Analysis of the Sustainability of Bridges

Hung Wai Hang
GuangDong Country Garden School, Foshan, China, 528100
Author’s Email: 2729807651@qq.com

Abstract. Bridge is an indispensable infrastructure since ancient times, and the structure types of bridge are divided into beam type, arch type, cable-stayed bridge and suspension bridge. Bridges need to be safe and strong for a long time. Architects are always looking for ways to make Bridges last longer. This paper analyzes the sustainability of bridges. The way to extend the service life of the bridge will be discussed.

1. Introduction
The sustainable design, construction, and use of buildings are based on the evaluation of the environmental pressure (related to the environmental impacts), social aspects (related to the users’ comfort and other social benefits), and the economic aspects (related to the life-cycle costs).[1]

Through the data, it is found that the bridge structure, the material of the bridge and all aspects of the bridge have a great impact on its sustainability and service life. By consulting bridge drawings and papers, people will learn about various aspects of some bridges, such as hollow piers. Hollow bridge columns have become increasingly popular in bridge construction during the last few decades. Hollow sections are often used for tall bridge columns to reduce their mass, reduce seismic inertia forces, and reduce foundation forces.[2]

2. Suitable building materials
The materials used for bridges are important for the sustainability of bridges. In areas of highly corrosive environments, salty lakes and oceans, we need to choose cement raw materials with high permeability and corrosion resistance, such as those containing chloride, sulfate and silica fume. Many sea crossing bridges use anti-corrosion, and the most famous Hong Kong Zuhai Macao Bridge is a very good example. How the Hong Kong Zuhai Macao Bridge achieve anti-corrosion, it is found that the materials of Hong Kong Zuhai Macao Bridge are not only cement materials with high permeability and corrosion resistance but also a kind of high-performance coated steel bar technology. Located in an area with high temperature and humidity, the steel box girders and reinforcing bars in concrete structures of the HZMB will be severely affected by corrosion, and many countermeasures have been taken to guarantee the 120-year design service life of these structures. For steel structures, they are externally covered with C5-M level anticorrosion coating, including epoxy zinc-rich primer, epoxy mica iron intermediate paint, and fluorocarbon topcoat. The internal faces of the steel structures are covered with thinner anti-corrosion coating. Some dehumidification systems are also applied to ensure that the relative humidity of the inside air is under 50% (Meng et al., 2014a). For reinforced concrete structures, the pile-caps and pier columns are pre-cast as a single unit to avoid un-friendly wet connection works in the sea. Some new materials and construction techniques are also applied, such as high performance stainless steel rebar, epoxy coated rebar, and silane impregnation for concrete.[3] In the case of marine environmental corrosion, sisal fiber can effectively improve
concrete strength. With the increase in sisal fiber content, the compressive strength of concrete generally increases compared with concrete without sisal fiber.[4]

3. Good Bridge Support and Replacement of Bracket

The selection of bridge support can be divided into two parts: easy replacement and strong bearing capacity. The method to replace the stent more easily should be taken into consideration.

3.1. Set up support and construction platform

The abutment BAI support replacement uses abutment as a construction platform. Space is not enough parts of the support measures to ensure the safe implementation of construction. For the replacement of pier support, the use of special steel hangers fixed on the pier or cover beam as a construction platform.

3.2. Clean the top surface of the platform cap and cover beam

The soil stones and concrete blocks deposited on the top surface of the cap or cover beam should be cleaned up. When necessary, steel fiber can be used to clean up the concrete garbage, using a wire brush or clean the top surface of the table cap or cover beam to ensure that the working surface is clean and tidy when the support is replaced. The garbage and debris deposited in the expansion joint can be cleaned up to prevent the extrusion between the inner beam body of jacking.

3.3. Support investigation and re-inspection

To replace the support parts of the confirmation and inspection, on-site record the position of the support, number, disease, and take photos, photos should be taken of the complete construction process. The original state, replacement process and replacement completion, properly save the inspection records as one of the delivery documents.

It is necessary to check whether the original bearing model is consistent with the model provided by the design institute, and determine the jacking weight and the type and number of jacks according to the design bearing capacity of the bearing, measure the beam bottom elevation and review it according to the beam bottom elevation provided in the design drawings, and record the review in detail and properly keep it as one of the documents to be handed over.

According to the measurement records to determine the adjustment height of the top surface elevation of the bearing cushion stone, for the need to replace the ordinary support for the PTFE bearing, the top elevation of the bearing pad stone after transformation should be determined according to the model and height of the PTFE bearing to be replaced, so as to ensure that the bridge elevation after the replacement of the bearing meets the design requirements.

