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Strength and Deformation of Steel Column to Concrete Pile Connection

Contrainte et déformation d'un poteau en acier au point de jonction avec le pieu en béton

Tragwiderstand und Verformung von Verbindungen zwischen Stahlstützen und Betonpfählen

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1. INTRODUCTION

To utilize the aerial spaces over the railway tracks is fairly prospective solution for the shortage of land space in urban area like Tokyo. Because of limited construction site around tracks in everyday use,dispensing with footing beams ,that is,providing one pile foundation for one column as illustrated in Fig.1 achieves greater economy. Railway Technical Research Institute had organized the committee by scientific and administrative members besides Japan Railways group from 1988 to 1990 and studied technical problems to construct the high-rise over-track building structually characterized by having no footing beams.As the result,the seismic resistance design standard for it was established in 1990. The need for study of the mechanical behavior of the column-pile connection was cited in the committee.In this type of structure,the steel box column is directly inserted to the cast-in-place concrete pile reinforced by the steel pipe with continuously roll-formed ribs on its inner surface as shown in Fig.2. This report describes the summary of experimental and analytical study on the connection and the design method for it.

2. EXPERIMENTAL STUDY

Moment distribution of the story for accommodating tracks under the horizontal seismic force is shown in Fig.3. Moment and shear force of the column should be transferred smoothly to the pile in the connection.
17 specimens illustrated in Fig.4 were statically tested by reversed cyclic loading. The primary variables employed in this study were with/without ribs of the steel pipe,the embedded length of the column and the axial force of the column.The column of specimens modeled the prototype one under the inflection point . Solid column section was used to ensure that the column flexual capacity exceeded the anticipated strength of the connection. Fig.5 and Fig.6 show the test results indicating the effect of ribs of the steel pipe.As can be seen from these figures, the ribs restrict the slip-out of the infilled

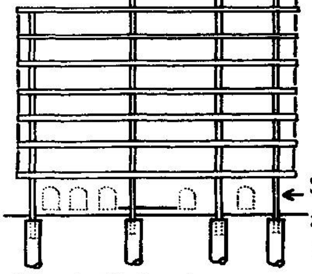

Fig.1 High-rise over-track building

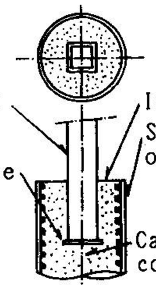

Fig.2 Column-pile connection

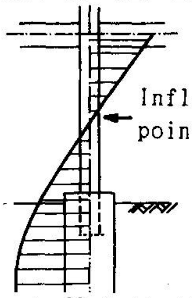

Fig.3 Moment distribution of story for accommodating tracks

concrete from the steel pipe due to the rotational deformation of the base plate and consequently enhanse the stiffness and strength of the connection. Fig.7 shows the test result indicating the effect of the embedded length of the column in the steel pipe with ribs. Followings can be seen,

- Stiffness and strength of the connection increase as the embedded length increases.
- Yield strength at which load-deflection curve becomes nonlinear corresponds to the load when the hoop stress of the pipe yields at the top of the connection.
- To ensure that the flexural capacity of the column above the connection exceeds the yield strength of the connection, the required embedded length of the column is over 1.5 times the height of its section.

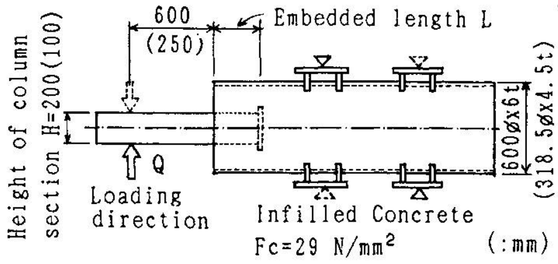

Fig. 4 Test specimen

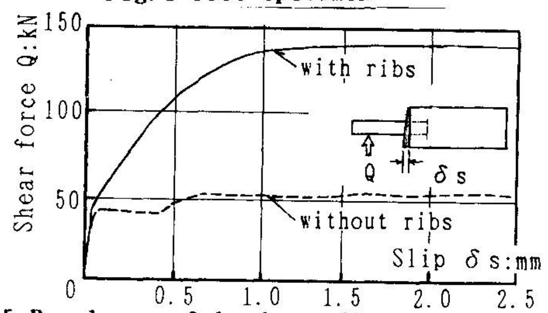

Fig. 5 Envelopes of load to slip-out of concrete curves(specimens with pipe 318.5⌀)

