https://doi.org/10.20965/jdr.2021.p0201



**Survey Report:**

# Challenges in the Preservation of Disaster Remains – Example of the Chelungpu Fault Preservation Park

**Cheng-Shing Chiang**[*1,†], **Tyan-Ming Chu**[*2], **Wen-Hao Chou**[*3], **Shin-Ho Lee**[*4], **and Jer-Fu Wang**[*5]

[*1]921 Earthquake Museum of Taiwan, National Museum of Natural Science
No.192 Xinsheng Road, Kengkou Village, Wufeng District, Taichung 41364, Taiwan
[†]Corresponding author, E-mail: wind@mail.nmns.edu.tw
[*2]Pro. Vision Environmental Engineering Corporation, Taipei, Taiwan
[*3]Center for Ecology and Environment, Tunghai University, Taichung, Taiwan
[*4]Chelungpu Fault Preservation Park, National Museum of Natural Science, Nantou, Taiwan
[*5]Department of Civil and Disaster Prevention Engineering, National United University, Miaoli, Taiwan

[Received July 30, 2020; accepted September 10, 2020]

**Taiwan is located along the boundary of the Eurasian and the Philippine Sea plates and experiences tens of thousands of earthquakes each year. Based on historical records, Taiwan has had several earthquakes of magnitude greater than 7.0. Notable and deadly quakes occurred in 1906 (Meishan Earthquake), 1935 (Hsinchu-Taichung Earthquake), and 1999 (Chi-Chi Earthquake). Statistically, Taiwan has had a major earthquake every 30–60 years. Therefore, earthquake museums are needed for long-term earthquake education and geoheritage exhibitions. Earthquake museums highlight disaster risks and preparedness information. The purpose of preserving earthquake remains is to educate visitors about Taiwan's natural disasters and provide a memorable experience that inspires earthquake preparedness. The Chushan trench across the Chelungpu fault is a good example of Chi-Chi Earthquake rupture. This trench has recorded the five most important earthquake events on the Chelungpu fault. Although the Chelungpu Fault Preservation Park (CFPP) has worked to preserve these earthquake remains, they have been threatened due to seepage over the years. The aim of this paper is to analyze trench seepage and explore the development of an anti-seepage model, to provide a reference for the preservation of earthquake remains and museum development worldwide.**

**Keywords:** earthquake museum, inheritance protection, earthquake remains

## 1. Introduction

Remembering natural disasters is of value to society, informing people of the dangers in their environment and encouraging preparedness for future disasters. Such memories may be expressed in different forms, such as memorial plaques and museums. In many Asian countries, the most common types of memorials related to natural disasters are those of earthquakes and tsunamis. Examples include memorials for the Hanshin-Awaji Earthquake in Japan (1995), the Sumatra Indian Tsunami in Indonesia (2004), the Sichuan Earthquake in China (2008), and the Tohoku Earthquake in Japan (2011). Each of these symbolizes collective memory. The main function of these museums and memorials is to pass on tsunami and earthquake experience. In Indonesia, China, and Japan, where natural disasters are common, museums and memorial halls are important places of social memory. Recently, studies have shown that they improve the social resilience of disaster-affected communities [1, 2].

Earthquake museums serve as a source of public information on the social impacts of natural disaster mitigation [3]. Earthquake remains are among the most important subjects in museums. Their educational meaning and psychological impact are significant. Earthquake remains and displays provide learning experiences and stimulate children's disaster preparedness at home and at school. However, earthquake remains are not easy to preserve, in comparison to museum collections, as they are often exposed to the atmosphere and can suffer damage due to weathering and erosion. Being able to preserve earthquake remains for a long time is important in passing on disaster prevention lessons.

Protection of earthquake remains is a challenge faced everywhere [4]. We present measures for protecting the earthquake remains at the Chelungpu Fault Preservation Park (CFPP). This paper includes a history of challenges in and a series of strategies for protecting the exhibition trench of the CFPP.

## 2. Earthquake Museums in Taiwan

At 1:47 am on September 21, 1999, central Taiwan experienced an intense earthquake of 7.3 on the Richter

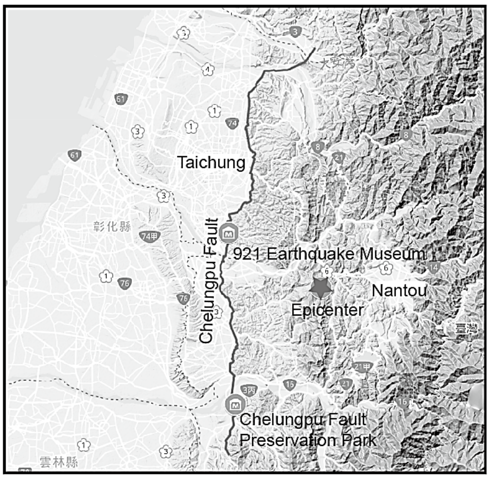



**Fig. 1.** Two earthquake-related museums in Taiwan.

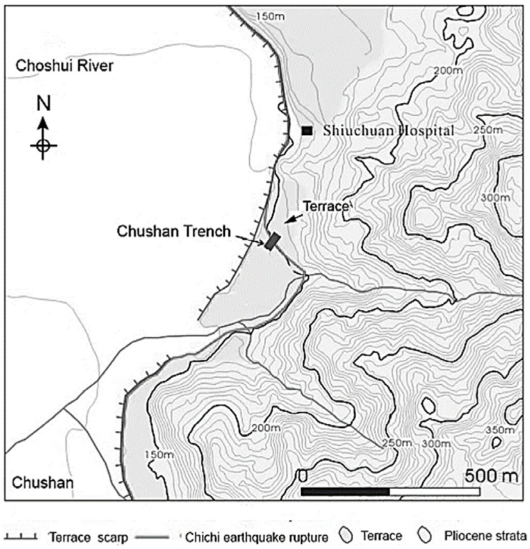



**Fig. 2.** Geological map of the CFPP and surroundings (modified from Chen et al. [8]).

scale [5]. It was the strongest earthquake to strike Taiwan in a century. As the epicenter was close to Chi-Chi Town in Nantou County, it was named the Chi-Chi Earthquake. It resulted in 2,415 deaths and more than 11,000 injured, as well as financial losses of approximately NT$300 billion. Following this, the National Museum of Natural Science (NMNS) established two earthquake-related museums: the 921 Earthquake Museum in Wufeng District of Taichung City and the CFPP in Chushan Township of Nantou County (**Fig. 1**).

