STUDY ON THE BEHAVIOUR OF PRECAST BEAM COLUMN JOINT USING STEEL PLATE CONNECTION (JPSP)

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Abstract: Joint beam column connection is the most critical part for a structure subjected to earthquake loading. This part should be designed such that any possible failure can be prevented. For a cast in situ structure, any failure in this joint can be prevented if all requirements in the design code are obeyed. For pre-cast construction, structural failure usually occurs at the beam-column connection. The research aimed at studying the strength of precast beam-column joint using steel plate as connector (JPSP – Joint Pracetak Sambungan Plat). The precast joints were then connected to precast beams and columns which formed beam-column sub-assemblages for both joint exterior and interior joints. The beam-column sub-assemblages were then tested in the laboratory using monotonic and cyclic loading procedure. Two samples (1 exterior and 1 interior joint) of JPSP were tested and their strength was compared with the strength of the equivalent monolith construction. The research reveals that no significant failures are observed at the core of the joints, where the reinforcing bars of the columns were connected to the bars of the joints by means of welding. Failures / cracks of the joints initiated and concentrated at the junction between the concrete grouting and the precast beam, approximately at the distance equals to the height of beam research is still required in order to obtain the response of the construction to simultaneous gravity and horizontal loads.

INTRODUCTION

It is widely known that precast construction has several advantages in comparison with conventional construction, so the use of the precast construction increases in the last years.

The research presented in this paper deals with the combination of precast joint (JPSP) and precast beams/columns. All elements of the structure were precasted, and connected together before subjected to monotonic and cyclic loading. The strength and the behavior of the JPSP are compared with those of the conventional structure.

METHODOLOGY

There were four samples tested in the laboratory, consisting of 2 samples for precast construction and 2 samples for conventional structures (monolith construction).

Connection

Joints, beams and columns were precasted, in which the beam divided into 2 segments. One segment becomes part of the joint, and the other segment will be connected later to the joints using JPSP. The beams’ segments were connected using bolts, as shown in Figure 1.

Figure 1 Connection of elements
Method for connecting the precast elements

a. Columns, beams and joints were prefabricated. The core of the joint is left without concrete. Four holes at each beam were provided.

b. Precast columns (top and bottom parts) were connected to the rebars of the core of the joint by means of welding. After connected with the weld, the holes was grouted.

c. The precast beam was connected to the joint using bolts to form beam-column sub-assemblies just before subjected to loading.

Design of samples

Due to the limitation of the test frame capacity, the size of the beams and columns were limited, as presented in Table 1.

<table>
<thead>
<tr>
<th>Description</th>
<th>Beam</th>
<th>Column</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width (B)</td>
<td>200 mm</td>
<td>250 mm</td>
</tr>
<tr>
<td>Height (H)</td>
<td>250 mm</td>
<td>250 mm</td>
</tr>
<tr>
<td>Concrete cover (d)</td>
<td>40 mm</td>
<td>40 mm</td>
</tr>
<tr>
<td>(f’c)</td>
<td>20 MPa</td>
<td>20 MPa</td>
</tr>
<tr>
<td>length (L)</td>
<td>1050 mm</td>
<td>1500 mm</td>
</tr>
</tbody>
</table>

TEST PROCEDURE

Interior Joint

To obtain as much data as possible, the beam column subassemblies were tested in two directions. After beam in x direction tested, the sample was turned 90° and then tested again. The load applied in two ways, namely monotonic one and two-direction.
EXPERIMENTAL RESULTS

Maximum Load

a. One-direction Monotonic Loading Interior
The load was applied with 100 kg increment until the sample reached its maximum capacity.

<table>
<thead>
<tr>
<th>No</th>
<th>Test samples</th>
<th>Pmax (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
</tr>
<tr>
<td>1</td>
<td>Monolith Interior</td>
<td>8</td>
</tr>
<tr>
<td>2</td>
<td>JPSP Interior</td>
<td>16</td>
</tr>
</tbody>
</table>

b. Two-direction Monotonic Loading Interior
Table 3 shows the maximum loading applied for the interior joints.

<table>
<thead>
<tr>
<th>No</th>
<th>Test samples</th>
<th>Pmax (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
</tr>
<tr>
<td>1</td>
<td>Monolith Interior</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>JPSP Interior</td>
<td>16</td>
</tr>
</tbody>
</table>

c. Monotonic Two-direction Exterior

<table>
<thead>
<tr>
<th>No</th>
<th>Samples</th>
<th>Pmax (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
</tr>
<tr>
<td>1</td>
<td>Monolith Exterior</td>
<td>14</td>
</tr>
<tr>
<td>2</td>
<td>JPSP Exterior</td>
<td>22</td>
</tr>
</tbody>
</table>

d. Cyclic Loading, Exterior

<table>
<thead>
<tr>
<th>No</th>
<th>Samples</th>
<th>Pmax (kN)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Left</td>
</tr>
<tr>
<td>1</td>
<td>Monolith Exterior</td>
<td>13</td>
</tr>
<tr>
<td>2</td>
<td>JPSP Exterior</td>
<td>13</td>
</tr>
</tbody>
</table>

Crack Patterns
The crack patterns were observed throughout the application of loading.

a. Monolith Construction
Figure 6 shows the crack patterns for the monolith construction. In general, it can be seen that the cracks initiated at the beam ends.

(a) Front beam

(b) Rear beam

Figure 6 Crack patterns of monolith construction

b. Precast Construction (JPSP)

a. Beban 2 arah (sisi B_ker dan C_kanar)
For the precast construction, similar crack patterns with the monolith construction were observed at the initial phase of loading.
At the subsequent loading, the cracks concentrated at the junction between the grouted joints and the beams. This shows that the bonding between the old and new concrete failed, although a special bonding agent was used before grouting of the core of the joint. Further loading resulted in the failure of the beam ends (the tongue), as shown in the Figure 7.

(a) Front beam

(b) Rear beam

Figure 7 Crack patterns of JPSP

Load-Displacement Relationship

Monolith and JPSP Exterior

a. Two-direction loading

Figure 8 Load-displacement diagrams of Monolith and JPSP Exterior

Figure 9 Load-displacement diagrams of monolith and precast exterior joints under cyclic loading

The figure shows that under cyclic loading, the displacement for JPSP is higher than monolith construction.

Monolith and JPSL Interior

a. Two-direction loading

Figure 10 Load-displacement diagrams of interior monolith and JPSP under two-direction loading

Figure 8 shows that the strength and the stiffness of the JPSP are lower than those of the monolith construction. This may be contributed to the fact that the tongue of the connection and the bonding between the old and new concrete failed.
b. One-direction loading

Figure 11 Load-displacement diagrams of interior monolith and JPSP under one-direction loading

CONCLUDING REMARKS

1. In general, the type of cracks for both precast and monolith construction are similar, namely flexural cracks. The cracks initiated at the connection between the precast and the grouted segments. This can also be seen from the lower deflection for JPSP.

2. The strength of the JPSP is higher than the strength of the monolith construction. Cracks at the outer parts can be reduced by using better material for bonding.

REFERENCES


Syarif, BP. 2008 : Kajian Eksperimental Balok Kolom Eksterior Menggunakan Balok Beton Pracetak dan Kolom Baja Profil Kotak, Pascasarjana Unhas

