Investigation on the Shear Behavior of Reinforced Concrete Haunched Beams

Chenwei HOU
Ph.D. candidate
Tokyo Institute of Technology
Tokyo, Japan
hou.c.ab@m.titech.ac.jp

Chenwei Hou, born 1989, received his bachelor degree from Zhejiang Univ. and finished his master course in Tokyo Institute of Technology. His research interest covers structural design of reinforced concrete.

Koji MATSUMOTO
Assistant Professor
Tokyo Institute of Technology
Tokyo, Japan
matsumoto.k.ar@m.titech.ac.jp

Koji Matsumoto, born 1980, received his PhD from Hokkaido University, Japan. His research interest covers structural concrete.

Junichiro NIWA
Professor
Tokyo Institute of Technology
Tokyo, Japan
jniwa@cv.titech.ac.jp

Junichiro Niwa, born 1956, received his PhD from The University of Tokyo, Japan. His research interest covers prestressed concrete and reinforced concrete.

Summary

This study aims to clarify the shear resistance mechanism of reinforced concrete haunched beams (RCHBs). Based on the new parameter of the bending position of tensile steel bars, three RCHBs without stirrups and three RCHBs with stirrups were tested. The results demonstrated that the bending positions of tensile rebars near the loading point highly influenced crack propagations and shear capacities in RCHBs. It was due to different contributions of arch action and stirrups in the shear resistance. The calculated shear carried by stirrups with the angles of diagonal shear cracks showed good correspondence with the experimental results.

Keywords: RC haunched beam; crack pattern; arch action; angle of diagonal cracks.

1. Introduction

Fig. 1: RC structures with haunched beams

In simply supported or continuous bridges, structural portal frames and mid-rise framed buildings, reinforced concrete haunched beams (RCHBs) with bent longitudinal bars are widely used in the shape of large haunches (*Fig. 1*). Such beams can reduce the structure's weight and contribute to an aesthetic design of the appearance. However, it is insufficient of the experimental data to predict the shear behavior of RCHBs. Moreover, rational and economical design method for RCHBs in the JSCE specifications for concrete structures or the United States (ACI-318-11) specifications has not been established yet [1-2]. Engineers are using such beams based on the empirical and uneconomic design which may not be safe and accurate. Therefore, it is necessary to explore the shear resistance mechanism of RCHBs to ensure the reasonable design.

Apart from the haunch's inclination and the effective depth at the mid span, the authors found that the bending position of the tensile rebar is also one important parameter. However, the influence of the bending position of the tensile rebar has not been investigated. With the objective of clarifying the shear resistance mechanism of RCHBs, three RCHBs without stirrups and three RCHBs with stirrups were tested based on this new parameter.

2. Results and discussions with conclusions

Figure 2 shows the crack patterns in the specimens just after the peak. The experimental parameter is the distance between the loading point and the bending position of tensile rebars, which were 0 mm, 100 mm and 300 mm in the specimens. The white dashed lines at the bottom represent the

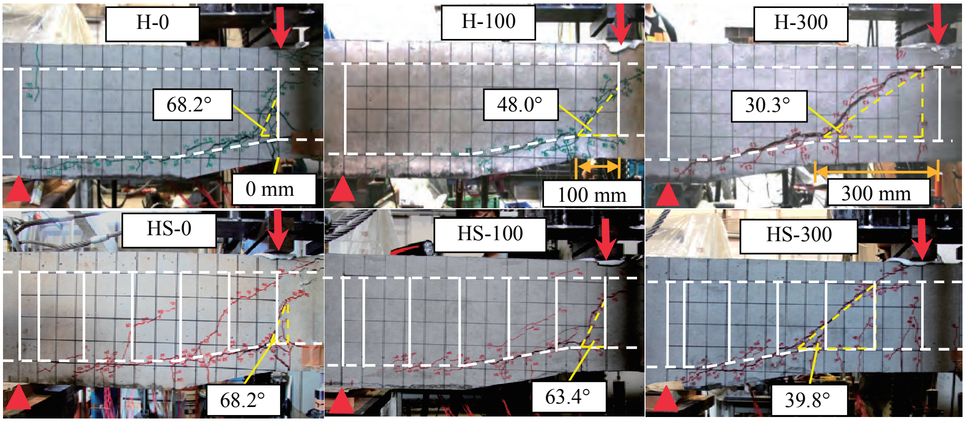

Fig. 2: Cracks just after peak load

positions of tensile longitudinal bars while the white solid lines represent the positions of stirrups. In the case of the three RCHBs with stirrups, the main crack patterns show similarity with those of RCHBs without stirrups, especially for the beams with same dimensions (for example H-0 and HS-0), that the main diagonal crack started from the bending position, developing along inclined rebars and towards the loading point. Such crack patterns resulted in the arch action and the different areas of concrete above the diagonal cracks caused different contributions of arch actions. Finally, the concrete crushed near the loading point.

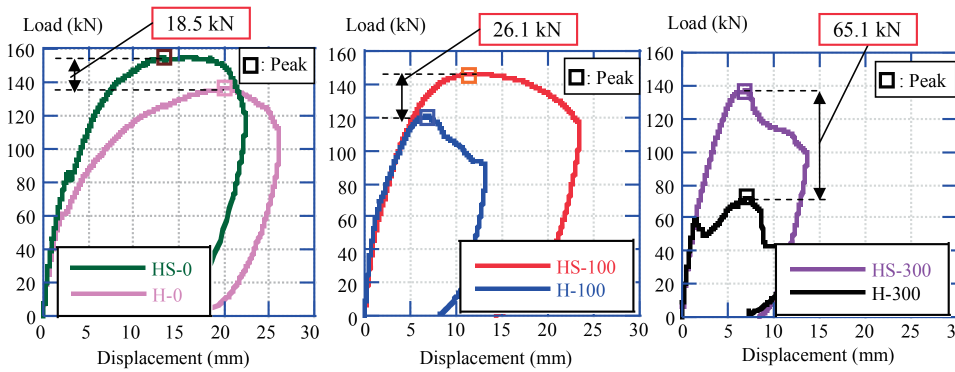

Fig. 3: Load-displacement curves

Figure 3 shows load-displacement curves for all the six specimens. The different angles of main diagonal cracks made the shear carried by stirrups different in three beams, resulting in the smaller load gaps between RCHBs with stirrups than the load gaps between RCHBs without stirrups.

3. References

[1] JSCE, "Standard Specifications for Concrete Structures-2007, Structural Performance Verification", *JSCE Guidelines for Concrete*, No. 15, 2010.

[2] ACI-318-11, "Building Code Requirements for Structural Concrete (ACI-318-11) and Commentary (ACI-318R-11)", *American Concrete Institute*, Farmington Hills, Michigan, USA, 2011.