The 921 Earthquake Post-Disaster Recovery Commission of the Executive Yuan of Taiwan and local governments invited relevant scholars and experts to survey the disaster areas. From their findings, the damaged campus of Guangfu Junior High School in Wufeng District of Taichung City possessed the conditions for developing an international-class museum including fault displacement, collapsed buildings, and uplifted riverbed. Thus, this campus was chosen to create the 921 Earthquake Museum with the purposes of preserving this site and remembering this disaster. It not only records the history of the Chi-Chi Earthquake, but also provides earthquake-related education. On September 21, 2004, this museum officially opened. Since then, it has carried out science education activities, such as development of lesson plans and teaching aids, and organized events to disseminate information about hazard mitigation. In 2017, the National Fire Agency of Taiwan reported that this venue has been certified as a Mission Readiness Test (MRT) site by the International Search and Rescue Advisory Group (INSARAG). In early 2018, this museum began working with the Fire Bureau of Taichung City Government to carry out rescue dog training in the collapsed buildings in the northern section of the campus to simulate real conditions following an earthquake. NMNS will continue to collaborate with fire and rescue units to enable visitors to gain a better understanding of the importance of disaster preparedness. NMNS also established the CFPP, which preserves a precious cross-section of fault rupture discovered by scientists during their research on recent earthquakes. From 2002, more than 10 years were required to excavate, backfill, and re-excavate this section of fault, as well as to shore up collapsed areas. Finally, this park started official operations on May 1, 2013, incorporating the latest projection mapping technology into exhibitions to provide the public with an understanding of faults and earthquakes. The trench, which is the highlight of the CFPP, is located on an unconsolidated area of recent alluvial deposits. The walls around the trench are comprised of soft soil and sedimentary strata, which can easily collapse, especially during typhoons and heavy rain. Therefore, anti-seepage structures and long-term monitoring is required [6, 7].

### 2.1. Local Geology of the CFPP

The CFPP is located on an alluvial terrace near the southern boundary of the Zhuoshui River Valley. This park is situated on a mini alluvial fan formed from a gully to the southeast (**Fig. 2**). Geological studies have indicated that the shallow geology of the site consists of a series of unconsolidated strata of mud and fine sand. There is a thick gravel layer at a depth of 7.5 to 8.5 m to the west (footwall) of the fault zone. The gravel layer on the east side of the thrust fault was uplifted about 7 m, to about 2 to 3 m below the surface (**Fig. 3**). To the east of the CFPP is the Pleistocene Western Foothill Zone, which consists mainly of interlayers of sandstone and shale [8, 9].

### 2.2. Collapse History of the Trench at the CFPP and Preservation Measures

In November 2002, the Chushan trench was excavated in the Chushan area, in the southern portion of the ground rupture of the Chelungpu fault. The location was approximately 5 km south of the Zhuoshui River and approximately 5 km north of Chushan Township (**Fig. 2**). The

