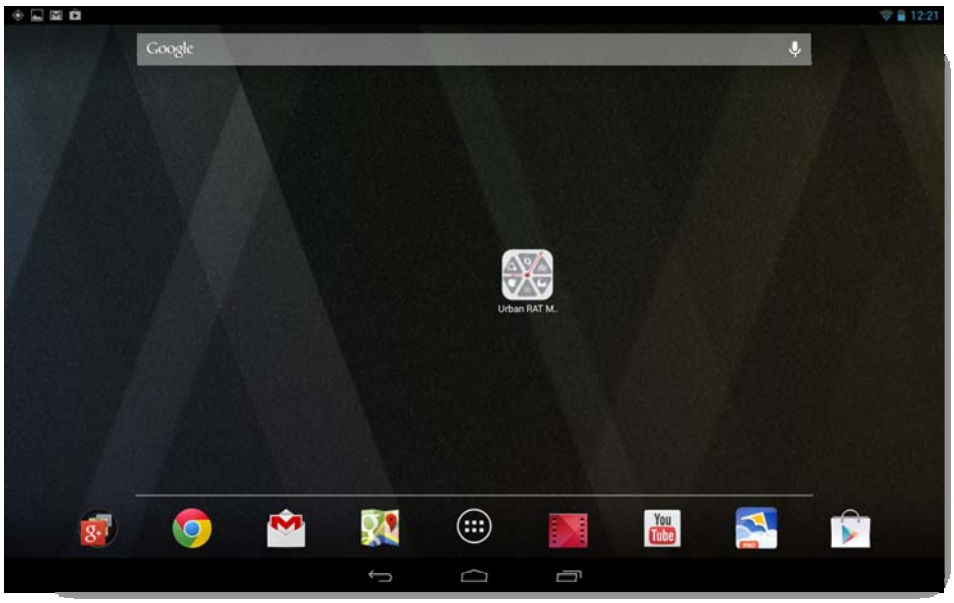
Stage 1: Installation of app

The application is distributed as a single APK file (android package file) which is the standard way to distribute and share Android programs. The APK file is within the zipfile called URBAN RAT.ZIP.

1. Enable you Android device to install from unknown sources.
2. Goto Settings-> Security on your device.
3. Ensure that you have clicked 'Unknown sources' in order to allow installation of apps from sources other than the Play Store.



4. Transfer the file called urbanRAT.apk to your Android device. You can do this any way you want, either as an attachment to an email or via a cloud storage service like DropBox, Google Drive or SugarSync, all of which provide between 2 GB and 5 GB of free storage to new users.
5. Navigate to your Download folder on your android device or to the folder in which you have the urbanRAT.apk file.
6. Click on the urbanRAT.apk file and choose to allow the installation of the app.
7. Depending on the version of Android you have, the app's icon will be added to one of your home screens and/or found within your app folder. Look for the following icon:



Stage 2: Using Urban RAT Mobile

The application is started like any other Android application. The main screen reflects the desktop application.

1. Travel to and observe building.
2. Enter parameters.
3. Ensure that there are longitude and latitude parameters visible in the 'Geographic Information' section of the app home screen.
4. Click the "Save" button once you are satisfied with the data entry.

The BuildingID is automatically updated as a unique key value for each building entered.

If the next building that you observe has parameters similar to the one you have just saved, then use the "Copy Last" button to copy the previous parameters to the entry form. Therein you can modify just those that are different and save time. When you copy the last record, a new building identifier is created and photos are not copied.

DATABASE

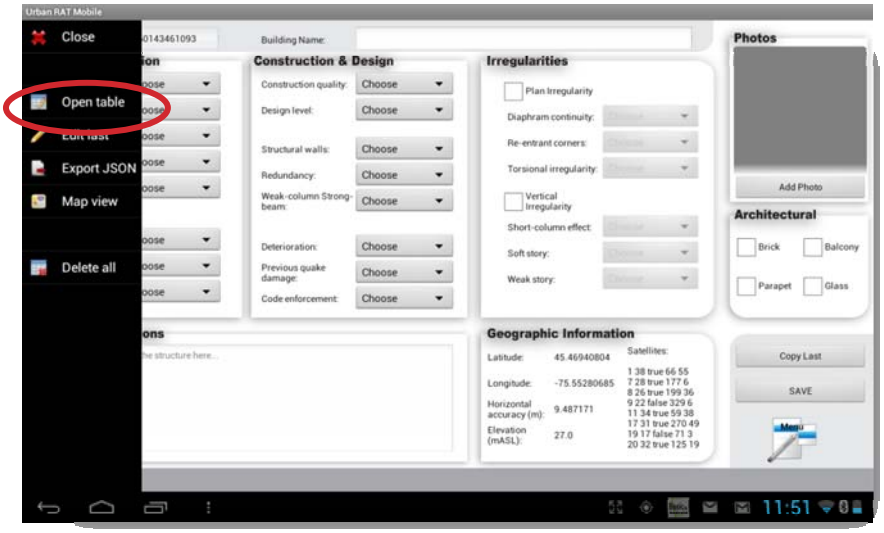
The user entry forms for the dataset contains all of the values represented in table below:

