The Cultural and Technological Elements That Promote the Advance of History: Research on the Evolution of Architectural Structure

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Abstract. Based on the research on the evolution of architectural structure, this paper reflects on the elements that push history forward. We analyze the influence of the cultural and technological elements on the architectural structure, and conduct further analysis by combining such two elements. For the analysis by means of such combination, we firstly take the assembly space as an example to provide a framework which combines the historical time and the physical space. At the intersection of the two directions, we list some classical buildings and then describe the cultural and technological elements that influenced them one by one. Similarly, we illustrate the characteristics of some Chinese bridges and some landmark buildings at different stages, as well as the cultural and technological elements which influenced them. Besides, we clarify the development relationship between the two elements on the basis of a large number of cases. Through introduction of some academic viewpoints, this paper analyzes relevant data, researches the cultural and technological elements that influenced the architectural structure development, and has eventually clarified the relationship between these two elements. It is not difficult to find out that the cultural and technological elements were interdependent in the history of architectural structure development, but resulted in separation of them. The cultural element is primarily embodied in the design partition by architects of the external and internal spaces of a building to satisfy the requirements for functionality and aesthetics, while for the technological element, the structure engineers are in place to ensure the quality of buildings. We can see that in the near future the breakthroughs in science and technology will eclipse the technological element, while the cultural one will become the only significant factor that influences the architectural development.

Introduction

In the development of civilization over the past thousands of years, human beings had always created wonders during the progress.

After countless times of compromise and struggle, the sound of a bomb at the Bastille raised the curtain of the French Revolution. In this unprecedented battle against tyranny, the enlightenment thoughts such as natural rights and separation of powers had found an excellent experimental field. The rapid development of capitalism in France had tremendously diffused the ideas of progress with respect to freedom and democracy, and made indelible contributions to the development of the modern capitalism.

With the progress of thoughts and culture, the earthshaking reformation had also happened in the fields of science and technology. With the exploration of generations, mankind had eventually ushered in the Industrial Revolution in the 19th Century. The great invention of steam engine and a large number of machines had substantially promoted the productivity and the subsequent emergence of internal combustion engine made it possible for mankind to conquer the sky. Now electronic computer and integration network have pushed the civilization to a new level.

Coincidentally, architecture, an industry closely related to life and production, had experienced
great evolution in the fast-changing development. The people in the primitive society could only use timber or local materials to build shacks as a shelter. Architectures in the early slavery society, like the Ancient Egypt and Greece, had been confined to small inner space. Individual architecture emphasized the mystification of the outer space or the narrow space inside a building. Just like the Khufu Pyramid with the length of the base side of 230 meters and the height of 146 meters, it had used a total of 2.6 million pieces of stone, each of which weighed 2.5 tons; however, the tomb inside had an area of less than 50 square meters.

Nevertheless, Romans used a new material-Roman concrete-to create a new structural form of a large-span roof by means of the new barrel vault, groin and cross vault, and then acquired the continuous and compound architectural space; as the result, a building had become a piece of authentic architecture. It was just the emergence of the new-type building material created in the Ancient Rome times that had facilitated the emergence of the new structural form and further rendered the new and larger interior space for human activities. For example, the Baths of Caracalla in Rome could accommodate nearly 2,000 people, the dome of which had a span of vault of 53 meters.

![Figure 1. High Cathedral of Saint Peter.](image)

The architects in the Middle Ages had inherited the technology of the Roman cross vault, on the basis of which the form of vault had been further developed and the new system of beam columns which was similar to that of the frame structure system was invented, further creating the Gothic churches. Fig. 1 is the famous Cologne Cathedral.

After the Industrial Revolution, the appearance of new building materials like reinforced concrete with brand new architectural ideas brought great changes to large framed buildings. Also the generalization of truss structure and cable-suspension structure had provided great supports for the development of modern architecture. For example, the Eiffel Tower which was completed in 1889 had a height of 300 meters. Currently, some advanced concepts such as compound-type tensegrity and membrane structure have kept injecting new blood into the construction industry.

