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Tensile strength of the grout-filled head-splice-sleeve

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HIGHLIGHTS

- A new type of splice sleeve to connect bars, head-splice sleeve (HSS) is proposed.
- Tensile test result of HSS presents that the HSS has enough tensile strength to deliver stress of bars.
- A proper design process for HSS is proposed on the base of test result.

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ABSTRACT

This paper presents an experimental result to identify the bond behavior of head-splice-sleeve (HSS) with the consideration of several design factors as variables. In addition, it attempts to investigate strength evaluation method in consideration of the bearing effect caused by head attached to the bar and the bond strength between the embedded bar and grout mortar.

As a result, the HSS specimen without head underwent a brittle mortar failure before yielding while the HSS specimens with suitable head size showed sufficient ductile behavior and rebar failure at the end. It was contributed to the bearing action of the head inside sleeve. From the analysis on the effect of head size, it was recommended that a suitable diameter ratio between head and bar is 1.3 for the design purpose. In addition, a proper design process was proposed for the HSS based on the test result and it was found that the ratio of test result and calculation result obtained by the equation ranged from 0.99 to 1.10 and the average ratio was 1.01. From this, it can be said that the strength of HSS with standard head size is suitably predicted by using the proposed equation.

1. Introduction

Splice-sleeve is a typical mechanical connection which has widely been applied in recent years to secure the unity of bars used in construction work, and it has mostly been applied to the joints of precast concrete members. Since the splice-sleeve has characteristics that ensure good applicability with respect to the large diameter bar, it has largely been used in the connection of vertical members such as a column. However, the currently used splice-sleeve requires that a separate sleeve for filling of grout mortar should be installed in the joints of members. In addition, a long sleeve shape formed for securing the enough embedded length of rebar leads to the disadvantage of lowering the construction ability.

Accordingly, the head-splice-sleeve (HSS) being developed to make up for the disadvantages requires no separate sleeve for injecting mortar because high strength mortar is filled into the sleeve in advance, and it is a detail optimized by reducing the development length of rebar as the bond strength is improved due to the head attached to rebar. For the economical and reasonable design of the developed HSS, there is a need to identify the bond behavior according to the development length of rebar, and the effect of head.

In this regard, this paper seeks to identify the bond behavior of HSS through experiments with several design factors as variables. In addition, it attempts to investigate the strength evaluation method in consideration of bearing effects caused by the head and bond stress between the embedded bar and grout mortar.

2. Previous researches

Since the development of splice-sleeve in the 1960s, various types of splice-sleeve for connection of precast concrete members have been developed and studied by many researchers.

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Einea et al. [1] developed a steel pipe sleeve and investigated the bond strength of rebar embedded in grout mortar surrounded by the sleeve through an experiment. As experimental parameters, the shape of sleeve and the development length of rebar affecting the bond behavior were selected. From the test, it was confirmed that the sleeve developed in the study can exert 125% of the yield strength of rebar, and the effects on the bond strength between the embedded rebar and the grout mortar were analyzed based on the quantitative estimation of the bond strength due to confining effects of sleeve. Higher bond strength can be achieved by confining the grout surrounding the rebar, and if proper grout compressive strength and confinement are provided, the development length of rebar is 7 times shorter.

Ahn et al. [2] also developed a steel pipe sleeve and conducted a tension test using the development length of rebar as a variable after producing the splice-sleeve specimen for D25 and D19 rebar. The confining effects by sleeve were measured by using gauges attached to the sleeve surface. The results of calculating the confining force from the strain distribution on the sleeve surface measured in the experiment confirmed that circumferential confining stress reached up to more than 20–30 MPa, and this confining stress showed a tendency to increase as the rebar development length decreases.

Ling et al. [3] performed incremental tensile load test about various type of splices shaped pipes, square hollow sections and aluminum which are currently used in the field. As a result they found that under confinement, the required anchorage length of the bars can be shortened to nearly nine times the diameter of the spliced bar.

A geometric transformation of sleeve shape into types such as WBS (Welded Bar Sleeve), THS (Tapered Head Sleeve) was mad by Ling et al. [4] to provide a mechanism of confining stress acting on the rebar of steel pipe sleeve. An experiment was conducted by varying the sleeve diameter ranging from 50 mm to 75 mm and the rebar embedded length ranging from 75 mm to 125 mm. The experimental results showed that the reduction in sleeve diameter from 75 mm to 50 mm helped to obtain about 15% higher bond strength, and the increase in rebar development length from 75 mm to 175 mm helped to obtain about 30–40% higher bond strength. Through an additional study, Ling et al. [5] revealed THS has a 30% higher tensile capacity compared with WBS from the tensile test. Also they found that with the active confinement, the required bar embedded length of the splice can be reduced to 8 times of the bar diameter.

Coogler et al. [6] investigated the behavior of offset mechanical splices through direct tension test to find the variation when the splice both restrained and unrestrained from rotating. From the test, they found that the critical case is where the splice is not restrained from rotating. Also significant findings such as a classification of splice failure modes and characterization of in-place splice behavior were suggested by performing flexural beam test about long concrete beams under both monotonic and fatigue loading conditions.

Seyed et al. [7] presented the bond behavior of deformed steel reinforcement bars connected by a grouted spiral connection. From tensile and flexural pull out test, they revealed that the bond performance between rebar and grout can be improved significantly due to the confinement provided by the spiral.

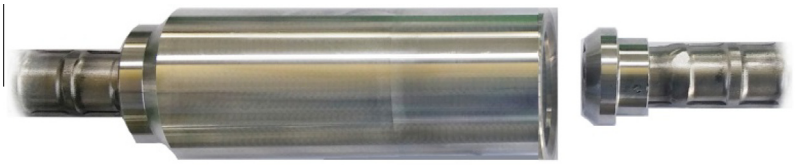

Fig. 1. Shape of HSS.

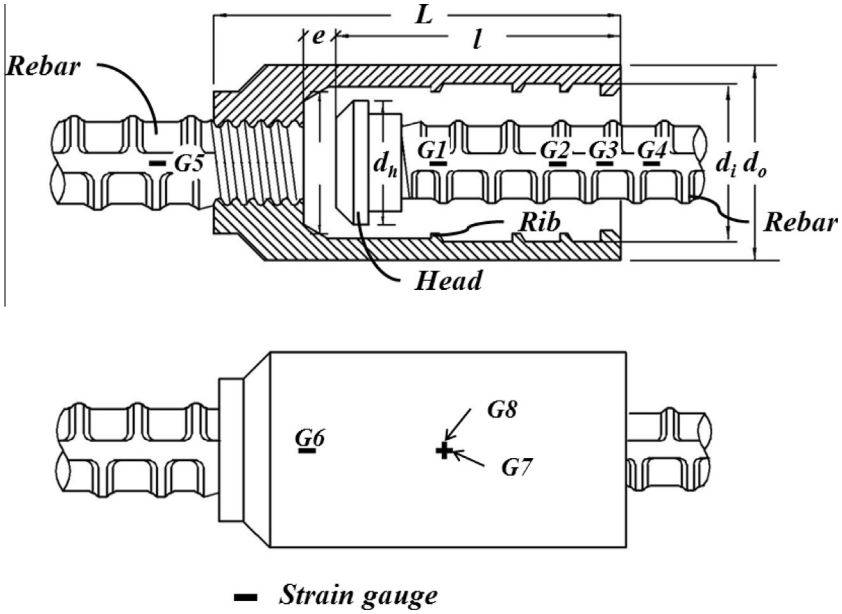

Fig. 2. Detail of head-splice-sleeve.