Study on Seismic Behavior of Reinforced Concrete Structures Based on Ultimate Bonding State

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Abstract: The theory of seismic design based on ultimate bond state is a new theory of seismic design which has emerged in recent years. It has aroused strong repercussions in the field of engineering structures and aroused strong interest of structural engineers and scholars. Based on the analysis of the stress of special-shaped joints in reinforced concrete frames, the concept of "small core" determined by trabecular columns is proposed. It is concluded that the bearing capacity of special-shaped joints in frames depends on the "small core" of special-shaped joints. For different performance requirements and analysis methods, appropriate material constitutive model, section partition method and simulation unit are selected to make the analysis results close to the actual engineering situation. During the earthquake process, the structural energy response balance, the structural hysteretic energy and damping energy consumption increase with time, and tend to be stable in the later stage of seismic action. The structural kinetic energy and elastic variable performance are zero at the end of the earthquake. During the design process, engineers can select different side-shift modes to design the structure according to the specific design requirements of the project.

1. Introduction

In recent years, with the improvement of living standards, people have put forward new requirements for living conditions. A new system of reinforced concrete frame structure with special-shaped columns has emerged in residential structures. Earthquakes are sudden natural disasters. The occurrence of destructive earthquakes will not only cause damage to buildings and engineering facilities, but also cause casualties and economic losses [1]. About five million earthquakes occur on the earth every year, that is to say, tens of thousands of earthquakes occur every day on average. The ultimate goal of seismic design under large earthquakes is to prevent structural collapse and ensure the safety of human life [2]. But during this period, many earthquakes occurred in many countries and regions of the world. With the development of economy, population growth and topographic structure in these areas, highway and railway bridges and other transportation hubs have been built continuously, which has become the focus of road traffic development in China, The earthquake has caused people to varying degrees of casualties and uncountable economic property losses [3]. In order to prevent earthquake disasters and mitigate the losses caused by earthquakes, some countries have conducted a series of studies on earthquake prediction and engineering earthquakes since the beginning of this century, which has enabled people to have a certain understanding of the natural phenomenon of earthquakes. Designed for the performance requirements of structures under different levels of seismic action, the required buildings are expected to perform as expected in future earthquakes.

Nowadays, among the seismic design methods of building structures in China, there are many applications. The more extensive method is the mode decomposition reaction spectrum method. When applying this design method, we generally choose the elastic response spectrum as the design response spectrum [4]. In order to transform the performance-based seismic design ideas into reality, it is necessary to establish the correspondence between the performance level of the building structure and the structural response indicators that can reflect the seismic performance of the structure. Appropriately control the stiffness distribution so that the structure or component can

reach the stage of elastoplastic deformation, and form a corresponding seismic energy dissipation mechanism to ensure structural reliability [5]. Based on the analysis of seismic performance of structures, according to the different defense objectives, the performance objectives of structures are divided into different levels. Designers can choose the seismic defense objectives and measures that meet the needs of owners to implement the seismic design of buildings. By choosing a reasonable design calculation method, the capacity level of the designed structure can meet the pre-designed goal. This idea of setting the demand first and then verifying it by design calculation is obviously more in line with the needs of the project. Building codes and design rules of various countries gradually introduce it into the future seismic design of the structure.

2. Methodology

The actual engineering structure is mostly a multi-degree of freedom system with complex spatial relationships. Accurate analysis of the actual multi-degree-of-freedom space system is quite difficult considering the various load distributions and the extremely complex nonlinear characteristics of the reinforced concrete material itself. Under the action of the site, the deformation of the structure, including local displacement and overall lateral displacement, can still be in the elastic stage, and the normal use of internal facilities and structures is not impaired. A steel strain gauge is attached to the longitudinal rib at the intersection of the column and the beam, and a strain gauge is attached to the stirrup of the node core to measure the strain. The compressive strength of concrete cube specimens which are not subjected to high temperature and are subjected to high temperature is tested under normal tensile bond strength. Therefore, an important precondition for seismic response analysis of structures is to obtain a structural calculation model which is convenient for theoretical analysis and without losing the requirement of actual accuracy. Under the action of accidental earthquake, the deformation of the structure is allowed to enter the elastic-plastic state, and certain repairable damage occurs. The normal use of internal facilities and structures can be maintained.

