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Prediction model of resistivity and compressive strength of waste LCD glass concrete

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ABSTRACT

The purpose of this study is to establish a prediction model for the electrical resistivity (Er) of waste LCD glass concrete and then, to analyze the results obtained from a series of laboratory tests. A hyperbolic function is used to perform nonlinear multivariate regression analysis of the electrical resistivity prediction model, with parameters such as water-binder ratio (w/b), curing age (t) and waste glass content (G). Furthermore, the relationship of compressive strength and electrical resistivity of waste LCD glass concrete is also found by a logarithm function and the compressive strength evaluated by the electrical resistivity of nondestructive testing (NDT). According to the relative regression analysis, the electrical resistivity and compressive strength prediction models are developed. The calculated results are in accordance with the laboratory-measured data, which are the concrete electrical resistivity and compressive strength of various mix proportions. The regression analysis results show that a good agreement is obtained using the proposed prediction models. Therefore, the predicted results for electrical resistivity and compressive strength are mostly accurate for waste LCD glass applied in concrete. However, further study is needed in regard to applying the proposed prediction models to other ranges of mixture parameters.

1. INTRODUCTION

The manufacturing of LCD panels applied to information display devices is widely used in our life in televisions, computer monitors, mobile phones and computers, personal digital assistants, navigation systems and projectors. Since it was listed as the first-stage development priority of the “Two Trillion Core Industries Program”, Taiwan’s flat-panel display industry has flourished. Taiwan's output accounted for 38% of the global large-size LCD panel production in 2011, and Taiwan has become one of the largest producers of LCD panels, second only to Korea. With the substantial increase in

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production, large amounts of waste are derived from the manufacturing process (Gao *et al.*, 2008). Hence, the proper disposal of waste LC glass is an urgent issue.

The major materials of liquid crystal displays include glass (85–87%), polymer membrane (12.7–14%), and liquid crystal (0.12–0.14%) (Chang, 2005; Roland *et al.*, 2004). Liquid crystal is composed of glass substrates, liquid crystal, ITO (Indium tin oxide) conductive glass and black matrix (chromium oxide), and is characterized as an interim state between a solid and a liquid (Wang *et al.*, 2014). The main chemical constituents of waste LCD glass are SiO_2, Na_2O and a small amount of indium-tin-oxide conducting film. The conducting film is coated on the LCD to reduce the resistance of the substrate's surface, which enhances light transmittance and conductivity. Therefore, direct landfill, incineration and composting treatments are inappropriate for waste LCD glass (Lin, 2007). Glass contains large amounts of silicon and calcium, and it is classified as a Portland material. Furthermore, the addition of crushed waste glass to concrete as a fine aggregate can effectively reduce the air content and unit weight of concrete and improve its performance (Topcu and Canbaz, 2004). As a result, material costs can be reduced, as well as lead to a decrease in CO_2 emissions, thus making this recycling process the preferred method for sustainable development.

An inspection-based maintenance management framework, a particularly non-destructive testing (NDT) method, has been widely used to carry out inspections (Sheilsa *et al.*, 2012). Especially, the strength assessment of existing buildings is a challenge for structural engineers who need to feed structural computations with material data. Such assessment is required under various conditions: (a) when some damage has developed through time, (b) when new requirements have to be addressed because of changes in regulations or in the loads to be supported or (c) when the material's condition must be checked because of some suspicion, e.g. when the concrete in control cast cylinders may differ from the concrete in the building itself. In any case, non-destructive testing (NDT) techniques offer an interesting approach (Breysse, 2012). The methods of ultrasonic pulse velocity and electrical resistivity of non-destructive testing have been widely applied to the investigation of mechanical properties and the integrity of concrete structures (Ramezanianpour *et al.*, 2011; Shariq *et al.*, 2013; Solis-Carcano and Moreno, 2008; Vipulanandan and Garas, 2008).

Previous studies have generally focused on investigating the workability and strength properties of recycled concrete, and there has been less discussion of the property prediction model based on the electrical resistivity and compressive strength of various concrete materials. Therefore, based on the results of previous studies on concrete with various mixture ratios of waste LCD glass (Wang and Huang, 2010a & 2010b), the relationships between the electrical resistivity and the influencing factors, such as waste glass content and water-binder ratio and age, were chosen as the focus for this study.

2. CHARACTERISTICS OF ELECTRICAL RESISTIVITY AND WASTE LCD GLASS CONCRETE

Wang *et al*. (2014c) used different ratios by adding LCD glass powder as a replacement for cement, and they also used glass sand as a replacement for natural sand for concrete. The setting time and compressive strength increased as the