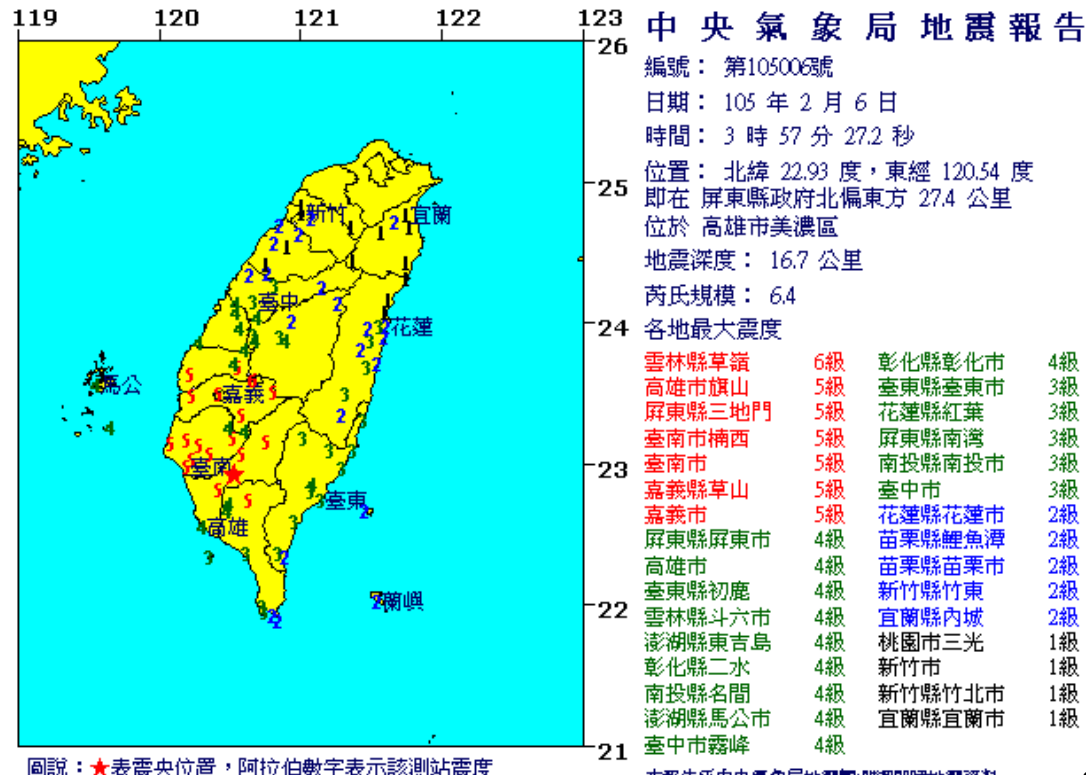


February 6, 2016 (local time)
M_L-6.4 Meinong Earthquake
Kaohsiung City, Taiwan

2016/02/06 – Ver5.0

2016.02.06 Meinong Earthquake

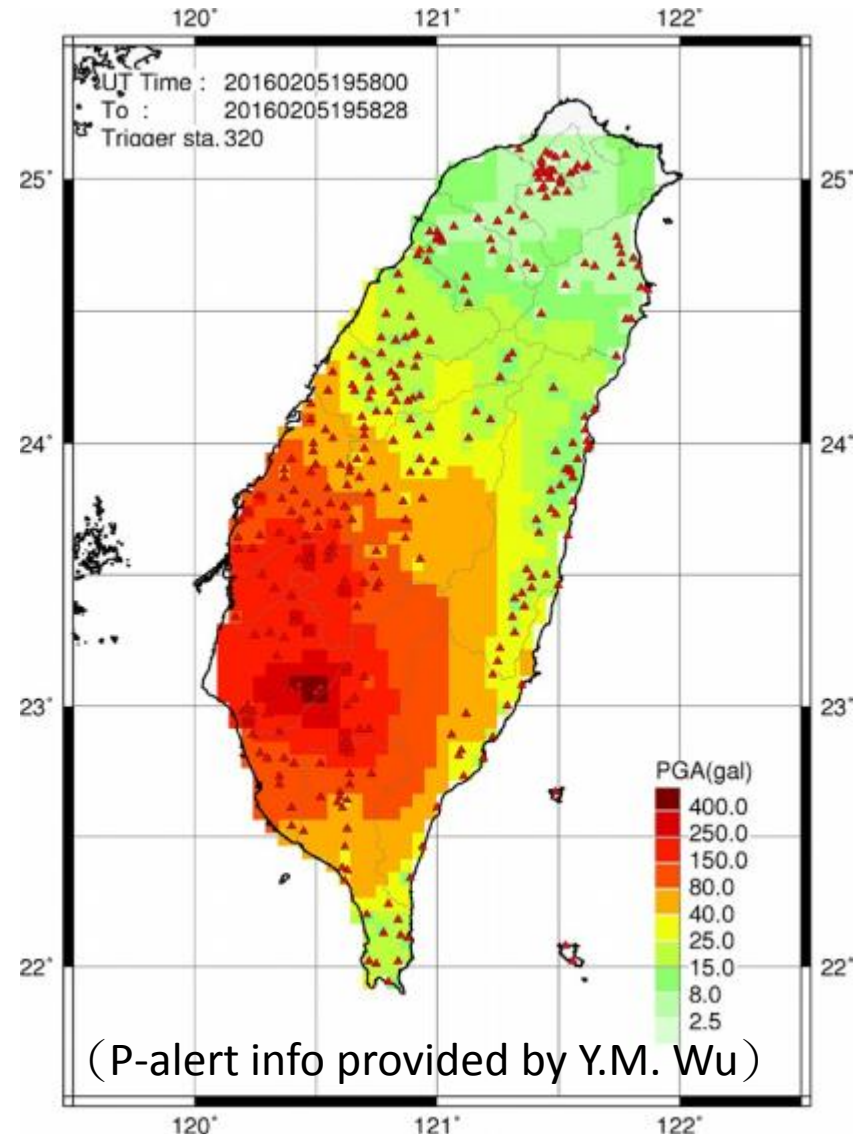
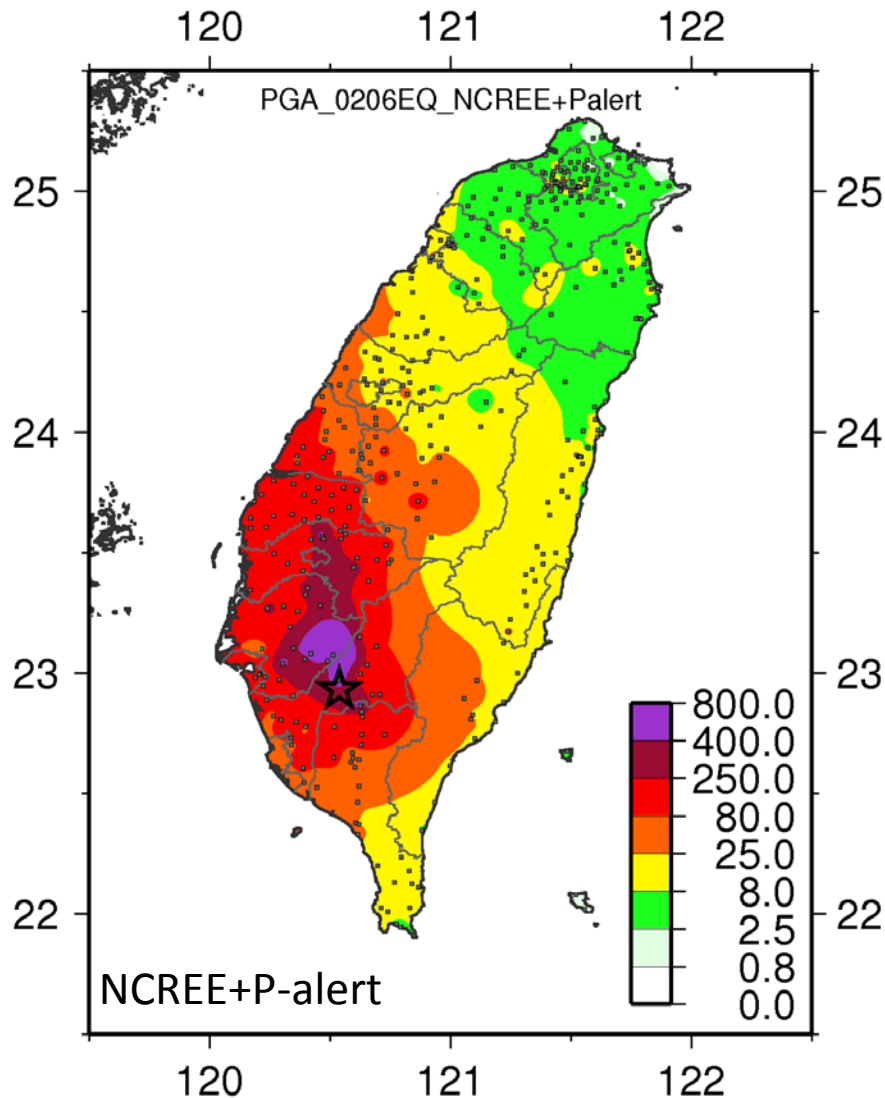
- M_L 6.4, occurrence at 3: 57: 27.2 am, Feb. 6, 2016, local time (or, 7: 57: 27.2 pm, Feb. 5, 2016, UTC), CWB-defined Intensity Level 6 observed at TSMIP Caoling Station, Yunlin County
- Epicenter located at 22.93° N Lat., 120.54° E Long., focal depth 16.7 km, (Meinong District, Kaohsiung City), 27.4 km Northeast of Pingtung County Hall



本報告係中央氣象局地震資訊網即時地震資料
地震通報之結果。

Source: Central Weather Bureau, Taiwan

Shaking Intensity Contour

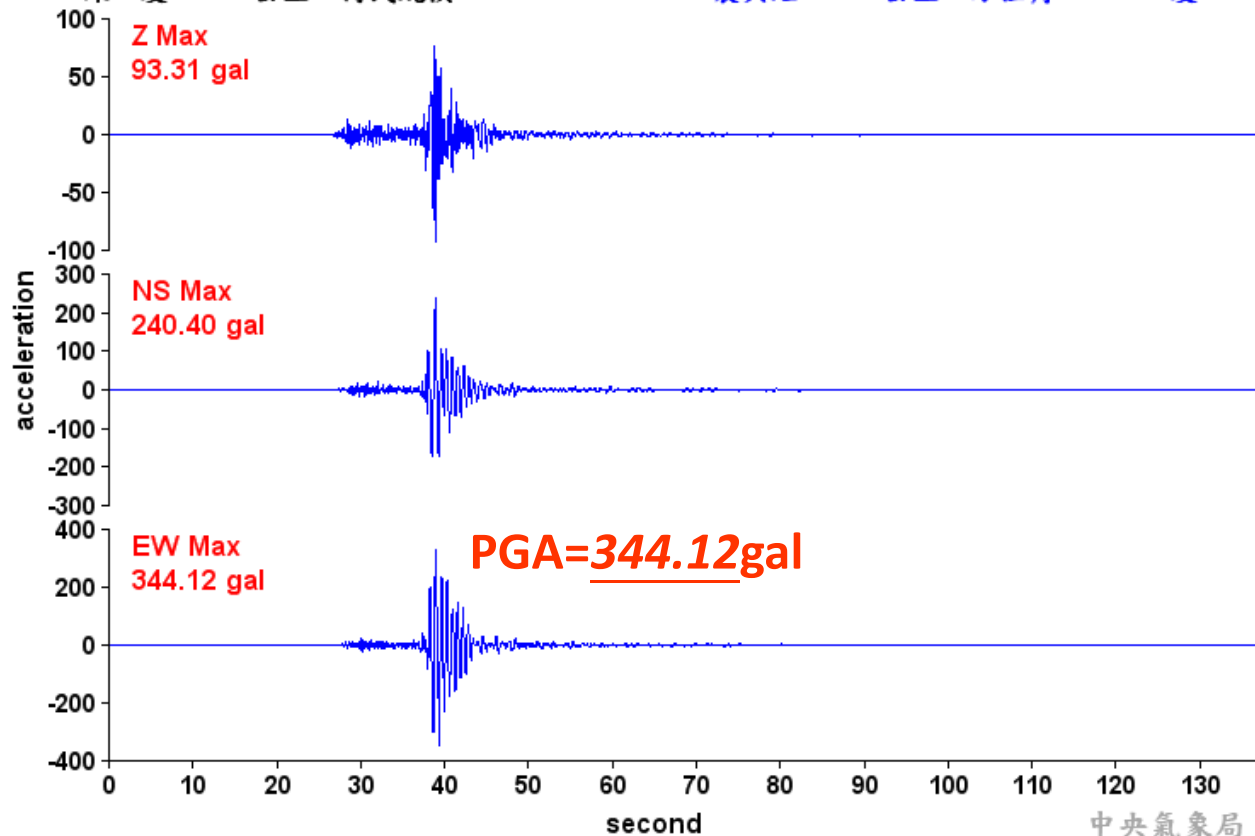


Waveforms recorded at Near-Fault Station

Caoling (CHN5) Intensity Level 6

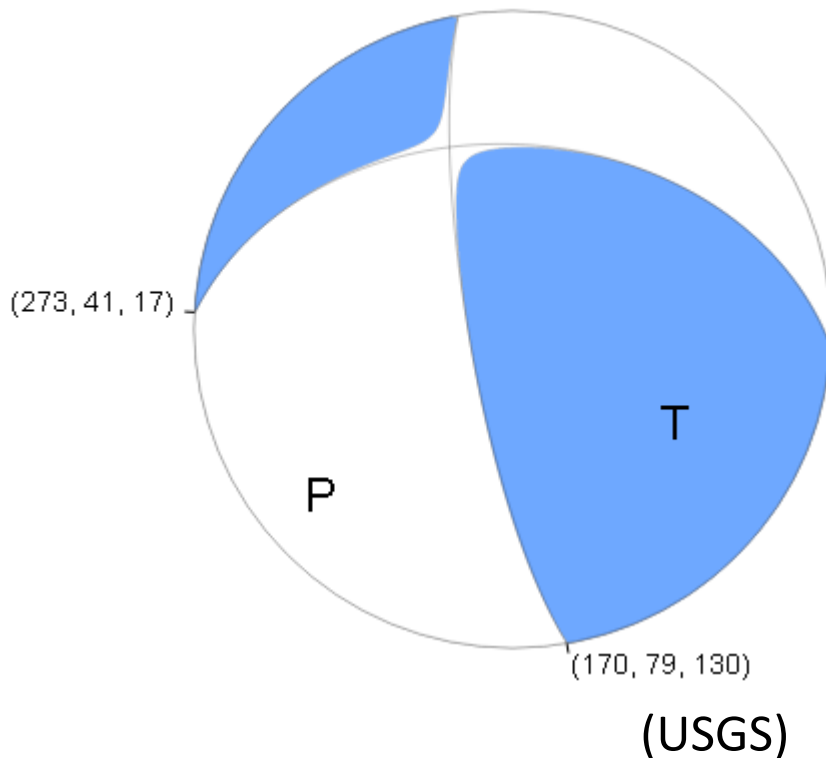
地震資訊
發震時間：2016/02/06 03:57:27
震央位置：東經120.54度，北緯22.93度
深度：16.7公里，芮氏規模：6.4

