The hazard and risk assessment of Taipei Metropolitan through earthquake scenario from open data

Ming-Kai Hsu[1,2],
Kuo-Fong Ma[2,3], Chung-Han Chan[3] and Danijel Schorlemmer[4]

- *[1] Taiwan International Graduate Program (TIGP)–Earth System Science Program, Academia Sinica and National Central University, Taiwan*
- *[2] Earthquake-Disaster & Risk Evaluation and Management (E-DREaM) Center, National Central University, Taiwan*
- *[3] Institute of Earth Sciences, Academia Sinica, Taiwan*
- *[4] GFZ German Research Center for Geosciences, Potsdam, Germany*

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What is seismic risk?

- Seismic risk is defined the probability of damage caused by earthquakes in a specific period or by single earthquake event.

Hazard × **Exposure** × **Vulnerability** = **Seismic Risk**

Hazard	Exposure	Vulnerability	Seismic Risk
Observed Damage Earthquake	2013 NCDR 500m x 500m Grid-Based Building Data	PGA fragility curve	Damage Map
PSHA		PGV fragility curve	
Scenario	Open data	SA fragility curve	

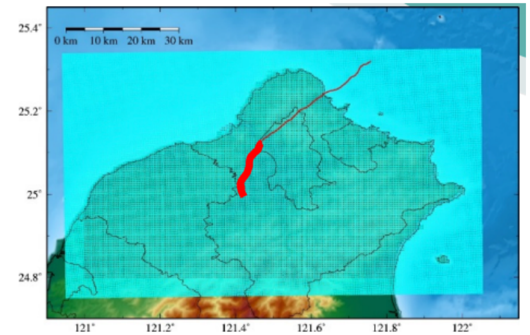
- We have evaluated the scenario-based loss estimation using our developed PGA, PGV and SA fragility curve according to the Shanchiao fault earthquake simulation.

M_L 6.6 Shanchiao fault scenario

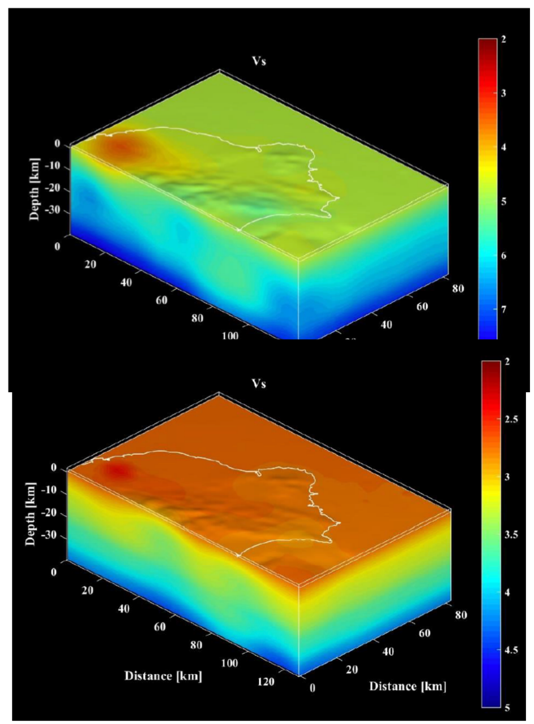
Ground motion simulation (Rupture toward South)

- ✓ Both consider TEM &CGS source parameter and fault geometry
- ✓ Topography & Tomography model
- ✓ NCDR 500x500 m grid
- ✓ Engineering basement 760 m/sec

