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DEVELOPMENT OF NEW TIMBER CONSTRUCTION METHODS AND NUMERICAL TOOL IN DESIGNING CONNECTION

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1. In 1992, a new post & beam method using reinforcing column and dowel that called And-Z method was developed. The main features of And-Z method are its column members, simple jointing system and ability to labor-saving. This is a research program about the column-sill joint of And-Z method. Column-Sill Joint is very important for resisting vertical load under seismic and wind load. So there are some prescripts of Column-Sill Joint in Japanese building code. But if using hold-down connector (the connector governed in building code), there will be happened some constraints in building design. Because it is bigger and longer than the connector used before, I designed smarter metal connector not only for And-Z method but also other post & beam methods, and the column-sill joint with the designed connector were tested by monotonic and cyclic load. From the outcomes of the tests, short-term allowable stress for choosing column-sill joint in structural design is obtained.
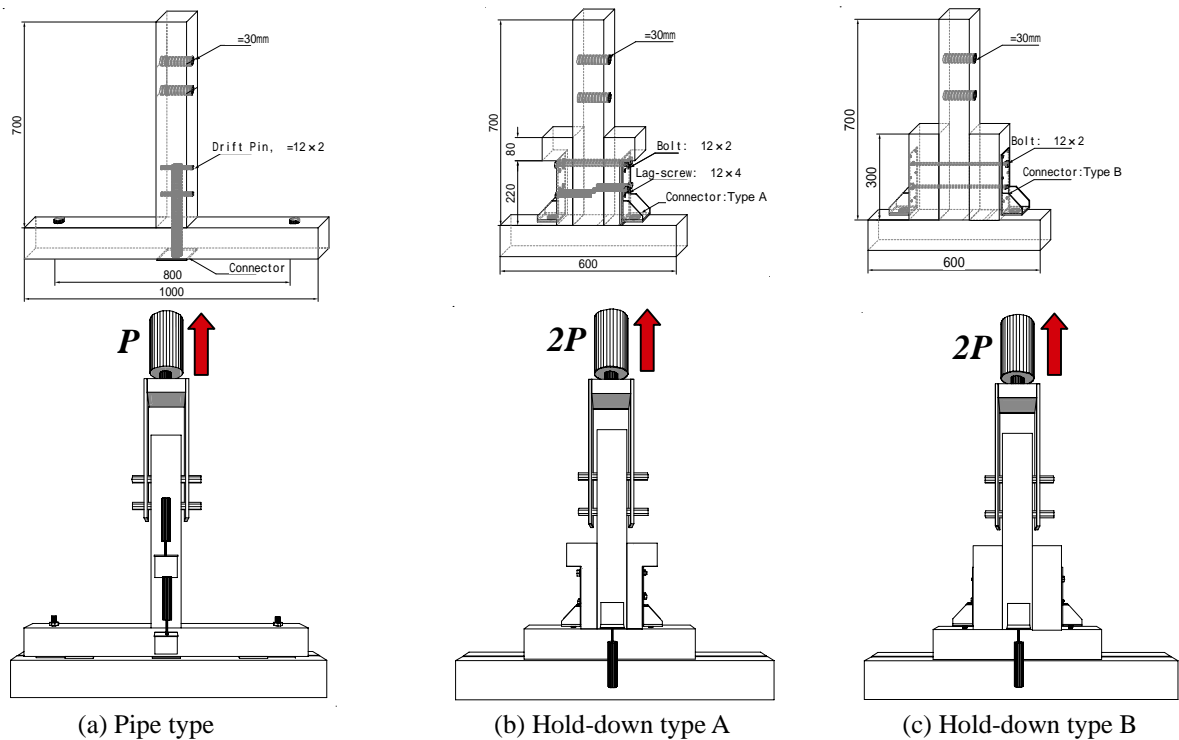
(a) Pipe type   (b) Hold-down type A   (c) Hold-down type B

Figure 3.1 Loading apparatus of the Column-sill joint test

Table 3.3 The short-term allowable stress

Specimens	K	Average of Yield load (P_y)	Standard deviation of Yield load	Average of Maximum load (P_{max})	Standard deviation of Maximum load	TL by P_y	TL by 2/3 of P_{max}	The short-term allowable stress (TL)
		kN		kN		kN	kN	kN
Pipe Type	3.152	26.8	4.8	37.8	3.3	11.7	14.8	11.7
Hold-down Type A	2.464	20.2	1.8	35.8	3.2	15.8	16.0	15.8
Hold-down Type B-I	3.152	14.9	1.4	28.2	2.5	10.5	10.9	10.5
Hold-down Type B-II	2.336	16.5	3.4	29.4	4.8	8.6	8.4	8.4

