

Disaster Response and Adaptation -Lessons Learned from Hualien Earthquake

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Background (1/2)

❖ Taiwan is well acquainted with natural disasters.

- ▶ Located in the Northwest Pacific typhoon corridor and on the seismically active Ring of Fire.
- ▶ **Typhoon**, the most frequently occurring natural disaster
 - On average 3-5 typhoons hit Taiwan every year.
 - Typhoon Morakot (2009) caused landslides that buried Kaohsiung's Xiaolin Village, and killed nearly 700 people.
- ▶ **Earthquake**, the most devastating natural disaster
 - Roughly 100 earthquakes per day.
 - Chi-Chi Earthquake (1999) destroyed more than 100 thousands of buildings and killed more than 2,400 people.

❖ Long illness makes the patient a good doctor!

Background (2/2)

	921 Chi-Chi Earthquake	403 Hualien Earthquake
Time	1999/09/21 1:47 am	2024/04/03 7:58 am
Location	Nantou	Offshore of Hualien
Depth	8.0 km	15.5 km
Richter Scale	7.3	7.2
Duration	102 seconds	60 seconds
Energy	46 atomic bomb	32 atomic bomb
Fatality	2,496	18

Lessons learned from 921 Earthquake (1/4)

❖ Reform building and bridges codes

▶ Buildings

- Design Specifications for Concrete Structures
- Seismic Design Specifications and Commentary of Buildings

▶ Highway & Railway Bridges

- Seismic Design Provisions and Commentary for Highway Bridges
- Seismic Design Provisions and Commentary for Railway Bridges



❖ Institutionalize search and rescue capacity

- ### ▶ Inter-organizational cooperation

❖ Improve warning and management systems

- ### ▶ Earthquake early warning systems (SMS)
- ### ▶ Landslide risk classification management system

Lessons learned from 921 Earthquake (2/4)

❖ Landslide risk classification management system

- ▶ For highway and railway side slopes.
- ▶ Classify segments into four levels: A, B, C, D.
- ▶ Evaluate A and B levels segments by **Rock-fall Hazard Rating System (RHRS)** ranging from 1 to 5 degrees.

UAV, LiDAR, 3D Point Cloud

Level	Stability	Inspection	Monitoring	Ground anchor inspection
A	Unstable	Every month	Every week	Every half year
B	Partially unstable	Every season	Every month	Every 2 years
C	Stable	Every year	Every season	Every 4 years
D	Completely stable	Every 3 years	None	Every 4 years

Degree	1	2	3	4	5
Inspection method					
Inspection frequency					
...					

Lessons learned from 921 Earthquake (3/4)

❖ Landslide risk classification management system

► Different disaster responses for four levels:

Level	A	B	C	D
3 hour rainfall > 120mm	1	1	1	1
48 hour rainfall > 350mm	2	1	-	-
Typhoon warning lifted	1	1	1	1
Earthquake > M6.0	3	3	3	1
Large-scale landslide	4	4	4	4
Red alert of river mudslide	1	1	1	1

Response	Actions
1	Special inspection in two days
2	Special inspection in 14 days
3	Special inspection in 7 days, Morning inspection last 1 week, Aerial/satellite photograph
4	Morning and evening inspection last 1 week, Aerial/satellite photograph

Lessons learned from 921 Earthquake (4/4)