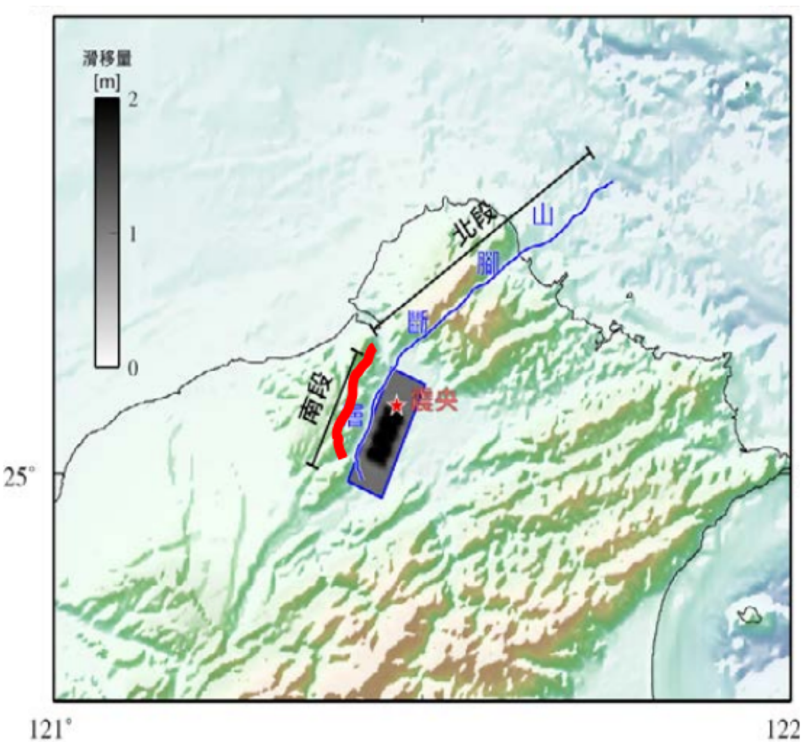
NCDR 500x500 m grid

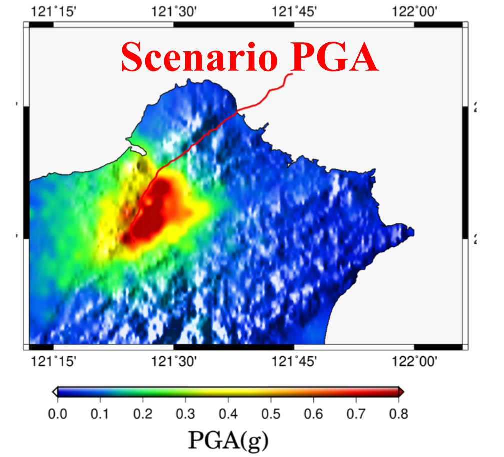


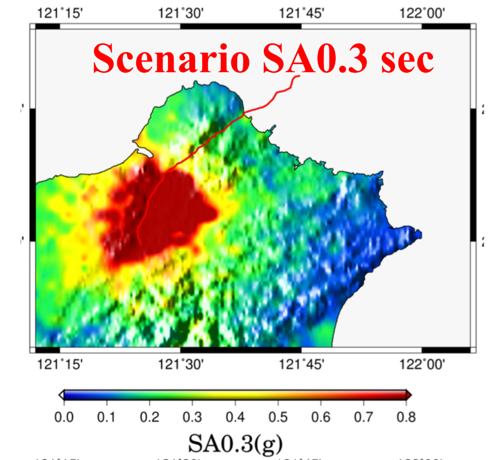
Tomography

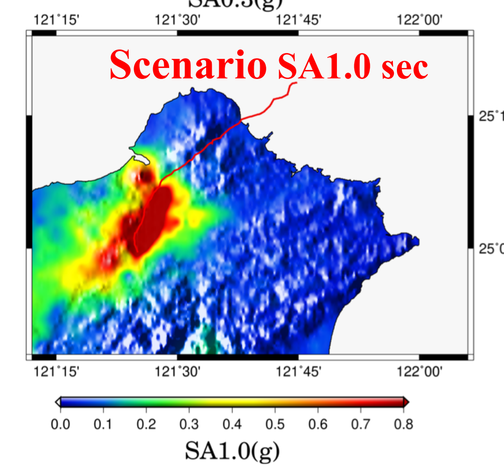


(Kuo-Chen et al. 2012)









(Ming-Che Hsieh, Sinotech)

Building Data & Classification

✓ NCDR (2013): 500m by 500m grid based floor area data

No.	Type	Description
1	W	Wood, Light Frame
2	S	Steel moment frame (steel braced frame)
3	S2	Steel light frame
4	RC	Concrete moment frame (moment frame with shear wall)
5	RM	Reinforced masonry wall
6	URML	Unreinforced masonry wall
7	SRC	Steel reinforced concrete frame

Table1. Building classification

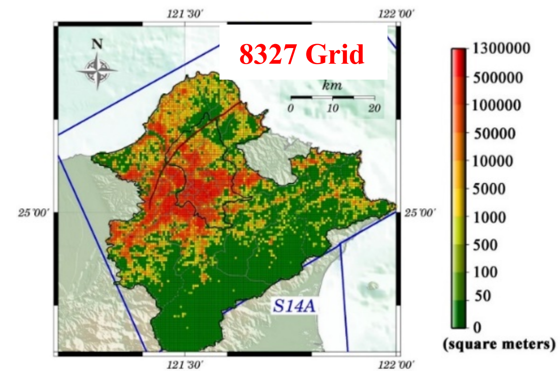
No.	Type	Description	Height Range Stories	Height Typical Stories	Height Meters (m)	Replacement cost
1	W	Wood, Light Frame	All	1	4.2	3000
2	SL	Steel moment frame (steel braced frame)	1-3	2	7.2	6000
3	SM		4-7	5	18.0	7000
4	SH		8+	12	46.8	8000
5	S2	Steel light frame	All	1	4.6	4000
6	CL	Concrete moment frame (moment frame with shear wall)	1-3	2	6.0	6000
7	CM		4-7	5	15.0	7000
8	CH		8+	12	36.0	8000
9	PCL	Precast concrete frame	1-3	2	6.0	5500
10	RML	Reinforced masonry wall	1-7	2	6.0	6500
11	RMM		4-7	5	15.0	6000
12	URML	Unreinforced masonry wall	1-2	1	2.7	3000
13	SRCL	Steel reinforced concrete frame	1-3	2	7.2	6500
14	SRCM		4-7	5	18.0	7500
15	SRCH		8+	12	45.8	8500

