

Influence of the 1999 Chi-chi Earthquake on the Cultural Heritage Conservation System in Taiwan

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SUMMARY:

On September 21, 1999, a great earthquake with Richter scale $M=7.3$ struck central Taiwan area. In this earthquake, several thousand buildings were seriously damaged or collapsed, including lots of government listed heritage architectures. It was the most severe disaster since the announcement of Cultural Heritage Preservation Act of Taiwan in 1982. After the earthquake, besides the restoration of the damaged heritage architectures, government also changed some of Cultural Heritage Preservation Act. In general, the change is based upon the lessons obtained from the Chi-chi earthquake damage, which includes following: (1) Besides monument, the listed heritage architecture adding the category of "Historic Building", which is used to avoid the valuable old buildings to be improperly reconstructed or destroyed after earthquake, (2) The emergency response related procedures is provided for the local government and owner of private listed heritage architecture, (3) The modern techniques including materials or structure strengthening methods could be applied in the restoration work for improving the earthquake resistance of heritage architectures. Due to these changes, in the afterward twelve years, when nature disaster such as earthquake or typhoon occurred again, the response and restoration of government or owner of private heritage architecture are more efficient, and lots of old buildings which is valuable in the traditional culture or building craft are protected. Furthermore, in the conservation practice of heritage architecture, the concepts of conservator or an architect is not so constrained as before. Under the principle of authenticity of heritage architecture, properly modern strengthening techniques are adopted in many conservation design cases of monument or historic building, which is also associated with the reuse consideration.

Keywords: Emergency Response, Conservation System, Cultural Heritage, Chi-chi earthquake

1. INTRODUCTION

On September 21, 1999, a Richter scale $M=7.3$ earthquake occurred at central Taiwan area (Figure 1), in which 2,415 people were killed with 29 people missing and 11,305 injured. Totally 51,711 houses were collapsed and 53,768 houses were partially collapsed, resulting 320,000 people were afflicted by the disaster. The earthquake was the largest and the most disastrous in Taiwan for hundreds of years. It brought a serious damage on Taiwan's cultural heritage in addition to its extreme shock to the society. After the earthquake, the government, together with the scholars and experts, devoted into the disaster relief work immediately. However, it could not respond to the major disaster since there was no related disaster recovery system in Cultural Heritage Preservation Act. On February 9, 2000, the governmental organizations concerned made an emergency amendment on Cultural Heritage Preservation Act, which was then revised again in 2005. All these revisions result in significant changes in both the concept and system of Taiwan's cultural heritage conservation.

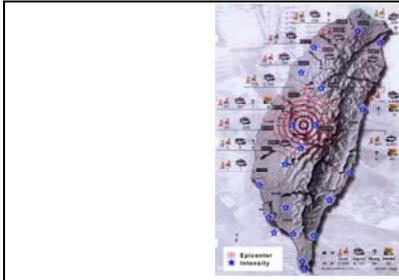


Figure 1. Intensity contour and disaster map of chi-chi earthquake



Figure 2. Reconstructed Lin An-Tai Historic House

2. BACKGROUND OF CULTURAL HERITAGE CONSERVATION SYSTEM IN TAIWAN

In 1980s, Taiwan had accumulated a powerful economic strength. The government promoted the urban modernization, one case of the Taipei city government tried to extend and widen Dunhua South Road, which required demolishing the Lin An-Tai historic House (Figure 2). This aroused the objection from both the architectural industry and cultural industry. In spite of repeated reports, descriptions, parliament inquiries and public appeals, the city government finally decided to include it into the removal list first and rebuild it in other places later, for there was no protection law on cultural heritage and the authorities also had no perception of monument conservation. After the event, the cultural industry realized the importance of establishing a Ministry of Culture and passing Cultural Heritage Preservation Act, thus it reported it to the government. Finally, the government established the Council for Culture Affairs in 1981 in charge of the national cultural affairs, and Cultural Heritage Preservation Act was released and executed in 1982. The Ministry of the Interior announced the list of first batch of designated monuments in 1983.

