Experimental Study on the Effect of Natural Crack Characteristics on the Chloride Penetration

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1. Introduction

Main factor for durability design and service life estimation of RC structures exposed to marine environments

- Load Services
- Cracking
- Mix proportions of concrete
- Environmental factors
1. Introduction

Crack Studied on Concrete

Artificial cracks

Natural cracks

The definition of the tortuosity

The concept for the constrictivity
1. Introduction

Crack studied on Concrete

Artificial cracks

- Disadvantages such as:
  - Not reflected reality,
  - The crack surface containing more cement paste
  - Not tortuous, etc.

- However, the artificial cracks are easy to model and have clear result.
1. Introduction

- The natural cracks are very complicated to model and experiment.
- Up to now, there are different methods to create the natural cracks.

In this research, crack studied on concrete.
2. Experiment Program

The signification of the experiment procedure is determination the influence of chloride penetration depth on the crack width (W) and crack depth (L).

Short-term diffusion test combined by ASTM C1202 and Nordtest NT build 492
2. Experiment Program

a. Generate the single crack by bending beam.
b. Sawing cubic concrete specimen from beam
c. Cubic concrete specimen containing single crack

d. STDT test

e. Splitting specimen
f. Chloride penetration depth at crack (L = 42 mm)
3. Results and discussions

3.1 The influence of crack width on the chloride penetration depth

\[ y = -1584.8x^2 + 514.41x + 15.484 \]

\[ R^2 = 0.8481 \]
3. Results and discussions

3.2 The influence of crack depth on the chloride penetration depth

\[ y = 0.5103x + 28.043 \]

\[ R^2 = 0.8496 \]

Slope coefficient of real crack \( \approx 0.51 \)
3. Results and discussions

3.3 The tortuosity and constrictivity of crack

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3. Results and discussions

3.3 The tortuosity and constrictivity of crack

Experimental results of artificial crack by Marsavina (2008)

Slope coefficient of artificial crack \( \cong 0.97 \)
3. Results and discussions

3.3 The tortuosity and constrictivity of crack

• Ishida (2009) assumed that the tortuosity of crack is unity, then:

\[
\tau = 1.0
\]

The constrictivity parameter of the crack is a function of crack width:

\[
\delta_{cr} = 0.99 \tanh \{3.8W_x (\log(W_x) + 5.5)\} + 0.01
\]
3. Results and discussions

3.3 The tortuosity and constrictivity of crack

\[ y = 0.5103x + 28.043 \]
\[ R^2 = 0.8496 \]

\[ y = 0.7844x + 11.457 \]
\[ R^2 = 0.9313 \]

Converted by the assumption of crack tortuosity and crack constrictivity parameters
3. Results and discussions

3.3 The tortuosity and constrictivity of crack

Slope coefficient: 0.51 (real crack)

Ishida assumed the tortuosity of crack is unity: $\tau = 1.0$

Slope coefficient: 0.78 (Converted)

Slope coefficient: 0.97 (artificial crack) by Marsavina

Propose the tortuosity parameter for real crack:

$$\tau = \frac{0.97}{0.78} \approx 1.24$$
4. Conclusions

The paper presents the experimental studies on the natural crack characteristics that have an influence on the chloride penetration phenomenon:

With varying crack characteristics, the chloride penetration depth varied directly proportional to crack width or/and crack depth.

Besides crack width and crack depth, the results show that the shape and trend of the crack plane also influence on the chloride penetration.

The experimental tortuosity parameter of crack is proposed to be 1.24 for the natural crack created by bending moment.
Thank you for your kind attention!