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Beam to-Column-Connections with Composite Beams

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This research deals with the contribution of reinforced concrete slab of composite beams on the strength and the deformation capacity of steel beam-to-column connections subjected to seismic loading.

Dimension and configuration of specimens are shown in figure 1 and table 1. Relative yield strength of panel-zone to that of adjoining members is expressed marks "Rpy" and "sRpy" in table 1. Those are considered to be the key parameter on the evaluations of strength, deformation capacity and energy absorption of beam-to-column connections.

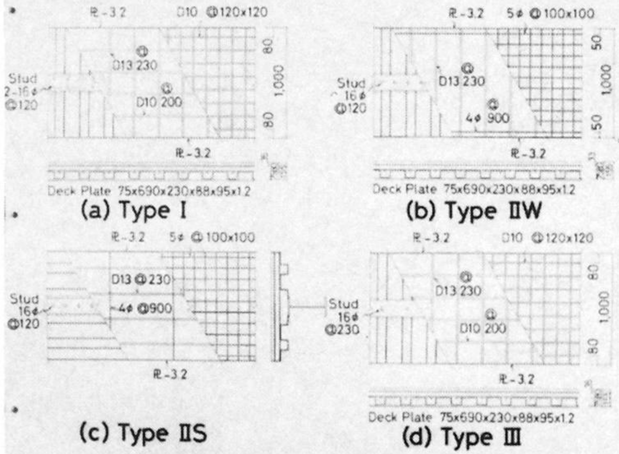
Figures 4a-4c are the summary of representative relations between load and shear deformation of panel-zone. Vertical axis represents the ratio of load to calculated yield strength of beam-to-column connection composed of bare steel beams and column, while horizontal axis represents the ratio of shear deformation of panel-zone to calculated yield shear deformation. Dotted lines in figures 4a-4c show the test results of beam-to-column connections of the same configuration without concrete slab. The reinforcing effect of steel beam-to-column connections by the reinforced concrete slabs of composite beam is illustrated.

A model to take the effect of concrete slab into consideration is proposed in figure 5. In this model, the strength of panel-zone is considered to increase by the enlargement of nominal volume of panel-zone as shown in the figure 5. Relation between "sRpy" (relative yield strength of panel-zone to that of adjoining steel members) and strength, deformation capacity and energy absorption are shown in figures 6a-6d with the other test results of beam-to-column connections composed of bare steel beams and column. The empirical formulas in figures 6a-6d are obtained by regression analyses on the test results of beam-to-column connections composed of bare steel beams and column. Shiftings to the estimated results of yield strength of enlarged panel-zone are indicated by arrows. The seismic behavior of steel beam-to-column connections with composite beams can be evaluated by making use of the model in figure 5 and empirical formulas in figures 6a-6d.

BEAM-TO-COLUMN CONNECTIONS WITH COMPOSITE BEAMS

Table 1 Specimens

No.	Specimen	Column	Beam	Slab type	Rpy	sRpy
1	Z0-I	H-300x300x22x22	H-350x175x9x12	I	1.13	0.80
2	A0-I	H-300x300x16x16	H-350x175x9x12	I	0.63	0.62
3	B'0-I	H-250x250x12x16	H-350x175x9x12	I	0.56	0.40
4	B'0-III	ditto	ditto	III	0.56	0.40
5	B'1-I	ditto	ditto	I	0.49	0.80
6	C0-I	H-250x250x 9x16	H-350x175x9x12	I	0.33	0.33
7	C0-IIW	ditto	ditto	IIW	0.51	0.33
8	C0-IIS	ditto	ditto	IIS	0.28	0.33



(a) Type I (b) Type IIW (c) Type IIS (d) Type III

Fig. 2 Details of Concrete Slabs

$R_{PY} = {}_PP^C_Y / P^C_{mY}$ $sR_{PY} = {}_PP^C_Y / {}_SP^C_{mY}$ $\mu_{20} = \delta_{20}/\delta^C_Y$ $E_0 = {}_SP^C_{mY} \times \delta^C_Y$