So what lead the construction industry to develop? Fundamentally, it is the unlimited possibilities provided by the demand for cultural progress as well as science and technology. The paper conducts a brief discussion about the achievement obtained from the research on the development of the architecture from the levels of culture and technology.

**Related Research Work**

Here are some similar works by others. Professor Su Chaohao asserted that structural element developed in the form of deconstruction. From the evolution of girder and truss to BSS (Beam String Structure), we can see that with the progress of deconstruction, structural strength was improved because of division of work among components on the one hand; the proper separation of components helped achieve higher integral rigidity with the equal material consumption so as to master a larger spatial scale on the other hand [1][2].
Fig. 2 is the analysis of the deconstruction of the evolution of structural element. The digestion and feedback of the input of technological and cultural elements from the environment are reflected on the synergic relation with the architectural system in a historical and dynamical manner. Such synergic relation is embodied in the three stages as follows:

1. Interdependent: From the ancient period to the Renaissance Period, the society witnessed the backward productive force, the social consciousness was at a low level, the architectural technology was at the stage when experience predominated, and the development of the architectural system was slow and repeated between advances and retreats. Structure was inseparable from architecture, demonstrating the artistry of architecture while accomplishing the technical mission; and technological and art were interdependent.

2. Separation and confrontation: In the laissez-faire capitalism in the modern time, scientific rationality had gained great respect and the demand for socialized mass production stimulated the rapid development of science and technology. This in practice had led to the extremely imbalance between the technical and artistic development inside the architectural system, with the outstanding difference being embodied in the fast development of the structure technique. The structure and architecture began to go their own ways, the separation of which was embodied in the division between structure and the building industry and profession, as well as the opposition between architects and structure engineers.

3. Multiple composition: A remarkable feature of the generation and development of the modern architecture was the application of new structure and materials, which commenced with the synergy between structure and architecture, technology and art, thus becoming a new-round recombination with the structural technology as the leading element.

In Wu Xuyang’s opinions, the architectural history is an evolutionary history of structure, as well as a development history of mechanics, but a point has been proved that both the architectural mechanics and structure play an important role in architecture. When looking back, we could not help but sighing with emotion about human being’s wonderful thinking and its skilful manipulation of the architectural mechanics, while feeling awed at the great power of nature[3].

Cui Jin held that there existed the interconnection between structure and architectural form in many aspects—from the fact that the architectural form is completely determined by structure to that that the demand for structure has been entirely neglected at the time of determining the form of a building and its aesthetic value. Specifically, the process includes the structure of decoration, the structure as ornament, the structure as a building, the architectural form produced by structure, the structure’s being accepted and the structure’s being ignored. [4].

The Cultural Element that Influenced the Evolution of Architectural Structure

In the prehistoric period, aboriginals generally used crude timber or local materials to build shelters, primarily to guarantee safety and convenience for farming or grazing. There was a lack of the demand for the beauty of architectural art, as well as the lack of the capability of building a large assembly space despite of the demand therefor. After the advent of the slavery society, some advanced civilizations had built some well-known buildings. Egypt Pharaohs had mobilized hundreds of thousands of slaves to build the magnificent pyramids, inside which narrow and small passages were arranged to emphasize the mystery of the nether world. Greek architects used white marble to create the Parthenon Temple, whose elegant and slightly curved uprights were regarded as treasure left by the Greek civilization to the entire world. People at that time had got used to
constructing large temples where religions and deities were worshipped, but the inside space was still simply straight and square. Roman rulers liked to build grand temples for gods to seek for blessing or highlighting achievements. The Pantheon built with Roman concrete had successfully introduced a large vault and the circular opening at the center of the vault to let in the soft diffused light which illuminated all living creatures below. In the peaceful atmosphere, the buildings with the religious significance reminded people of some subtle links human beings and gods. Hagia Sophia was another architecture that had successfully raised the echoes of people for religion. The light had produced a feeling of surpassing material on the spherical surface of the exquisite and unimaginable dome of the church. “It seems that the vault does not sit on the solid walls, but hung by a golden chain from the sky to cover the space of the hall.” According to people at that time, when the last Mass was held in the Cathedral, believers of the West and East Churches embraced each other as if they had all entered the Kingdom of Heaven. This must be the dream sought after by every architect.