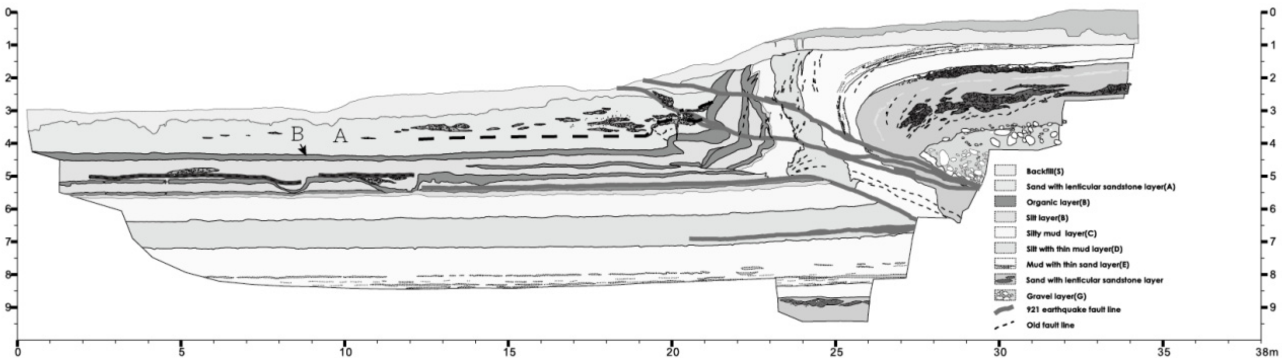



**Fig. 3.** Geological profile along the north wall of the CFPP (modified from Chen et al. [9]).

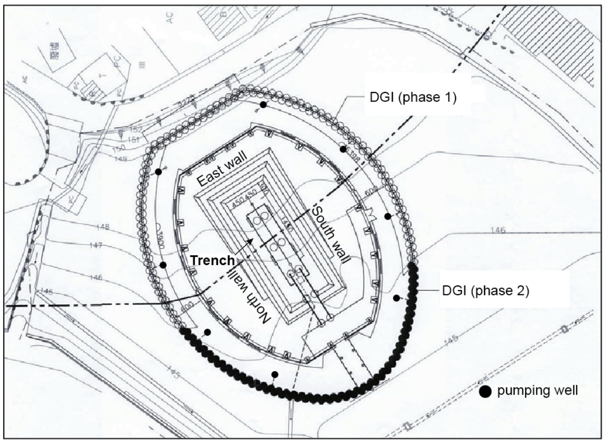



**Fig. 4.** DGI curtain and eight pumping wells outside the preservation dome.

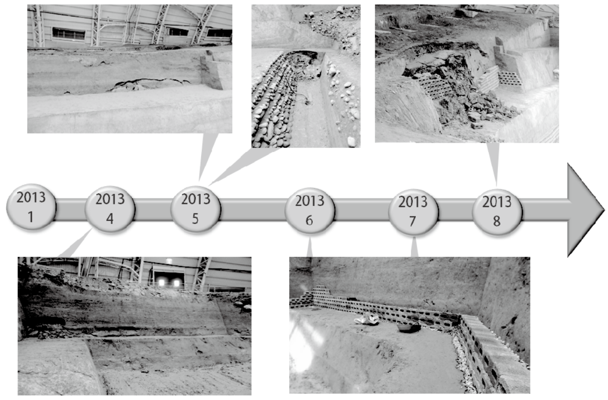



**Fig. 5.** The collapse history of the CFPP trench.

original plan was to backfill the trench after a geological survey. Later, the government decided to preserve this trench for exhibition and educational purposes. However, the trench had been exposed to an uncontrolled environment for 3 years. During that period, it eroded and collapsed due to heavy rain, surface runoff, and seepage. To preserve the stratification, the trench was re-excavated and exfoliated sheets with a thin layer of the trench surface (later displayed in the exhibition hall of the CFPP) were produced. After that, in 2005, the trench was backfilled with sand bags to prevent further destruction.

The original Chushan trench was excavated in the SE-NW direction, 35-m in length, 14-m in width, and 8-m in depth [8]. After two re-excavations, the width of the trench increased to 17.5 m [10]. When the site was selected for an earthquake fault museum, protection of the trench was the main concern. A protective dome, an enclosed underground curtain produced via double grid injection (DGI) method at a depth of 11–14 m, and a 6 m wide concrete pavement covering of the space between the dome and the DGI curtain were designed and constructed. In addition, eight pumping wells were drilled 18 m deep to the underlying gravel aquifer outside the dome to lower the groundwater table (**Fig. 4**).

According to the construction report, the DGI curtain was produced by injecting cement grout (including bentonite and clay) and water glass ($(Na, K)_2SiO_3$). The pH of the water glass was about 11.5. Before injection, sulfate acid was mixed with the water glass to neutralize the pH and minimize the impact on the environment. Due to engineering constraints, the top of the DGI curtain is at a depth of 1 m below the surface. Since grouting is not suited to gravel, only limited or no DGI curtain was constructed on the eastern part of the dome, where the gravel layer in the hanging wall is only 1 to 3 m below the surface.

Following the construction of the dome and "waterproof" facilities, re-excavation work began in October 2012. It was divided into two stages. In the first stage, most of the sand bags used to backfill the trench were removed with a mini excavator. In the second stage, the surface of the trench was repaired and trimmed by an archeology team from NMNS. The excavation was conducted during the dry season. There were no significant issues with water and the work was finished successfully. The CFPP started its trial operation in early 2013, but the rainy season began in early April that year resulting in continuous seepage at the second-level in both the south and north profiles of the exhibition trench. At the end of August, the north profile collapsed. The collapse history of this trench is shown in **Fig. 5**.

**Table 1.** Water quality sample analyzed items.

| Sampling date | Sampling location | Quantity | Analyzed items |
|---|---|---|---|
| 2013/8/9 | Rainwater | 1 | On-site measurement: temperature, pH, and conductivity |
| | Fourth level trench seepage | 1 | |
| | Groundwater pumping well | 2 | Laboratory analyses: pH, conductivity, main anions and cations including calcium, magnesium, sodium, potassium, total alkalinity (bicarbonate), chloride, sulfate, nitrate, iron, and manganese. Silica was analyzed in selected water samples from the south and north walls and well water. |
| | South and north walls | 2 | |
| 2013/8/10 | South and north walls | 2 | |
| 2013/8/11 | South and north walls | 2 | |
| 2013/8/16 | South and north walls | 2 | |
| 2013/8/23 | South and north walls | 2 | |
| 2013/9/2 | Surface water on the north wall | 1 | |

To save the museum, it was necessary to prevent further collapse of the trench, which meant finding the seepage source and pathway, and taking appropriate action as soon as possible. A hydrogeological study was proposed. The main study methods included site hydrogeological survey and water geochemistry investigation.

## 2.3. Hydrogeological and Geochemical Surveys

At the CFPP site, the average annual precipitation can reach 2,834 mm and the saturated groundwater table is about 10 m under the surface. Rainfall and subsurface water are the main possible sources of seepage. Since the park is on a mini alluvial fan, the land surface of the site inclines with the fan slope from east and northeast to west and southwest. Surface runoff from the hill slope runs west and southwest to the park. Therefore, most of the infiltration into the dome should come from the east and northeast. Theoretically, the east and south walls of the trench should have the most seepage. However, monitoring results showed that there is more seepage from the north wall than from the south wall. Moreover, there is no seepage from the east wall.

The local ambient aquifer is in the gravel layer and the groundwater level is about 11 to 14 m below the surface at the footwall, which is about 4 to 5 m lower than the bottom of the trench. Therefore, seepage must be from surface infiltration not groundwater. Since the groundwater in the aquifer is not a factor, operation of the pumping well system was called off.

