콘크리트 수직시공이음 접합면의 전단강도에 대한 실험적 연구

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Experimental Study on Interface Shear Strength of Concrete in Vertical Construction Joint

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Abstract : In massive concrete placement, cracking problem due to hydration heat is frequently encountered. One of measure to solve this problem is to make a construction joint. However, it is cumbersome to make it by chipping the surface of joint. In this study, push-out test for 18 specimens was conducted to compare the interface shear strength of construction joints whose surfaces were prepared with three methods: chipping, rib-lath, folded rib-lath. Compared to the specimens made with conventional surface chipping, those with rib-lath showed excellent performance increasing shear resistance capacity and the role of shear key conceived by folding rib-lath played important role in enhancing shear resistance.

초 록 : 수화열에 의한 균열은 대규모 콘크리트 타설시 흔하게 접하는 문제이며 이에 대한 해결은 시공이음을 만드는 것이다. 일반적인 방법으로 접합면을 할석으로 처리 하나 이 작업은 번거롭고 품질의 일관성을 유지하기 쉽지 않다. 본 연구에서는 접합면을 3가지 방법으로 처리하여 접합면의 전단강도를 비교하기 위한 18개의 시험체에 대한 push-out실험을 수행하였다. 할석으로 접합면을 만든 시험체에 비해 리브라스를 이용한 시험체가 전단저항에 월등한 성능을 보여 주었으며 그리고 리브라스를 절곡하여 만든 전단키가 전단저항을 향상시키는데 큰 역할을 하였다.
Key Words : vertical construction joint, rib-lath, interface shear strength of concrete

1. Introduction

Forming construction joints between new and old concrete is inevitable in massive concrete pours. For the preparation of joint surfaces it is necessary to remove laitance and moisten surface of old concrete before the placement of fresh concrete to increase the bond between old and new concrete in addition to chipping the surface. Various surface treatment methods are well summarized by Bussell and Cather[1]. Structural performance of construction joint may be deteriorative due to complicated work of reinforcement and form work at construction joint. To increase shear friction it is common practice to chip concrete surface causing constructional inefficiency and difficulty in quality control of structural capacity at the construction joint. Zhu[2] conducted three-point bend test on notched repaired beams with the interfaces to evaluate the bond strength between new and old concrete. Moriwaki et al[3,4] added polymer cement mortar to conventional materials and evaluated the flexural behavior of the vertical construction joint and the performance of the polymer-modified mortar. Ujike et al[5] evaluated mechanical properties of construction joint under combined tensile

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and shear stresses. Tsuji et al[6] examined the structural behavior of RC beam made of self-compacting concrete. Chipping concrete surface is a traditional method to increase shear friction of concrete. However, this method is cumbersome and quality of joint is depends on craftman's ability. To overcome these problems metal lath was invented and used in US, Japan.

In this study, pushout tests were conducted to compare the interface shear strength of concrete in vertical construction joints made with three methods; (1) chipping, (2) rib-lath, (3) folded rib-lath, whose shapes are shown in Fig. 1. Referred to the nominal shear strength in ACI[7] code, shear capacity of vertical construction joint is compared and adequacy of strength evaluation equation is discussed.

2. Experimental Program

To conduct pushout test of specimens with vertical construction joint 18 specimens are made. As summarized in Table 1, two curing periods are selected and three types of surface treatment are employed. Compressive strength of concrete was 27.9MPa, 31MPa for a-series and b-series, respectively. Each specimen has three samples. The configuration of test sample is shown in Fig. 1.

