Study on Hysteresis Performance of Precast RC Energy-Dissipated Beam-Column Joints

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Abstract. A prefabricated energy-consuming RC beam-column joint is designed to connect prefabricated notched beams with prefabricated columns by metal bolts using angles and metal damper connectors as connecting parts. The design concept of the prefabricated joint is to reduce the damage to the main structure and Increase the mechanical performance of the beam-column joint by strengthening the deformation ability of the joint through the damping connector to yield energy in the earthquake. The hysteretic characteristics of the beam-column joint are studied under cyclic reversed loading, which preliminarily verified the viability of the proposed joint connection method. Studies have shown that the proposed prefabricated beam-column joints are the same as the Beam-column joints that were poured on-site, and the joint load-carrying capacities and energy-dissipating capacities are all improved.

Keywords: beam-column joint; dry connection; force performance.

1 Introduction

The application of prefabricated concrete frame building has become more and more extensive, which has the advantages of convenient construction, green environmental protection, and so on, which is in line with the development direction of China's building industrialization at the present stage. Previous earthquake damage investigations have shown that the failure of beam-column joints has a great impact on the overall damage degree of frame structures, and the performance of joints directly affects the overall seismic performance of structures. XU[1] et al. designed a steel connector for prefabricated RC beam-column joint connection. However, the concrete in the center of the beam was damaged in advance during loading, resulting in insufficient performance of the steel connector, In terms of bearing capacity, assembled joints are lower. Ketiyot et al. [2] adopted the dry connection method and implanted the shaped steel into the core area of the prefabricated RC beam-column joint as an energy-dissipating component. The research shows that In terms of energy consumption is better. In summary, the research on RC dry beam-column joint has been widely used by scholars, and a variety of different dry connection methods have been proposed, but some connection

P. Liu et al. (eds.), *Proceedings of the 2024 5th International Conference on Civil, Architecture and Disaster Prevention and Control (CADPC 2024)*, Atlantis Highlights in Engineering 31,
https://doi.org/10.2991/978-94-6463-435-8_17

methods still have problems. For instance, insufficient bearing capacity, low ability of energy-consuming levels, and complex construction technology.

Therefore, a new prefabricated RC energy-dissipating beam-column joint is designed. The joint uses a metal damper as a connecting member at the lower part of the beam end, which provides reliable connection stiffness and strength while providing a certain energy dissipation capacity. Based on the numerical simulation method, the mechanical properties of cast-in-place joints and prefabricated RC energy-dissipating, when the displacement load acts, the beam-column joint is compared[3]. Validity of this connection is preliminarily verified, as shown in Fig 1.