After the fall of the West and East Rome one after another, Europe entered the Dark Middle Ages. The wide spread of Christianity had caused the emergence of a number of Romanesque churches. In order to urge people to devote themselves to the religion, Romanesque churches employed the heavy and gloomy structural form, which made the devout believers in the Middle Ages full of horror of the hell and thus pray for God’s blessings. History had always experienced the spiral development. Later the upsurge of liberalism brought the possibility for the luxurious and elegant architecture in the Greco-Roman Period, witnessing the emergence of the vintage Gothic churches at the right time. The Gothic churches which swept across the continent of Europe within a short time were different from the plain or even gloomy Romanesque churches. The Gothic churches reflected the trend of humanism, like a beam of light passing through the dark ages. Take Cologne Cathedral as an example, the light from the lower side had liberated itself, inspiring people’s longing for the more mysterious space. Through the bright and lively but unmeasured stained glass, the lights which passed through the slim columns mixed with the shadows produced a formidable but wonderful effect as well as a wonder of mystery and transparency thanks to the struggle of the rough stones in the competition. Meanwhile, the round rose windows, the stained glass frescoes, the decoration of a variety of agile and elegant carvings as well as the rising pinnacle had combined to bring the feeling of being close to God and the Heaven, while teaching people to love and fear God. Accidentally, the architecture of the Oriental, such as the temples in China and Japan, also developed in the direction of liveliness and brightness; for example, Gojunoto at Hōryū-ji demonstrated the slender and delicate aristocratic style.

Since the Industrial Revolution, the emergence of new building materials and ideas had opened a new door for architecture. People pursued for high-rise buildings which challenged the skylines in the increasingly crowded metropolises. Gifted engineers had skillfully used reinforced concrete and brand-new truss structure, among which Fazlur Rahman Khan was the champion. The Sears Tower in Chicago was Khan’s favorite work, which employed the bundled tube structure made by steel frames, while the surface of which was covered by black aluminum walls and coated glass curtain walls. The form of bundled tube created with the combination of architectural design and structural innovation divided the tower into nine units, and the forms of facades in different directions were different. Such individualized innovation encouraged the universal creation. After Khan passed away, numerous architects and engineers learned from him in the challenging creation of a variety of skyscrapers beyond our imagination, and the history of architecture had entered an unprecedented new stage. Nowadays the birth of composite tensegrity and membrane structure will further meet the demand for super assembly space. This combination that might make the outer surface into any form had created the ultramodern and green buildings, which had acquired the future style and could satisfy the needs of environmental protection. Not hard to see that the development of social culture and the demand for aesthetics had also guided the evolution of the architectural industry.
The Scientific and Technological Elements that Influenced the Evolution of Architectural Structure

In Su Chaohao’s point of view, there were two sources of the human architectural structure progress: experience and science. Technology from these two kinds of knowledge was called respectively “experiential technique” and “scientific technology.” With the progress of human civilization and the upholding of scientific rationality, the progress of structural technology showed the evolution law from the stage with experiential technology as the leader to that with scientific technology as the leader when we examined it from the ability of thinking of “man,” the behavioral intermediary in the evolution of structural evolution.

