NARLabs 國家實驗研究院
國家地震工程研究中心
NCREE National Center for Research on Earthquake Engineering

Summary Report of Hualien Earthquake in Taiwan on April 3, 2024 (2nd edition, V2.0)

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NCREE, Taiwan

May 25, 2024

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Members of the Emergency Response Team

Chairperson: Chung-Che Chou

Emergency Response Operation Manager (Deputy Chairperson): Chiun-Lin Wu

Deputy Emergency Response Operation Manager: Juin-Fu Chai

Executive Secretary: Chi-Hao Lin

Disaster Summary： Bo-Han Lee

Disaster Information Collection

Chun-Chung Chen, Chih-Shian Chen, Hsiao-Hui Hung, Jyun-Yan Huang, Yu-Wen Chang, Shih-Liang Chen, Che-Min Lin, Chin-Hsun Yeh, Shu-Hsien Chao, Zheng-Kuan Lee, Chia-Chuan Hsu, Jui-Liang Lin, Tsung-Chih Chiou, Min-Lang Lin, Yuan-Tao Weng, Te-Kuang Chow, Hsuan-Chih Yang, Che-Yu Chang, Shang-Yi Hsu, Fan-Ru Lin, Tzu-Chieh Chien, Zhen-Yu Lin, Wei-Hung Hsu, Wei-Chung Chen, Bai-Yi Huang, Ching-Hsien Huang, Chung-Han Yu, Chieh-Min Ho, Lee-Hui Huang

Outline

- Seismic Source and Ground Motion Characteristics
- Early Seismic Loss Estimation
- NCREE EEWS Performance
- Bridge Damage
- Building Damage
- Geotechnical Damage
- Non-Structural Component (NSC) Damage

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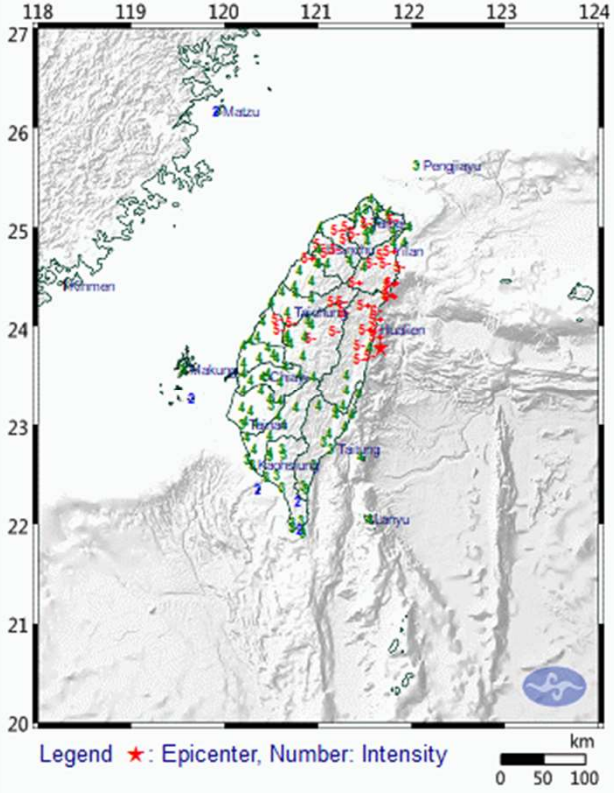
The 3rd Apr. 2024, Hualien, Taiwan earthquake

- A local magnitude M_L 7.2 earthquake occurred at 7:58:09 on 3rd Apr. 2024 local time (UTC+8). The epicenter is located offshore Hualien (25 km from the government building of Hualien County at SSE direction). The intensity was reported as 6+ in 和平, 6- in Hualien City and 太魯閣, and 5- in Taipei and New Taipei city.
- The epicenter is located at N 23.77°, E 121.67°, and the epicenter depth is 15.5km.



CWA EARTHQUAKE REPORT

Earthquake No.: 113019
Origin time (Taiwan Standard Time: GMT+8):
4/ 3/2024 7:58: 9.9
Epicenter: 23.77°N, 121.67°E,
i.e. 25.0 km SSE of Hualien County Hall
Focal depth: 15.5 km
Magnitude (ML): 7.2

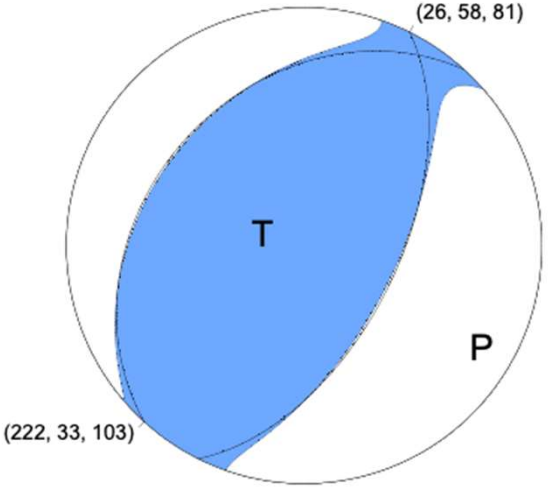
Local Largest Intensity:

Hualien County	6+	Hsinchu City	4
Yilan County	5+	Tainan City	4
Miaoli County	5+	Keelung City	4
Taichung City	5-	Pingtung County	4
Changhua County	5-	Penghu County	3
Hsinchu County	5-	Lienchiang County	2
Nantou County	5-	Kinmen County	1
Taoyuan City	5-		
New Taipei City	5-		
Taipei City	5-		
Taitung County	4		
Chiayi County	4		
Yunlin County	4		
Kaohsiung City	4		
Chiayi City	4		

From Central Weather Administration

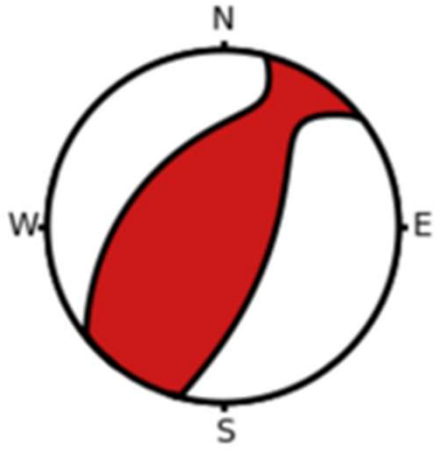
Focal Mechanism

- The USGS's W-phase and Centroid Moment Tensor announcement indicates reverse faulting, in which the resolved moment magnitude (Mw) is 7.37 and the focal depth is 23.5 km.
- The Global Real-Time Moment Tensor Monitoring System by IES resolved a similar focal mechanism with the USGS. The resulting Mw is 7.66, and the focal depth is 35.5 km.
- Incorporated Research Institutions for Seismology (IRIS) IES resolved a similar focal mechanism.



(USGS)

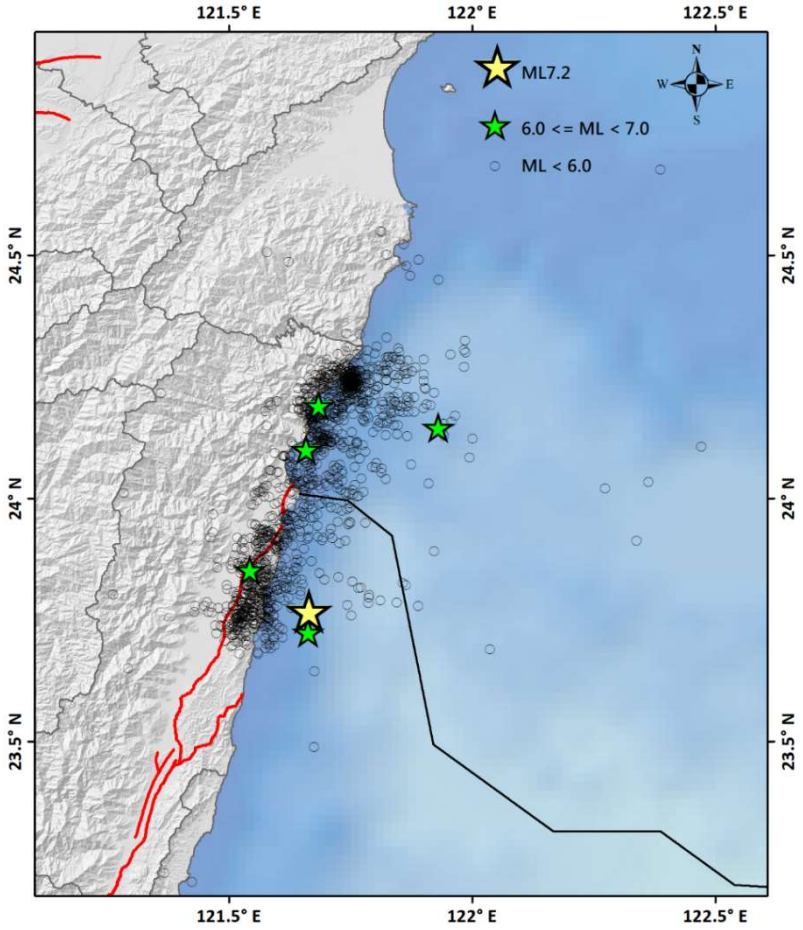
(GRMT, IES)

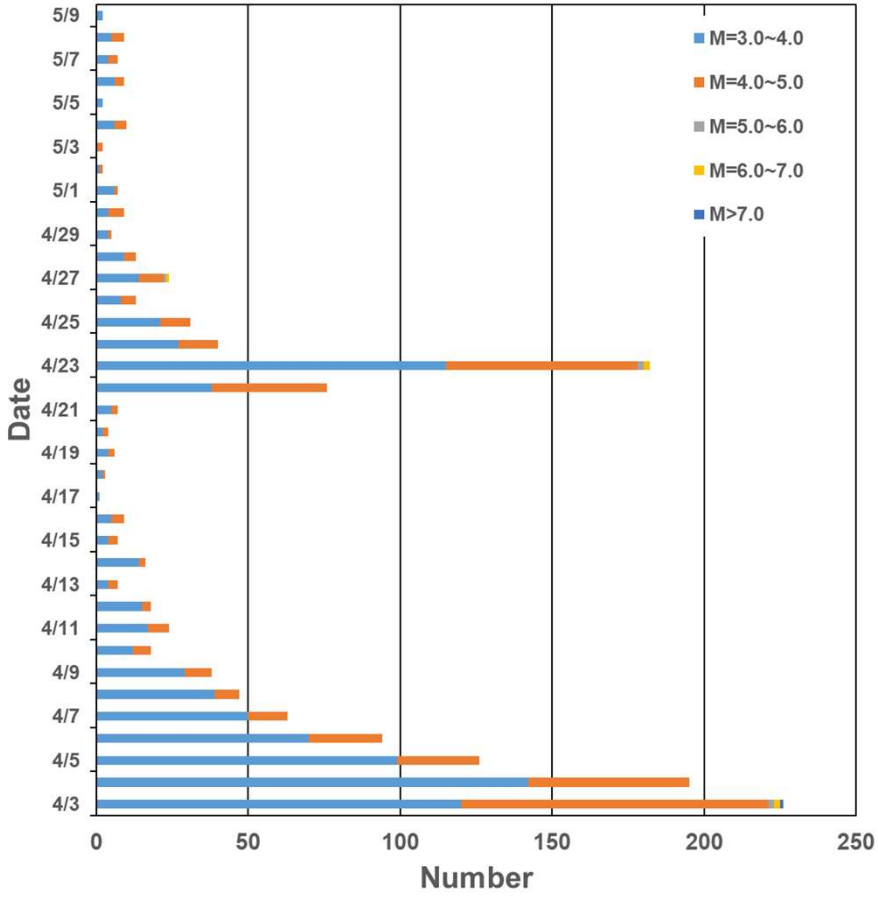


(IRIS)

Aftershock Activities

- The Central Weather Administration (CWA) announced 1416 aftershocks until 11:02 on 9th May, including four events with magnitudes greater than M_L 6.0. The highest intensity of this event is 5+.





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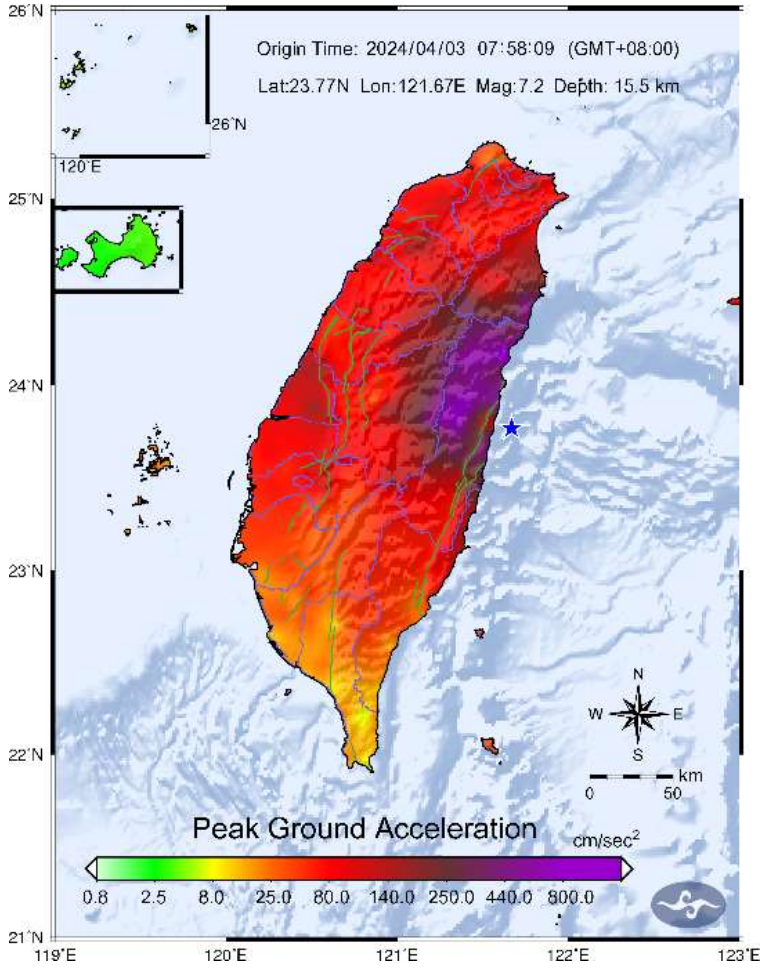
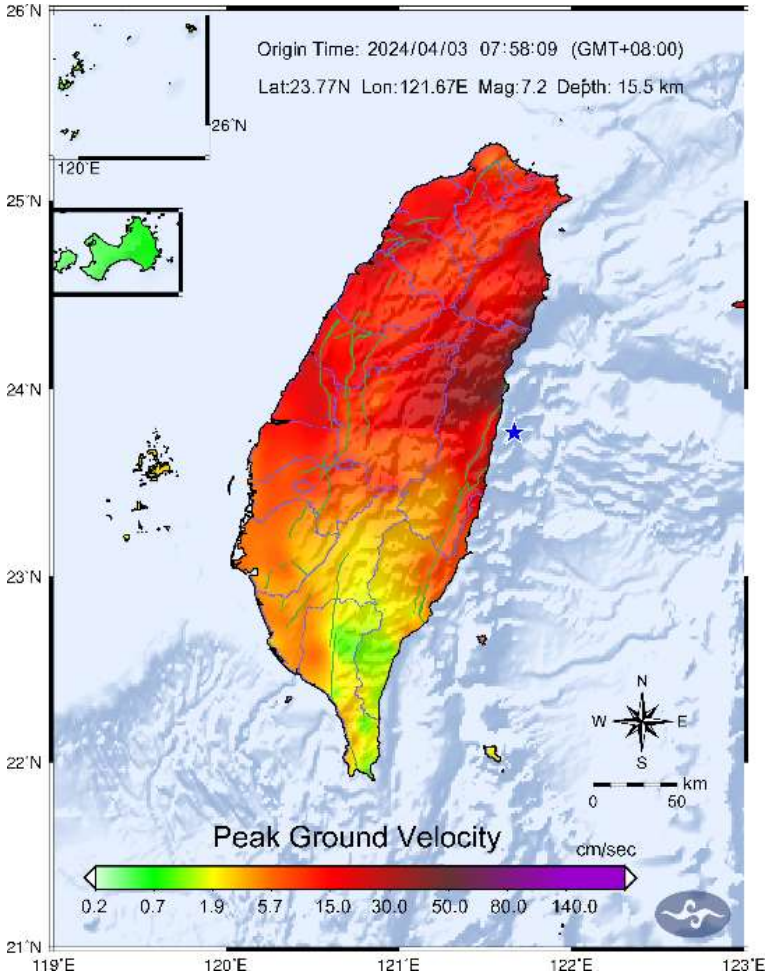
PGA and PGV Map by CWA

0403 M_L 7.2, Depth 15.5km





From Central Weather Administration

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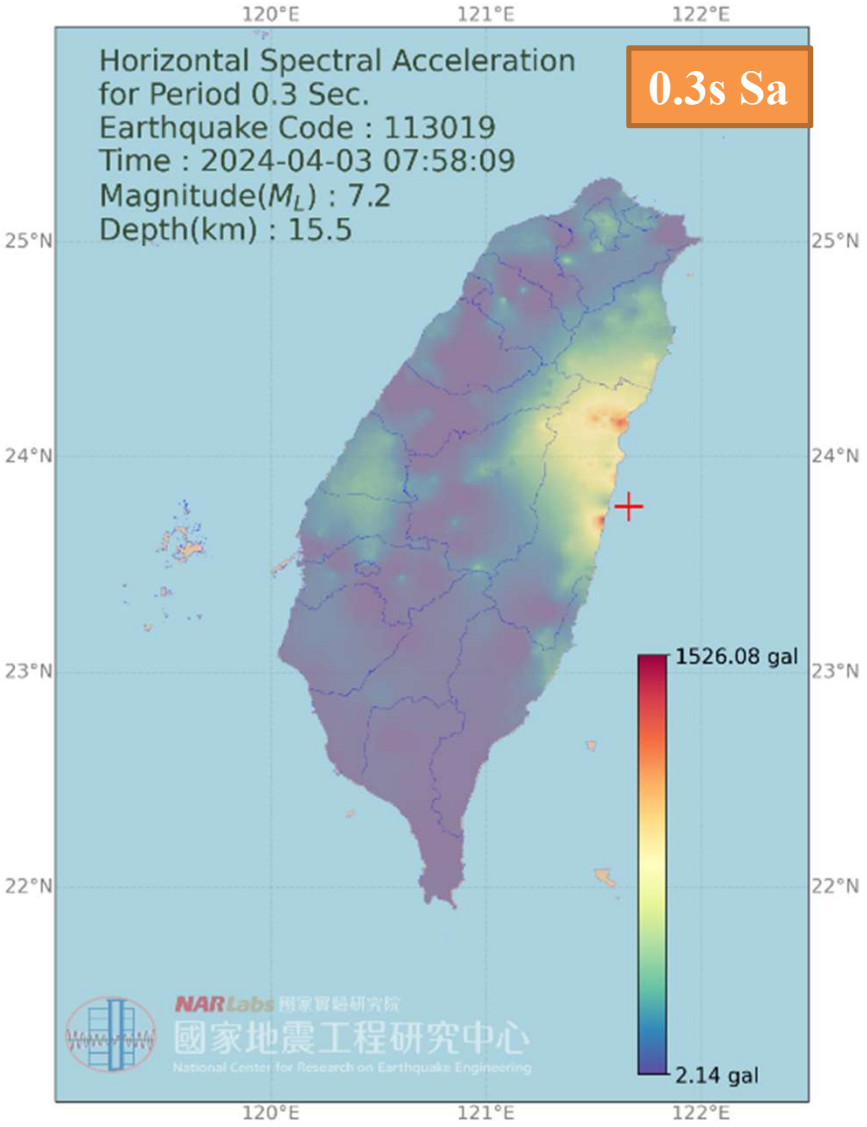
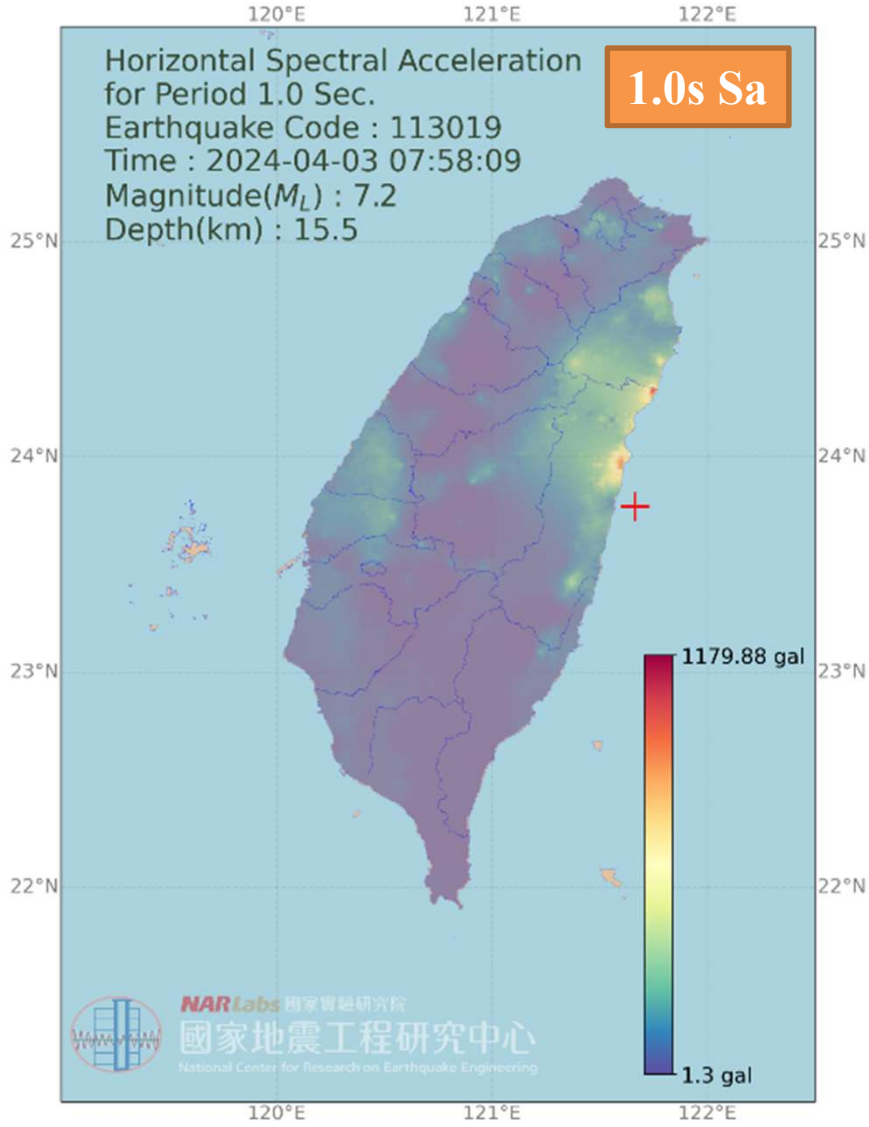
Spectral Acceleration Maps

0403 M_L7.2, Depth 15.5km





Time Histories

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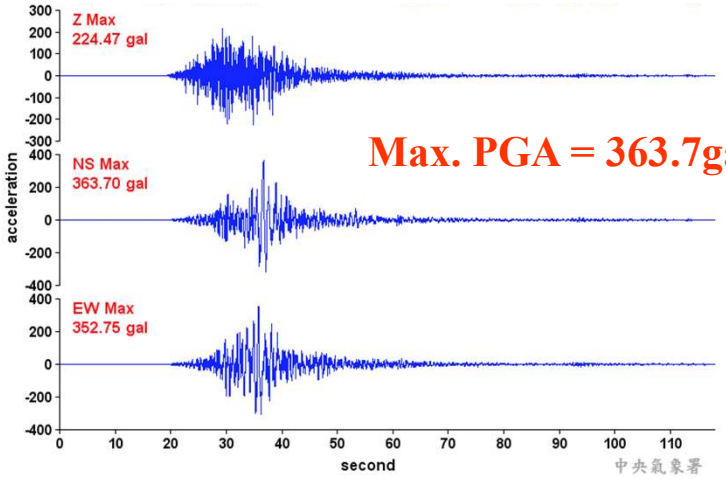
0403 M_L7.2, Depth 15.5km

