

## Exploring the Nexus of Landmark Architecture and Urban Development: A Case Study of the National Taichung Theater

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**Abstract:** Every City Around The World Showcases Its Iconic Landmark Building, Enhancing The Allure Of Its Urban Landscape. However, In Taiwan, The Absence Of A Distinct Architectural Identity Or Symbolic Representation Poses Challenges For Foreigners In Grasping The Essence Of The Nation. This Study Focuses On The National Taichung Theater As A Pivotal Case To Investigate How Landmark Buildings Influence Urban Development.

The construction of the National Taichung Theater encountered multiple challenges. Inspired by the remarkable design of the Guggenheim Museum in Taichung, the architectural industry experienced a surge of creativity, inspiring and influencing architects. The theater itself has garnered global attention as a manifestation of these inspirations. Designed by Japanese architect Toyo Ito, it embodies the Spectacle of the Sound Cave concept. The process involved addressing construction method difficulties, incorporating advanced techniques and innovative technologies. The building's irregular and asymmetrical shape, constructed with reinforced concrete, added to its complexity.

The magnificent National Taichung Theater adorns Taichung's 7th land consolidation zone, captivating citizens with its ever-changing appearance and infusing the city with a rich cultural ambiance. This newly established landmark has become a source of pride for Taiwanese citizens, and its anticipated positive and extensive impact on the city's development is undeniable.

**Keywords:** landmark building, city development, National Taichung Theater.

### I. Introduction

Looking at major cities worldwide, nearly every town boasts unique and significant buildings that serve as landmarks and symbols. For instance, in recent years, the "Sailing Familia" in Dubai has garnered much attention, standing proudly by the seaside. The "White House" in Washington, USA, and the "Sagrada Familia Church" in Barcelona, Spain, have been under construction for a century, with the latter designed by the late architect Gaudi, breaking away from traditional concepts, featuring complete asymmetry and presenting various irregular shapes. Despite being unfinished, it has been recognized as a UNESCO world cultural heritage, adding to its legendary and extraordinary status. Other notable examples include the "Guggenheim Museum" in Bilbao, the iconic "Eiffel Tower" and "Arc de Triomphe" in Paris, the towering "Sky Tree Tower" in Tokyo, Japan, and the stunning "Sydney Opera House" in Australia. Whenever one introduces a country or city, simply mentioning these architectural wonders often suffices to represent them.

Returning to Taiwan, if foreigners wish to experience or imagine Taiwan through its buildings, it appears challenging to identify a more prominent "totem" or iconic structure. Using the "Presidential Palace" to represent Taipei seems peculiar, as it originally served as the "Governor's Palace" during Japan's rule over Taiwan. Similar buildings might have been demolished long ago if they were located in Korea. In Taipei's early history, the "National Palace Museum" or "The Yuanshan Hotel" might have been considered for such representation. However, in recent years, the "101 Building" has emerged as a fortunate contender, having once held the title of the world's tallest building. It now better symbolizes the modern image of Taipei.

As for Taichung, selecting representative buildings seems to be more elusive. Over the years, a singular structure has yet to emerge as a clear representative. Even today, Taichung City continues to adopt the "Lake Heart Pavilion" in Taichung Park as its "city emblem" or totem. This choice may appear peculiar as the pavilion, built on October 24, 1908, was constructed by the Japanese to celebrate the "full-passage of the Taiwan Longitudinal Railway" as a memorial building for the railway's opening. During that time, Prince Gong Zairen of the Japanese imperial family came to Taiwan to preside over the occasion, with Minister of Railways Hasegawa Kinsuke guiding him to rest in the pavilion. Despite its historical significance, the "Lake Heart Pavilion" lacks the luster to represent Taichung in the contemporary context convincingly.

During the Japanese occupation era, numerous landmark buildings were constructed in "Taichung Prefecture," encompassing Taichung County, Changhua, and Nantou. Notable structures include Taichung Railway Station and Taichung State Hall on Minquan Road in Taichung City. Following the Republic of China government's administration in Taiwan, the Taichung State Hall was repurposed into the old Taichung City Government Building. Prominent buildings like the "Changhua Bank" and the "Cooperative Treasury" were also established on Liberty Road.

After the Restoration, Taiwan adopted a policy of "Bringing Out Asia and Entering Europe," leading to the adoption of various Western influences, including architectural styles. As Taiwan became the first colony of this period, several large-scale public buildings were erected. The prevalent architectural trend at the time was European "Gothic" architecture. However, the use of these buildings, similar to the "Huxin Pavilion" in Taichung Park, as representatives of Taichung might be perceived as lacking legitimacy, given their association with colonial rulers.

