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Retrofitting and Moving Protection for Historical Buildings in Jinan City

ZHANG Xin[1-2, a], LI Shibin[1-2,b] and LIU Tao[1,c]

[1]College of Civil Engineering, Shandong Jianzhu University, Jinan, China

[2]Shandong Provincial Key Lab of Appraisal and Retrofitting in Building Structures, Jinan, China

[a]zhangxin1964@163.com, [b]lsbtj@163.com, [c]liutao0633@yahoo.com.cn

Abstract: Retrofitting and moving protection for historical buildings have vital historical and cultural value for they concern both the development of human society material civilization and the continuation of human cultural heritage. Jinan City is ranked among the second group historic and cultural cities of China, where has many valuable historical buildings. The urban construction advances by leaps and bounds in Jinan City since the nineties, which brings tremendous challenge for the protection of historical buildings. The state of the art of protection and retrofitting for the historical buildings in Jinan City is summarized. Three protection schemes, namely in situ retrofitting and minimum distance moving protection as well as long distance moving protection, are adopted in Jinan City. Six finished protective projects are discussed from a structure viewpoint. Retrofitting and monolithic moving techniques are presented for different historical buildings according to the style and features as well as requirements, and also the pivotal techniques for improving aseismatic performance are suggested. Some retrofitting details as to members are also introduced. This will be helpful for the protection of historical buildings.

Keywords: Historical building, protection, retrofitting, monolithic moving

Introduction

Historical buildings are the most reliable witness of a city. They record valualbe historic informations of their era including politics, economy, culture, technology and so on. They also have vital historical and human as well as researchful value. The protection for historical buildings of worldwide scope began from the late 19th century, which was represented by Britain, France, Italy and so on(Shen and Wang 2007). The Venice Charter was passed in 1964, which affirmed the value and function of historical buildings, and also took historical buildings as witness of human heritage and history. Since then, historical buildings are treasured increasingly abroad. In China, with the development of economy and urbanization, historical buildings are confronted great challenge in recent decades. Initially, historical buildings were not protected effectively for the limitation of cognition and consciousness. There was much pity to be left. Nowadays, plenty of importance is attached to the protection for historical buildings according to the Cultural Relics Preservation Law of China.

Historical Buildings Protection in Jinan City

Jinan is a venerable city, which has 4600 years history and also is rated among the national famous historical and cultural cities. Many European-style buildings were constructed since the open of Jinan port in 1904. The urban construction advances by leaps and bounds in Jinan City since the nineties, which brings tremendous challenge for historical buildings protection. Some historical buildings were destroyed. For instance, the old railway station built in 1912 be Germanic in style was demolished in 1992, which was the most famous railway station in the Far East and had an vital position in modern architectural history. This deserved reflection. There is a most profound lesson to be learned from this.

To our delighted, much work has been done to protect historical buildings with the support of all social classes and the government. The struggle objective for realizing new span and constructing new city of springs was presented in 2003, in which historical buildings protection was emphasized. For

the limitation of historical buildings in structural integrity and aseismatic performance, the protection for historical buildings includes not only architecture and city planning but also structural engineering. A good retrofitting schemes must be reliable, economical, and convenient in constructionand. Most work has been done for historical buildings protection and strengthening by us in Jinan City. Three protection schemes, namely in situ retrofitting or minimum distance moving protection or long distance moving protection, are adopted. As to the historical building be not conflict with the new city planning, in situ retrofitting is adopted above all, which can reserve and renew the style and features such as the Old Railway Station Waiting Room and the Old Post Office as well as the Old Cinema in Jinan. As for the historical building be conflict with the new city planning and be integrated smoothly into the surrounding environment, minimum distance moving protection is adopted such as the Old Bank and the Old Drugstore in Jinan. As for the historical building be conflict with the new city planning and be not integrated smoothly into the surrounding environment, long distance moving protection is adopted such as the Old Villa in Jinan. The six representative projects are discussed from a structure viewpoint.

Engineering Practice in Jinan City

The Old Railway Station Waiting Room The waiting room built in 1958 was an inner reinforced concrete(RC) frame structure with two floors. The surrounding longitudinal walls were all bearing walls. The plane shape was L and there was a shrinkage joint with 20mm width as shown in Fig. 1. There was an independent foundation of RC under the column, and a strip foundation of rubble under the wall.

