日本建築学会大会学術講演梗概集
（関東） 2020 年 9 月

Bond Behavior in Cracked Concrete by Expansion Agent Filled Pipes
Part 2: Bond strength degradation in side-split type specimens

Regular Member ○Amadou Sakhir Syll *
Regular Member Togo Aburano *
Regular Member Toshiyuki Kanakubo **
Regular Member Juan Jose Castro ***

Concrete crack Rebar corrosion Crack width
Bond strength Bond test Splitting

1. INTRODUCTION

The fib Model Code 2010 [1] and the Japan Concrete Institute in its concrete structure rehabilitation research committee report 1998 [2] gave an evaluation of the bond degradation as a function of crack width due to corrosion. Also, an overview of the current research indicates that existing studies have achieved only primary knowledge regarding the potential correlation between bond and the surface crack width. However, there still a research gap in this respect.

In Part 1, concrete cracked by expansion agent filled pipes in bond test specimens has been presented. In this paper, those specimens are subjected to a pull-out test and a relationship between the maximum pull-out load of rebar and surface crack width as a variable is discussed.

2. PULL-OUT TEST RESULT

Test results of pull-out tests are shown in Table 1. All specimens experienced failure due to splitting. The specimens without crack failed by single splitting due to the limited cover thickness. In the crack induced specimens, most of them failed by side-splitting due to the opening of the pre-existent crack. In side-splitting failure, some specimens presented newly side crack (N1 with one new crack, N2 with two new cracks).

The pull-out load versus slippage relationships are shown in Fig. 1. From these plots, it is apparent that the stiffness did not decrease in cracked specimens. As the pull-out load increase, the slip seems to increase in an almost linear way. However, as soon as the bond strength is reached, a steeper descending curve is measured for uncracked specimens when compared to cracked ones. Hence a more sudden bond degradation is noted due to the occurrence of new cracks or the widening of the induced cracks.

Fig. 2 shows the maximum pull-out load versus crack width relationship. It can be seen that the maximum load decreases as the crack width increases. As expected, there is a significant correlation between residual bond strength

Table 1 Test result

Specimen name	Crack width (mm)	At Maximum load		Remarks
		Load (kN)	Slip (mm)	
S.18.NC.1	0	50.51	0.444	Single split
S.18.NC.2	0	46.36	0.962	Single split
S.18.C.0.08	0.08	31.36	0.508	Side split N1
S.18.C.0.2	0.20	22.87	0.352	Side split N2
S.18.C.0.6	0.60	17.22	0.832	Side split O
S.18.C.0.65	0.65	25.10	0.121	Side split N1
S.18.C.0.75	0.75	4.19	1.102	Side split O
S.18.C.0.85	0.85	4.29	0.676	Side split O
S.30.NC.1	0	42.97	0.592	Single split
S.30.NC.2	0	61.73	0.166	Single split
S.30.C.0.15	0.15	49.46	0.348	Single split
S.30.C.0.25	0.25	31.25	0.308	Single split
S.30.C.0.35	0.35	26.86	0.468	Side split O
S.30.C.0.50	0.50	33.20	0.610	Side split O
S.30.C.0.60	0.60	19.77	0.488	Side split N1
S.30.C.0.85	0.85	12.53	0.724	Side split O

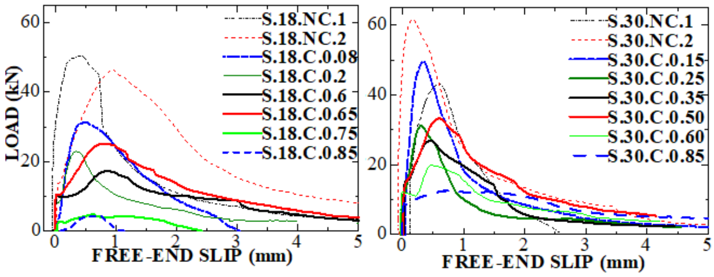

Fig. 1 Pull-out load vs. slippage

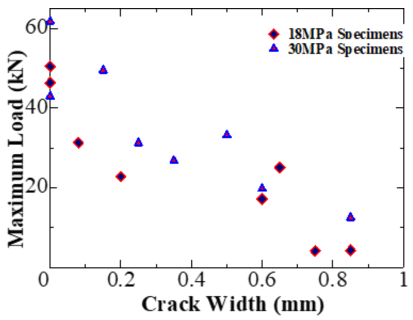

Fig. 2 Max load vs crack width

and induced crack width.

The decrease of the pull-out load is more severe in 18MPa than in 30 MPa specimens. A possible explanation for this might be that the 30MPa concrete has a stiffer response than the 18MPa concrete in both compression and tension therefore the crack opening may be delayed.