Fundamentally speaking, experience is a kind of memory of human brains, including natural and social phenomenon and human behavior; therefore, the structural technology based on experience can directly or indirectly find its “prototype” from the natural phenomenon. In other words, structural technology based on experience is the model or analogy of the natural phenomenon of a certain form, such as the tents of nomadic people and the hanging spider webs, as well as the Egyptian pillars and big trees’ trunks. Greek and Roman column types also followed the technical style of such simulation, and other examples even included the Gothic architecture in the Middle Ages, whose towering columns and pointed arch structure seemed like thick forests. Just like what Hegel described: “When I see the solid columns and the dome on top of them which seem to meet the purpose of mechanics, I would at least think of the dome vault supported by a wood…….” Gothic architecture means on the basis of inheriting the technology of Roman cross vault, it developed the cross vault into 4-class bone vault, while converting single-centered vault into double-centered one, thus forming frame-style and double-centered pointed vault. Meanwhile, the side thrust produced by the vault was passed to the cross wall outside through the flying buttress wall, a new mechanical component. In such way had the whole structural system demonstrated the whole process of bearing capacity of the frame: the load of the roof was transmitted to the pointed rib bed vault-columns (vertical force)-foundation-base, while the horizontal thrust produced by the vault was transmitted to the cross wall, then to the foundation and then the base. At this time the rib bed vault developed into the form of beam column and replaced the classical pillar, reaching the perfect combination of structure and form of Gothic churches in the Middle Ages. Cologne Cathedral, whose construction started in 1248, has been praised as the most perfect paragon among all Gothic churches. It covers an area of 8,000 square meters with the covered area of approx. 6,000 square meters. It has a length of 144.55 meters from east to west and a width of 86.25 meters from south to east. At the center of the cathedral stand two steeples connected with the door wall by bricks. Its southern steeple has a height of 157.31 meters, while the northern one 157.38 meters; hence it had become the second tallest steeple in Europe. Eleven thousand small steeples had been arranged to serve as a background for the two high steeples, which reached to the sky just like two sharp swords. In total, 400,000 tons of stone had been used to complete the whole project (Fig. 3 and 4).

![Figure 3. The inside view of vaults in the Cologne Cathedral.](image1)
![Figure 4. The force flow of the Gothic Cathedral.](image2)

The scientific structural technology is not “the prototype” directly from the nature, but “the
rational structure” formed through the abstraction of the structural phenomenon, creating “existence” from “non-existence.” Once the rational model is established, people can deduce through theory and then generate the rational configuration. Therefore, its development tendency gradually deviates from the prototype in the nature. Scientific theory is essentially the results of men’s innovative thinking, but men’s innovation has no limit, so the structural technology created on the basis of the scientific theory represents the development direction of the structural technology and leads the thinking of designers. For example, after the Industrial Revolution and along with the industrial development in the mechanical times, a large amount of artificial materials, which were pure in nature and had been authenticated by experiments and produced by some certain raw materials, had been put into use; and structural steel and newer reinforced concrete were the pure results of computation, which guaranteed the accurate and full use of such materials. Consequently, the new changes in the architectural form brought about thereby had been embodied in the architecture by large frames. The Eiffel Tower is the paragon of the scientific structural technology.

Completed in 1889, the Eiffel Tower is 300 meters tall and its antenna is 24 meters tall, with the total height of the tower of 324 meters. It consists of a myriad of isolated steel elements, which looks like a bunch of model elements. It has 18,038 steel elements, which weigh a total of 10,000 tons. A total of seven million holes were drilled and 2.5 million rivets were used in the project. During the construction, Architect Eiffel had created many innovative technologies: (1) Different from other large constructional projects, he had manufactured all components inside his workshop. This means that these components could be quickly installed after they were delivered to the construction site; (2) Every rivet hole was drilled within the tolerance of 0.1mm in advance so that 20 riveting groups could assemble 1,650 rivets every day; (3) Every element used to build the tower weighed less than three tons so that even small cranes could be widely used. It took one year to build the base and more than eight months to complete the iron tower. The whole project was completed on March 31, 1889. A total of 5,300 drawings were conducted by 50 architects. Eiffel’s calculation was very accurate: the factory at Levallois-Perret produced 12,000 components of different specifications, none of which required modification and no accident occurred during the construction period of two years.

The Blend of Cultural and Technological Elements Influenced the Evolution of Architectural Structure

We illustrate how the interaction between cultural and technological elements influences the evolution of architectural structure by two examples.

Assembly Space

We firstly take assembly space as an example to propose a framework that combines the historical time and the physical spatial scale. At the intersection of two directions, there are some classical buildings that we use to describe the cultural and technological elements that influenced these architectural structures one by one.

Table 1. The Evolution of Assembly Space.