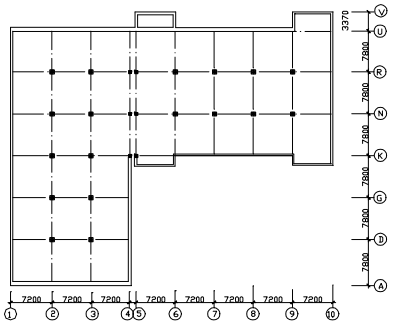

Figure 1: Plan drawing

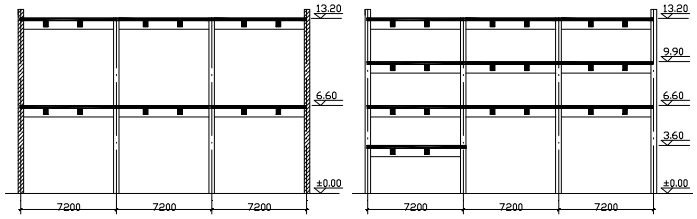

Figure 2: (a) Before retrofitting (b) After retrofitting

During the retrofitting, based on the results of examination and appraisal as well as the actual Chinese design code of concrete structure(GB50010-2002), the inner frame structure was replaced by frame structure in 1992. Namely, the RC columns were added in longitudinal walls at colonnade locations, and the RC affiliation beams were established along longitudinal walls. Simultaneously, the shrinkage joint was canceled, and the two sides columns were retrofitted to integral columns. This satisfied the actual Chinese design code. The slabs that live load be increased were strengthened by post-pouring concrete layer. The original frame columns and beams be not satisfied bearing capacity were strengthened by using section increment. The original foundations were underpinned by mini and micro piles.

According to requirements, the building should be selling ticket, office, meeting as well as restaurant, and also the built-up area should be increased from 4501 to 6000 square meters. Taking economy and construction, the interior storey-adding method was adopted because the original floor height was 6.6 meters. Then the two-storey building turned a four-storey building. The section plane drawings before and after retrofitting were both shown in Fig. 2.

The Old Bank The bank having about 80 years history was the only existing baroque style building in Jinan as shown in Fig. 3. It was a two-storey bricky timberwork building with an attic. The built-up area was about 600 square meters. The Weiliu road was planned to widen in 2005, which

made the building became a backout building(Zhang et al. 2007). For protecting the bank as well as not affecting the road, the building was moved 15 meters toward the west after many discusstions as shown in Fig. 4.

Figure 3: The old bank moving spot

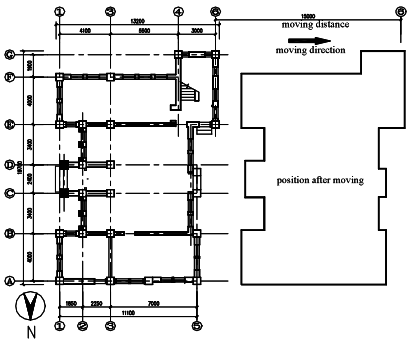

Figure 4: The plan drawing and position

For safety of the moving, detailed and reliable construction schemes and protection measures were presented after careful survey, examination and analysis. The superstructure was underpinned to low track girders through double top track girders and the steel rollers. The top track girders were located under the walls. There were a lot of diagonal girders among the top track girders, which formed a lying truss with great horizontal stiffness. This could assure safety of the superstructure during the moving process. After the new foundation was built, the building was drawn to the position by many synchronous hydraulic jacks. The rollers between the low and top track girders were preserved, which formed the vibration-isolation system combined with laminated rubber bearings located the joint between the longitudinal and lateral walls.

The old bank was preserved through monolithic moving technique, which had vital effects for the development of the spring city. The project was the first monolithic moving for historical buildings in Shandong province, and was the first application of vibration-isolation technique in the protection for historical buildings. Through the field dynamic testing, the aseismatic performance of the bank was improved greatly for the vibration-isolation layer made up of rollers and laminated rubber bearings. Nowadays, the old bank was a famous restaurant in Jinan City.

The Old Drugstore The building named “Hongjitang Drugstore” was built in 1920, which was a two-storey bricky timberwork structure with two towers in north and south as shown in Fig. 5. It was protected by monolithic moving for the near road widen in 2008. Namely, the two towers were moved about 11.6 meters toward the north together, then were moved about 16 meters toward the east together, and then were rotated 3.8 angles together as shown in Fig. 6. After being moved to the new position, the building was lifted 0.4 meter upward(Xia and Jia et al. 2008).