RC

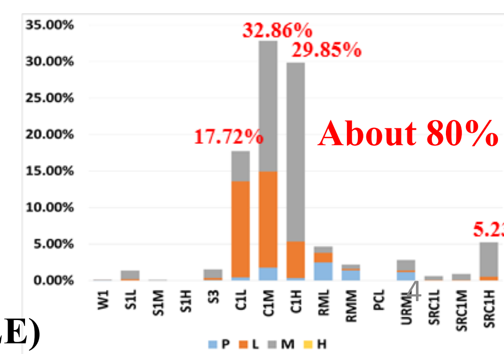
SRC

(NCREE)

- *Building distribution (500mx 500m floor area data)*



Distribution of building according to type of construction



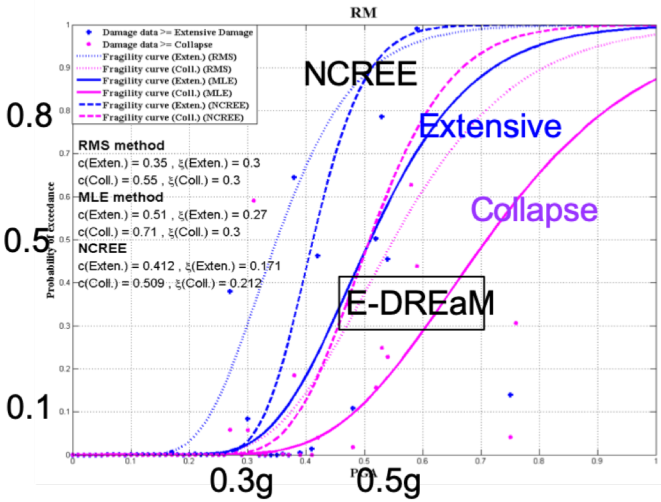
Developed Damage Based PGA/PGV Fragility Curve: 1999 Chi-Chi (M7.3) and 2016 Meinong (M6.5) Earthquake

(Hsu et al. , 11NCEE, 2018)

Fragility function:

$$F_j\left(s;c_j,\zeta_j\right)=\frac{1}{2}+\frac{1}{2}erf\left[\frac{\ln\left(s/c_j\right)}{\zeta_j\sqrt{2}}\right]$$

$$j=0,1,2,\cdots,J$$



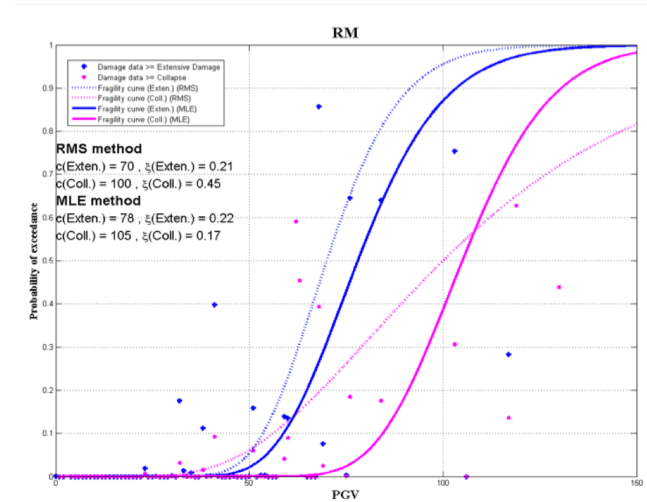
S: intensity/PGA/PGV
Cj: Median
ζ j: deviation

PGA: Peak Ground Acceleration
PGV: Peak Ground Velocity

1.Maximum Likelihood Estimate (MLE)

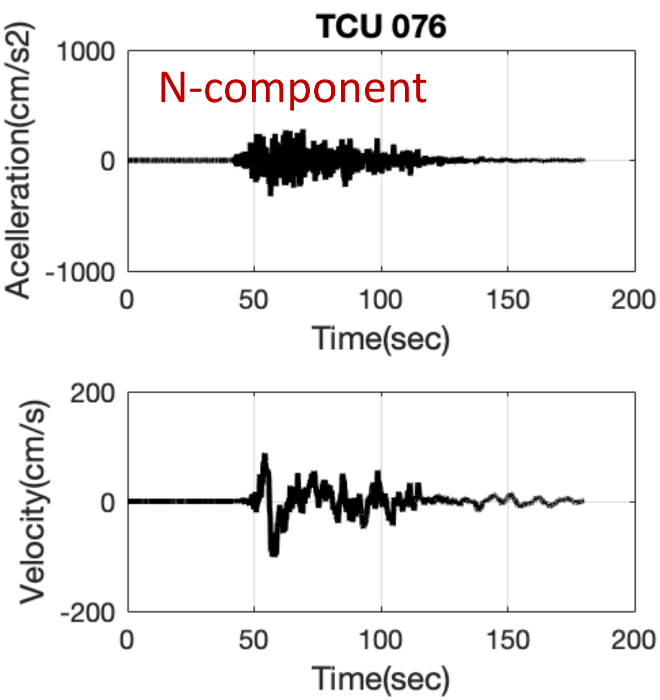
$$\mathbf{L}_j^B(\mathbf{c_j},\,\xi_j)=\prod_{k=1}^{k_g}\binom{X}{X_k}\left[F_j\right]^{X_k}\left[1-F_j\right]^{X-X_k}$$

