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TECHNICAL PAPER

A dual role on cleaning and healing of foreign agents for sustainable smart buildings using nano-TiO_2

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Abstract

Cracks incessantly act as a precursor on the surface of the structure, which facilitates the ingress of water and other foreign agents. Such activities would deteriorate the functionality and reduce the lifetime of the building. In this regard, an attempt was made to clean (self-cleaning) and heal the cracks by itself (self-healing). The mechanism involved in the proposed study was autogenous healing. Nano-titanium dioxide was used as a healing agent, and the properties were compared with the conventional admixture at a recovery period of 14, 28, and 56 days, respectively. Nano-TiO_2 was partially replaced with cement by various dosages viz., 0.5, 1, 1.5, 2, and 2.5 wt.%, respectively. Self-cleaning was analyzed through photocatalytic activity, phase composition and BET analysis. Similarly, the properties of the healed samples were tested against physiomechanical properties including air content, bulk density, compressive strength, and durability aspects of water absorption–immersion, sorptivity, permeability, and seepage flow. Scanning Electron Microscope (SEM) and X-ray Diffraction (XRD) are the microstructural studies. Performance of the healed samples was examined through crack width, and healing degree. Nano-TiO_2 particles accelerate the self-healing ability with a reduction in crack width by 13–36%. The ingress of water by sorptivity was reduced from 25 to 6.5%. The efficiency of permeability reduction was achieved by 19–37%. The potential of the research will elevate the life span of the structure as well saves the time and manpower owing for maintenance and repair.

Keywords Nano-titanium dioxide · Self-cleaning · Self-healing · Physiomechanical properties · Photocatalytic · Healing degree

Introduction

The cementitious compound undergoes disintegration in micro- and macro-scales due to the contamination of the environment, shrinkage, and temperature changes. One of the factors affecting the durability of the structures would be the ingress of harmful substances through the cracks and resulting in CO_2 emissions. The cracks may be either surface cracks or internal cracks. Surface cracks caused by external factors which facilitate the ingress of harmful substances, whereas internal cracks reduce the performance of the structures [1, 2]. Such things would cost repairmen and reconstruction of infrastructure [3–6]. In this aspect, an urgent need is required to explore a new method to repair a crack. Therefore, self-healing becomes a desirable method to repair and heal the cracks [7]. The self-healing method is a complete cement-based process investigated over decades. French Academy of Science (1836) stated that the self-healing process without a healing agent resulted in the formation of CH, and CSH products in a crack. This phenomenon would be due to the hydration process of unreacted cement particles called autogenous healing. However, autogenous healing would not provide a promising effect in the cementitious compound since healing of crack width would be maximum of 0.3 mm [2, 8–10]. Besides self-healing by autogenous method, so-called artificial healing has been adopted, containing any biological [11–13]/chemical [14, 15]/mineral admixtures [16, 17] in the cementitious matrix. These admixtures were incorporated into the cementitious matrix by pre-mixing to repair the cracks and reduce the permeability of water.

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