Variable	Values
BUILDTYPE	C1H; C1L; C1M; C2H; C2L; C2M; C3H; C3L; C3M; PC1; PC2H; PC2L; PC2M; RM2H; RM2L; S1H; S1L; S1M; S2H; S2L; S3; S4H; S4L; S4M; S5H; S5L; S5M; URML; URMM; W1; W2
BUILDNAME	Variable
BUILDAREA	Variable
VERTIRREG	No; Yes
PLANIRREG	No; Yes
CONSTQUAL	Average; Extremely good; Extremely poor; Good; Poor
CONSTYEAR	Variable
NUMSTORIES	Variable
BUILDUSE	See Appendix A
OCCUP	>1000; 0-10; 101-1000; 11-100
ECONIMPACT	Average; Negligible; Significant
DESIGNQUAL	Extremely good; Extremely poor; Good; Moderate; Poor
DETERATION	Extremely good; Extremely severe; Good; Moderate; Severe
PREVQKDM	Moderate; Negligible
CODEENFRCE	High -Code; Low-Code; Moderate-Code; Special High - Code
FLOORELEV	Mid-height; Same level; Slightly different
SPACEAD	Close; Far apart; Moderate; Very close
WKCOLSTRBM	Moderate; Negligible; Not Applicable
DPHRMDIS	Low; Moderate; Not Applicable; Very low
RETRNTCORN	High; Low; Moderate; Negligible; Not Applicable
TORSIRREG	High; Low; Moderate; Negligible; Not Applicable; Very high; Very low
SHRTCOLEFF	Not Applicable
SOFTSTORY	High; Low; Moderate; Negligible; Not Applicable; Very high; Very low
WEAKSTORY	High; Low; Moderate; Negligible; Not Applicable; Very low
NOTES	Variable
OCCUPCLASS	See Appendix A
STRCTWALL	Bare frame; Heavily reinforced masonry walls; Heavily reinforced shear walls; Lightly reinforced masonry walls; Lightly reinforced shear walls
REDUND	Average (1.0 > nrr > 0.50); Good (nrr > 1.0); Poor (nrr < 0.5)
ADDRESS	Variable
Brick	Architectural feature
Parapet	Architectural feature
Balcony	Architectural feature
Glass	Architectural feature
PHOTO	Variable

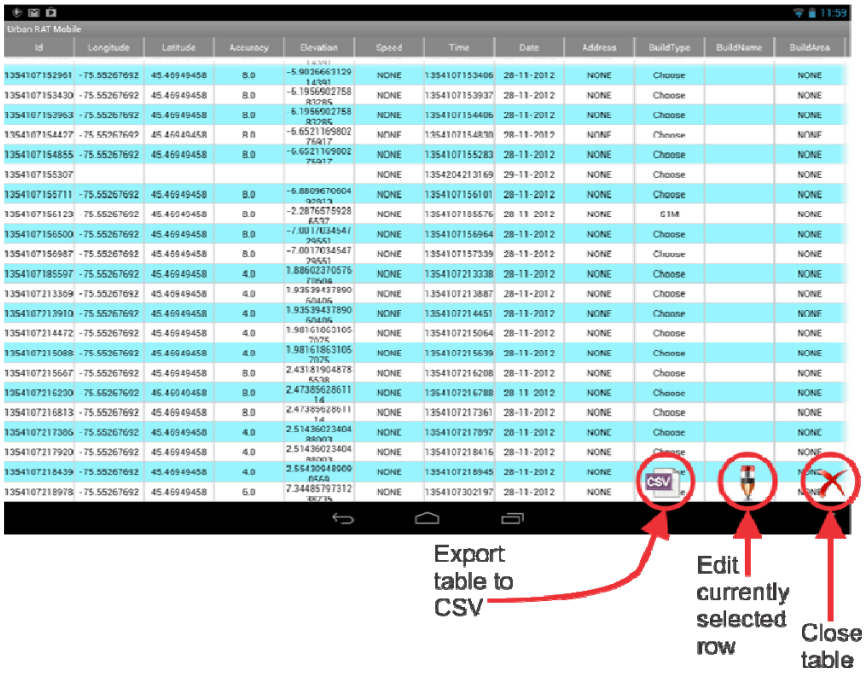
Stage 3: Viewing/Reviewing/Editing data already entered in database

The application allows you to see the database that has been entered in the database on the Android device. .

