Earthquake Engineering, Tenth World Conference © 1992 Balkema, Rotterdam. ISBN 90 5410 060 5

Behavior of exposed-type 'fixed' column base connected to riser foundation concrete

Sadayoshi Igarashi
Osaka University, Japan

Shigetoshi Nakashima
Osaka Institute of Technology, Japan

Haruyoshi Kadoya
Okabe Engineering Co., Ltd, Tokyo, Japan

Masahiro Suzuki
Asahi Chemical Industry Co., Ltd, Tokyo, Japan

ABSTRACT: The mechanical properties of exposed-type "fixed" column bases made of steel are affected by the composition of the connection to the base plate, the anchor bolt, and the shape of the column base. In this study, we examined the mechanical behavior of the column base by applying repeated bending and shearing forces to the top of the column under zero axial force using a life-size model of an exposed column base. A base with a relatively small section and riser foundation concrete exhibited remarkable differences in rigidity and durability with different anchorage methods.

1 INTRODUCTION

Since the steel column base forms the connection between different structural units of steel construction and concrete construction, it has a complex linkage mechanism. It is considered extremely important to clarify the mechanical properties of column bases from the point of view of earthquake-resistant design.

The stress is transmitted to the foundation through the base plate in a steel column base. By investigating the different methods of fixing the anchor bolt, the effects of differences in anchorage method on the durability and rigidity of the exposed-type column base were examined. A foundation column with a riser was selected, as it is considered disadvantageous in securing durability of the column base, and the sectional dimensions were also made relatively small.

It has also been pointed out that exposed-type column bases are affected easily by construction conditions, particularly the accuracy of anchor bolt positioning and the finish accuracy of the contact surface between the under face of the base plate and the upper face of the concrete. Poor conditions may make this connection unstable, reducing the security and durability of the column base and affecting the structure.

A special grouting method designed to overcome this was adopted for specimen No. 4 (Fig. 1). The bolt hole in the base plate was enlarged to absorb some horizontal movement of the anchor bolt, while adhesion was secured by using a special washer and forcing a non-shrinking mortar with good fluidity into both the clearance between the under face of the base plate and the upper face of the foundation concrete and that between the anchor bolt and the base plate so as to smoothen the flow of force throughout the connections.

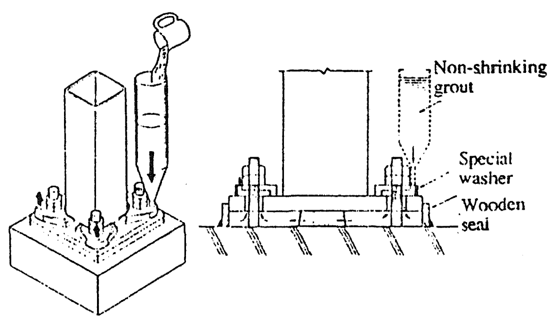


Figure 1. Special grout method

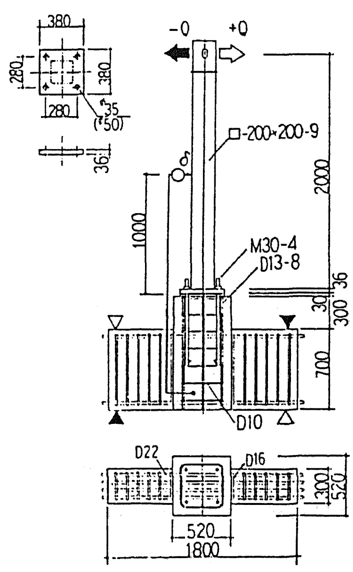


Figure 2. Test specimen

2 EXPERIMENTAL PROCEDURE

Figure 2 shows the shape, dimensions, and testing method of the model column base.

The models tested all had the same base plate (plane plate), column member (square steel pipe), foundation shape (RC foundation riser) and diameter, strength, and anchor bolt embedding depth.