From Central Weather Administration

Heping (EHP), Int.= 6-

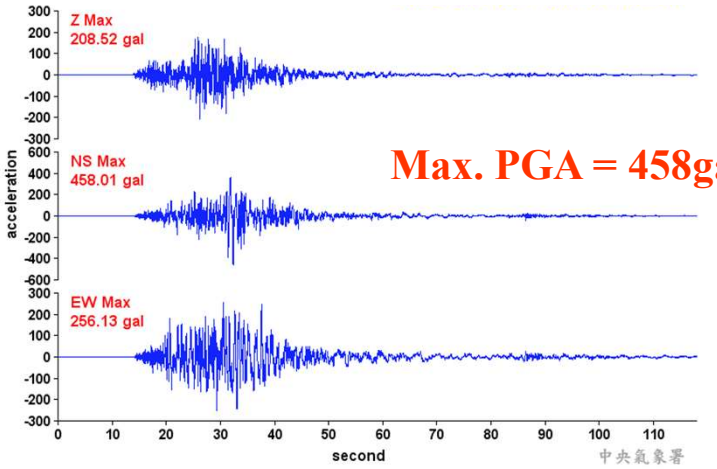
Stalon=121.75, Stalat=24.31, Dist.= 60.42km, BAZ=188.17



Max. PGA = 363.7gal

Hualien City (HWA), Int.= 6-

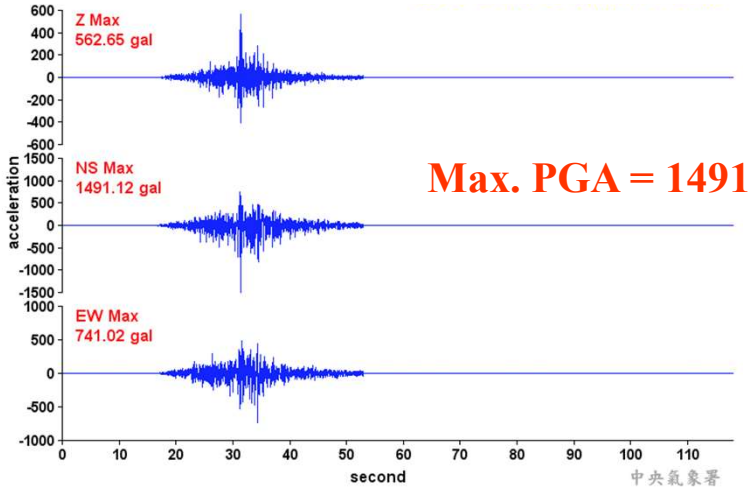
Stalon=121.61,Stalat=23.98,Dist= 23.41,BAZ=167.05



Max. PGA = 458gal

Taroko (ETL), Int.= 6-

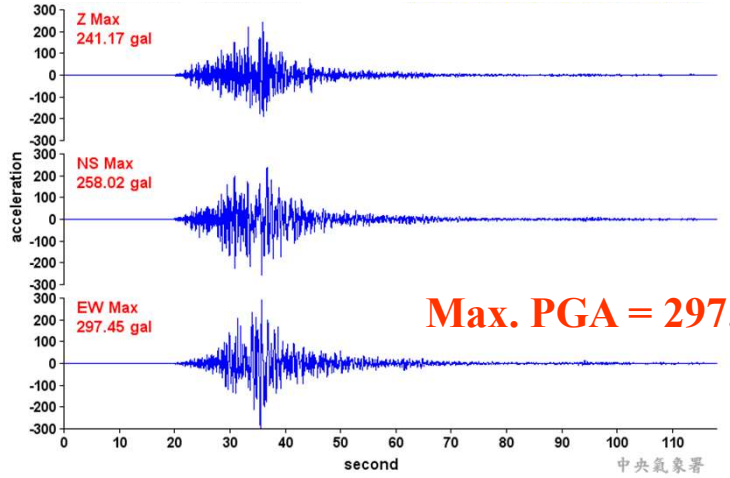
Stalon=121.62,Stalat=24.16,Dist= 43.37,BAZ=174.33



Max. PGA = 1491.1gal

Aohua (EAH), Int.= 5+

Stalon=121.74,Stalat=24.33,Dist= 62.51,BAZ=186.94



Max. PGA = 297.5gal

Observed Data and Design Spectra

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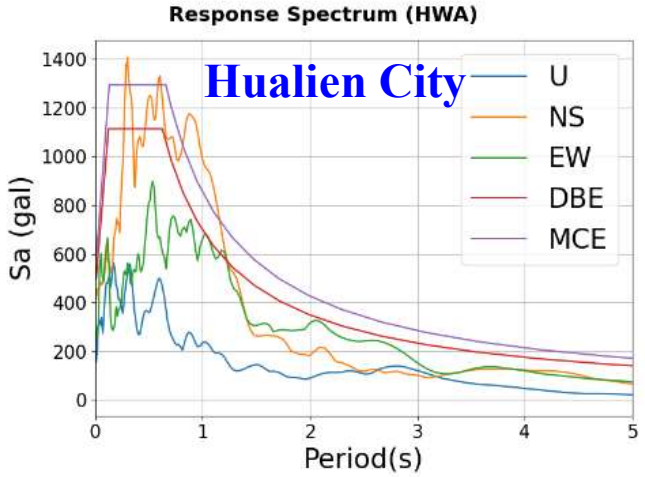
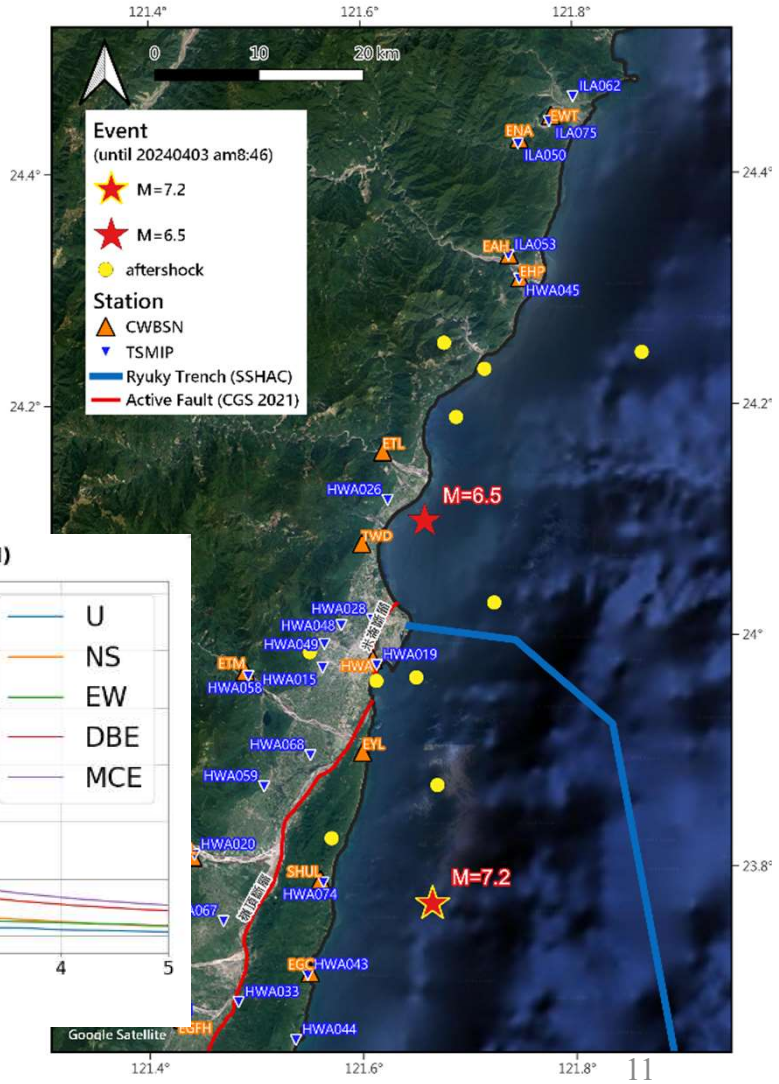
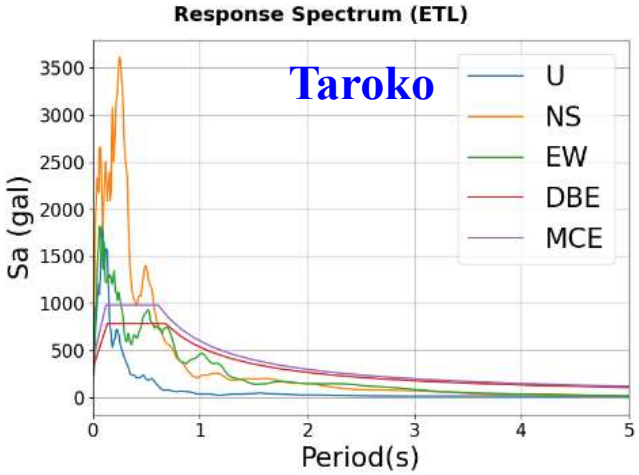
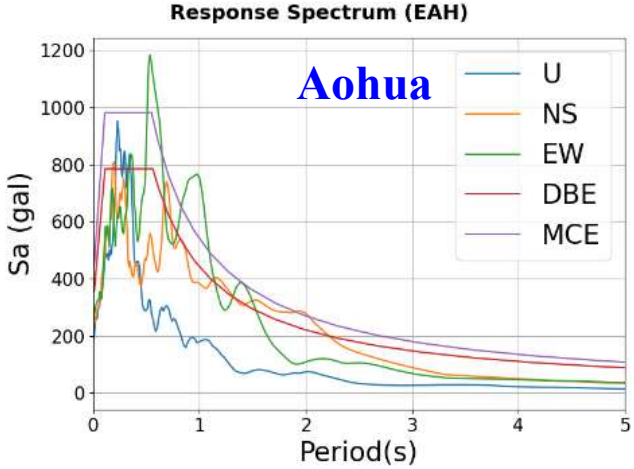
0403 M_L7.2, Depth 15.5km









DBE and MCE for Horizontal

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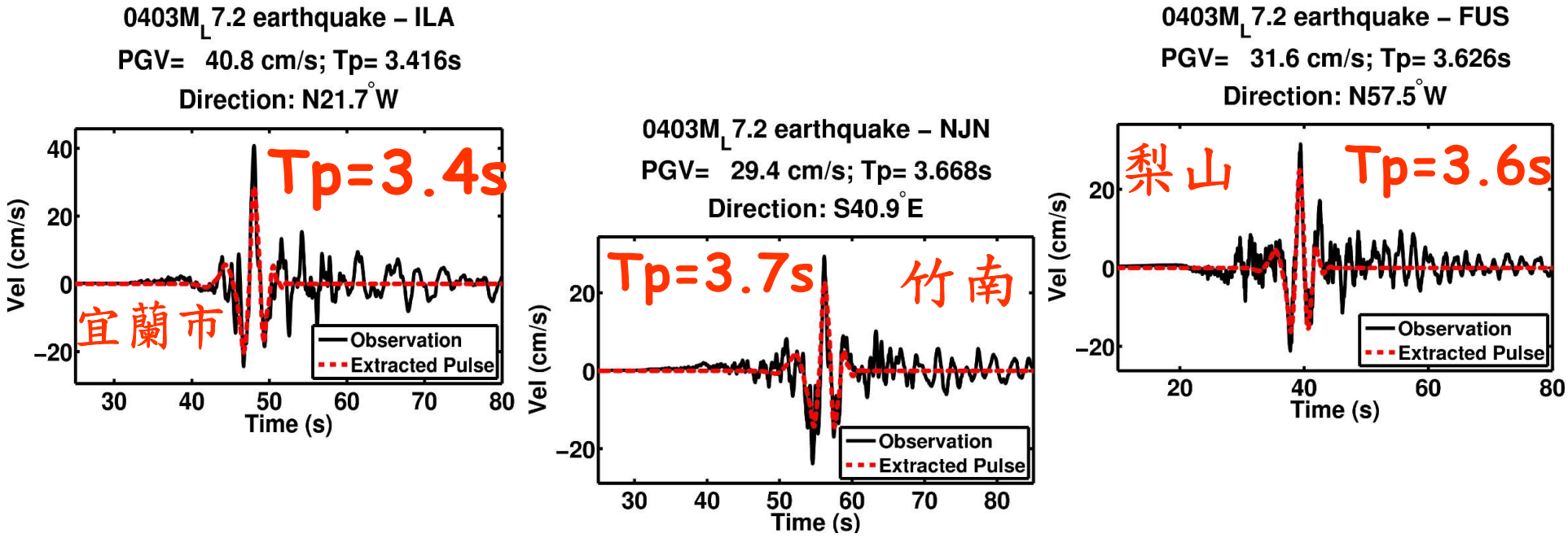
Pulse-Like Velocity Time Histories

- Three stations observed the pulse-like velocity (velocity pulse) from the Taiwan Rapid Earthquake Information Release System (RTD) till 15:30 on 3rd Apr. The extracted pulses are derived from Shahi and Baker's 2014 method. The corresponding pulse periods are 3.4 to 3.7 seconds.
- The PGV observed near the source at 和平、Hualien city are 65.7cm/s and 56.3cm/s, which are larger than the three stations but did not extract a velocity pulse.



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Pulse-Like Velocity Time Histories

- There are 11 additional pulse-like velocity time history observed by the TSMIP stations, listed as follows:

Station codes	Longitude	Latitude	Pulse Period(s)	PGV(cm/s)
ILA	121.76	24.76	3.4	40.8
FUS	121.24	24.25	3.6	31.6
NJN	120.87	24.68	3.7	29.4
ILA004	121.7907	24.7435	2.9	55.4
ILA006	121.8327	24.6397	3.1	50.9
ILA026	121.7728	24.6733	4.0	49.2
ILA037	121.7228	24.7435	2.5	42.5
ILA042	121.7987	24.6875	2.9	59.3
ILA046	121.7423	24.6650	3.4	27.2
ILA049	121.7563	24.7638	3.4	40.9
ILA059	121.8297	24.6655	3.4	55.5
ILA068	121.8573	24.5972	1.5	36.6

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Pulse-Like Velocity Time Histories

- There are 11 additional pulse-like velocity time history observed by the TSMIP stations, listed as follows:

Station codes	Longitude	Latitude	Pulse Period(s)	PGV(cm/s)
TCU033	120.8703	24.6835	3.9	33.6
TCU035	120.7970	24.6142	3.7	25.4

CWA Earthquake Report for the Largest aftershock

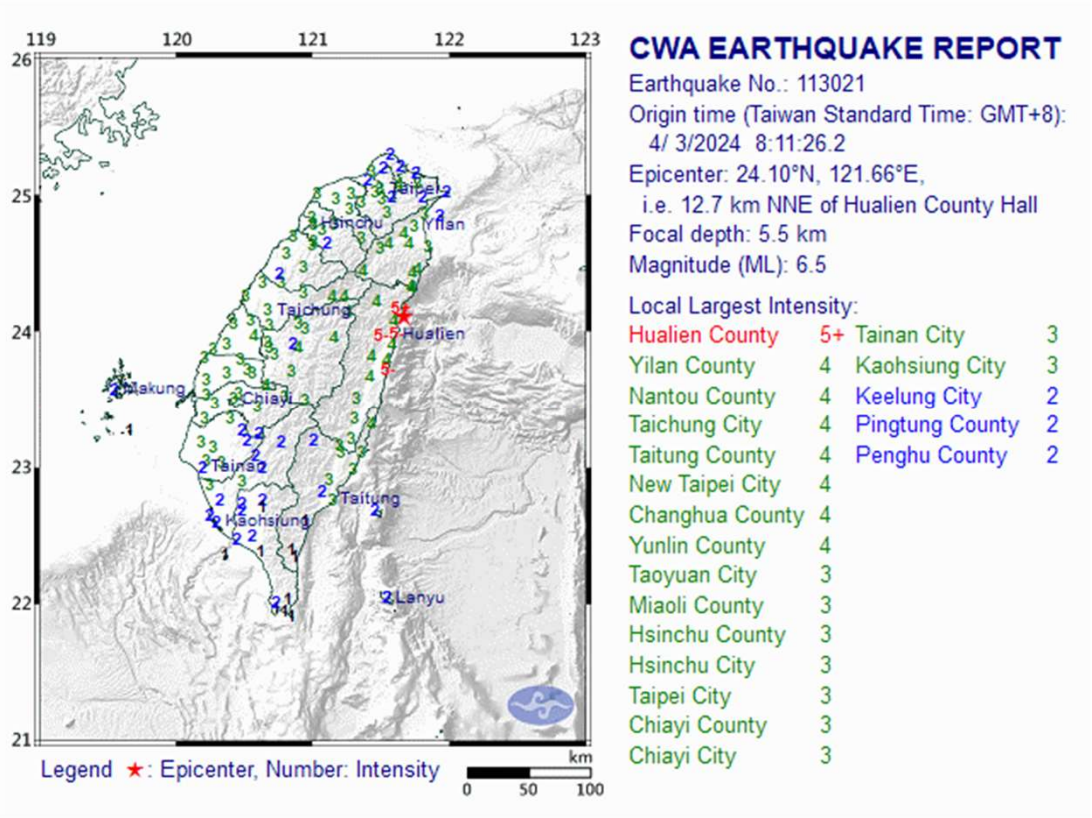
- Earthquake No.: 113021

  Origin time (Taiwan Standard Time: GMT+08:00): 4/ 3/2024 8:11:26.2

  Location: 24.10N 121.66E, i.e. 12.7 km NNE of Hualien County

  Depth : 5.5 km

  Magnitude(M_L): 6.5



From Central Weather Administration

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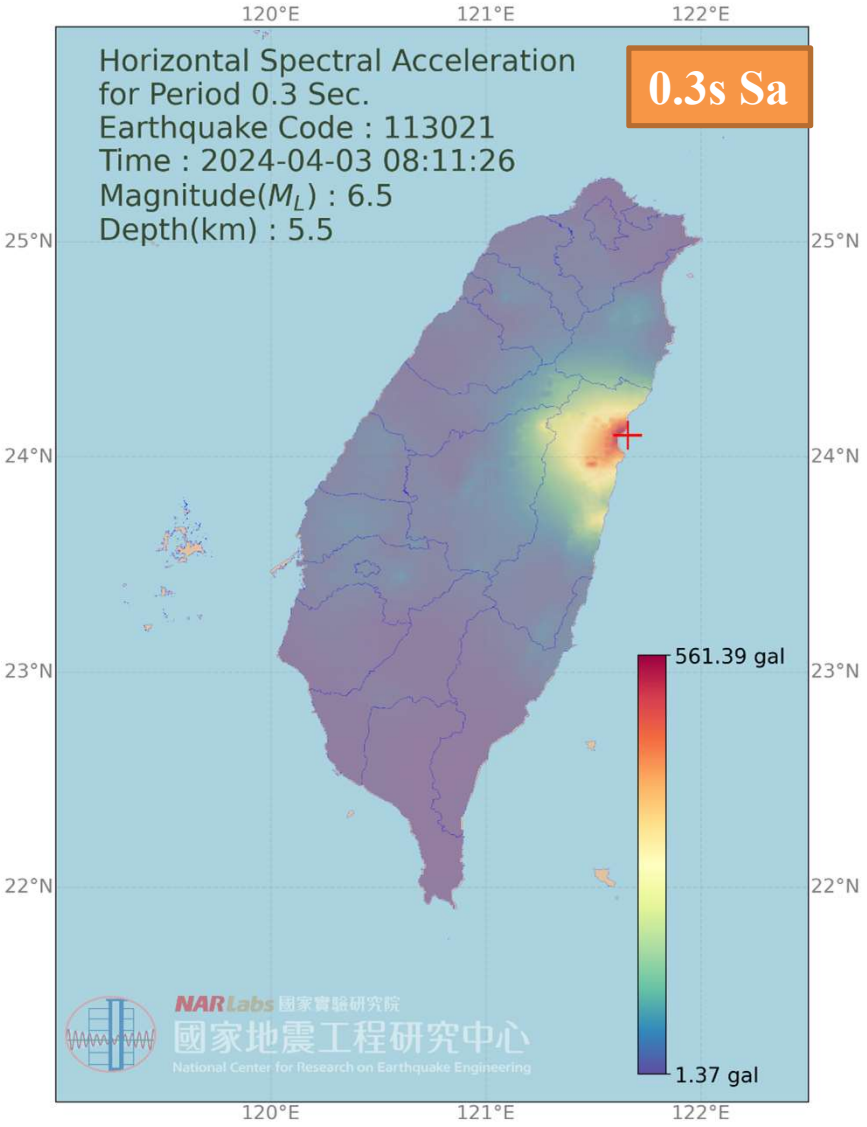
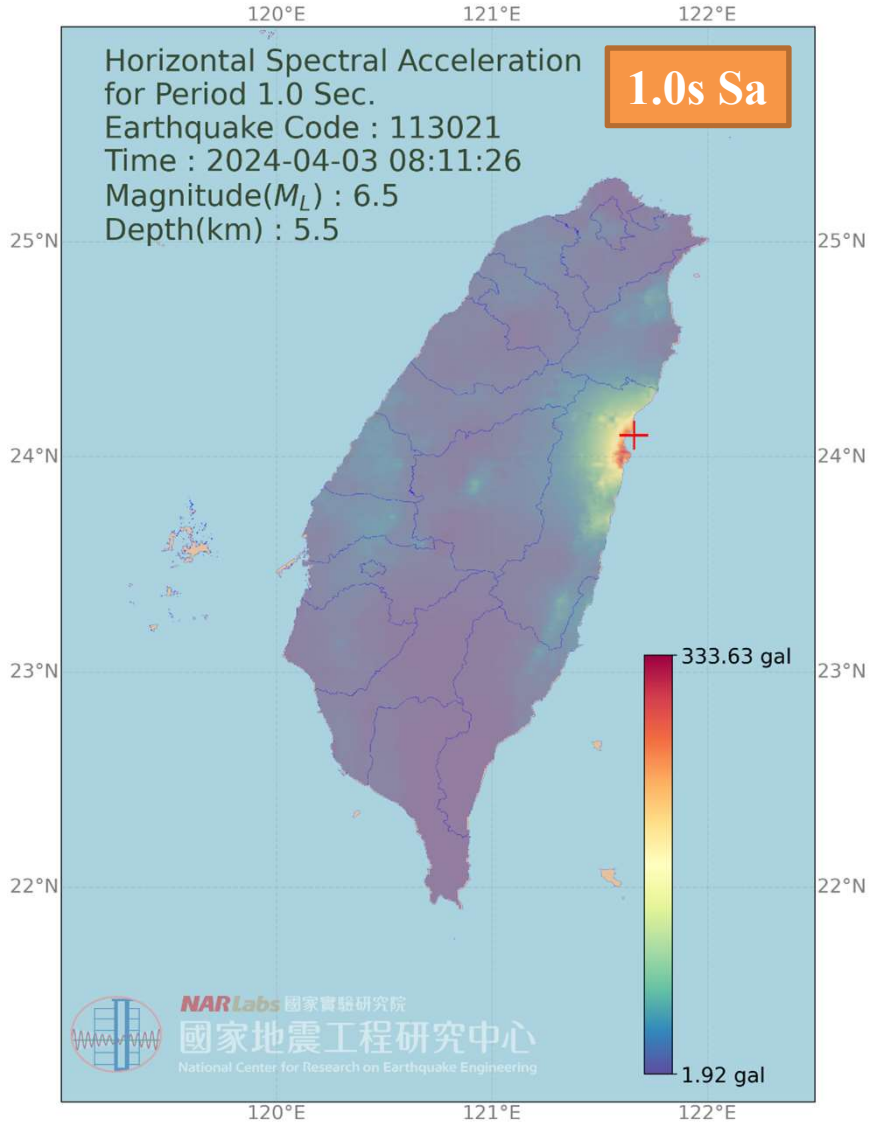
Spectral Acceleration Maps