1. Click on the “Menu” icon or on the device menu icon in the action bar at the bottom of the screen.
2. In the app menu, click on the ‘Open table’ icon:



3. You will now see the database of entries within the mobile application:



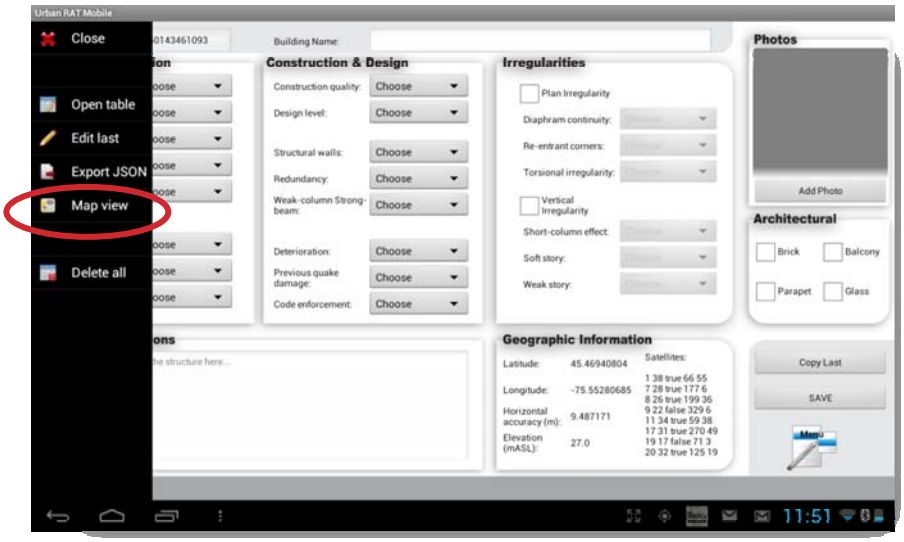
4. You can select a row and click on the “Edit currently selected row” icon to edit the data within the home screen data entry form.

5. Selecting the “Export table to CSV” will export the currently selected table to a comma separated values file with a unique name within the application folder on the external storage area of your Android device.

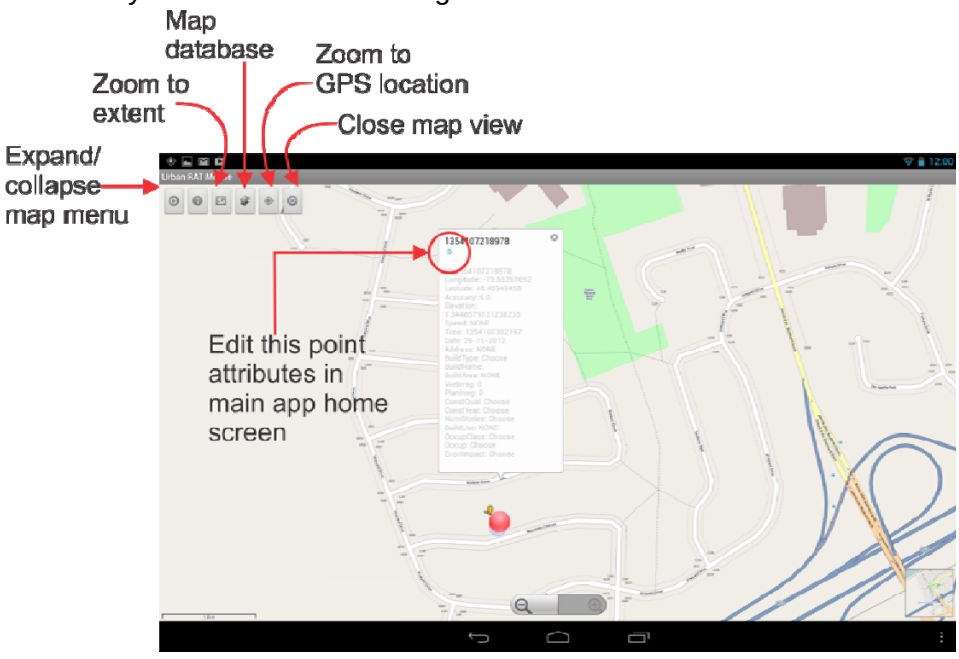
Stage 4: Viewing map and/or data on map

The application allows you to view a map of your immediate surroundings and plot the data that has been entered into the application’s database onto the map.

