# Seismic Behavior of RC Beams with Curtailed Second Layer Longitudinal Rebar Confined with High Strength Reinforcement

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## Background

The use of high strength shear rebar may reduce the amount of shear reinforcement required, leading to more economical design and better construction quality. However, bond split failure may happen on RC beams due to insufficient shear reinforcement. Current design method from AIJ Guidelines 1999 for bond splitting failure was derived from truss and arch mechanism in continuous longitudinal rebars. It is important to know the limitations of this method in designing RC beams with curtailed second layer rebar.

## Objectives

- To study the effect of second layer curtailed rebars amount and length on shear capacity.
- To evaluate AIJ Guidelines 1999 bond capacity equation for beam with curtailed second layer longitudinal rebar.

## Experimental Setup


Photo 1. Loading System

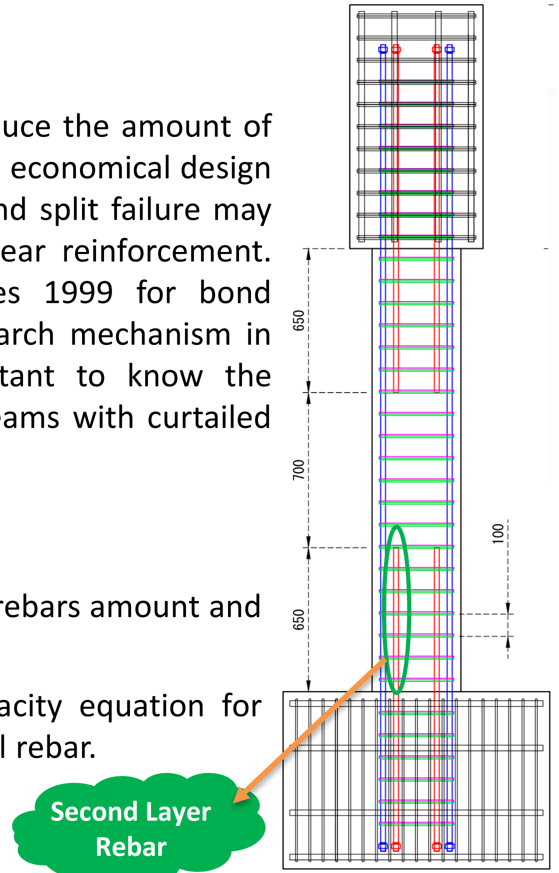



Fig 1. Specimen No. 2

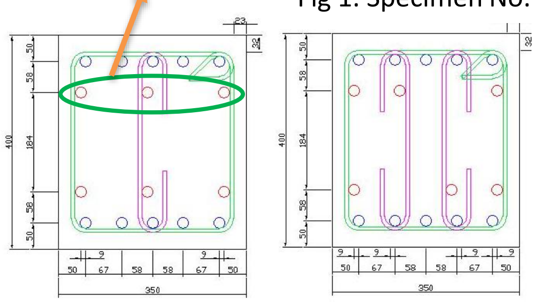


Fig 2. Cross Section of No. 2 and No. 4

Table 1. Test Variables and Calculated Capacity

| No | Specimen Name | f'c [MPa] | Second Layer Rebar | | Shear Rebar Ratio (pw) [%] | Flexure | Shear | Bond Split (AIJ) | | Result (Qexp) | Qexp/Vbu | | Note |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | No. of bars | Ld [mm] | | Qfu [kN] | Vsu [kN] | Vbu1 [kN] | Vbu2 [kN] | [kN] | $V_{bu1}$* | $V_{bu2}$** | |
| 1 | N-5-2 | 25.9 | 2 | 650 | 0.46 | 497 | 549 | 301 | 430 | 357 | 1.18 | 0.83 | Less curtailed rebar |
| 2 | N-5-3 | 25.6 | 3 | 790 | | 548 | 544 | 299 | 428 | 415 | 1.39 | 0.97 | Benchmark |
| 3 | N-5-4 | 28.9 | 4 | 940 | | 600 | 597 | 317 | 452 | 477 | 1.50 | 1.05 | More curtailed rebar |

*Vbu1: only 1st layer long. rebar is considered, **Vbu2: both layers are considered

Concrete compression strength (f'c), shear rebar ratio ($p_w$), the number and development length of second layer rebar (Ld) were chosen as the specimens variables. U7.1 rebar with nominal yield strength 1275 MPa were used as shear reinforcement. All specimens were designed to fail in bond split failure.