3. Shear Strength in Code

In this section, ACI 318-95 was used to confirm the shear strength in construction joint interface. Shear strength provided by concrete members subject to flexure and shear only shall be computed as

$$v_c = \frac{1}{6}\sqrt{f_{ck}} \quad (1)$$

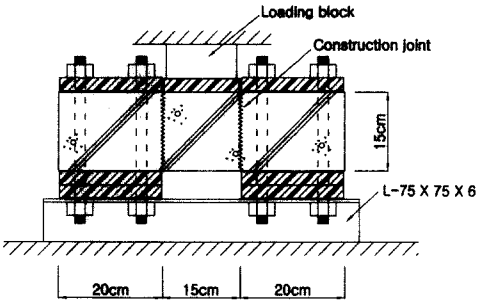
Table 1. Summary of specimen

Specimen Series	Curing Age (day)	Treatment of Joint Surface
Ch-a	14	Chipping
Ri-a		Rib-lath
Fo-a		Folded rib-lath
Ch-b	28	Chipping
Ri-b		Rib-lath
Fo-b		Folded rib-lath

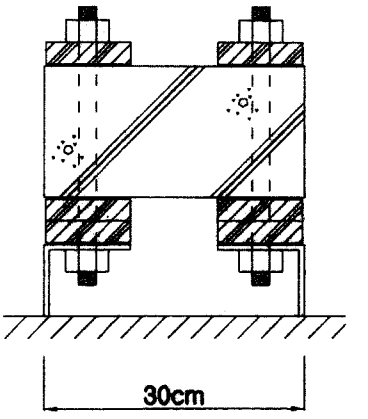
(a) Rib-lath

(b) Folded rib-lath in specimen mold

Fig. 1. Shape of rib-lath



(a) Front View



(b) Side View

Fig. 2. Configuration of test setup

and when shear force is large compared to moment, the shear strength of concrete member is

$$v_c = 0.29\sqrt{f_{ck}} \quad (2)$$

Where, the unit of f_{ck} is MPa. If the shear strength of unreinforced concrete member is over the values from Eq. (1) and Eq. (2), code requirement for nominal shear strength is satisfied. In the section 11.7.4 of ACI 318-95, when shear-friction reinforcement is perpendicular to shear plane the shear strength shall be computed as

$$V_n = \mu A_{vf} f_y$$

However, this equation considers only the dowel action of rebars and neglect the contribution of concrete to shear friction. In the section R11.7.3 of ACI 318-95, to include concrete in the shear friction the following equation is suggested.

$$V_n = 0.8 A_{vf} f_y + A_c K_1$$

This equation can be used to evaluate the shear strength in unreinforced construction joint as follows:

$$V_n = A_c K_1 \quad or \quad v_c = K_1 \quad (3)$$

where, K_1 is 2.76 MPa for normal weight concrete.

4. Results of Experiment

The test result of 18 specimens is listed in Table 2. The difference between maximum and minimum of failure load in Fo-a series is 34%, which is mainly due to difficulty of maintaining consistent quality in making joint surface which is the main factor to affect shear resistance capacity. For the b-series specimens initial cracking load is measured and in Fig. 3, ultimate failure load is shown. It is clear that using rib-lath is more effective than the conventional chipping method. In Ch-series specimen, initial cracks occurred and propagated along the joint surface and then final failure is arrived. The surface of failed specimen was smooth. However, in Ri- and Fo-series, initial cracks occurred along the surface and then, crack propagated inside the specimen rather along the surface, which is the indication of increase of shear resistance.

Table 2. Ultimate failure load

Specimen	Shear Strength (KN)
Ch-a	124, 165, 122
Ri-a	271, 307, 255
Fo-a	294, 212, 321
Ch-b	262, 228, 203
Ri-b	323, 375, 292
Fo-b	321, 431, 420

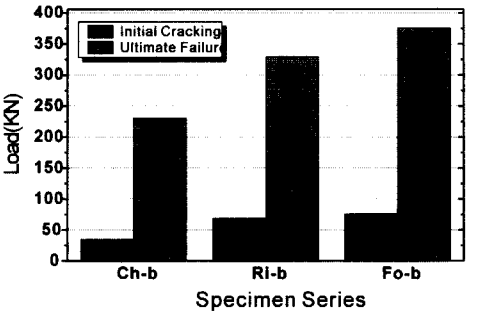


Fig. 3. Average shear strength(b-series)