0403 M_L6.5, Depth 5.5km





Time Histories

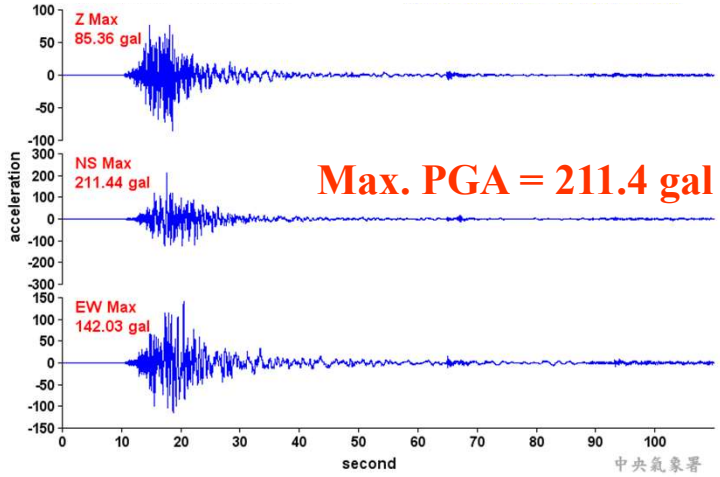
NARLabs

0403 M_L6.5, Depth 5.5km

From Central Weather Administration

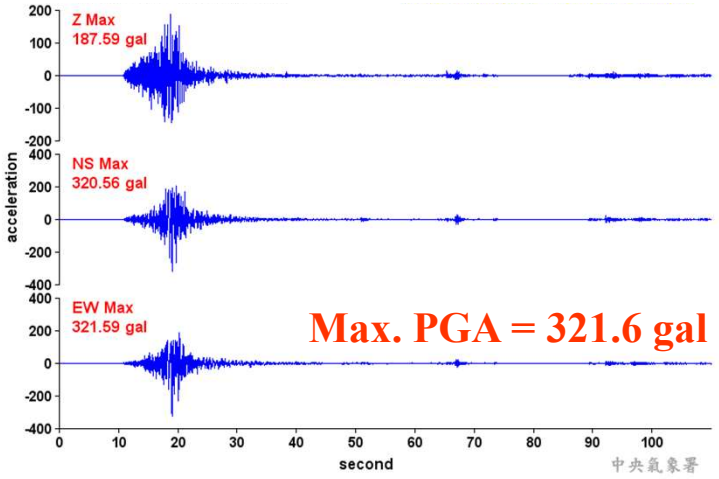
Hualien City (HWA), Int.= 5-

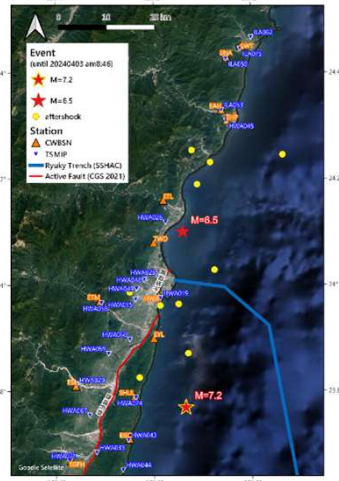
Stalon=121.61,Stalat=23.98,Dist= 14.64,BAZ= 18.50

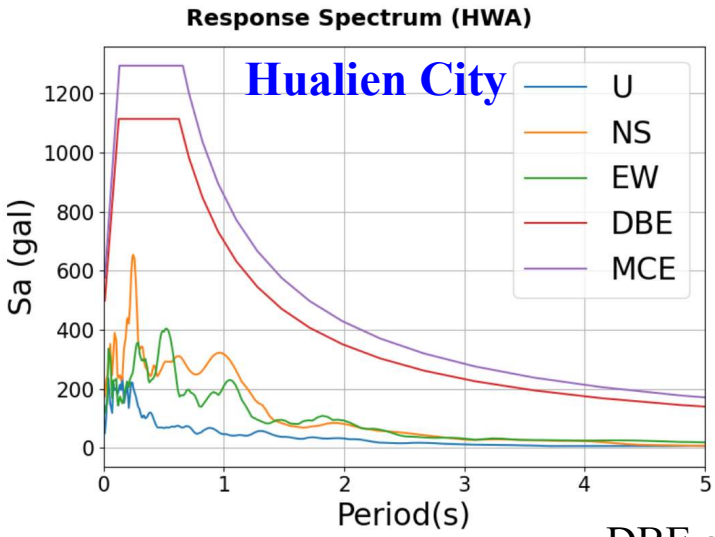


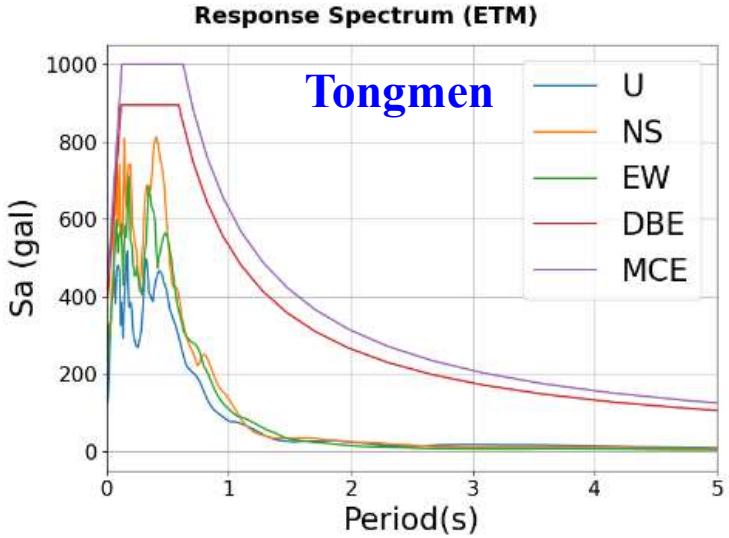
Tongmen (ETM), Int.= 5-

Stalon=121.49,Stalat=23.97,Dist= 22.54,BAZ= 48.66









DBE and MCE for Horizontal

Outline

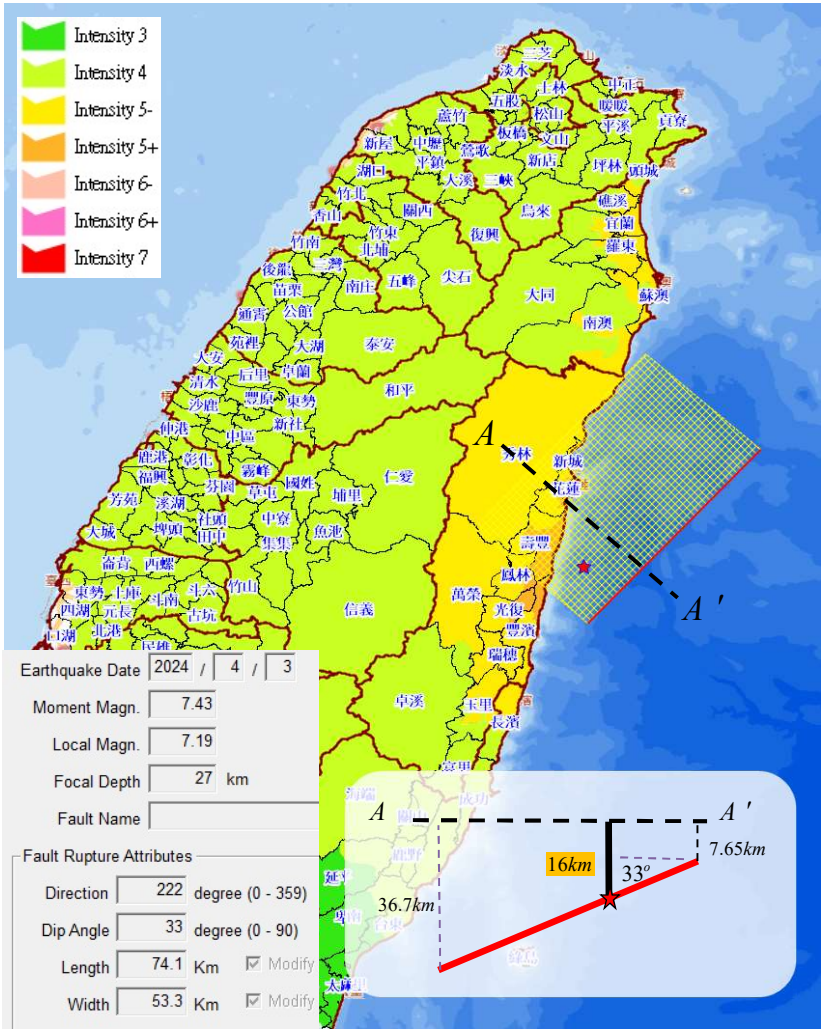
- Seismic Source and Ground Motion Characteristics
- Early Seismic Loss Estimation
- NCREE EEWS Performance
- Bridge Damage
- Building Damage
- Geotechnical Damage
- Non-Structural Component (NSC) Damage

Seismic Source Parameters Assumed

- Depth：15.5~35.5km
- Magnitude：M_L7.2 、 M_W7.37~7.66
- Direction & Dip :USGS Focal mechanisms

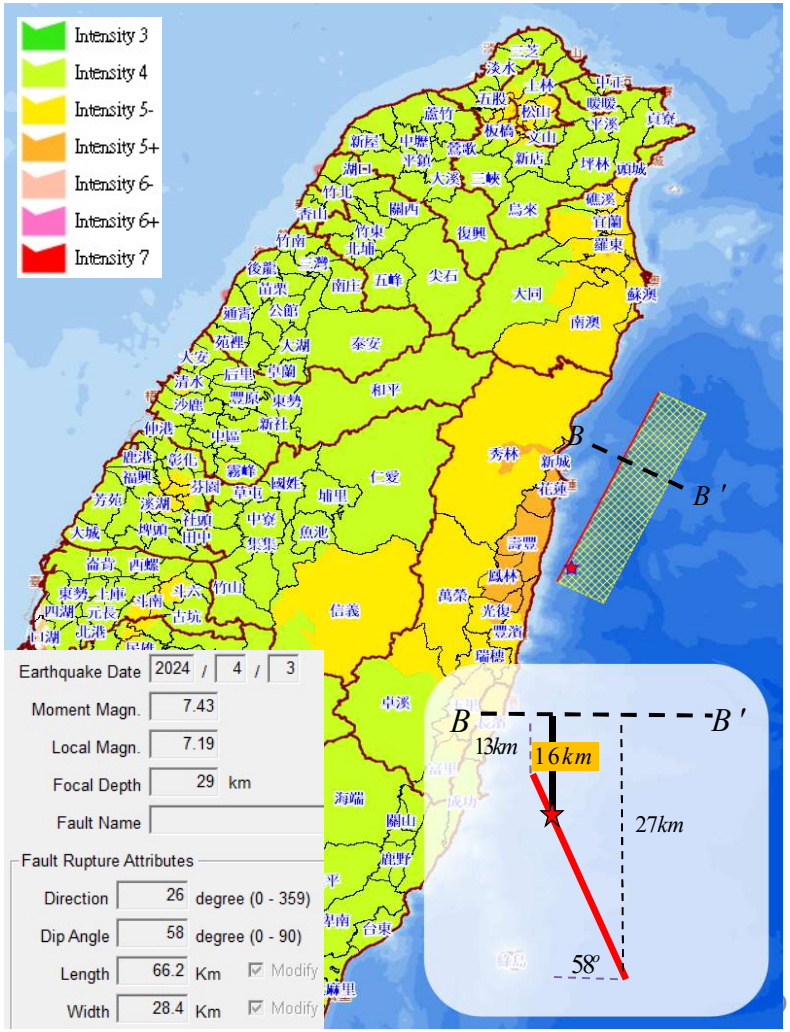
Scenario 1

- Sloping northwestward
- Subduction interface GMPE



Scenario 2

- Sloping southeastward
- Reverse fault GMPE

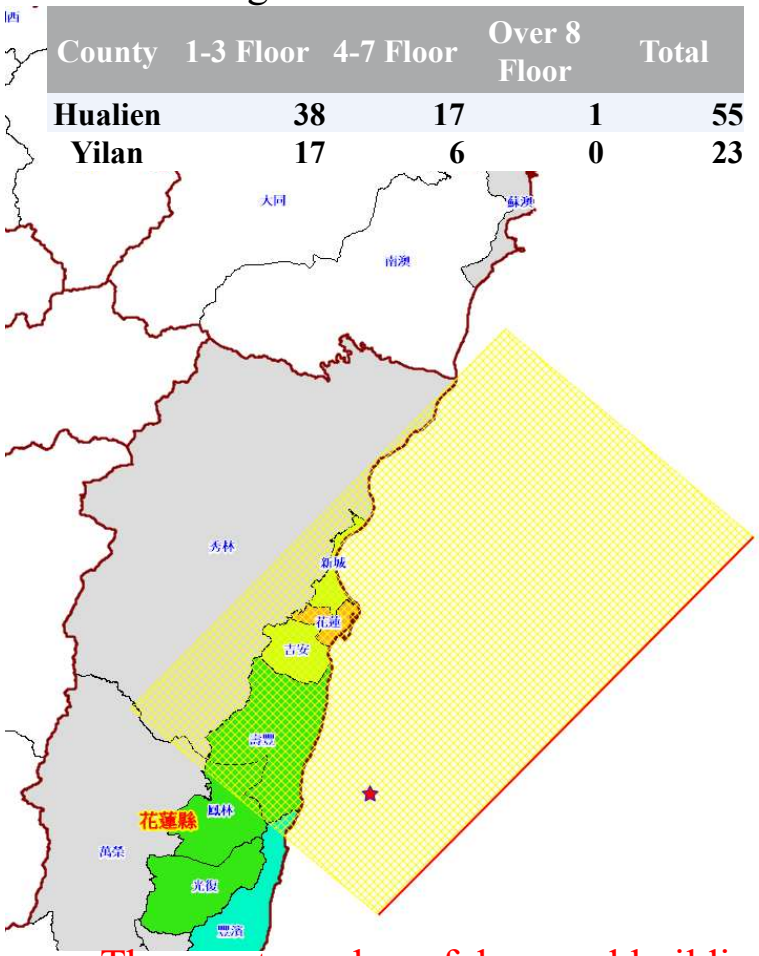


Estimation of building damage

Scenario 1

●Estimated result：about 78 buildings at least severe damaged.

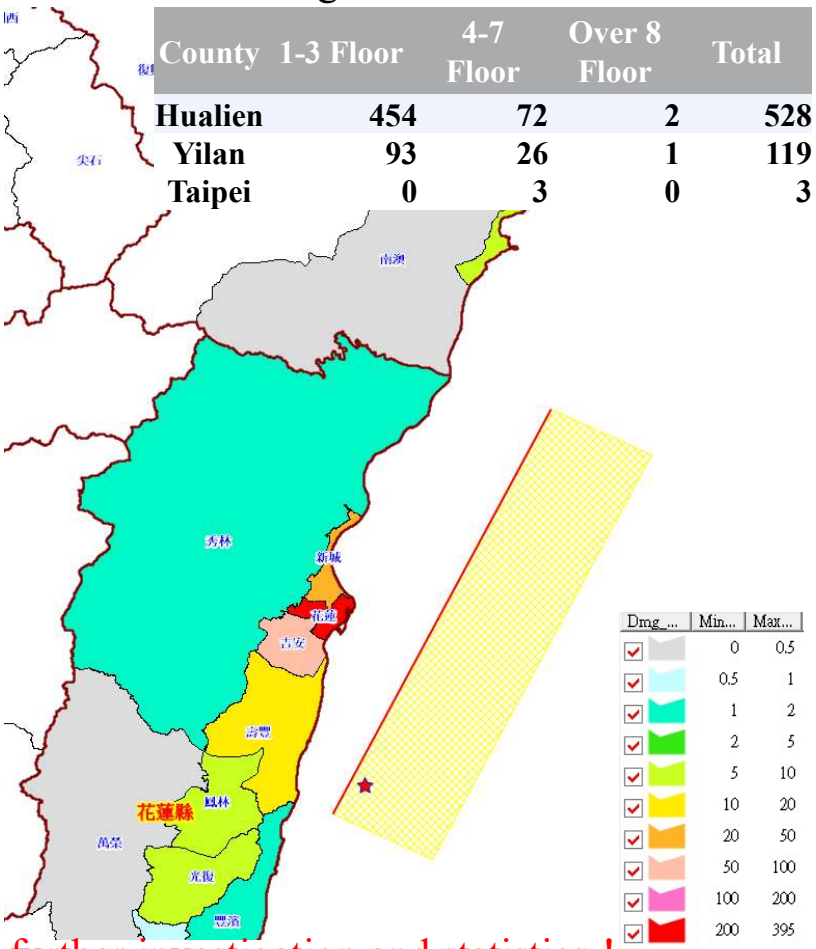
County	1-3 Floor	4-7 Floor	Over 8 Floor	Total
Hualien	38	17	1	55
Yilan	17	6	0	23



Scenario 2

●Estimated result：about 650 buildings at least severe damaged.

County	1-3 Floor	4-7 Floor	Over 8 Floor	Total
Hualien	454	72	2	528
Yilan	93	26	1	119
Taipei	0	3	0	3



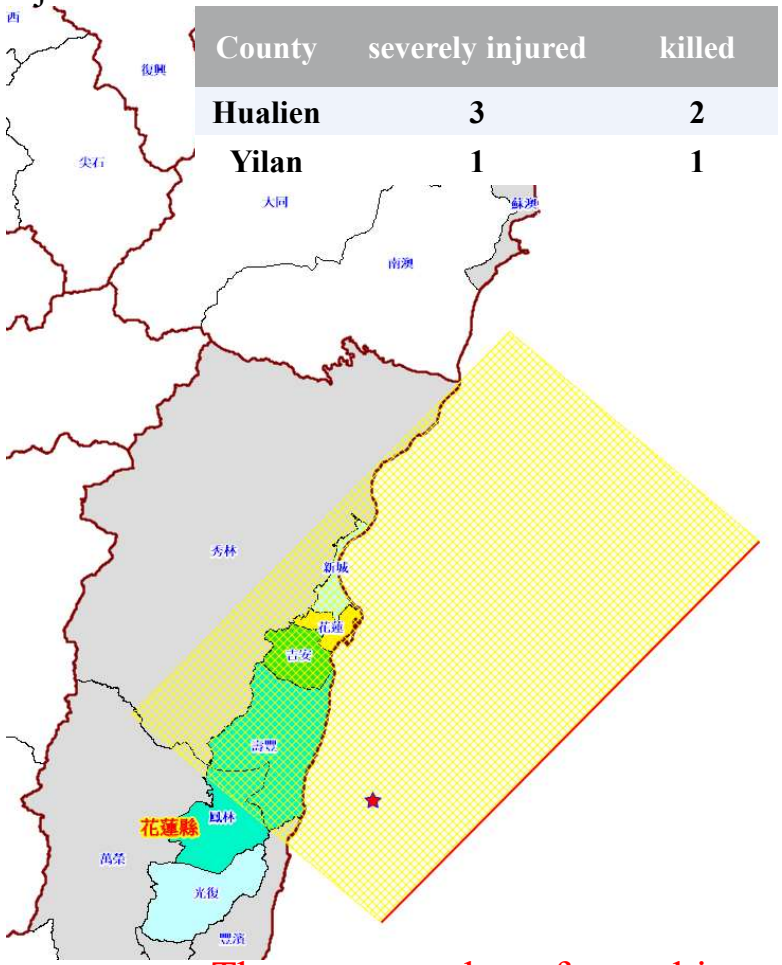
The exact number of damaged buildings awaits further investigation and statistics！

Estimation of casualties

Scenario 1

●Estimated result：about 7 people severely injured or killed

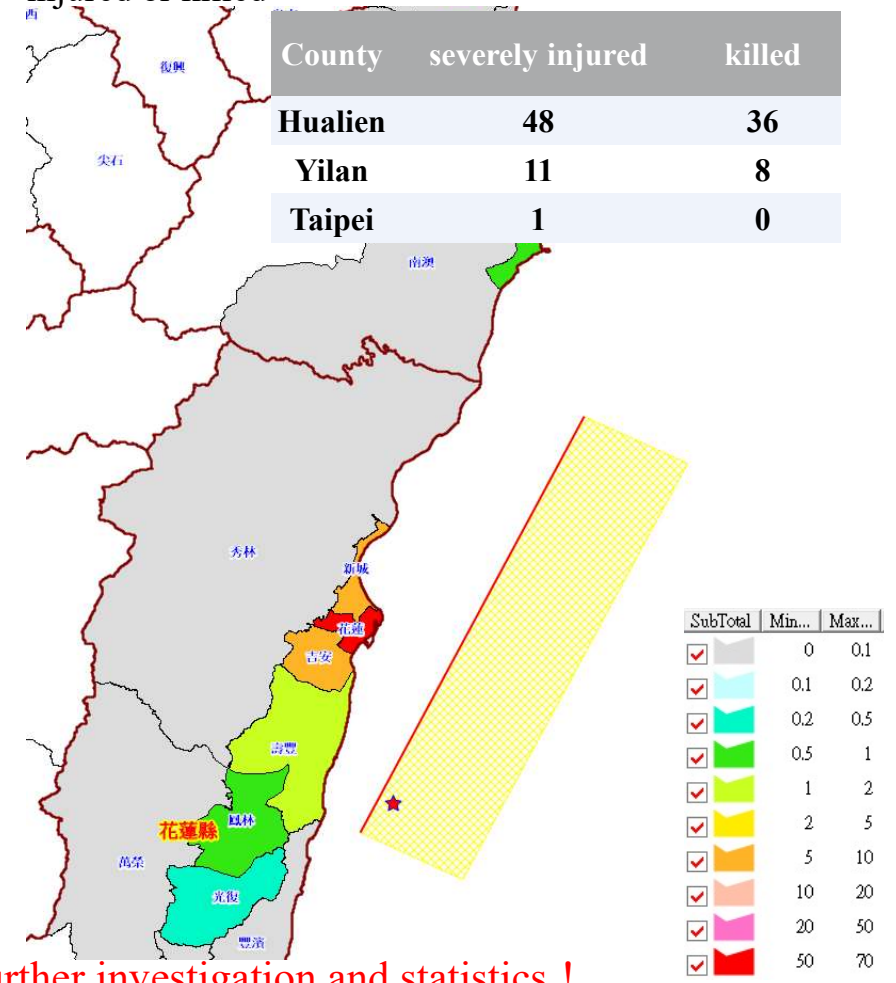
County	severely injured	killed
Hualien	3	2
Yilan	1	1



