

# Issues of Specifications for Seismic Design of Highway Bridges and Suggestions

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**Abstract.** This article elaborates the development of the specifications for seismic design of highway bridges in China, analyzes the issues of Chinese seismic design of highway bridges from the vague construction index, unscientific material selection and low seismic precautionary intensity, and puts forward measures of specifications for seismic design of highway bridges based on the present status of seismic design of highway bridges in China. Hope that this article could provide some reference and recommendations for the relevant personnel in the field.

## 1. Introduction

In recent years, there are more and more earthquake disasters in China, especially the shocking earthquake in Wenchuan in 2008. Once the earthquake occurs, which not only damages the building seriously, but also makes the building collapse, and seriously threatens and damages the lives of the residents and social economy in our country. In order to ensure the safety of people's lives and properties, the normalization of the seismic design of highway bridges must be ensured, some seismic designs of highway bridges of advanced countries can be referred, and on this basis, combined with the Chinese own conditions of highway bridges to establish the Chinese seismic design concept of highway bridges, so as to achieve good anti-seismic effect and the integration with seismic design of highway bridge of advanced countries. However, according to the current situation, in the process of carrying out the seismic design specifications of highway bridges, the seismic index, seismic period, shear strength of bridges, etc. are not clear, which have brought difficulties to the seismic design of highway bridges. Therefore, it is necessary for us to take the corresponding improvement measures according to the issues of seismic design specifications of highway bridges, so as to improve the seismic capacity of highway bridges.

## 2. Elaboration of the development of the specifications for seismic design of highway bridges in China

With the steady development of bridge construction in our country, the original seismic design of bridge has been unable to meet the requirements of the current seismic design of highway bridges. Since China promulgated the relevant mechanisms of seismic design of highway bridges in 2008, existing seismic design concepts of highway bridges and the ways have been regularized. And they are also the basic factors to improve the seismic capacity of the bridge structure.

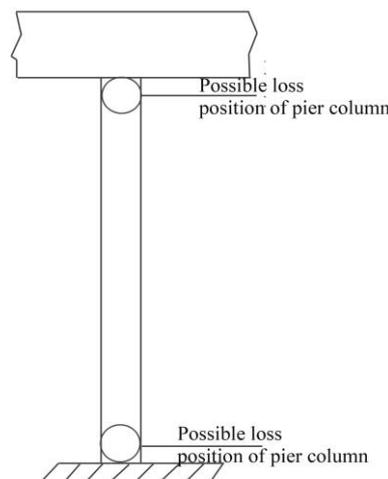
At present, in the seismic design of highway bridges, the principle of "highway bridges should not be damaged in small earthquakes, should be repaired in medium earthquakes and should not collapse in large earthquakes" should be upheld, although the related mechanisms of new seismic design of highway bridge has been perfected based on the original seismic standards, and solved the issues in



the original seismic standards. However, there are still many issues compared with the seismic technologies of bridge construction in advanced countries.

### 3. Present status of seismic design of highway bridges in China

Most of the bridge structures in our country are simply supported bridges and bridges of simply-supported into continuous, and the top of bridge provides special shape supports to piers by laminated rubber bearings. When an earthquake occurs, the bearings will be damaged or moved, the bridge's way of force transmission is damaged, and the inertia force transmitted to the lower end of the bridge will be reduced gradually. Influenced by the earthquake, the structure of the lower end of the bridge will not be seriously damaged, but the appropriate measures of collapse-proof still need to be taken. The seismic failure mode of bridge structure is shown in figure 1:



**Figure 1.** Seismic failure mode of bridge structure

When earthquake occurs, because different countries have different force transmission systems of bridge frame, so the characteristics of earthquake damage for bridge are also different, the bridges in USA have frame pier with the connection of pier and beam. Japan mainly uses steel support, which could effectively prevent the channel of force transmission of bridge form breaking. The current seismic design code of bridge in China mainly uses the content of bridges seismic design code of various countries, does not pay attention to differences in bridges' structure system, while strengthens force transmission without fracture when the force transmission system of bridge structure affected by the earthquake in China, namely, the bearing connecting the top structure of the bridge and the low structure of the bridge would be compromised, let the inertia force on top structure of the bridge be transmitted to the low structure of the bridge by bearing, at the same time the plastic hinge arranged in the pier dissipates force caused by earthquake, and thus achieves the anti-seismic effect.