測站資訊
波線起始時間：2016/02/06 03:57:15
測站位置：東經120.68度，北緯23.60度
震央距：75.7公里，方位角：190.81度



Focal Mechanism Solution

- The focal mechanism solutions reported by CWB-Taiwan and USGS are similar
- Mixture of reverse and strike slip rupture



CWB Early Automatic Report (EAR) :
Origin Time : 2016 2 5 19:57:27.00 (UT)
Hypocenter : 22.93 N 120.54 E 16.66 km
ML : 6.42

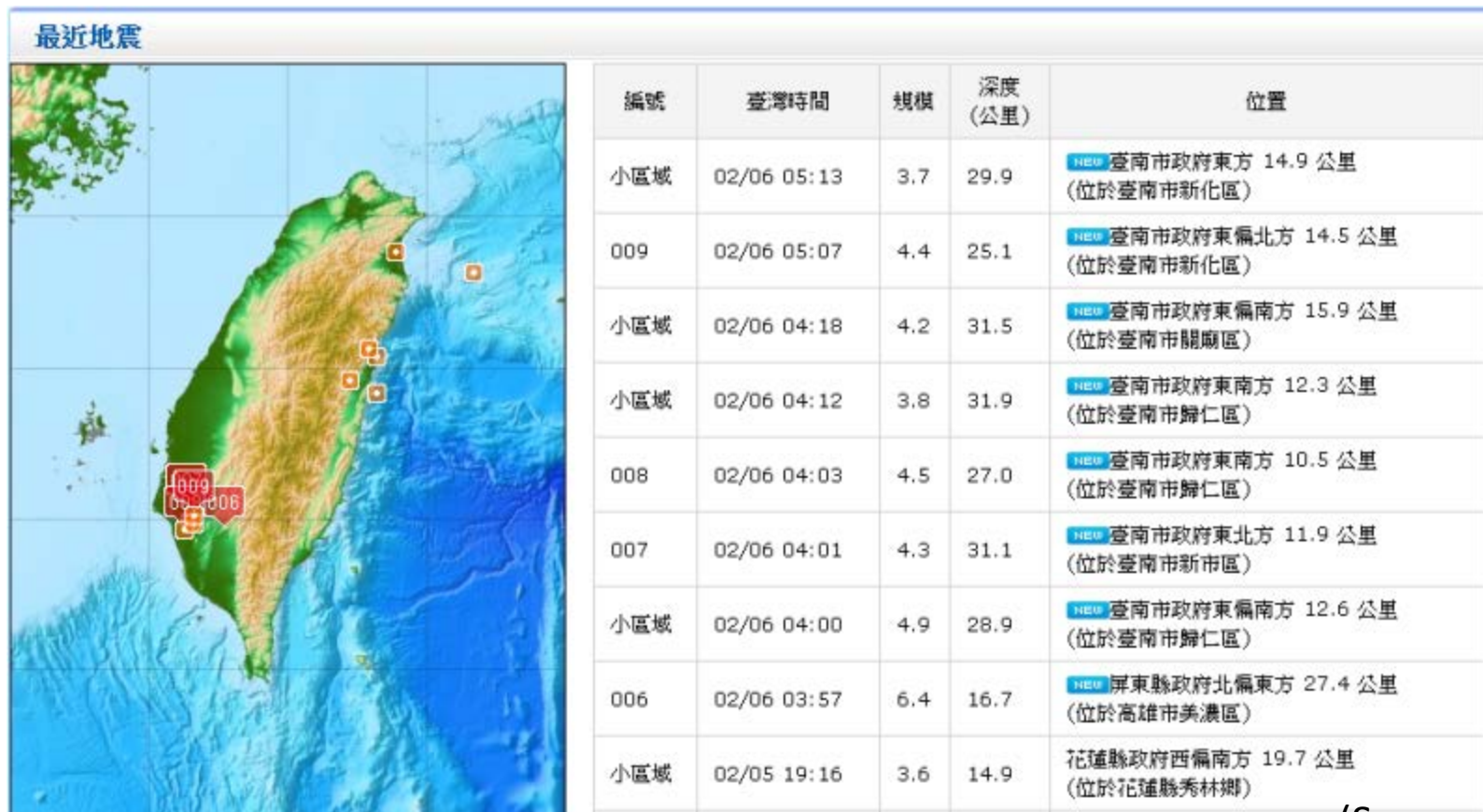
```
CWBSN_BB moment-tensor solution :
43.0017014    0.0002969    64.3091202
0.0002969    0.0000000    365.4462585 x 1E+16 Nt-m
64.3091202    365.4462585    0.0000000
Centroid depth : 26 km
Mw : 6.37
Azgap : 210.35
Average MISFIT : 0.629 (The fit is poor )
```

```
Best double couple solutions :
nodal plane(1) strike/dip/slip: 254.70/31.76/ -19.42
nodal plane(2) strike/dip/slip:  1.38/79.92/-120.28
```

(CWB CMT)

Activities of Aftershocks

- 7 aftershocks observed as of 6:00am, Feb 6 (local time) according to CWB
- Max. magnitude of aftershocks measures $M_L 4.9$; all 7 aftershocks were located west of the main shock and had deeper focal depths



(Source: CWB)

USGS Earthquake Hazards Program

- USGS reported the earthquake magnitude to be $M_W-6.4$
- Epicenter located at 22.871° N , 120.668° E ; focal depth 23 km

Data Source US³



2016-02-05 19:57:27 (UTC)

2016-02-06 03:57:27 (UTC+08:00) in your timezone

[Times in other timezones](#)

Nearby Cities

28km (17mi) NE of Pingtung, Taiwan

35km (22mi) SE of Yujing, Taiwan

46km (29mi) NE of Kaohsiung, Taiwan

48km (30mi) ESE of Tainan, Taiwan

672km (418mi) E of Hong Kong, Hong Kong

Major Historical Earthquake in Proximity

Epicenter, focal depth, and focal mechanism of the quake is similar to M_w -6.4 Jiasian, Kaohsiung Earthquake (高雄甲仙地震) on March 4, 2010

10/ 3/ 4 0:18:53.00(UT)

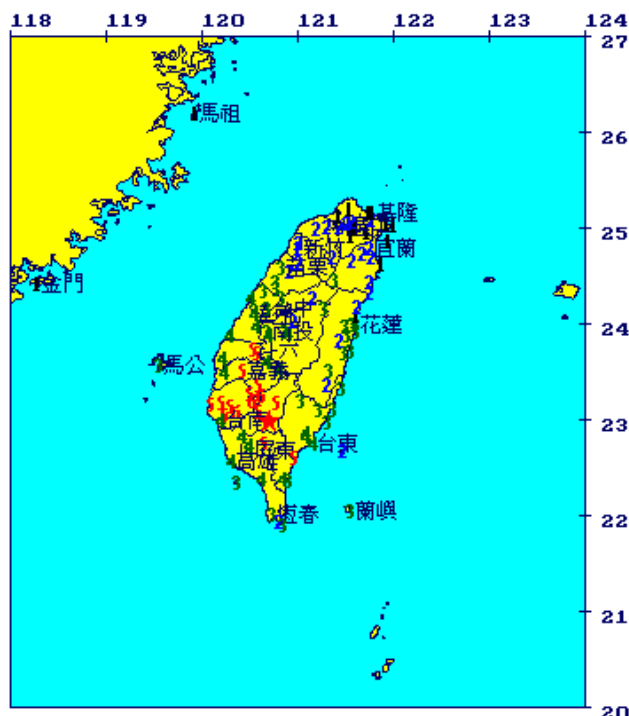
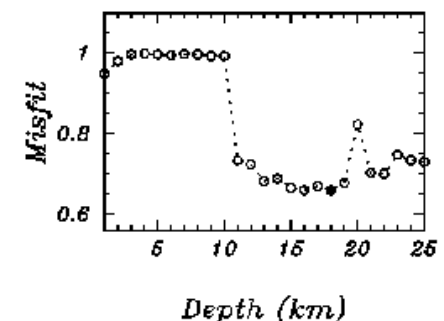
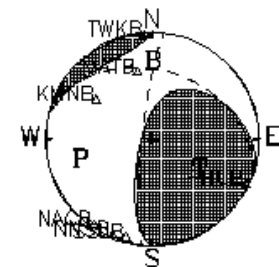
Lat.=23.00 Long.= 120.73

Depth= 18 km M_w = 5.97

	Strike	Dip	Slip
Plane 1:	289.54	32.88	12.68
Plane 2:	188.85	83.16	122.24

Iso.= 0.0% CLVD= 26.1%

Misfit average= 0.660



中央氣象局地震報告

編號：第99015號

日期：99年3月4日

時間：8時18分52.1秒

位置：北緯22.97度，東經120.71度

即在高雄甲仙地震站東南方17.1公里

地震深度：22.6公里

芮氏規模：6.4

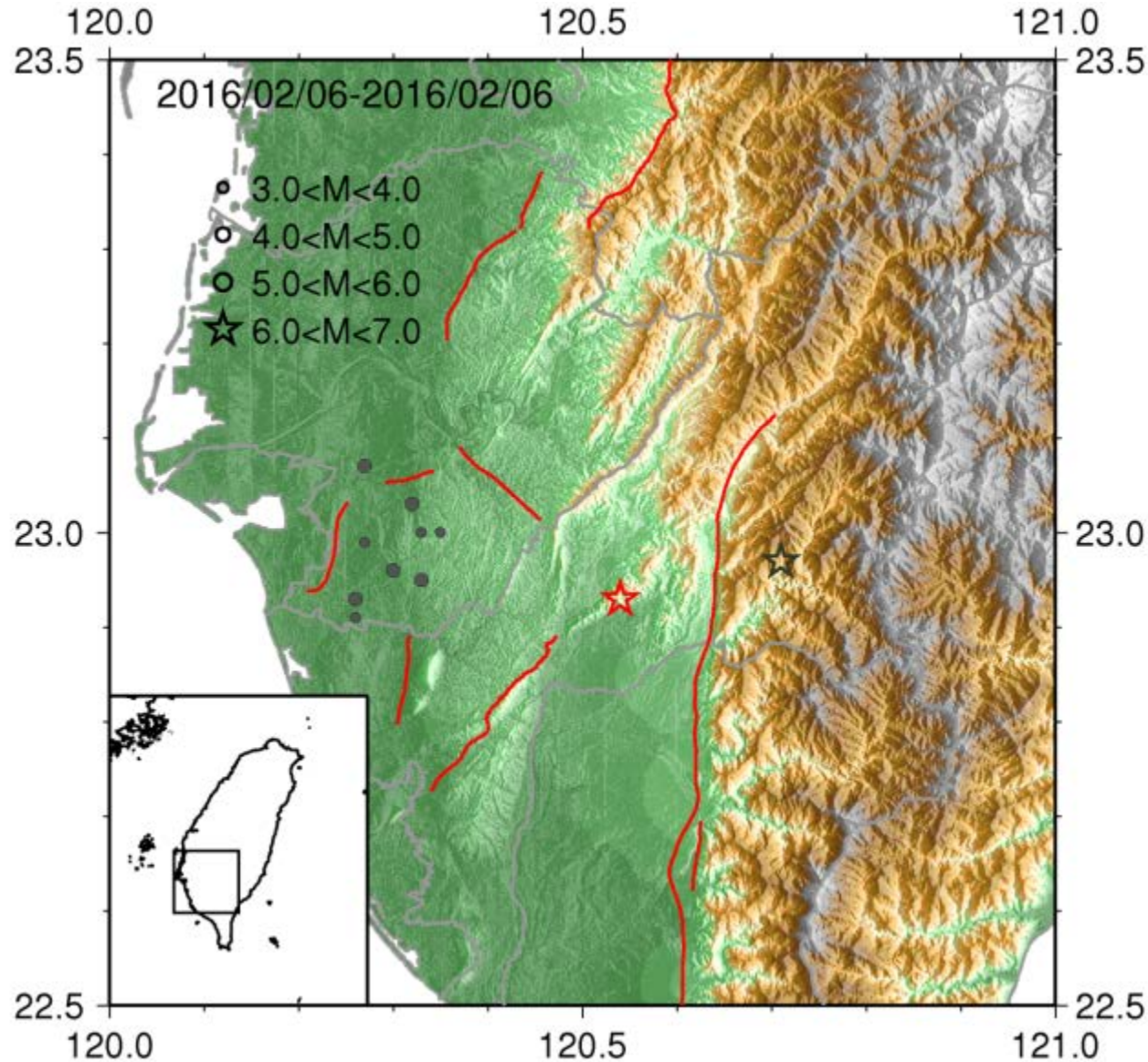
各地最大震度

台南楠西	6級	花蓮紅葉	3級
嘉義大埔	6級	南投市	3級
高雄甲仙	5級	台中市	3級
屏東三地門	5級	澎湖馬公	3級
台東太麻里	5級	花蓮市	3級
嘉義市	5級	苗栗鯉魚潭	3級
雲林古坑	5級	宜蘭南山	3級
斗六市	5級	苗栗市	3級
屏東市	4級	桃園三光	2級
台南市	4級	新竹市	2級
台東市	4級	新竹竹北	2級
高雄市	4級	宜蘭市	2級
南投名間	4級	桃園市	2級
彰化大城	4級	台北板橋	2級
彰化市	4級	台北市	2級
台中港	4級	基隆市	1級