Scenario 2

●Estimated result：about 104 people severely injured or killed

County	severely injured	killed
Hualien	48	36
Yilan	11	8
Taipei	1	0



The exact number of casualties awaits further investigation and statistics！

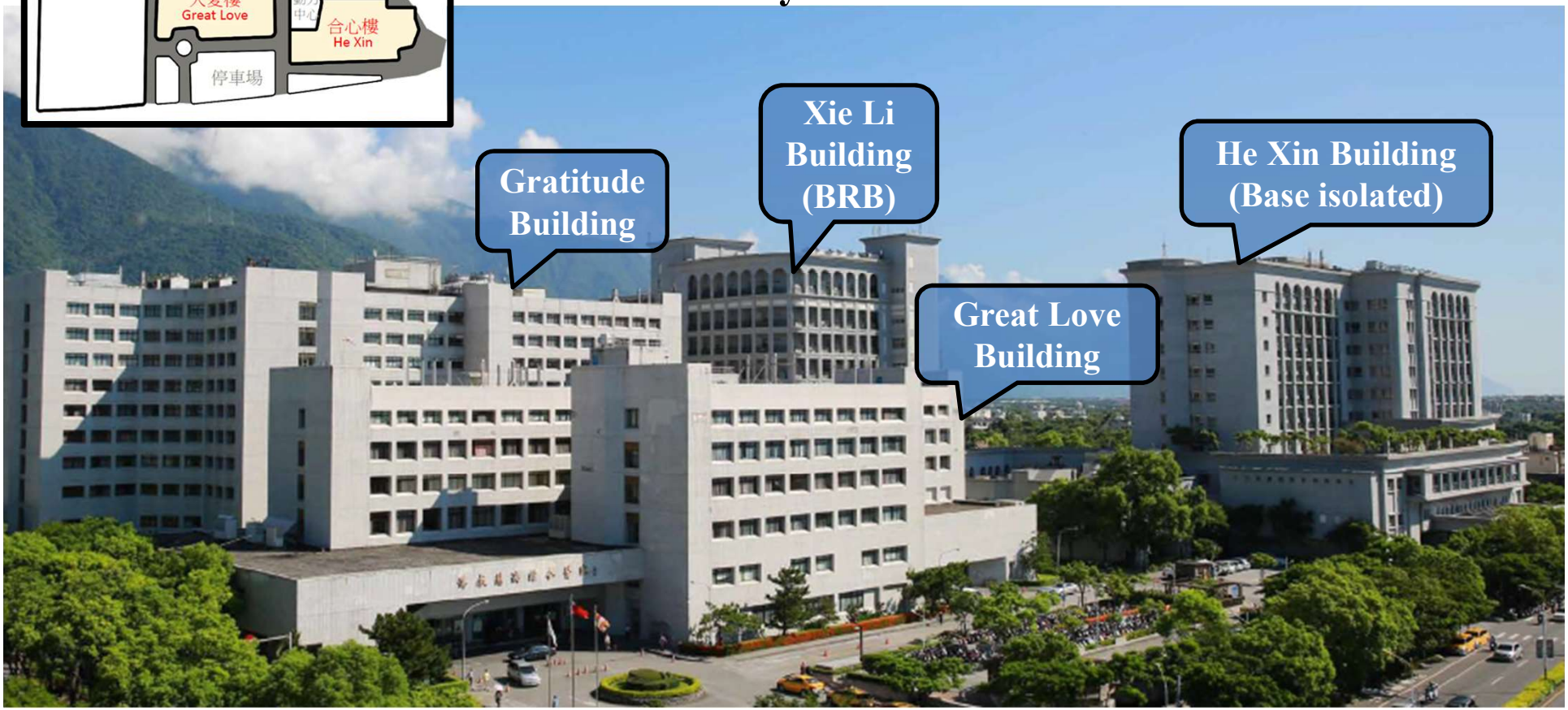
NARLabs

Outline

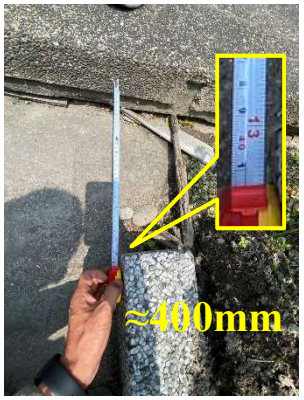
- Seismic Source and Ground Motion Characteristics
- Early Seismic Loss Estimation
- **Isolated Building Damage**
- Building Damage
- Geotechnical Damage
- Non-Structural Component (NSC) Damage

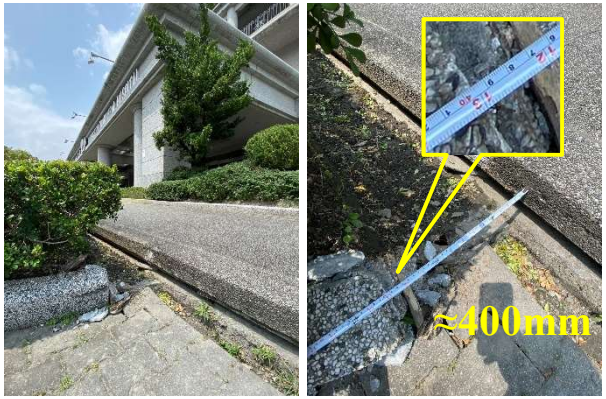
Hualien Tzu Chi Medical Center

- **Without any structural damage and damage in isolation system.**
- **Minor nonstructural damages due to movement of isolation system.**

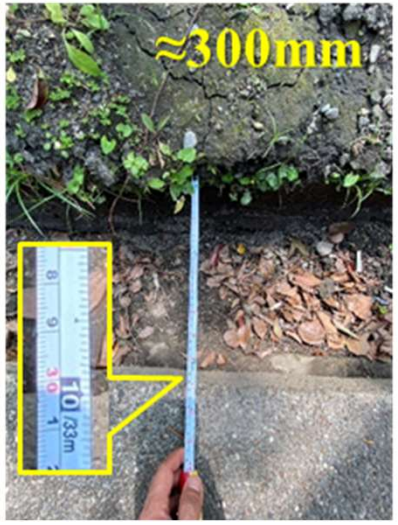



≈300mm


≈400mm


≈400mm

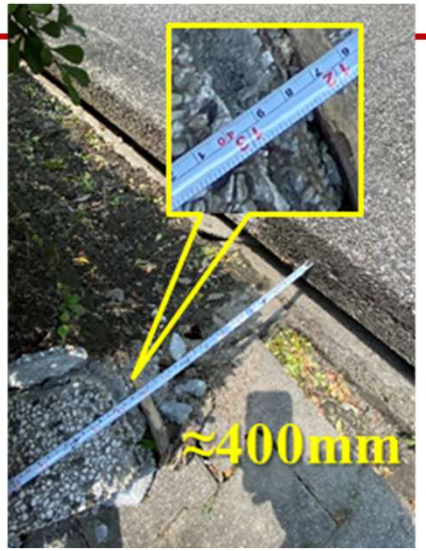
Surrounding Areas of He Xin Building

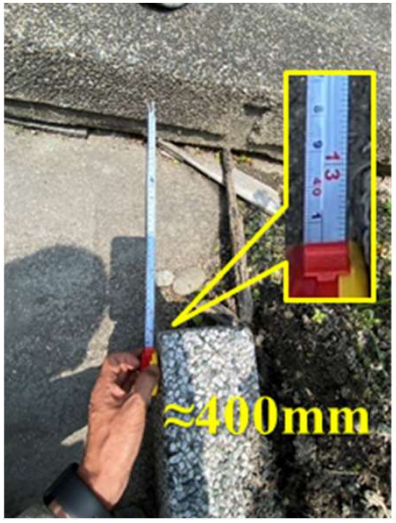


The maximum pushing displacement (isolation displacement) in longitudinal dir. could be roughly measured as 300mm

Damages of stone slabs due to insufficient isolation moving space

Surrounding Areas of He Xin Building





400mm in transverse direction

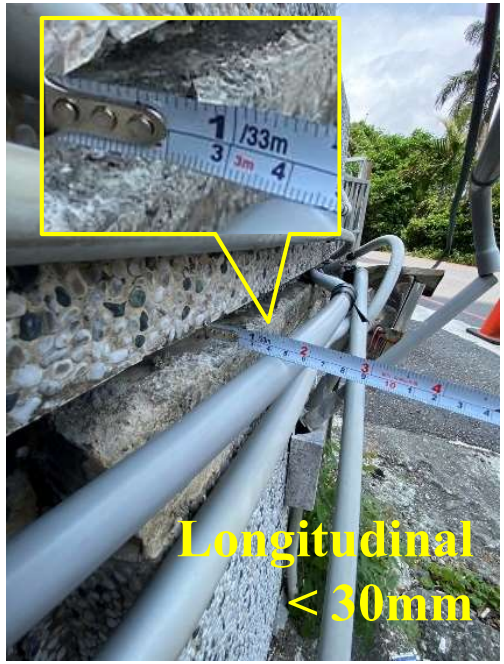
Damages of garden stone pillars due to insufficient isolation moving space

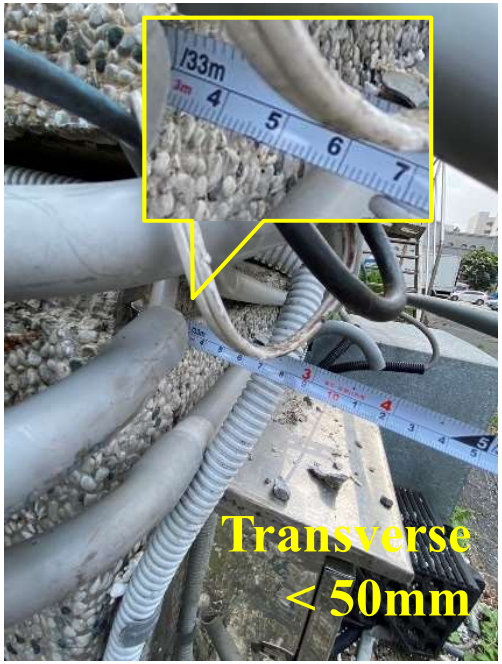
Surrounding Areas of He Xin Building

Insufficient isolation moving space

Surrounding Areas of He Xin Building

Insufficient isolation moving space

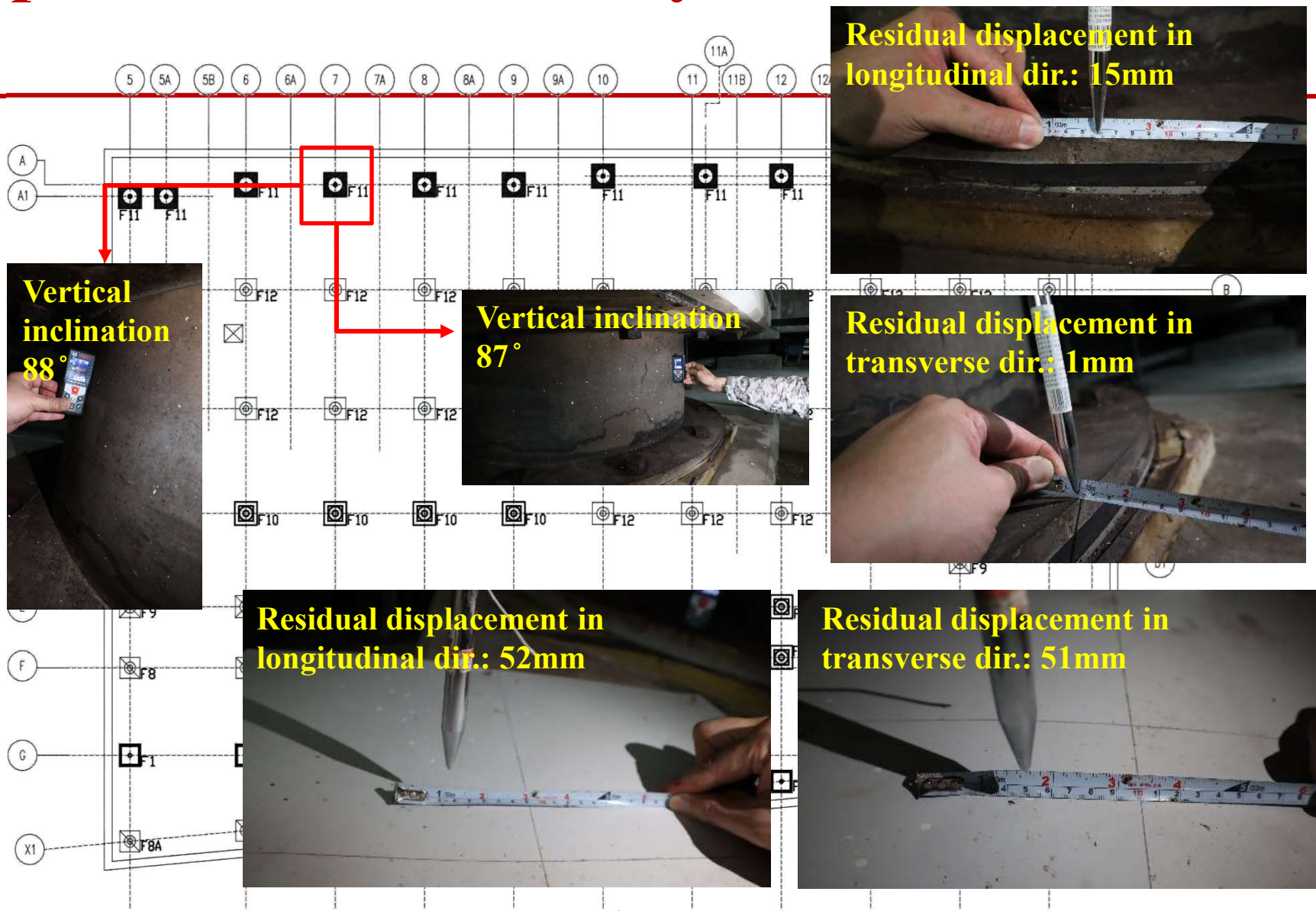




Measured residual displacement：
Longitudinal < 30mm;
Transverse < 50mm

Inspection of Isolation System

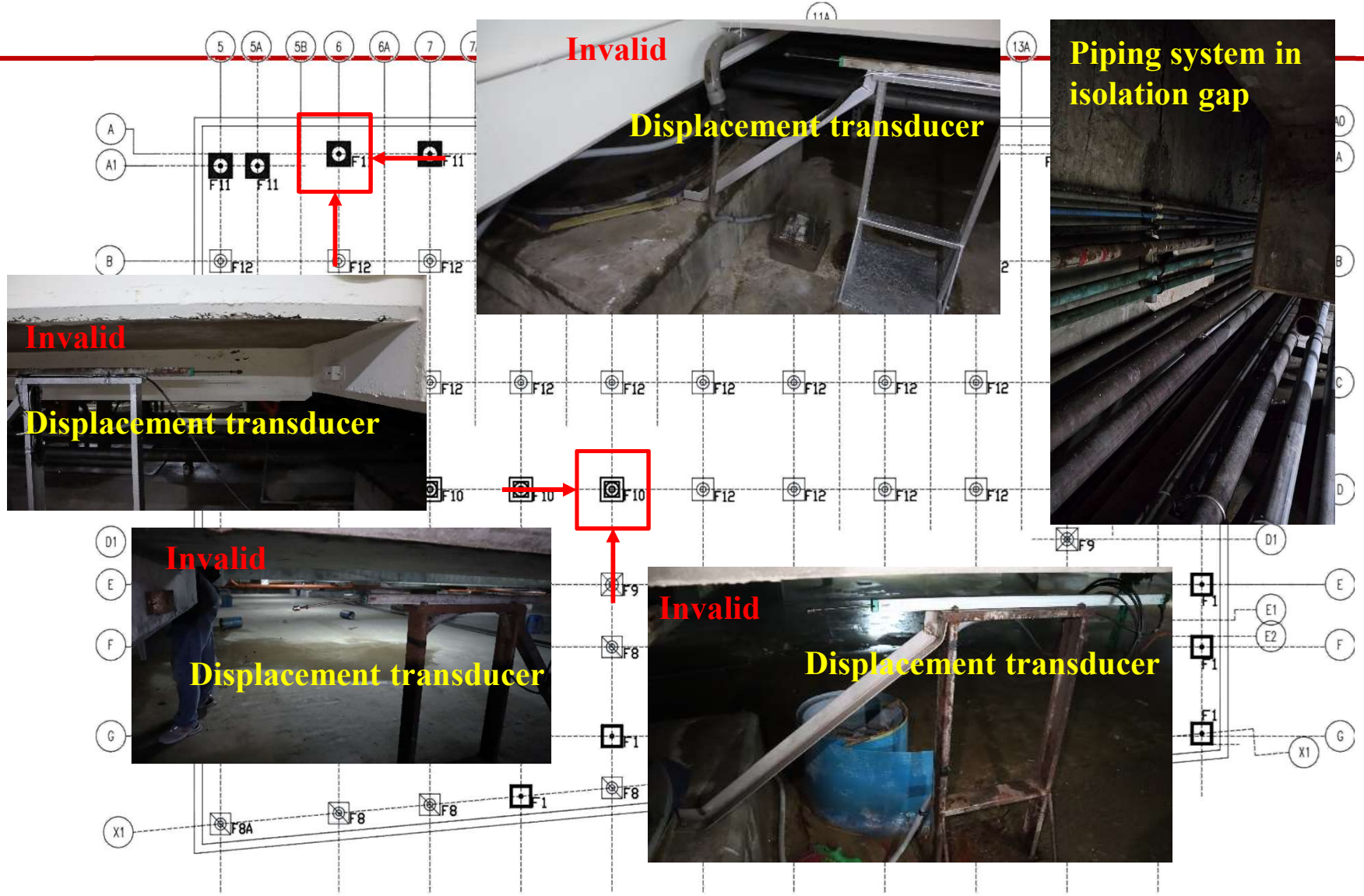
NARLabs



Measurement from recording panel.
(The residual displacements correspond to original location)

