

# Seismic Behavior Analysis of Exposed Rigid Box Column Hybrid Joints

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**Abstract:** The connection joints of the upper and lower structures of exposed rigid box columns are the key to the seismic design of RC frame light steel storey adding hybrid structures. The low cycle repeated loading tests were carried out on two exposed rigid box column hybrid joints with I-shaped and box shaped upper columns, respectively. The failure mode, hysteresis curve, skeleton curve, strength degradation, stiffness degradation and energy dissipation capacity of the joints were compared and analyzed. And compared with the full welding of the inner diaphragm, the finite element model of the joint under the two conditions is established, the stress and deformation of the steel joint are compared and analyzed, and the safety of the joint is evaluated for reference in engineering design and construction under similar conditions.

**Keywords:** Seismic behavior; exposed rigid box ; column hybrid joints

## 1. INTRODUCTION

Proceeding from China's national conditions and realistic conditions, the method of adding light steel to the RC frame structure can increase the use area without disturbing the original structure, and can effectively alleviate a series of resource and environmental problems such as serious land tension, farmland loss, environmental pollution, etc; The exterior and structural functions of the building can be readjusted; It can also solve the problems of water leakage and thermal insulation of the original building roof. When the frame beam is rigidly connected with the column, the horizontal stiffening rib or horizontal stiffening diaphragm of the column shall be set at the corresponding position of the beam flange. The four sides of the horizontal stiffening diaphragm of the box column shall adopt groove full penetration welds.

For non-seismic fortification structures, the diaphragm shall be able to transfer the concentrated force at the beam flange, and the thickness shall not be less than half of the beam flange; For seismic fortification structures, the thickness shall be equal to the beam flange. The joint form proposed in this paper is that the precast beam can be placed in the dark area of the precast column to densify the section fibers and obtain accurate results.

The figure illustrates the use of fiber section by taking the column section on the socket as an example through the pre-stressed steel strand set at the center of the beam section. The concrete is divided into beams and columns for assembly. The angle steel on the upper part of the unbonded beam has loose fiber dimensions through the core area of the internal core area and the external protective layer area and is fixed at the node through the embedded anchor bolt to dissipate energy. The protective layer area at the abutted joint is dense, and the longitudinal reinforcement is defined separately by order. Pour polyacrylonitrile fiber mortar.

Exposed rigid box column hybrid joints is shown below.

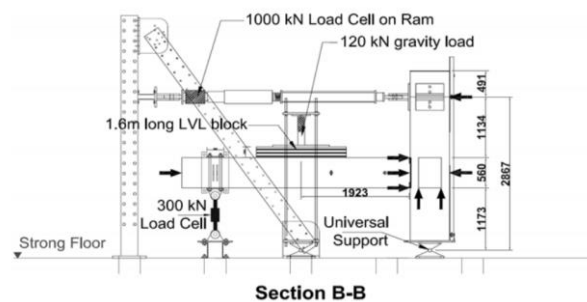


Figure. 1 Exposed rigid box column hybrid joints

## 2. THE PROPOSED METHODOLOGY

### 2.1 Size Design and Fabrication of Test Model

In this test, the test model is finally determined as a semi rigid box column steel frame support structure with two spans in X direction and one span in Y direction through ANSYS simulation calculation, taking into account the size of the shaking table and the maximum allowable loading limit (maximum allowable loading acceleration and displacement) in the structural laboratory of Harbin Institute of Technology. The beam column joints in X direction are hinged.

The Y-direction beam column joint is a semi-rigid connection with top and bottom angle steel. Therefore, this paper takes the joint as the research object, through the quasi-static test of two exposed rigid joint specimens, compares its strength, stiffness, ductility, energy dissipation capacity and other seismic performance, and deeply analyzes the reasons that affect the seismic performance of the joint, providing some technical support for the design and construction of RC frame light steel storey adding hybrid structure.

When the current passes through the slag, the resistance heat generated is used as the heat source to melt the base metal and filler metal to fill the weld bead, so as to realize the welding between the inner diaphragm and the main board. The model

is used for the reinforcement and prestressed steel strand), The steel bars in the plastic zone of the beam end adopt the compression only finite element model (that is, the tensile stress is to simulate the compression stress between the beam end and the column after the gap opens. According to the size of the bolts of the seismic station, the column base plate is designed, and the position of the structure in the seismic station is determined.

## 2.2 Seismic Performance Analysis

In order to prevent the shear force transmitted by the beam end or the bending moment at the semi-rigid joint from causing buckling damage to the column surface during the test, cross stiffeners are welded inside the columns at the beam and column joints. First, a four-story concrete frame with three spans and six column spacings is designed through PKPM modeling, and a light portal frame is added to the top floor to form a "4+1" RC frame light steel storey adding hybrid structure. The three spans are 6.9, 2.6 and 6.9 m respectively, that is, the top floor light portal frame has a span of 16.4 m, a column spacing of 7.2 m, and a storey height of 3.6 m. The design earthquake group in the area where the structure is located is the first group. In this paper, the Solid45 element in the ANSYS software element library is used for geometric and material nonlinear analysis.

Solid45 element is used to establish a three-dimensional solid structure model. The element is defined by 8 nodes, each node has 3 degrees of freedom: translation in x, y, z directions. The element has the functions of plasticity, creep, expansion, stress rigidity, large deformation, large strain, etc. The beam and column adopt nonlinear beam column element, which includes two kinds of elements based on force seismic performance analysis and one kind of element based on displacement, it can be selected according to specific conditions.

The stress of the prestressed steel frame is similar to that of a material, which depends on the aforementioned modeling method. For the new fabricated prestressed composite beam members, only the force is saved - mechanical movement. Reflection phenomenon of the structure under 70gal acceleration: the structure shakes very slightly under 70gal seismic wave, and the shaking amplitude of the seismic table is very small (after sorting out, the real maximum displacement of the structural column base, i.e., the seismic station shaking, is 10.854mm, which is collected from the IMPERIAL wave working condition). The displacement between the floors of the overall structure is not obvious.

Use the test piece to make the remaining concrete and make 3 pieces of 150 according to the standard test method  $\times$  one hundred and fifty  $\times$  150 concrete test blocks, after 28 days of natural curing at room temperature, carries out compressive strength test on the electro-hydraulic servo universal testing machine, and the measured average compressive strength of the cube is 32.17MPa.

## 3. CONCLUSION

In this paper, the pseudo static test of two exposed rigid joint specimens is carried out, and the following conclusions are drawn. Of course, these conclusions need to be further verified by more tests and theoretical analysis. The mechanical performance of the joint is analyzed, and the force transfer mechanism, stiffness and ultimate bearing capacity of the joint are compared with the commonly used four side welding model of diaphragms. It is concluded that the box

column in this project is safe to use the three-side welding method of inner diaphragms.

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