❖ Landslide risk classification management system

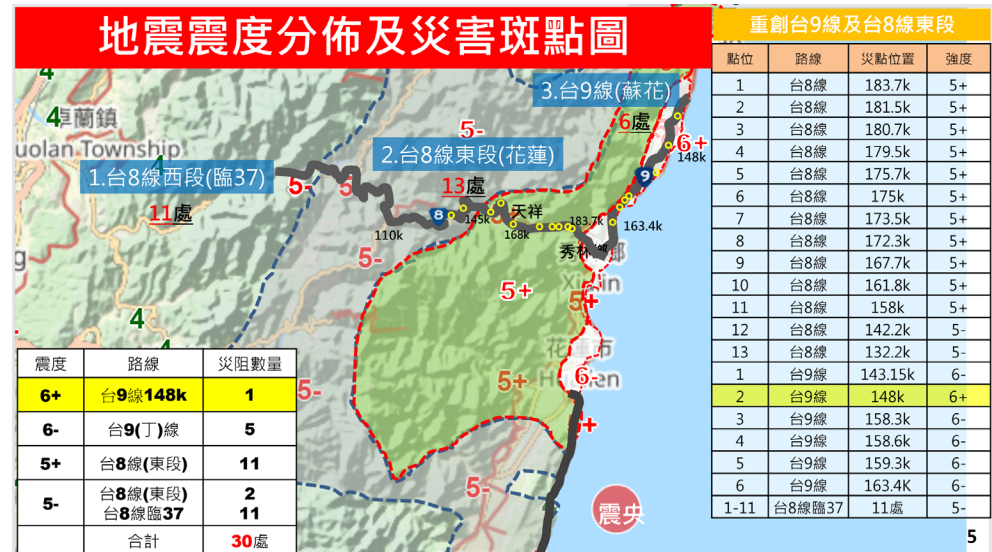
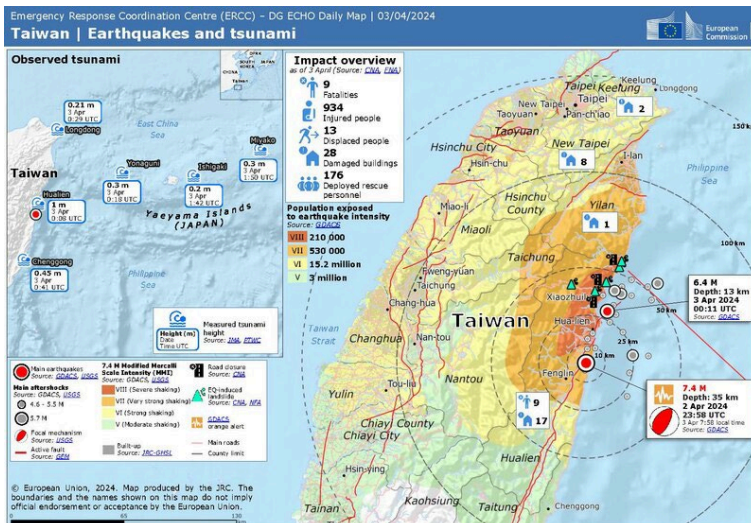
► Different disaster responses for four levels:

Level	A	B	C	D
3 hour rainfall > 120mm	3	3	4	4
48 hour rainfall > 350mm	1	1	2	2
Typhoon warning lifted	5	5	5	5
Earthquake > M6.0	6	6	6	6
Large-scale landslide	7	7	7	7
Red alert of river mudslide	8	8	-	-

Response	Actions
1	Low down the rainfall threshold
2	Strengthen waster level monitoring
3	Implement inspection operations
4	Disseminate heavy rainfall Information
5	Follow disaster prevention warning SOP
6	Follow disaster response SOP
7	Security and traffic control (if necessary)
8	Strengthen rescue deployment

Disaster Response for 403 Earthquake (1/5)

- ❖ **No. 8 & No. 9 Highways and Eastern Railway were seriously affected.**
- ❖ **Many road blocks for highways and railways.**

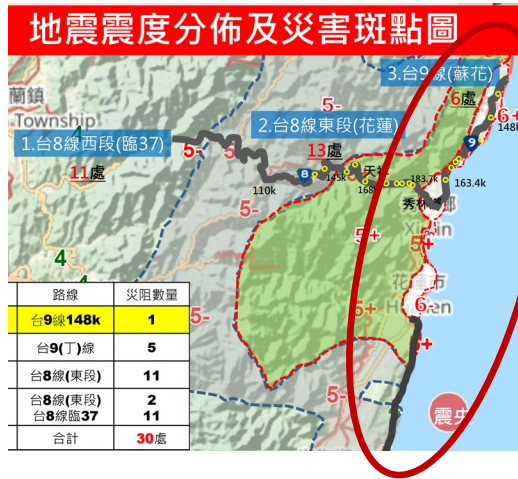


Source: Emergency Response Coordination Centre

Disaster Response for 403 Earthquake (2/5)

❖ No. 9 Highway

► Most of road blocks were recovered on 0403.