But because the bridges in China mostly use open laminated rubber bearings without any measures of anchoring, so in the earthquake it is not possible that there are no damages in the bridge under the influence of earthquake. Therefore, in the process of making specifications of bridge's seismic design in China, we should take account of our bridges' own situation and structural force transmission system, in accordance with the relevant design standard of our country, compare the conditions of bridge damage by earthquake in different countries, we can learn that, laminated rubber bearings are widely used in bridges in China, in the earthquake disaster, they can play a good anti-seismic effect. When the earthquake comes, laminated rubber bearings will be damaged first, and the lower end of the bridge structure will be protected, which is the design concept with better effect.

### 4. Issues of Chinese seismic design of highway bridges

#### *4.1. Vague construction index*

With the rapid development of social economy in China, people pursue higher and higher quality of life, and also put forward new requirements for the seismic grade of the bridge. But in the graphic and vertical design of the bridge, there is always a degree of complexity caused by vague construction index. The gradually increasing irregular phenomenon of graphic and vertical design of the bridge, brings challenges to the seismic design of highway bridges, and also affects the seismic capacity of highway bridges [1].

#### *4.2. Unscientific material selection*

In recent years, there are more and more earthquake disasters in China, therefore, the scientific and reasonable seismic design of bridge structure must be ensured for the design of highway bridges in earthquake prone areas. In addition, in the selection of construction materials, we must choose high-quality, high standard building materials. However, some construction enterprises deliberately choose some cheap construction materials of substandard quality in order to save money, and the safety of the bridges cannot be guaranteed.

#### *4.3. Low seismic precautionary intensity*

In the past years, due to the low level of the overall economic development of our country, the requirements for seismic precautionary intensity are relatively low, and the general standard of seismic precautionary intensity was set at around 10%. In order to cut corners, some of the construction units do not design the grade of seismic precautionary intensity in accordance with the standard, leading to the generally low seismic performance of highway bridges. Once the earthquake occurs, it definitely will bring harm to the society and the people.

### **5. Measures of seismic design specifications of highway bridges**

#### *5.1. Seismic concept design*

The occurrence time of most of the actual earthquakes is uncertainty, and the forms of actual earthquakes are also different, and when making specifications of seismic design of bridge, we should combine with the actual situation, at the same time take increasing the bridge's seismic performance as the design standard, and realize the full implementation of the specifications of bridge seismic design. In the process of bridge design, we should not only design the performance and the appearance of the bridge, but also fully consider the seismic performance of the bridge, and try best to use better seismic structure. In the design of seismic concept, the design of the weak links, such as the convergence point of upper end and the lower end of the bridge, should be strengthened, and the nature of the bridge pier and the rationality of the design of the hollow connection position should also be guaranteed [2]. According to the actual situation of the bridge construction, conduct a comprehensive analysis of the bridge seismic design and seismic response, check that whether the design meets the local seismic demand, and enhance the rigidity of bridge's weak link through the use of reinforcement and structural design, so as to enhance the seismic capacity of whole bridge. Finally, the seismic performance of the bridge should be comprehensively evaluated to ensure the rationality of the seismic structure system, so as to ensure the scientificity and efficiency of the bridge design scheme.