1. Click on the “Menu” icon or on the device menu icon in the action bar at the bottom of the screen.
2. In the app menu, click on the ‘Map view” icon:



3. Once clicked you will see the following screen:



4. If you click on the ‘Map database’ button your points will be added to the current map view.

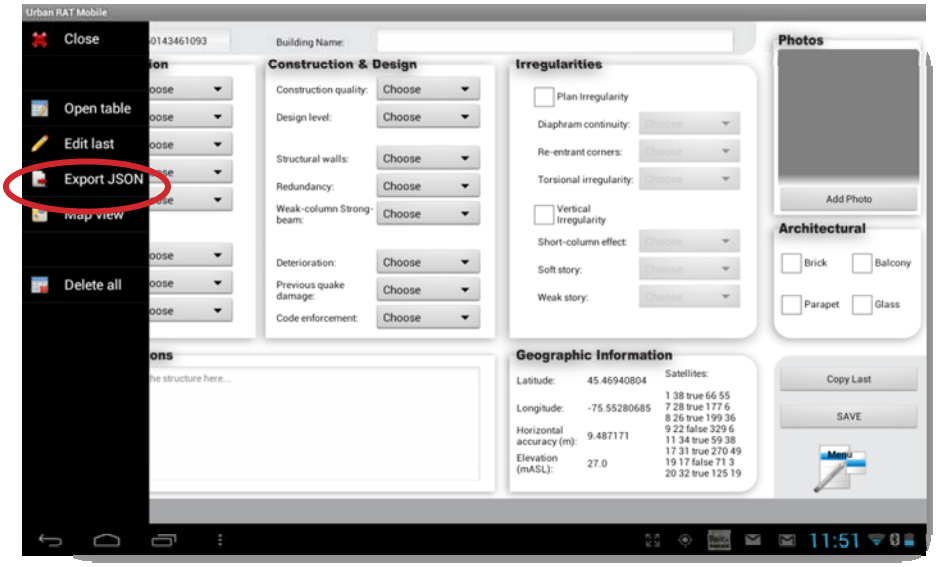
5. You can then click on any of the points to view that point's attributes.
6. If you wish to edit the attributes of a given point click on the 'Edit this point attributes in main app home screen' in the attribute pop-up balloon. You will then be returned to the edit screen where you can modify the attributes for that point of interest.

   The mapping functionality requires a live broadband connection to your Android device (e.g., WiFi, 3G or 4G). If you do not have a live connection then the map will not be displayed and you will a blank map area. However, you can cache the region of interest prior to embarking on a field data collection endeavor. To cache the map area you are interested so that it can be viewed without a live broadband connection; simply open the map view from the main menu when you have a broadband connection. Then, zoom and pan around the area of interest. Once you have zoomed and panned around the area of interest and waited for the map to be displayed, all of the map and zoom levels you have viewed will be available offline.

Stage 5: Exporting data to JSON file

The application allows you to export your database to a JSON file. JSON is java-script object notation, a common interchange format for data.

1. Click on the "Menu" icon or on the device menu icon in the action bar at the bottom of the screen.
2. In the app menu, click on the 'Export JSON" icon:

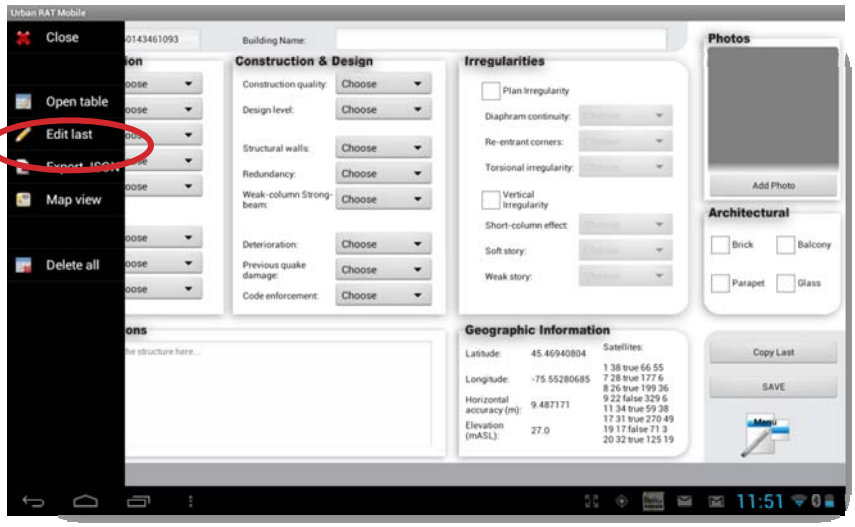


Note that the JSON file exported is in the form of a JSON array object.