圖說：★表震央位置，阿拉伯數字表示該測站震度

Source: CWB

2016 Meinong Main Shock, Aftershocks and 2010 Jiasian Earthquake Epicenters



Stations w/ Velocity Pulses

PGA Distribution calculated using
NCREE + P-alert + CWB stations

Black triangle: station observing velocity
pulses

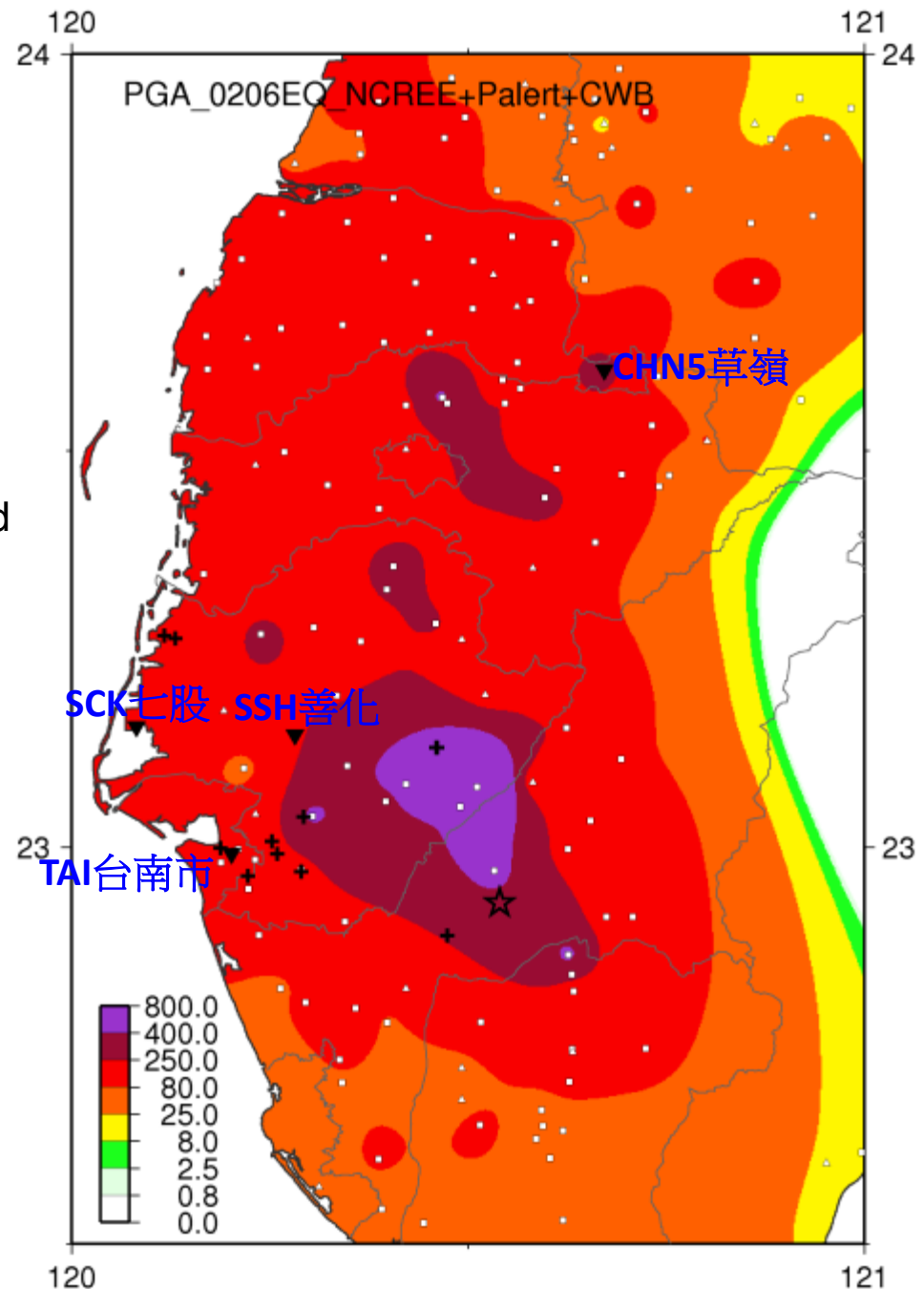
Black cross: building damage sites reported

White square: NCREE & P-alert stations

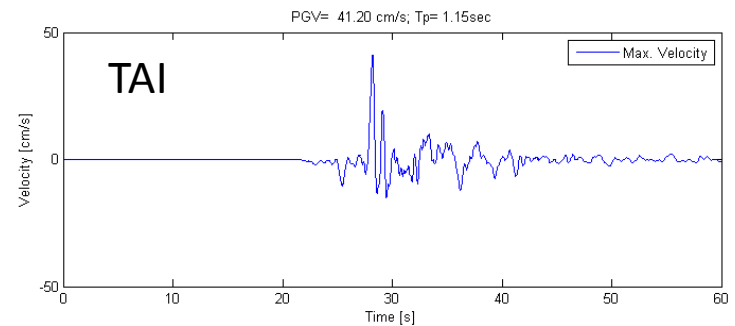
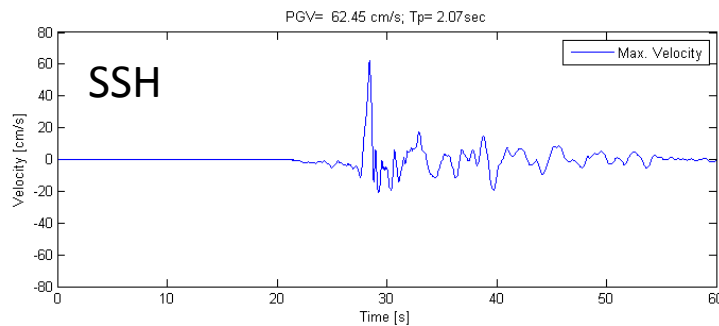
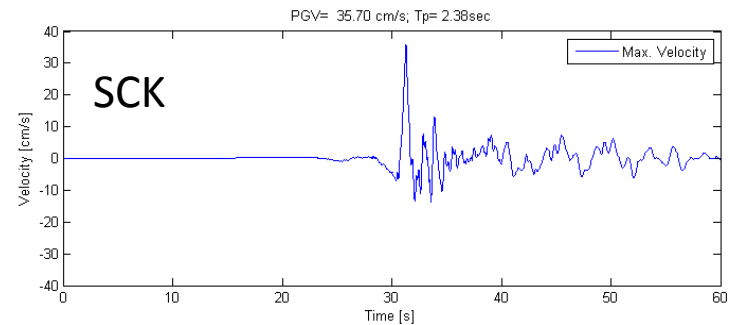
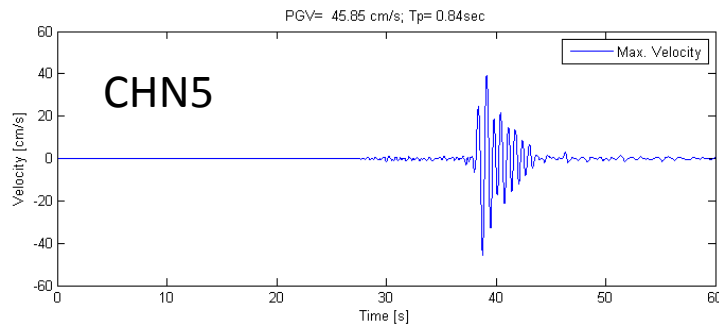
White triangle: CWB stations

Correlation seemingly exists between
velocity pulses observations and
building damage sites.

Station Code	PGV (cm/s)	Tp (pulse period)
CHN5	46	0.84
TAI	35	2.38
SSH	62	2.07
SCK	41	1.15



Velocity Pulses



T_p extracted using Shahi and Baker model (2014)

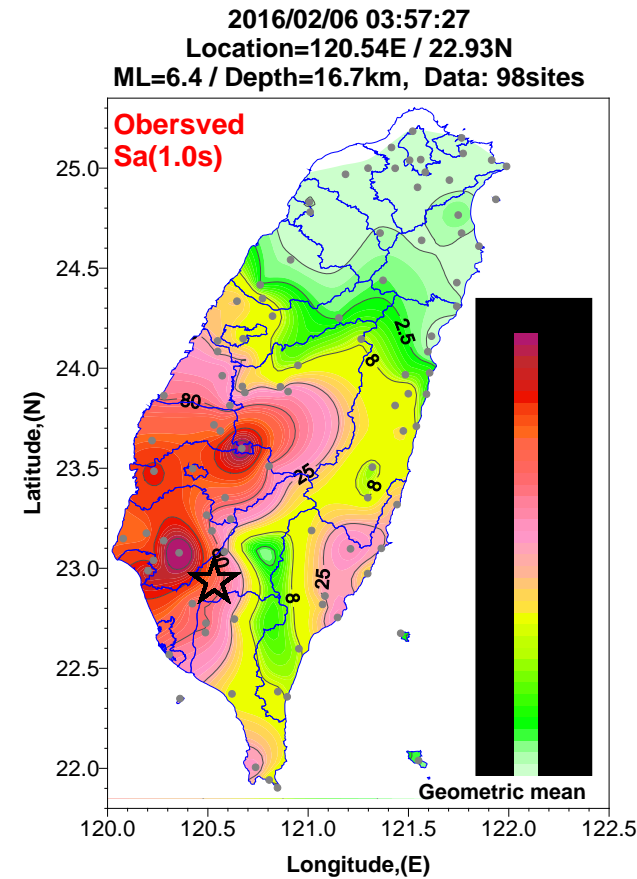
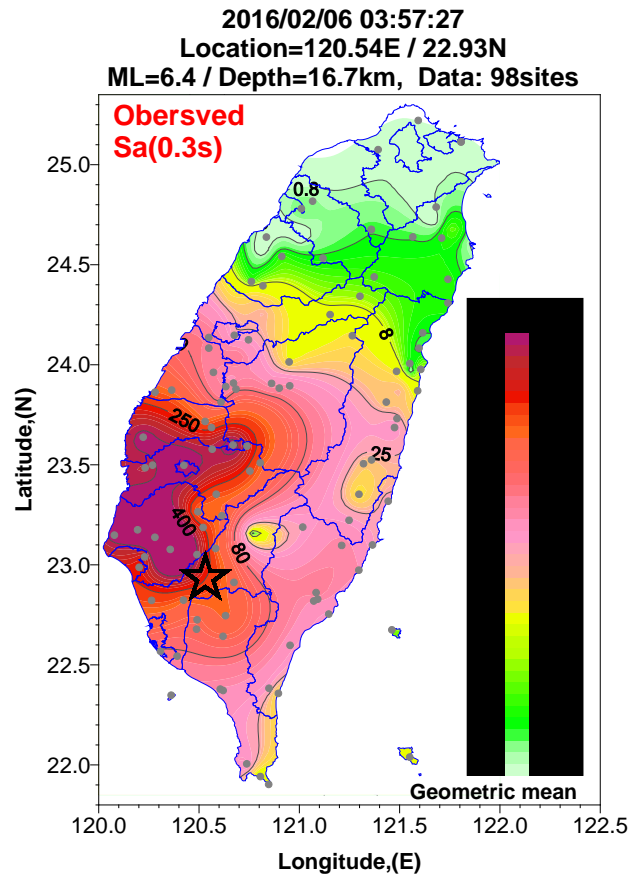
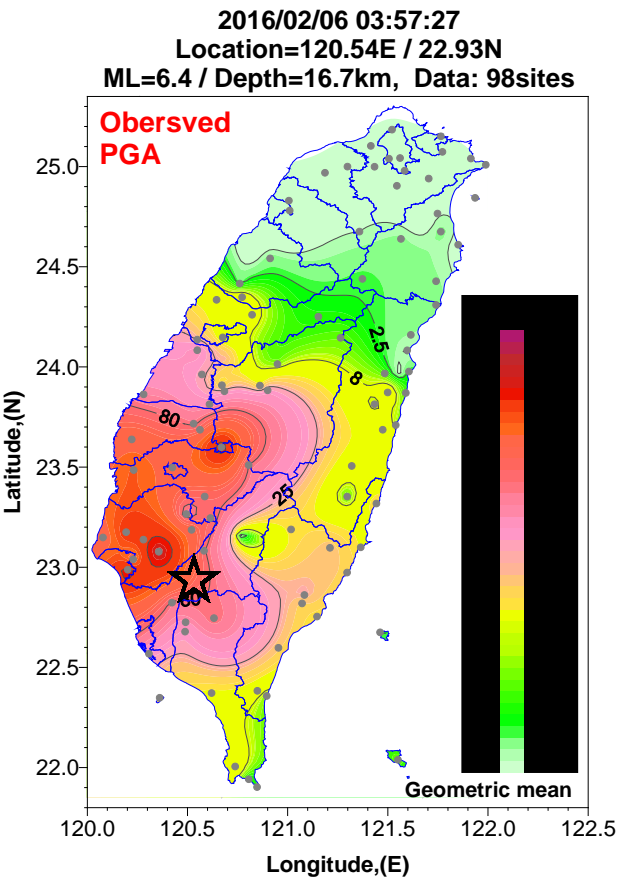
Shaking Intensity Contour

Database: CWB Real-Time Seismic Monitoring Network

PGA

Sa(T=0.3s)

Sa(T=1.0s)



Recorded Accelerograms and Response Spectra

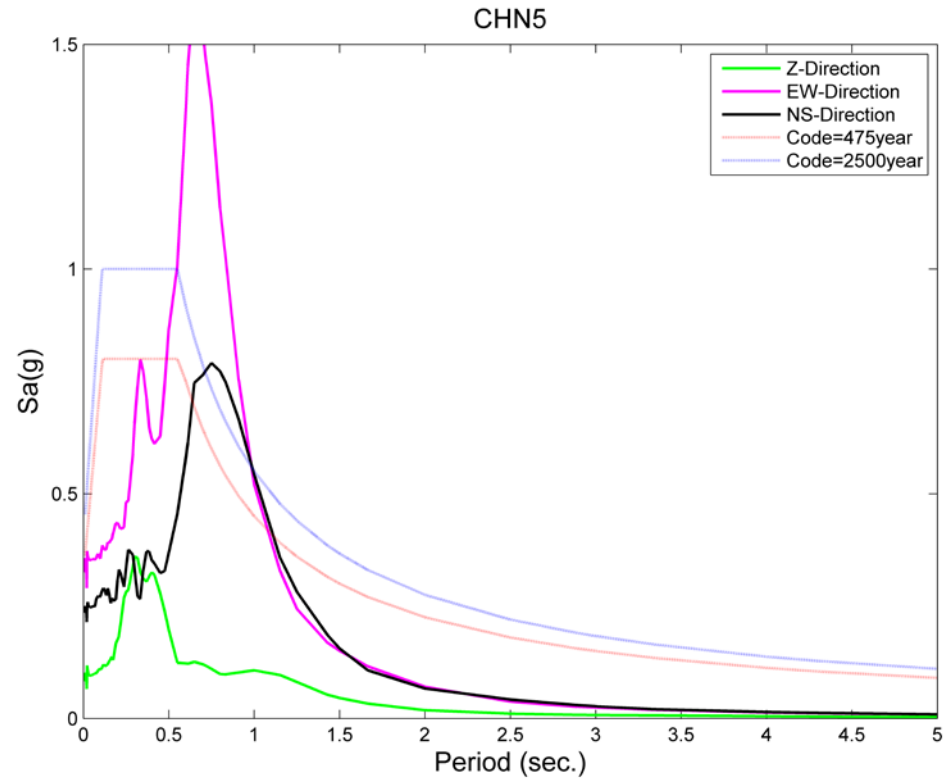
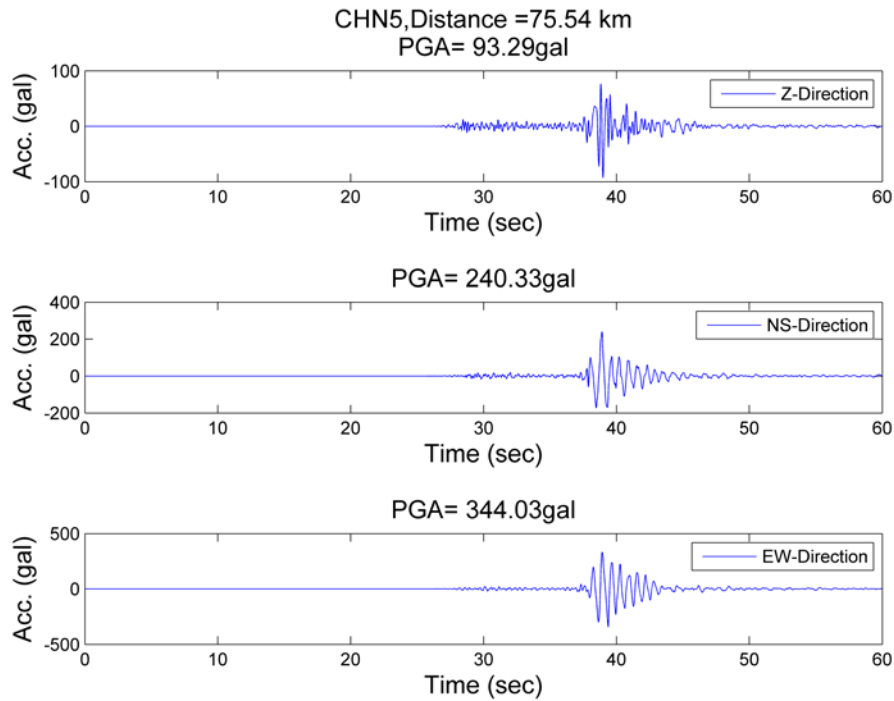
Stations observing PGA>80gal