Figure 5: The old drugstore moving spot

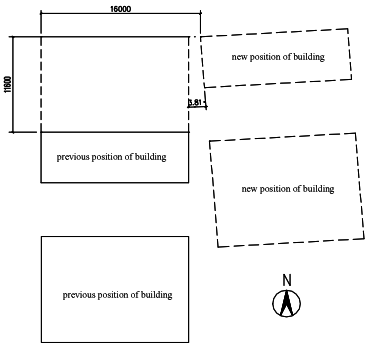

Figure 6: The old drugstore moving sketch map

For the limitation of integrity and earthquake resistance, there was high requirement in integrity of the underpinning structure and in stability during the moving construction process, and also the building need be strengthened for improving earthquake resistance. The double girders underpinning was adopted instead of direct underpinning under walls for the limitation of the building. For integrity

of the underpinning structure and the loading transmission of the superstructure, short beams were built to connect double sides underpinning girders every 1.5 meters, and also many horizontal diagonal stays were constructed. Considering the features of small weight and bad integrity as well as bad earthquake resistance, the sliding monolithic moving technique was adopted in the project which had the characteristics of stable moving and low libration as well as good adaptive ability for uneven tracks. The tractive system was made up of many synchronous hydraulic jacks controlled by PLC to ensure the smoothness and synchronization during the moving process. The dielectric plates were used as running gear. After moved to the new position, the laminated rubber bearings were installed between top underpinning girders and basement walls or columns, which formed a vibration-isolation layer with the sliding rubber bearings to improve aseismatic performance of the building. It showed that the smoothness of the moving could be effectively assured using the sliding moving technique for historical buildings with bad integrity. Combined with the moving, laminated rubber bearings could be installed to enhance vibration-isolation performance without changing architecture shape.

The Old Post Office The building built in 1919 was also a two-storey building structure of brick and concrete. A new annex floor was added by the construction unit as shown in Fig. 7. It showed that some external decorative coating of the walls scaled off, and bricks weathered. The safety and aseismatic performance of the building as well as the bearing capacity of members were checked in 2007. Plenty of protectiove remedy measures were adopted for some related members. Most walls were strengthened on both sides with steel meshed cement mortar according to the testing strength of blue brick and lime mortar. As to walls less than 1.5 meters in width were strengthened on each corner with angle steel edge-plated along their height. The diagonal cracks in walls were treated with chemical grouting. The parapets on the original roof were rebuilt because most were destroyed greatly, and some RC structure columns were added. The longitudinal rebars were anchored into slabs through the method of steel bar implanted by chemical adhesive.

Figure 7: The old post office

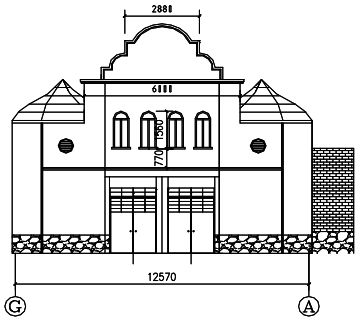

Figure 8: The cinema north solid drawing

Part RC columns had been strengthened by using section increment. But the incremental sections were detached from the original sections, the reinforcement corroded and protruded, and also the concrete cover shelled. Some measures were taken to solve this problem, namely eliminating vital part concrete, removing reinforment rust, smoothing with cement mortar, strengthening by angle steel edge-plated.

There were many cracks along rebar under the beams for reinforcement corrosion. Another measures were taken to solve the problem, namely eliminating crack surrounding concrete, removing rebar rust, renovating to original section, strengthening with two-layer SBC-300 carbon fiber cloth.

The building was the highest and biggest RC structure at that time in Jinan, which had a high research value in history and culture as well as science. Therefore, the incremental floor was demolished to renew its historic style and features with authenticity and integrity after discusstions. It was indicated that the consequent service life of the post was 30 years after the retrofitting.

The Old Cinema The building named “Xiaoguanghan Cinema” was built in 1904 by German, which was the pioneer cimema in Jinan City or even in China. The north solid drawing was shown in Fig. 8. It was a single storey large-space brick and timberwork structure with timber roof truss and timber purlin as well as corrugated steel plate roof. Some local position was a two-storey structure

with timber floors, beams and columns. The peripheral bricky walls were bearing walls with a strip foundation of rubble.