A geochemistry study was proposed to trace the seepage source and path using major dissolved constituents. Fifteen water samples were collected (**Table 1**). Analyzed items are listed in **Table 1**. The data quality of the water samples was checked by charge balance calculation.

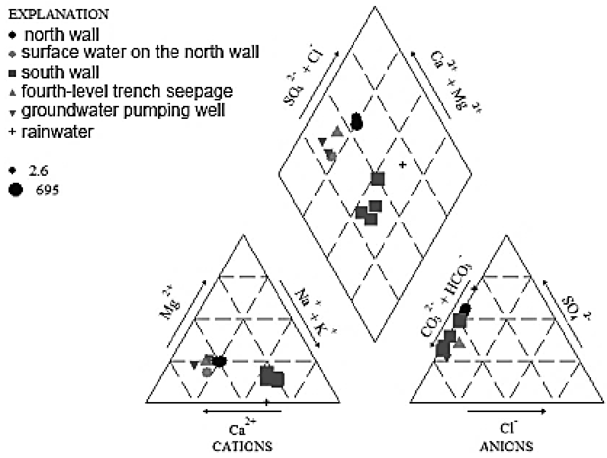



**Fig. 6.** Piper-Hill diagram of the water samples collected for seepage investigation.

In addition to the chemical analyses of the water samples from the fourth level of the trench, the charge balances of the remaining samples were within $\pm 10\%$ and data quality was acceptable. Water chemistry samples were simulated using the equilibrium-solubility module of PHREEQC [11].

Piper-Hill diagram was used to identify water sample chemical characteristics (**Fig. 6**). Fresh natural water was of Ca-$HCO_3$ type in the zone left to middle of the rhombus. The water type of south-wall seepage was (Na, K)-($HCO_3$, $SO_4$), which was fairly different from that of other water samples. The water type of the north-wall seepage was Ca-($SO_4$, $HCO_3$). Although this was similar to the surrounding natural water, its sulfate concentration was significantly higher. Concentrations of Na and K were also slightly higher than in the ambient water samples. By reviewing the site conditions, the differences in water chemistry of the south-wall and north-wall seepages were due to chemical reactions with the underground DGI curtain. The degree of impact of DGI on water chemistry was more significant for south-wall seepage than for north-wall seepage.

Total dissolved solids (TDS) were around 500–600 mg/L for the south-wall seepage and about 350 mg/L for the north-wall seepage. For comparison, the TDS of the natural groundwater were around 270 mg/L. The pH of the north-wall seepage ranged from 7.2 to 7.5, The pH of the south-wall seepage was about 8 and the pH of the natural groundwater was about 6.5. The $SiO_2$ content of the north-wall seepage was about the same as that of the natural groundwater. There was about twice as much $SiO_2$ in the south-wall seepage than in the north-wall seepage.

The chemical reactions that occurred in the DGI during the construction stage were as follows:

$$\begin{aligned} & H_2SO_4 + nNa_2O \cdot SiO_2 + 2nH_2O \\ & \qquad \rightarrow Na_2SO_4 + nSi(OH)_4 + H_2O \\ & Si(OH)_4 \rightarrow SiO_2(\mathrm{gel}) + 2H_2O \end{aligned}$$

DGI contents included several soluble compounds,

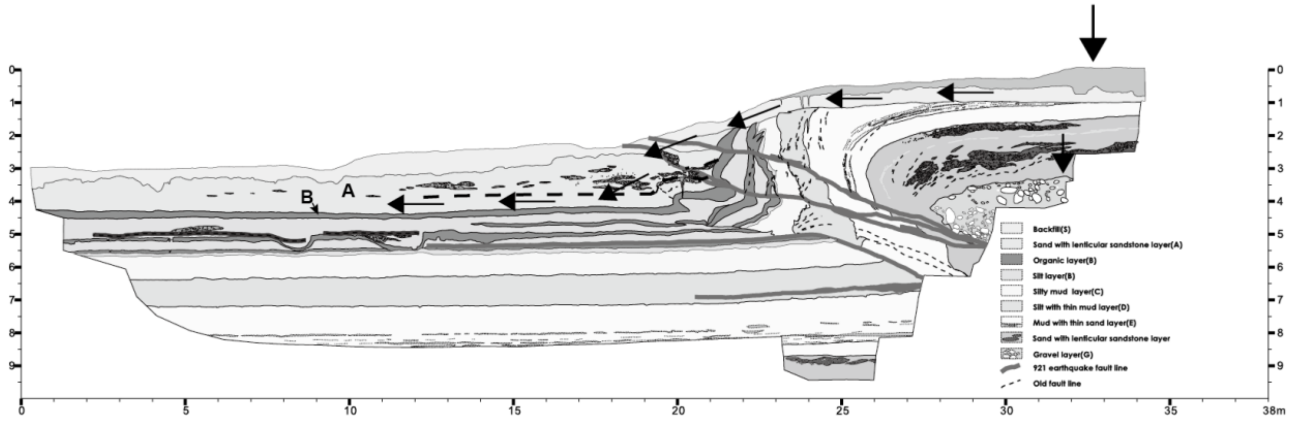



**Fig. 7.** Schematic diagram of the seepage path along the north wall of the trench.

such as $Na_2SO_4$, silica gel, and chemical compounds associated with cement and bentonite. When the infiltration reached the DGI, geochemical reactions increased the sulfate, sodium, potassium, calcium, and silica concentrations, as well as the pH, in the solution. There were similar trends for both the north-wall and south-wall seepages.