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<tr>
<th>Physical spatial scale</th>
<th>More than 20,000 M²</th>
<th>D Colosseum</th>
<th>G St. Peter's Basilica</th>
<th>I Crystal Palace</th>
<th>L Tokyo Dome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Huge(20,000 M²)</td>
<td>E Cologne Cathedral</td>
<td>F Florence Cathedral</td>
<td>H Eiffel Tower</td>
<td>K Sydney Opera House</td>
<td>J Yoyogi National Gymnasium Natatorium</td>
</tr>
<tr>
<td>Large(5,000 M²)</td>
<td>C Hagia Sophia</td>
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In Fig. 1, there are two dimensions: the horizontal dimension and the vertical one. The former represents the historical time axis, while the vertical one represents the change of the physical spatial scale. The horizontal dimension has been divided into five stages: the Ancient Greece and the Ancient Roma, the Middle Ages, the Renaissance Period, the contemporary time and the modern time, while in the vertical one, the measure increases from lower to upper in proper order, respectively small, medium, large, huge and that which exceeds 20,000 square meters. We will describe them one by one as follows.

A. Parthenon. Its intercolumniation is 4.3 meters and it adopted the Doric style consisting of eight columns. On the east and west side stand eight columns, while 17 columns on the north and south side respectively. The width from east to west measures 31 meters, while that from north to south 70 meters. The top of the gables of the two facades on the east and west (the facades of the whole temple) is 19 meters from the ground. In other words, the proportion of the height and width of its facades is 19 to 31, close to the favorite "golden section," which was popular among ancient Greek people. The temple itself is magnificent with the exquisite carving and the entire architecture looks graceful and magnificent.

B. Pantheon. The diameter of its dome is 43.3 meters; the width of its base is 7.3 meters; the thickness of the walls and the dome bottom is 6 meters; and the thickness of the top of the dome is 1.5 meters. In order to make the decrease in the thickness of walls of the dome become beneficial to the stability of the whole architecture of Pantheon, the walls of its dome was divided into 5 rows and 28 lattices in an orderly manner. Each lattice was carved and sunken from upper to lower, which not only made the decrease in thickness more reasonable, but also increased the artistic sense of the interior of the temple. The lights coming through the round hole at the center of the vault in combination with the peaceful and quiet atmosphere reminded people of a certain subtle link between man and God.

C. Hagia Sophia. The church was completed in 537, with the diameter of the vault of 31 meters and the height of the top of 56 meters. It created the open space made by the dome and four ribbed arches. The transitional components that used the dome as the square space to transit to the cylinder space had acquired the extreme originality. The two giant buttresses and the continuous semi-circle dome had successfully solved the horizontal thrust of the large central dome not only in terms of modeling, but also in terms of space. Below the incredibly exquisite vault, the lights produced a feeling that surpassed matter.

D. Colosseum. It has the perimeter of 527 meters and the height of 48.5 meters. Its long axis is 188 meters, while its short axis 156 meters. The long axis at the central “performance area” is 86 meters, while the short axis 54 meters. It was transformed from Nero’s artificial lake. Although only half of the framework is left, the majesty and vastness of the Colosseum can still be felt.

E. Cologne Cathedral. Built in 1248, Cologne Cathedral has been praised as the most perfect paragon of all Gothic churches. It covers an area of 8,000 square meters and the covered area of approx. 6,000 square meters. It has the length of 144.55 meters from east to west and the width of 86.25 meters from south to east. At the center of the cathedral stand two steeples connected with the door wall by bricks. Its southern steeple has a height of 157.31 meters, while the northern one 157.38 meters; hence it has become the second tallest steeple in Europe. A total of 400,000 tons of stone had been used to complete the whole project. It has been well-known for its lightness and elegance, or we can say that it is the most beautiful Gothic church in the world.

F. Cathedral of Saint Virgin Mary at Florence. Completed in 1470, the cathedral blended the
construction technique and the Romanesque style. The dome of the Florence Cathedral marked the beginning of the architectural history of the Italian Renaissance. The dome stands on a drum with a height of 55 meters (180 feet); the opposite sides of the octagon span for 42 meters (138.5 feet), the vault rises more than 30 meters (100 feet); hence, the church looks like a gentle ogive. The dome of the Florence Cathedral had been rightly considered as the first architectural work of the Italian Renaissance, as well as the first primrose of the new era.