No.9 Highway



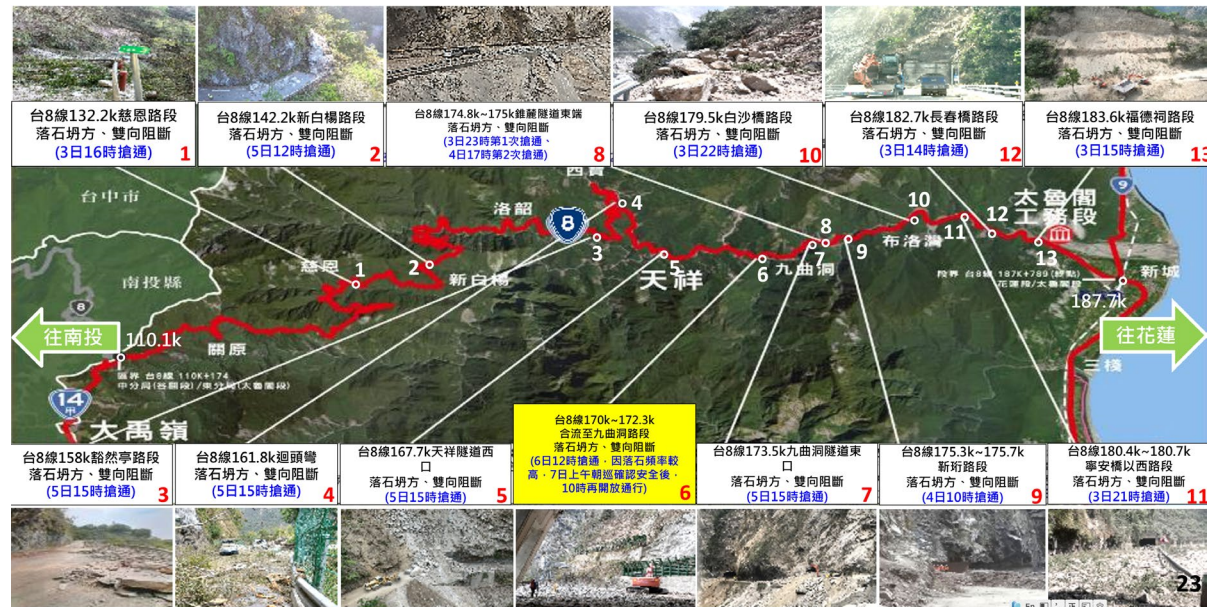
Rail



Disaster Response for 403 Earthquake (3/5)

❖ No. 8 Highway

► Most of road blocks were recovered in three days.



Disaster Response for 403 Earthquake (4/5)

❖ Disaster Response for Highways

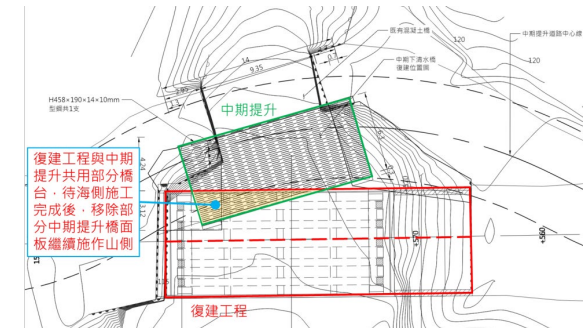
- ▶ Emergency rehabilitation:
 - 下清水 bridge open to cars on 0406
- ▶ Short term: 0403 ~ end of December
 - 下清水 bridge
 - End of May: Open to trucks and buses
 - Rebuild the bridge
 - Recover from 6 road blocks
- ▶ Medium term: two years
 - Open-cut tunnel for highway and railway.
- ▶ Long term:
 - Suhua Safety Project



0403



0406



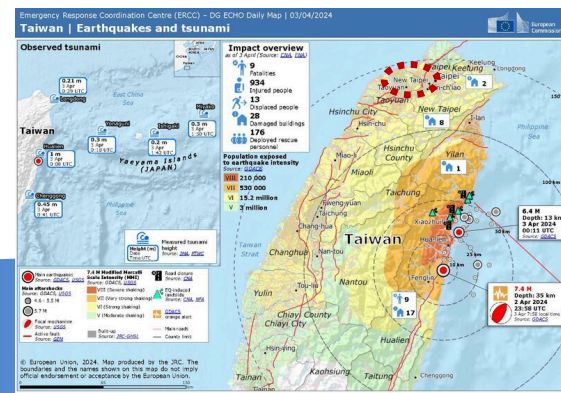
Disaster Response for 403 Earthquake (5/5)