${}_PP^C_Y$: Yield load of panel-zone

P_U : Ultimate strength of frame subassemblage

P^C_{mY} : Yield load of adjoining members, whichever is smaller

${}_SP^C_{mY}$: Yield load of adjoining steel members, whichever is smaller

δ^C_Y : Yield deformation of frame subassemblage

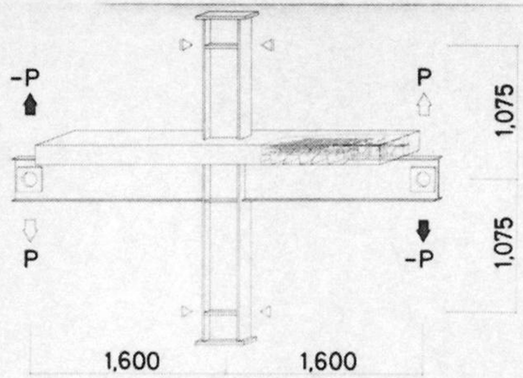


Fig. 1 Configuration of Specimens

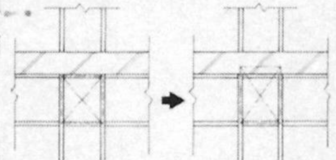


Fig. 5 Equivalent Enlargement of Panel Region

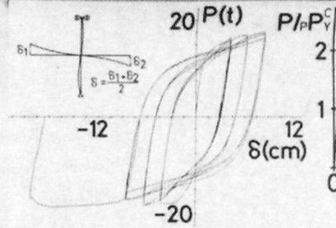
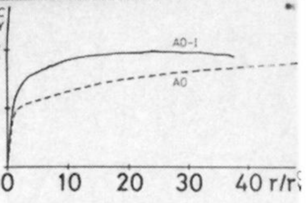
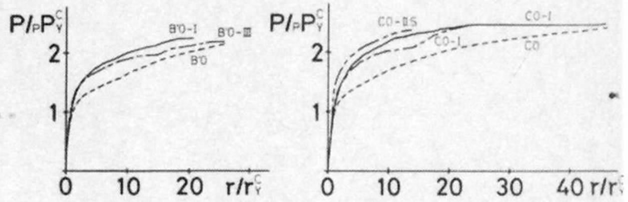


Fig. 3 Load-Deflection Curve



(a) Specimen Type A0



(b) Specimen Type B'0 (c) Specimen Type C0

Fig. 4 Load - Shear Deformation Curves

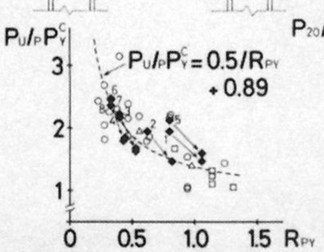


Fig. 6a $P_U/{}_PP^C_Y - R_{PY}$ Relation

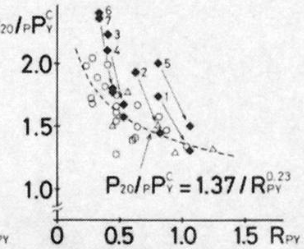


Fig. 6b $P_{20}/{}_PP^C_Y - R_{PY}$ Relation

$(P, E, \delta)_{20}$: At a point where shear deformation of panel-zone became twenty times the yield shear deformation

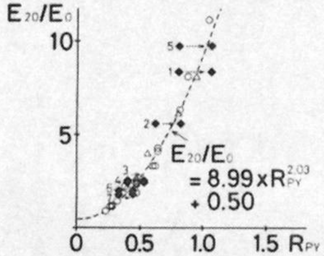


Fig. 6c $E_{20}/E_0 - R_{PY}$ Relation

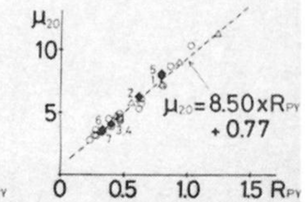


Fig. 6d $\mu_{20} - R_{PY}$ Relation

E : Absorbed energy of frame subassemblage

δ : Deformation of frame subassemblage shown in Fig. 3