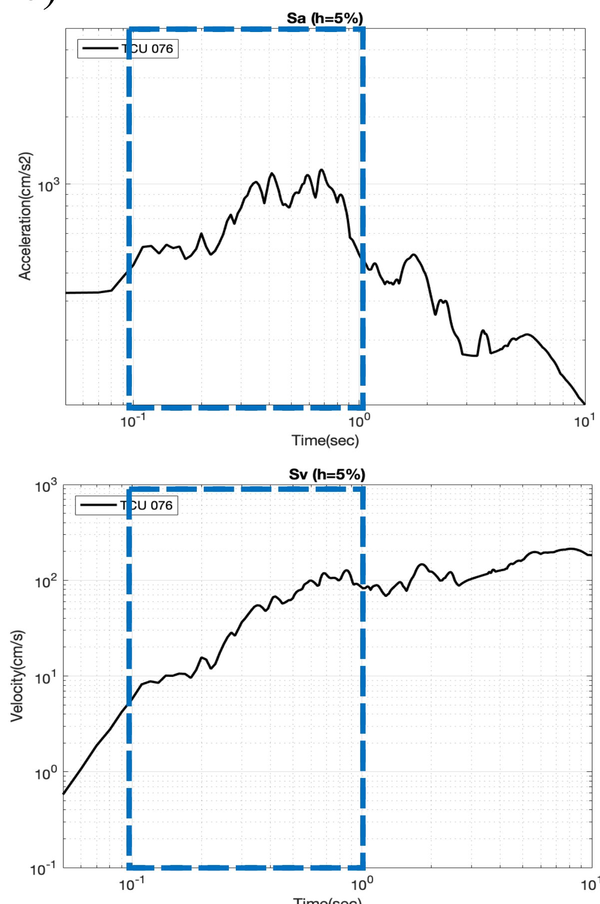
$$\frac{\partial lnL_j^B(c_j,\xi_j)}{\partial c_j}=\frac{\partial lnL_j^B(c_j,\xi_j)}{\partial \xi_j}=0$$

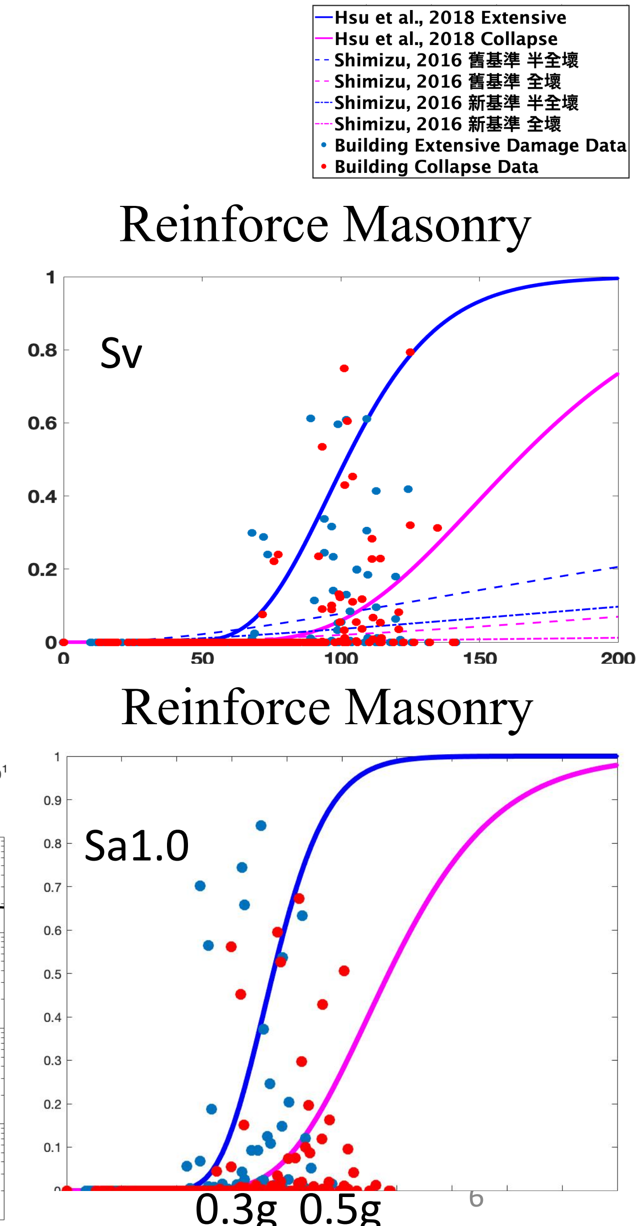


Developed Damage Based Sa/Sv Fragility Curve: 1999 Chi-Chi (M7.3) and 2016 Meinong (M6.5) Earthquake

- For Sa/Sv fragility curve
  - ✓ we choose 0.1 sec ~1 sec as our interval of period
  - ✓ We evaluate the Sa/Sv fragility curve based on damage data and compare to the fragility curve from Japan research result (Simizu, 2016)