G. St. Peter’s Basilica. Completed in 1589, St. Peter’s Basilica for the first time represented the theoretical discussion about the design method of the mechanism of collapse. In accordance with “the Virtual Displacement Theory,” the designer added five iron hoops to the vault, indicating the end of the age which featured the long-term reliance on the accumulation of experiences and feeling, as well as the beginning of the age which introduced the scientific and objective evaluation methodology. The steel structure was in the shape and the time would witness great changes.

H. Completed in 1889, the Eiffel Tower is 300 meters tall and its antenna is 24 meters tall, with the total height of the tower of 324 meters. The Eiffel Tower consists of a myriad of isolated steel elements, which looks like a bunch of model elements. It has 18,038 steel elements, which weigh 10,000 tons. A total of 7 million holes were drilled and 2.5 million rivets were used in the project. During the construction, Architect Eiffel had created many innovative technologies. This unprecedented steel architecture aroused fierce controversy in the Paris community. Many celebrities in the circle of literary and art opposed to the construction of the tower, claiming that it had damaged the elegance of Paris. Maupassant, a firm opponent of the tower, was asked why he kept dining at the restaurant under the tower every day, he replied, “Yeah! Because it is the only place from which I could avoid seeing it in the whole area of Paris.” However, history had eventually affirmed the architecture, which perfectly combined mathematics beauty with visual beauty. Nowadays, France is proud of such a landmark building.

I. Crystal Palace. The building, which was completed in 1854, was ever used as the exhibition hall of the First World Expo. It had consumed 900,000 square feet (equal to 84,000 square meters or eight and a half standard football fields) of glass, shocking the visitors from all over the world. The burn-down of this architecture was regarded as “the end of an age.”

The 20th Century, a challenge to possibilities

J. Yoyogi National Gymnasium Natatorium. The suspension cable roof structure with the high tension cable as the main body to create the large inner space with a feeling of tension and flexibility. The new architecture with a unique form and an excellent spatial feeling has been widely praised in the world architectural circle for its great structural skills and reasonable plane arrangement.

K. Sydney Opera House. The building covers an area of 1.84 hectares, with the length of 183 meters, the width of 118 meters and the height of 67 meters, equivalent to the height of 20 floors. It adopts the thin-shell structure made of precast concrete. It is the landmark building of Australia and one of most distinctive buildings in the world in 20th Century. In 2007, it was selected by UNESCO as the World Cultural Heritage.

L. Tokyo Dome. It is 45,000-seat multi-purpose stadium, ever serving as host to many international sporting events and entertainment. Its egg-shaped roof was made of the elastic film, and can generally control the air pressure inside the dome at 0.3% higher than the outside to maintain the appearance of the egg-shaped dome.

Evolution of Bridge Structure in China

Here we give another example to illuminate how the evolution history of Chinese bridge structure was influenced by the blend of culture and technology. We divide the evolution history of Chinese bridge structure into multiple stages and illuminate them one by one.

The first stage: the Western Zhou Dynasty and the Spring and Autumn Period. In this stage, the representatives of structure included the original single-plank bridge, the Tingbu bridge (stepping stone on water surface on which people cross a river or a stream), the girder bridge made of timber structure and the floating bridge, verifying that the backward productivity level, the use of wood
materials and the understanding of wood structure are the cultural and technological elements.

The second stage: It mainly includes the Qin and Han Dynasties, including the Warring States and the Three Kingdoms. At this stage, people had learned to use masonry in the design and construction, and the arched structure appeared; besides, people also used ironware to create such new components as stone columns, stone beams and stone bridge surface. The four major bridge types of girder bridge, floating bridge, rope bridge and arch bridge were all formed at this stage.

The third stage: The Tang and Song Dynasties. Unity and stability had been secured for a long time, with prosperous culture, in which the famous Zhaozhou Bridge was created. It is an empty-belly arc-shaped stone bridge and the earliest and best-preserved large stone arch bridge in China. Zhaozhou Bridge had been selected by the World Record Association as the oldest stone arch bridge with exposed shoulders in the world, thus creating a world record. Joseph Needham said, “Arch bridge is also regarded as the great masterpiece in the West; however, Li Chun, the outstanding artisan in China erected an arch bridge in 610AD, which can be comparable to that in the west, and even preeminent in terms of skills.” The similar bridge didn’t not show up in Europe until 1397 (about 700 years later according some records).

