Outline of "Rationalized Construction Methods for Reinforced Concrete Columns and Beams in Overseas Construction Projects"

「海外工事における鉄筋コンクリート造柱および梁の合理化施工法」の概要

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1. Introduction

The economies of South and Southeast Asia, especially India and Indonesia, have been growing steadily since the beginning of the 2000s, and investment in construction projects has been increasing rapidly in line with this growth [1]. However, labor and skill shortages among local construction workers mean that the use of reinforced concrete (RC) members is being converted to that of precast concrete (PCa) to ensure quality and shorten construction time. In general, mortar-filled sleeve joints must be used to join PCa members, but these joints are costly and require the use of low-skilled migrant workers because of the shortage of local construction labor. In addition, the shortage of skilled construction labor in these countries forces them to rely on low-skilled migrant workers, making the rationalization of construction methods an urgent issue. Against this background, the author has developed the following two construction methods to rationalize RC construction in a developing Southeast Asian country.

(1) PCa columns with non-contact lap splices using corrugated sheath pipes for the main bars of the columns.
(2) PCa beams using U-shaped half-PCa concrete formwork with non-contact lap splices for the bottom main bars of the beams.

This paper presents an outline of both construction methods, as well as experiments to verify their structural performance.

2. PCa Columns[2], [3]

(1) Outline of Construction Method

An overview of a PCa column is shown in **Fig. 1**, and the sheath pipes used in this column is shown in **Photo 1**.

In the country concerned, these sheath pipes, which can be procured locally, are used instead of mortar-filled sleeve joints. For a PCa column, joint bars protrude from another member into the sheath pipes embedded in the PCa column base, grout material is injected into the sheath pipes, and the joint bars and main bars of the sheath pipes in the column are joined by non-contact lap splices.

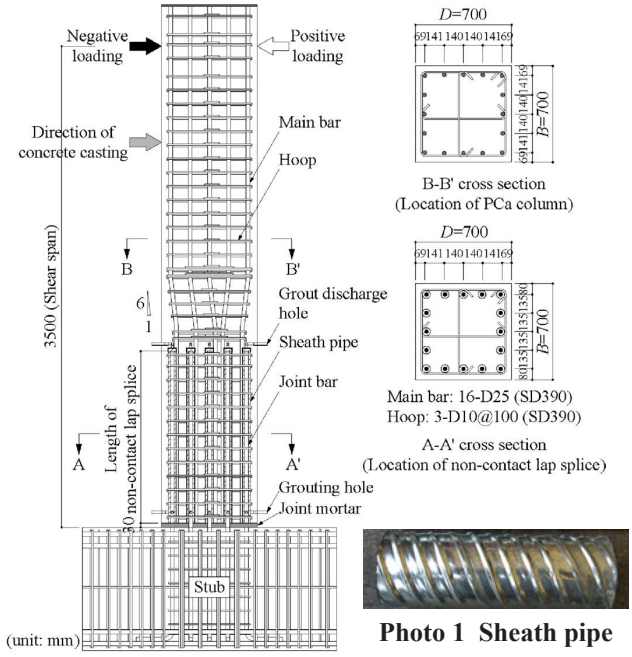

Fig. 1 Overview of PCa column

Photo 1 Sheath pipe

(2) Outline of Experiments

The specimens were four full-scale PCa columns, and the parameters were the length of the non-contact lap splices and the shear reinforcement (hoop) ratio. The compressive strength of the concrete and grout material, the sheath pipe diameter, the amount of column main bars, and the shear span to depth ratio (a/D) were the same for all specimens.

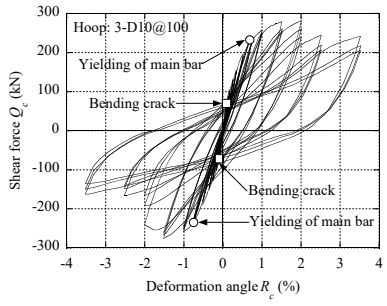

Fig. 2 Q_c–R_c relationship

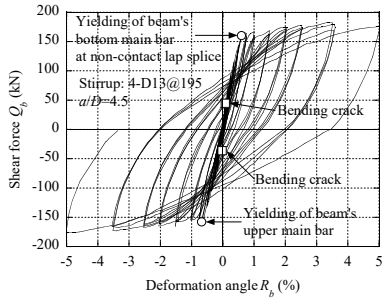

Fig. 4 Q_b–R_b relationship

An example of the relationship between the shear force (Q_c) and deformation angle (R_c) is shown in **Fig. 2**. The ultimate bending strength was reached at $R_c = 1.0\%$, and no significant decrease in shear force was observed up to $R_c = 2.0\%$ for positive loading and $R_c = -1.5\%$ for negative loading. Although the shear force drop was observed at $R_c = 2.5\%$ for positive loading, the ultimate bending strength was not reached in the final loading cycle. Bond splitting cracks along the column main bars were predominant under negative loading, and the shear force decreased at around $R_c = -1.5\%$. Subsequently, the stiffness decreased considerably under negative loading.