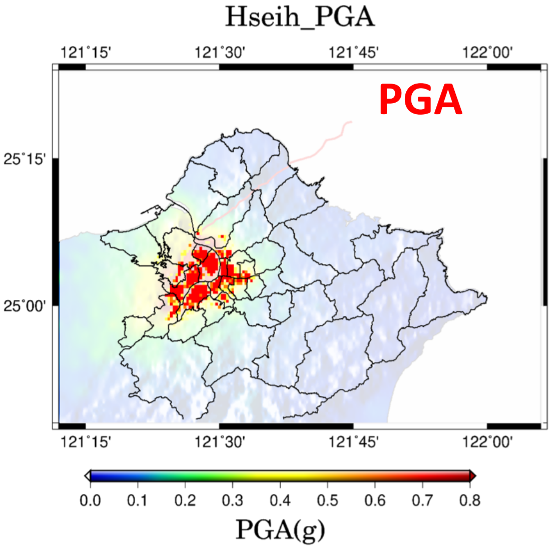


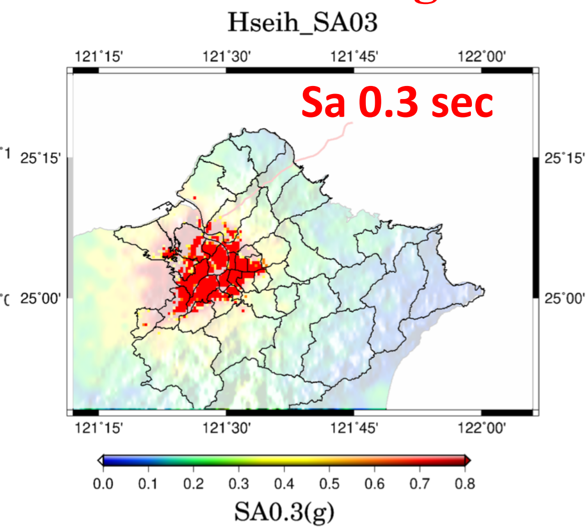


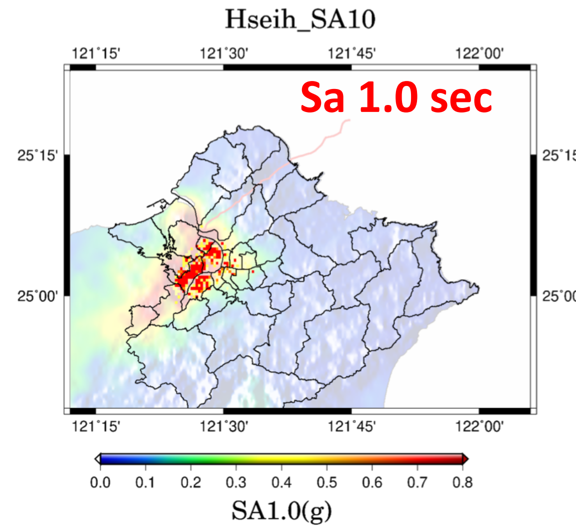


Seismic Risk Distribution

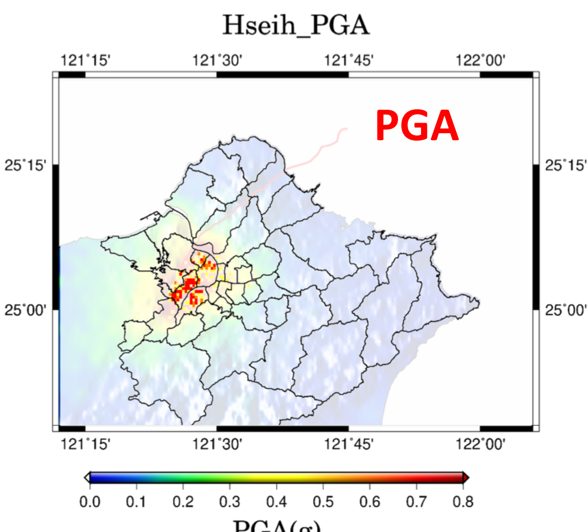
Extensive Damage

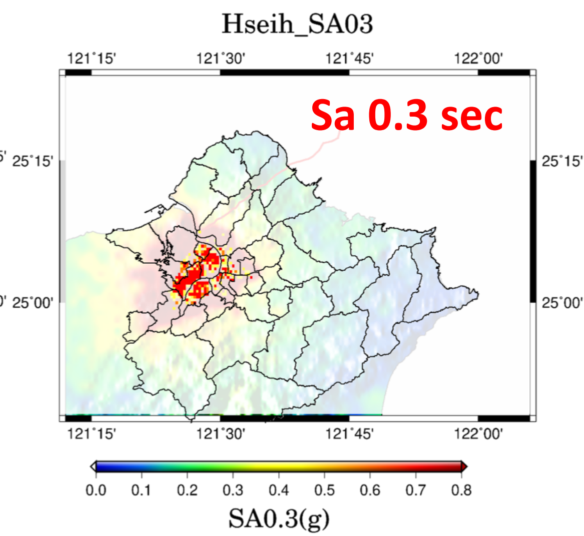


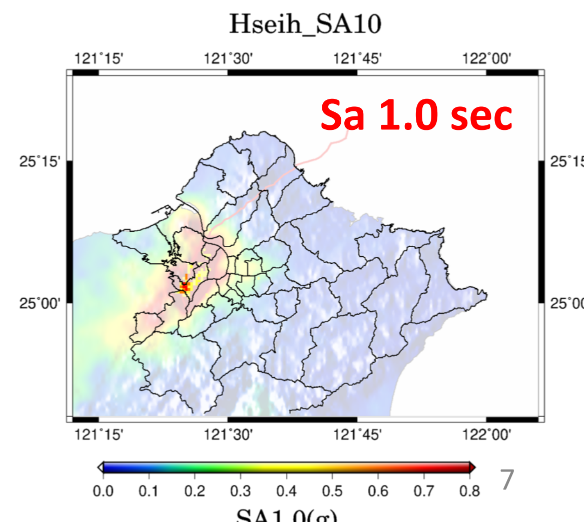




Collapse







Current status for exposure data in previous research

- Advantage:
  - ✓ 500 x 500 m grid based de-identification data
  - ✓ Statistics by government
  - ✓ Detail classification (type, area, height, construct year ......)

- Disadvantate:
  - ✓ Lack of information for each building
  - ✓ Not easy to obtain (Confidential data)
  - ✓ Can not updated in time

- In this study, we explore to use the open data to establish the new exposure model

OpenStreetMap (OSM)