2. New post & beam method using short corbel that called Angel method was developed in 2003. Until now metal connector (*kanamono* method) or pre-cutting joint have been used for column-beam joint of post & beam method, but there are problems; it needs mechanized pre-cut system or special connectors. Our basic concept is not using mechanized pre-cut system, and so simple column-beam joint is designed; only using short corbel and bolted joint. Some types of the column-beam joint with short corbel are designed and tested; with short corbel, metal connector of *kanamono* method and wooden joint of tenon. From the results, I made out the availability of column-beam joint with short corbel.
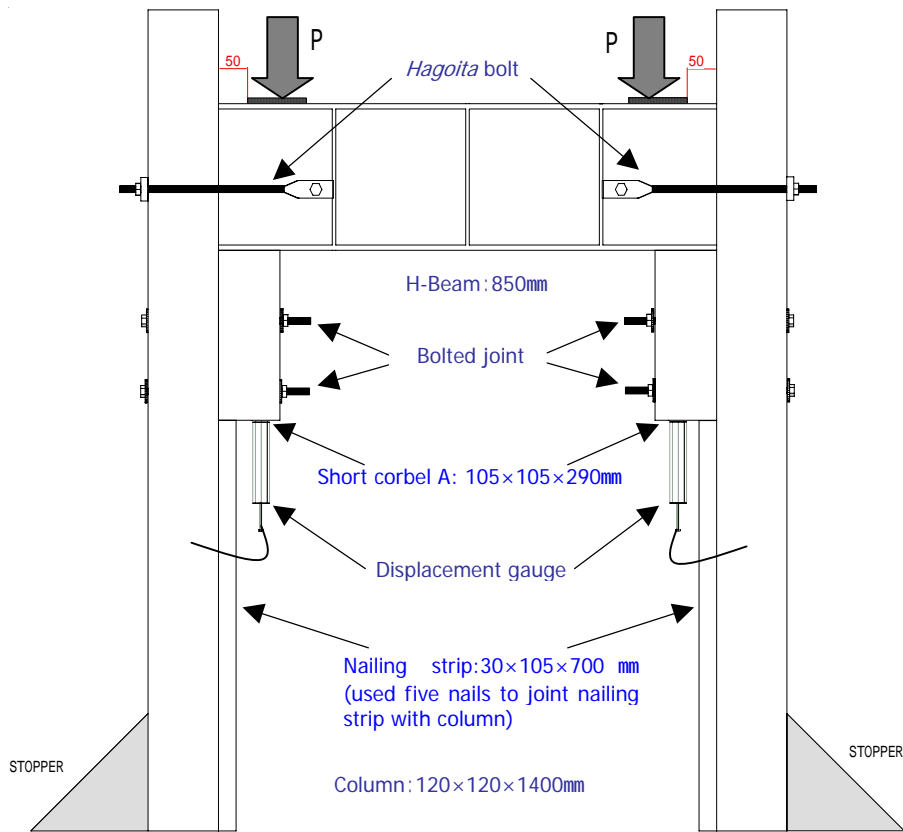
Figure 4.5 Loading apparatus of the Column-Beam joint test (test type of Corbel A-2 or A-4)

Table 4.5 The short-term allowable stress by the test results

Specimens	K	Average of Yield load (P_y) kN	Standard deviation of Yield load	Average of Maximum load (P_{max}) kN	Standard deviation of Maximum load	TL by P_y kN	TL by 2/3 of P_{max} kN	The short-term allowable stress kN
A-1	2.464	20.81	2.96	41.95	6.41	13.5	12.2	12.2
B-1	2.464	31.99	3.08	62.25	4.75	24.4	29.8	24.4
C-1	3.152	39.10	3.23	69.30	4.78	28.9	31.1	28.9
D-1	2.681	36.19	1.16	75.16	4.93	33.1	36.9	33.1
W	3.152	9.95	1.18	18.04	2.48	6.2	4.2	4.2
K	3.152	30.78	3.12	53.71	1.41	20.9	31.4	20.9