3. Cultural Heritage Damage and Response after “Chi-Chi Earthquake”

3.1 Introduction of Cultural Heritage before Earthquake

After the Cultural Heritage Preservation Act was released and executed, the government carried out the monument designation, researches and surveys as well as repairs immediately and actively. However, many repaired monuments were also seriously damaged in the earthquake. According to the regulations in Cultural Heritage Preservation Act then, the cultural heritages include antiquities, monuments, ethnic arts, folk customs related cultural artifacts, archeological sites, natural and cultural landscapes, which are in the charge of Ministry of the Interior, Ministry of Education and Ministry of Economic Affairs respectively. And related plans and common affairs had been determined jointly by Council for Culture Affairs and the other competent departments through consultation. In practice, only both the monuments and natural landscapes had been designated, conserved and maintained from 1981 when Cultural Heritage Preservation Act was released to “Chi-Chi Earthquake” in 1999. The main types of monuments and historic building as below (Figure 3).



(a) Temple



(b) Ancestral Hall



(c) Courtyard House



(d) Japanese Architecture

Figure 3. Main Types of monuments and Historic Buildings in Taiwan

3.2 Damage Caused by “Chi-chi Earthquake” on Cultural Heritage

Relevant the monument, the 921 Earthquake Cultural Heritage Rescue Team released the survey results of counties near the epicenter. The damages of four counties are shown as below: 4 at Taichung City, 4 at Taichung County, 24 at Changhua County and 5 at Nantou County, 37 damages in total with

the damage ratio reaching 74%(Table 1). According to another survey conducted Changhua County Government, among the 25 monuments, 1 site collapsed partially, 6 sites caused immediate dangers, 12 sites caused no immediate danger but required renovation and 6 sites were safe, thus the injury rate reached 76%. However, according to the investigation of the 921 Earthquake Cultural Heritage Rescue Team, there were 24 monuments in Changhua County being damaged, the injury rate reaching 96%. It could be seen that the earthquake cause overall damage on the monuments in different degrees. The seriously damaged monuments included national monument “Wufong Lin’s Residence” and County monument “Changhua Hsing-Hsien Academy of Classical Learning”, which were all collapsed.

As for the historic buildings, it was not legal cultural heritages when the earthquake occurred, the damage survey in charge of the cultural heritage rescue team that consists of Council for Cultural Affairs and folk experts and scholars. According to the statistics, all of the 888 historic buildings were damaged in four counties in the central Taiwan. Later, the rescue team assessed and selected some buildings worthy of conservation for re-survey, which included 92 sites in Nantou County, 14 in Taichung city, 43 in Taichung County, 48 in Changhua County, 7 in Yunlin County, 2 in Chiayi City and 1 in Chiayi County, and 207 sites in total (Table 1). Although these buildings weren’t the legal cultural heritages and thus beyond the protection of law, they were also paid attention to.

The disaster causes and main damages are further discussed as below:

- (1) **Earthquake magnitude $M=7.3$, with shallow seismic focus and serious damage:** According to the survey, the seismic degree near the focus is above intensity VI (PGA is above 250gal) and that of partial areas is also above intensity V (PGA is above 80gal). None of these monuments and historic buildings are of seismic design, thus the damage is extremely serious.
- (2) **Damage degree is related to the construction age of buildings:** Most of the monuments and historic buildings are mainly with long history, through the investigation, the old buildings are more different in seismic resistance of structural system even if given the same materials and structures. The ancient buildings might be severely damaged even if they were not near the fault.
- (3) **Damage degree is related to the earthquake intensity:** For instance, the earthquake intensity of counties near the seismic epicenter is the largest and the damage is the most serious. The damage degree is lower when it is far from the epicenter. Through the investigation, most of the brick masonry with damage above big danger are distribute at areas where the PGA is over 300gal (Figure 4), which is equal to intensity VI. Most of the adobe masonry with damage above big danger are distributed at areas where the PGA is over 200gal (Figure 5), which is equal to intensity V.
- (4) **Damage degree is related to the building construction:** According to the investigation, the building with the most severe damage is the adobe structure there are 22% collapsed, which is far larger than 9% of the brick masonry and box bond masonry (Table 2). The big damage is 35%, which is more than 3 times that of brick masonry and box bond masonry. However, there are 32% of the brick masonry are out of danger. It is shown that about 1/3 brick masonry weren’t damaged under the powerful 921 Earthquake with magnitude 7.3 (it is near 1/2 if accounted slightly damaged buildings), which deserves our attention.
- (5) **Damage degree is related to the construction orientation:** Generally, the geometries configuration and wall, beam and column of architecture are difficult symmetrical, therefore, the seismic capability in one axis might be higher and that of another axis is weaker. Under the effect of the same earthquake force, the damages might be different because of different configurations and orientations.
- (6) **Damage degree is related to soil condition of building site:** If the building is located at hard rock of soil type, then the building only bears the seismic force from the rock when earthquake occurs. However, if the building is located at soft soil, then the seismic wave from the rock might be magnified, or even it will result in soil liquefaction and landslide. Thus the upper structure of building is damaged, moreover, the foundation might settle or heave, causing a further damage on the building (Figure 7, 8, 9).

| | Previous Survey in Stage I | | Survey in Stage II |
|-----------------|----------------------------|-------------------|--------------------|
| | Monument | Historic building | Historic building |
| Taichung City | 4 | 2 | 14 |
| Taichung County | 4 | 118 | 43 |
| Changhua County | 24 | 391 | 48 |
| Nantou County | 5 | 356 | 92 |
| Yunlin County | 0 | 21 | 7 |
| Chiayi County | Uninvestigated | Uninvestigated | 2 |
| Chiayi City | Uninvestigated | Uninvestigated | 1 |
| Total | 37 | 888 | 207 |

Data source: according to Hsu Min-Fu and Lin Hui-Cheng data finishing

| | Adobe masonry | Brick masonry | Box bond masonry |
|---------------|---------------|---------------|------------------|
| No danger | 8% | 32% | 10% |
| Slight danger | 5% | 14% | 18% |
| Small danger | 11% | 20% | 32% |
| Medium danger | 19% | 14% | 21% |
| Big danger | 35% | 11% | 10% |
| Collapse | 22% | 9% | 9% |

Data source: (Chang, J. S. et al., 2001)

◆ Collapsed ■ Big danger ▼ Medium danger ◇ Small danger ○ No danger and Slight danger

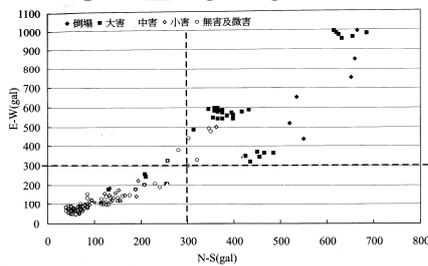


Figure 4. Relationship Diagram between Seismic Acceleration and Damage Degree of Brick Masonry. (Chang, J. S. et al., 2001)

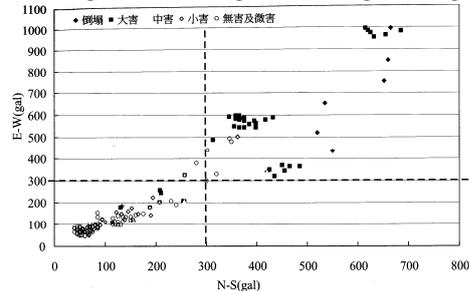


Figure 5. Relationship Diagram between Seismic Acceleration and Damage Degree of Adobe Masonry. (Chang, J. S. et al., 2001)



The back wall of Dou-Shan ancestral hall collapses out-of-plane force.



Continuous cracks at front windows of Peasants' Union building of Nantou City.