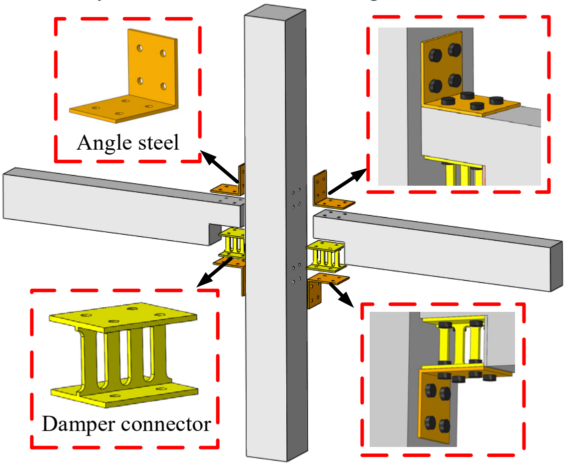

Fig. 1. Numerical model of RC energy-dissipating beam-column joints

2 Specimen introduction

In this paper, two beam-column joint models are simulated, including the cast-in-place beam-column joints XJ-1 as well as the prefabricated joint JD-1. The section length × width of the XJ-1 joint column is 300 mm×300 mm, and 4 longitudinal ribs are selected as HRB400 with a diameter of 20 mm, which is evenly placed along the circumference of the stirrup. The section length × width of the joint beam is 300mm× 200mm. Four HRB400 longitudinal beams with a diameter of 10 mm are selected to be evenly arranged around the stirrup. The stirrup spacing in the core area of the beam column is 50 mm, and that in the non-stirrup area is 100 mm. This is shown in Figure 2. Fig 3 shows the detailed design of JD-1 joints. For JD-1, the prefabricated column has the same size and reinforcement as the cast-in-place joint column. 4 models HRB400 in diameter are selected above the precast notched beam, and 4 models HRB400 in diameter are selected on the lower side, and they are uniformly arranged around the stirrup. Due to the consideration of the failure form of the precast notched beam, the stirrup in the concrete stirrup filling area on the upper part of the notched beam is selected with a diameter of 10 mm. The spacing is 40 mm. For other parts of the precast notched beam, the stirrup in the encryption area uses HRB400 with a diameter of 10 mm, a spacing of 50 mm, non-encryption region of 100 mm. The joint adopts displacement loading, and its loading amplitude is 6, 14, 24, 40, 56, 70, 86, and 100 mm, and displacement increment is 8 mm, 12 mm, and 16 mm, respectively[4].

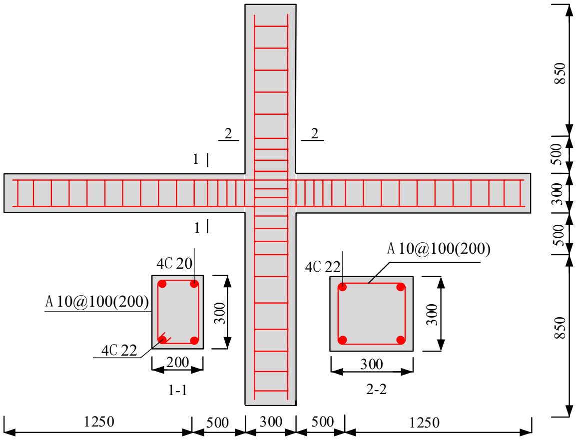

Fig. 2. XJ-1 joint

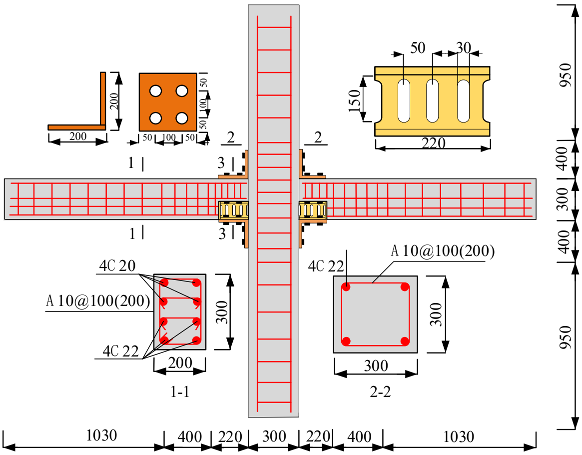

Fig. 3. JD-1 joint

3 Comparison of analysis results

3.1 Hysteresis analyze

Hysteresis curves are shown in Fig 4. When the displacements of the two types of joints are the same, the bearing capacity of the prefabricated joints is superior to cast-in-place joints, indicating that H-shaped damper and Angle steel in the prefabricated joints play an important role in bearing. When the loading displacement is small, the specimen deformation of two types of joint concrete specimens is small, and the bearing capacity increases, when the augment of displacement. The bearing capacity of prefabricated specimen JD-1 is superior to that of cast-in-place specimen XJ-1, significantly. Among them, the ultimate bearing capacity of cast-in-place specimen XJ-1 is 39.51 kN, and that of prefabricated specimen JD-1 is 52.68 kN. Compared with specimen XJ-1, the bearing capacity of JD-1 the growth rate was 33.3%[5] as shown in Fig 5.

