

Experimental seismic performance research on a new assembled monolithic column joints

WANG Yu-liang 1, 2 and Jintao Cui 1, 2

¹ School of Civil Engineering, Tianjin Chengjian University, Tianjin, China

² Key Laboratory of Protection and Retrofitting for Civil Building and Construction of Tianjin, Tianjin, China

Abstract: A new assembled monolithic column joints were put forwards: local outsourcing steel tube column joints. Through four full-scale specimens under cyclic loading contrast test, the failure form, hysteresis curve and skeleton curve were studied. The test results show that: the overall performance of outsourcing steel tubal column joint is better than other tradition joints, for without drawing or detachment phenomenon; Under the same conditions, node hysteresis curve and skeleton curve are similar to cast-in-site RC columns. These joints also have good ductility and energy dissipation capacity. Rupture of the test's samples belongs to large eccentric compression failure, which ductility is better. The research results can provide the reference of theory research and practical engineering application connected to the assembled monolithic column.

Keywords: assembly integral, local outsourcing steel tube, seismic performance, hysteresis curves, skeleton curves.

1 Introduction

Currently, reinforced concrete engineering dominates the multistoried and high-rise building of our country and it has great advantages in cost and molding. However, the construction of reinforced concrete engineering adopts the cast-in-place system. This system has been widely accepted and used in the engineering field, but it also has obvious flaws. Great labor intensity, poor quality, long construction period, and low production efficiencies, low construction speed more material consumption and so on. Especially in the present, the number and the skill of labor service personnel is decreasing day by day and the age of labor increases. So the reform of building construction method is urgently needed and it tends to factory production and field assembly industrialization. The main load-bearing parts of assembly integral hybrid frame structure are transported to the construction site after pre-produced in the factory and then connected to form a whole structure by a variety of techniques. This structure is more flexible, strongly adaptable. And it has the features of good integrality, convenient construction, shortening construction period, cost reduction, reducing construction waste, improving engineering quality and so on.

This paper proposes a new assembly monolithic column-column connection node-local outsourcing assembly monolithic steel frame column joints. Column joint is connected by outsourcing steel tube. A transverse rod bolt is arranged between the outsourcing steel tube and the prefabricated concrete column and the gap of outsourcing steel tube and the prefabricated concrete column is poured by quick-setting properties of high strength grout so that integrity of node has no less than the integrity of the cast-in-place column. In this paper, it is the failure mode, hysteretic curve and skeleton curve that is studied and Seismic energy dissipation capacity of assembly monolithic column that is analyzed through four full-scale comparative test specimens at low levels under cyclic loading.

2 Specimen design

This experiment was designed two full-scale outsourcing steel tube assembly monolithic column and two full-scale the integral cast concrete column compared specimens: W01, W02, XJ01 and XJ02. Among them, W01 and W02 are local outsourcing steel tube assembly integral framework columns, hereinafter referred to as the assembly column, XJ01 and XJ02 are the integral cast concrete column.

The height of the upper column is 1200mm and that of the lower column is 1500mm(containing foundation beam).The upper and the lower columns are connected to form the prefabricated. The longitudinal steel bars are equipped with 8 HRB400 steel bars whose diameter is 22mm.The rectangular high strength composite spiral stirrups are equipped with 5mm diameter steel bars and their spacing is 50mm(the spacing of part column encryption areas is 30mm).Outsourcing pipe is disposed in the area of the upper and lower column. Outsourcing pipe consists of two identical “[”type welded steel hoop and it is made of a type of bean shaped steel plate with 5mm thick mark size(the effective plate thickness is 3.8mm).The gap of 5-10mm between outside steel pipe and concrete column is reserved and bonded by high strength grouting material in the late.8 transverse reinforcement bars are arranged in the connecting area of the upper and the lower columns and two ends of them are welded with outsourcing steel plate hoop; they pass through the reserved hole of concrete column. Which the height of specimen W01 is 1290mm and its column base is reinforced by local outsourcing steel pipe; the height of W02 is 850mm and is not reinforced by local outsourcing steel pipe because the local outsourcing steel pipe is set in the seam area according to anchoring requirements. Specimen XJ01 and XJ02 are cast contrast column; their stirrups are equipped with rectangular high strength compound spiral hoop with diameter 5mm and the spacing of stirrups is 50mm; longitudinal reinforcement bars are equipped with 8 HRB400 steel bars whose diameter is 22mm.The dimensions and reinforcement are shown in Figures 1 and 2.

