Study on the causes and methods of influencing concrete deflection

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Abstract. Under the long-term effect of static load on reinforced concrete beam, the stiffness decreases and the deformation increases with time. Therefore, the calculation of deflection is more complicated. According to the domestic and foreign research results by experiment the flexural deflection of reinforced concrete, creep, age, the thickness of the protective layer, the relative slip, the combination of steel yielding factors of reinforced concrete deflection are summarized, analyzed the advantages and disadvantages of the traditional direct measurement of deflection, that by increasing the beam height, increasing the moment of inertia, increase prestressed reinforcement ratio, arching, reduce the load, and other measures to reduce the deflection of prestressed construction, improve the reliability of structure.

1. Introduction
The component under external force (load), or in a non-uniform temperature field temperature change when the rod axis displacement in the direction perpendicular to the axis of the shell surface in line or line displacement perpendicular to this line, the displacement is defined as deflection. In short, it refers to the maximum deformation of the beam, truss and other bending members under load, usually refers to the vertical direction of the Y axis, that is, the vertical deformation of the component. The deflection of a thin plate or thin shell is the displacement of each point on the middle surface of the middle surface. The law of the deflection of the object with the position and time is called the deflection function or displacement function. It is one of the methods to calculate the strain and stress by calculating the deflection function. Domestic and foreign scholars and research institutions for the definition of deflection and research methods are not the same, but consistent in essence.

Determination of mechanics of concrete structure deflection is an important research content, the deflection of bridge is one of the most important indicators of the safety of the bridge structure, the bridge engineer proposed many effective deflection measurement methods. Bridge span structure, most of the dial gauge displacement and deflection, the method in the safety assessment of old bridge or bridge acceptance is still widely used in China, the maintenance of the bridge. After extensive research scholars, it is found that the method has more advantages, but also many problems, such as bridge in water environment can not be measured directly, for the special geographical position, such as across the canyon and other Takahashi also cannot use the direct method of measurement. In addition, the use of direct methods for deflection measurement, regardless of layout or revocation of instruments, are more complicated time-consuming.

2. Research status at home and abroad
Based on the analysis of creep of concrete filled steel tubular members, Han Bing et al. Further
analyzed the influence of creep on the deflection of members. The formula for calculating the deflection of members in the creep process is derived. The formula is considered in the creep process, steel ratio, load, and the influence factors of concrete steel, this formula is applied to analyze the influence of concrete creep on the deflection of the component, the deflection creep will increase the flexural members. Generally speaking, when the creep stops, the deflection of the member is 1.17~1.20 times of the initial deflection.

According to the change of the thickness of the concrete cover in the concrete structure, the quantitative analysis of the ultimate bearing capacity of the structure and the deflection under the limit of the normal use of the structure were carried out by Gu Hongxiang [16]. The analysis shows that the change of the thickness of the concrete cover caused by the displacement of the steel bar is not to be neglected. Therefore proposed to the concrete structure engineering reasonably reinforced concrete protective layer thickness design, strictly control the thickness of reinforced concrete protection, to ensure that the reinforced concrete protective layer thickness deviation with concrete construction quality acceptance allowable range of measures.

Xu Qiang [3] deduced the calculation method of the deflection of three types of beam at different ages in his study, and calculated the deflection value of three kinds of beam in different age. By the deflection calculated value, the results indicate that with the increase of concrete age, with a section of concrete deflection increases the speed will be smaller; in different sections, in the same age, the large deflection of small cross-section, small deflection section; different section, the deflection section is small than the growth rate of large section of the fast.

According to the concrete creep law, Cheng Xiaofei [11] deduced the calculation formula of creep of CFRP strengthened reinforced concrete beam, a calculation model of deflection of reinforced concrete beams strengthened with CFRP considering the influence of concrete shrinkage and creep. Based on the model verification, when considering the creep of concrete, the deflection of the reinforced beam is 10.3% -2.2%.

Application of ANSYS finite element software to analyze the creep effect of concrete was studied by Shen Feifeng [10]. The research take a continuous frame bridge as an example, analyzes the influence of creep on the deflection, the concrete creep was on the deflection effect of long-span bridges the conclusion.

Through the establishment of deflection of thin-walled U steel - concrete beam model, beam equilibrium differential equation is derived by Shen Jianhua [8], calculation formula of deflection of composite beams under different loads were obtained, 8 of composite beams of calculation and comparison, the results show that the thin walled U steel - mixed large slip effect concrete beam the deflection. In the same connection of shear connector under shear thin-walled U steel - concrete beam connection degree than ordinary steel - concrete beam is low, due to the increase of shear connectors, the degree of shear connection coefficient can be improved from 0.66 to 0.75.

Zhang Xide [21] believes that there is a relative slip between the concrete beam and plate, when the combination of beam according to the partial interaction design, become the main characteristics of slip, slip has great effect on the deflection of composite beam, slip the deflection increases up to 19.2%.

In the analysis of several factors affecting the steel - concrete composite beam deflection calculation, Chen Shiming [17] of Tongji University pointed out, the linear elastic calculation method and the allowable value of the ratio of deflection to span deflection checking design, easy to overlook the influence of Liang Gangliang yield. Analysts believe that the steel beam bottom strain, steel flange and the concrete between the slip and residual stress of steel beam, local yield, the allowable value of the ratio of deflection to span, span depth ratio, slip and residual stress and construction load and other factors will affect the deflection calculation of composite beams.

Based on the analysis of the advantages and disadvantages of several common methods of bridge deflection measurement, a new method for measuring the deflection of bridge is proposed by Yang Yinghao of Chang'an University. According to a certain rule, the inclinometer is placed on the bridge deck, the value of the relevant section is measured, and then the deflection curve of the bridge is fitted.
The reliability of the method is verified by the experiment.

3. Methods to reduce the deflection of concrete
The deflection is closely related to the stiffness of the section, the elastic modulus of the material, the supporting condition and the load. In the case of the same load, the support will be reduced from the simple support to the fixed, increase the stiffness of the section (beam height, width, height more effective), the use of high elastic modulus of the material, can effectively reduce the deflection. At the same time, it is considered that the simplest way to reduce the deflection is to increase the height of the beam section by increasing the beam height and increasing the moment of inertia. In addition, the tensioning of prestressed reinforcement, increasing the rate of reinforcement is often used to reduce the deflection of the measures.

In addition to increasing the height of the beam section, but also the use of arch way, can effectively reduce the deflection. After the transformation of the components, the appearance is more beautiful. Secondly, it can also be used to reduce the load, the use of load can not be reduced, but the dead load can be reduced, such as the use of hollow floor, hollow beam, light wall, etc.. By construction of prestress, the structure of a reverse deflection, reloading, it can also reduce the deflection.

4. Conclusion
In recent years, with the application of high strength steel in the design of non prestressed concrete structures in our country, the size and volume of the structural members have been reduced, and the stiffness of the members has been adversely affected. Therefore, the deflection calculation and control of ferroconcrete flexural members become more important. Through the research, it is found that the creep, age, temperature and humidity environment, the thickness of the protective layer, the relative slip, the yield of the composite steel beam and so on, are the important factors that affect the deflection of reinforced concrete.

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