Station Code	名稱	Long.	Lat.	Re (km)	PGA(V) (gal)	PGA(NS) (gal)	PGA(EW) (gal)	Max PGA (gal)
CHN5	草嶺	120.68	23.6	75.7	93.31	240.4	344.12	344.12
TAI	臺南市	120.21	22.99	35	82.49	152.17	233.82	233.82
SCL	佳里	120.2	23.17	44.08	54.37	232.93	224.73	232.93
SSH	善化	120.29	23.14	34.65	65.44	229.04	225.09	229.04
CHN7	六腳	120.24	23.48	68.9	20.1	190.81	175.32	190.81
CHY	嘉義市	120.43	23.5	64.06	39.9	118.5	171.37	171.37
WSF	四湖	120.23	23.64	84.78	27.46	164.67	129.8	164.67
SCK	七股	120.09	23.15	52.41	31.76	103.48	163.18	163.18
TAI1	永康	120.24	23.04	33.34	44.98	105.16	148.34	148.34
CHN1	楠西	120.53	23.19	28.72	77.46	147.45	123.94	147.45
WGK	古坑	120.57	23.68	84.08	19.62	105.16	109.46	109.46
SSD	三地門	120.64	22.74	22.65	71.3	105.46	62.15	105.46
SGS	甲仙	120.59	23.08	17.92	72.38	104.86	63.82	104.86
CHN4	草山	120.59	23.35	47.46	55.93	104.68	88.95	104.68
TWM1	旗山	120.43	22.82	15.99	31.4	87.93	57.72	87.93
ALS	阿里山	120.81	23.51	70.37	34.16	84.04	71.42	84.04

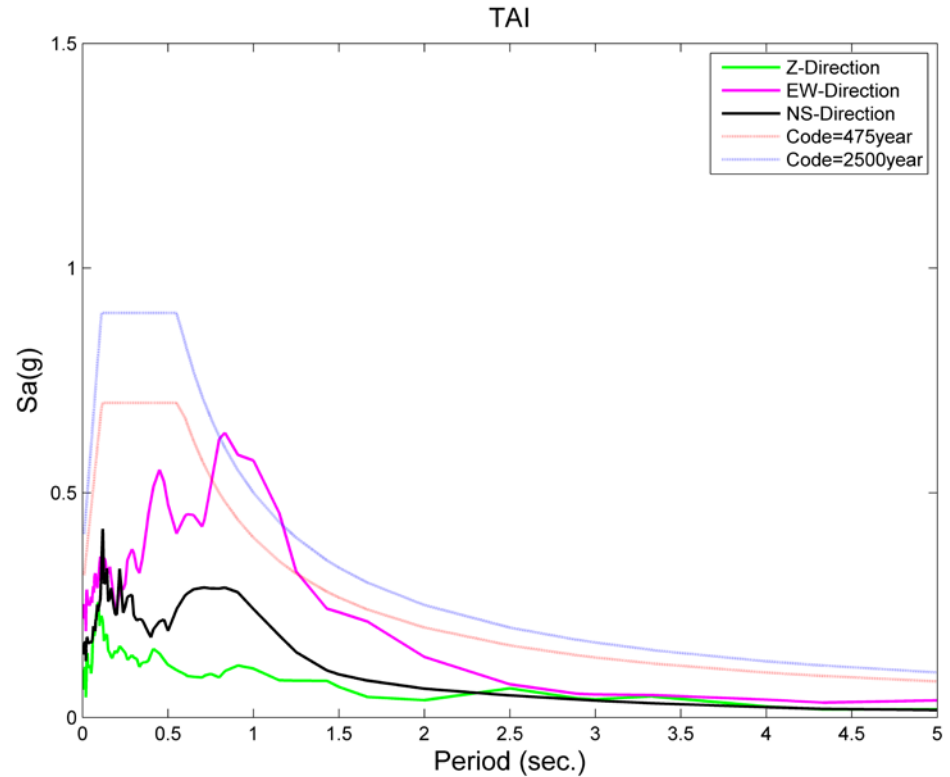
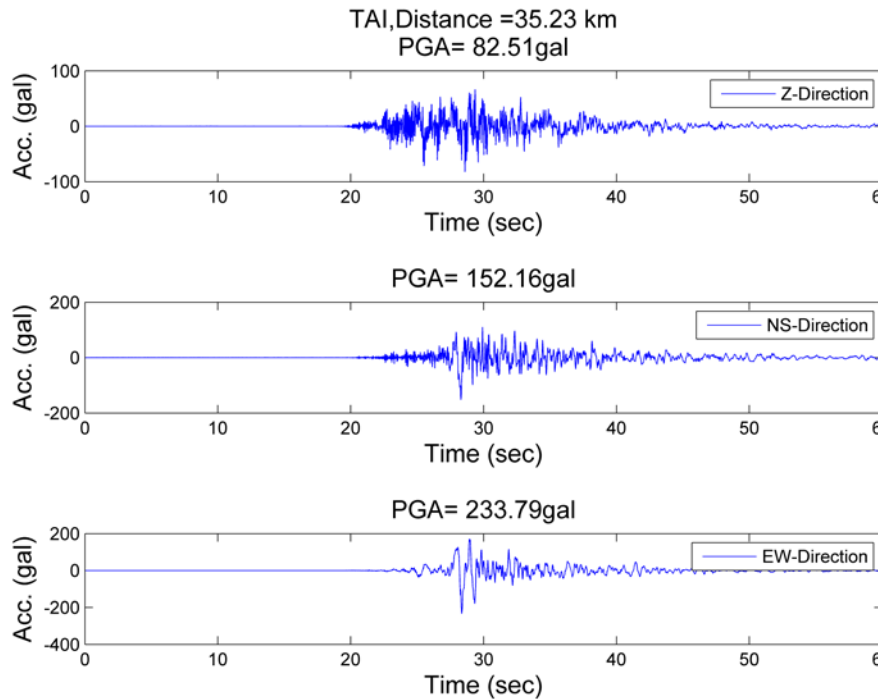
震度六級

震度五級

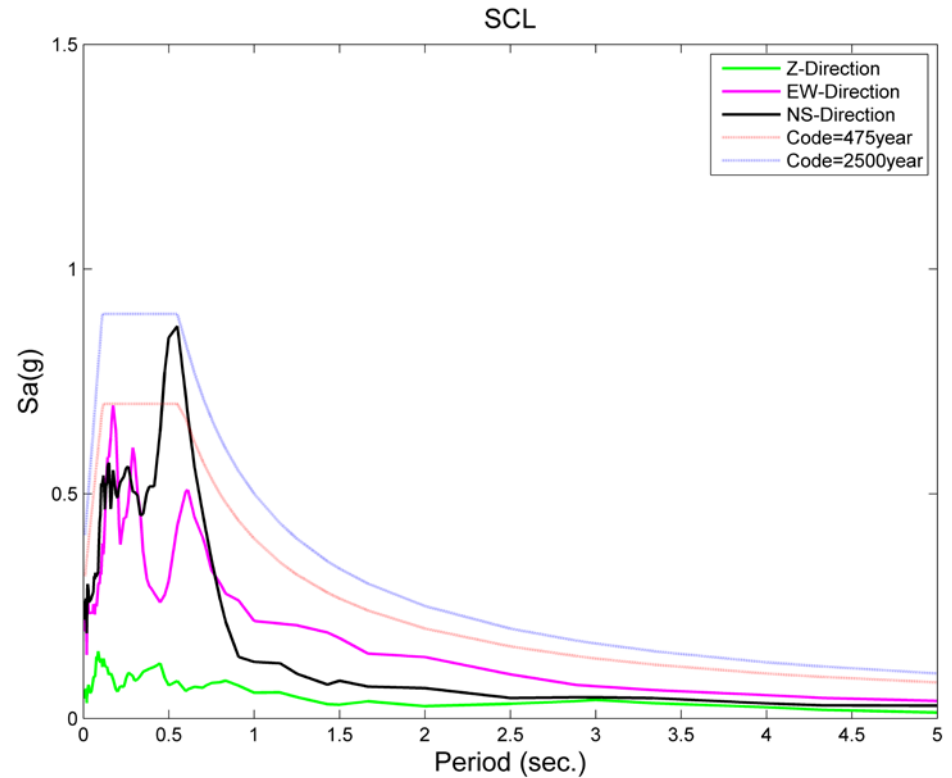
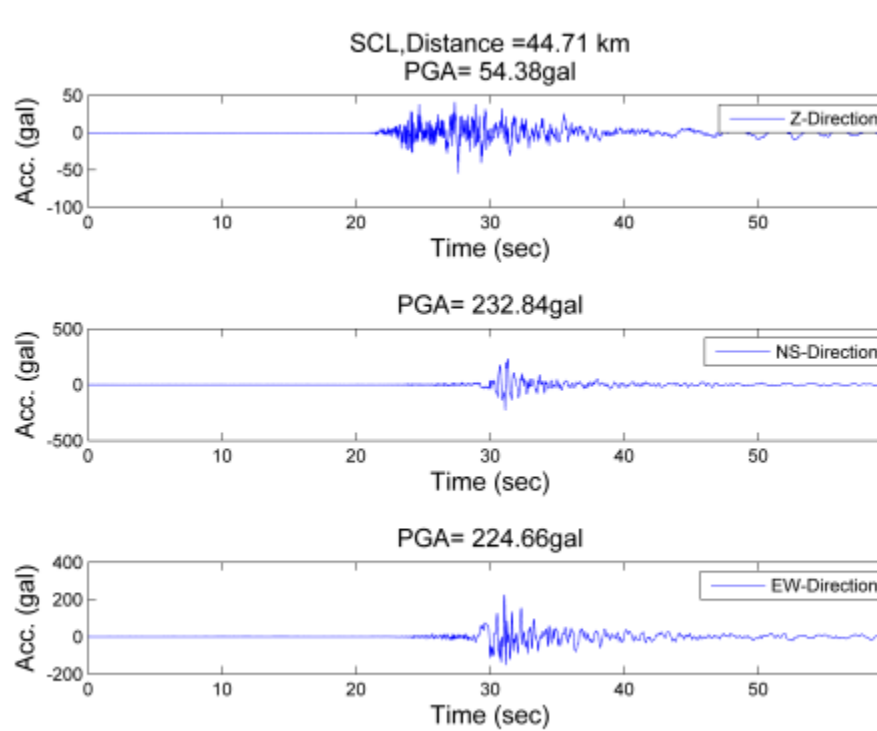
Station CHN5 (Caoling)



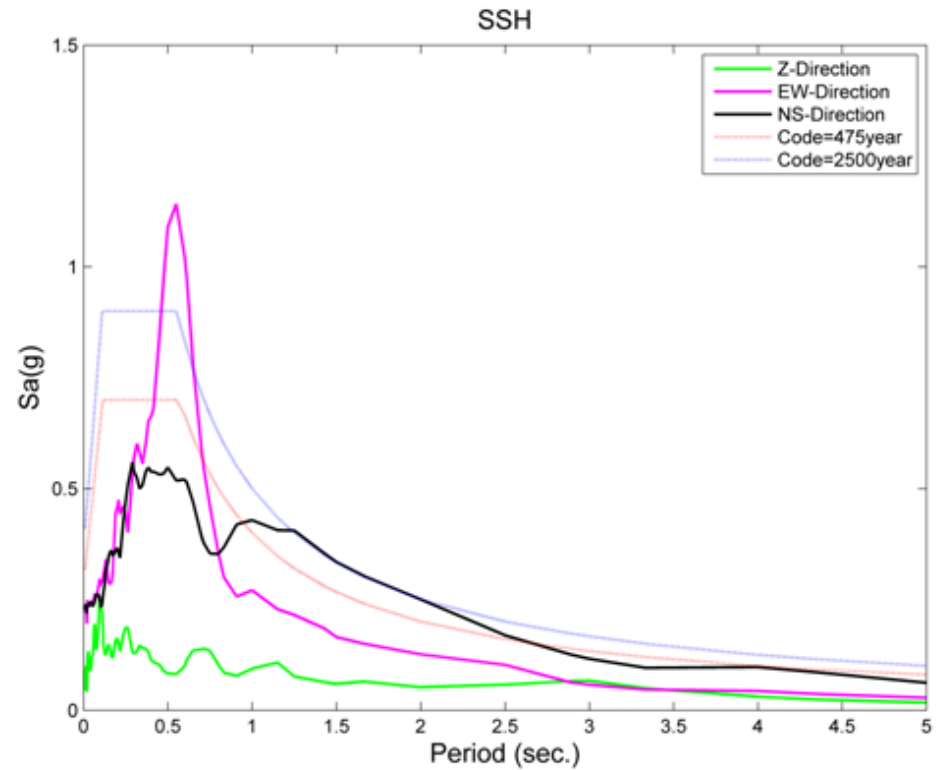
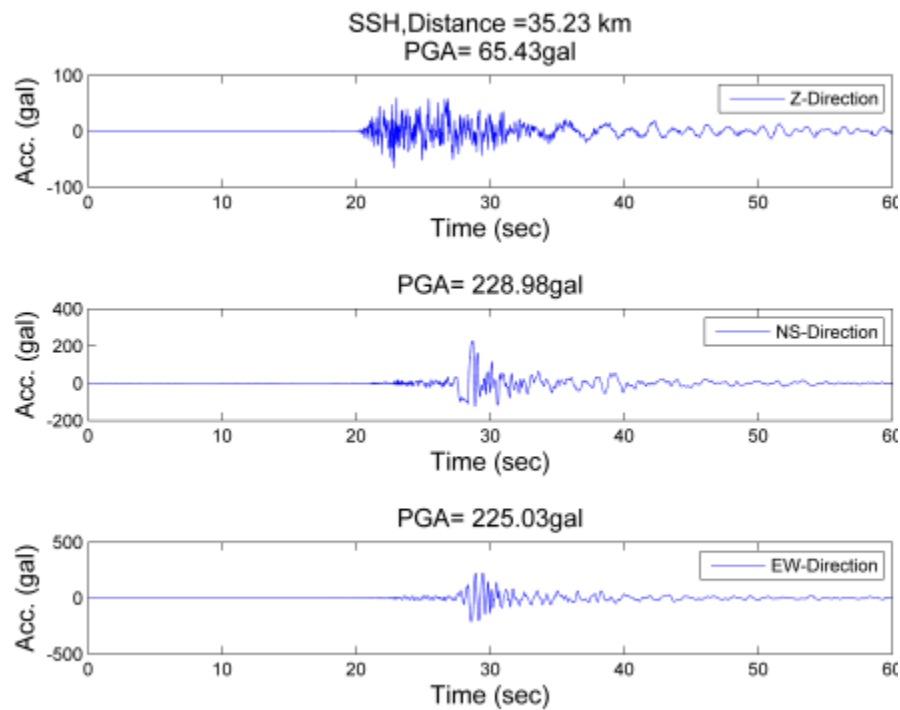
Station TAI (Tainan City)



