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Artikel: A draft design code for concrete filled steel tubular columns in Japan

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A Draft Design Code for Concrete Filled Steel Tubular Columns in Japan

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Summary

In Japan, a new draft design code for concrete filled steel tubular columns was elaborated by the committee on composite structures (Chairman : Prof. H. Nakai) in JSCE. The code is mainly for the civil engineering structures such as piers of highway bridges, compression members of truss and arch bridges, etc. and it was written by the format based on a limit state design method.

1. Introduction

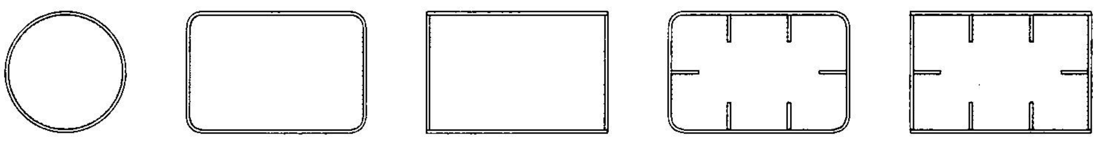
In early 1960th, steel reinforced concrete columns were developed for buildings and concrete filled steel tubular(CFST) columns were applied to electric power transmission towers, in Japan. In the latter half of 1970th, applicability and advantages of CFST columns to the highway bridge piers were investigated through many experimental works. Thereafter, a design recommendation was specified by Hanshin Expressway Public Corporation. In late 1980th, the application was realized for large scale highway bridge piers. Recently, the CFST columns have been attracted special attention as a seismic advantageous type.
Under these circumstances, the committee on ultimate strength of composite structures was organized in JSCE in order to prepare a design code for composite structures based on a limit state design method and a draft design code for CFST columns was elaborated. The paper describes the outline of the code.

2 Application Range and Fundamentals

The types of composite columns are limited to CFST columns as shown in *Fig. 1*, because the columns of bridge piers are remarkably larger than those of buildings. Besides, rigid diaphragms for restraining the filled concrete should be provided at both ends of the column to ensure enough composite action between the filled concrete and steel tube without any shear connectors.
The code can be also applicable for steel contribution factor δ between the following limits, as same as BS5400 and DIN18806.

$$0.2 \leqq \delta \leqq 0.9 \tag{1}$$

where, δ is the steel contribution factor for compressive strength of composite section.



(1) (2) (3) (1) (2)

a) *Unstiffened type* b) *Stiffened type*

Fig. 1 Typical cross sections of concrete filled steel tubular columns.

3. Basic design strength of composite cross section

3.1 Design strength for axial compression

Ultimate strength of composite column under axial compression P_u can be calculated by using the local buckling strength f_{cuo} based on ECCS buckling curve and design strength of concrete f'_{cd}.

$$P_u = \phi \kappa (f_{cuo} A_s + 0.85 f'_{cd} A_c) \quad (2)$$

where, ϕ is the resistance factor and κ is the reduction factor for general buckling given by cross section of steel member and slenderness ratio of column referred to ECCS buckling curve. A_s and A_c are the cross section areas of steel and concrete, respectively.

3.2 Design strength for flexure

Flexural strength of composite column M_u can be calculated by using the plastic section modulus Z obtained by assuming linear strain distribution at the cross section and neglecting the tension side concrete, because the slip is restrained by rigid end diaphragms. It is experimentally certified that the ultimate bending strength decreases to about 90% of the full plastic moment by local buckling. Therefore, the stress f_{cuo} is used for the maximum strength of plate under compression.

$$M_u = \phi f_{cuo} Z \quad (3)$$

3.3 Local buckling strength of steel tube

For the composite column with rectangular cross section , local buckling strengths of steel tube after hardening of filled-concrete are given for both unstiffened and stiffened type by considering that the plates can deform only outside of the column. For the column with circular cross section, the strengths as steel members may be used.

4. Verification for Ultimate Limit State

The safety of composite columns at ultimate limit state can be verified by using basic design strength given by Eqs.(2) and (3) and the design resultant force for ultimate limit state.
The equations for verifying the composite columns subjected to combined axial compression and flexure are given for uniaxial and biaxial bending using the factor based on *M-N* interaction curves corresponding to δ obtained by many experimental studies. Moreover, the effect of shearing stress due to shearing force and torsional moment to the ultimate strength of composite column is considered by reducing the maximum strength of steel tube based on yielding criterion by Von Mises' hypothesis.

5. Verification for Serviceability Limit State

The permanent deformation due to yielding of surface steel plate must be prevented in order to keep the serviceability and durability of composite columns. Therefore, a verification for working stress is specified in addition to the verification for deformation.

6. Design Details

6.1 Connection of beam-column

When concrete is casted in beam over a half of the flange width from the corner of beam-column joint, shear lag phenomenon hardly occurs in the flange plate of beam. Therefore, the concrete filling range in beams is specified, and the check for shear lag phenomenon is omitted at beam-column joint after hardening concrete.

6.2 Diaphragms

Three-types of diaphragm are specified such as end diaphragms to restrain the slip between filled concrete and steel tube, diaphragms at the beam-column joint to transmit the bending moment of the beam to the column, and intermediate diaphragms to prevent the local buckling of the tube.