Four anchorage methods were used for the anchor bolt, as given below, and their configurations and dimensions are shown in Fig. 3.

1 J-type anchor bolt using round steel (test specimen No. 1)

2 Anchorage plate placed at the bottom of the anchor bolt by means of round steel and adhesion at the axial part is cut off from the concrete using a paper sleeve. (test specimen No. 2)

3 As in 2 above, except that tension is introduced into the anchor bolt by turning the nut. (Tension amounting to about 30% of the yield strength of the anchor bolts was introduced in order to enhance the initial rigidity of the column base.) (test specimen No. 3)

4 The test specimen was a screw threaded deformed bar with the anchorage plate at the bottom (Fig. 3, 3). (test specimen No. 4)

3 RESULTS OF TESTS AND EXAMINATIONS

Table 1 shows the results of the tests on each test specimen and Fig. 4 shows the hysteresis curve for each test specimen.

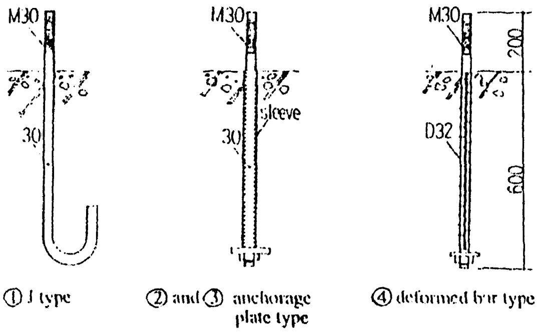
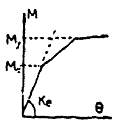


Figure 3. Anchor bolt

Table 1. List of experimental results

Specimens No.	Cracking moment Mc (KN-m)	Yield moment My (KN·m)	Ultimate moment Mu (KN·m)	Mu/My	Failure types	Ki ×10⁴ KN·m/rad
No. 1	94.0	132.4	139.2	1.05	A · C	0.104
No. 2	98.4	137.4	147.0	1.07	A · C	0.141
No. 3	98.2	137.6	154.6	1.13	A · C	0.191
No. 4	98.8	129.4	196.0	1.51	B · D	0.190



A: Yield of anchor bolts.

B: Tension failure of anchor bolts.

C: Collapse of foundation concrete.

D: Compression failure.

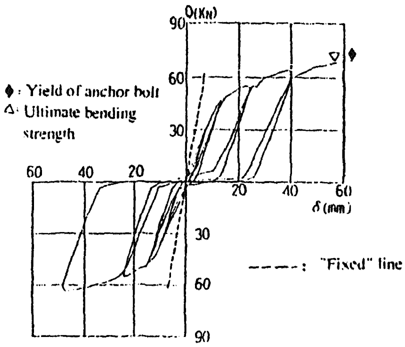


Figure 4.1. Q-δ curve (No. 1)

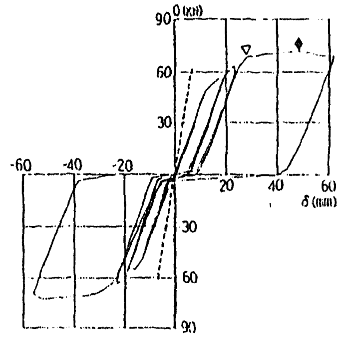


Figure 4.2. Q-δ curve (No. 2)

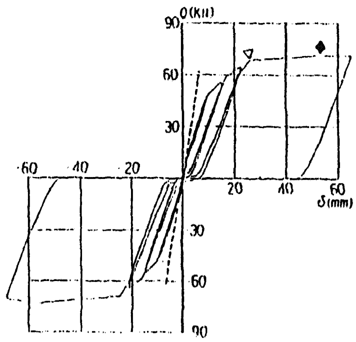


Figure 4.3. Q-δ curve (No. 3)

