University of Tabriz

Journal of Civil and Environmental Engineering
Volume 54 (2025), Issue 4, 93-105

EXTENDED ABSTRACT

Investigating the Relationship Between Water Penetration Rate and Concrete Surface Strength in Severe Freeze-Thaw Conditions and Developing a New Theory

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Received: 25 May 2024**; Reviewed:** 22 February 2025**; Accepted:** 03 March 2025

Keywords:
Friction transfer method, Water infiltration rate, Freeze-thaw cycles, Surface strength, Theoretical model.

1. Introduction

In this study, cubic concrete samples with dimensions of 15 millimeters were cured at ages of 7, 28, 90, and 120 days, and subjected to varying freeze-thaw cycles at durations of 40, 100, and 160 cycles. The surface resistance of the samples was evaluated using the friction transfer method. The volume of water penetration into the concrete was determined using a novel cylindrical chamber test, and the results were compared with a new fractal model.

2. Methodology

2.1. Experimental study

The freeze-thaw cycles were conducted based on the ASTM C666-B standard. According to this standard, the thawing of concrete samples occurs in water, while the freezing is conducted in air. Concrete permeability was measured using a novel cylindrical chamber device. This method, invented by Naderi, is a precise technique with broad applicability for measuring the permeability of concrete and other building materials both in a laboratory setting and on-site. Permeability device is depicted in Fig. 1-a. Additionally, the surface resistance of the concrete was assessed using the friction transfer test. This test can be used to determine the surface strength of materials and components employed in the road construction, building, and structural industries. Furthermore, beyond laboratory conditions, this test can also be performed on-site during the service life of buildings and structures and the apparatus is shown in Fig. 1-b.

Publisher: Vice Chancellery for Research & Technology, University of Tabriz
https://doi.org/10.22034/CEEJ.2025.61955.2360
Online ISSN: 2717-4077
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(a) (b)

Fig. 1. Test setup: a) Demonstration of permeability device which is mounted on concrete spacemen, b) The view of the friction transfer test setup which is in use

3. Results and discussion

3.1. Results of regression analysis

Taking into account the regression analysis between the surface strength obtained from the friction transfer method and the flow rate, a power relationship with an intensity coefficient of 90 and a coefficient of determination of 84% is derived. In this context, there is an inverse relationship between the flow rate and surface strength, because as surface strength increases, the flow rate decreases. The increase in surface resistance reduces the pores and capillary channels in the concrete. This condition leads to a decrease in the flow rate as well as a reduction in penetration volume, as shown in Fig. 2.

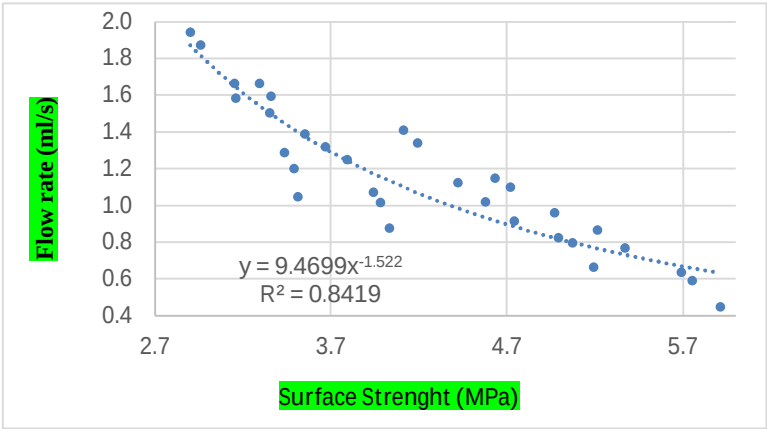

Fig. 1. Results of regression analysis between flow rate and surface strength of concrete specimen

4. Conclusions

With the increase in the number of severe freeze-thaw cycles, the volume of water penetration into the samples has increased. By comparing the permeability of normal concrete with that of concrete subjected to severe freeze-thaw conditions, it was observed that the increase in the volume of penetration for specimen affected by 40, 100, and 160 cycles in 120-day-cured concrete was 42.8%, 93%, and 156%, respectively. By employing the novel cylindrical chamber test, it is possible to measure the volume of water penetration into concrete under normal and severe freeze-thaw conditions without damaging the specimen. The correlation coefficient between the volume of water penetration and the depth of water penetration in concrete obtained from the cylindrical chamber test is 97%.