Bond Behavior of RC Beam with Cut-off Bars

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Summary

There are many differences of bond regulations between the AIJ code and the ACI code. In the AIJ code, bond stresses within a distance d from the end of a beam are assumed to be zero because of tension shift, where d is effective depth. By contrast, the ACI code does not. Another difference is checking for continuous bars. The AIJ code considers bond failure of continuous bars although the ACI code does not. The objective of this study is to verify these bond regulations.

Four RC beam specimens with single layered bars were tested. Test variables were length and the number of cut-off bars. Bond failure was observed before flexural yielding in all the specimens, and tension shift was not observed. The postulate in the ACI code is appropriate in such cases. Bond failure occurred along not only cut-off bars but continuous bars. The observed bond strengths of the continuous bars almost agreed with those calculated from the AIJ code.

Keywords: RC beam; cut-off; bond stress; bond strength; single layer.

1. Introduction

There are many differences of bond regulations between the Japanese RC building standard (AIJ code) [1] and the ACI building code (ACI code) [2]. In the AIJ code, bond stresses within a distance d from the end of a beam are assumed to be zero because of tension shift, where d is the effective depth. Based on this assumption, the AIJ code requires that d is subtracted from the development length in calculating bond stress of cut-off bars. By contrast, the ACI code does not. Another difference is checking for continuous bars. The AIJ code considers bond failure of continuous bars although the ACI code does not. The objective of this study is to verify these bond regulations.

2. Experiment

Four RC beam specimens with single layered bars are tested. They are 1/3 scale models with high strength reinforcements. Figures 1 and 2, and Table 1 show specifications of specimens, where c_f is the length from the end of the beam to the point where the cut-off bars are no longer required. Test variables are length and the number of cut-off bars. The lengths of cut-off bars do not satisfy the AIJ code requirement, and hence all the specimens are designed to fail in bond splitting.

The reversed cyclic loads were applied under anti-symmetric bending. All the specimens failed because of bond splitting before flexural yielding.

3. Strain Distribution of Cut-off bar

Open circles (○) in Fig. 3 show the values of strain gauges attached to the cut-off bars of 1HL. Solid circles (●) show the values calculated from the bond strength, τ_{bu}, of the AIJ and ACI codes. The observed strain distribution agrees with assumption of not the AIJ code but the ACI code. The observed bond stresses are approximate to the ACI τ_{bu}. From the above, there is no need to consider tension shift in the cases where plastic deformation does not occur.

4. Bond Strength of Continuous Bar

Although the ACI code does not consider bond failure of continuous bars, bond failure occurred along not only cut-off bars but continuous bars in this experiment. It is consequently indicated to check continuous bars like the AIJ code.

Figure 4 compares the bond strengths of continuous bars calculated from the AIJ code and the maximum bond stresses which are observed in sections L_A and L_B (shown above in black). In the case A (Fig. 4(a)), bar spacing for the calculated values is determined considering only continuous bars. The section L_A also contains only continuous bars. In the case B (Fig. 4(b)), bar spacing which is determined including cut-off bars is used for calculation. L_B is the section in which the AIJ code considers bond stress to occur. The observed values are equal to or less than the calculated strengths in the case A. They are in good agreement with the calculated values in the case B (except for 2H).

5. Conclusions

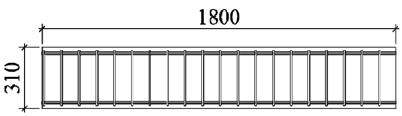
(1) Bond failure was observed before flexural yielding in all the specimens, and tension shift was not observed. The postulate in the ACI code is appropriate in such cases.

(2) Bond failure occurred along both cut-off bars and continuous bars. The observed bond strengths of the continuous bars almost agreed with those calculated from the AIJ code in the cases that bar spacing is determined considering not only the concerned bars but all the bars in the same layer.

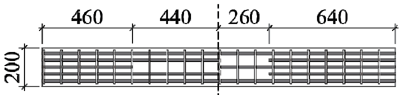
References

[1] Architectural Institute of Japan, "AIJ Standard for Structural Calculation of Reinforced Concrete Structures", 2010.

[2] American Concrete Institute, "Building Code Requirements for Structural Concrete and Commentary", *ACI 318-11*, 2011.



(a): Side View



(b): Top View (1HS) *(c): Top View (2H)*

Fig. 1: Bar Arrangements (Unit: mm)

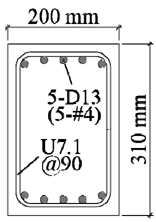


Fig. 2: Cross section

Table 1: Test Specimens

Specimen	Cut-off Bar Number	Cut-off Bar Length (mm)	c_f+d (mm)
1HS	1	460	460
1HL	1	640	
2H	2		640
3H	2	820	820
	1	460	460

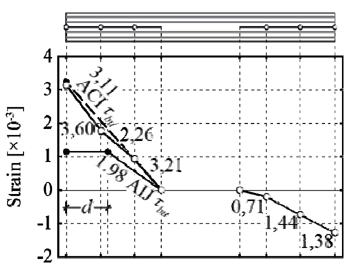
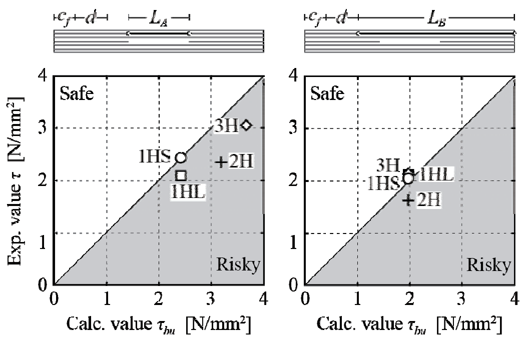


Fig. 3: Strain Distribution
(1HL, R = 1/50)



(a): Case A *(b): Case B*

Fig. 4: Bond Strengths of Continuous Bars