❖ Displacements in Circular Line (New Taipei Metro)

- ▶ Rails had shifted 20 to 92 centimeters.
- ▶ Train service between Banqiao and Zhonghe are suspended and replaced by shuttle bus service.
- ▶ Three-stage restoring plan:
 - Stage 1: Industrial Park and Banqiao stations
 - Stage 2: Zhonghe and Dapinglin stations
 - Stage 3: Banqiao and Zhonghe stations
- ▶ The restoring is shortened from 14 to 8 months.



環狀線營運路線
Circular Line Route MAP



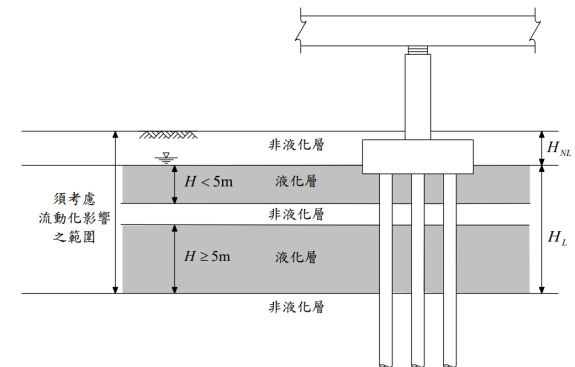
Adaptation to Disasters (1/4)

❖ Strategy 1: Strengthen disaster resistance

S1-1: Develop disaster risk evaluation method



S1-2: Revise design codes



S1-3: Avoid high disaster potential areas



S1-4: Introduce novel technology, method and materials



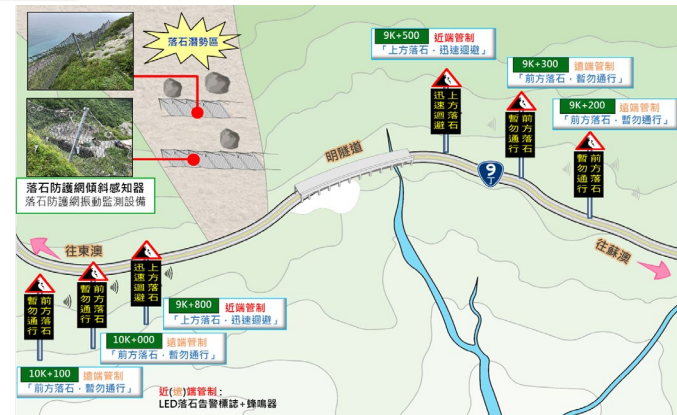
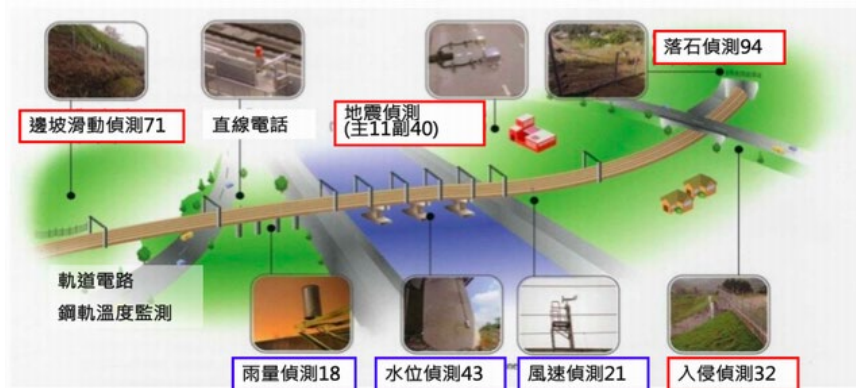
Adaptation to Disasters (2/4)

❖ Strategy 2: Develop disaster response capability

S2-1: Integrate inter-transportation responses and supports

- Railway being blocked ≥ 3 hours \rightarrow Bus feeder service
- Both railway and highways being blocked ≥ 2 days \rightarrow Air and sea transportation