#### *5.2. Main points of regularizing seismic design of highway bridges*

First, reduce the weight of the bridge structure's itself, reduce the structure center of gravity, so as to reduce the impact and internal force of bridge structure brought by the earthquake; second, strengthen the stability of the bridge, and guarantee the bridge structure's hardness center of gravity and the center of the quality are together, in order to reduce the seismic stress enhanced by reverse [3]; third, in the process of designing bridge structure, ensure the rationality of length and height, as far as possible to avoid the damages caused by differences of various positions and natures; fourth, in the scope of the specification, the appropriately reduce the structural rigidity, use ductile materials to enhance the seismic performance of bridge structure, thereby reducing the impact of the earthquake;

fifth, pay high attention to the dressing and processing of bridge foundation, reduce the probability of deformation of the foundation, and avoid the failure of foundation.

Assume that the structure rigidity of bridge has symmetry, so its seismic performance is much higher than that of bridge whose structure rigidity does not have symmetry, and the bridge with different span is easier to be affected by the earthquake, especially the bridge with big difference of pier height, it can not only make pier appear higher horizontal seismic force, suppose span is different, it will make pier with a large span appear strong seismic force. Therefore, in the process making specifications of bridge seismic design, as far as possible to avoid building bridges with different spans in earthquake prone areas, combine with the actual situation, take appropriate bridge, and taking some measures of energy dissipation for the bridge with strong seismic horizontal force, so as to alleviate the concentrated stiffness on the top the bridge pier. At present, most of China's bridges adopt the seismic bearing, which resolves the seismic capacity of bridges, a part of the bridge structures cannot be used in high seismic region, based on the original seismic performance of bridge structure, design a new type of bridge structure in accordance with the conditions of the area, and calculate the position of its displacement, standing in the perspective of design, carry out regulate design of the whole function of bridge structure for increasing the seismic performance of bridge structure [4].

### *5.3. Seismic design measures of new bridge*

The traditional seismic design code of bridge mainly enhances the seismic performance of the bridge in two aspects, the first is the strength of the bridge; the second is the ductility of the bridge. However, at present, we cannot accurately understand and explain the seismic performance of the bridge structure, and therefore the bridge structure will be damaged by the earthquake in varying degrees. In order to effectively prevent the emergence of this phenomenon, in the design of the bridge, we integrate steel reinforced concrete into the design, because of its strong bearing capacity and strong shear capacity, compared with reinforced concrete it has good ductility, can control the deformation of the bridge in a reasonable range, so as to improve the quality of highway bridges and increase the seismic performance of bridges.

### *5.4. New material for solving the issues*

For the original design of highway bridges, the reinforced concrete is usually used for the bridge building structure, and the main load construction of the whole bridge is reinforced concrete. Its defect of large gravity somehow influences the seismic capacity of long-span structures. At the same time, the reinforced concrete structure does not have strong cracking resistance, and once heavily influenced by strong force, the whole bridge structure will be changed. For this phenomenon, we can use steel reinforced concrete or prestressed concrete to replace the original reinforced concrete [5]. Compared with reinforced concrete, bearing capacity of steel reinforced concrete is much better, and steel reinforced concrete has good shear-bearing capacity and ductility, which can effectively reduce the probability of deformation of bridge under the earthquake. The bearing capacity of prestressed concrete structure is 30% higher than that of reinforced concrete. At the same time, in the process of bridge construction, because of their lighter weights, lower building heights and strong durability, so they can effectively enhance the ductility of the bridge structure, and the bridge will not crack because of earthquake.

## **6. Concluding remarks**

In short, in the context of the increasing requirements of current seismic design of highway bridges, it is necessary to ensure the design staff to well analyze and evaluate the seismic capacity of highway bridges. Although the earthquake is uncertain, as long as we comprehensively study the influence of earthquake on the structure of highway bridge, comprehensively consider the influence factors when making the code of bridge's seismic design, continuously adjust and regulate the seismic program, take corresponding measures to enhance the seismic performance of bridge structure, strictly uphold the key points of the code of bridge's seismic design, so as to reduce the damage of bridge caused by the earthquake to minimum, and ensure the safety of bridge.

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