Based on site investigations, the possible sources of infiltrated water inside the dome were:

1. Rainfall leakage from the dome.
2. Infiltration of the surface runoff from the cracks in the pavement outside the dome.
3. Infiltration penetrating the DGI curtain on the south (upstream) side.
4. Shallow infiltration into the dome from the east where there was limited or no DGI curtain.
5. Vertical infiltration of rainwater into subsurface.

When the infiltration encountered a less-permeable layer and accumulated on top, it formed a temporary perched saturated layer at shallow depth. The saturated water layer then flowed laterally down-gradient. When the lateral flow encountered the DGI curtain, the hydraulic gradient difference across the curtain drove infiltration and diffusion toward the downstream side of the curtain, finally penetrating the DGI. Based on water chemistry, part of the south-wall seepage was from this flow path.

A large amount of water flowed into the dome area from the east where there was lack of DGI curtain. However, most of the infiltration ran down into the gravel layer, then vertically into the aquifer below. A small portion was able to pass the fault zone and reach the footwall north of the trench. The saturated infiltration then flowed laterally along the bottom of layer A, which lies on top of the footwall with a higher permeability than the underlying layer B. Finally, the water seeped out at the boundary of A and B layers along the western part of the north wall (**Fig. 7**).

The results of this study explain why there was more seepage from the north wall than from the south wall. Combining the local hydrogeology and water chemistry data, it can be concluded that most of the south-wall seepage runs through the DGI curtain and most of the north-wall seepage is from infiltration passing through the section with limited DGI curtain on the east side of the dome (**Fig. 8**).

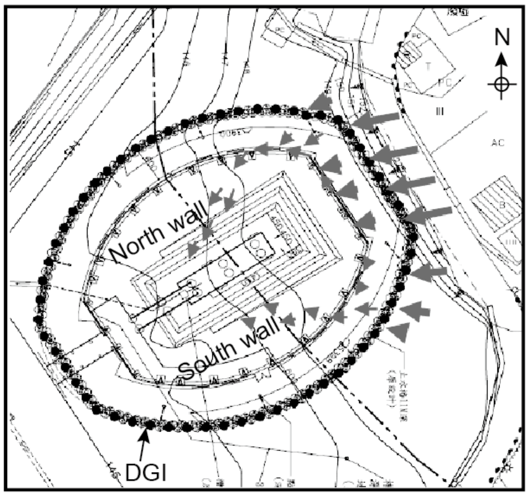



**Fig. 8.** Schematic diagram of the seepage path in the CFPP.

## 3. Reinforcement of Waterproof Measures and Long-Term Monitoring

Based on the results of the hydrogeological survey, a shallow steel sheet pile curtain outside the DGI was proposed for the eastern portion of the dome to stop shallow infiltration. A long-term monitoring network was also created. Monitored items include precipitation, soil moisture content, amount of seepage, and groundwater table.

### 3.1. Automatic Monitoring System

The aims of monitoring activities are: 1) evaluating the conditions related to changes in the trench to produce a database; 2) understanding the controlling factors of collapse of the trench; 3) assessing the risk of natural hazard, and 4) providing a base for designing and implementing

