Ultimate strength and ductility in concrete-filled double steel tubular columns

Ultimate Strength and Ductility in Concrete-Filled Double Steel Tubular Columns

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Summary

This paper deals with the ultimate strength and ductility in concrete-filled double steel tubular columns. Two types of rectangular and circular cross-section were treated herein. First, the interaction curves concerning the ultimate strength of the cross section between axial force and bending moment are presented in comparison with normal composite columns. To evaluate the earthquake resistance of the column, the ductility is an important factor. Therefore, the ductility of these columns are, next, reported and compared with the reinforced concrete columns.

1. Assumptions for analysis

The following assumptions are used for the analysis of the column. a) The plane cross section of the column remains plane. b) The concrete strength in tensile area is ignored. c) Steel and concrete parts show full composite action. d) The state of full plastic stress is assumed for the analysis of *M-N* interaction.

2. *M-N* interaction curve

As one of the numerical examples for the circular section, Fig.1 shows *M-N* interaction curves of the cross section for concrete-filled double steel tubular column in comparison with the steel and the concrete-filled single steel tubular columns. The numerical data for the calculation is shown in Table 1. From the curves, it is found that the maximum load carrying capacity ratio (M_{max}/M_{pl}) is 1.90 for concrete-filled single steel tubular columns. In the case of concrete-filled double steel tubular column, however, its value is 1.35. The reason of this decreasing can be explained clearly that the cross sectional area of concrete in concrete-filled double steel tubular column is less than the concrete-filled single one. Therefore, it is recognized that the effect of cross sectional area of concrete for the maximum load carrying capacity of the composite column is one of the important factors for the design. The *M-N* interaction curves for the rectangular section have same properties with circular section.

Table. 1 Numerical Condition

Yield strength of outside steel tube	σ_{y1}	235 N/mm^2
Diameter of outside steel tube	d_1	2000 mm
Thickness of outside steel tube	t_1	9 mm
Yield strength of inside steel tube	σ_{y2}	235 N/mm^2
Diameter of inside steel tube	d_2	1200 mm
Thickness of inside steel tube	t_2	9 mm
Specified concrete strength	σ_{ck}	23.5 N/mm^2

3. Ductility

To evaluate the ductility of the column, an actual bridge pier shown in Fig.2 was selected. The calculations were executed for three types of column, namely, reinforced concrete, concrete-filled single and double steel tubular column in which the column has same external dimensions. The yield and ultimate horizontal displacement at the top of column, δ_y and δ_u, are defined as the values when the strains of steel and concrete reach the yield and ultimate strains at most outer side of steel and concrete, respectively. Using these values the rate of ductility for column, μ, is calculated as follows:

$$\mu = \delta_u / \delta_y$$

Fig.3 shows the relationships between horizontal force and displacement of three columns. Concrete-filled steel tubular columns have large load carrying capacity and ductility compared with reinforced concrete column. Furthermore, the ultimate displacement in double steel tubular column is smaller than concrete-filled single one. However it is identified that the both composite column has almost same load carrying capacity.

4. Conclusion

A burden against the foundation can be reduced by employing the double steel tubular structure for column since the dead weight of bridge pier reduces. Furthermore, it can be mentioned that the concrete-filled double steel tubular column has almost same mechanical characteristics compared with the concrete-filled single one.

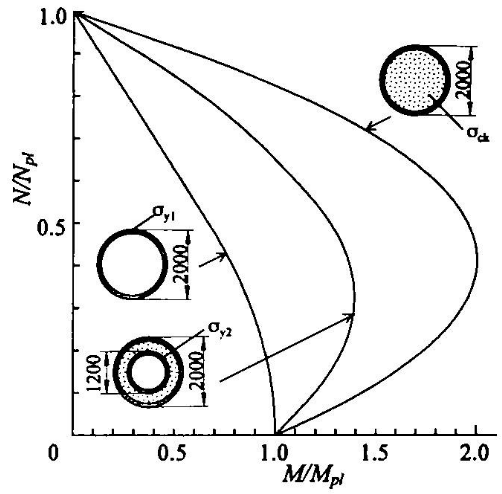

Fig. 1 M-N interaction curves of three types of column section

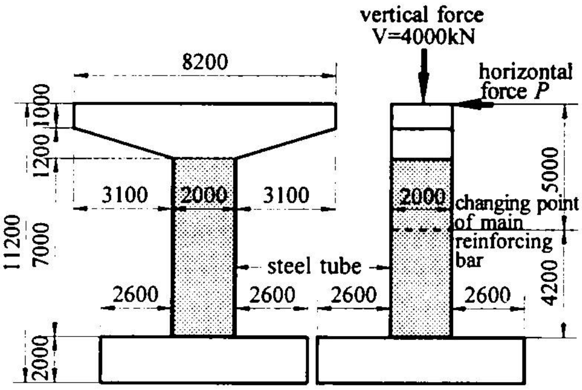

Fig. 2 Analytical model

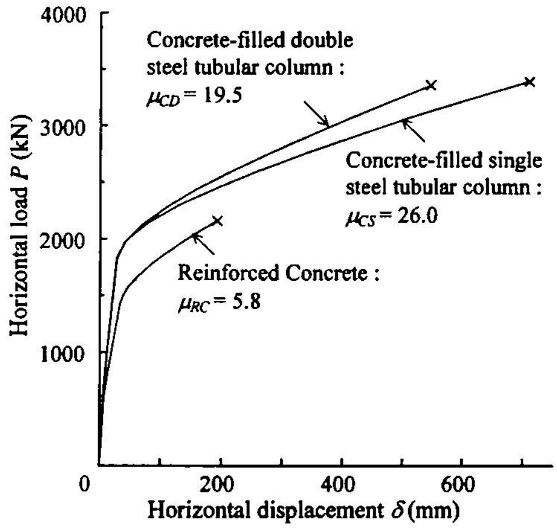

Fig. 3 P-δ Relationship