- Volunteered Geographic Information (VGI) data produced by volunteers which upload the information related to specific locations, while OpenStreetMap is an international effort to create a free source of map data through the efforts of volunteers
- OpenStreetMap uses a topological data structure, with four core elements
  - *Nodes (Points)*
  - *Ways (Polygons)*
  - *Relations*
  - *Tags*

(openstreetmap.org)

Open data by Taipei city Government

- About one million household data from the *house unit permit data* provided by Taipei city government open data platform contain very detail building information such as building structural material, construct year, floor area, building height, floor number, cost ……
- After filter the household data in the same location , about 200,000 household data consider in this study.

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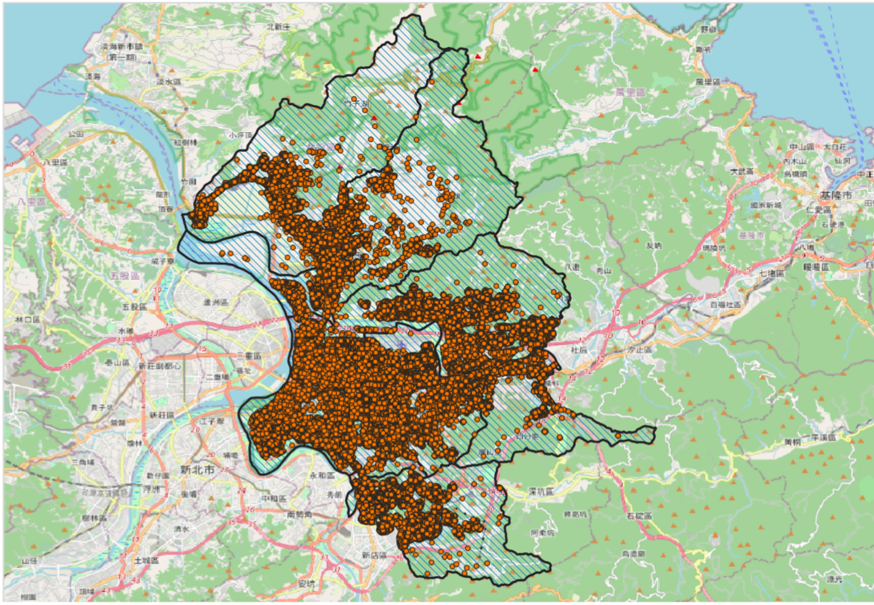
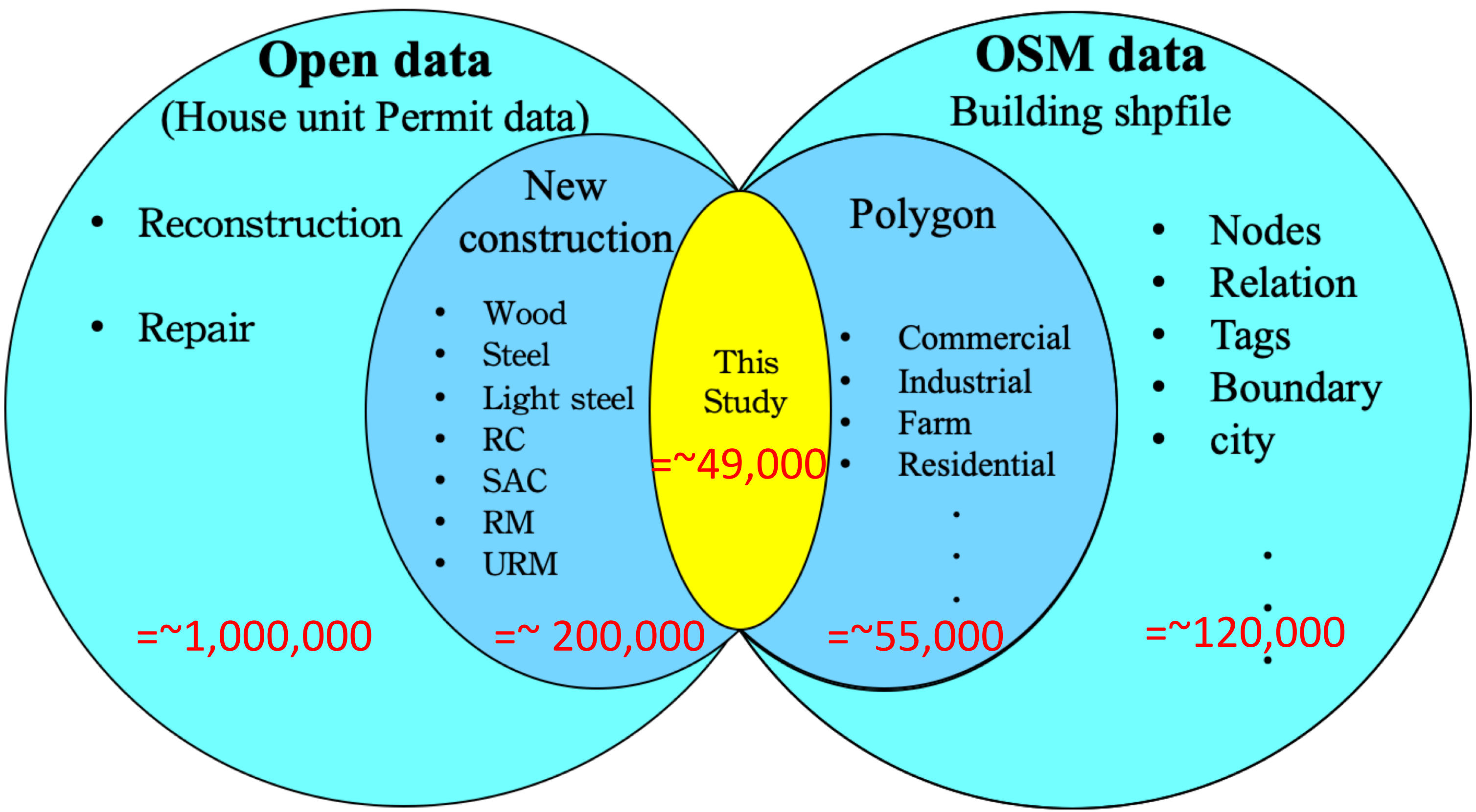
Building structural material



