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Experimental Behavior of Encased Steel Column-Base Connections

Comportement expérimental du pied de poteau métallique de type encastré

Experimentales Verhalten von einbetonierten Stahlstützen

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INTRODUCTION

In designing earthquake-resistant steel structures, it is extremely important to clarify the mechanical characteristics of steel column bases. The relative displacement of the 1st story of the structure under lateral forces is remarkably affected by the degree of fixity of the column bases. In Japan, the case often arises where such degree is found insufficient, so the sectional area of the column member must be increased to meet the requirement restricting the story displacement. However, it is difficult to attain an enough degree of fixity for the exposed type of column bases. This is because it is very hard to maintain a high degree of precision in positioning the anchor bolts and in working out the contact surfaces between the base plates and levelling grout under them. To increase the degree of the fixity, therefore, encased column bases, namely, steel column bases enclosed with reinforced concrete are in use in Japan. Also, exposed type steel column bases damaged by lateral loadings are repaired with this constructional method.

EXPERIMENTAL RESULTS AND DISCUSSION

A total of seven specimens, i.e., two exposed type and five encased type column base specimens were tested. As shown in Table 1, the experimental factors were the presence or absence of encasing concrete, height and sectional area of concrete encasement and loading methods. As shown in Fig. 1, the axial load was zero, and at one position which was considered the point of inflection of the column member, the lateral loads were applied monotonously or repeatedly.
The relations between the lateral load [Q] and the displacement [δ] at 1m height above the bottom surface of the base plate are shown in Figs. 2 and 3. In Fig. 2, the envelope curves of the Q-δ relations under the repeated load are shown, too. As can be seen from this figure, it is clear that the differences between the Q-δ curves under the monotonic loading and the envelope curves under the repeated loading are relatively small. The solid straight line shown in Fig. 2 represents the calculated stiffness of an ideal steel column perfectly fixed at the base. Although the degree of fixity and strength of exposed type column bases are small, they increase remarkably if the bases are encased in reinforced concrete. When the encasement height is more than about twice the depth of steel section, these column bases may be regarded as perfectly fixed because the stiffness of these columns is larger than that of the steel column ideally fixed at the base. The specimen in which the sectional area of the stub column is enlarged shows a little increase in the stiffness and strength. The relations between the load [Q] and the lateral displacement [δb] of the base plate are shown in Fig. 4. In the encased type specimens, little lateral movement of the

base plate takes place until the maximum load is reached. Certain examples of cracks which occurred in the stub column are shown in Fig. 5. The test results are shown in Table 1. In this test, the maximum load on the specimens having an encasement height smaller than about twice the depth of steel section is governed by bond failure of the chord reinforcement in the stub column. Therefore, it is necessary to provide a sufficient bond length to avoid failure at this portion. When the moment-resistance of steel column bases themselves becomes smaller, the larger concentrated force is caused near the top of the stub column. In such cases, it is necessary to reinforce the stub column with the ties to prevent shear failure of the stub column.

From this experiment, it was clarified that the encased type column base is useful for increasing the stiffness and strength of the column bases and also for strengthening or repairing column bases damaged by lateral loading.