S2-2: Introduce disaster risk monitoring mechanism



S2-3: Invest early warning system



Adaptation to Disasters (3/4)

❖ Strategy 3: Enhance disaster resilience

S3-1: Ensure disaster response routes accessible

S3-2: Pre-position emergency equipment

S3-3: Place backup systems

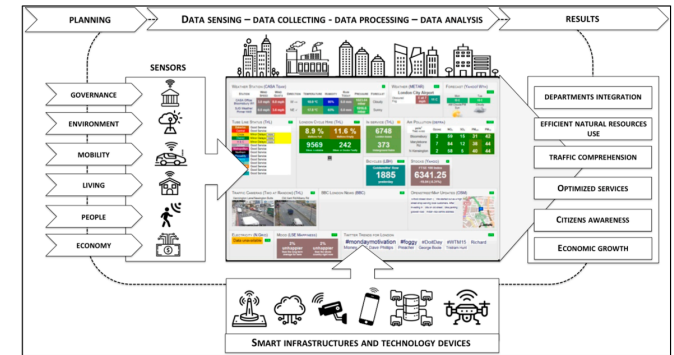
地震模擬時間：白天上班時段



- 建物嚴重損毀逾 5 仟棟
- 重傷及死亡人數近 6 仟人 (白天上班時段)
- 人員受傷就醫量大，醫療資源嚴重缺乏
- 需要住院最多逾 4 仟人，尚缺逾 2 仟病床
- 收容需求超過負荷，需跨縣市收容
- 需要收容人數逾 19 萬人，北市目前能量仍缺逾 3 萬人的收容能量
- 道路橋梁嚴重阻斷，影響人命救援、就醫、避難、救災資源調度
- 北市目前規劃之救援道路，均嚴重受損
- ★全區電力設施受損，影響通訊、交通、醫療院所、收容場所、應變作業

S3-4: Raise public awareness and education

S3-5: AI enabled sensor city



Source: D'Amico et al. (2020)



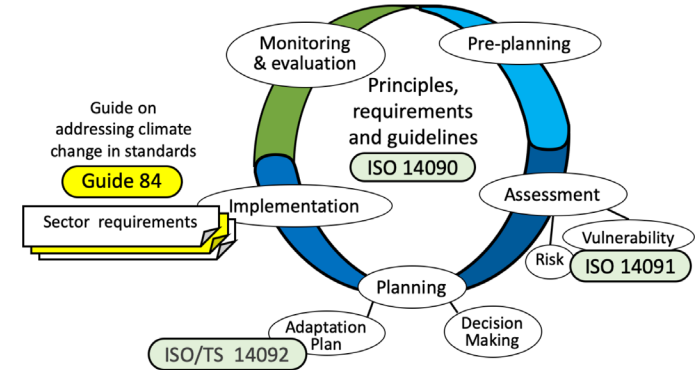
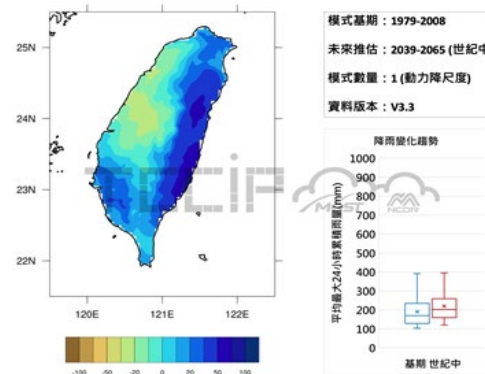
Source: Red Cross (2013)

Adaptation to Disasters (4/4)

❖ Strategy 4: Improve disaster response decision-making

S4-1: Develop risk management database and decision support system

S4-2: Build adaptive capability



Conclusions (1/1)

- ❖ **Earthquake is the most devastating natural disaster:**
 - ▶ Unpredictable
 - ▶ Devastating damage, followed by tsunami, landslide, ...
- ❖ **Every earthquake is a lesson to learn how we can prepare ourselves, although it is a hard lesson...**
- ❖ **Adaptations to disasters**
 - ▶ Strengthen disaster resistance
 - ▶ Develop disaster response capability
 - ▶ Enhance disaster resilience
 - ▶ Improve disaster response decision-making

THANKS
Q & A