House unit permit data in Taipei city

Combine OSM & Open data

- Case in Taipei city (Capital in Taiwan)
- The address for open data need to convert to the latitude and longitude for WGS84
- By using GIS software, we try to combine the OSM polygon and the house unit permit data for searching the similarity and relationship.



Conversion between address and the lat./ lon.

- Two methods to convert the address to the latitude and longitude

1. **Google API key (geocoding API)**
   - ✓ Providing $200 UST/month for free (using **28,000** times for free per month)

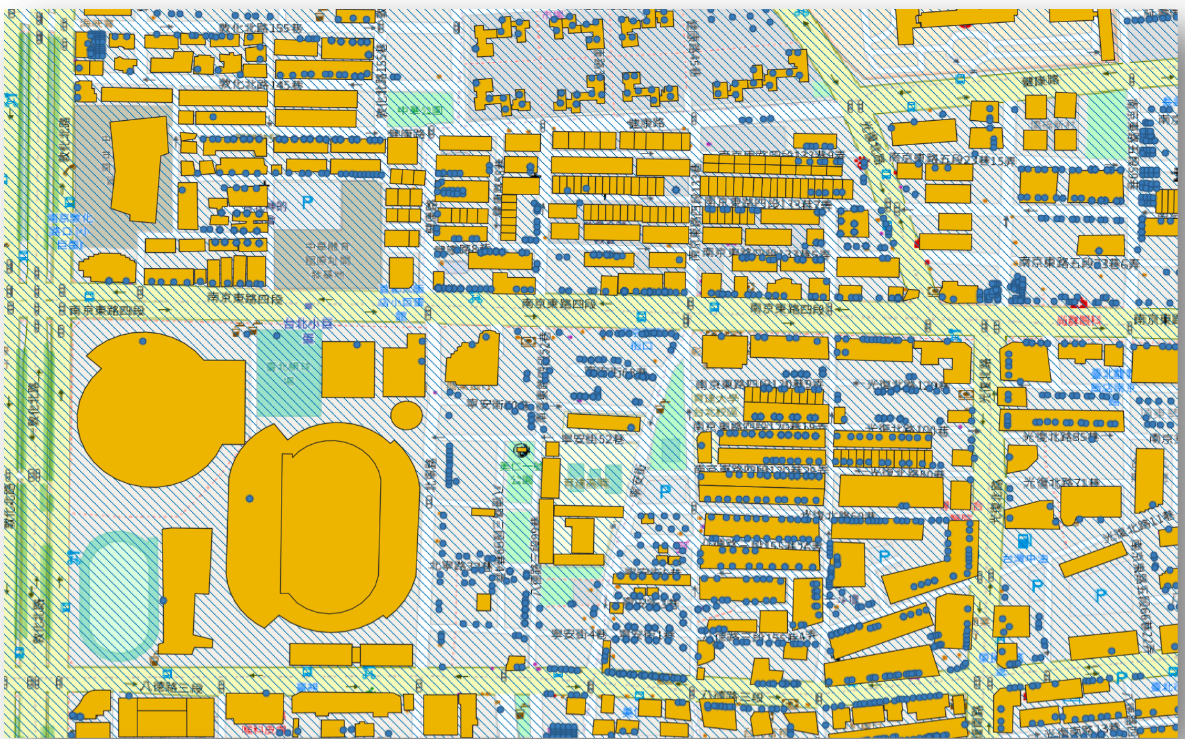
- **Taiwan Geospatial One-Stop (TGOS)**
  - Established by Ministry of the Interior in 1990
  - Searching 10,000 times/day for free (**300,000** for free per month)