## II. Literature Review

The National Taichung Opera House construction in the seventh phase of Taichung City's regional redevelopment plan was an extremely challenging public project. The project commenced in 1992 and spanned over 15 years to create a unique music and art center in Taiwan. However, the prolonged timeline and difficulties significantly impacted the project's progress. This article delves into the process in-depth. The Construction Process's complexity: Promoting the National Taichung Opera House project involved collaboration between local government units and the Provincial Department of Education. Establishing cooperation agreements and international competitions was crucial to ensuring fairness and professionalism. However, international collaboration brought about challenges in communication, cultural differences, and other aspects, further extending the execution period of the entire project. Efforts to Overcome Challenges: Despite facing numerous difficulties, relevant entities did not give up. Through unity and cooperation, government agencies actively sought solutions, and encouraging public participation and involvement became pivotal in driving the project forward. Policymakers and project implementers focused on streamlining procedures, enhancing decision-making efficiency, and ensuring a smooth project progression.

In conclusion, constructing the National Taichung Opera House within the seventh phase of Taichung City's regional redevelopment plan was demanding. It spanned over 15 years, and encountered various obstacles along the way. This article thoroughly examines the complexities involved in the process. In promoting the "Taichung National Opera House," the primary and most significant challenge was financial matters. The initial proposed budget for construction costs stood at 2.4 billion New Taiwan Dollars (TWD). However, from the beginning, when the Taichung City government decided to adopt the "international competition plan," the contractors involved knew that such a budget would be insufficient to construct an opera house that meets international standards. Nevertheless, for specific reasons, they refrained from openly expressing these concerns.

The challenge arose when applying for central government subsidies, as the budget mentioned above figure was used as the basis for the application. Additionally, a specific completion time was agreed upon with the central government. Failure to adhere to this "limited time" frame would result in the inability to secure the corresponding subsidies. Consequently, the organizers had no choice but to persist and proceed, adopting a "bridge the bow of the boat" mentality to keep the project moving forward. According to recollections from Mr. Xiao Jiaqi, the deputy mayor at the time, they faced immense pressure, particularly regarding the risk of falling behind the Guggenheim due to budgetary constraints, which could severely impact Taiwan's international reputation. As a result, they made every effort to seek assistance from the parliament. Eventually, representatives from Japan's Ito Office went to the parliament to explain the situation to the council members, leading to the Taichung City Council's agreement to increase the total budget to 4.36 billion TWD. Simultaneously, the central government agreed to provide a subsidy of 49% for this amount.

Throughout this period, the organizing committee had to proactively address the financial challenges, striving to balance the budget and ensuring the smooth implementation of the project. While providing adequate funding, they also had to ensure that the engineering quality met international standards to create an outstanding National Opera House, elevating Taiwan's position in the global cultural and artistic sphere. This project serves as a reminder of the importance of overcoming financial challenges and precise budget management in promoting large-scale public projects as crucial factors for achieving established objectives.

## III. Introduction to the Method

- (1) Turnkey Contract: This is a procurement method used by the government where it explicitly sets out the budget, requirements, functions, and purposes and openly invites qualified construction companies to

participate. Under this model, the construction companies form their team of architects and submit design proposals based on the government's announcement. After the bidding process is completed, an evaluation team commissioned by the government reviews and assesses the recommendations, and the final awardee is determined through a joint decision-making process. This contracting approach enables collaboration between the government and construction companies to ensure the successful implementation of the project and to deliver optimal results that meet the government's needs and standards.

- (2) **Price Bidding:** Price bidding is currently the most common contracting mode for public works; however, its main challenge lies in its tendency to lead to low-cost bidding, thereby compromising the quality of the projects. This is also one of the primary reasons for the overall poor quality of public works in Taiwan. Low-cost bidding may prompt contractors to cut costs by skipping essential steps, using substandard materials, or neglecting careful construction practices, consequently impacting the overall quality and durability of the projects. To ensure smooth progress and reliable outcomes of public works, it is essential to explore more effective contracting models and contract systems that guarantee public projects' quality and safety standards while safeguarding the interests of investors and users.
- (3) **Lowest Bid for Heterogeneous Procurement:** "Taichung National Opera House." As the first opera house in Taiwan with a unique design, the Taichung City Government approached the project cautiously to ensure its quality. Instead of adopting the "lowest price standard," the government chose the "lowest bid under heterogeneous conditions" right from the outset, aiming to ensure that this landmark opera house in Taiwan would be a lasting legacy for future generations through rigorous scrutiny. During the implementation of the "lowest bid under heterogeneous conditions," the criteria and thresholds were set exceptionally high. Although the Taichung City Government entrusted us with the opera house project, we were bound to comply with the requirements stipulated in the bidding regulations to participate in the bidding process. This approach underscores the government's cautious approach to ensure the project's superior quality standards in this significant cultural endeavor.