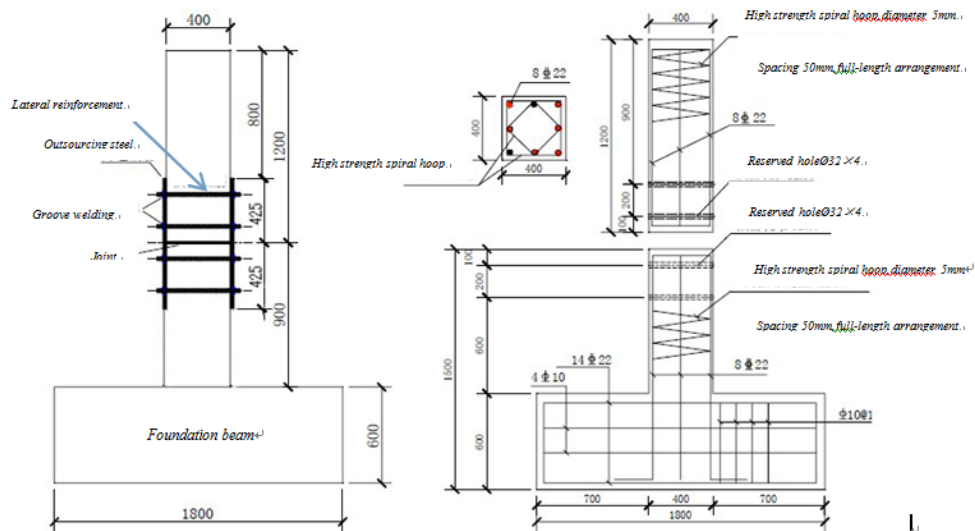


Figure 1. Structural details of W01, W02

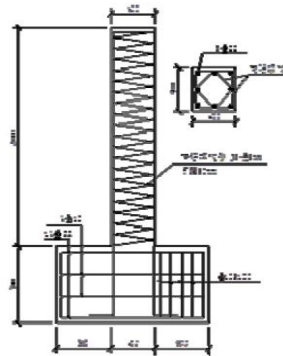


Figure 2. Structural details of XJ01, XJ02

3 Experiment results and analysis

Failure modes of four specimens are shown in Figure 3. Prefabricated column and integral cast column in the test are all experienced three stages: no cracking, working with seam and destruction. Because the axial pressure is relatively large, the plastic hinge region of the column is also very large. Prefabricated column necked obviously at the junction surface, there are all plastic hinge region under the prefabricated column and the concrete is less damaged at the bottom of the column 3-4cm; the plastic hinge is formed by the yielding of the column combined with the anchor and plastic hinge region developed from the top to the bottom through observation of longitudinal strain; under the restriction effect of the steel plate hoops, the concrete cover is almost not peeling off after the plastic hinge region is damaged; the root of the cast-in-place column is almost completely destroyed, plastic hinge region developed from the top to the bottom and concrete cover is almost all peeling off after the plastic hinge region is damaged. In the test, outsourcing steel pipe of prefabricated column W01 and W02 was not found visually observable significant deformation; the strain of outsourcing steel pipe is much smaller than the yield strain; there is no obvious integral slippage between outsourcing steel pipe and concrete column and the damage of all the specimens is from maximum bending moment of the column foot.

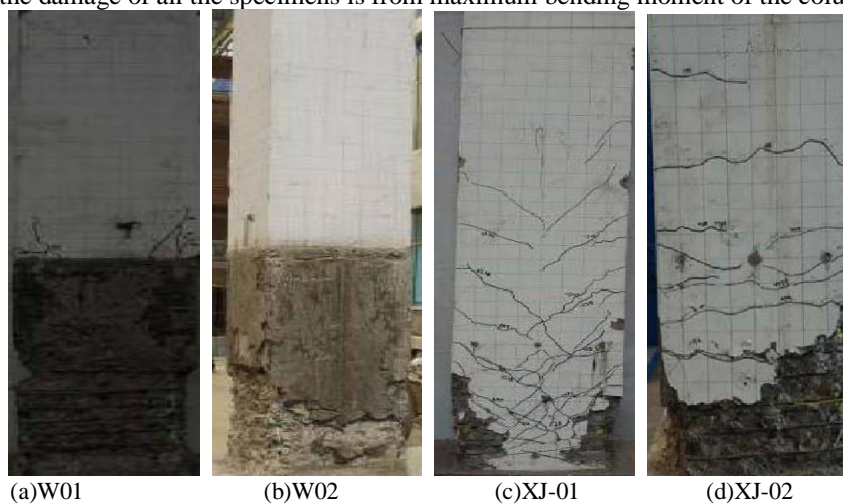


Figure 3. Failure form of specimens

For specimen W01 whose column foot is restricted by outsourcing steel pipe, the test axial compression ratio 0.6 is equal to the design axial compression ratio 1; the yield of lateral longitudinal reinforcement when the columns damage is estimated through column foot longitudinal reinforcement strain and the damage is also the large eccentric compression failure with good ductility. Steel stress-strain diagram of specimen W01 is shown in Figure 4.