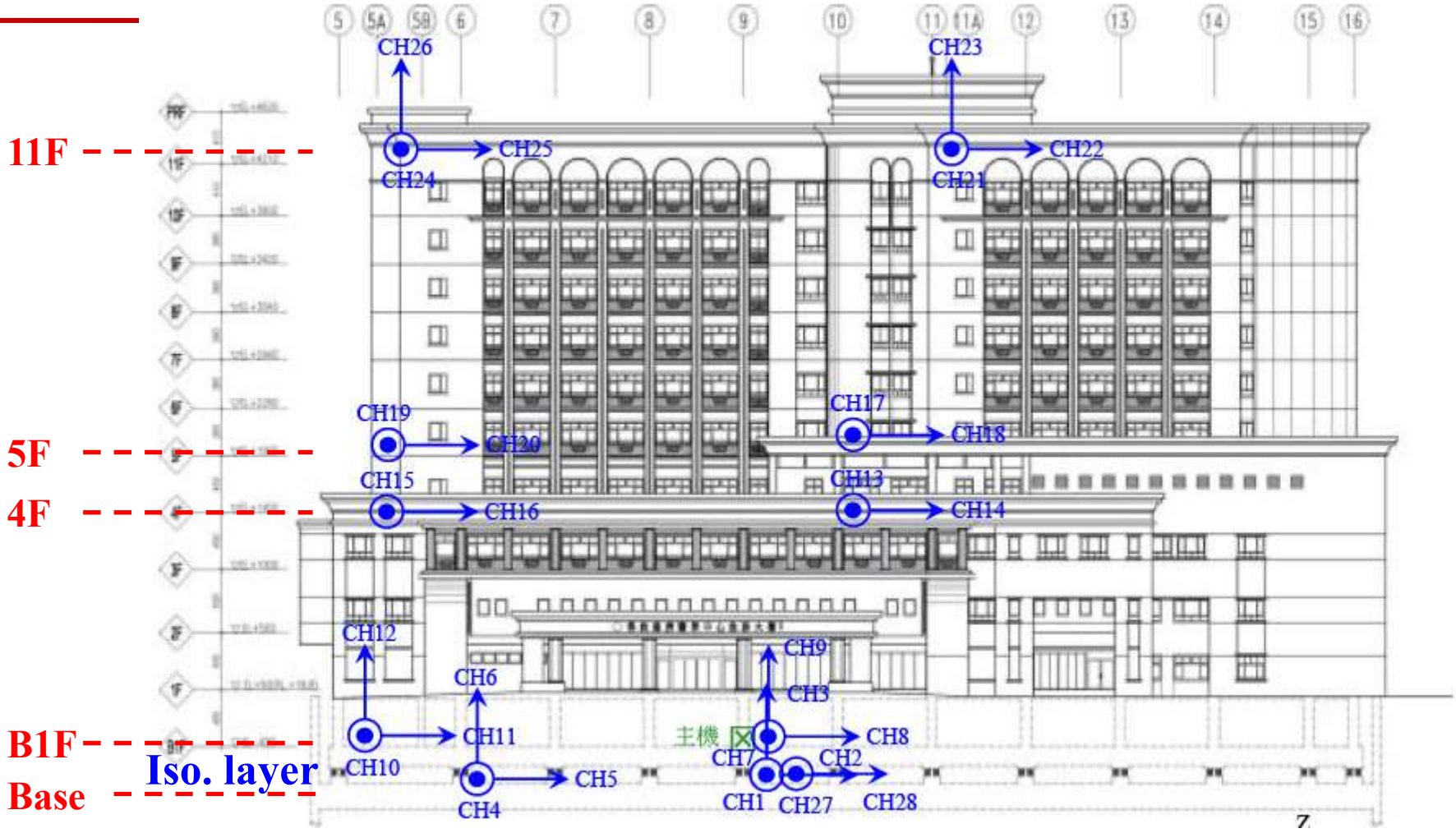
Defects in Isolation Layer

NARLabs



Instrumentation of He Xin Building

NARLabs



CH1~CH26 : Accelerometer

CH27~CH30: Displacement transducer

Instrumentation of He Xin Building

NARLabs

Base floor

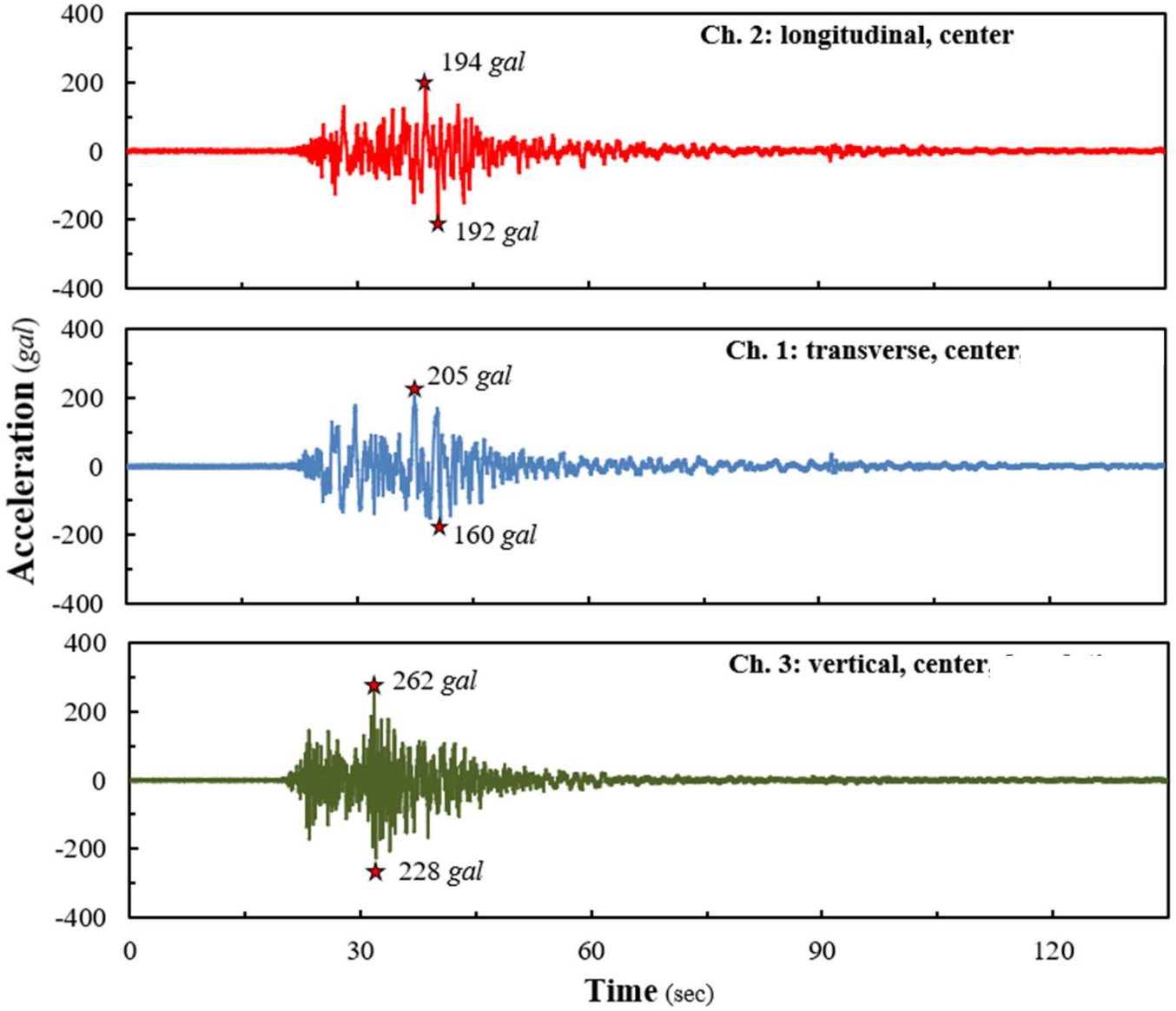
CH1~CH26 : Accelerometer

CH27~CH30: Displacement transducer

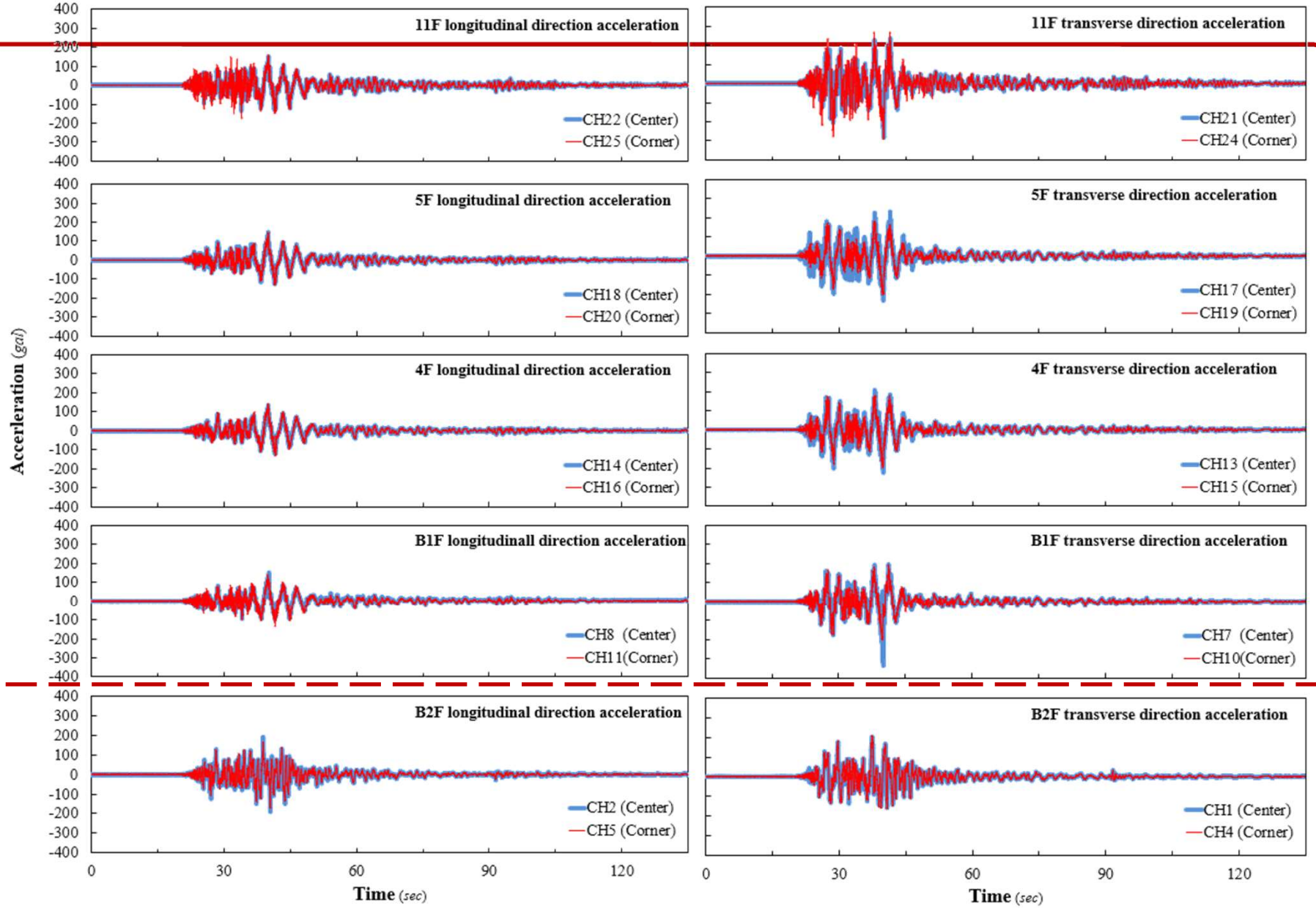
Input Excitations

NARLabs

Acceleration history records at the center of base floor



Acceleration Records of Each Floor



Peak Acceleration Values of Each Floor

(unit: gal)

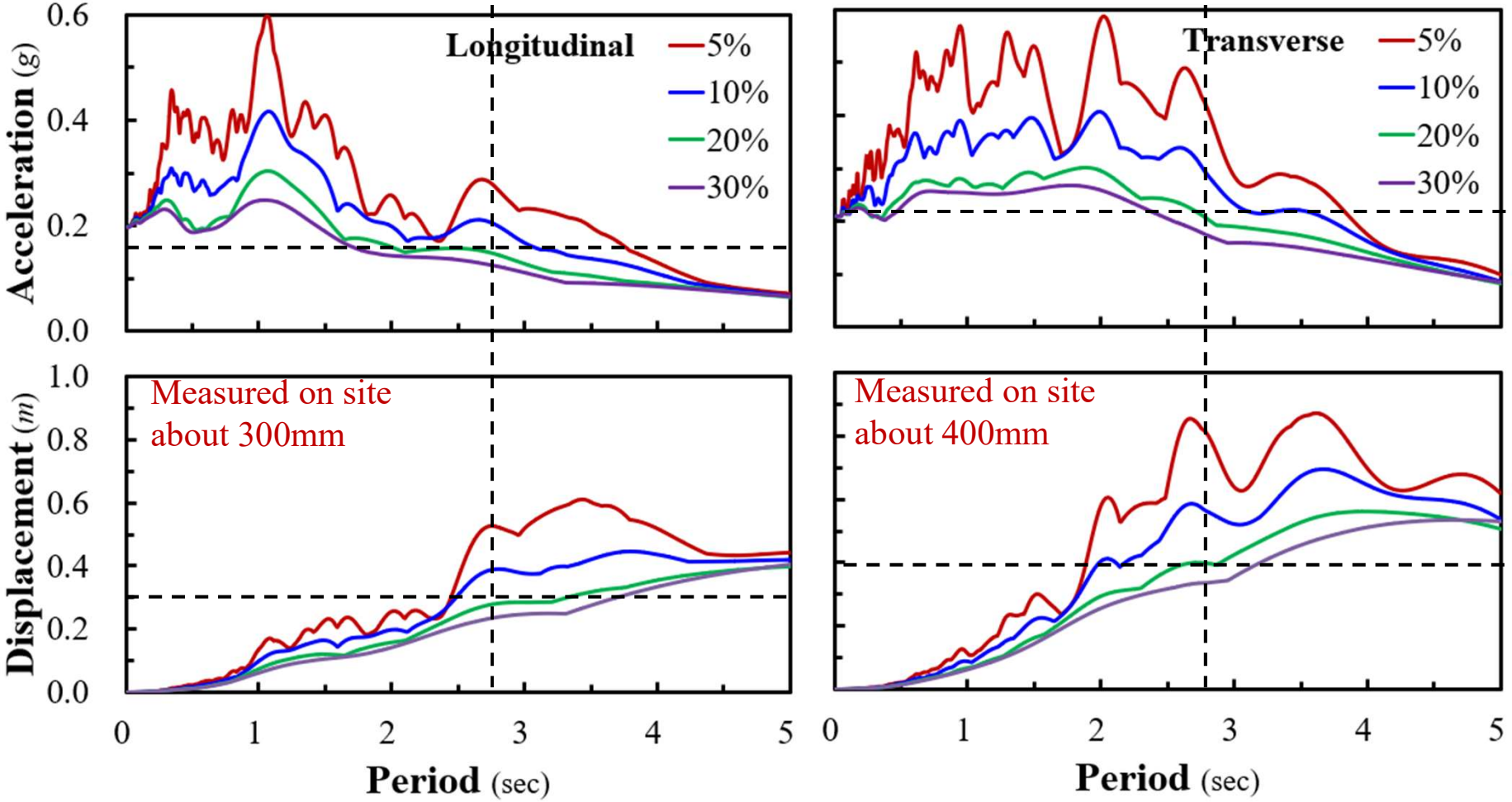
Floor	longitudinal	transverse
11F	152	290
5F	148	202
4F	135	198
B1F	152	200
B2F	194	209
11F / B2F	78%	139%
5F / B2F	76%	97%
4F / B2F	70%	95%
B1F / B2F	78%	96%

Input Excitation Spectra

NARLabs

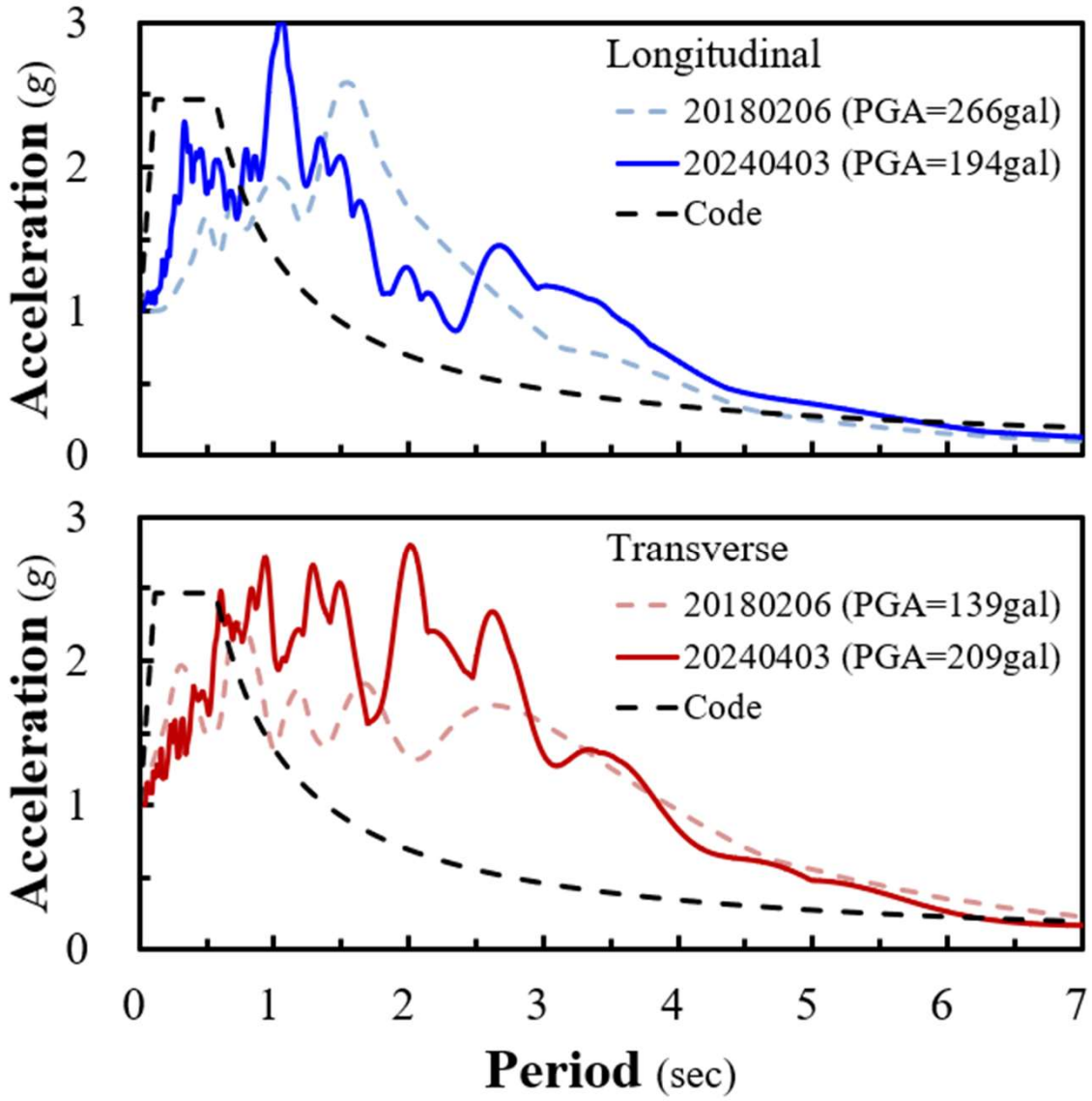
Design values from static analysis:
Effective period = 2.76sec
Equivalent damping ratio = 28%
Design displacement = 238.48mm
Total design displacement = 292.51mm

Design values from spectrum analysis：
Design displacement = 350mm
Actual design displacement = 600mm
Actual isolation gap = 700mm



Comparison of Input Excitation Spectra

Normalized to EPA=1g



Outline

- Seismic Source and Ground Motion Characteristics
- Early Seismic Loss Estimation
- Isolated Building Damage
- **Building Damage**
- Geotechnical Damage
- Non-Structural Component (NSC) Damage

Damaged bldg.

5-story Residential bldg.

Hualien City

民視新聞

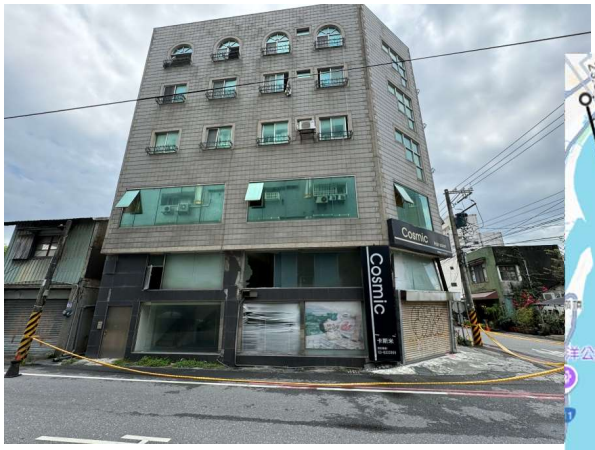
Soft/weak story failure

Damaged bldg.

5-story Residential bldg.

Hualien City

- RC Column failure
- Bldg. inclined



Damaged bldg.

4-story Residential bldg.

Hualien City

Column protective layer peeling off

Damaged bldg.

4-story Residential bldg.

Hualien City

RC Beam-Column Connection Failure

Partition walls damaged

Damaged bldg.

School bldg. in Hualien City

windowsill shear failure

Damaged bldg.

6-story Residential bldg.

Hualien City

Walls shear failure

Wall protective layer peeling off

Damaged bldg.

4-story Residential bldg.

Hualien City

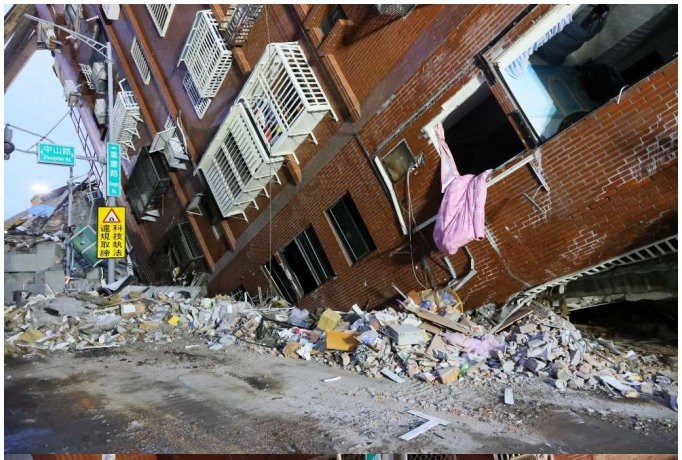
The bottom of RC column crack

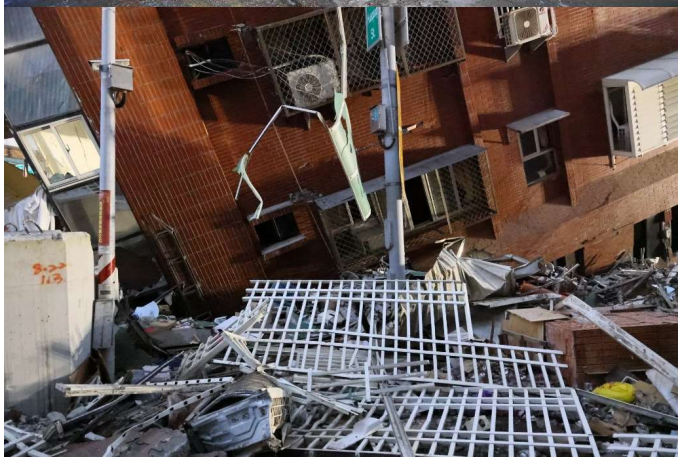
Damaged bldg.

10-story Residential bldg.

Hualien City, Hualien County

- **Soft/weak story failure**





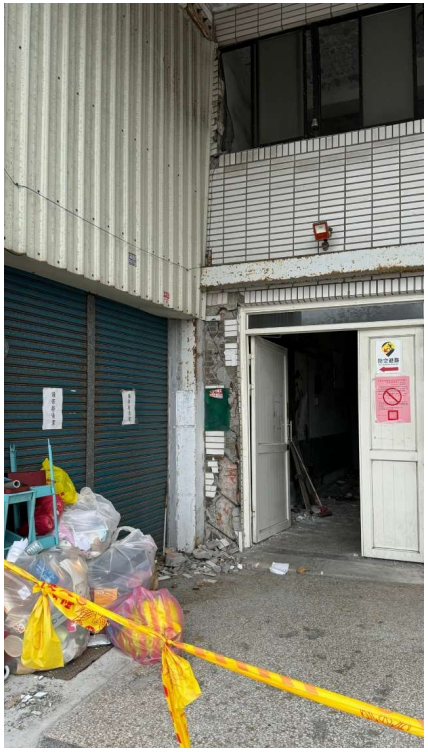
Damaged bldg.

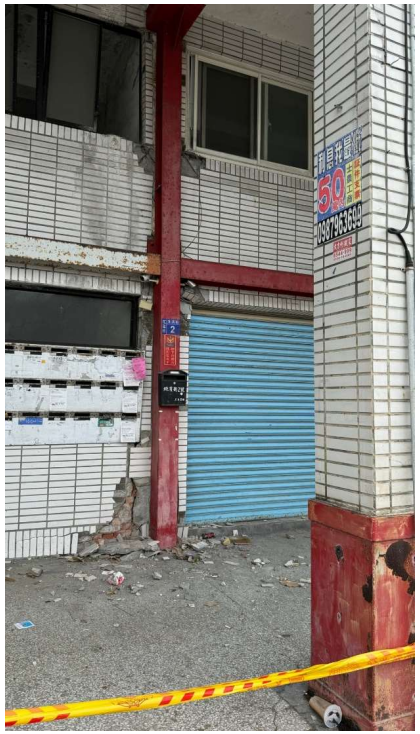
6-story Residential bldg.

Hualien City

RC columns at 1st-story crack

windowsill shear failure





Damaged bldg.

6-story Residential bldg.

Hualien City

NARLabs

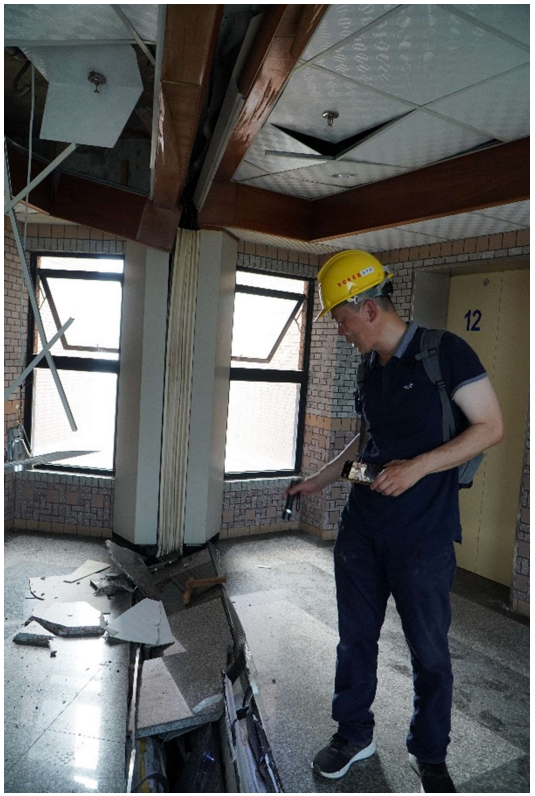
Severe Damage to the Ground Floor

Damaged bldg.

Residential bldg.

Renli 5th St., Ji'an Township, Hualien County

RC Wall failure



Damaged bldg.

Residential bldg.
Hualien City

- **RC Columns flexural failure**
- **Walls damaged severely**

距震央23.97km

Damaged bldg.

6-story Hotel bldg. Hualien City

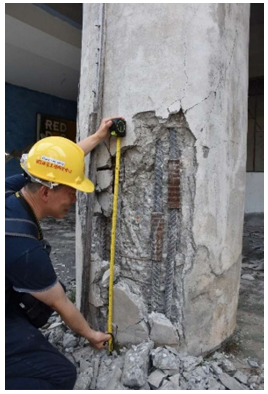
- **RC Columns and walls damaged severely**

Damaged bldg.

12-story Residential bldg.

Hualien City

- RC Walls and Partition walls shear failure
- RC Columns shear failure

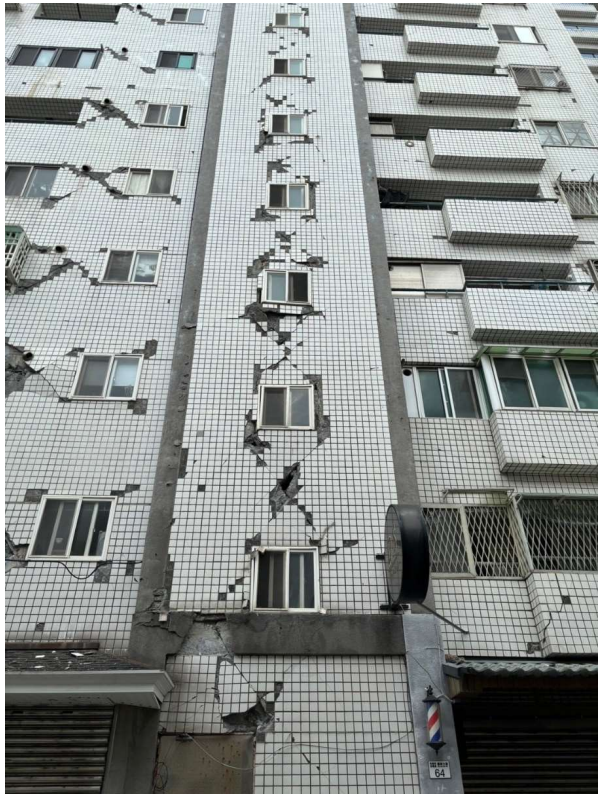


Damaged bldg.

Residential bldg.

Hualien County

RC Walls Shear failure



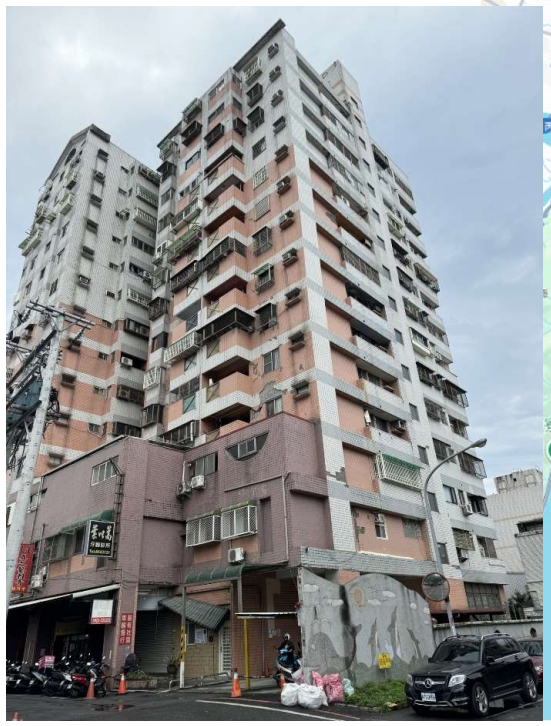
Damaged bldg.