In the overall engineering system, each single project, that is, a single building, is not a separate one. It is closely related to each part of the entire engineering system, and any single project problem may be implicated in the entire engineering system. For the high-rise building structure, due to the high height, the lateral displacement curve of the structure is curved and sheared. At this time, the proportion of the axial deformation of the vertical members on the floor in the lateral movement of the structure is increased and often cannot be ignored. The occurrence of initial cracks and the final crushing of concrete occur at the central line of the upper column in the middle of the core. On the premise of guaranteed bond quality, the bond strength between CFRP and concrete after fire is higher than that of concrete after fire. Generally, the failure of bond occurs in shallow concrete. Because the structural deformation in earthquake often exceeds the allowable range of the structure, which leads to the destruction of the building structure, the displacement index can well reflect the damage degree of the structural components. In this case, the bending-shear interlayer model should be used to simulate the nonlinear behavior of the structure. Compared with shear interlaminar model, bending-shear model can consider the effect of interlaminar bending deformation more widely.

Control collapse to ensure life safety. Concrete failure in core area, buckling of compressive longitudinal bars or fracture of stirrups. Compared with conventional design methods, performance-based seismic design of bridges improves the seismic performance of structures, as shown in Table 1.

Table 1 Seismic performance comparison

Seismic performance	Conventional method	Performance-based approach
Local ductility	Difficult to estimate	Direct correlation with overall ductility
Integral seismic performance	Unpredictable	Can predict
Failure probability of collapse prevention	Finite	Maximum in probability sense

The concrete protective layer of piers and columns allows the occurrence of small cracks, but does not allow the occurrence of fragmentation and peeling phenomenon. The bearing capacity of unconstrained concrete does not reach the yield limit of steel bars, and the bridge is basically in an elastic state to ensure normal use. However, the increasing force and the area of baroclinic rod are still small; at the same time, it should be noted that the force outside the "small core" in the large core is smaller and the cracks are less. After high temperature, the depth of failure surface of concrete increases obviously compared with that of normal temperature. This may be due to the infiltration of carbon fiber glue into the surface concrete after high temperature, which strengthens the integrity of local concrete in a certain depth range under the interface. From a probabilistic point of view, the seismic risk level is the probability that a particular intensity of an earthquake will occur within a certain number of years. The deformation of the structure is easier to observe and record than the change in strength, and it is easier to perform comparative analysis. Therefore, the displacement-based calculation and analysis method is an important way to achieve seismic performance of structural performance. The size of the diffusion area is related to the height difference of the beam section and the height difference of the column section, that is, it is related to the cross-sectional size of the large core and the "small core". Among them, the curve type resilience model can reflect the continuous change of the stiffness of the member, which is close to the accuracy of the actual force of the actual member, but the disadvantage is that there is a great difficulty in determining and calculating the stiffness.

3. Result Analysis and Discussion

The essence of energy analysis of building structure is to study the energy transfer and dissipation relationship between the structure itself and the ground under earthquake action. When the energy dissipation capacity of the structure under earthquake is greater than the total input value of the structure under earthquake, it can be considered that the structure is safe. With the strengthening of external action, concrete cracks extend and expand to reach the ultimate bearing capacity of unconstrained concrete, and the protective layer begins to crush and peel. At this time, the confined concrete in the core area is not subjected to much force and the internal structure is not damaged. Stirrups in this area are still indispensable. They still bear the edge shear from the beam reinforcement, because they do not bear the edge shear from the trabecular reinforcement. The load of some specimens will fluctuate at this stage, but the range of variation is not large. Continue to apply the load and peeling damage may occur immediately. As the earthquake time continues, the total energy of the structure increases continuously; the structural displacement increases continuously, and the cumulative plastic damage of the structure also increases, and the structural hysteresis energy and damping energy consumption increase with time. Since the elastic model is assumed, the stage of elastoplastic analysis of the structure is not considered, and only the simple structure under the small external action can be analyzed.