3. BOND STRENGTH DEGRADATION

The maximum pull-out load is normalized by the pull-out splitting strength of uncracked specimens. In Fig. 3, our test results are compared to the fib Model Code and the formula proposed by the Japan Concrete Institute.

The prediction with fib Model Code 2010 shows good agreement when the induced crack width is around 0.3mm. However, for other specimens, our results are overestimated or underestimated for 18 MPa specimens.

The prediction with Japan Concrete Institute 1998 is in good agreement with some 18MPa specimens. However, our results are overestimated for 30 MPa specimens.

An exponential fitting curve gives a better correlation than linear or logarithmic fitting. Therefore, the following equation can be used for prediction of the maximum pull-out load:

$$P_{(Wcr)} = P_0 \cdot e^{-0.46 W_{cr}}$$

Where $P_{(Wcr)}$: Pull-out load; P_0: Pull-out load of a specimen without crack; W_{cr}: Crack width.

Fig. 4 shows the experimental result and the prediction model. The concrete crack width can potentially be a good indicator to characterize bond strength degradation.

In our previous study [3], a formula expressing the deterioration of the bond obtained with single splitting type (Fig. 5) specimens has been proposed. In Fig.6, that model is compared to the one obtained in this paper. It can be seen that the deterioration of the bond is more severe in a side-splitting specimen than in a single-splitting specimen. This result may be explained by the fact that the number and position of induced crack can heavily affect the deterioration of the bond.

4. CONCLUSIONS

The test is carried out on a side split type specimen. In summary, these results show that there was a significant exponential correlation between pull-out strength and surface crack width and the decrease of the pull-out load is more severe in 18MPa than in 30 MPa specimens. The deterioration of the bond due to the induced cracks was more severe in a side-splitting specimen than in a single-splitting specimen.

ACKNOWLEDGEMENT

This study was supported by the JSPS KAKENHI Grant Number 17K18917.

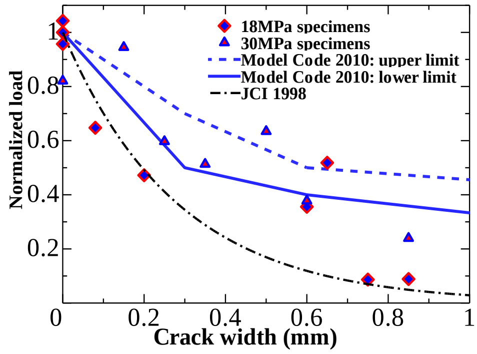

Fig. 3 Results in comparison with literature

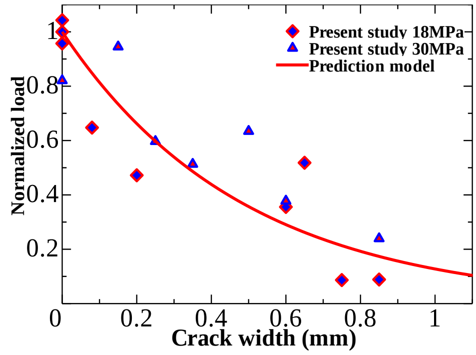

Fig. 4 Result and prediction model

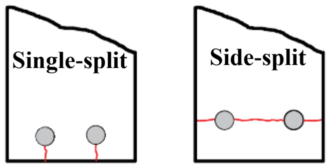

Fig. 5 Splitting mode

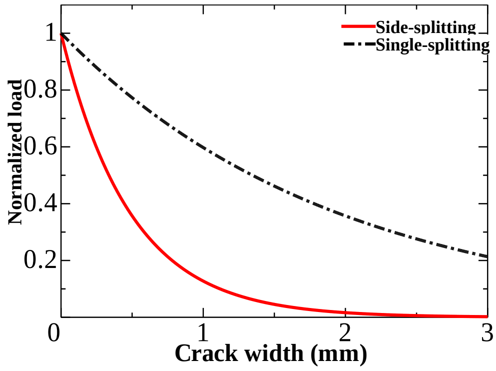

Fig. 6 Bond deterioration

REFERENCES [1] fib Model Code 2010, Vol.1. International Federation for Structural Concrete, Lausanne, Switzerland.

[2] 日本コンクリート工学協会，コンクリート構造物のリハビリテーション研究委員会報告書，1998

[3] Syll, A. S., Kanakubo, T., Aburano T., Castro, J. J., Bond Behavior in Cracked Concrete by Expansion Agent Filled Pipes, Summaries of Technical Papers of Annual Meeting, AIJ 2019.9

* Master Program, Dept. of Eng. Mechanics and Energy, University of Tsukuba

** Prof., Dept. of Eng. Mechanics and Energy, University of Tsukuba, Ph.D.

*** Prof., Architecture and Building Engineering Program, University of the Ryukyus, Ph.D.