Cracks at arcades and arch.

Figure 6. Pictures of monument and Historic Building Damages



Figure 7. Building leans forward due to foundation settlement (Chang, J. S. et al., 2001)



Figure 8. Terrace rises because of soft ground (Chang, J. S. et al., 2001)



Figure 9. Wall body is bent (Chang, J. S. et al., 2001)

3.3 Relevant Emergency Response Measures after Earthquake

After the earthquake occurred, Ministry of the Interior and Council for Cultural Affairs were in charge of the cultural heritage restoration. This was the first major disaster for cultural heritage and the authorities had no experience, but the Council for Cultural Affairs and Ministry of the Interior established the emergency response team immediately and took a series of emergency response

measures, all of which became important procedures of emergency response to major disasters of cultural heritage.

- (1) **Establish an emergency response team:** After the earthquake, the cultural heritage was seriously damaged. The experts and scholars volunteered to the disaster-stricken area to assist the disaster recovery. Due to the lack of experience, the Council for Cultural Affairs established the 921 Earthquake Cultural Heritage Rescue Team together with the experts and scholars and the Ministry of the Interior established the 921 Earthquake Monuments Restoration Guidance Team. The government and civil groups worked together into the cultural heritage rescue work. Soon afterwards, the local government also invited the experts and scholars as well as the representatives from related institutions, upon the requirements of the disaster, to establish the local cultural heritage emergency response team, map out the emergency response principle and guide the response measures (e.g. guide the building manager to take necessary emergency support and protection measures so as to carry on the cultural heritage rescue work) for the monuments and historic buildings.
- (2) **Carry out cultural heritage disaster investigation:** Since monuments are included in legal cultural heritages, Ministry of the Interior asked the local government to carry out primary research and evaluation through the administrative system, then invited the experts and scholars to conduct the site investigation, and then worked out a follow-up renovation and reconstruction plan. Besides, Council for Cultural Affairs united 17 universities to establish a 921 Earthquake Cultural Heritage Rescue Team which was composed of 50 teachers from Department of Architecture and cultural heritage related departments to go into the disaster-stricken area for cultural heritage disaster investigation.
- (3) **Request the Reconstruction Committee to postpone the removal of historic buildings:** After Council for Cultural Affairs and experts and scholars completed the investigation, totally 742 historic buildings were counted as worthy of conservation but without monument value, so they didn't belong to the legal cultural heritages and thus could not be listed in protection scope. There were still many buildings identified as severely damaged and would be removed immediately. Council for Cultural Affairs appealed the 921 Earthquake Post-Disaster Recover Commission, Executive Yuan to postpone the removal of these buildings. Through the assessment of relevant experts and scholars, a list of total 222 sites for removal suspension was proposed and then the funds for re-survey and reconstruction was estimated immediately.
- (4) **Revise Cultural Heritage Preservation Act emergently and add the Historic Buildings into cultural heritages:** Since these buildings are identified as having no monument value but are worthy of conservation, the government proposed to revise Cultural Heritage Preservation Act emergently by adding the "historic building" as a kind of cultural heritage. It haven't been designated as monuments but are of historic or cultural value. Later on, the local government made the registration measures for these historic buildings, protecting them from removal.
- (5) **Conduct the cultural heritage safety protection and emergency consolidation:** Initially post-earthquake, the people could enter into partial damaged monuments and historic buildings to pick up the fallen components, which caused a further damage on the monuments. Thus the cultural heritage rescue team of central authorities and emergency response team of local authorities guided all the managers in charge of monuments and historic buildings to carry out the emergency consolidation and safety protection. E.g. dispatch special person to guard and establish an isolation zone, warning board or reporting procedure, etc., to avoid improper access of people causing damage or danger on monuments. Furthermore, the tilted building needed emergency shoring, consolidation and cover to avoid further damage on ancient building caused by the earthquake aftershock or raining.
- (6) **Proceed with professional classification of collapsed cultural heritages:** There were two monuments seriously damaged and they were almost collapsed completely. To know the cause of damages and maintain the value of cultural heritage after repair, the government authorized the clearing and recording. It is required to inspect and record each component, and classify, register, tabulate and save the records so as to use the original materials primarily during the reconstruction and maintaining of the authenticity of monuments after repair.
- (7) **Apply for budget of cultural heritage repair and reconstruction funds:** Cultural Heritage Conservation Fund wasn't included in the budget of "post-disaster reconstruction". However,

