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Fatigue Analysis for Void Repair of Cement Concrete Pavement with Under Slab by Polymer Grouting

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Abstract

After the appearing of voids beneath cement concrete slabs, the pavement loses a continuous and uniform lower support structure, and the stress state of the road panel is extremely unfavorable. The polymer grouting repair is timesaving, efficient and pollution-free. In order to verify the performance improvement and fatigue damage evolution of cement concrete pavement before and after grouting repair, a material damage constitutive model was established. The UMAT subprogram was introduced into the finite element software ABAQUS to analyze the structure under the action of moving cyclic loading, stress response and fatigue damage evolution process before and after regional grouting repair. The results show that the Mises stress and vertical displacement of the grouting repairing slab are very close to the normal state, which indicates that the grouting repair has a prominent influence on the bottom void of the slab. With the rise of loading time, the fatigue damage of the pavement structure is increasing, but the trend is gradually reduced, and the number of load times and the degree of fatigue damage are nonlinear. From the long-term cyclic loading and comprehensive analysis of the construction period, the polymer grouting repair is better than cementitious grout.

Keywords: Cement Concrete Pavement; Void under Slab; Polymer Grouting; Fatigue Constitutive Model; Fatigue Damage.

1. Introduction

Cement concrete pavement has many good features and is a high-grade pavement with excellent performance. However, in operation, due to the repeated action of the vehicle loads, the underlying foundation will have a certain plastic deformation. Or the concrete slab will be warped due to the influence of temperature, so that the local extent of the concrete slab is no longer in continuous contact with the foundation. That is, there is a partial void under the concrete slab. The force on the concrete slab is extremely unfavourable. Under the action of the load, the edge of the vacant part will produce local stress concentration, and the repeated load of the heavy traffic will eventually lead to the rupture of the slab, thus affect the functioning condition of the road surface [1].

Polyurethane is one of the largest polymer products in the plastics range. In the past few decades, the use of polyurethane materials to repair and strengthen civil engineering infrastructure has become very widespread [2]. Because it has adhesive properties with other materials, as well as self-supporting features that do not require additional adhesives. This material has been widely used in highways, urban roads, maintenance of airport runways, foundation reinforcement, dam seepage prevention, high-speed rail uplift and other engineering fields [3-4].

Kai Liu et al. (2019) [5] researched that the rigid polyurethane grout materials with different densities show elastoplastic or atypical brittle characteristic, which will significantly affect their performance. Although the

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