The bridge bearing is an important component in the bridge system. If the disease is serious, it must be replaced. A kind of suspended support composed of section steel is used to replace the bridge bearing. The support is suspended on the bent cap as the support platform for lifting the bridge Jack. After lifting a certain height, the bearing is replaced. At the same time, the safety of the whole structure should be checked, This method is easy to operate and has little influence on traffic.[5]

3.4. The most gravity bearing structure of bridge

The superstructure of bridge is divided into suspension type (cable-stayed bridge and suspended plain bridge), beam slab type (continuous beam, simply supported beam and continuous rigid frame), and arch type (basket type arch bridge, through type arch bridge and type arch). The substructure of bridge is divided into pile foundation, expanded foundation (concrete foundation, stone foundation) and gravity foundation (one-way thrust pier and abutment).

Bridge span has the strongest bearing capacity. The smaller the bridge span, the stronger the bearing capacity. From the appearance, the arch structure has the strongest bearing capacity. Because the arch structure is affected by the weight of the material, it can not design a large span. In addition, the substructure required by the arch structure is relatively strong (because the arch has to produce a
lot of thrusts when it is stressed), so the bearing capacity of the arch bridge and the force should be maximum.

The ultimate bearing capacity of a bridge structure refers to the maximum bearing capacity of a bridge under external load, which is corresponding to the maximum bearing capacity of the structural members, fatigue failure or deformation that is not suitable for continuing bearing capacity.[6]

3.5. Material with a strong load-bearing capacity

3.5.1 Concrete. Most of the prestressed concrete bridges built in China are made of C40-C50 concrete, and then plastic concrete is prepared with additives such as water reducing agent, and pumping concrete technology is developed. With the increase of bridge span, in order to reduce the dead weight of bridge structure, concrete gradually develops towards high strength and light weight. As a modified material of concrete, micro silica powder high strength concrete has the characteristics of easy pouring, overall compaction, long-term stability and high strength, which can improve the internal quality of buildings and has great promotion and application value in the bridge construction market.

3.5.2 Rolled steel. The prestressed steel used in Bridges has been developing towards high strength, low relaxation and large diameter. At present, the prestressed steel mainly includes three categories: high strength steel wire, steel strand and high strength coarse steel bar. The higher strength of prestressed steel, sometimes increases the risk of hydrogen stress corrosion. These adverse characteristics should be paid attention to.

3.5.3 Prestressed steel. The post-tensioning process is greatly simplified by the use of large tonnage prestressed steel beams. For the bridge constructed by suspension casting, the number of prestressed beams in each cycle can be greatly reduced, and the anchor points can be fixed on the section through the flat bending of the prestressed beams, which greatly saves the time of the processes such as beam crossing, tensioning and grouting, so as to speed up the construction progress. In addition, the large-tonnage prestressed beam is easy to be distributed. After reasonable selection, the structure size can be enlarged due to the difficulty of distribution, resulting in material waste, and the complex anchor tooth block can be reduced, so as to simplify the template and speed up the construction period. However, its strength and stiffness are slightly lower than those of the corresponding bonded prestressed tendons.

3.5.4 Other new materials and a variety of materials combined application. New materials such as fiber-reinforced plastics, with durability and corrosion resistance in a variety of environments, light weight, high strength and non-magnetic advantages, used mainly in the aerospace and aviation industry, now into the construction industry. The combination of prestressed concrete and reinforced concrete, prestressed concrete and fiber reinforced concrete and other materials and the advantages of unbonded prestressed tendons will be paid more and more attention. The application of unbonded prestressed tendons in long-span Bridges is increasing day by day, but the strength and durability of unbonded prestressed tendons still need further research and continuous improvement.

Fiber-reinforced resin matrix composites have been widely used in aerospace field because of their high specific strength, high specific stiffness, anisotropy and high design ability. At the component level of the bearing capacity of the composite material component evaluation, because of the complexity of big, the connection of the scale of the structure forming leads to the failure mode with diversity. Some local failure can cause the early failure of the whole structure of behavior and structural failure of the main control factors of uncertainty. The bearing capacity of the numerical prediction error of the results and the experimental results are difficult to control within 15%. At the same time, it is an industry trend to gradually reduce the dependence of structural analysis on tests in the component design process of large composite materials. Therefore, it is necessary to further
improve the numerical prediction method for the bearing capacity of large complex composite components.[7]

4. Conclusion
The materials of bridge construction should be changed according to the needs of the bridge. In the areas with strong erosion-resistance should be used, such as coastal areas, corrosion-resistant materials, cement raw materials with high permeability and corrosion resistance, such as those containing chloride, sulfate and silica fume. Only the right material can make the bridge life increase. Easy replacement of bridge supports can make work more efficient. Bridge can be easier replacement to be more sustainable. A bridge structure with a strong bearing capacity can lead to longer bridge life and fewer problems due to load, resulting in greater sustainability. And the support material with stronger bearing capacity is also a way to make the bridge more sustainable and have a longer life.

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