when Council for Cultural Affairs found that the monuments and historic buildings in disaster-stricken area were seriously damaged, it firstly suggested protecting those, and then applied for the budget of cultural heritage reconstruction funds from the 921 Earthquake Post-Disaster Recover Commission, Executive Yuan. Meanwhile, it also appealed the private enterprises to raise the cultural heritage reconstruction funds in disaster-stricken area.

- (8) **Stipulate relevant regulations on cultural heritage repair in disaster-stricken areas:** The cultural heritage reconstruction is different from general reconstruction project since it is involved with the cultural heritage value preservation and holds different requirements on the craftsman and repair methods, thus the stipulation of relevant purchase and emergency response methods are needed urgently. It was also necessary to stipulate the protection and registration method for newly-added “historic building” so as to meet the needs of reconstruction. Thus the Ministry of the Interior and Council for Cultural Affairs stipulated relevant regulations for disaster-stricken areas respectively to meet the special needs. All those regulations contributed a lot to the follow-up cultural heritage reconstruction.
- (9) **Carry out the cultural heritage repair desire investigation:** According to the regulations of Cultural Heritage Preservation Act, the monuments are designated and conserved compulsorily. After the earthquake, the government and the owner of monuments reached consensus on the renovation. However, the newly-added “historic building” adopted the registration system and it was conserved in way of tutoring reward. The Council for Cultural Affairs investigated the historic buildings for postponed removal and learned the building status and the renovation desire of the owners. Owners of 68 buildings were willing to apply for the renovation fund subsidy and 98 buildings were subsidized by other organizations or themselves. As for the rest of buildings, the owners weren’t willing to undertake partial funds or they needed to collect the opinions of their families.
- (10) **Establish service center for each zone to assist the control of reconstruction project quality:** After the earthquake, many renovation works were carried out at the same time. Under the condition that local governments were short of hands and professional capacity, the renovation quality of monuments and historic buildings might be affected. To control the project quality, the Council for Cultural Affairs divided the earthquake-stricken area into three zones, which were instructed by the professional teams respectively. The professional teams would visit the renovation sites on behalf of the Council for Cultural Affairs to know the project progress, and they would also assist the local governments to solve some professional engineering problems, so as to complete the project in schedule and maintain a certain renovation quality.

4. Changes of Relevant Conservation Systems after Chi-Chi Earthquake

When the government and experts and scholars devoted themselves into the disaster recovery, they found that Cultural Heritage Preservation Act lacked corresponding major disaster emergency response measures. To protect these important cultural heritages, the government renovated the heritages and revised the law simultaneously, making the cultural heritage conservation system perfect gradually. As a summary, the major effects of Chi-Chi Earthquake on the cultural heritage conservation system were as below:

4.1 Revise the law comprehensively and unify the cultural affairs right

Although the law was revised emergently after the earthquake to meet the needs of disaster recovery, Cultural Heritage Preservation Act needed a further revision on the impractical articles. Thus the Council for Cultural Affairs revised the law comprehensively and structurally and it released the new Cultural Heritage Preservation Act in 2005. The new Act not only reviewed the implementation difficulties over the past twenty years but also adopted the concepts of world heritage conservation, making the Taiwan’s cultural heritage conservation system more perfect.