Stage 6: Editing last entry

The application allows a quick method to edit the last entry in your database.

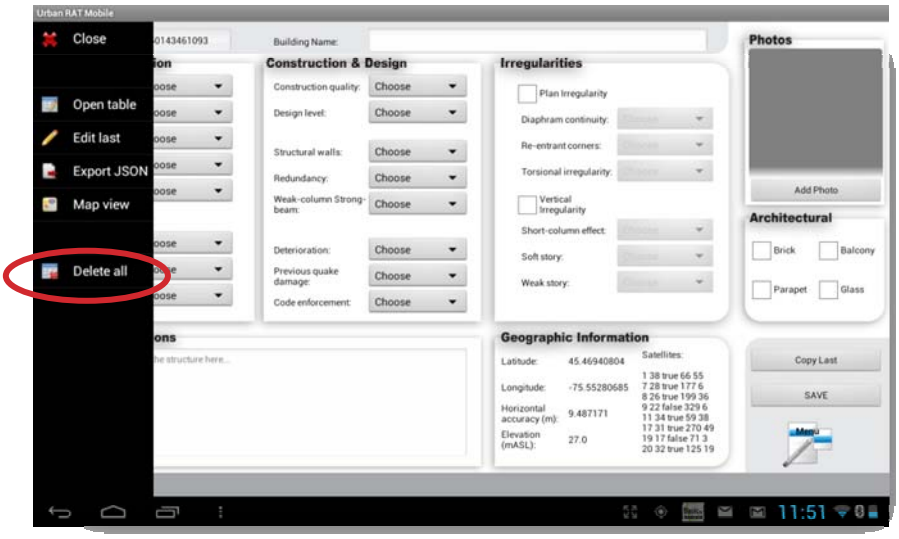
3. Click on the “Menu” icon or on the device menu icon in the action bar at the bottom of the screen.
4. In the app menu, click on the ‘Edit last” icon. You will be returned to the application home screen in edit mode.



Stage 7: Deleting database

The application allows you to delete the entire database from local storage.

5. Click on the “Menu” icon or on the device menu icon in the action bar at the bottom of the screen.
6. In the app menu, click on the ‘Delete all” icon. This is irreversible.



APPENDIX A: DESCRIPTION OF VARIABLES COLLECTED

Table 1 identifies the variables collected for each structure in the Ottawa Database. These are described below.

Building Type

Erreur ! Source du renvoi introuvable. Building type presents the structural building classification from the Data Standardization Guidelines for Loss Estimation – Populating Inventory Databases for HAZUS®MH MR-1 FEMA document. Building classifications comprise 36 classes. The purpose of a building inventory classification system is to group buildings with similar damage/loss characteristics into a set of pre-defined building classes. Damage and loss prediction models can then be developed for model building types which represent the average characteristics of the total population of buildings within each class. The building inventory classification system used in this methodology has been developed to provide an ability to differentiate between buildings with substantially different damage and loss characteristics. The following primary parameters affecting building damage and loss characteristics were given consideration in developing the building inventory classification system.[i]

TABLE 2: HAZUS BUILDING CLASSIFICATION FROM HAZUS®MH MR-1 2003

Table B.2 Structural Building Classifications (Model Building Types)

No.	Label	Description	Height			
			Range		Typical	
			Name	Stories	Stories	Feet
1	W1	Wood, Light Frame (≤ 5,000 sq. ft.)		1 - 2	1	14
2	W2	Wood, Greater than 5,000 sq. ft.		All	2	24
3	S1L	Steel Moment Frame	Low-Rise	1 - 3	2	24
4	S1M		Mid-Rise	4 - 7	5	60
5	S1H		High-Rise	8+	13	156
6	S2L	Steel Braced Frame	Low-Rise	1 - 3	2	24
7	S2M		Mid-Rise	4 - 7	5	60
8	S2H		High-Rise	8+	13	156
9	S3	Steel Light Frame		All	1	15
10	S4L	Steel Frame with Cast-in-Place Concrete Shear Walls	Low-Rise	1 - 3	2	24
11	S4M		Mid-Rise	4 - 7	5	60
12	S4H		High-Rise	8+	13	156
13	S5L	Steel Frame with Unreinforced Masonry Infill Walls	Low-Rise	1 - 3	2	24
14	S5M		Mid-Rise	4 - 7	5	60
15	S5H		High-Rise	8+	13	156
16	C1L	Concrete Moment Frame	Low-Rise	1 - 3	2	20
17	C1M		Mid-Rise	4 - 7	5	50
18	C1H		High-Rise	8+	12	120
19	C2L	Concrete Shear Walls	Low-Rise	1 - 3	2	20
20	C2M		Mid-Rise	4 - 7	5	50
21	C2H		High-Rise	8+	12	120
22	C3L	Concrete Frame with Unreinforced Masonry Infill Walls	Low-Rise	1 - 3	2	20
23	C3M		Mid-Rise	4 - 7	5	50
24	C3H		High-Rise	8+	12	120
25	PC1	Precast Concrete Tilt-Up Walls		All	1	15
26	PC2L	Precast Concrete Frames with Concrete Shear Walls	Low-Rise	1 - 3	2	20
27	PC2M		Mid-Rise	4 - 7	5	50
28	PC2H		High-Rise	8+	12	120
29	RM1L	Reinforced Masonry Bearing Walls with Wood or Metal Deck Diaphragms	Low-Rise	1-3	2	20
30	RM2M		Mid-Rise	4+	5	50
31	RM2L	Reinforced Masonry Bearing Walls with Precast Concrete Diaphragms	Low-Rise	1 - 3	2	20
32	RM2M		Mid-Rise	4 - 7	5	50
33	RM2H		High-Rise	8+	12	120
34	URML	Unreinforced Masonry Bearing Walls	Low-Rise	1 - 2	1	15
35	URMM		Mid-Rise	3+	3	35
36	MH	Mobile Homes		All	1	10