3. PCa Beams[3], [4]

(1) Outline of Construction Method

An overview of a PCa beam is shown in **Fig. 3**. A U-shaped half-PCa beam (U-shaped PCa beam) fabricated by embedding U-shaped stirrups in advance is used as formwork and is erected such that its edge hangs on a conventional RC or PCa column by a few millimeters. The beam is constructed by laying its bottom main bars directly above the shear keys on the inside bottom section of the U-shaped PCa beam and casting concrete thereafter in the U-shaped groove.

The beam's bottom main bars to be placed in the bottom cross section of the U-shaped PCa beam and the beam's bottom main bars to be placed on site directly above the shear keys on the inside bottom surface of the beam are joined by non-contact lap splices.

At the non-contact lap splice sections, shear keys are formed with checkered steel plates on the four inner faces of the U-shaped PCa beam (both sides, bottom and cross section of the U-shaped PCa beam) and at the cross section in contact with the columns. Outside the non-contact lap splice sections, the horizontal joint surfaces of the PCa beam and the post-casting

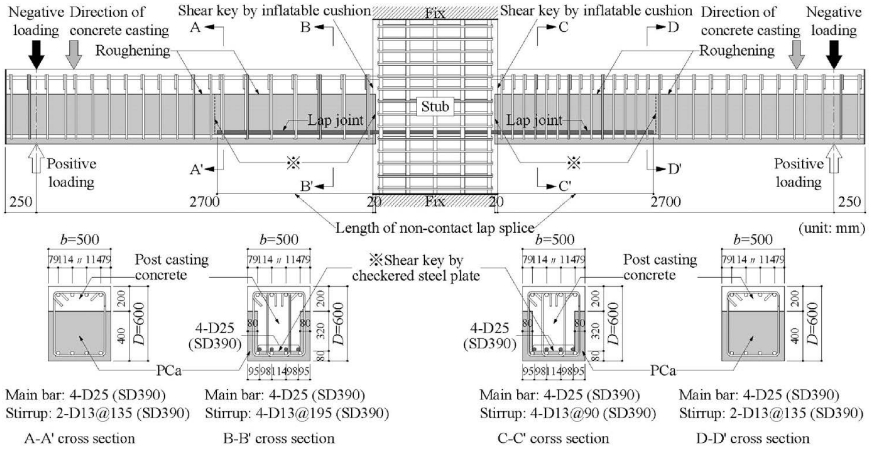

Fig. 3 Overview of PCa beam

concrete are roughened, and shear keys are formed with inflatable cushions on the cross section of the post-casting concrete in contact with the columns to integrate them with the post-casting concrete.

(2) Outline of Experiments

The specimens were three full-scale PCa beams, and the parameters were the length of the non-contact lap splices, the shear reinforcement (stirrup) ratio, and the beam depth. The concrete strength, beam main bars, and shear span were the same for all specimens.

An example of the relationship between the shear force (Q_b) and deformation angle (R_b) is shown in **Fig. 4**. This shows the historical properties of a flexural toughness type beam that retained its bearing capacity until the last loading cycle after beam bending yielding.

4. Conclusion

As a rationalization method for RC columns and RC beams in overseas construction projects, PCa columns with sheath pipes and PCa beams with U-shaped half-PCa formwork and non-contact lap splices for the main bars of the columns and the bottom main bars of the beams, respectively, were developed, and their structural performance was confirmed through experiments.

References

[1] Research Institute of Construction and Economy: *Chapter 3: Overseas Construction*, Construction Economics Report, No. 62, pp. 263-277, Apr. 2014 (in Japanese).

[2] Kanemoto, K., et al.: *Structural Performance of Precast Reinforced Concrete Columns using Non-contact Lap Splice by Sheath Pipe*, Proceedings of the Japan Concrete Institute, Vol. 41, No. 2, JCI, Tokyo, pp. 583-588, Jul. 2019 (in Japanese).

[3] Kanemoto, K.: *Rationalized Construction Methods for Reinforced Concrete Columns and Beams in Overseas Construction Projects*, Construction Equipment, pp. 63-69, JIP, Tokyo, Feb. 2018 (in Japanese).

[4] Kanemoto, K., et al.: *Structural Performance of Precast Reinforced Concrete Beams using Half Precast Form of U-shaped with Non-contact Lap Splice*, Proceedings of the Japan Concrete Institute, JCI, Tokyo, Vol. 40, No. 2, pp. 463-468, Jul. 2018 (in Japanese).