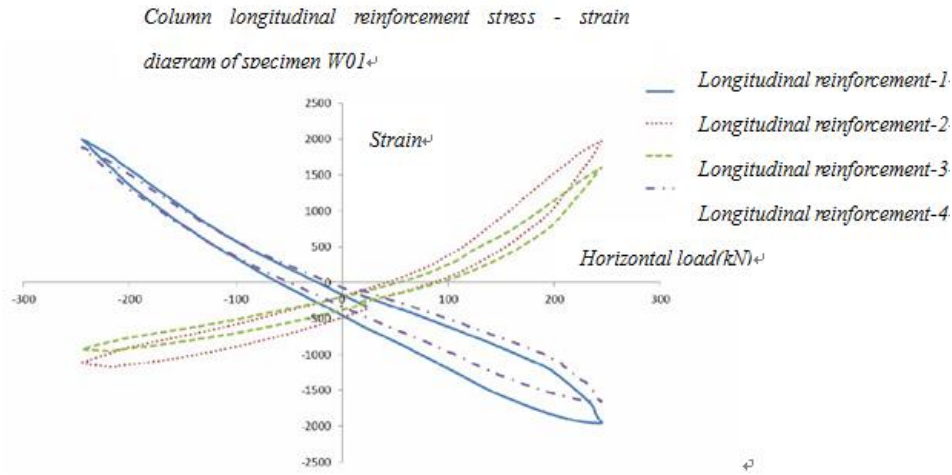


Figure 4. Load-strain of bars

After the test of prefabricated connection column, using a crane to lift the upper column has a dead weight drawing impact on specimens. After lifting, there are no cracks and slip phenomenon in the anchor joint. And that shows after the destruction of the specimen, the bond-anchorage of pulp anchor steal bar is still good.

The hysteresis curves of the four specimens are shown in Figure 5 and skeleton curves are shown in Figure 6, where the abscissa unit of hysteresis curve and skeleton curve is mm and the unit of ordinate is KN. Figure 4 shows that whether cast column or prefabricated column, its hysteresis curve is full of shuttle shape and it has good seismic performance; the hysteresis curve of prefabricated column shows unobvious bow and there is a “pinch” phenomenon. That indicates a bond slip. This is because when the concrete inside the steel plate hoops almost fail, local steel plate hoops have better restriction effect so that nodes can maintain good performance. But a weak pinch phenomenon has been produced in the latter part of the loading process of displacement due to the of weakening of bond force which is between local outsourcing plate and concrete and slip becoming large at the larger displacement. From Fig.6, under the same axial compression ratio, the peak load of the prefabricated column is higher than the cast column but bearing capacity of prefabricated column decreases faster.