## Results

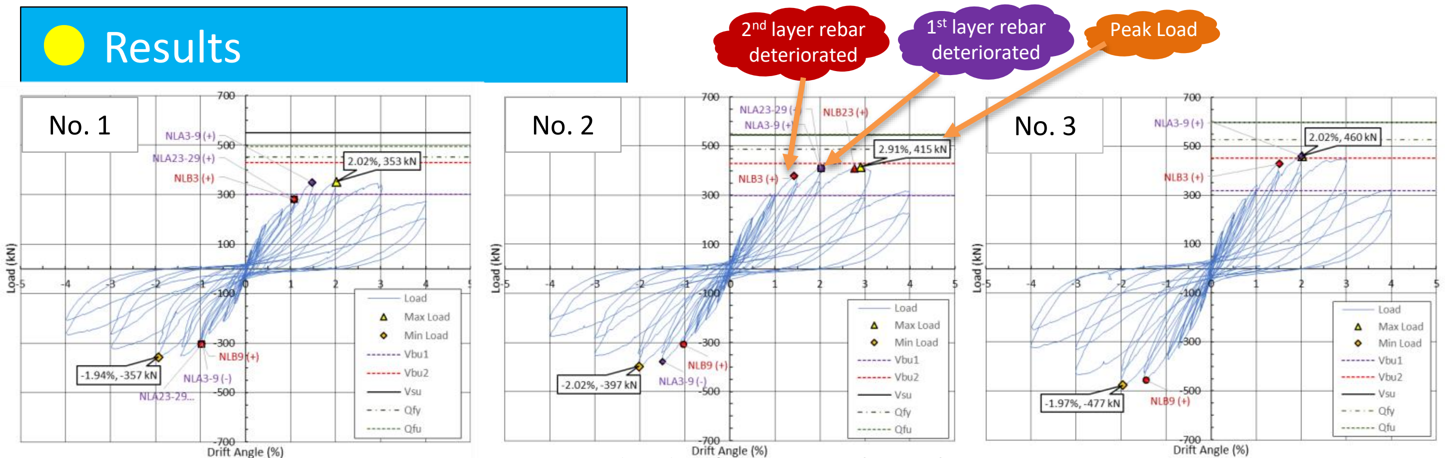



Fig. 3. Load and Deformation Relationship

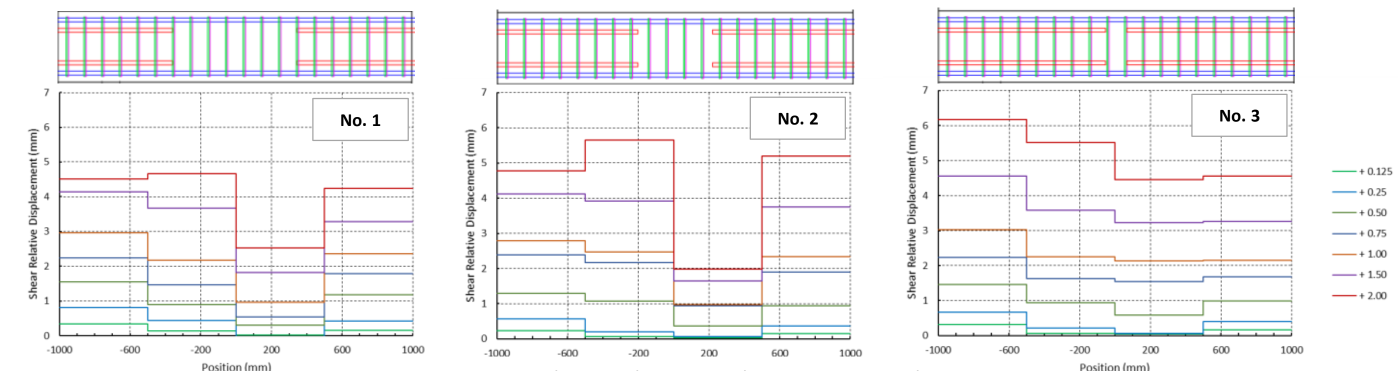
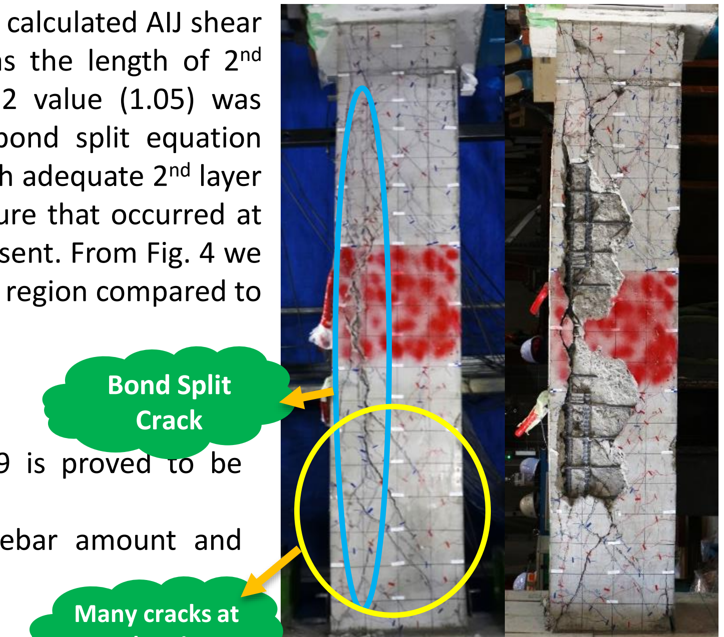



Fig. 4. Relative Shear Displacement Distribution

Table 1 shows the ratio between shear capacity and calculated AIJ shear bond capacity (Qexp/Vbu2). The ratio increases as the length of 2nd layer rebars increase, and the highest Qexp/Vbu2 value (1.05) was obtained from specimen 3. It appears that AIJ bond split equation (Vbu2) can predict shear capacity for specimens with adequate 2nd layer rebar development length (Ld). This caused by failure that occurred at beam's end region, where 2nd layer rebars were present. From Fig. 4 we can see that shear displacement were higher at end region compared to middle, indicating shear failure at the end region.




(a) At Peak Load (b) After Loading

Photo 2. Specimen No. 2

## Conclusions

- Shear bond capacity from AIJ Guidelines 1999 is proved to be adequate for specimen No. 3.
- Shear bond capacity increases as 2nd layer rebar amount and length increase.

## Contribution to Society

**We can design economical RC structures by better understanding high strength shear rebar and rebar curtailment**