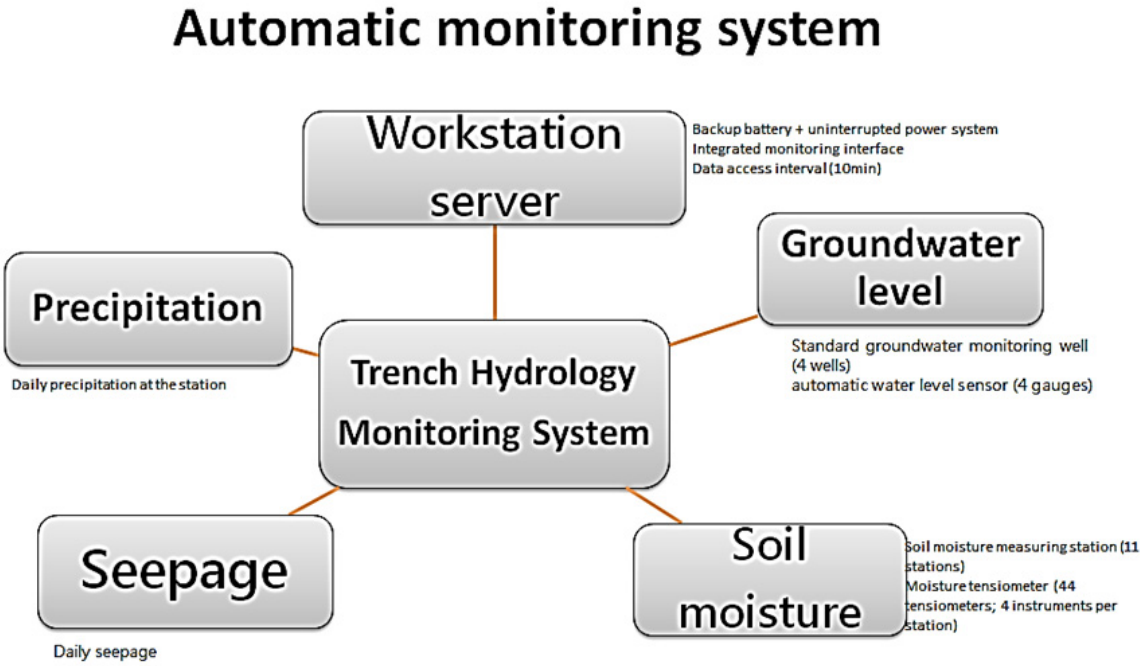



**Fig. 9.** Automatic monitoring system.

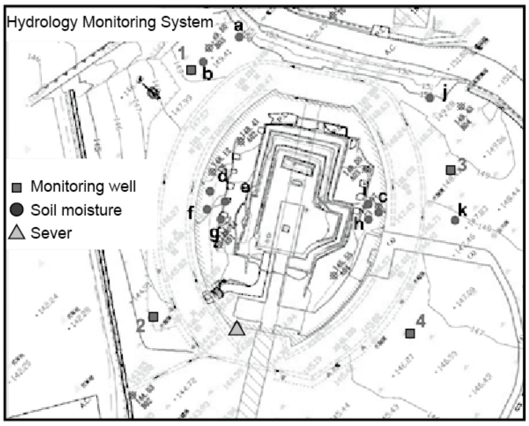



**Fig. 10.** Distribution map of hydrology monitoring instruments.

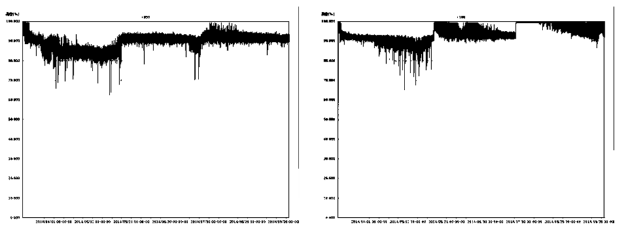


**Fig. 11.** Daily soil moisture records from automated observation stations in the automatic monitoring system database. Two examples of soil moisture records at depths of 0.5 m (left) and 1 m (right).

proper protection measures. The automatic monitoring system is an online, automated, and real-time information/data integration system. It collects hydrological data from instruments in the area around the trench, including groundwater level, soil moisture at different depths, amount of seepage, and precipitation (**Fig. 9**). The distribution of the monitoring devices is shown in **Fig. 10**.

Four monitoring wells have been placed around the dome to monitor the groundwater table. There is also a precipitation recording station. Two seepage-volume recording stations monitor the amount of seepage from the north wall and the south wall of the trench, respectively. Eleven soil moisture monitoring stations have been installed inside and outside the dome. At each station, devices have been set up at four different depths: 0.5 m, 1 m, 1.5 m, and 2 m.

The dataset contains raw data and processed data collected from the automatic monitoring system and stored in a workstation server. A numbering system is used to designate each device. The data file of each automatic observation network is named according to the device number. Two examples of the observed soil moisture data profiles are shown in **Fig. 11**. They include variation in the moisture content at different depths. Measurements of the amount of seepage from the north wall and south wall are recorded separately to understand the risk of collapse along each wall. Daily precipitation is also integrated to explore the relationship between precipitation and seepage (**Fig. 12**). Comparing daily precipitation with seepage, seepage velocity of rainwater infiltration can be estimated. With the above information, it is possible to evaluate the flow path and speed of seepage from infiltration. The result is reliable information for strategic analysis and further preservation measures.

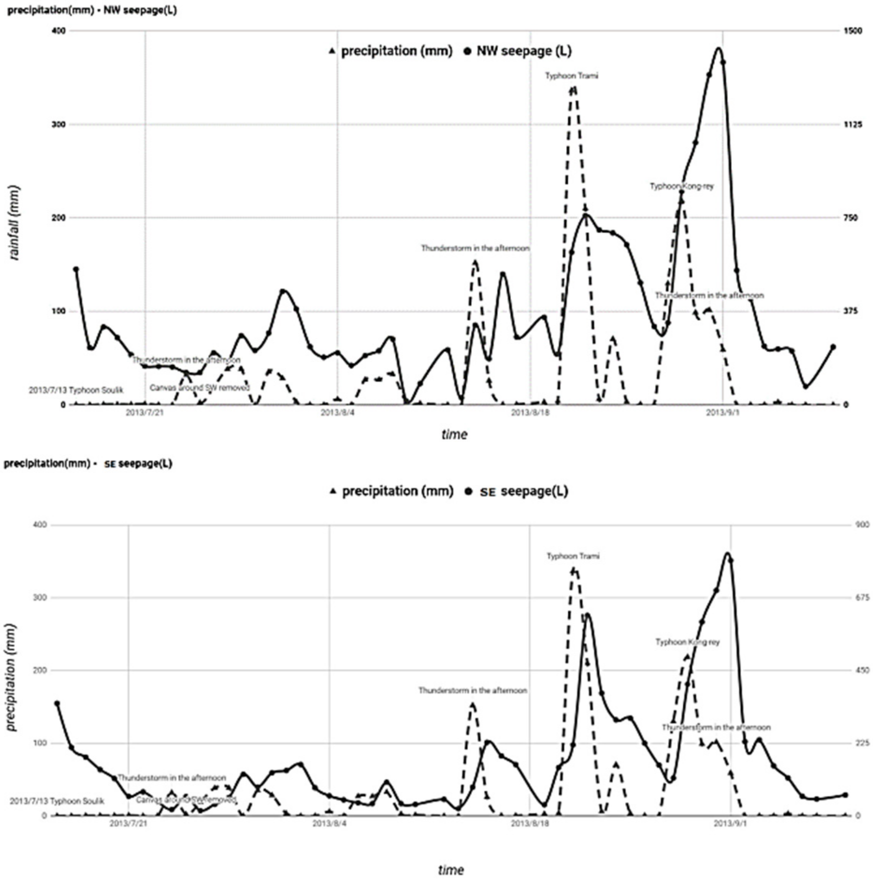



**Fig. 12.** Daily precipitation and seepage records from automated observation stations in the automatic monitoring system database.

### 3.2. Improvement Strategy and Steel Sheet Pile

To stop possible infiltration from surface runoff and lateral flow at shallow depth, two measures were implemented. The cracks along the edge of the concrete surface surrounding the dome were carefully sealed to prevent leakage from runoff. A 3-m long steel sheet pile was driven into the ground outside the DGI to stop lateral infiltration at shallow depth (**Fig. 13**). This steel curtain was not able to be installed along the shallow gravel layer.