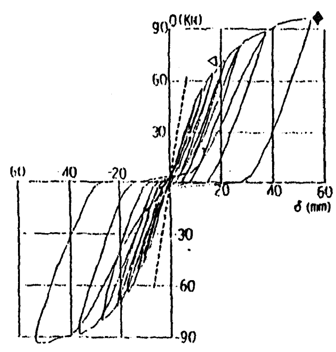


Figure 4.3. Q-δ curve (No. 4)

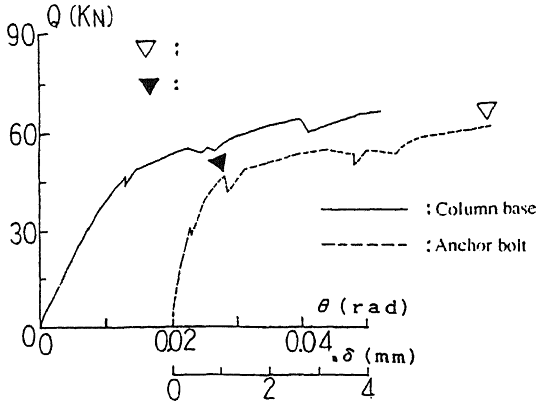


Figure 5.1. Q-θ (Q-aδ) related envelope line
<No. 1>

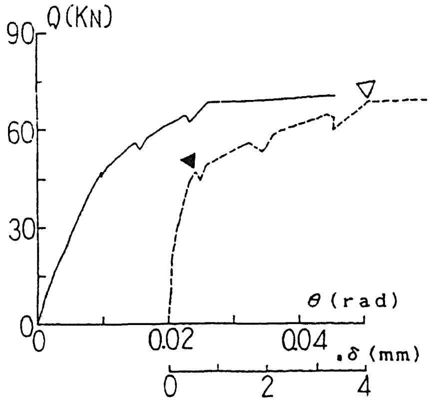


Figure 5.2. <No. 2>

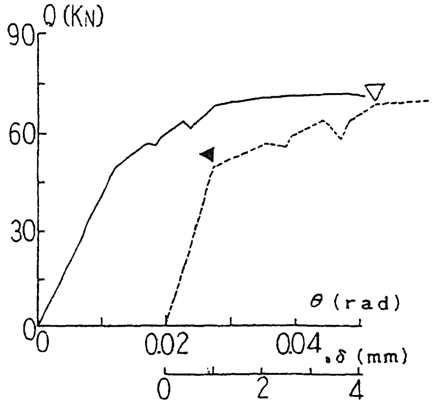


Figure 5.3. <No. 3>

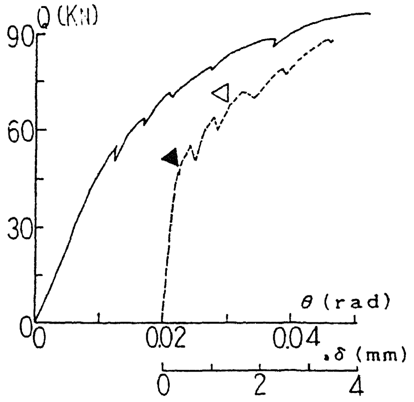


Figure 5.4. <No. 4>

1. Rigidity of column base

The initial rigidity of the column base correlates with the behavior of the anchor bolt. Figure 5 contrasts the hysteresis curve of each column base and slippage as an envelope line during normal loading.

The anchor bolts of 1 - 3 suffer increased slippage after shear cracking occurs in the concrete, reducing the rigidity of the column base. In the case of 1 , there was great slippage of the anchor bolt, and its rigidity was the lowest. In the case of 4 , although bending cracking was seen in the concrete, the slippage was small and the loss of rigidity also small. The initial rigidity of column base that used the anchor bolt in the case of 3 and 4 was about the same.