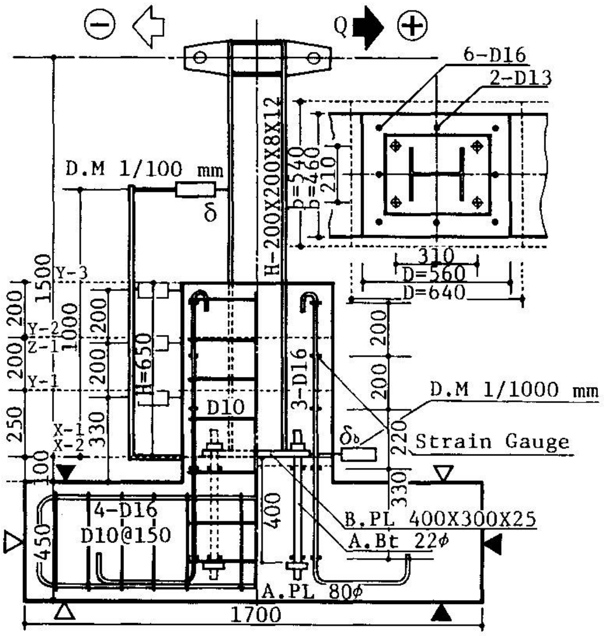

Fig.1 Column-base connection specimen

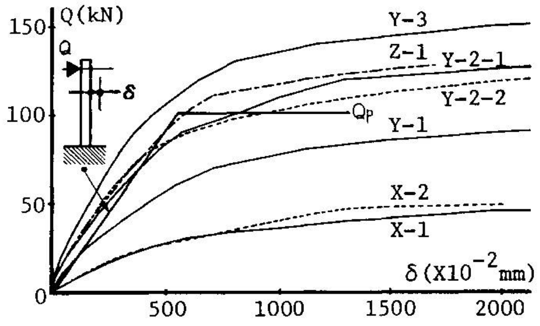

Fig.2 Load(Q)-displacement(δ) curves under monotonic loading

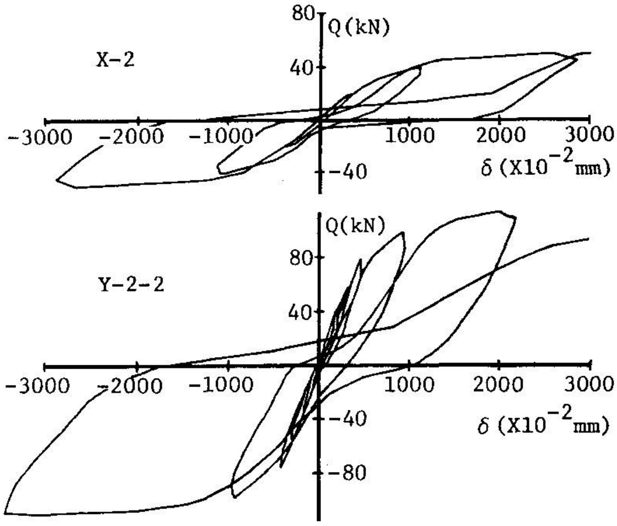

Fig.3 Load(Q)-displacement(δ) curves under repeated loading

Table 1 Test factors and test results

Specimen Symbol	Encasement (cm) b×D	Encasement (cm) H	Loading Method ※1	Initial Flexural Cracking Load (kN)	Maximum Load (kN)	Failure Mode ※2
X－1	—	—	M	—	55	A
X－2	—	—	R	—	56	A
Y－1	46×56	25	M	30	92	R
Y－2－1	46×56	45	M	30	131	R, S
Y－2－2	46×56	45	R	15	111	R, S
Y－3	46×56	65	M	30	157	S
Z－1	54×64	45	M	30	141	R

※1 M : Monotonic
R : Repeated

※2 A : Yielding of Anchor Bolts
R : Bond failure of Chord Reinforcing Bars
S : Shear Failure of Stub column

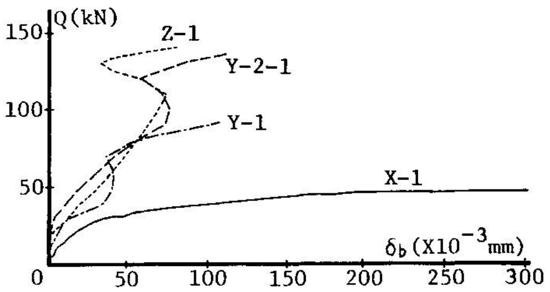

Fig.4 Load(Q)-displacement of base plate(δ_b) curves

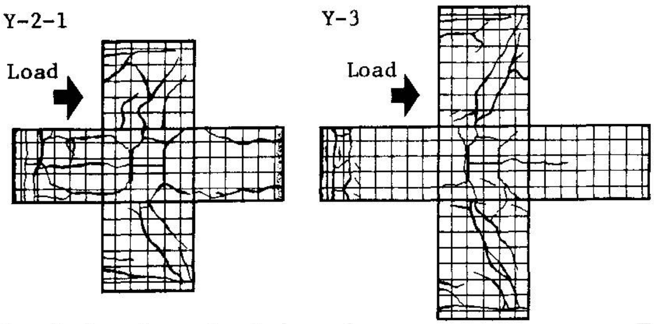

Fig.5 Cracks of stub column after test