14-story Residential bldg.

Hualien City

RC Columns shear failure

Tiles falling



Damaged bldg.

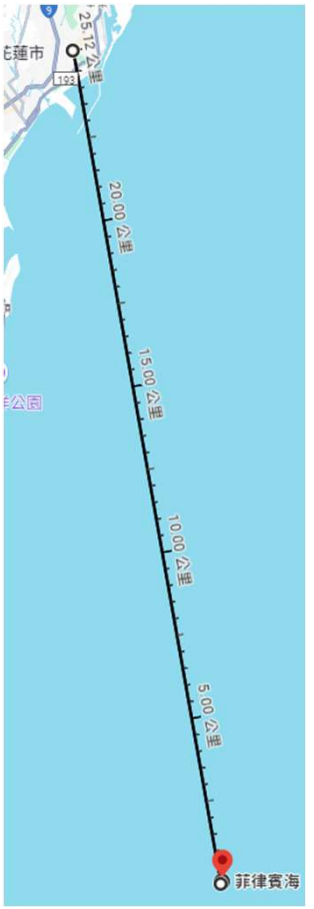
Hotel bldg. Hualien City

NARLabs

RC Column concrete bursts, steel bars buckle

https://www.cna.com.tw/

距震央25.12km

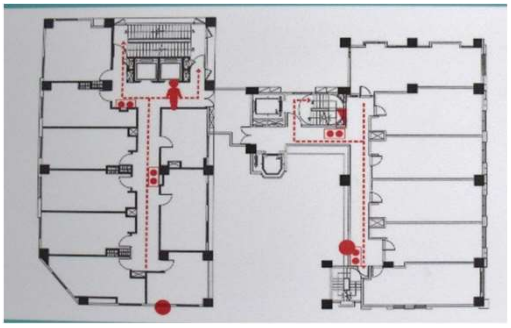


Damaged bldg.

Hotel bldg. Hualien City

NARLabs

RC Columns damaged severely



Damaged bldg.

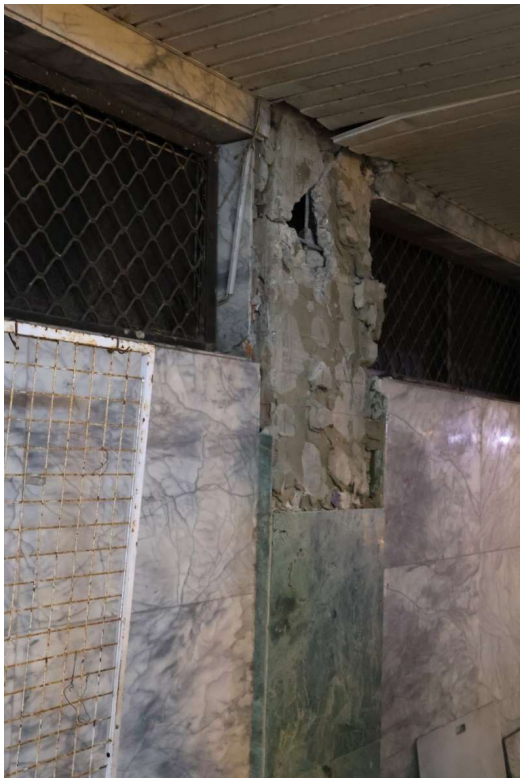
Hotel bldg. Hualien City

RC Walls shear failure

Damaged bldg.

Commercial bldg. Hualien City

Non-structural walls damaged

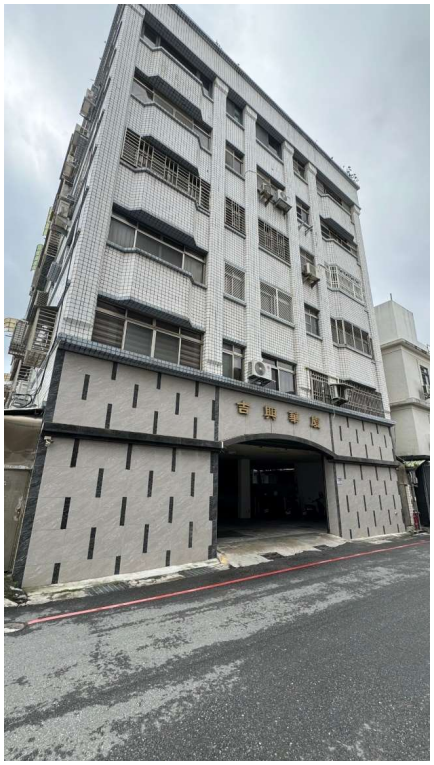


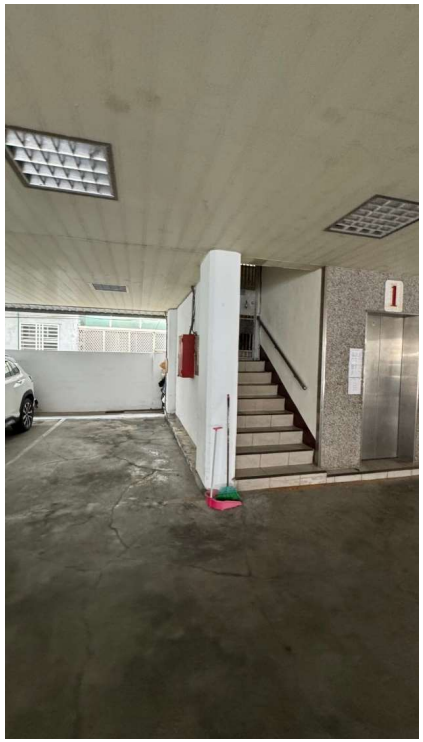
Retrofitted bldg.

6-story Residential bldg.

Hualien City

- Retrofitted with RC shear walls
- Minor cracks in stucco



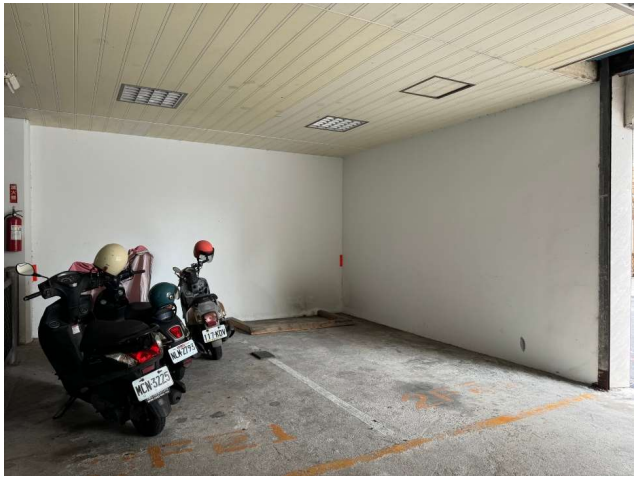


Retrofitted bldg.

Residential bldg.
Hualien City

NARLabs

Retrofitted with RC shear walls and wing walls



Retrofitted bldg.

NARLabs

Seismic weak-story retrofitted bldg.

Hualien County

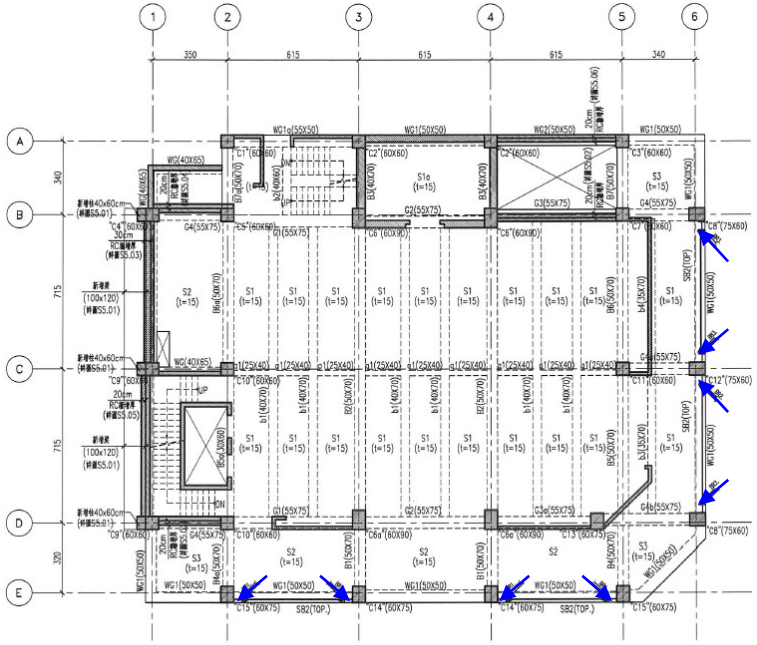
距震央25.83km

Retrofitted with RC Walls

Retrofitted bldg.

NARLabs

Office Building Retrofitted with SBRB in Hualien City



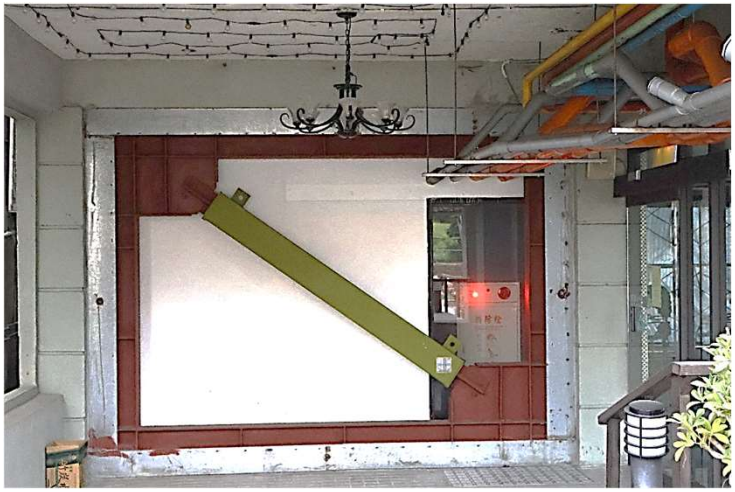
壹層結構平面圖

↙ : SBRB Location

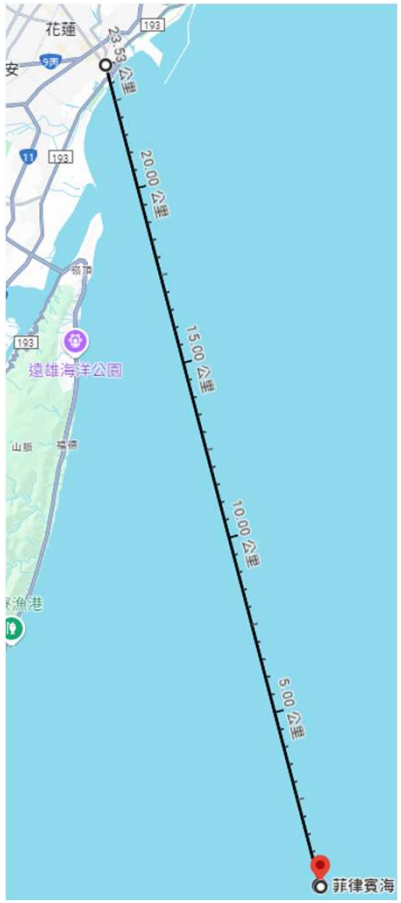
Retrofitted bldg.

NARLabs

Hotel Building Retrofitted with BRB in Hualien City



距震央23.53km



Retrofitted bldg.

NARLabs

School Buildings Retrofitted with RC Columns Jacketing and RC Shear Walls in Hualien City

距震央24km

Retrofitted bldg.

NARLabs

Elementary School Buildings Retrofitted with RC Shear Walls in Hualien City

距震央24.02km

NARLabs

Retrofitted Building A00600 in Taipei City

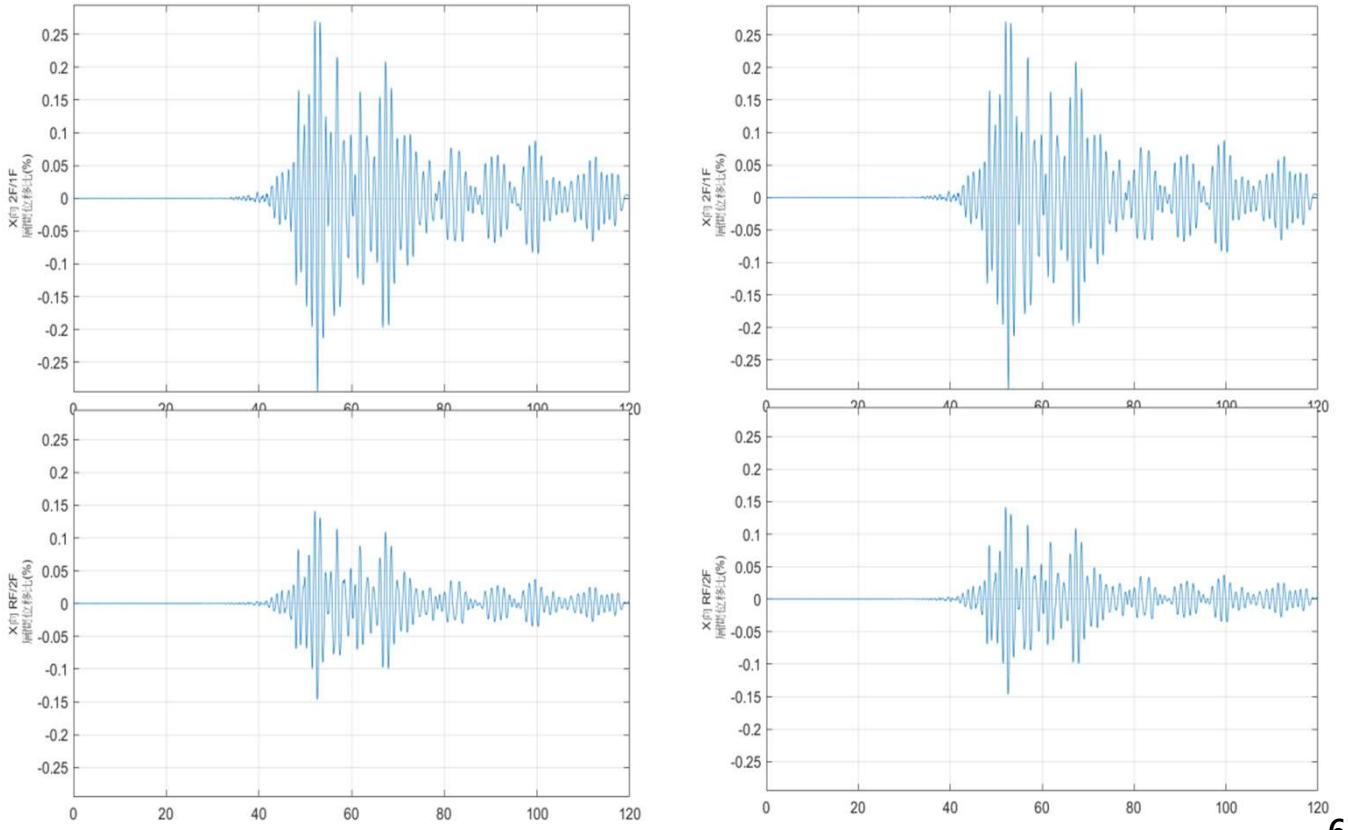
Accelerometers were installed on the ground-floor base, the second-floor slab, and the roof slab for structural monitoring

- Seismic Intensity: 5-Weak
- Structural Damage Severity: Light
- Maximum Acceleration on 1st-floor slab: 86.2 gal
- Maximum Acceleration on 2nd-floor slab: 90.0 gal
- Maximum Acceleration on roof slab: 266 gal
- Displacement Ratio (1st floor): 0.295% (Safety threshold: 0.250%)
- Displacement Ratio (2nd floor and above): 0.146% (Safety threshold: 0.250%)

NARLabs

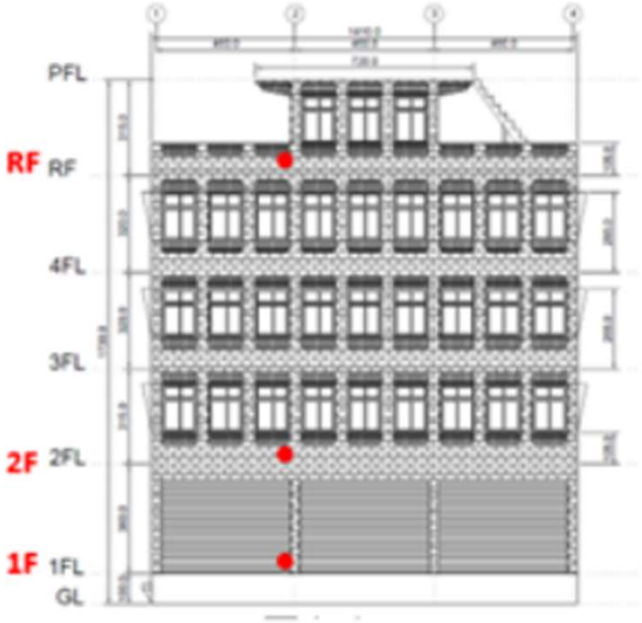
Retrofitted Building A00600 in Taipei City

Floor displacement time history



NARLabs

Retrofitted Building A01900 in Taitong City



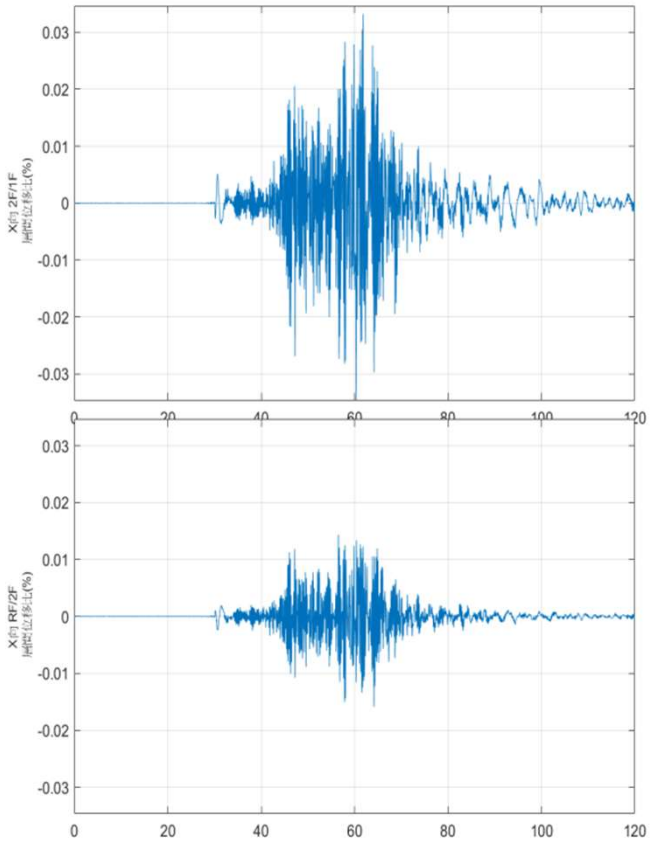
地震儀安裝立面圖

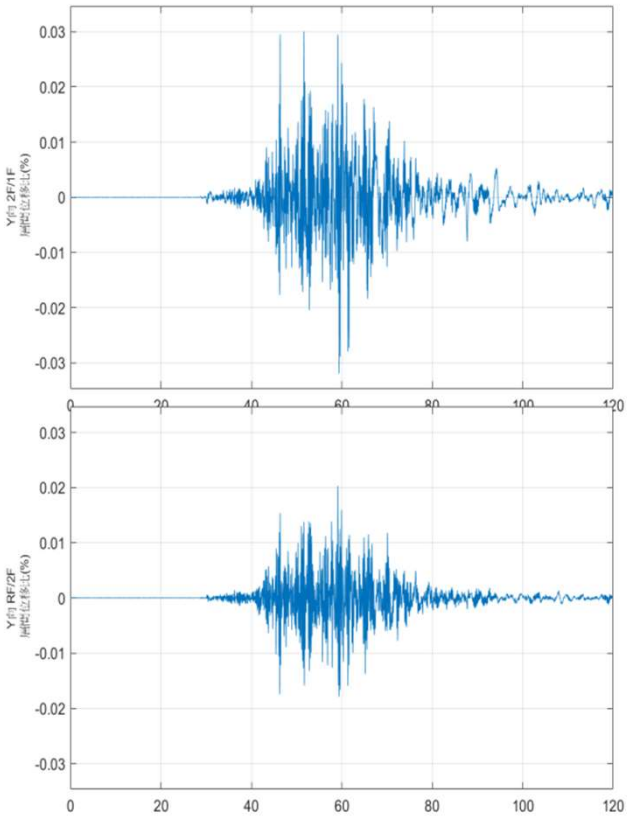
- Seismic Intensity: 4
- Structural Damage Severity: Light
- Maximum Acceleration on 1st-floor slab: 105 gal
- Maximum Acceleration on 2nd-floor slab: 175 gal
- Maximum Acceleration on roof slab: 319 gal
- Displacement Ratio (1st floor): 0.035% (Safety threshold: 0.02%)
- Displacement Ratio (2nd floor and above): 0.146% (Safety threshold: 0.250%)

NARLabs

Retrofitted Building A0900 in Taitong City

Floor displacement time history





NARLabs

Outline

- Seismic Source and Ground Motion Characteristics
- Early Seismic Loss Estimation
- Isolated Building Damage
- Building Damage
- **Geotechnical Damage**
- Non-Structural Component (NSC) Damage

NARLabs

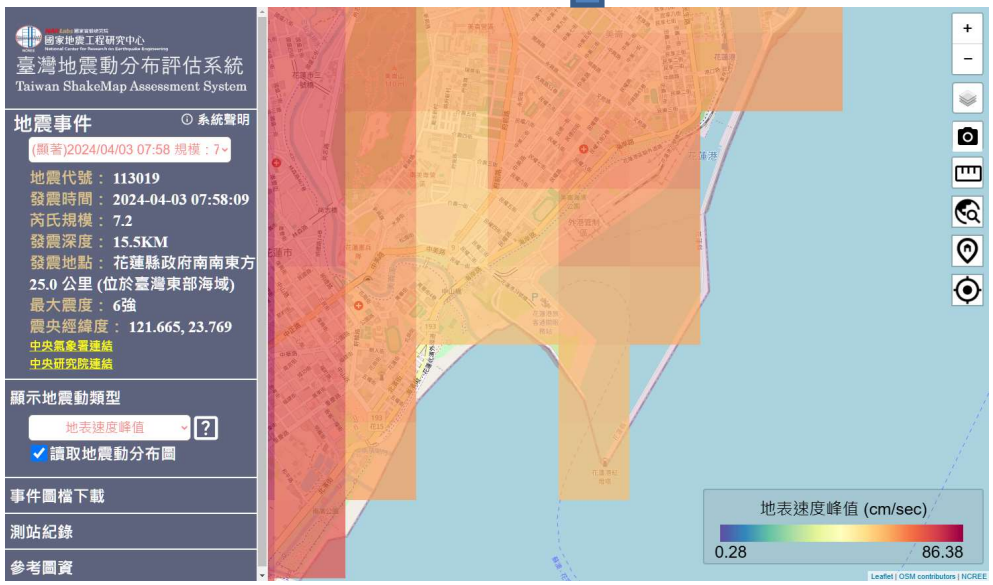
Hualien port (1/2)

- Distance=23 km to the epicenter.
- The earthquake caused subsidence and soil liquefaction behind pier 23-25.

Location	#25
PGA(gal)	410.5
PGV(cm/s)	58.7
Sa0.3s (gal)	776.9
Sa1s (gal)	596.6

* Interpolation values.

GOOGLE MAP



https://seaport.ncree.org/smap/

NARLabs

Hualien port (2/2)

- The backfill subsidence was most severe at pier 25. The gravel sand backfill areas behind the dock lines also showed sand boils and cracks.

Sand boils

Pier No,	Max. Subsidence
#25	70cm
#23~#24	50cm
#19~#22*	50cm
#17~#18*	12cm

* provided by the Hualien Port Authority.