2. Durability of column base

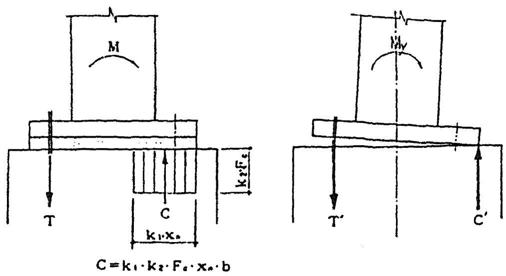
The yield load of the anchor bolt in each test specimen was about the same. However, there was a significant difference in the durability of the column bases.

Column bases with an anchor bolt of round steel, as in the case of 1 and 3 , suffered immediate collapse of the concrete simultaneously with yielding of the anchor bolt, and thus had the greatest durability. In the case of a column base with an anchor bolt formed from a deformed bar, case 4 , the durability of the column base increased even after the anchor bolt yielded, reaching a maximum at the time of the collapse of the concrete.

The pressure loading mechanism of the column base can be modeled generally as shown in Fig. 6. However, if there is a sudden extension of the anchor bolt due to yield or similar, the compression zone is concentrated on the end of the base plate resulting in failure of the concrete. When a deformed bar is used as an anchor bolt, the extension after yielding is relatively small, so migration to the base plate end of the resultant force of concrete becomes slower as the elongation of the anchor bolt after yielding is relatively small, and the bending durability of the column base wall increase.

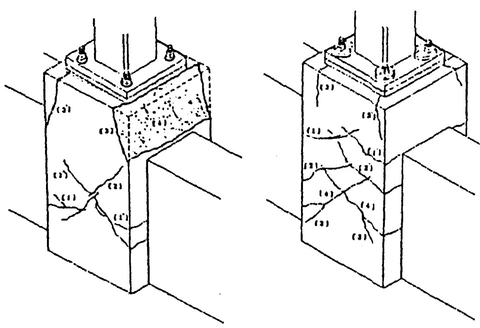
There is thus a remarkable difference between the rigidity and durability of a column base depending on the type of anchor bolt in the case of an RC foundation with a riser portion.

These results confirm that an anchor bolt formed using a deformed bar is most effective in enhancing the durability of the exposed-type column base.



(a) Stress block (b) My model

Figure 6. Theoretical model



<No. 3> <No. 4>

Figure 7. Crack and its occurring sequence

Table 2. Properties of materials

STeel	σ_y (N/mm²)	σ_t (N/mm²)	El (%)
STeel columns □-200x200-9	410	490	19
Base plates t=36	380	570	37
Anchor bolts D32	380	600	30
φ30	360	580	28

Concrete & Mortar	σ_c (N/cm²)
Concrete	28.0
Mortar	53.5

4 CONCLUSION

1. In the case of an exposed-type column base, it is important to secure the foundation concrete to the under face of the base plate, thus ensuring a smooth flow of forces.
2. The durability of exposed-type column bases with a riser foundation varies according to the method of anchoring the anchor bolt. An anchor bolt consisting of a deformed bar is effective as regards enhancing the durability and rigidity of exposed-type column base.

Also, the modelization of the load bearing mechanism shown in Fig. 6 can be used to accurately evaluate column bases using anchor bolts.

REFERENCES

Nakashima, S., S. Igarashi, H. Kadoya, M. Suzuki, and N. Noda 1991. Experimental study on exposed steel square tubular column bases using a special grout method: 4th International Symposium, *Tubular Structures*: 109-118.

Nakashima, S., H. Kadoya, S. Kiriyama, S. Igarashi, and T. Suzuki 1989. Behavior of full scale exposed type steel square tubular column bases under lateral loading, International Symposium on Tubular Structures, Lappeenranta, Finland.

Nakashima, S. and S. Igarashi 1988. Influence of details of column bases on structural behavior: *Proc. 13th IABSE Congress*: 705-701. Helsinki.

Nakashima, S., T. Suzuki, and S. Igarashi 1989. Mechanical characteristics of exposed type steel column bases: *Proceedings of the International Colloquium, Bolted and Special Structural Joints*: 148-152. Vol. 2, USSR National Committee of International Association for Bridge and Structural Engineering, Moscow.