The following is a list of engineering difficulties encountered during the construction of the Taichung National Opera House:

- (1) The architect, Ito Toyo, is Japanese, and his way of thinking differs significantly from ours. From the beginning, the construction team faced significant challenges in fully understanding his design concept. These difficulties include at least the following: A. Traditional floor plans cannot adequately express the type of building. B. Construction personnel need to familiarize themselves with 3D drawings. C. The entire building features non-traditional curved surfaces, and the changes in the curved walls cannot be fully grasped through X-Y coordinates alone. D. Communication difficulties arise due to limited technical capabilities among the workers.
- (2) To ensure compliance with the high-quality standards set by Architect Ito, immediately after signing the contract, Ito Architects requested Liming Construction to send five engineers to Japan for a week to visit some of his projects there and understand his quality requirements.
- (3) To address the unique challenges of the entire project and reduce engineering errors and various interface conflicts, a Building Information Model (BIM) team was established in October 2009 upon deciding to participate in this project. Since we had no prior experience in this area, we had to purchase multiple sets of 3D drawing software for cross-modeling applications. The purchased software includes Rhino, Solid works, Ideas, Tekla, AutoCAD, Autodesk Revit, and Sketch Up. Additionally, experts were invited to teach and guide the team members.
- (4) Through 3D simulation planning, the entire surface of the structure was divided into 1372 units, and the height was divided into five levels. This unitary method is akin to assembling building blocks. Even minor errors during this process could result in joint misalignment or make the assembly impossible.

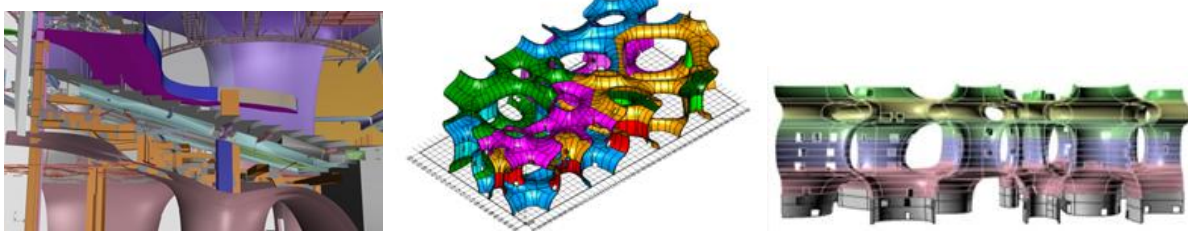


Figure 1 3D planning simulation diagram

- (5) Due to the incompatibility between the drawings and drawing programs for the cantilever steel structures of the curtain towers and auditoriums in the Chinese Theatre and the Grand Theatre, integrating the interface posed significant challenges. This construction method was encountered for the first time, leading to a wave of resignations among the personnel responsible for the drawings in the company, as they were unable to fulfill the task. Ultimately, to address the issue, Liming Construction had to take the initiative to explore and independently complete the subsequent work.
- (6) During heavy overnight rain, the house experienced water leakage, and the implementation of the curved wall and auditorium seating area's steel structure encountered significant challenges, further exacerbated by the contractor's malicious intentions. The construction project was short-lived, as the contractor deceitfully obtained a massive payment of up to 60 million yuan from the company before suddenly disappearing, leading to the heartless shutdown of the company. In response to this crisis, Liming Construction promptly activated crisis management measures. They swiftly secured a factory in the Taichung Industrial Zone and established another one on the construction site. Liming Construction not only independently developed innovative curved wall technology but also utilized this opportunity to obtain a patent for this construction method.
- (7) Due to the irregularity of the curved wall, the Ito architect team initially tried various approaches for the construction commissioned and supervised in Japan, but the results could have been better. Later, they also proposed using metal mesh to cover the curved wall; however, a consensus on the accurate fixation of the metal mesh still needs to be reached. They even considered using traditional iron wire binding. This method fails to control the structure's dimensional accuracy and poses potential issues. As a result, the initial construction specifications stipulated that the height of each grouting should be limited to 90 centimeters. The concrete used for the curved wall is 6000PSI (capable of withstanding 6000 pounds per square inch) 420KG/CM<sup>2</sup> SCC self-compacting concrete, which can self-fill without a vibrating rod and relies on external models for vibration.
- (8) To address the irregularity of the curved wall, with thickness ranging from only 40 centimeters to a maximum of 80 centimeters, iron wire binding would inevitably lead to "explosions." Collaborating with colleagues in the company, we devised the "threaded nut method," wherein nuts are welded onto circular iron plates of spacers, securely fastened with butterfly pieces and threaded nuts, and reinforced using #4 steel bars as support aggregates to fix the structure firmly. This innovative construction method increased the height of each grouting from 90 centimeters to 300 centimeters in one go, accelerating the speed threefold and achieving 100% accuracy, effectively ending the "explosion" issue. The improvement incurred additional costs of approximately 12.77 million yuan for Liming Construction (see Table 1).