The reinforced concrete pavement has sunk and tilted.

NARLabs

Meilun River

- Signs of liquefaction were observed on the left bank sandbar of the Meilun River
- Similar liquefaction phenomena were observed at the same location during the previous earthquake.

Suspected sand boils possibly caused by soil liquefaction.

NARLabs

NSCs Reconnaissance Team

Organization	Members
National Center for Research on Earthquake Engineering	Juin-Fu Chai, George C. Yao, Jui-Liang Lin, Fan-Ru Lin, Wei-Hung Hsu, Wei-Chung Chen, Bai-Yi Huang, Min-Chi Ko, Wen-Hsuan Huang, Kun-Ru Liu
National Cheng Kung University	Yu-Lin Chung, Ya-Yu Hsiao
National Kaohsiung University of Science and Technology	Keng-Chang Kuo
National Research Institute for Earth Science and Disaster Prevention	Jun Fujiwara, Ryota Nishi
Nagoya University	Takuya Nagae, Kazuki Takaya
Tokyo University	Tatsuya Asai

NARLabs

Reconnaissance buildings

* Unit: gal. retrieved from https://smap.ncree.org/, 15th May

Building	City	Cl.	Constr.	Story	Basement	PGA*	$S_{a,\ 0.3s}$*	$S_{a,\ 1.0s}$*
Hospital bldg. A1	Hualien City	Hospital	RC	5	1	418	786	669
Hospital bldg. A2			RC	7	1	418	786	669
Hospital bldg. A3			RC	7	0	418	786	669
Hospital bldg. B1			SC	10	1	395	606	673
Hospital bldg. B2			SRC	10	1	395	606	673
Hospital bldg. C1	Shoufeng township, Hualien County		RC	4	1	366	714	580
University library DL		School	SRC	6	1	321	542	592
University bldg. D1			RC	4	0	321	542	592
University bldg. D2			RC	4	0	315	520	556
University bldg. D3			SC	4	0	338	581	572
University library E	Taipei City		RC	8	1	112	203	137
Winery warehouse F	Hualien City	Factory	RC	1	0	347	613	467

NARLabs

Reconnaissance NSCs

Category	NSCs	Located buildings
Architectural components	T-bar ceilings	Hospital building A2 and C1; University building D2, D3; University library DL
	Nonstructural walls	Hospital building A2 and B1; University building D2
	Elements connected to structures	Hospital building C1
Equipment	Cooling tower	Hospital building A3 and B1
	Elevator	Hospital building C1
	Water tanks	Hospital building A1, A3 and B2
	Air conditioning	Hospital building A2, B1 and C1
	Pipelines	Hospital building A2 ,A3, B1, B2 and C1; University building D3; University library DL
Contents	Stacked cargo	Warehouse F
	Bookshelves	University library DL
	Furniture and experiment equipment	Hospital building B1

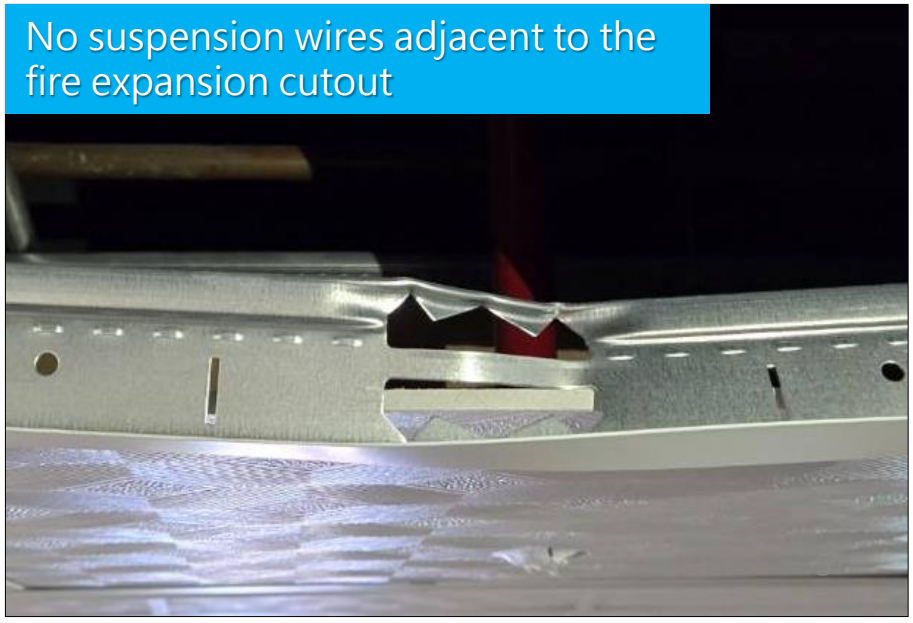
Hospital building A2

Damaged ceiling at elevator hall on the first floor ↑

Deformed ceiling grid above the nursing station on the sixth floor ↑

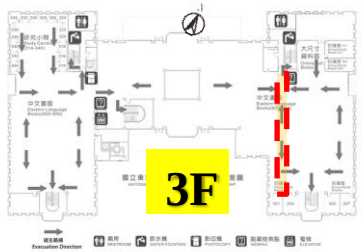
Status quo (repaired)

No suspension wires adjacent to the fire expansion cutout

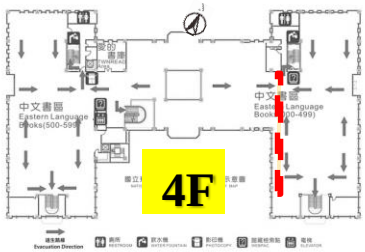


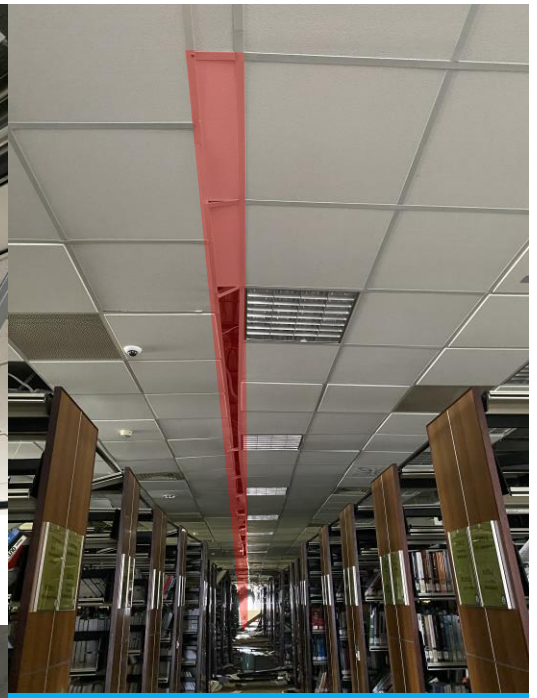
University library DL

Fallen ceiling at the edge (3F)



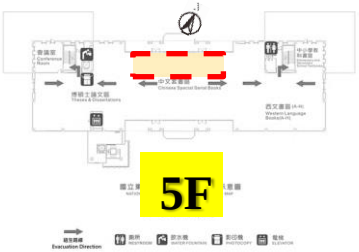
Fallen ceiling at the edge (4F)



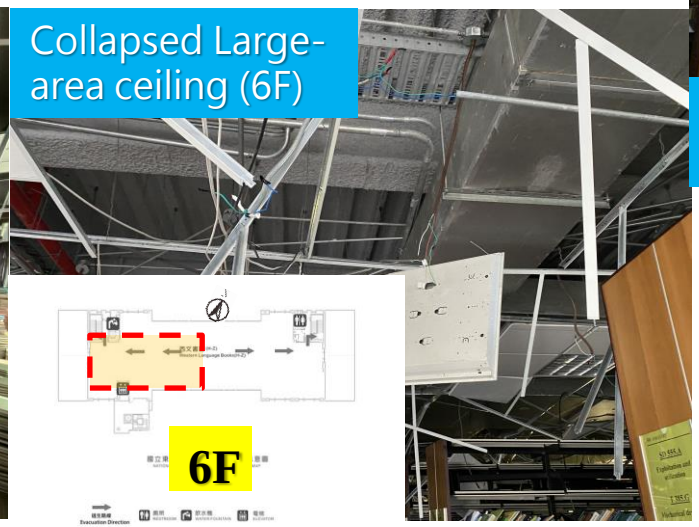


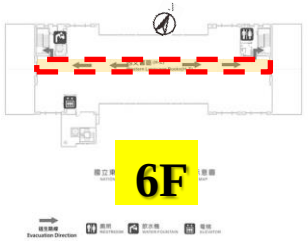
Damage at discontinuous area of the ceiling (6F)

Collapsed Large-area ceiling (5F)



Collapsed Large-area ceiling (6F)





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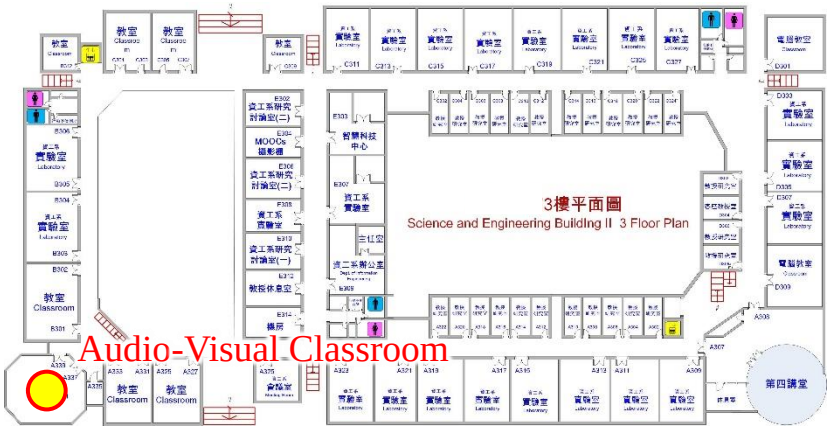
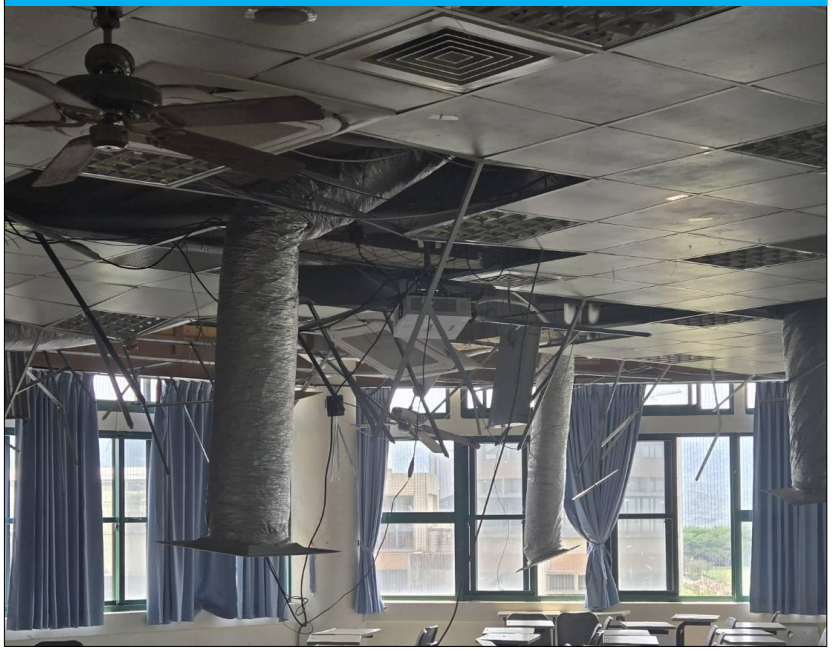
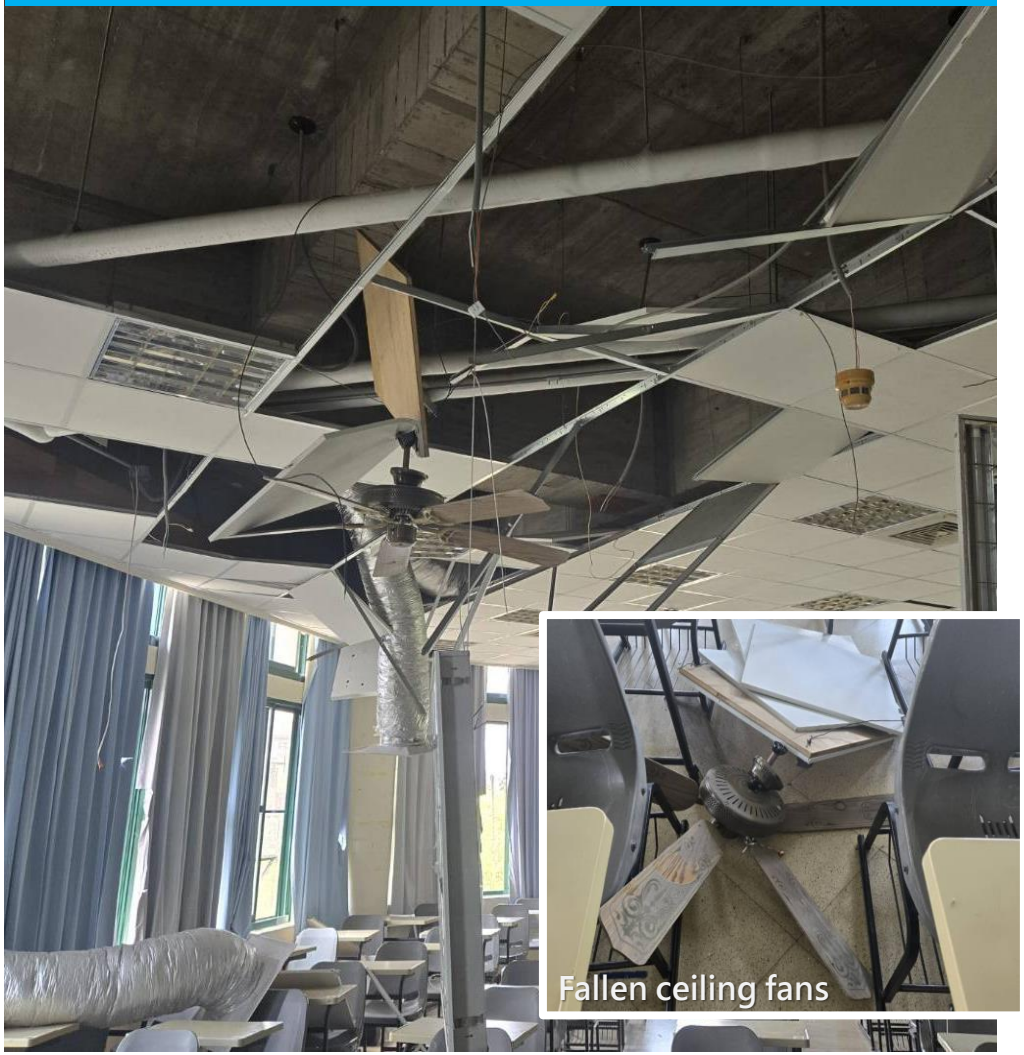
University building D2



Fallen ceilings, light fixtures, and air ducts (4F)



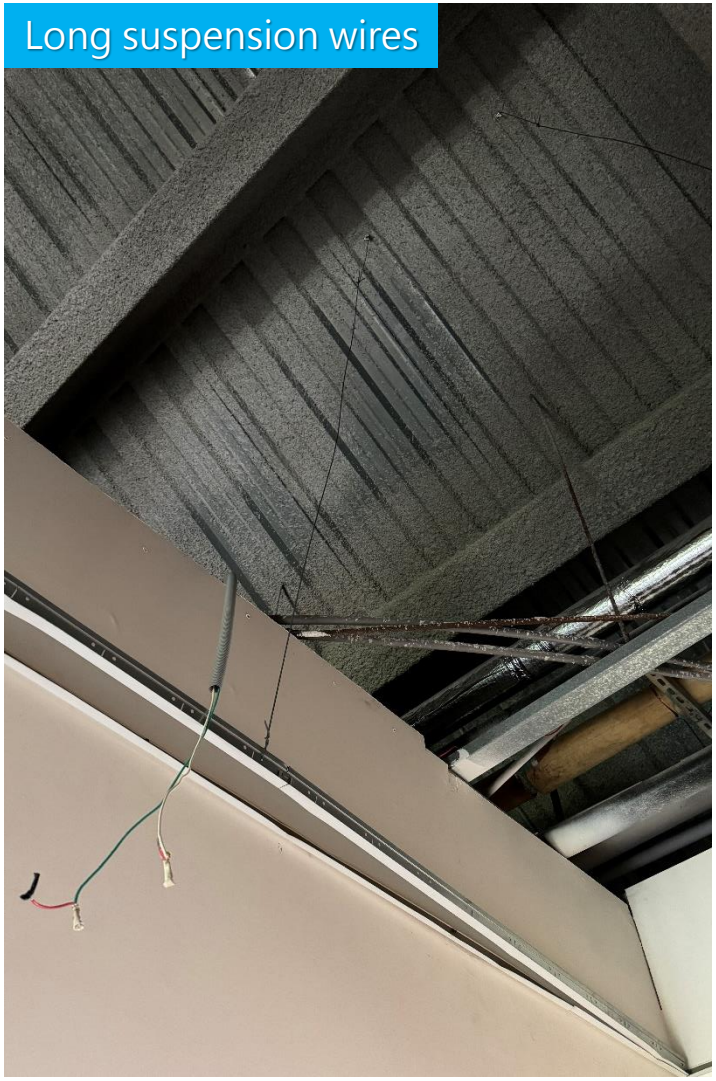
Fallen ceilings, light fixtures, air ducts and ceiling fans (3F)



University building D3

The pitched roof caused varying suspending lengths→

Damage concentrated on the T-bar ceilings ↓



Hospital building A2

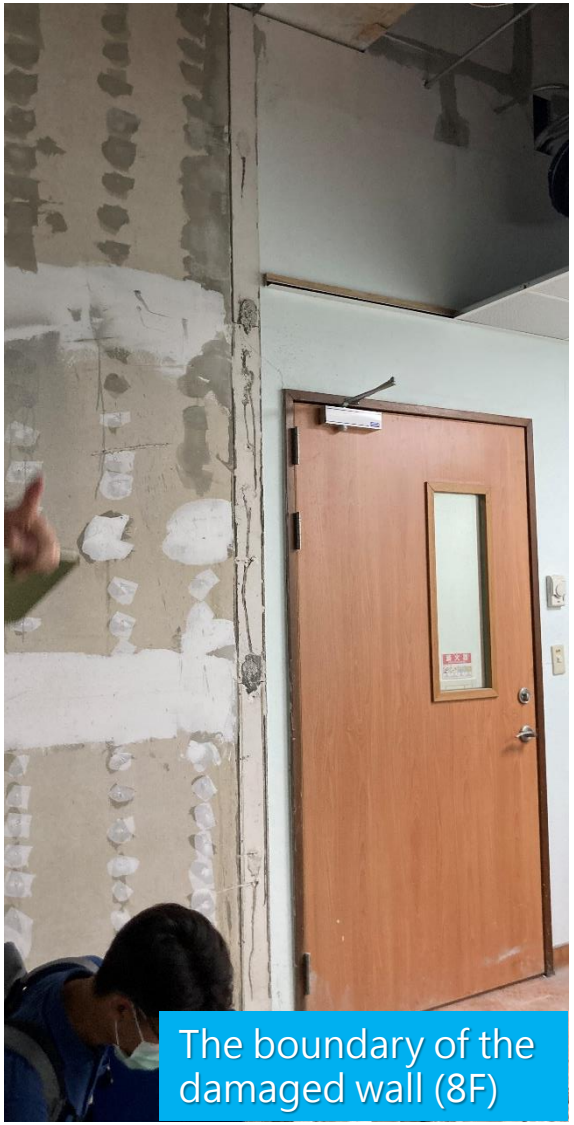
Shear cracks of the masonry walls of the wards on the fifth and sixth floors were observed.

Damaged masonry walls (5F)

Cracked tiles on the opposite side of the wall

Hospital building B1

Tilted lightweight aggregate concrete (LWAC) walls (6F & 8F)



The boundary of the damaged wall (8F)

University building D2

Collapsed windproof walls, composed of LWAC (rooftop)

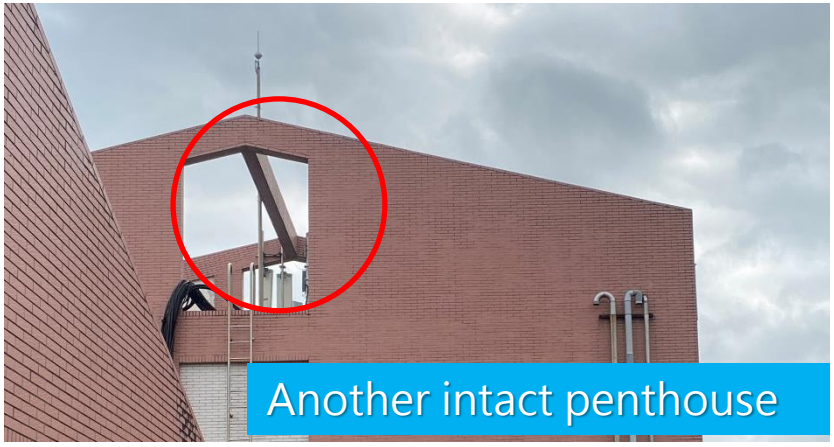
Failed anchorage of the collapsed wall

Partially-damaged windproof wall

Hospital building C1

A beam connected to decorative gables collapsed on the penthouse

Photo credit: Hospital C



Another intact penthouse

Hospital building A3 and B1

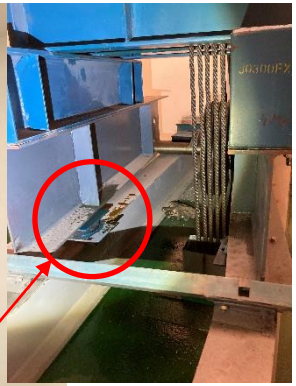
Collapsed air-inlet layer of the FRP cooling tower (Hospital A)

The base of the FRP cooling tower was damaged and tilted (Hospital B)

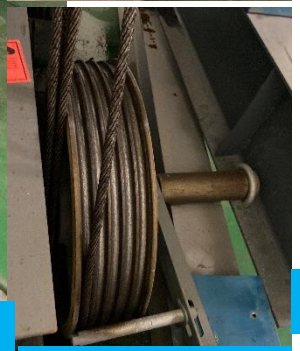
The anchorage at the support legs of the base was damaged

Hospital building C1

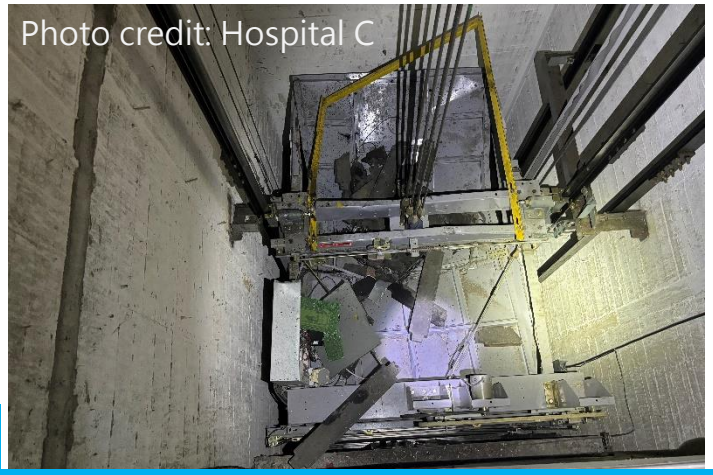
The hoist machine of Elevator D had permanent displacement and shifted cable