After the completion of the steel curtain at the end of 2014, the seepage problem along the south wall of the trench was effectively resolved, but seepage along the north wall was not significantly reduced. The steel sheet pile to the northeast of the fault line was not deep enough, resulting in gaps for water to run through. Most of the seepage was along the bottom of layer A close to the fault zone (**Fig. 7**). A large-diameter well was placed inside the dome on top of the northern footwall near the fault zone to intercept the seepage. Finally, the seepage was controlled and the soil strata became stable.

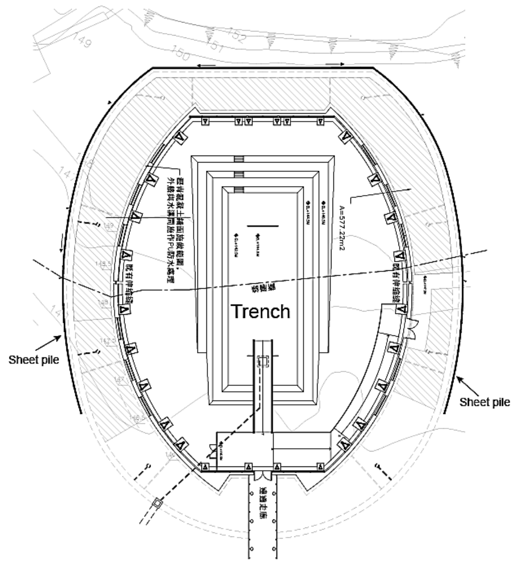



**Fig. 13.** Layout of sheet pile curtain.

## 4. Summary

Earthquake remains are unique geoheritage. So far, little research on earthquake remains has been conducted in Taiwan. In this paper, which takes the CFPP as an example, we analyzed seepage and explored the development of anti-seepage model, to provide references for preservation of earthquake remains and museum development in Taiwan and abroad.

Earthquake remains cannot be restored if significantly damaged. In this case, continuous monitoring has been applied to the conservation of geoheritage. In the future, similar earthquake remains around the world will encounter extreme climate anomalies and even more difficult challenges to their preservation. At the CFPP, monitoring data provides valuable information for continuous improvement of preservation strategies.

**Acknowledgements**

We would like to thank the National Museum of Natural Science of Taiwan for maintaining protective systems and applications under the leadership of Dr. Wei-Hsin Sun. This study was mainly supported by the Ministry of Science and Technology, Taiwan, under grants 109-2116-M-178-003.

**References:**

[1] A. Eyre, "Remembering: community commemoration after disaster," H. Rodríguez, E. L. Quarantelli, and R. R. Dynes (Eds.), "Handbook of Disaster Research," pp. 441-455, Springer, 2005.

[2] S. Nicholls, "Disaster memorials as government communication," Australian J. of Emergency Management, Vol.21, No. 4, pp. 36-43, 2006.

[3] E. MacDonald, V. Johnson, M. Gillies, and D. Johnston, "The impact of a museum-based hazard education program on students, teachers and parents," Int. J. of Disaster Risk Reduction, Vol.21, pp. 360-366, 2017.

[4] L. Wang and M. Tian, "A discussion on the development model of earthquake relic geopark – a case study of the Qingchuan Earthquake Relic Geopark in Sichuan Province, China," J. of Cultural Heritage, Vol.15, Issue 5, pp. 459-469, 2014.

[5] W.-T. Liang, J.-C. Lee, K. H. Chen, and N.-C. Hsiao, "Citizen Earthquake Science in Taiwan: From Science to Hazard Mitigation," J. Disaster Res., Vol.12, No.6, pp. 1174-1181, 2017.

[6] K. Sako, R. Fukagawa, and T. Satomi, "Slope Monitoring System at a Slope Behind an Important Cultural Asset," J. Disaster Res., Vol.6, No.1, pp. 70-79, 2011.

[7] S. S. Putra, B. W. Ridwan, K. Yamanoi, M. Shimomura, Sulistiyani, and D. Hadiyuwono, "Point-Based Rainfall Intensity Information System in Mt. Merapi Area by X-Band Radar," J. Disaster Res., Vol.14, No.1, pp. 80-89, 2019.

[8] W.-S. Chen, C.-C. Yang, I.-C. Yen, L.-S. Lee, K.-J. Lee, H.-C. Yang, H.-C. Chang, Y. Ota, C.-W. Lin, W.-H. Lin, T.-S. Shih, and S.-T. Lu, "Late Holocene Paleoseismicity of the Southern Part of the Chelungpu Fault in Central Taiwan: Evidence from the Chushan Excavation Site," Bulletin of the Seismological Society of America, Vol.97, No.1B, pp. 1-13, 2007.

[9] W.-S. Chen, N. Matsuta, and C.-C. Yang, "6. Characteristics of Coseismic Thrust-Related Folding from Paleoseismic Investigation Responsible for the 1999 Chi-Chi Earthquake of Central Taiwan," S. D'Amico (Ed.), "Earthquake Research and Analysis: Seismology, Seismotectonic and Earthquake Geology," pp. 125-142, InTech, 2012.

[10] W.-J. Huang, W.-S. Chen, Y.-H. Lee, C.-C. Yang, M.-L. Lin, C.-S. Chiang, J.-C. Lee, and S.-T. Lu, "Insights from heterogeneous structures of the 1999 $M_w$ 7.6 Chi-Chi earthquake thrust termination in and near Chushan excavation site, Central Taiwan," J. of Geophysical Research: Solid Earth, Vol.121, Issue 1, pp. 339-364, 2016.