Station SCL (佳里)



Station SSH (善化)



NCREE Real-Time Seismic Monitoring Network

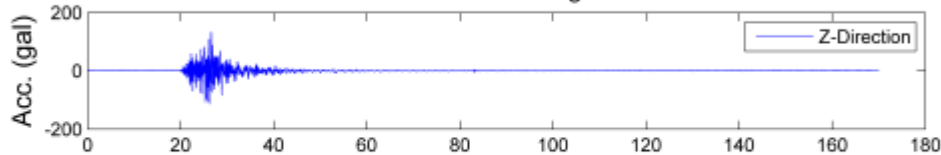
- Stations observing PGA>20gal

Re = 21.5km

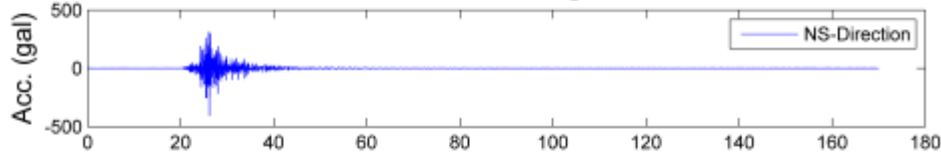
Station	Name	E	N	PGA_U,gal	PGA_N,gal	PGA_E,gal
A730	南化埔仔	120.50	23.05	133.732	407.994	327.928
A800	茂林萬山	120.68	22.91	65.438	158.471	101.689
A660	六腳溪厝	120.28	23.50	36.330	138.891	184.579
A620	梅山圳北	120.57	23.58	31.837	79.585	96.053
A590	二林香田	120.37	23.87	24.072	60.057	72.547
A771	路竹北嶺	120.27	22.82	28.233	50.669	59.984
A601	豐山	120.75	23.59	17.975	39.016	42.083
A600	達邦特富野	120.76	23.47	24.155	33.905	35.178
A770	大寮林園	120.40	22.54	13.807	28.637	28.800
A530	魚池東光	120.96	23.89	9.855	28.097	23.062
A810	瑪家佳義	120.63	22.64	19.682	27.570	33.943
A560	南投永興	120.64	23.89	12.969	27.446	26.643
A860	枋寮瓦礫	120.61	22.38	13.049	25.783	29.582

Station A730 (南化埔仔)

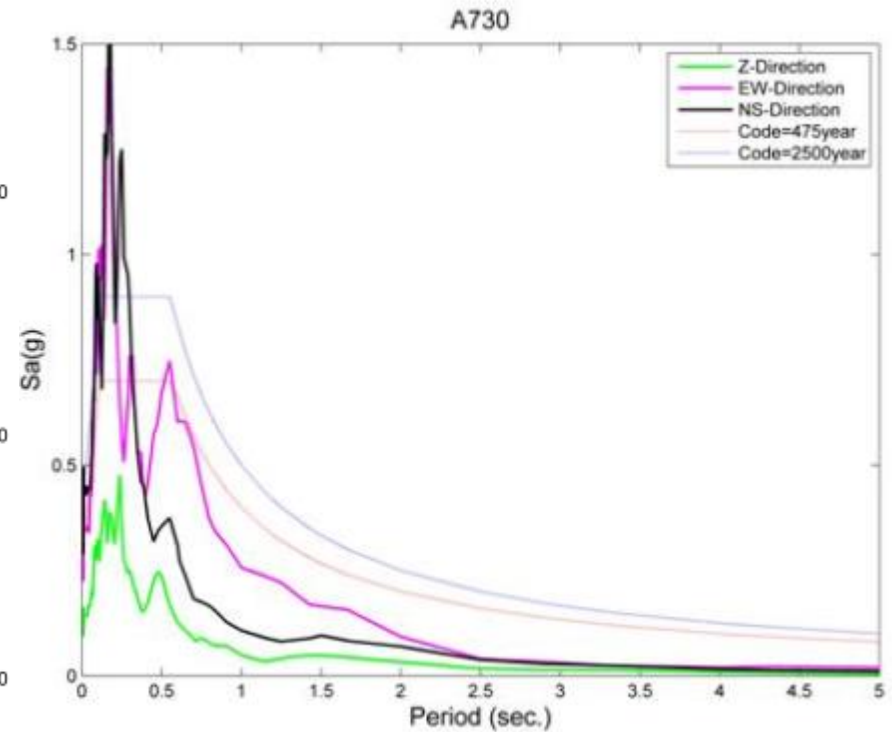
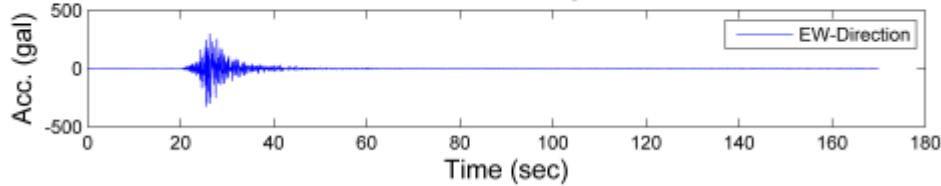
A730, Distance = 13.55 km
PGA= 133.73gal



PGA= 407.99gal



PGA= 327.93gal



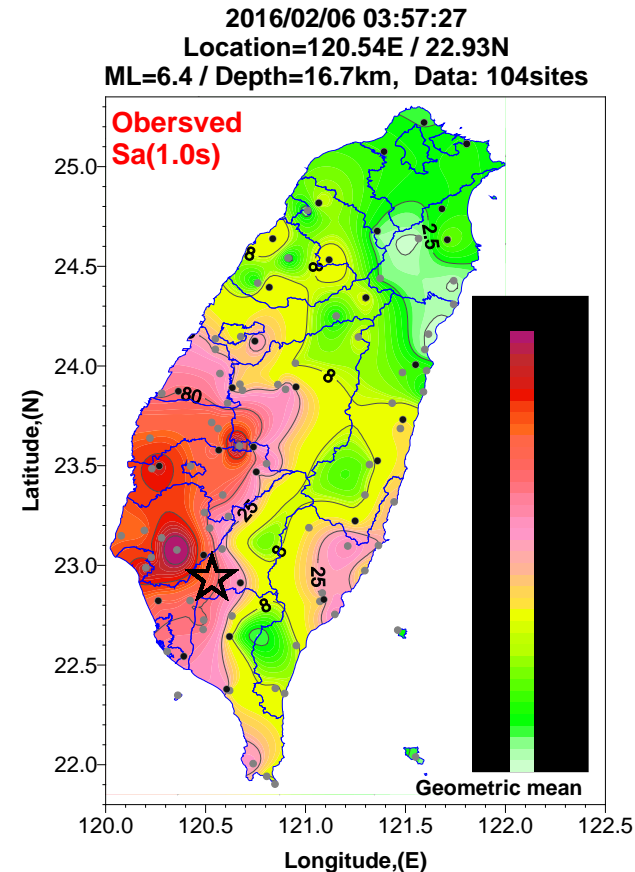
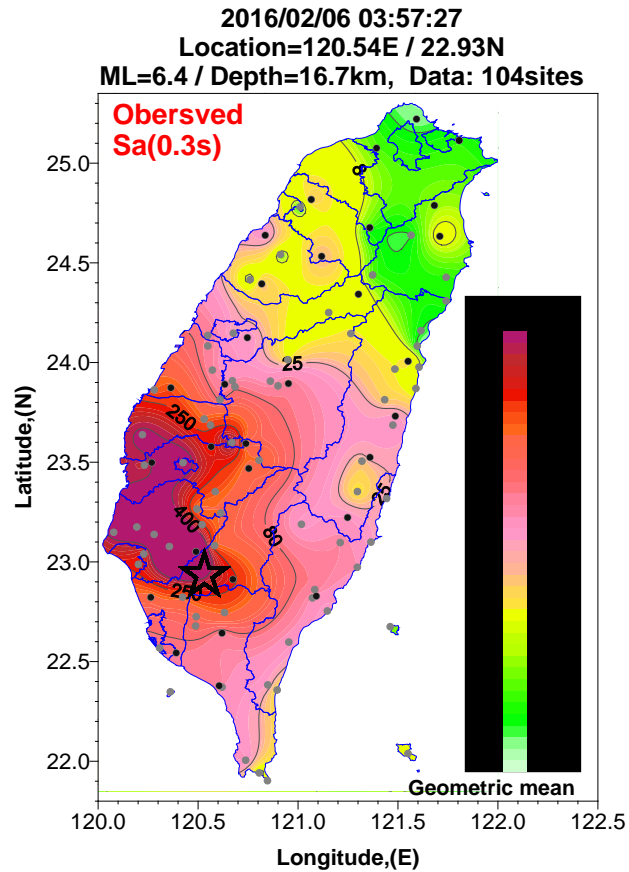
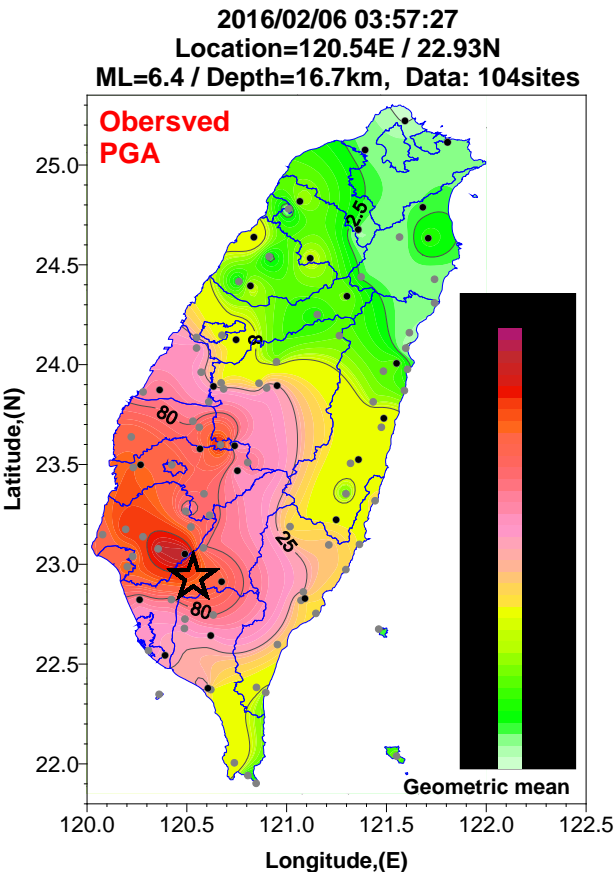
Shaking Intensity Contour

Database: CWB and NCREE Real-Time Seismic Monitoring Networks

PGA

Sa(T=0.3s)

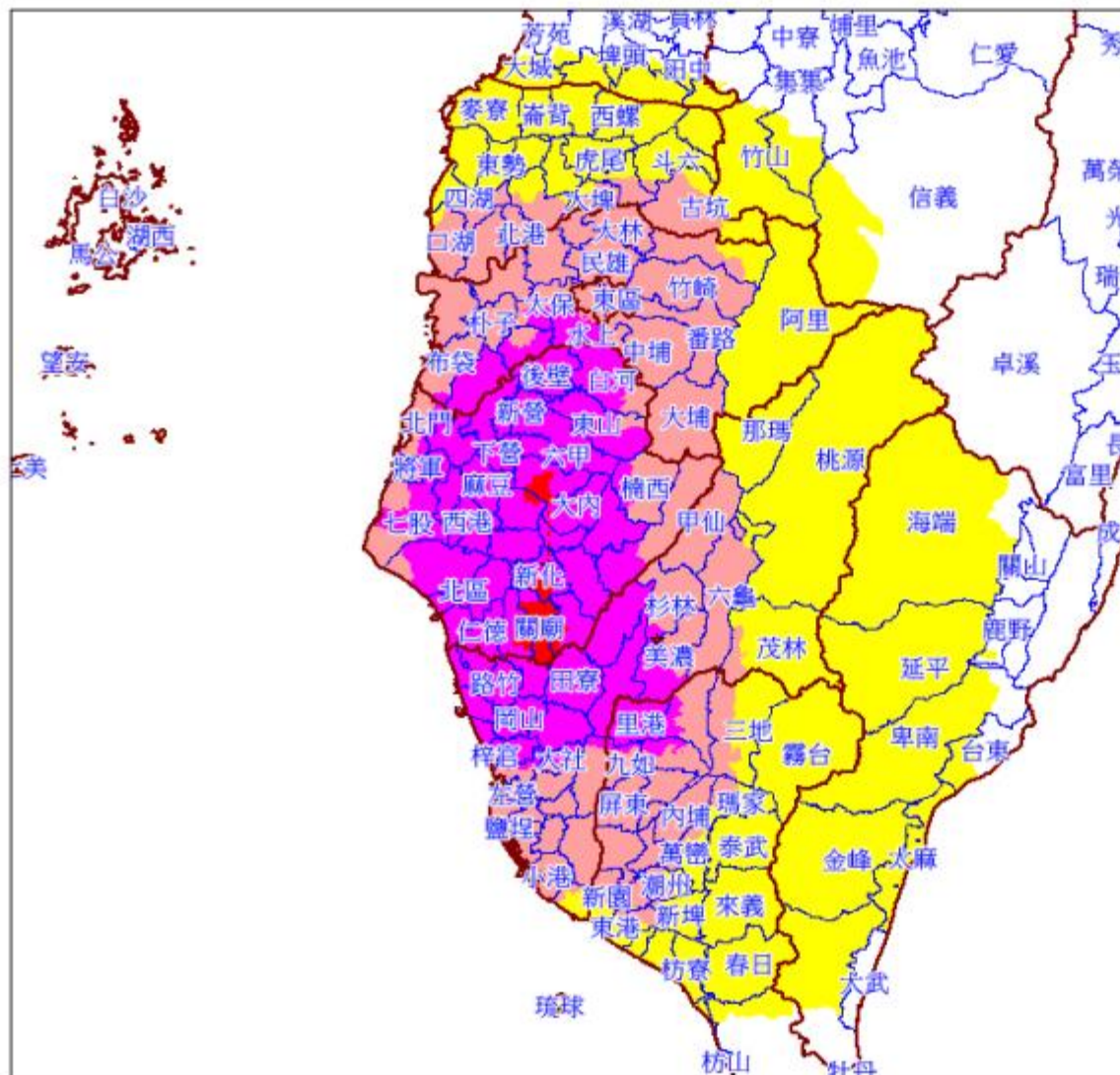
Sa(T=1.0s)