In addition, the original Cultural Heritage Preservation Act of Taiwan assigned the cultural heritage management right to different departments, except for the Council for Cultural Affairs, the other

departments weren't in charge of the core businesses. It resulted in large lag in staffing level, budget planning and conservation concept, thus some departments actively promoted the law but some others didn't implement it. For this reason, when Cultural Heritage Preservation Act was revised comprehensively after the earthquake, it especially assigned the cultural affairs right specifically. Except that the Council of Agriculture in the charge of the natural landscapes, the Council for Cultural Affairs takes charge of other affairs such as monuments and historic buildings, settlements, cultural landscapes, archeological sites, antiques, traditional arts, folk customs and related cultural artifacts.

4.2 Expand the cultural heritage conservation scope

(1) Add the historic building registration system : Taiwan's original Cultural Heritage Preservation Act specified the cultural heritages into five types, namely antiques, archeological sites, folk arts, folk customs and related cultural artifacts and archeological sites as well as natural and cultural landscapes. After the earthquake, the law was revised emergently on February 9, 2000 and the "historic building" registration system was added.

(2) Adjust the cultural heritage conservation types : After the urgent law revision, the Council for Cultural Affairs reviewed the Cultural Heritage Preservation Act comprehensively again. And it released new Cultural Heritage Preservation Act on February 5, 2005, making Taiwan's cultural heritage conservation system more complete. It reviewed the implementation experience over the past twenty-third years and increased the cultural heritage types by referring to the classification structure of the UNESCO. The revised content consists of 7 types and 9 items of monuments and historic buildings, settlements, archeological sites, cultural landscapes, traditional arts, folk customs and related cultural artifacts, antiques and natural landscapes, which further expands the cultural heritage conservation scope.

4.3 Strengthen the management and maintenance system of monuments and historic buildings

Most of the Taiwan's monuments are mixed structures made of brick, earth, stone and wood. Wooden structure is easily damaged by termites in warm and humid environment, which is right the environment in Taiwan. But in the past, the daily management and maintenance weren't respected in Taiwan, some monuments were often damaged by the termites due to the ignorance of maintenance. After the earthquake, it is found that the buildings with better management and maintenance suffered lighter damages while those with worse management and maintenance suffered more severe damages. This discovery started to pay attention to the daily management and maintenance of monuments. It also stipulated relevant regulations in Cultural Heritage Preservation Act and revised the "Measures Governing the Management and Maintenance of Historic Monuments" in the hope of establishing a more perfect management system. In addition, it extended the functions of service centers, which shall instruct the manager about the daily management and maintenance work besides its original mission, assist drawing up the project of management of maintenance and visit each monument and historic building regularly. In this way, the government can know the management and maintenance status of each monument and historic building, and the manager of each monument and historic building also pays more attention to the daily management and maintenance.

4.4 Establish a disaster prevention system of cultural heritage

Taiwan's cultural industry didn't have the experience of disaster prevention and recovery before. Initial the earthquake, the disaster recovery was messy, but various emergency response, renovation and reconstruction projects were completed and the cultural heritage disaster prevention system was gradually established under the cooperation of the government and experts and scholars. After the earthquake, it made the "Measures Governing the Management of Historic Monuments Affected by Natural Disasters" to establish an emergency response team and stipulate the response treatment principle and system when major disaster occurs. Afterwards, Taiwan was attacked by 88 Flood on August 8, 2009, an earthquake with a scale of M=6.4 at JiaShian Kaohsiung in 2010 and other cultural heritage fires. However, all levels of cultural heritage competent authorities and building managers

had already taken emergency measures according to the system without any panic, thus the recovery was much faster.

5. Changes in Restoration Technologies and Construction Methods after Chi-Chi Earthquake

Before the earthquake, the concept of “original technique, skill and material” was emphasized for monument repair in Taiwan. After the earthquake, it was found that the past repair concept couldn’t withstand the damage caused by the earthquake, thus the modern technology was considered to be adopted for the cultural heritage repair. Furthermore, the “if necessary, modern technologies and construction method shall be adopted to enhance the monument’s resistance to earthquake, nature disaster, flood, termite and its durability” were added in the Cultural Heritage Preservation Act, in the hope of expanding the life of monuments and historic buildings and raising the shock resistance of buildings.