3. At last, I used three-dimensional finite element method (ANSYS software package) to analyze the strength properties of bolted joint. I made a model for bolted joint; every model size is about same to the double shear test of bolted joint, but bolt and nuts were modelled that just had only one piece. It was assumed that the bolt might sustain large plastic deformations and, therefore, the steel member was modelled as an elasto-plastic material with material

nonlinearity as like wood member. The numerical analysis was carried out about not only parallel to grain but also perpendicular to grain. And double shear test of bolted joint with wooden side members is carried out. In the results, the nonlinear analysis was similar to the experimental value and the values of reference literatures. Therefore, I think that it is possible to design joint system with three-dimensional finite element method.
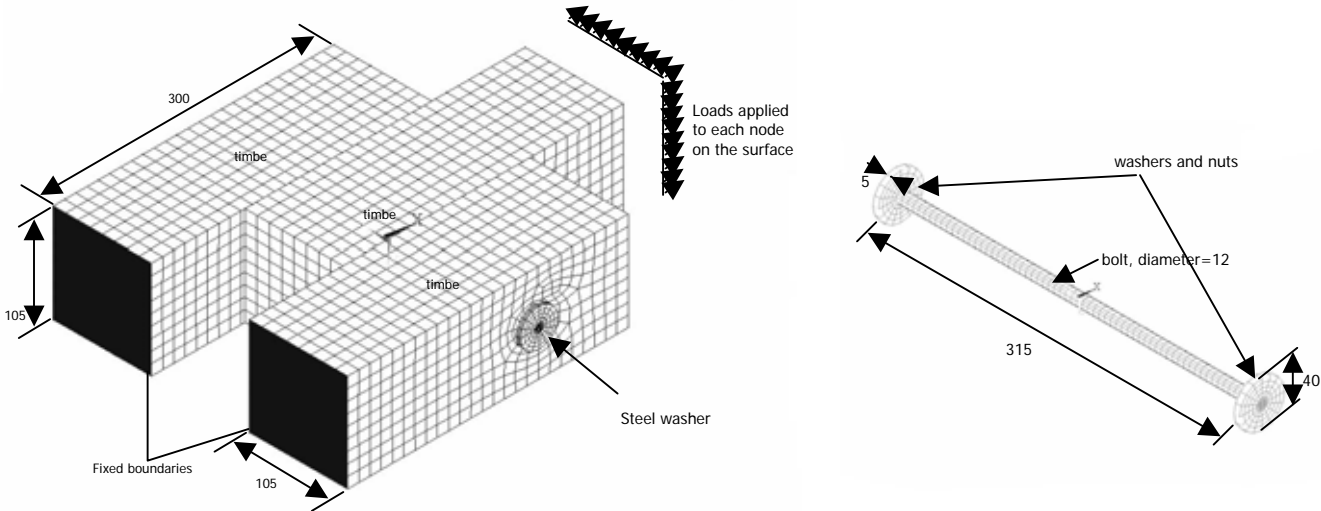

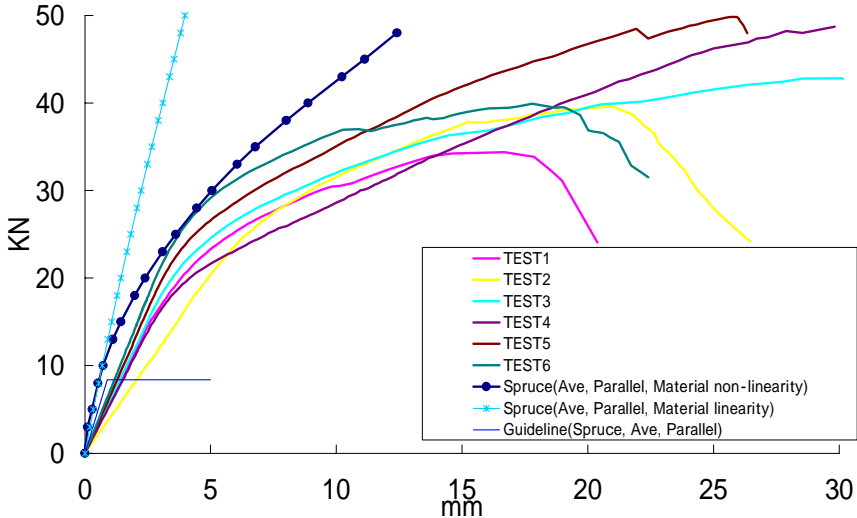Figure 5.1 and 2 Mesh generation for a bolted joint (dimensions in mm).

Figure 5.12 Comparison of experimental results and calculated result, with result from EYT and theory of beam on elastic foundation