● CWB stations

● NCREE stations

PGA Distribution Estimated by TELES



日期：2016/2/6
 時間：3:57:27.10
 芮氏規模：6.40
 震央經度：120.5400
 震央緯度：22.9300
 震源深度：16.60 公里

地表最大加速度

PGA Intensity
By Pga

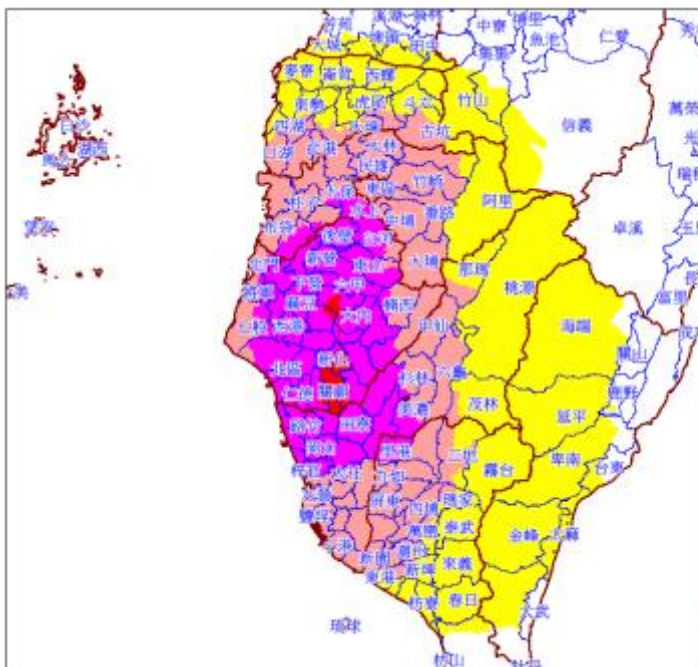
- 0.25 to 0.33
- 0.16 to 0.25
- 0.08 to 0.16
- 0.025 to 0.08
- 0.008 to 0.025
- 0 to 0.008

台灣地震損失評估系統
 Taiwan Earthquake Loss Estimation System

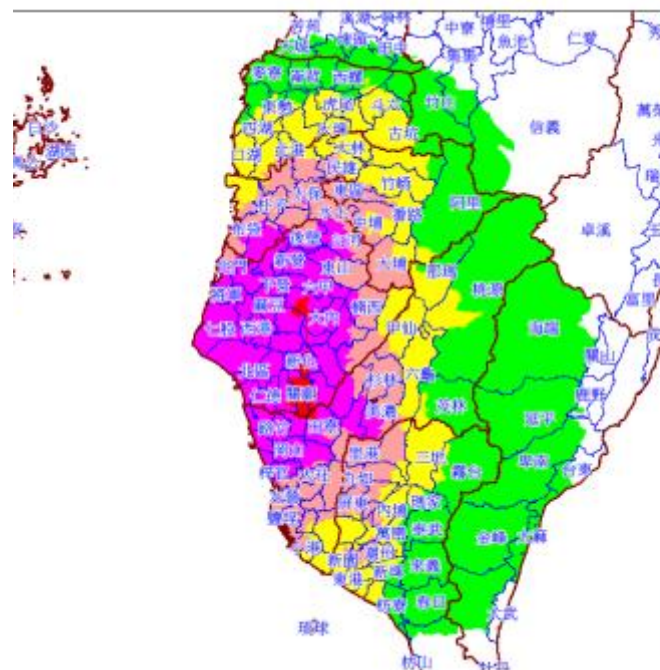


國家地震工程研究中心
 National Center for Research on
 Earthquake Engineering

Spectral Accelerations Estimated by TELES

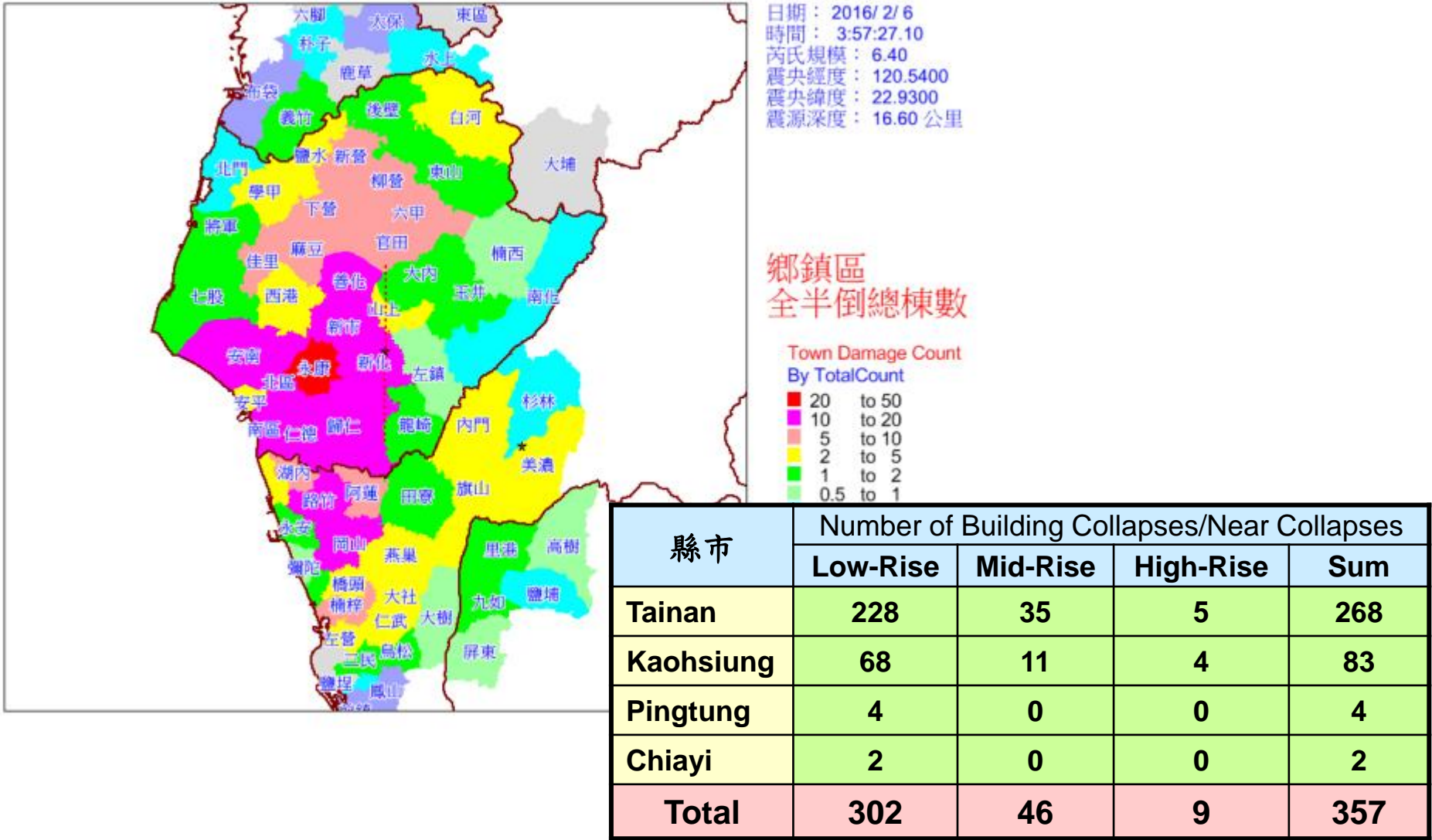


Sa (0.3sec)



Sa (1sec)

Building Collapses and Nearly Collapses Estimated by TELES



Print and Electronic Media Reports (1/2)

台南多棟大樓倒塌國官警消全力救援

(News Radio, Broadcasting Corporation of China, 中廣新聞網, 5:57am, Feb 6, 2016)

- 台南市永康永大路維冠大樓，整棟十六樓高的建築，不堪強烈地震搖晃倒塌，橫倒在「永大」路上。國軍官兵以及警消人員都已經趕到現場，包括消防署南部特搜中心，以及屏東和高雄特搜人員正在進行救援。目前已經救出三十四人。
- 台南歸仁也有大樓倒塌，七樓變四樓。地點在台南市歸仁區大仁路與大通路路口，目前正在救援中。
- 山上區南洲里房屋傾斜，有多名民眾受困，在五點左右，先救出三人，之後再救出七人，目前屋內初步勘查，已經沒有人受困。
- 東區長東街市場附近有大樓傾斜無人受困。新化京城銀行大樓傾斜，無人受困。另有多起電梯受困狀況，目前都已經解除。

Print and Electronic Media Reports (2/2)



Building collapses in Yongkang District , Tainan

Sites of Severe Losses and Damages

1. Weikuan Jinlong (維冠金龍/燦坤) Complex, Yongkang District, Tainan City
2. King's Town Bank (京城銀行), Sinhua District, Tainan City
3. Dachih Market Place (大智市場), East District, Tainan City
4. Wind God's Temple (風神廟), West Central District, Tainan City
5. On Xinyi N. Rd. & Daren St., Gueiren District, Tainan City
6. Temple of Goddess Mazu, Cishan District, Kaohsiung City (旗山天后宮)
7. Lane 101, Taizi Rd. (太子路), Rende District, Tainan City
8. 205 Minzu Rd. (民族路), Yujing District, Tainan City
9. Tainan Municipal Yujing Junior High School (玉井國中)
10. Tainan Municipal Beimen Elementary School at Yuhu Branch (北門國小玉湖分校)

Sites of Losses and Damages

- 12 Lane 27, Sec. 5 Fuan Rd., Annan Dist., Tainan City (building tilt and displaced)
- 93 Lane 141, Dade St., South Dist., Tainan City (broken water pipeline, possibly elevator shaft damage or drop, wounded civilians, building damages)
- 104 Nanzhou, Shanshang Dist., Tainan City (Building collapse)
- 18 Alley 9, Lane 100, Heping Rd., Guanmiao Dist., Tainan City (unoccupied 1-story building collapse)
- 13 Nanxing St., Gueiren Dist., Tainan City (collapse of a 3-story RC building)
- 17 Shengkeng 3rd St., Guanmiao Dist., Tainan City (top story collapse of a 3-story RC building)

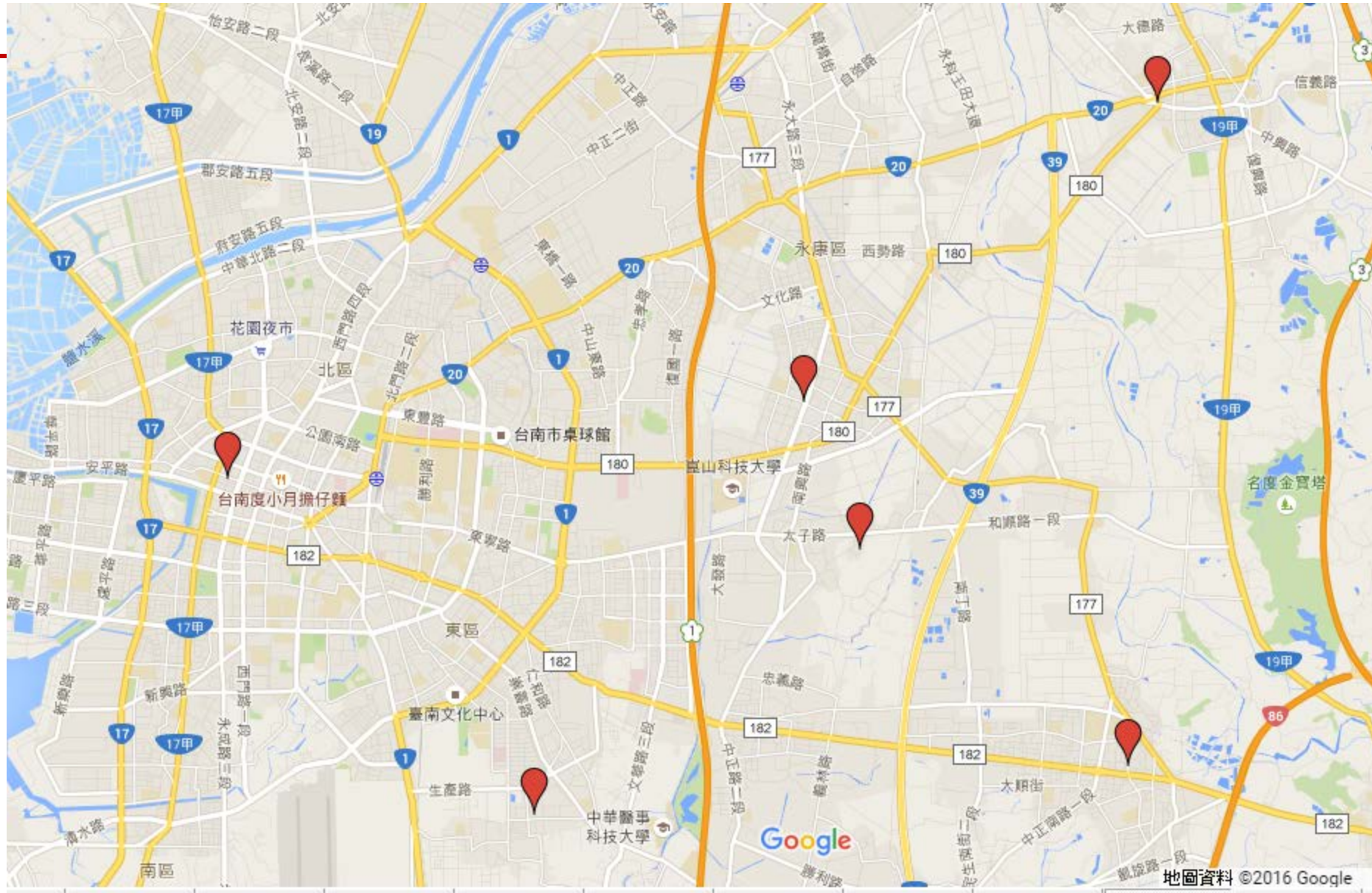
Coordinates of Reconnaissance Spots and TELES-Estimated PGAs