Address

Alpha-numeric addresses are approximated using reverse geocoding from each structure's geographic coordinates.

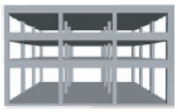
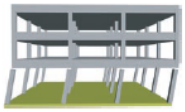
Name of Building

Building names are provided where they are apparent.

Building Area

Building area is defined as the area of footprint multiplied by the number of stories in square meters.

Vertical Irregularities

vertical conditions	resulting failure patterns	performance	code remedies
		**V1 Stiffness Irregularity: Soft Story**	
		Common collapse mechanism. Death and much damage in Northridge earthquake.	Modal Analysis, +65 feet high in SCD D,E,F. Extreme case not permitted in seismic use groups E and F.
		**V2 Weight/Mass Irregularity**	
		Collapse mechanism in extreme circumstances.	Modal Analysis,+65 foot high in SDC D,E,F.
		**V3 Vertical Geometric Irregularity**	
		Localized structural damage.	Modal Analysis,+65 foot high in SDC D,E,F.
		**V4 In-Plane Irregularity in Vertical Lateral Force System**	
		Localized structural damage.	Model Analysis, +65 foot high is SDC D, E, F. 25% increase to diaphragm connection design force. Supporting members designed for increased forces.
		**V5 Capacity Discontinuity: Weak Story**	
		Collapse mechanism in extreme circumstances	Modal Analysis, +65 foot high in SDC D,E,F.

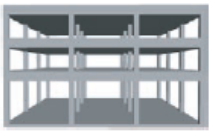
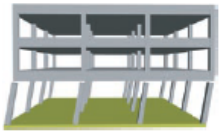
(SOURCE: FEMA 2006)

SHORT COLUMN EFFECT

The short- or captive-column failure occurs due to partial restraining of the columns that are, in turn, subjected to high shear stresses and fail in shear if unable to resist these stresses.

SOFT STORY

A soft-story occurs when a lateral system is less stiff (i.e. more flexible ; has to do with ability to resist lateral displacements) than the system in the floor above or below. An example would be a system with columns + masonry infill above and at the ground level you have just columns and no masonry (for example an open parking area at the ground level).

vertical conditions	resulting failure patterns	performance	code remedies
		**V1 Stiffness Irregularity: Soft Story**	
		Common collapse mechanism. Death and much damage in Northridge earthquake.	Modal Analysis, +65 feet high in SCD D,E,F. Extreme case not permitted in seismic use groups E and F.

(SOURCE: FEMA 2006)

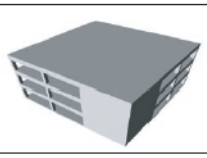
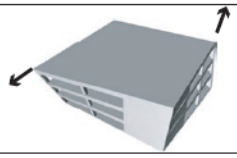
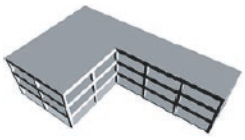
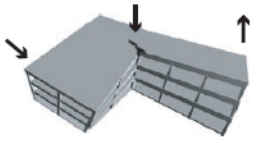
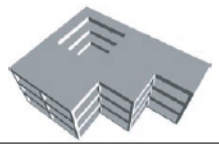
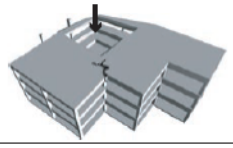
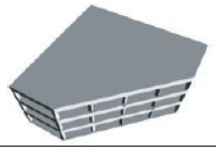
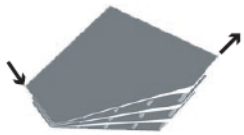
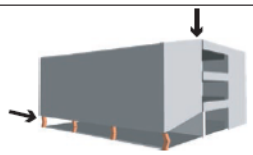
WEAK STORY

