PREDICTED METHOD FOR BOND STRESS DEPENDED ON CRACK WIDTH IN CORRODED REINFORCED CONCRETE

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1. INTRODUCTION

Reinforced concrete can encompass many types of structures and components. At use stage, cracks occur in concrete, and corrosion results in the formation of rust of which volume has two to four times of the original volume. Rust reduces strength capacity as a result of both the reduced cross-sectional area and corrosion cracks in the surface rebar. It is well known that the bond stress degrades dramatically, as rebar embedded in concrete are corroded. To illustrate the mechanism of bond stress is very important, and it is a precondition to estimate the residual load capacity of reinforced concrete. For these reasons, recent researchers on predicted models have taken a high toll, and many results have been obtained. However, there is still no accurate estimated model.

Based on this background, the objective of this study is to propose a model to estimate bond stress of corroded reinforced concrete.

2. BOND ACTION OF CORRODED RC

In the previous literature[1], the interaction force makes an angle β with the axis of rebar due to the presence of ribs. The interaction force can be resolved into radial (internal stress) and tangential (bond stress) component (see Fig.1). Eq.1 can be obtained.

$$p_i = \tau \cdot \tan \beta \tag{1}$$

where,

β: angle between the surface of rib and the rebar axis

τ : maximum bond stress (N/mm^2)

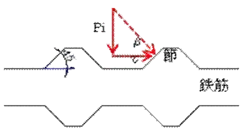

Fig.1 interaction force

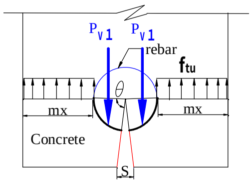

Fig.2 Mechanical mode

2.1Bond action in the cracked plastic stage

In plastic stage, crack will not occur in concrete untill every point at the plane of horizontal concrete cover has reached the ultimate tensile concrete stress, shown in Fig.2. Assume the vertical line passing the center of rebar is the axis of symmetry of corrosion crack, and θ is the angle between horizontal axis of rebar and corrosion crack can be calculated as follows:

$$\theta = \pi/2 - S/2c \tag{2}$$

where,

S: width of crack which is changing with internal pressure (mm)

c: concrete cover depth in crack direction (mm)

The vertical force acting on concrete with unit length can be calculated as follows:

$$P_V = 2P_{vi} = 2\int_0^{\theta} \cos\theta \cdot p_i \cdot \frac{d}{2} d\theta \tag{3}$$

where,

d: diameter of rebar (mm)

p_i: internar pressure (N/mm^2)

The tensile force acting on concrete with unit length can be calculated as follows:

$$F = 2 f_{tu} \cdot m_x \tag{4}$$

where,

f_{tu}: ultimate tensile stress of concrete (N/mm^2)

m_x: length of concrete cover in horizontal direction (mm)

Based on the balance of force and Eq.1, bond stress can be calculated as follows:

$$\tau = \frac{2 f_{tu} \cdot m_x}{d \cos(S/2c) \tan\beta} \tag{7}$$

3. EXPERIMENT

The meanings of alphabet in the name of specimens are shown in Fig.3. The method of electrolysis test is

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adopted. All the beam specimens are monotonically tested untill failure with four-point flexural loading. The loading span and supported span are 350mm and 1800mm respectively. They were loaded under displacement control at a velocity of 0.5mm/min. In the specimens of pullout test, tensile force applied on rebar increased at the speed of 9.8kN/min.

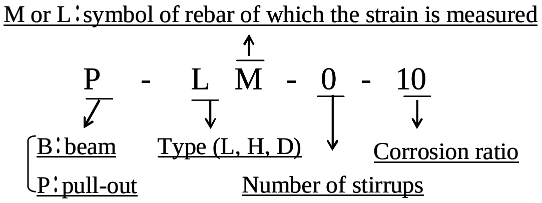

Fig.3 Name of specimens

4. Data analysis

Each of the specimens has two or three main rebar. However, the effect of internal pressure of each rebar was ignored. Based on the corrosion cracks of these beam, not only the corrosion crack at bottom surface, but also the corrosion cracks in horizontal direction are taken into account. Fig.4 shows the mechanical model with three rebar.

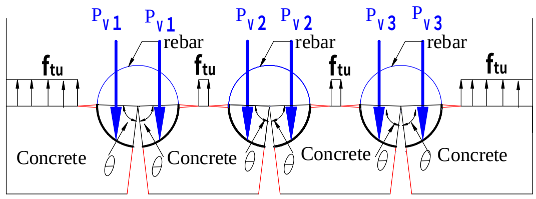

Fig.4 Mechanical model

(1)Ultimate tensile stress at bond splitting failure

Both the effect of concrete and the stirrups is taken into account. With regard to the part of stirrups, both the residual mass ratio and number of stirrups are taken into account. It can be expressed as follows:

$$f_{tu} = f_t + f_{st} = f_t \cdot (1 + \gamma \cdot n)$$

where,

f_t : tensile strength of concrete (N/mm^2)

γ : residual mass ratio of stirrups

n : number of stirrups in unit calculated region

(2)Effective width of concrete

Here define effective width of concrete to denote the width of concrete where cracks have not occurred. Moreover the concrete located between two rebar is affected by individual two rebar, and the corrosion crack is longer. For simplify, coefficient 0.5 is multiplied. Eq.8 Shows the calculation of specimens with three rebar.

$$\begin{cases} C_1' = (1-\lambda)\cdot C_1 \\ C_2' = \dfrac{1}{2}(1-\lambda)\cdot C_2 \\ C_3' = \dfrac{1}{2}(1-\lambda)\cdot C_3 \\ C_4' = (1-\lambda)\cdot C_4 \end{cases} \tag{8}$$

where,

λ : coefficient of crack propagation

C_i : width of concrete before corrosion (mm)

C_i' : effective width of concrete (mm)

Here, Eq.9 is adopted to calculate the coefficient λ.

$$\lambda = 2.4(\alpha / 100)^{2/3} \tag{9}$$

where,

α : corrosion ratio of rebar (%)

The value of both experimental and estimated maximum bond value is shown in Fig.5, which indicates that the many of the data is in ±30% region. It is reasonable to simplify the mechanical model as shown in Fig.4, and it is feasible to estimate the maximum mean bond stress by promoted method in this paper.

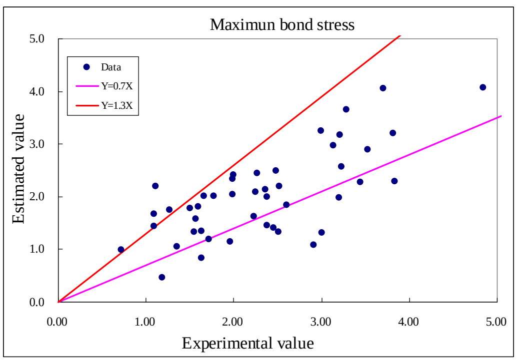

Fig.5 Experimental and estimated value

5. CONCLUSIONS

(1) The internal bond stress of cracked reinforced concrete can be estimated by corrosion ratio of rebar, corrosion crack and tensile strength of concrete.

(2) The maximum bond stress of cracked reinforced concrete can be estimated by internal stress.

REFERENCES

(1)Tepfers, R.,"*Cracking of Concrete Cover along Anchored Deformed Reinforcing Bars*," Magazine of Concrete Research, Vol. 31, No. 106 Mar. 1979, pp.3-11,