The initial cost of life cycle cost in seismic design refers to the initial design cost, which is the initial volume of the structure. Similarly, the initial cost of an earthquake retrofit is also the initial retrofit cost. For example, welded bottom punch (WBH), welded top and bottom punch (WTBH) and welded cover flange (WCF), as well as proprietary connection modification methods. In order to improve the seismic performance, the improved connection was tested and verified. As shown in Figure 1.
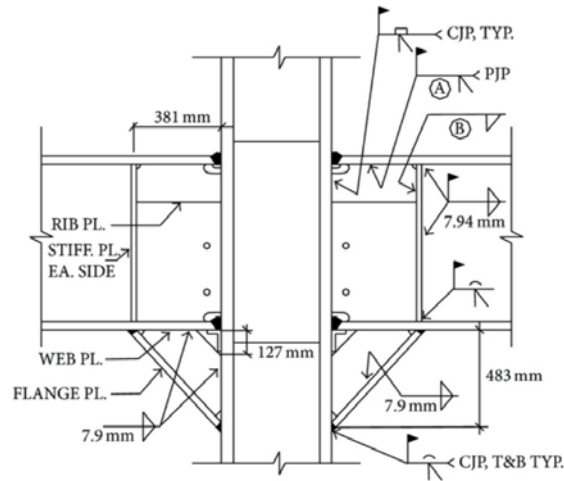
Figure 1 Welding punch improves the details of the connection

The axial force has no obvious influence on the crack and the ultimate load. The reason is that the cyclic loading is repeated in the presence of the axial pressure, so that the cumulative damage effect of the concrete in the core area of the joint is larger than that without the axial force. The bonding length has a certain relationship with the development process of the interface peeling. For the specimens with short bonding length, the peeling failure process is short and may not be observed. Before the peeling failure occurs, most of the specimens have no load fluctuation phase, and the precursors are not damaged. obvious. It is worth noting that when determining the performance objectives of the structure, we must not blindly set it too high or set too low, because setting the performance target of the structure can significantly improve the safety of the building structure. It reflects a kind of energy dissipation characteristic of the structure itself. Damping energy dissipation itself does not cause structural damage. The cracks of the concrete at the two ends of the diagonal core of the joint under the action of bending moments in the other direction should be closed. The cracks in the middle of the diagonal core are the widest. For the specimens with longer bond length, the peeling process is relatively long. Some specimens appear load fluctuation stage, and the peeling sound is more frequent, so it is easy to detect the precursor of peeling failure.

When the structure does not collapse, the hysteretic energy dissipation of the structure is improved and its distribution is controlled. It makes the hysteretic dissipation energy appear more at the beam end than at the column end, and makes the interlayer distribution of the hysteretic dissipation energy more uniform rather than concentrating on a certain layer. The model calculates the increase coefficient of maximum stress and related strain of concrete, and the stress and strain coefficients of tension softening section. The restraint effect of stirrups is reflected by changing the stress and strain values. Without considering the non-uniformity of the stirrup stress, it is considered that all the stirrups can yield and play a role. The hysteretic energy of the structure embodies the cumulative plastic damage of the structure. The selection of hysteretic model of steel constitutive relation has great influence on the hysteresis curve under reciprocating load. Reasonable selection of the stress mechanism of steel bar is the key to ensure the accuracy of numerical analysis. This is because the upper column has a small cross section, and under the horizontal force of the column top, the area of the compression zone is small, and the restraining effect on the core core concrete is objectively weakened.

4. Conclusions

A combination of theoretical analysis and software simulation was used to explore the seismic performance of performance-based reinforced concrete frame structures. By analyzing and summarizing the national building structure and the seismic resistance of bridges, the limit state of the performance level of the bridge is given, which is the boundary of yield, service and damage

control. The two parameters of the thickness of the steel floor and the spacing of the perforated steel plate have an influence on the ultimate bearing capacity of the steel-concrete composite two-way plate. The stirrup can improve the bearing capacity of the special-shaped joint, but the yield unevenness coefficient of the stirrup should be considered in the calculation formula of the bearing capacity of the special-shaped joint. The quasi-static test of reinforced concrete short columns strengthened with CFRP after fire was carried out to investigate the influence of the amount and mode of CFRP reinforcement on seismic performance and reinforcement effect. The test proves that the reinforcement technology is feasible. In seismic design, displacement-based seismic design theory based on displacement control is more conducive to the realization of our design objectives: when earthquake disasters occur, it can not only reduce casualties, but also reduce economic losses, and find an optimal balance between the two. In this paper, a formula for calculating the shear capacity of special-shaped joints in reinforced concrete frames is presented, which is clear in concept, simple in calculation and more suitable for engineering design.

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