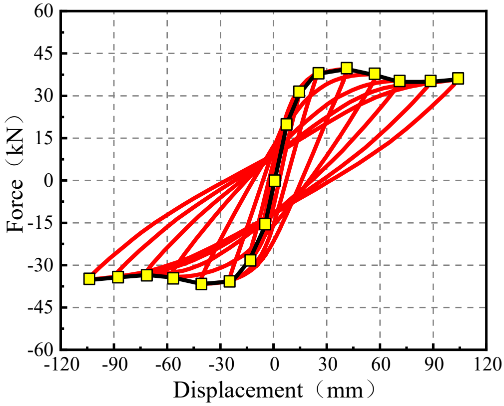

Fig. 4. Hysteresis curve of XJ-1 specimen

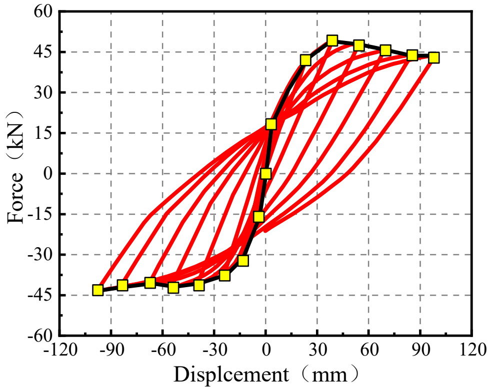

Fig. 5. Hysteresis curve of XJ-1 specimen

3.2 energy-dissipating capacity

For both types of joints, when loaded to 60 mm, the cast-in-place joint is superior in terms of energy consumption. However, due to the small displacement, at the start loading, the H-type dampers' energy consumption is not obvious, and the energy consumption of the joint is borne by the concrete on the upper side of the gap of the prefabricated notch beam. Because the section size of this part is smaller size that of the normal beam section, the energy dissipation capacity is low. When loading continues, there is a big difference in energy consumption between two types of beam-column joints among which the former slowly rises with the continuous external load increase while the latter significantly increases, that is, the greater the load, the more significant the energy consumption effect of H-type dampers. At start loading, no plastic and elastic deformation occurred in the damper connection, and the cumulative energy consumption curves of the two types of joints are close to each other. With the increase of displacement load, two types of beam-column joint accumulation curves have a bigger difference. When the loading was completed, the cumulative energy consumption of cast-in-place specimen XJ-1 was 13306.6J, and the total cumulative energy consumption of prefabricated specimen JD-1 was 17604.7J, respectively, which was enhanced by 32.3%, as shown in Fig 6.

The equivalent viscous damping coefficient of the specimen is shown in Fig 7. At the initial stage of loading, the energy dissipation capacity of XJ-1 specimen is good, and its equivalent viscous damping coefficient is up to 0.177. With the increase of displacement load, the energy dissipation of assembled joints mainly depends on the plastic deformation of the damper connector. When the loading was completed, the equivalent viscous damping coefficients of the assembled specimens JD-1, JD-2 and JD-3 reached the maximum, which were 0.175, 0.194 and 0.214 in order.

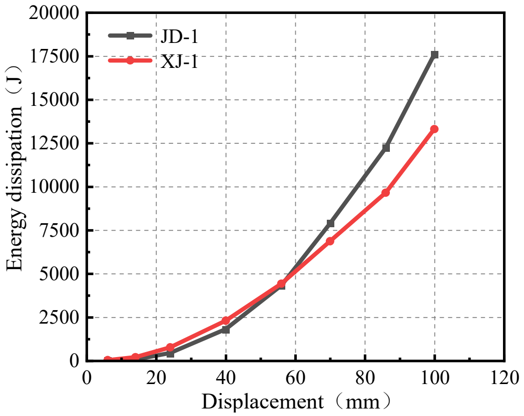

Fig. 6. Energy-dissipating capacity

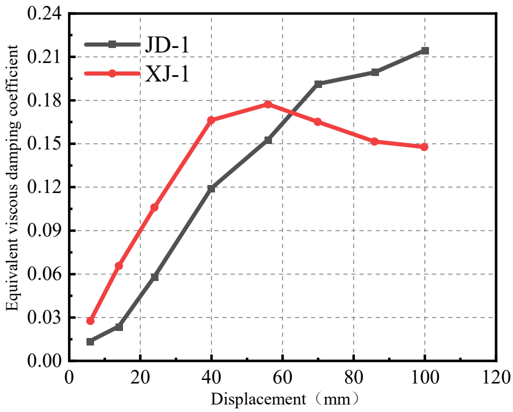

Fig. 7. Equivalent viscous damping coefficient

4 Conclusion

1. A new prefabricated RC energy-dissipating beam-column joint is proposed. By comparing with the cast-in-place joint, the bearing capacity and energy consumption level are improved to different degrees, and the feasibility of the joint is preliminarily verified.
2. In terms of bearing capacity, the JD-1 bearing capacity level has been improved by 33.3%. The cumulative energy consumption level increased by 32.3%. The results can provide design ideas and theoretical references for prefabricated energy-dissipating beam-column joints.

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