Google API key

Taiwan Geospatial One-Stop (TGOS)

Combine OSM & Open data

- The combination result show some gap between two data.
  - Possible reason:
    - ✓ Missing data for the house unit permit data.
    - ✓ The accuracy for the address conversion
    - ✓ Data confidence for the open street map polygon



Use satellite imagery to improve the open street map data

- The OSM polygon in Taipei city still need to improve its completeness.

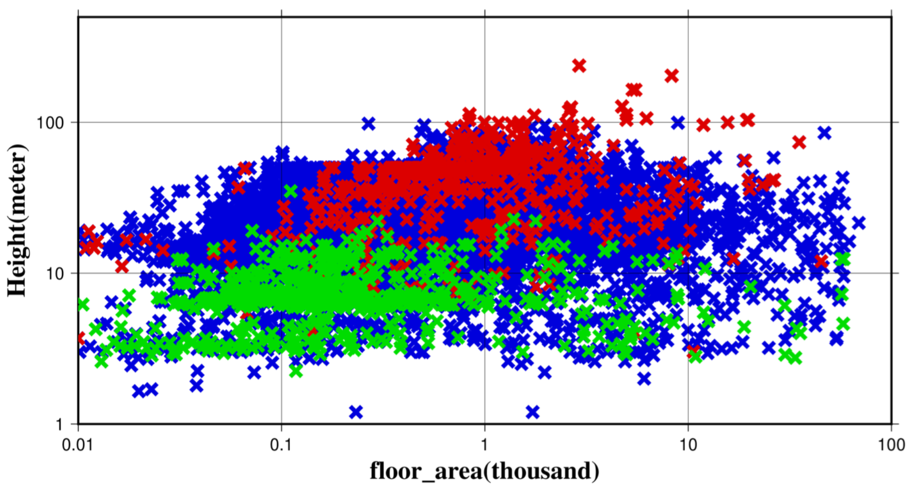
- The house unit permit data help us search where the OSM polygon still lack of completeness

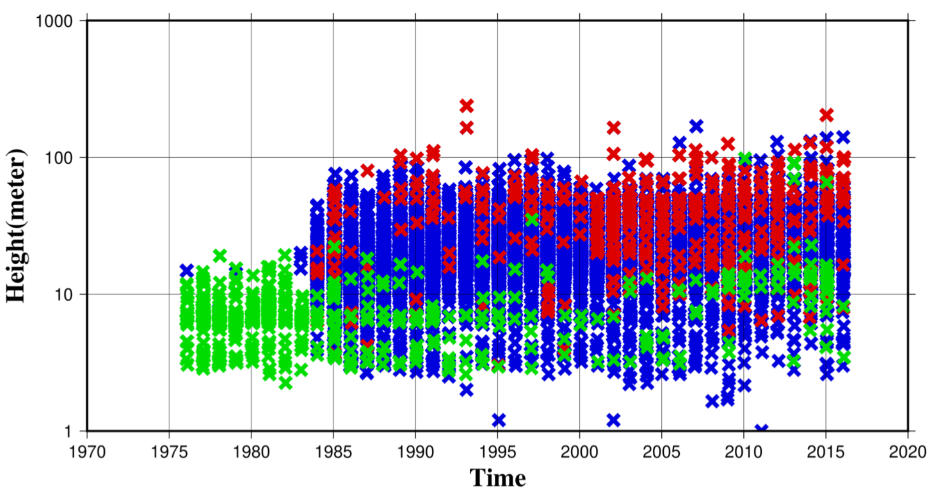
- In order to improve data confidence, refer to the satellite imagery from ESRI World Imagery data, we try to fill a vacancy of the OSM polygon.

Building data identification

- We explore to the building feature according the building height, floor area or construct year ......
- Take RC (reinforced concrete), RM (reinforced masonry), SRC(Steel reinforced concrete) for example.
- Refer the classification, try to fill in the attribute data information for the OSM data.

Red : SRC building Blue: RC building. Green :RM building





Summary

- Taking advantage on the open data policy, we collected the OSM data and house unit permit data, explore to the establishment of the open exposure data in buildings in the Taipei Metropolitan.
- The house unit permit data can help us improve the OSM data completeness in Taipei city.
- This Taipei case study can help us to find some building classification to improve the OSM data building information in other city which is lack of detail message.

Thank you

for your listening ~