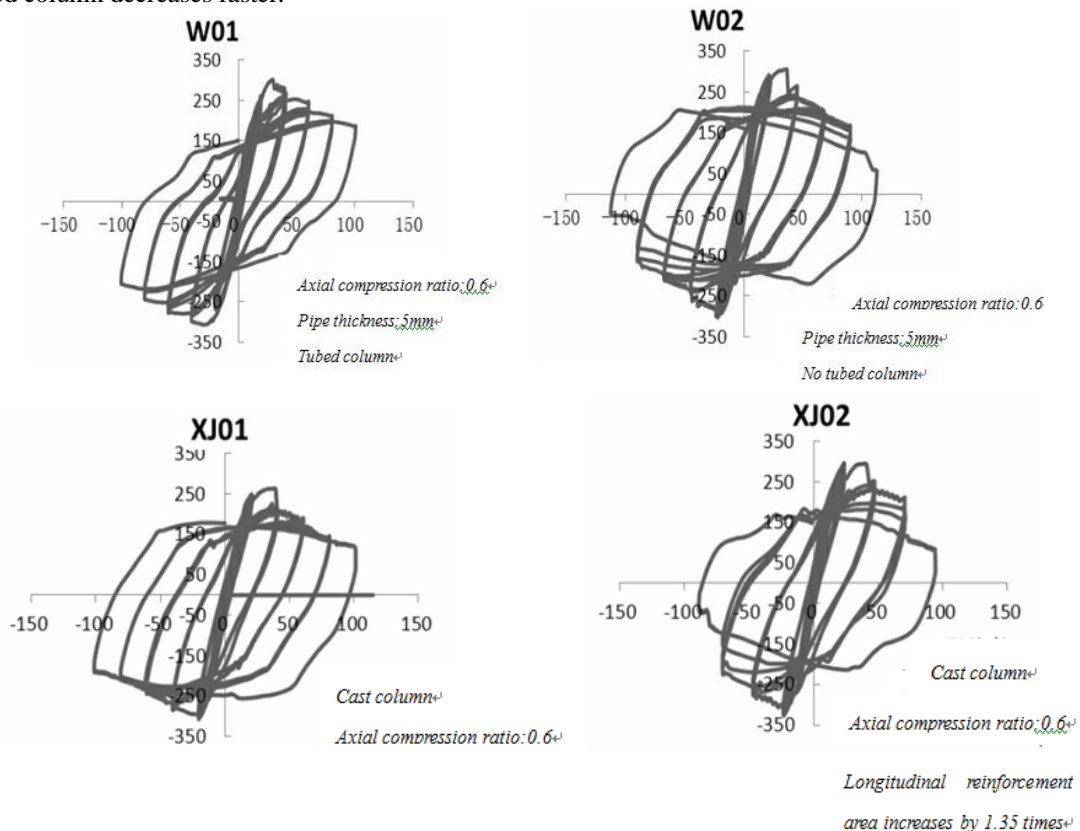


Figure 5. Hysteresis curves of specimens

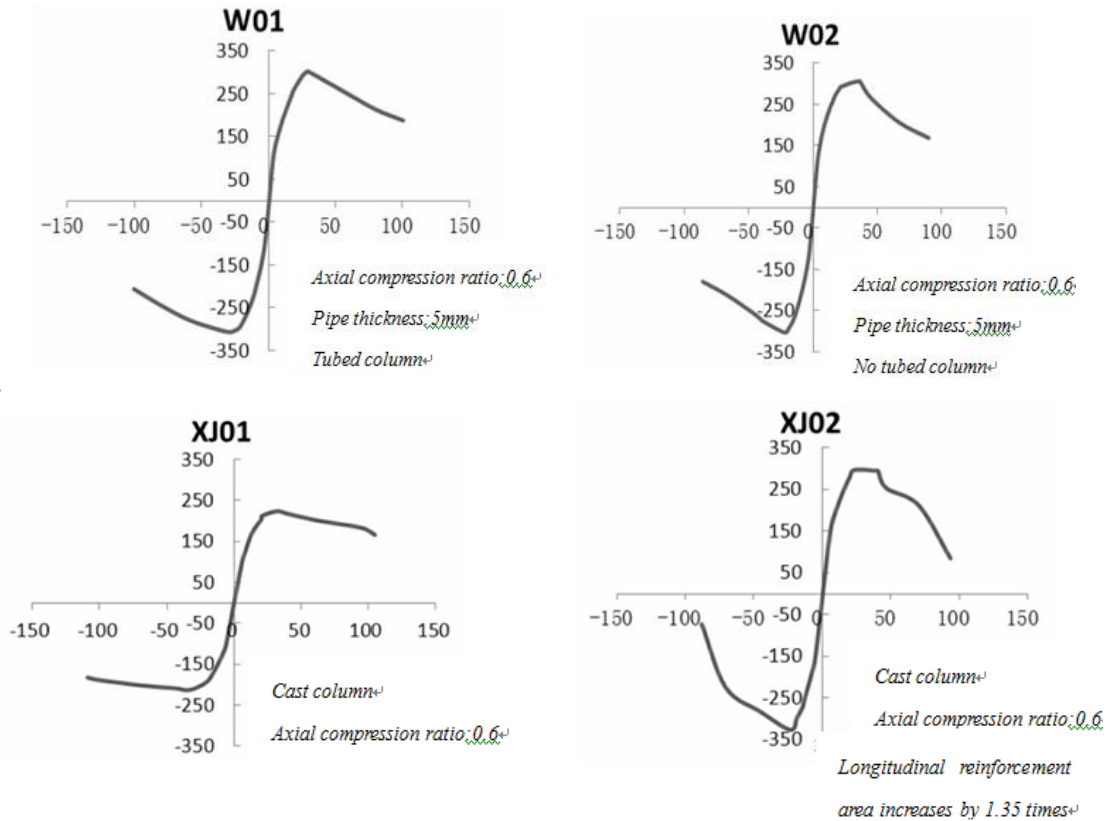


Figure 6. Skeleton curves of specimens

4 Conclusions

In this paper, the damage state, hysteresis curve and skeleton curve of four full size specimens are studied through contrast test under low cyclic loading. And drawing the following conclusions:

- (1) The hysteresis curve of each specimen is full of shuttle shape, which has good ductility and energy dissipation capacity.
- (2) Tensile side longitudinal reinforcement yield and the damage is large eccentric compression damage with good ductility when specimen component damaged.
- (3) The integrity and seismic behavior of new outsourcing steel column joint meet the requirements, which can provide a reference for engineering application.

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