A weak story occurs when a lateral system is less strong (weaker, able to take less force) than system in the floor above.

vertical conditions	resulting failure patterns	performance	code remedies
		**V5 Capacity Discontinuity: Weak Story**	
		Collapse mechanism in extreme circumstances	Modal Analysis, +65 foot high in SDC D,E,F.

(SOURCE: FEMA 2006)

Plan Irregularities (SOURCE: FEMA 2006)

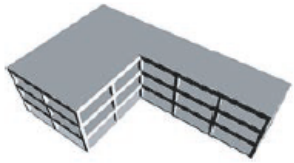
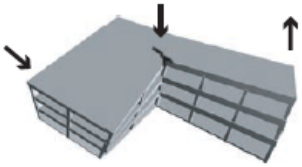
plan conditions	resulting failure patterns	performance	code remedies
		**P1 Torsional Irregularity: Unbalenced Resistance**	
		Localized damage. Collapse mechanism in extreme instances.	Modal Analysis, +65 foot high in SDC D,E,F. 25% increase to diaphragm connection design forces. Amplified forces to max of X3.
		**P2 Re-entrant Corners**	
		Local damage to diaphragm and attached elements. Collapse mechanism in extreme instances in large buildings.	25% increase in diaphragm connection design forces.
		**P3 Diaphragm Eccentricity and Cutouts**	
		Localized structural damage.	25% increase in diaphragm connection design forces.
		**P4 Nonparallel Lateral Force-Resisting System**	
		Leads to torsion and instability, localised damage.	Combine 100% and 30% of forces in 2 directions, use maximum.
		**P5 Out-of-Plane Offsets: Discontinuous Shearwalls**	
		Collapse mechanism in extreme circumstances.	Modal Analysis, +65 foot high in SDC D,E,F. 25% increase to diaphragm connection design forces.

(SOURCE: FEMA 2006)

DIAPHRAGM CONTINUITY

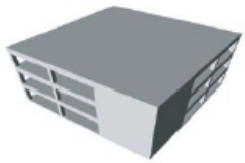
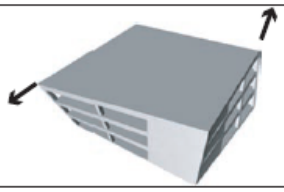
The diaphragm consists of the flooring system (concrete slab, metal deck, wood deck etc…) that carries the inertia forces causes by the earthquake and distributes them to the vertical elements of the lateral load resisting system (e.g. shear walls, etc…). Irregularities in diaphragms include large openings in the floor, re-entrant corners

RE-ENTRANT CORNERS

plan conditions	resulting failure patterns	performance	code remedies
		**P2 Re-entrant Corners**	
		Local damage to diaphragm and attached elements. Collapse mechanism in extreme instances in large buildings.	25% increase in diaphragm connection design forces.

(SOURCE: FEMA 2006)

TORSIONAL IRREGULARITY

plan conditions	resulting failure patterns	performance	code remedies
		**P1 Torsional Irregularity: Unbalenced Resistance**	
		Localized damage. Collapse mechanism in extreme instances.	Modal Analysis, +65 foot high in SDC D,E, F. 25% increase to diaphragm connection design forces. Amplified forces to max of X3.

(SOURCE: FEMA 2006)

Construction Quality

- Condition of slope of ground around building
- Proper drainage for the foundation of building
- Angles of building components (90 degree angled walls)
- Walls, trusses, and supporting beams meeting at proper right angles. Solid foundation, solid supporting structures, and well joined components
- Overall façade/masonry work (quality of mortar and workmanship, etc…)

Year of Construction

The year of construction is an educated guess or based on keystone markings where available. The recent acquisition of construction ages from municipal databases if available will provide exact age of construction for all structures and will be integrated into this database.

Number of Stories

The number of stories is counted by the analyst.

Occupancy

The general building stock is also classified based on occupancy. The occupancy classification is divided into general occupancy and specific occupancy classes. For the methodology, the general occupancy classification system consists of seven groups (residential, commercial, industrial, agricultural, religion/nonprofit, government, and education). There are 33 specific occupancy classes. The building occupancy classes are given in Table 3, where the general occupancy classes are identified in boldface. The distribution of specific occupancies classes within each general occupancy class can be computed for each census tract based on the occupancy square footage inventory[ii].