When the emergency consolidation was roughly completed after the earthquake, the authorities immediately assisted the monument and historic building recovery and reconstruction work. Meanwhile, they also carried out the renovation for 58 monuments and emergency consolidation for 31 sites, renovation for 45 historic buildings and emergency consolidation for 6 sites, resulting in NT\$ 1,433,214,000 of monument repair funds and NT\$ 599,069,255 of historic building repair funds, NT\$ 2,032,283,255 in total. Most of these repair projects adopted new reinforcing techniques, as illustrated below:

5.1 Brick Masonry Wall Strengthening Method:

It includes the attached steel plate (Figure 10B), additional steel frame, joint imbedded with stainless steel strips, attached steel wire mesh reinforcement, attached CFRP reinforcement, wall center rebar-planting reinforcement (Figure 10A), wall crack U-shape iron reinforcement and top of the wall with steel confine beam reinforcement. And other reinforcement techniques such as RC shear wall or wall thickening were added.

5.2 Adobe Masonry Wall Strengthening Method

The generally-adopted strengthening methods include wall body surface paved with steel or flax mesh (Figure 10D), wall surface paved with bamboo strips, crack filled with wood members, embedded with bamboo strips, steel H beam reinforcement, wall top covered with steel plate and moisture control of the wall.

5.3 Japanese-style Wooden Wall Strengthening Method

This kind of wall damage modes include: 1. Diagonal crack of bamboo-mud wall, the surface plaster work decoration is stripped; 2. Wooden frame is tilted, the joint breaks; 3. Wall foundation shifts. The designers have the following strengthening method against these damage modes: 1. diagonal bracing strengthening (Figure 11A); 2. corner strengthening by steel plate (Figure 11B) and other techniques.

5.4 Roof and Floor Strengthening Method

The roof and floor of Taiwan’s monuments and historic buildings vary in type, It is different in damage mode and strengthening method. For example, most of the traditional residence roofs are made of “gable-supported purlins”, thus the purlins might be pulled out and fall during earthquake, causing roof collapsed. The strengthening methods include the roof end stainless box strengthening (Figure 11C), stainless steel hoops for purlins, strengthening at the internal side of gable wall. In addition, the RC slab might been had steel corrosion and concrete carbonation, the strengthening methods include steel plate and CFRP added on beam and floor, floor steel bar repairing of slab, crack filled with epoxy resin,