For safety it was examined and appraised in 2009. The corrugated steel plates corroded badly, and collapsed here and there. The nodes became loosened or disengaged. The roof near stairwell had no bearing capacity. Finally, the roof was replaced by new corrugated steel plate with a thickness from 0.6 to 0.8 millimetre, and the suspended ceilings were all removed and replaced by light steel keel gypsum board with thermal coating. The fracture trusses and purlins were replaced, and the cracking trusses and purlins were strengthened. For local second floor collapse, the step floor was replace by a new plane timber floor, and a connectiove corridor of light steel was added for interior space. The original north external wall had been removed, and there were no primal style and features. Also, the peripheral bearing walls weathered badly. The north external wall was renewed by RC structure, and the roof of both sides octagonal houses was replaced by cast-in-situ concrete roof, and the original architecture sculpt of the top was resumed. All peripheral bearing walls were strengthened on both sides with steel meshed cement mortar. Simultaneously, all partition walls were repaired protectively.

The building is the oldest cinema in China had vital cultural significance, which was the witness of trade and communication between China and the west. The original baroque style was renewed after the retrofitting, which had vital cultural relic protection value.

The Old Villa The building with a complicated sculpe in roof was one of the most famous residential building in China with a history of about 80 years, which had many features such as harmony of proportion and appropriate of scale in architecture as well as reasonable in function as shown in Fig. 9. It was a local two-storey brick and timberwork structure with a lime clay strip foundation under the wall. Its length was about 15 meters in north-south, and its width was about 9 meters in east-west. The total height was about 6.5 meters. The integrity of the superstructure was poor by reason of longer service. The strength of the mortar was almost zero. For protecting the historical building as well as planning the shanty town in Jinan, it was moved to a new place with a distance about 30 kilometers by the research institute of engineering assessment and repair of shandong jianzhu university in March 1st, 2009. The Fig. 10 showed the long distance moving spot. For there were many overbridges along the path, the complicated roof was removed specially for safety. It was the longest moving for buildings in China.

Figure 9: The old villa appearance

Figure 10: The moving spot

The building was drawn by a large-scale hydraulic flat trailer made in France, which had many merits such as wire control operation, whole hydraulic upward-downward, self-propelled, controlled full-hydraulic steering, flexiblely assemble. Twenty group carts arranged in two-line with a total 128 wheels were applied in the moving. The large-scale hydraulic flat trailer was composed of heavy-duty part and traction part, which had power equipment by itself. The flat trailer was shown in Fig. 11.

The moving construction was made up of several processes. Namely, construct wall joists of RC under the indoor ground, then underpin the building up 0.8 meter, then place the trailer in position, then promote the underpan and transfer loading to the trailer, then start up the trailer and move the building to new position, then land the underpan and transfer loading to the supporting wall and new foundation, then joint the superstructure and substructure, then renew the building. Finally, the old villa was located in Shandong Jianzhu University as shown in Fig. 12. This not only protected the

historical building but also upgraded the cultural details of Shandong Jianzhu university. Now, the old villa served as an exhibition hall of moving technique in buildings(Liu and Zhang et al. 2009).

Figure 11: The flat trailer

Figure 12: The old villa after moving

The long distance moving was an epoch-making event in China. The successful engineering practice provided valuable experience for engineers. In a sense, it was a landmark for building monolithic moving in China, and broke a new path for the protection of historical buildings.

Epilogue

Historical buildings are inestimable wealth of the society. The protection for historical buildings has far-reaching significance. There is before us a heavy responsibility and a long way to go. This is a system project involving architect and city planner and structure engineer as well as the government. Some effective schemes can be adopted to protect historical buildings such as in situ retrofitting and minimum as well as long distance moving in accordance with specific conditions. Althouth much work has been done, pertinent key technology need to be further studied.

The original service functions of histitorical buildings may not satisfy the modern requirements, but which can be improved with the style and features in architecture. Then the historical building can be used to develop a food business or tourist industry or service industry.

Some measures can still be taken to raise enough money for protecting historical buildings by market operation and society positive factors under fund shortage in the government. For example, the longest distance moving of the old Villa in Jinan City. In a word, We should make joint efforts to protect historical buildings at any cost.

Acknowledgement

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