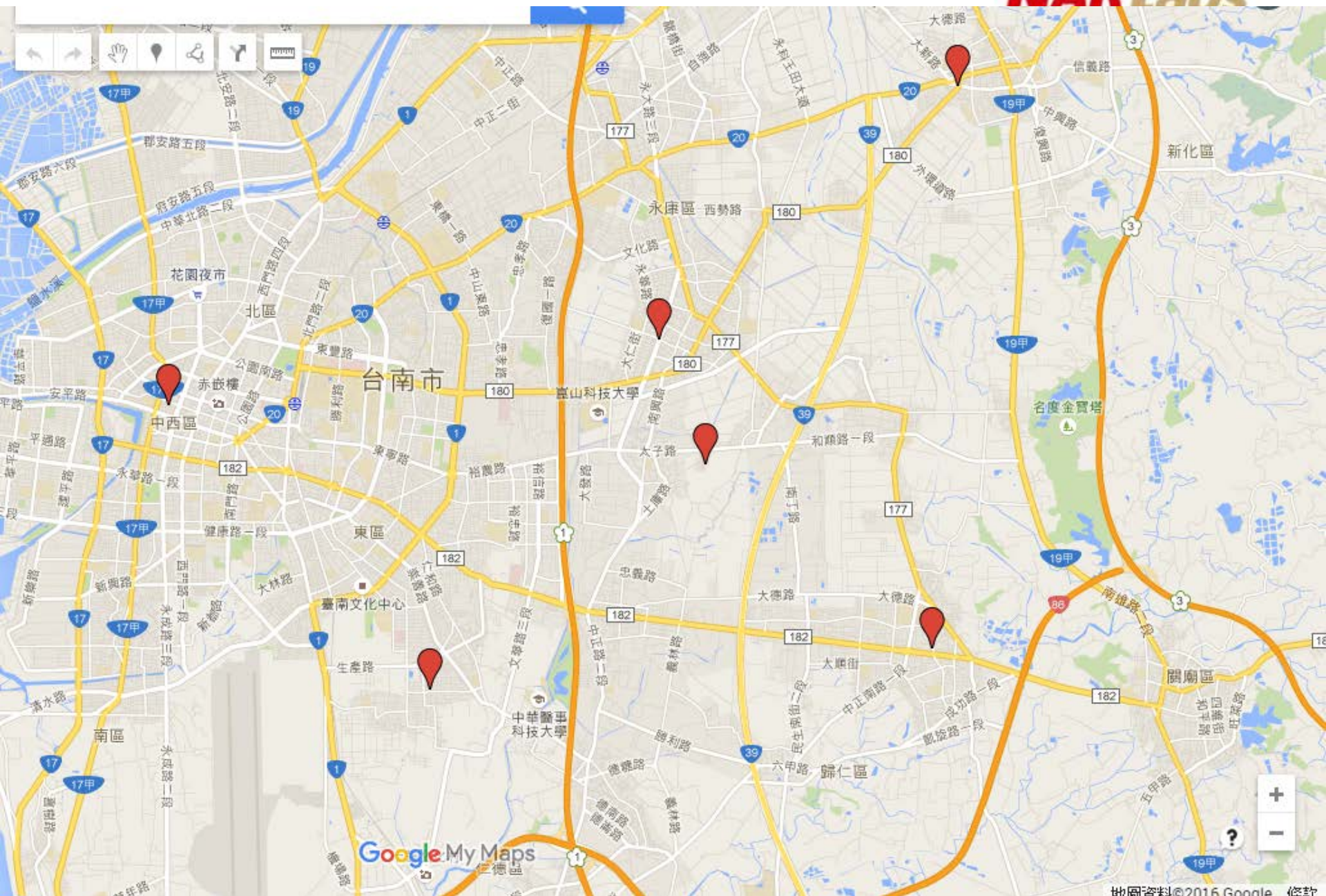
No.	0206 Meinong Eqk. Location of Major Damages	Long._WG S84	Lat._WGS 84	Long._TW D67	Lat._TWD 67	Estimated PGA (gal) GeoMean
1	Weikuan Jinlong (維冠金龍/燦坤) Complex, Yongkang District, Tainan	120.261	23.00523	120.253	23.00697	144
2	King's Town Bank (京城銀行), Tainan	120.301	23.03636	120.2929	23.0381	171
3	Dachih Market Place (大智市場), Tainan	120.231	22.96216	120.2225	22.9639	163
4	Wind God's Temple (風神廟), Tainan	120.196	22.99711	120.1876	22.99885	219
5	On Xinyi N. Rd. & Daren St., Tainan	120.298	22.96727	120.2895	22.96901	220
6	Temple of Goddess Mazu, Cishan (旗山天后宮)	120.482	22.88667	120.4742	22.88842	303
7	Lane 101, Taizi Rd. (太子路), Tainan	120.267	22.98984	120.2593	22.99158	151
8	205 Minzu Rd. (民族路), Tainan	120.468	23.1238	120.4598	23.12555	217
9	Yujing Junior High School, Tainan	120.47	23.12379	120.4615	23.12554	220
10	Beimen Elementary School at Yuhu Branch, Tainan	120.139	23.2616	120.1311	23.26333	141
11	Beimen Elementary School (北門國小), Tainan	120.125	23.26509	120.1171	23.26682	126



20160206主要災情座標.kmz

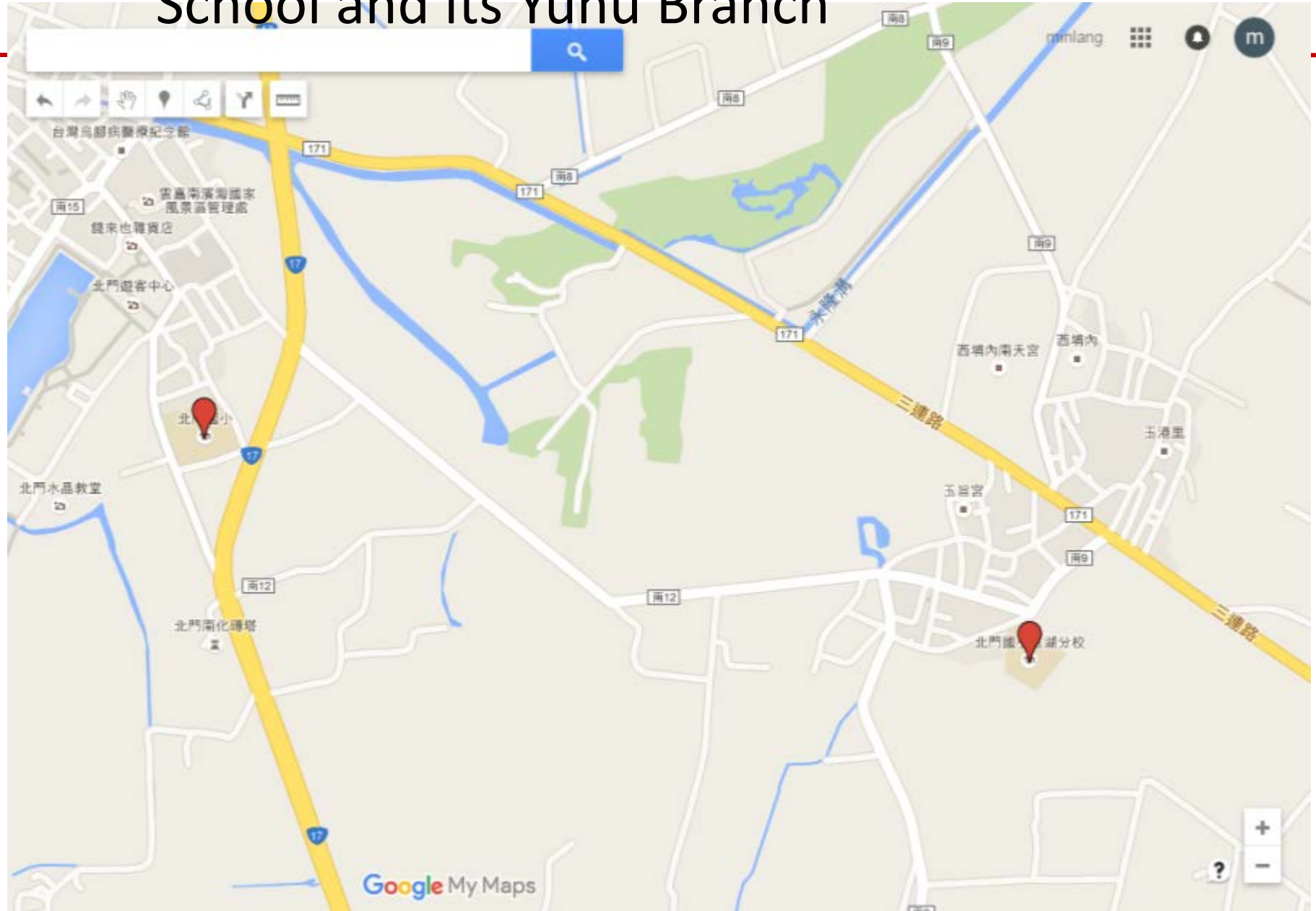
NAR Labs





Tainan Municipal Beimen Elementary School and its Yuhu Branch

NARLabs



Tainan Municipal Yujing Junior High School



(1) Weikuan Jinlong (維冠金龍/燦坤) Complex

- On Section 2, Yongda Rd. and Guoguang 5th St., Yongkang District, Tainan City
- 16-story RC building collapse



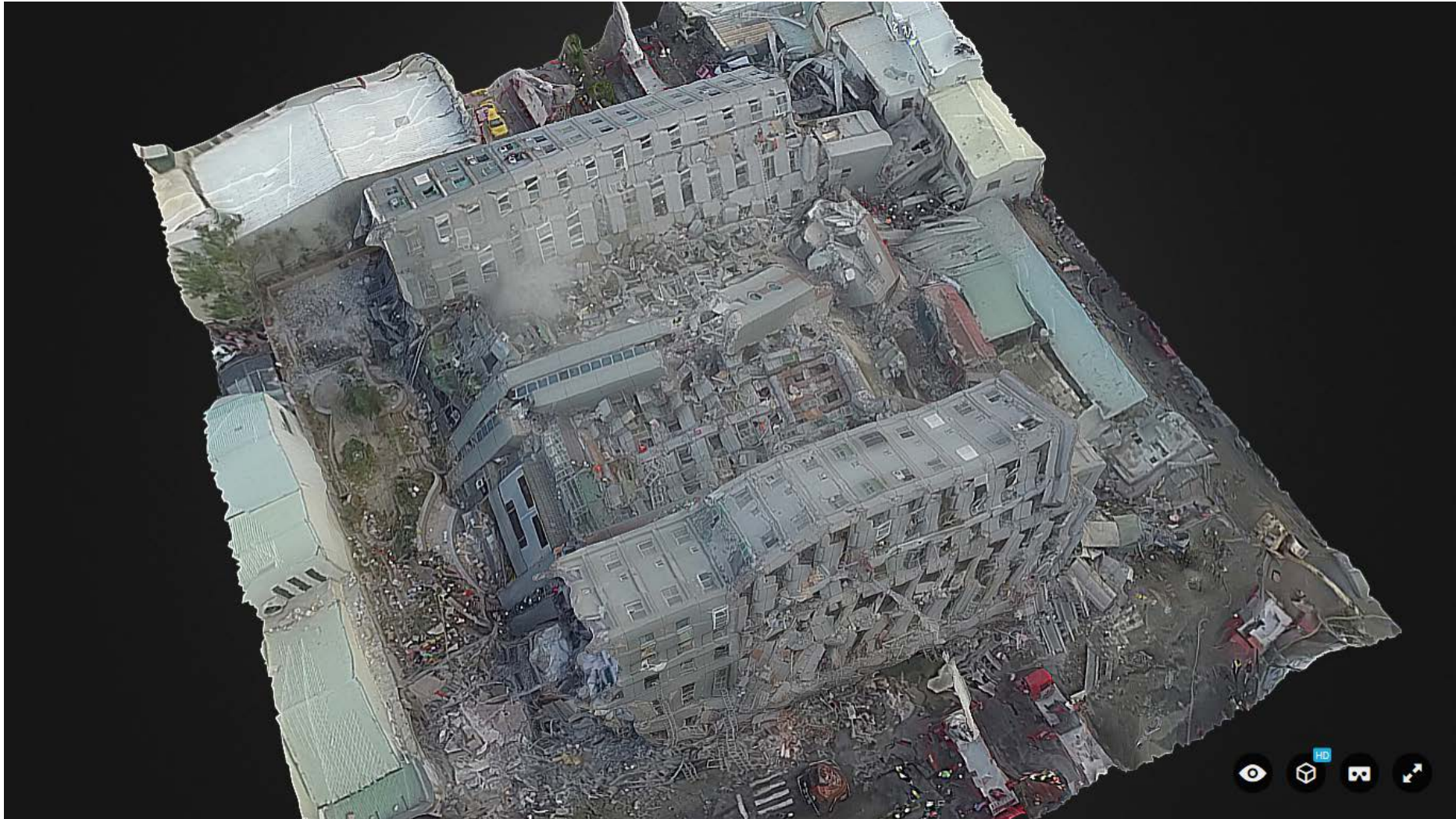
Before Earthquake (Google Street View)



Before Earthquake (Google Street View)



After Earthquake



After Earthquake



After Earthquake



After Earthquake







(2) King's Town Bank (京城銀行), Sinhua District

- 586 Zhongshan Rd., Sinhua District, Tainan City
- 10-story

Before Earthquake (Google Street View)



Before Earthquake (Google Street View)



Photographical View of King's Town Bank (京城銀行) after Earthquake



Photographical View of King's Town Bank (京城銀行) after Earthquake



(3) Dachih Market Place, East District

- Lane 103, Changdong St., East Dist., Tainan City
- Commercial-residential complex building (4-story above ground, 1-story underground)
- Soft 1st story collapse, some of 4-story buildings became 3-story



After Earthquake



高阿賢

12 mins · 11

台南市東區大智里菜市場倒了!!二樓變一樓，裡面還有人沒出來，希望平安!



After Earthquake



After Earthquake



(4) Wind God's Temple (風神廟), West Central District

- 8, Lane 143, Section 3 Minquan Rd., West Central District, Tainan City



After Earthquake



(5) On Xinyi N. Rd. & Daren St., **NAR Labs** Guiren Dist.