Table 1 Material improvement location and the cost difference

	Raw Materials	Improved Material
The first layer of plain weave mesh	0.28mm*18mesh	0.3*18mesh
The second layer of diamond mesh	t=0.8mm sw32 Lw50	1.6t*1.6t*28mm*52mm
The third floor	Spot welded wire mesh	#4Bamboo steel bars and butterfly pieces
Remove after pouring	Cannot be dismantled	Removable
Fixed way	0.9mm #20Galvanized wire	Ball Screws and Nuts
Cost difference	-	An increase of NTD:12.77 million

- (9) Due to the distinct differences in point loads and surface loads that the curved wall has to bear, its support method becomes a crucial challenge. Before construction, we conducted stress analysis through computer simulation and preplanned "subsidence observations," performing weekly monitoring. Thanks to strict control over construction quality, the variation of the curved wall remained significantly lower than the design value. The structure remained intact and unaffected even when encountering several earthquakes during the construction process.

#### IV. Results and Discussion

The Opera House's walls are constructed with irregular curved designs, making using ceiling partitions to accommodate air-conditioning pipelines impractical. As a result, we adopted a rare and unique construction method in Taiwan known as the "floor radiant cooling system" to replace all the air-conditioning systems in the project. This innovative system delivers cool air from the floor, preserving the aesthetic appeal of the curved walls while optimizing available space and achieving highly efficient air conditioning.

Furthermore, the interior walls of the Opera House exhibit irregular curves, making it impossible to install the conventional "smoke-proof hanging version" fire protection system. In response to this challenge, we introduced a specialized fire protection system called the "water curtain waterproof equipment," suitable for unique spaces. This is also the first time that this type of fire prevention device has been used in China. The device has obtained approval from the relevant regulatory authorities. In the event of a fire, it can generate mighty water columns at specific intervals to suppress the fire, isolate a safe area, and achieve the objectives of on-site fire protection and safety objectives. Due to this case's entirely irregular overall structure, special attention needs to be given to various safety measures. Additionally, this case has garnered global attention. Therefore, during the implementation process, the responsible labor inspection unit almost adopted an urgent method of marking personnel and conducted inspections at the construction site at any time.



Figure 2. On-site personnel construction drawings (a)



Figure 3. On-site personnel construction drawings (b)

#### V. Conclusions and Recommendations

The business types in the construction industry can be roughly divided into two categories: one is "civil engineering" related to land and water projects, including contracting roads, bridges, tunnels, harbors, and other projects; the other is "building construction," which includes schools, restaurants, residential buildings, factories, hospitals, villas, shopping malls, office buildings, and public works projects.

Initially, Liming Construction's primary focus was on building construction. In the early days of its establishment, the company mostly took on projects in the central region due to a lack of established reputation.

However, in 1997, the "Asian Financial Crisis" erupted, leading to the closure of many construction companies. As a result, the company faced numerous bad debts and encountered significant challenges. After weathering this crisis, the company shifted its focus toward developing projects with a sound financial system. As a result, they proposed "schools, factory offices, and supermarkets" as the main development direction. On September 21, 1999, a major earthquake occurred in Taiwan, the most significant in the past 100 years, severely damaging many schools. The government, private enterprises, and charitable organizations focused on restoring school classrooms. In this context, Liming Construction also took on numerous school projects, marking the beginning of the company's involvement in public projects.

Due to the cooperation with the Taichung City Government, we established an excellent interaction based on our previous projects. Eventually, we were entrusted once again to undertake the Taichung National Opera House project. This project's high difficulty has been acclaimed as one of the most challenging buildings in history. With the joint efforts of our company team, we overcame numerous challenges and completed this project, earning us multiple awards. It is a great honor for us to have received the prestigious "Architectural Figure of the Year 2015" award, which is presented only once a year.

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