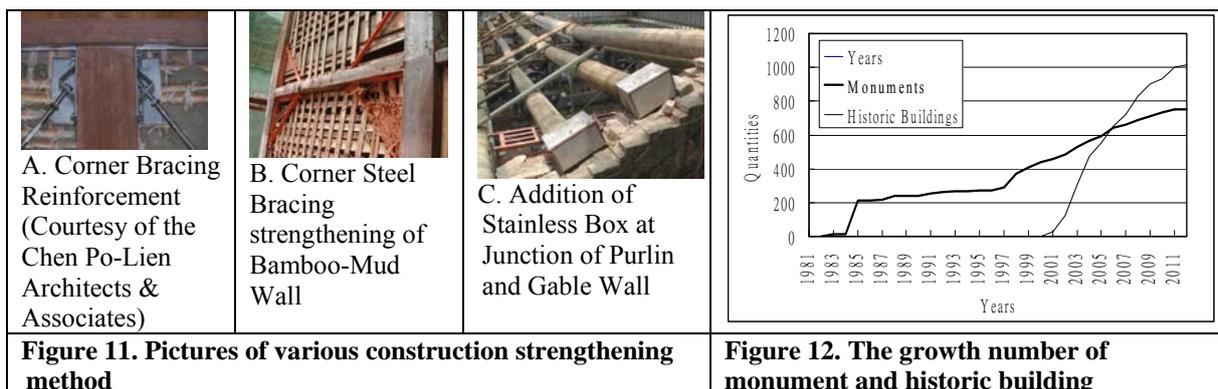
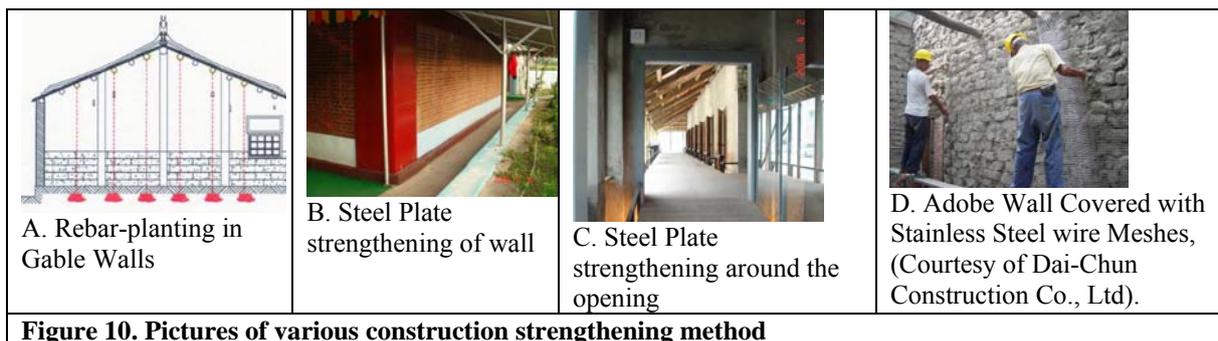
5.5 Foundation Strengthening Method

Structurally, the foundation bears all the vertical load and seismic forces of its above buildings and transfers them to the soil. If the foundation is of poor structure, or with degradation or the poor underground soil, there might be damage on the upper structure. As for the foundation strengthening, the historic buildings in reconstructed areas can be classified into: (1) Low pressure grouting of soil, (2) adding Granular pile; (3) Moisture proof gravity grouting of foundation wall, (4) Newly-added foundation beam and girder, (5) crack injection with epoxy resin, etc.

5.6 RC Structure Strengthening Method

Because of material creep, concrete carbonation, or cracks eroded by rain water, the internal steel bars in RC structure are eroded, making the cracks bigger as the section expands. In the vicious cycle, RC structural strength will be decreased continuously, which will cause a bigger damage when the earthquake occurs. The emphasis of strengthening techniques focuses on improving the strength and ductility. strengthening techniques include: enclosing steel plates, adding shear walls and pasting CFRPs.

The above strengthening methods are developed after the earthquake, and the application and discussion of these strengthening methods are made currently and domestically. In addition, the seismic assessment was also required while repairing the monuments.



6. CONCLUSION

The renovation achievements of monuments and historic buildings after the earthquake have been praised by the public. And the reuse plan after renovation attracts many visitors, which populates the cultural heritage conservation positively and draws people's attention on the cultural heritage conservation. In addition, the cultural affairs right was in the charge of the Council for Cultural Affairs

after the earthquake, which also promotes the cultural heritage conservation project more quickly.

According to the statistics from the earthquake to now (March 2012), the number of monuments has been increased from 427 to 742 and that of historic buildings from 0 to 1012. Comparing to the growth rate of monuments before the earthquake, Taiwan's cultural heritage conservation develops flourishingly for 13 years after the earthquake. It can be found from the figure 12 that the registered number of designated cultural heritages in Taiwan shows a trend of rapid growth after the big earthquake in 1999.

There is a well-known saying: "crisis is turning point" in Taiwan. Although the 921 Earthquake has brought a serious impact on Taiwan's cultural heritage conservation for lack of major disaster response experience, under the strong cooperation among the government organization and experts and scholars, the historic buildings that might be removed have been kept and Taiwan's cultural heritage conservation system and concept change a lot, furthermore, the improved repair technologies and reconstruction methods as well as the experience will become the milestone in Taiwan's cultural heritage conservation history.

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