3. ANALYTICAL STUDY

To predict the stress and the deformation of the connection before the yield strength, the connection was modeled as shown in Fig.8.The effect of ribs of steel pipe was taken into consideration in the rotational rigidity Kr. Horizontal modulus of Winkler's elastic medium Kh is calculated by the horizontal deformation of the infilled concrete and the steel pipe. Analytical results evaluated conservatively the experimental results as shown in Fig.7.

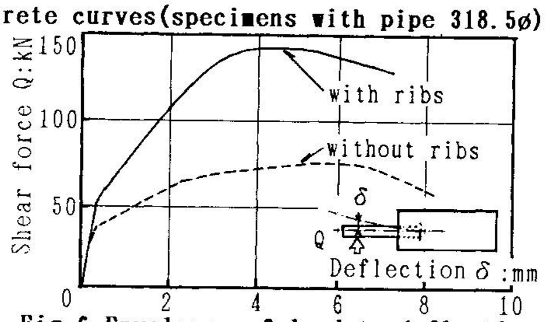

Fig. 6 Envelopes of load to deflection curve(specimens with pipe 318.5⌀)

4. DESIGN OF CONNECTION

In the seismic resistance design of the connection,it is regulated that the hoop stress of the reinforcing pipe which is calculated by above analysis should not yield before the mechanism of the story for accommodating tracks developed by plastic hinges in beams,columns or pipes.

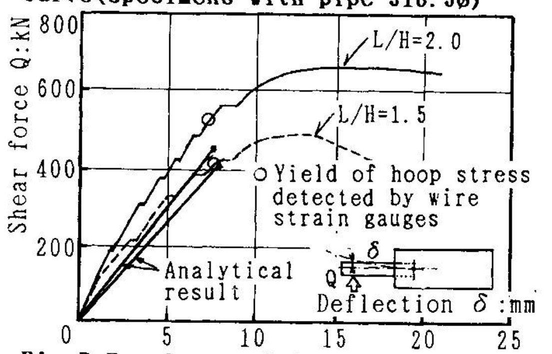

Fig. 7 Envelopes of load to deflection curve(specimens with pipe 600⌀)

5. CONCLUSION

By the experimental and analytical study of the column-pile connection, the design method for it was developed. 9-stories station building is now under construction in Ooi-town in Tokyo

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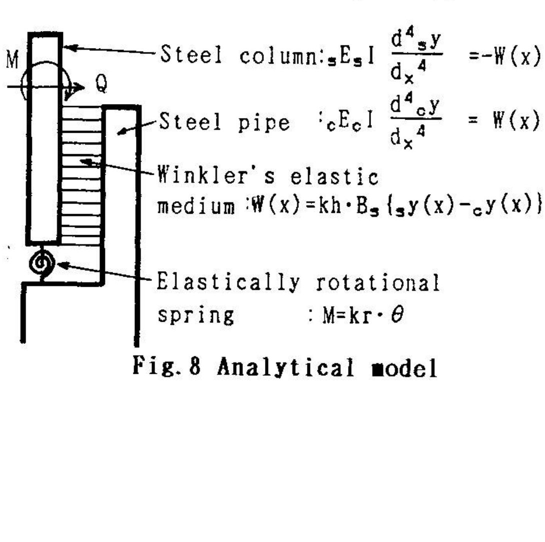

Fig. 8 Analytical model