[11] D. L. Parkhurst and C. A. J. Appelo, "User's guide to PHREEQC (version 2) – A computer program for speciation, batch-reaction, one-dimensional transport, and inverse geochemical calculations," Water-Resources Investigations Report 99-4259, U.S. Department of the Interior, U.S. Geological Survey, 1999.

**Name:**
Cheng-Shing Chiang

**Affiliation:**
Associate Research Fellow, 921 Earthquake Museum of Taiwan, National Museum of Natural Science

**Address:**
No.192 Xinsheng Road, Kengkou Village, Wufeng District, Taichung 41364, Taiwan

**Brief Career:**

2000-2008 Assistant Professor, Hsiuping Institute of Technology
2008-2012 Associate Professor, Hsiuping University of Science and Technology
2012-2017 Assistant Research Fellow, Chelungpu Fault Preservation Park, National Museum of Natural Science
2017- Associate Research Fellow, 921 Earthquake Museum of Taiwan, National Museum of Natural Science

**Selected Publications:**

- "Insights from heterogeneous structures of the 1999 $M_w$ 7.6 Chi-Chi earthquake thrust termination in and near Chushan excavation site, Central Taiwan," J. of Geophysical Research: Solid Earth, Vol.121, Issue 1, pp. 339-364, 2016.
- "The modern Kaoping transient fan offshore SW Taiwan: Morphotectonics and development," Geomorphology, Vol.300, pp. 151-163, 2018.
- "Three types of modern submarine canyons on the tectonically active continental margin offshore southwestern Taiwan," Marine Geophysical Research, Vol.41, No.1, Article No.4, 2020.

**Academic Societies & Scientific Organizations:**

- American Geophysical Union (AGU)
- Geological Society Located in Taipei
- Chinese Taipei Geophysical Society (CTGS)

**Name:**
Tyan-Ming Chu

**Affiliation:**
Senior Geologist, Pro. Vision Environmental Engineering Corporation (PVEEC)

**Address:**
No.65 Songde Road, Xinyi District, Taipei 110, Taiwan

**Brief Career:**

1995 MOH and Associates Engineering Consultants
1998 CH2M Hill Engineering Consultants Inc.-Taiwan Branch
2003 Hua-Yi Professional Hydrogeological Consultants Corp.
2011 PVEEC

**Selected Publications:**

- "The Study of Hydrology Geology for Groundwater Recharge Test Well in Pingtung Chunglong Area," Chia-Nan Annual Bulletin: Science & Technology, Vol.37, pp. 188-194, 2011.

**Academic Societies & Scientific Organizations:**

- Taiwan Professional Geologist Association

**Name:**
Wen-Hao Chou

**Affiliation:**
Research Fellow, Center for Ecology and Environment, Tunghai University

**Address:**
21-1, Lane 154, Guochi Street, Longjin, Taichung 404, Taiwan

**Brief Career:**
2003-2019 Deputy Director, National Museum of Natural Science
2005- Adjunct Professor, Taipei National University of the Arts
2019- Research Fellow, Tunghai University

**Selected Publications:**
- "Cognition: from the Views of Biology, Folklore, and Society," 225pp., National Museum of Natural Science, 2018.
- "Evolution in Daily Life," 298pp., National Museum of Natural Science, 2019.
- "Cultural Visions: Let's Go Anthropology," 262pp., National Museum of Natural Science, 2020.

**Academic Societies & Scientific Organizations:**
- Society for the Study of Amphibians and Reptiles (SSAR)
- Herpetologists' League (HL)
- Chinese Association of Museums (CAM)

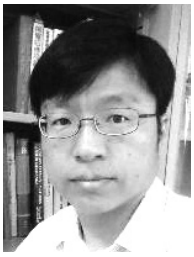
**Name:**
Shin-Ho Lee

**Affiliation:**
Contracted Service Personnel, Chelungpu Fault Preservation Park, National Museum of Natural Science

**Address:**
No.345, Section 2, Jishan Road, Zhushan Township, Nantou 55782, Taiwan

**Brief Career:**
2009- Assistant Researcher, Institute of Nuclear Energy Research
2012- Project Manager, National Yunlin University of Science and Technology
2013- National Museum of Natural Science

**Selected Publications:**
- "Simulation of Decay Nuclide Transport in Fracture Medium Using Time Domain Particle Tracking Method," East Asia Forum on Radwaste Management (EAFORM), 2010.



**Name:**
Jer-Fu Wang

**Affiliation:**
Assistant Professor, Department of Civil and Disaster Prevention Engineering, National United University

**Address:**
2 Lienda, Miaoli 36063, Taiwan

**Brief Career:**
2009- Assistant Research Fellow, 921 Earthquake Museum of Taiwan, National Museum of Natural Science
2015- Associate Research Fellow, 921 Earthquake Museum of Taiwan, National Museum of Natural Science
2016- Assistant Professor, Department of Civil and Disaster Prevention Engineering, National United University

**Selected Publications:**
- "A novel rapid screening method for health monitoring of building structures from earthquake records," Advances in Structural Engineering, Vol 22, Issue 16, pp. 3544-3557, 2019.
- "Vibration control for serviceability enhancement of offshore platforms against natural loadings," Smart Structures and Systems, Vol.24, Issue 3, pp. 403-414, 2019.
- "Development of optimal design theory for series multiple tuned mass dampers considering stroke and multiple structural modes," J. of Physics: Conf. Series, Vol.744, Article No.012231, 2016.

**Academic Societies & Scientific Organizations:**
- Chinese Taiwan Society for Earthquake Engineering (CTSEE)
- Chinese Society of Structural Engineering (CSSE)