TABLE 3 BUILDING OCCUPANCY CLASSES

Label	Occupancy Class	Example Descriptions
	Residential	
RES1	Single Family Dwelling	House
RES2	Mobile Home	Mobile Home
RES3	Multi Family Dwelling RES3A Duplex RES3B 3-4 Units RES3C 5-9 Units RES3D 10-19 Units RES3E 20-49 Units RES3F 50+ Units	Apartment/Condominium
RES4	Temporary Lodging	Hotel/Motel
RES5	Institutional Dormitory	Group Housing (military, college), Jails
RES6	Nursing Home	
	Commercial	
COM1	Retail Trade	Store
COM2	Wholesale Trade	Warehouse
COM3	Personal and Repair Services	Service Station/Shop
COM4	Professional/Technical Services	Offices
COM5	Banks	
COM6	Hospital	
COM7	Medical Office/Clinic	
COM8	Entertainment & Recreation	Restaurants/Bars
COM9	Theaters	Theaters
COM10	Parking	Garages
	Industrial	
IND1	Heavy	Factory
IND2	Light	Factory
IND3	Food/Drugs/Chemicals	Factory
IND4	Metals/Minerals Processing	Factory
IND5	High Technology	Factory
IND6	Construction	Office
	Agriculture	
AGR1	Agriculture	
	Religion/Non/Profit	
REL1	Church/Non-Profit	
	Government	
GOV1	General Services	Office
GOV2	Emergency Response	Police/Fire Station/EOC
	Education	
EDU1	Grade Schools	
EDU2	Colleges/Universities	Does not include group housing

Economic Impact

Any increase or decrease in the productive potential of the economy. For example, these buildings can have an effect on commerce, employment, etc…

Design Quality (FEMA 2006)

SUPPORT

1. **Support** mechanical loads
   - Sufficient strength and stiffness (from structural engineer)

CONTROL

2. Heat Flow **Control** (Temperature and Energy)
   - avoid thermal bridges, reasonable insulation: HVAC energy + capital cost savings
   - control air leakage,
   - excessive glazing = winter discomfort and summer overheating (esp. west glass)
3. Condensation **Control**
   - surface condensation, i.e. thermal bridges, corners, etc.
   - interstitial condensation (summer & winter) by vapour diffusion and air leakage
4. Air Flow **Control**
   - air barrier systems, compartmentalization, convection loops in batts
   - control of stack effect, HVAC,and wind-induced air flows, odour, dust
5. Rain **Control**
   - climate, site, building orientation, shape
   - deflection, surface drainage, drying, and enclosure rain control strategies
6. Crack/movement control
   - control of cracking and movement are complementary
   - consider creep, sag, shrinkage, swelling, both moisture and temperature movement
7. Fire and Smoke **Control**
   - fire resistance rating, flame spread, smoke produced, toxins generated
   - special situations, often involved in design decisions (e.g., combustible vs non-combustible)
8. Sound and Vibration **Control**
   - airborne sound reflection, transmission, and impact borne sound transmission
   - special situations are sometimes important, always needs some consideration

FINISH

9. **Finish**
   - colour, pattern, texture, etc of interior and exterior interfaces
   - architecture and interior designers

Decrease in Resistance

DETERIORATION

Examples of deterioration oare peeling paint, erosion of mortar joints, decayed floorboards, insect or termite attacks, roof defects, rusting

Structural steel is exposed to water from rain causing corrosion is also an example.

DAMAGED FROM PREVIOUS EARTHQUAKE

If present or previously documented/reported.

CODE ENFORCEMENT

Code enforcement is an educated guess based on age and structure as to whether code enforcement is likely high, medium or low.

Increase in Demand

STRUCTURAL WALLS

Heavily reinforced walls - are generally made of reinforced concrete or several layers of brick

Lightly reinforced walls are represented by seemingly flimsy materials such as sheet metal , wood planks , even hedge walls .

REDUNDANCY

Redundancy is the building in a state of being no longer needed or useful.

WEAK COLUMN – STRONG BEAM

Weak column – strong beam occurs when inappropriate column/beam relative strengths are evident.

The failure of a column can affect the stability of the whole building, but the failure of a beam causes localized effect. Therefore, it is better to make beams to be the ductile weak links than columns.

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[i] IBID
[ii] IBID

REFERENCES

FEMA 2006. Risk Management Series, Designing for Earthquakes: A Manual for Architects. FEMA 454, pp.394

FEMA 2003. HAZUS-MH MR1, Advanced Engineering Building Module, Technical and User's Manual. National Institute of Building Sciences, Washington DC. Pp.119