Outline of “Development and Application of Slender Columns Using Concrete with a Design Strength of 300MPa”

「設計基準強度300N/mm^{2}のコンクリートを用いたRC細柱の開発と適用」の概要


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1. Introduction

Ultra-high-strength concrete has been developed with aims such as the construction of structures of high quality and high durability and the creation of more flexible space. It has been applied mainly to the lower-floor columns in super-high-rise condominiums. In the course of working to develop materials with even higher strength, the authors have focused on slender reinforced concrete (RC) columns as members that allow effective application, conducting technical studies on various aspects of materials, structures, and fire resistance. This paper outlines the development and introduces the application of slender RC columns that use concrete with a design strength of 300MPa[1].

2. Required Performance and Joint Details of Column End

Seismic horizontal loading is not imposed on slender RC columns, but these columns can constitute structures together with shear walls and a seismic isolation and/or response control system. These columns are required to remain intact even under high axial load and large horizontal displacement. It is also necessary to shorten the buckling length with high rotational stiffness at the column ends under long-term loading and fire conditions.

We have proposed a new type of socket joint as shown in **Fig.1**. The columns are inserted into the sockets and the gaps are filled with high-strength mortar. Confinement within the socket is expected to improve the compressive behavior of the column concrete. This joint has lower rotational stiffness and higher horizontal displacement capacity compared to conventional joints[2].

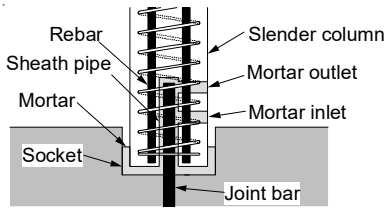

Fig.1 Joint details of column end

3. Structural and Fire Resistance Tests

To evaluate the horizontal displacement capacity during earthquakes, a series of structural experiments

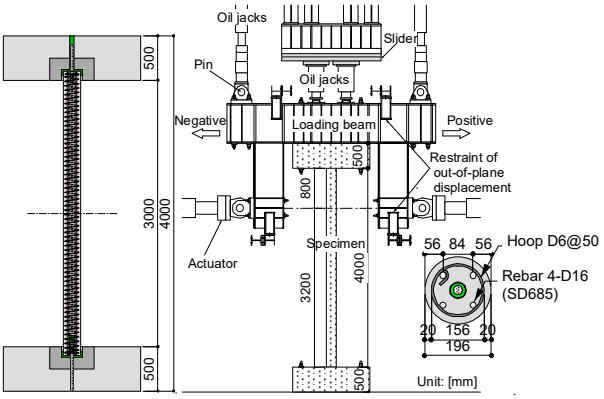

Fig.2 Structural tests

was conducted (**Fig.2**). The test specimens were four circular slender columns with a cross-sectional diameter D of 196mm, height L of 3,000mm or 4,000mm, and a concrete strength of 300MPa. All specimens were reinforced with longitudinal bars and hoops and subjected to reverse cyclic lateral displacement under constant axial load. The horizontal displacement capacity (drift angle) of columns with an L/D ratio of 15 or 20 was at least 1/50 rad under an axial load ratio of 0.17–0.33.

The test specimen for the fire resistance test was a circular slender column with $D = 220$mm and $L = 3{,}400$mm, simulating the columns in the building. The specimen was subjected to a fire temperature history as specified in ISO834 after loading with an axial force ratio of 0.22 at the top of the column[3]. The corresponding fire resistance time was 112 min. As a result, the structural fire safety of this column was confirmed because the estimated fire duration time that is required on the following building parts of fire-resistive construction is under 60 min (**Fig.3**).

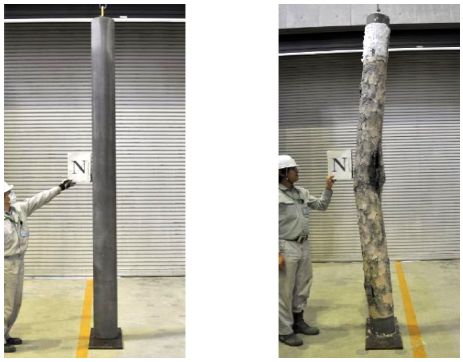

Fig.3 Specimen before (left) and after (right) fire resistance test

4. Application

The slender column developed using ultra-high-strength precast concrete with a design strength of 300MPa was applied to the office building shown in **Fig.4**, which is a three-story RC structure with a base isolation system. The first floor contains five slender circular columns with a diameter of 220mm and a height of 3,750mm.

The concrete was made using a binder that we developed specifically and by applying heat treatment with a maximum atmospheric temperature of 190°C (**Fig.5**). The concrete has stable qualities and produced compression test results ranging from 319 to 332MPa, thereby exceeding the requirements.

This extra strength of the column concrete allowed the cross-sectional areas of the members to be reduced, as well as affording higher structural safety and providing larger spaces within the building (**Fig.6**).

5. Conclusion

We have developed a slender column using an ultra-high-strength precast concrete with a design strength of 300MPa that has been applied to columns in an office building. This technique won the Award of the Japan Concrete Institute in 2014. By using it in combination with a seismic isolation and/or response control system that has advanced and become widespread in recent years, it is expected that use of the developed slender column will spread in the future.

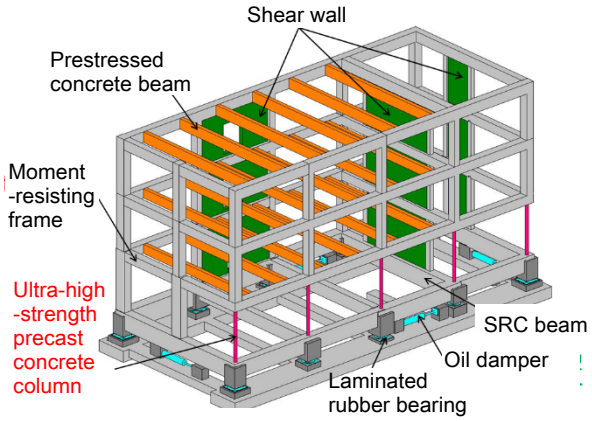

Fig.4 Structural overview

Fig.5 Concrete flow

Fig.6 Interior view

References

[1] Yamamoto K., Kuroiwa S., Jinnai H., Tsujiya K., Yoshida Y., and Namiki S.: *Development of 300MPa Precast High-Strength Concrete Members*, Proc. of the 9th Symposium on High Performance Concrete, Rotorua, NZ, pp. 413-418, Aug. 2011.

[2] Okada N., Imai K., Hattori A., and Komuro T.: *Structural Performance of Slender Reinforced Concrete Columns Using Ultra High Strength Concrete with Compressive Strength of 300N/mm²*, Journal of Structural and Construction Engineering, AIJ, Vol.79, No.704, pp. 1535-1545, Oct. 2014.

[3] Kato M., Michikoshi S., Baba S., and Imai K.: *Buckling Strength of Slender Reinforced HSC and VHSC Columns in Fire*, 9th International Conference on Structures in Fire, USA, pp. 94-101, 2016.