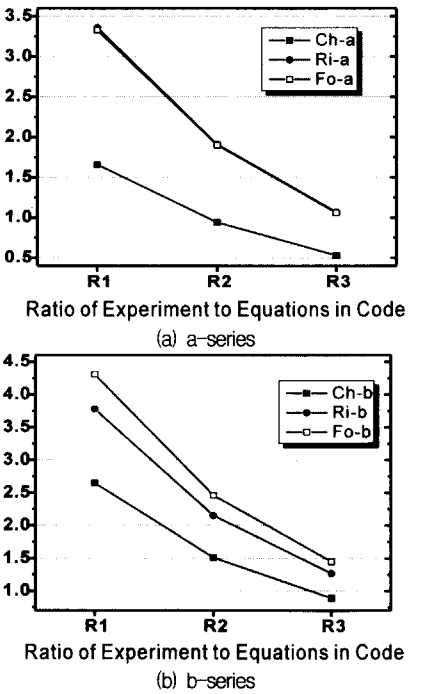


Fig. 4. Comparison of shear strength

In Fig. 4, the ratios of the experimental shear strength in Table 2 to nominal strength from Eq. (1), Eq. (2), Eq. (3) are illustrated, where R1 stand for the ratio of the average experimental value of each series to the value from Eq. (1), and so forth. For Eq. (1) and Eq. (2) ratio of all specimen series except Ch-a is over 1.0. However, for Eq. (3), series Ch-a, Ch-b shows only 53, 89 % of nominal strength, respectively. As expected, Ri-b and Fo-b series showed 27, 45% over the nominal strength, respectively. Judging from the result of this test, Eq. (1) and Eq. (2) underestimated shear strength of concrete, while Eq. (3) seems to be adequate to predict shear friction of concrete.

In Fig. 5, to figure out the effect of curing age on the shear strength development the ratio of a- to b-series is illustrated with respect to equations in ACI. Eq. (1) and Eq. (2) showed similar result, while Eq. (3) showed more strict strength prediction.

In Fig. 6, evaluation of joint shear strength based on Eq. (3) is shown, where the ratio of Ch-b series is set as a benchmark. Fo-b series is over by 60% compared to Ch-b series. At the half of required curing time Fo-series does not show difference from Ri-series but after the required curing time Fo-series showed better performance by 14% over Ri-series.

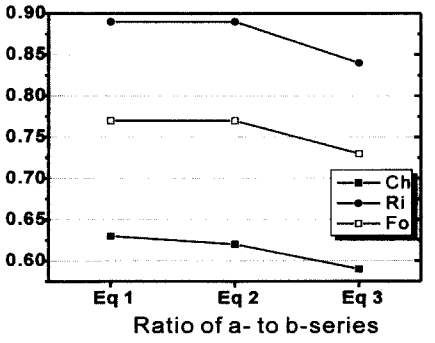


Fig. 5. Effect of curing age

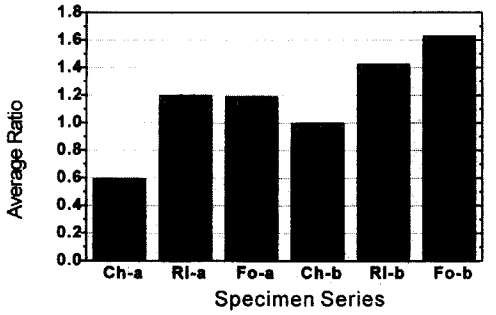


Fig. 6. Joint evaluation based on Eq. (3)

5. Conclusions

This study carried the experimental evaluation of interface shear strength of concrete in vertical construction joint. To make construction joint in a massive concrete member without sacrificing structural safety three types of interface treatment are compared. Based on the result of experiment, the findings of this study are as follows:

1) The use of rib-lath in making vertical construction joint is more efficient than conventional surface chipping method in constructional point of view, leading to the saving of labor cost and construction waste.

2) Judging from the result of this test, Eq. (1) and Eq. (2) underestimated shear strength of concrete, while Eq. (3) seems to be adequate to predict shear friction of concrete.

3) Compared to the specimens made with conventional surface chipping, those with rib-lath showed excellent performance increasing shear resistance capacity by over 40%.

4) The role of shear key conceived by folding rib-lath played important role in enhancing shear resistance, leading to 14% increase of shear strength.

In the future, the aspect of constructional efficiency which includes quality control and required labor, cost for material would be examined.

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