Unfixed Rubber pads



Shifted cable



Falling of counterweight blocks of Elevator C

Falling of counterweight blocks of Elevator A

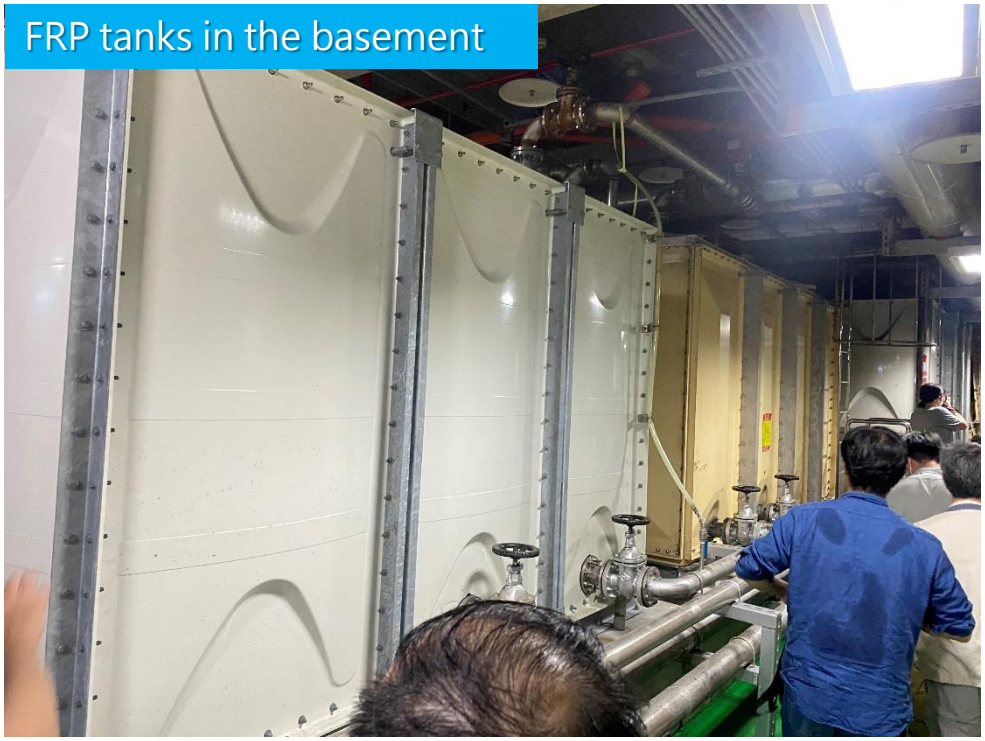
Hospital building A1 and A3

Collapsed tanks at rooftop of Bldg. A1

Damaged piping joints connected to the hot water tank in Bldg. A3 (repaired)

Hospital building B2

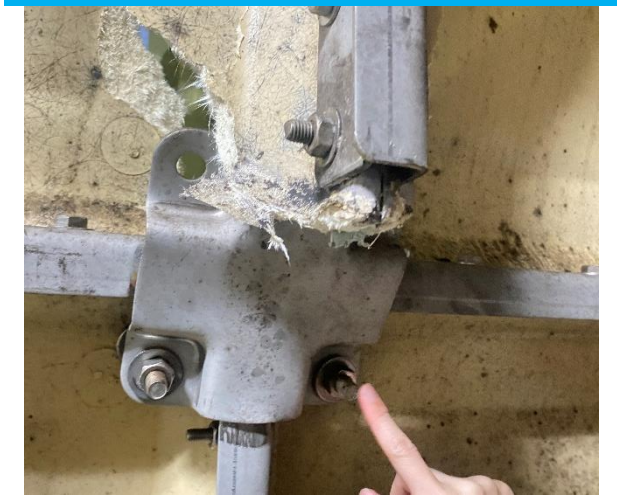
FRP tanks in the basement



- In the basement, there are four FRP tanks, each with slight variations in form. The FRP panels are joined with angle steel. The innermost tank suffered damage.
- Among the four tanks, only the angle steel of the damaged one was not well-connected. The connection joints were damaged during the earthquake, resulting in tearing and damage to the FRP tank wall.↗

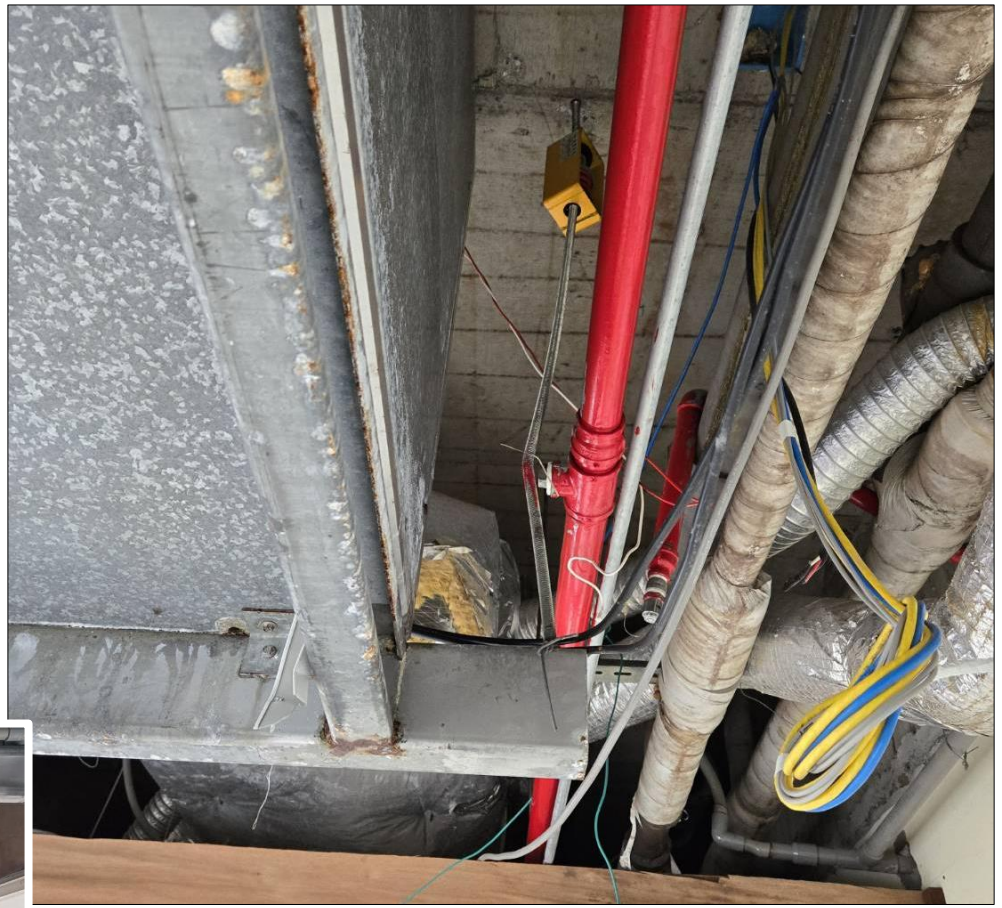
Tearing and damage to the FRP tank wall

Damage to the connection joints



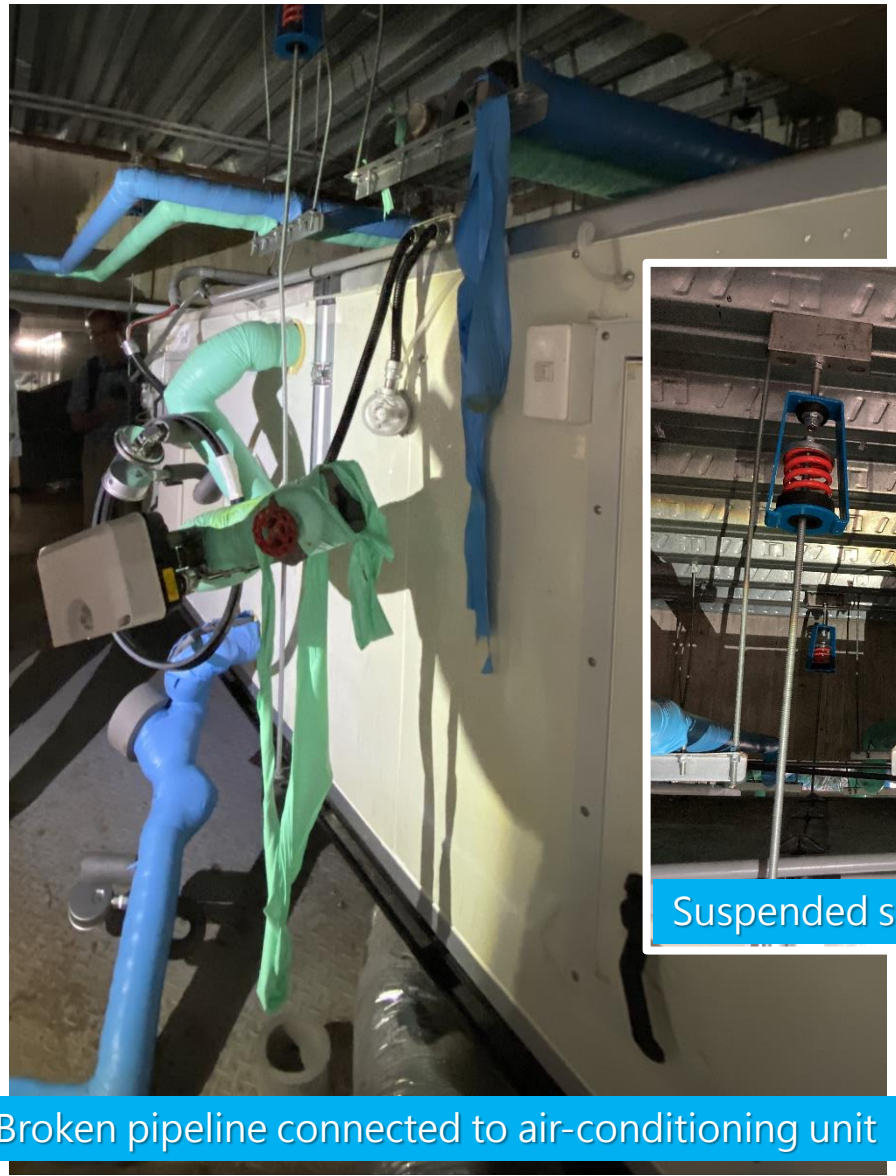
Hospital building A2

Excessive displacement of the pre-cooling air conditioning unit led to the rupture of the chilled water pipe connected to it (5F)

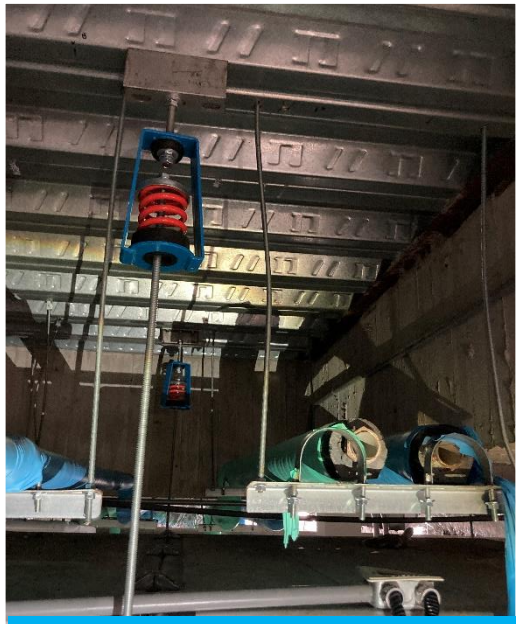


Excessive displacement of the air conditioning unit led to complete rupture of the adjacent fire sprinkler head due to impact (6F)

Hospital building B1



Broken pipeline connected to air-conditioning unit



Suspended spring isolator

Anchorage failure

Separated ventilating machine and ductworks

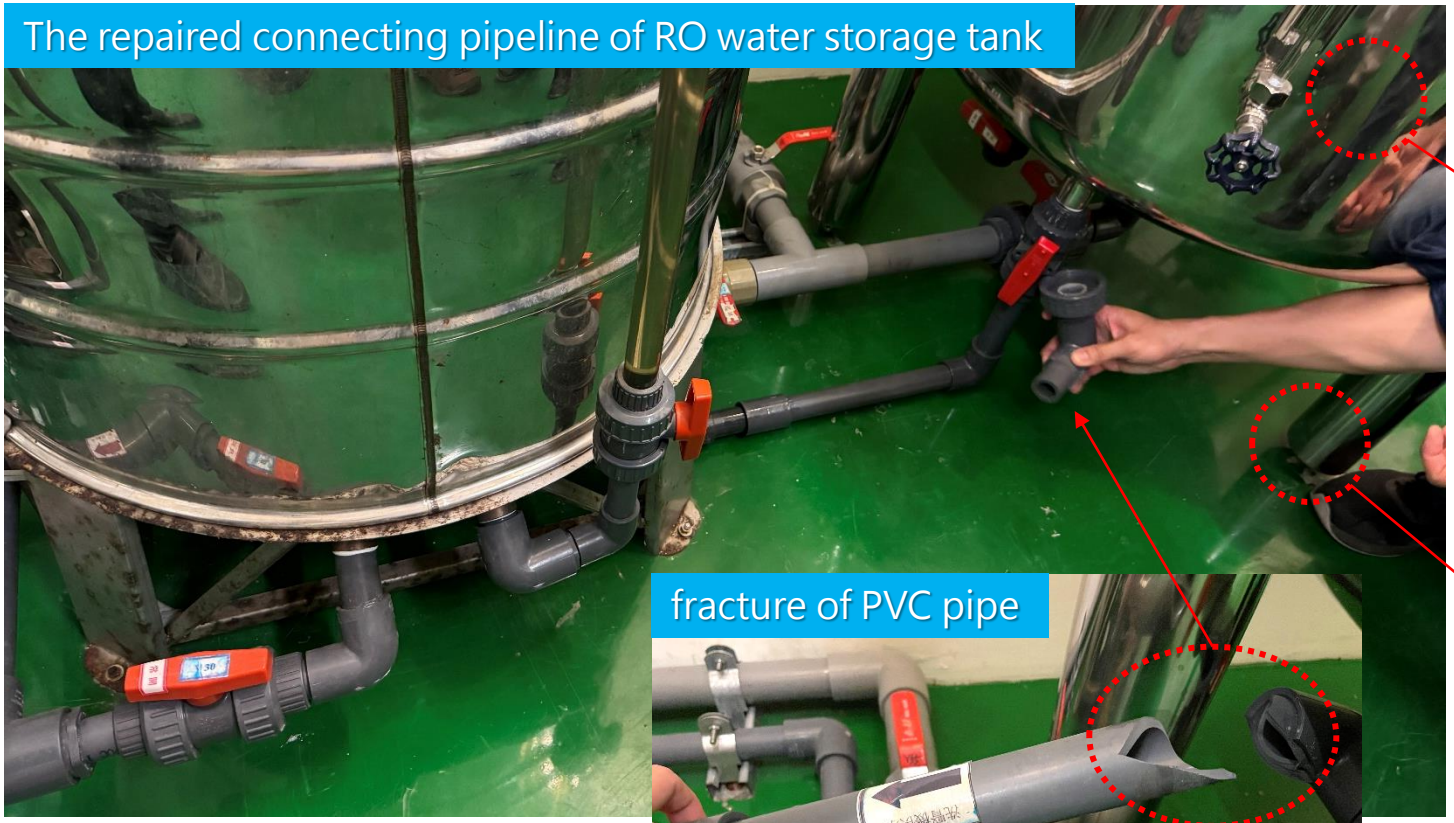
Hospital building C1

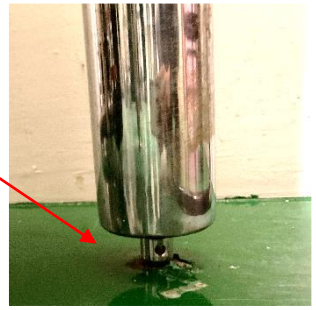
Status quo (repaired)

Excessive displacement of the small fan-coil unit resulted not only in the rupture of the connected water pipes but also in the shear failure of the suspension rods

Hospital building C1

The repaired connecting pipeline of RO water storage tank





fracture of PVC pipe

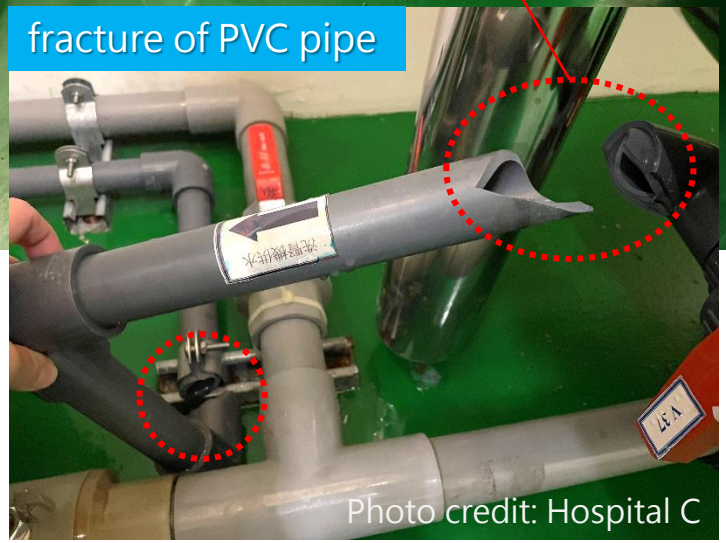


Photo credit: Hospital C

Freestanding water storage tank

University library DL and building D3

Damaged ductworks (6F of Bldg. DL)

Dislocation of the bath modules led to pipeline damage (4F of Bldg. D3)

Winery warehouse F

Several confined wine jars dropped

Collapsed stacked boxes

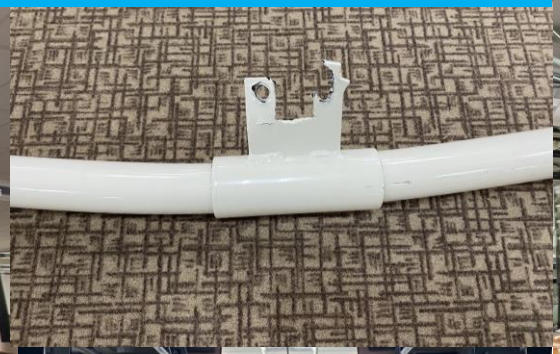
Unconfined stacked wine jars collapsed

Collapsed stacked boxes

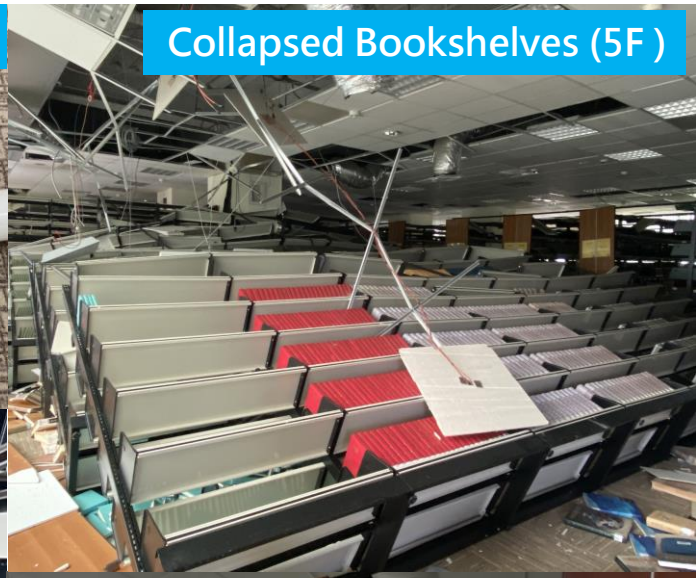
University Library DL

Collapsed CD shelves (2F)

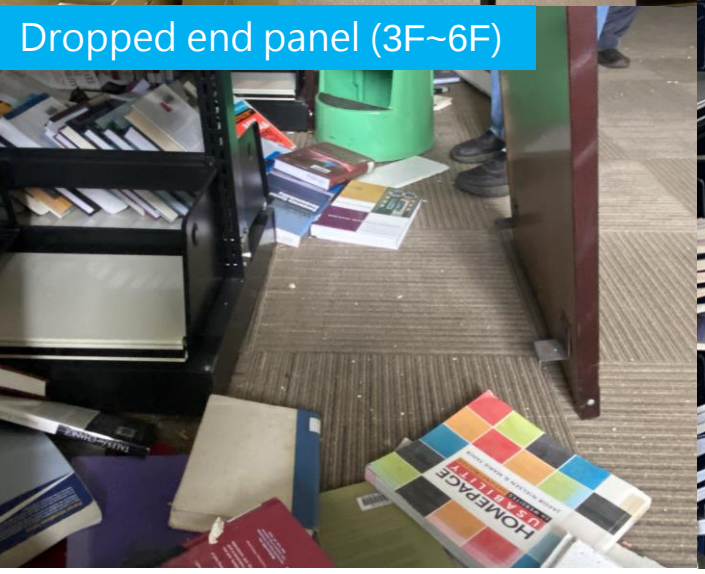
Deformed transverse ties (2F)



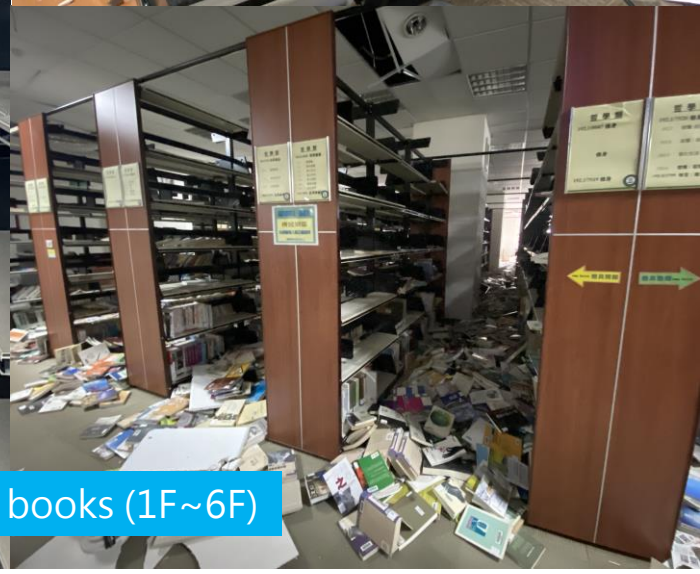
Collapsed Bookshelves (5F)



Dropped end panel (3F~6F)



Dropped books (1F~6F)

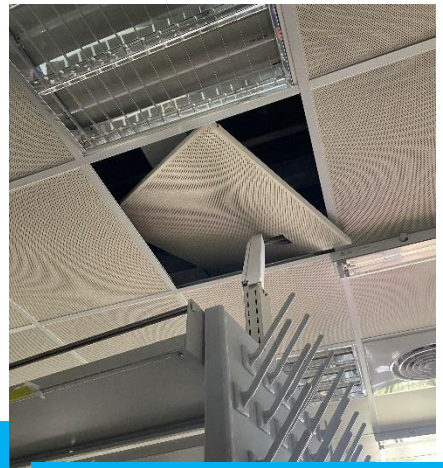


Laboratories on 10th floor of Hospital building B1

Partition wall damaged due to the tilted furniture

Overturned cylinder rack

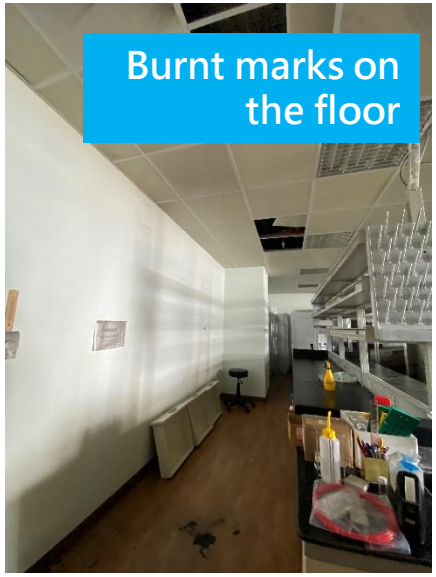
Partition wall damaged due to the displaced refrigerator



Ceiling damaged due to the displaced table

Partition wall hit by adjacent cabinets

Experiment equipment was fallen and fired, and triggered the fire protection system.



Burnt marks on the floor

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Thank you for your attention