- 46 Xinyi N. Rd., Guiren Dist., Tainan City
- 6-story RC building



Source: Google Street View

Google

圖為拍攝日期：3月 2015 © 2016 G



Map info from Google



(6) Temple of Goddess Mazu, Cishan District (旗山天后宮)

- 16 Lane 23, Yongfu St., Chishan District, Kaohsiung City
- Collapse of decorated archway



Map info from Google





(7) Lane 101, Taizi Rd. (太子路), **NAR Labs** Rende District, Tainan City





Source: Google Street View



Source: Google Street View



Source: Google Street View



南台灣地震 台南仁德區太子路樓房傾斜



中央社



訂閱

5,503

觀看次數：69

20160206中天新聞 仁德太子路101巷建物傾斜 鐵皮壓車



雲林四湖搖晃3.34秒

cti 中天新聞HD
LIVE

高雄6.4強震災情慘
國軍逾3百人赴台南

01, 台南又發生規模4



台南永大路

台南

最新

08:48:26

黃琲茹 記者

仁德太子路101巷建物傾斜 鐵皮壓車

南台大震 南市維冠金龍大樓倒塌 已知127人獲救

1:06 / 2:59



(8) 205 Minzu Rd. (民族路),
Yujing District, Tainan City

NARLabs



205 Minzu Rd. (民族路), Yujing District, Tainan City

NARLabs



205 Minzu Rd. (民族路), Yujing District, Tainan City

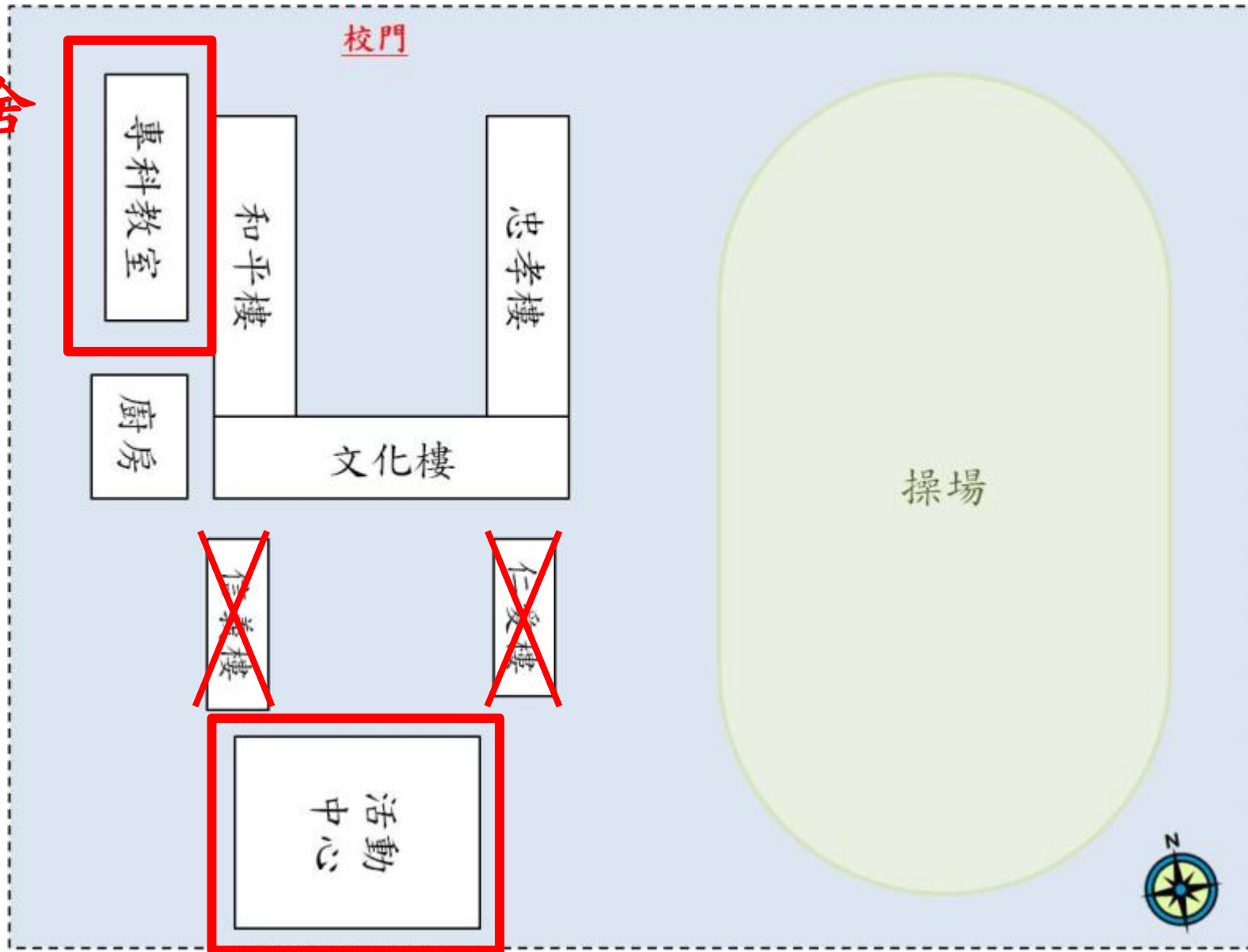


School Buildings

County	School	Building	Assessment Result	Estimated PGA (gal)
Tainan City	Yujing Junior High School	Junior College Building	CDR=1.08	220.3745
	Beimen Elementary School (Yuhu Branch)	West Building	Is=222(?)	125.5235
	Beimen Elementary School	West Building		125.5235
Pingtung County	Gaoshu Township (高樹鄉) Tianzi Elementary School (田子國小)	Classroom Building		
	Sandimen Township (三地門鄉) Cingye Elementary School (青葉國小)	Dancing Classroom		

Plan of Yujing Junior High School (玉井國中)

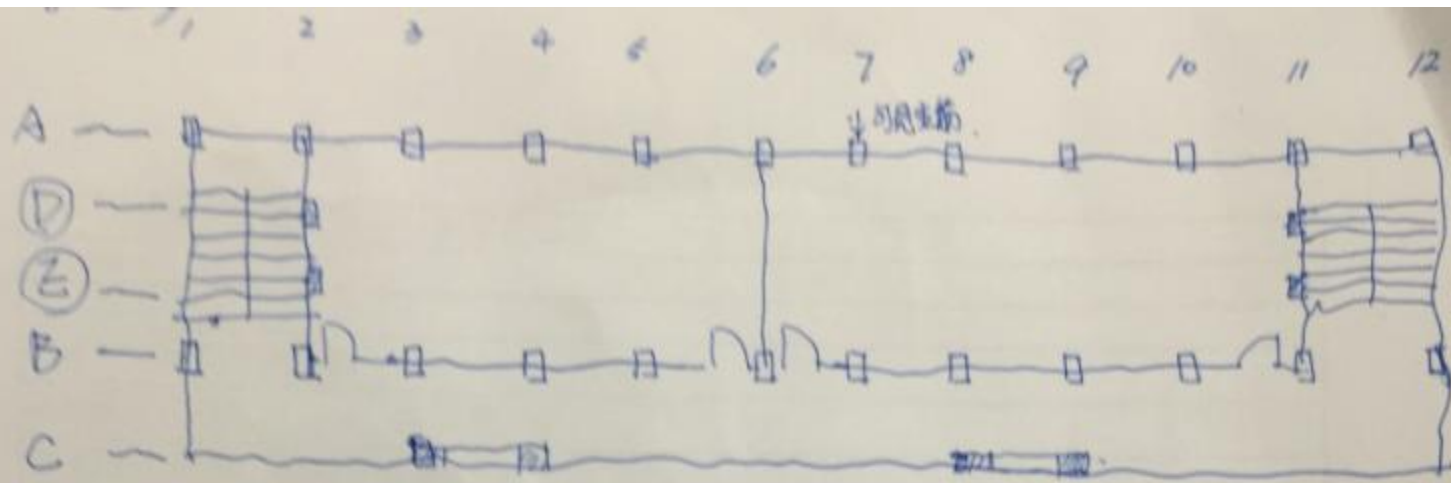
震損校舍



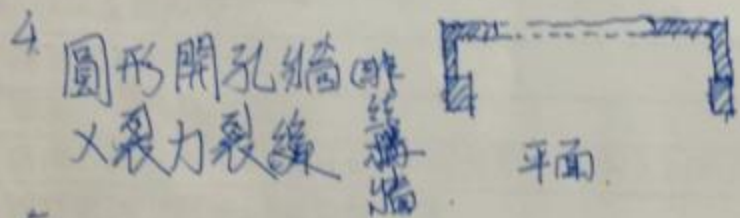
Junior College Building, Yujing Junior High School (玉井國中) before Earthquake

Built in 1998
Age of bldg: 28 yrs.
3-story





1. 窗台柱均出現 X 剪力裂縫 (~~B 7 no~~)
2. 長柱無損 or 撓曲裂縫 (B 6)
3. A7, B9 裂縫可見主筋



5. Y 向牆有斜向裂縫 (11 Line) (6 Line) (2 no)

Damage of Junior College Building, Yujing Junior High School (玉井國中)



Damage of Junior College Building, Yujing Junior High School (玉井國中)



Damage of Junior College Building, Yujing Junior High School (玉井國中) (A7 Column)



Damage of Junior College Building, Yujing Junior High School (玉井國中)



Activity Center, Yujing Junior High School (before Earthquake)

Built in 1997

Age of bldg: 29 yrs.



Damage of Activity Center, Yujing Junior High School



Damage of Activity Center, Yujing Junior High School



Damage of Activity Center, Yujing Junior High School



Damage of Activity Center, Yujing Junior High School

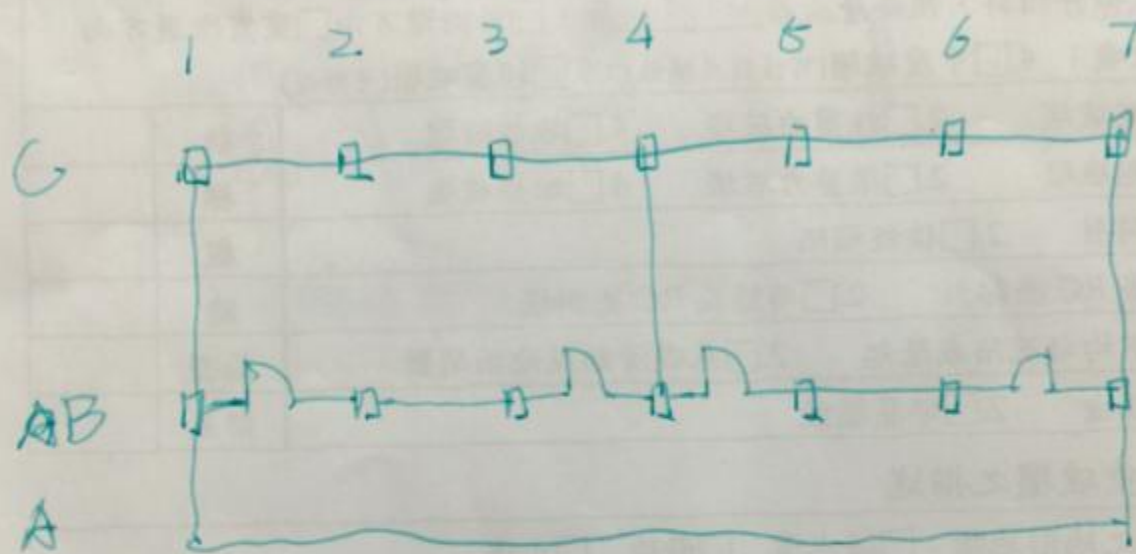


Damage of Yujing Junior High School



Plan of Beimen Elementary School at Yuhu Branch





◎ 73年建. 1F

◎ B4. B5. B6 補強過 (鋼板補強)

◎ B2 重直裂縫

West Building, Beimen Elementary School at Yuhu Branch (before Earthquake)



Damage of West Building, Beimen Elementary School at Yuhu Branch (北門國小玉湖分校)



Damage of West Building, Beimen Elementary School at Yuhu Branch



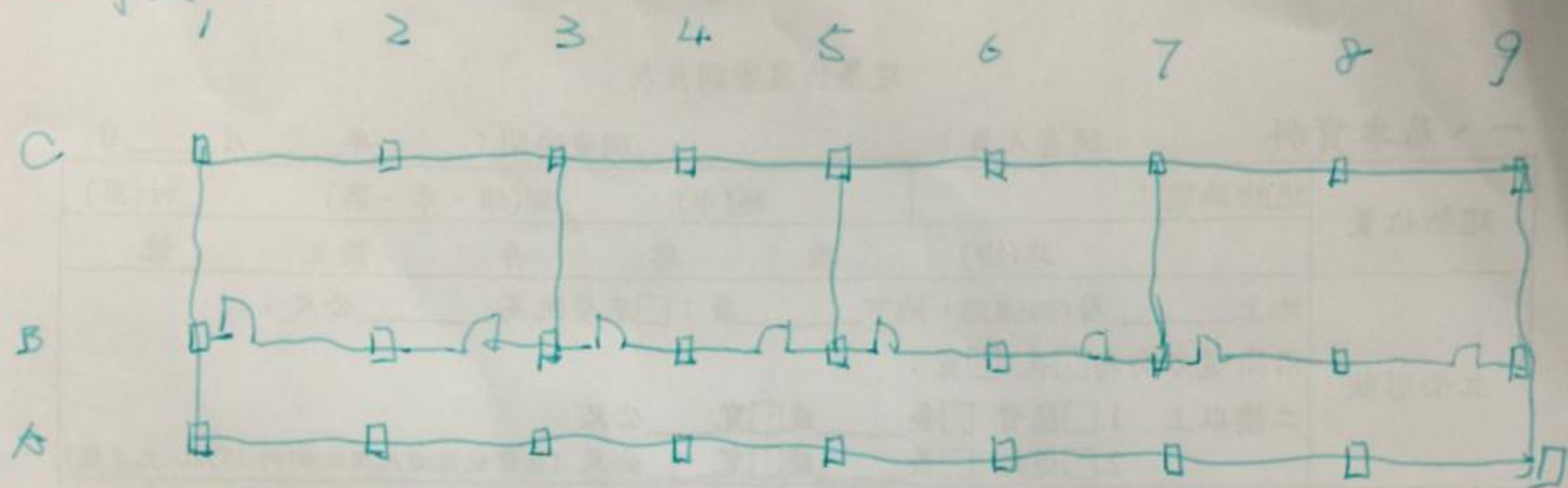
Plan of Beimen Elementary School (北門國小)

臺南縣北門鄉北門國民小學平面配置圖



震損校舍

北門國小



◎ 67年 1F

B4

◎ B2、B6 垂直向裂縫

◎ A23梁有見主筋 (推測非此起震造成)

West Building, Beimen Elementary School (北門國小) before Earthquake



Damage of West Building, Beimen Elementary School (北門國小)



West Building, Beimen Elementary School (北門國小) after Earthquake



Highway Bridges

- 10 cm settlement and ruptures on pavement surface were observed of the Tungshipu Bridge deck (東勢埔橋) on Provincial Highway #3, Neimen District, Kaohsiung, and was emergency closed
- Water pipeline broke at 12k+150 on Provincial Highway #20 (urban area of Sinhua Dist, Tainan), and 10 m of pavement surface sustained ruptures on the West Bound Fast Lane, road closed for traffic, and water supply was cut off.
- Pavement buckles (20 cm uplift) on Provincial Highway #3 in Cishan District (旗山)

Lifelines

- There were 69 major electric power line outages in Tainan City, affecting 12,1672 households
- Power outage in 467 households, Kaohsiung City
- Shutdown of Unit 2, Hsinta Coal-fired Power Plant (興達發電廠), Cieding District (茄苳區), Kaohsiung City
- Maanshan NPP's two nuclear units remained operational (unaffected)
- Shutdown of one distribution substation (D/S) in mountain area of Tainan, and shutdown of Longtien Secondary Substation (隆田二次變電所, S/S)

Nanpao (南寶) Golf Course

