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Study on water and chloride transport in cracked mortar using X-ray CT, gravimetric method and natural immersion method

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HIGHLIGHTS

- Water transport in cracked mortars was visually monitored by X-ray CT.
- Water absorption of cracked mortars was also investigated by the gravimetric method.
- Chloride transport in saturated and unsaturated cracked mortars was studied.
- The gravity effect of chloride transport in cracked mortars was considered.

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ABSTRACT

Concrete structures are frequently suffered to physical and chemical damage in the service period and then cracking is unavoidable. Cracks provide rapid access to aggressive agents and have a significant effect on the durability and service life of concrete structures. In this work, water and chloride transport in cracked mortars were investigated systematically. Firstly, the dynamic process of water transport in cracked mortars was visually monitored by X-ray CT and water absorption of cracked mortar was also quantitatively investigated by the gravimetric method. Later, chloride transport in saturated and unsaturated cracked mortars was studied by natural immersion method. What's more, the effect of gravity on chloride transport in cracked mortar was considered in this study. The results show that the threshold crack width for water absorption of cracked mortar is 0.1 mm. The effect of crack width on chloride transport in saturated and unsaturated mortars is different. The gravity effect improves the rate of chloride transport in cracked mortars.

1. Introduction

Concrete is one of the most important construction and building materials, which has been widely used in all kinds of engineering, e.g., civil, hydraulic, traffic, ocean, nuclear industry, etc., and play a critical role in the development of national economy. Concrete durability is always the focus to engineers and researchers as it directly affect the service life of structures [1–3]. For the research of concrete durability, more attentions are paid to sound concrete than cracked concrete. In fact, cracks are unavoidable when the concrete is suffered from external loads, shrinkage, temperature gradient, environment effect and other factors [4–7]. They provide rapid access to aggressive agents (Cl^-, SO_4^{2-}, CO_2, et al.) and increase the permeability and diffusivity of concrete, which accelerate the deterioration of concrete structures [6–8]. Then, a chain of "deterioration-cracking-further deterioration" may eventually result in the failure of concrete structure [9]. Systematic procedures for considering the effects of cracks on the durability of concrete structures are not widely available. A service life prediction model may provide overly optimistic results if it only consider the properties of undamaged concrete [10]. Therefore, it is of great significance to investigate the transport properties of cracked concrete and offer direct evidences to durability design and service life prediction.

In recent years, some researchers have studied the transport properties of cracked concrete. Firstly, for the preparation of cracked concrete, some mechanics methods were mostly used, such as feedback controlled splitting [4,5,9,11–13], flexure [14–18], tensile loading [19] and so on. Meanwhile, water permeability and chloride migration were used popularly for the description of

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Table 1
Chemical compositions of cement (wt%).

CaO	SiO_2	Al_2O_3	Fe_2O_3	SO_3	P_2O_5	Na_2O	K_2O	others
55.02	20.32	7.83	2.79	4.74	5.23	0.33	0.42	3.32

Table 2
Fundamental properties of cement.

Specific surface area (m^2/kg)	Setting time (min)		Compressive strength (MPa)		Flexural strength (MPa)	
	Initial	Final	3 d	28 d	3 d	28 d
375	150	204	35.2	66.4	6.2	9.3

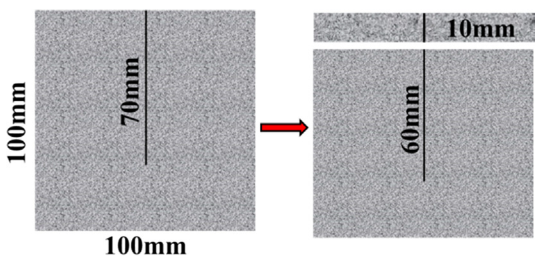

Fig. 1. The preparation of cracked mortar.

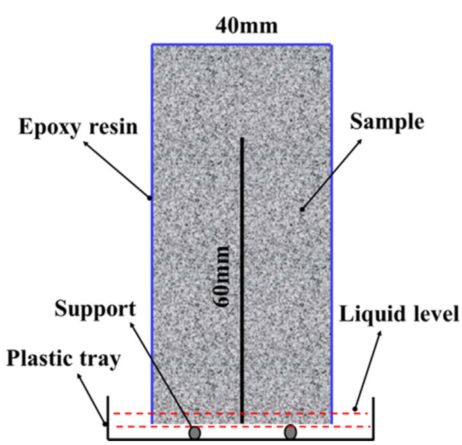

Fig. 2. Sample placement for X-ray CT scanning.

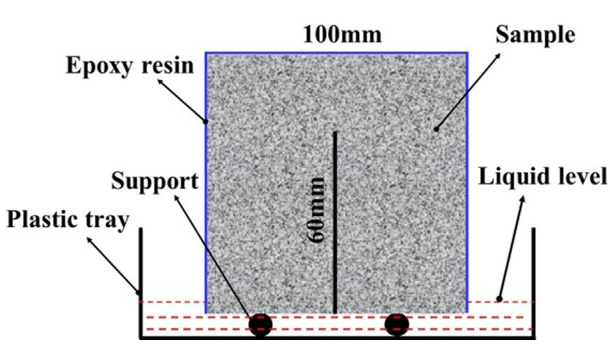

Fig. 3. Water absorption of cracked mortar.

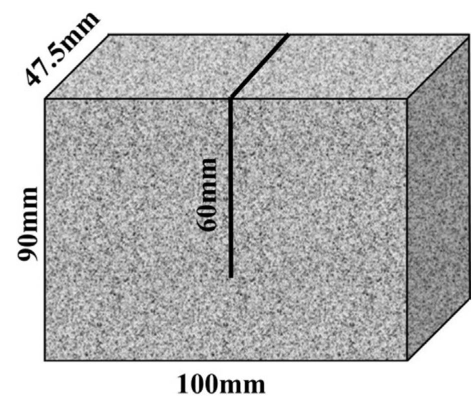

Fig. 4. Cracked mortar used for chloride transport test.

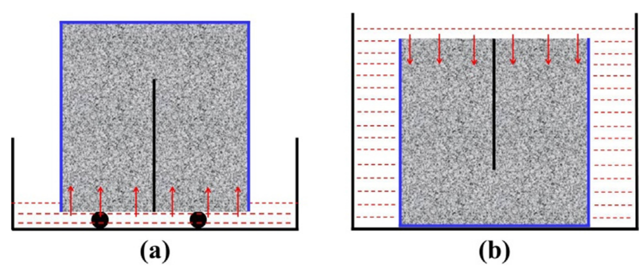

Fig. 5. Chloride transport into cracked mortar by two directions. (a) Upward, (b) Downward.

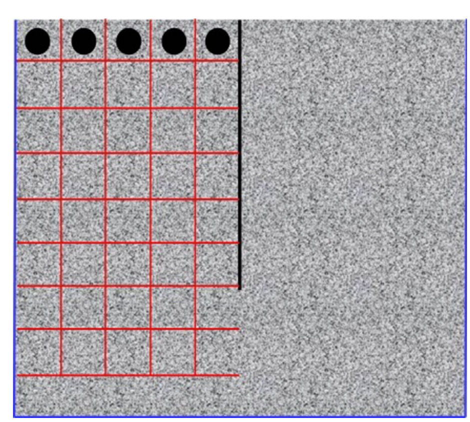

Fig. 6. Meshes of cracked mortar used for drilling powder.