The fourth stage: The Yuan, Ming and Qing Dynasties. The year of 1881 witnessed the technological revolution and the operation of the first railway. The enhancement of the technology of building rope bridges was exemplified by the Wannian Bridge at Nancheng in Jiangxi and the Panjiang Bridge in Guizhou built in the Ming Dynasty.

The fifth stage: The contemporary time, the Republic of China as well as the early period of New China and the Cultural Revolution. The Qiantang River Bridge is the representative landmark, a two-layered bridge for both railway and road traffic. It serves as the vital communication line which spans the south and north of the Qiantang River, connects with the Shanghai-Hangzhou-Nanjing Railway as well as the Zhejiang-Jiangxi Railway.

The sixth stage: Since the 1980s, China’s bridge technology started to improve, China entered a new period of reform and opening-up and its economy started to recover. The 110-meter Jiangmen Waihai Bridge and the Panyu Luoxi Bridge, a prestressed concrete continuous steel structure bridge with the span of 180 meters could represent the highest level of beam bridge in China in the 1980s; and then the Yangpu Bridge in Shanghai whose construction commenced in 1991 was another leap in the Chinese bridge history. It was a composite girder cable-stayed bridge. When it was completed in 1994, it became the cable-stayed bridge with the largest span in the world; hence, it was another milestone of the China’s long-span bridges, certifying that China was moving on the path to a world power in the field of bridge construction. In the aspect of arch bridge, the Sichuan Wanxian Yangtze River Bridge with a span of 420 meters had pushed China to the first place in terms of span of bridge. In 2008, the 8,146-meter Sutong Yangtze River Bridge was officially opened, which consisted of 113 piers, 92 of which stood in the river water. The No.68 and 69 piers served as those of the main tower, each of which cost approx. 600 million yuan, offering a spectacular scene. The piers had the length of 114 meters and the width of 48 meters, equal to the size of a football field, with the thickness of 9 meters. 50,000 cubic meters of concrete were consumed. The base of the pier consisted of 131 bored piles with the diameter of 2.5 to 2.8 meters each. The pier had the length of 120 meters. It was the bridge pile foundation which had the largest scale and was buried the deepest; therefore, it set the first world record for the Chinese bridge construction industry[6][7].

Conclusion

Through introduction of some academic viewpoints, this paper discusses and analyzes relevant data, deeply researches the cultural and technological elements that influenced the architectural structure development, and has eventually clarified the relationship between these two elements. It is not difficult to find out that the cultural and technological elements were interdependent in the history of architectural structure development, but resulted in separation of them. The cultural element is primarily embodied in the design partition by the architect of the external and internal spaces of a building to satisfy the requirements for functionality and aesthetics, while for the technological element, the structure engineers are in place to ensure the quality of buildings. In
ancient times, only a few stable structures were regarded as being able to sustain the building based on experience due to the restriction of technical concepts with respect to material and architecture. At that time, engineers determined all things related to architecture, while architects could only adjust and beautify the architectural appearance as per the framework with the determined structure. In this aspect, even the magnificent Pantheon and the delicate Florence Cathedral were no exceptions. With the breakthrough in science, as well as the invention of steel structure and bundled tube structure, architects had for the first time acquired the equal status as engineers. All structures tended to be stable and reliable and the importance of structure declined so that architects had eventually acquired room to demonstrate their talent. Under the support of mature structures, skyscrapers in cities and colossal domes had demonstrated the ambition of architects. The widely use of composite materials and the flawless analysis by electronic computers on mechanics structure had made it possible for the application of nearly any structures in modern and future buildings. Consequently, the significance of architecture rests with the design of architects, while engineers shall only be responsible for figuring out suitable structures to support the design. In the same manner, technological breakthroughs will weaken the influence of technological element in the near future, and cultural element will become the exclusive significant factor of influencing architecture so that any innovative design could come true in the future. Now, the demand for aesthetics and functionality has finally got out of the restriction of structure and architects will be able to create wonders with their inspirations and passion in the future architecture.

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