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Experimental Research on the Wearability, Corrosion Resistance, and Life Assessment of an Aluminum Alloy Bridge Deck*

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Abstract: High-performing wearability and corrosion resistance are required for an exposed aluminum alloy bridge deck, but existing experimental research remains limited. In this paper, feasible test methods are proposed based on an experimental study on the wearability and corrosion resistance of the aluminum alloy bridge deck of the Bengbu Bridge in Tianjin, China. The line friction test of standard specimens was adopted, and the aluminum alloy bridge deck's wearability was calculated. The electrochemical test was conducted to measure the corrosion rate and morphology characteristics of specimens that were corroded in various solutions that simulated the atmospheric environment. The test results show that the wearability and corrosion resistance of the aluminum alloy bridge deck are sufficient and met the project's requirements. The test methods proposed have practical significance for future engineering research, and the test results are useful for other engineering applications of aluminum alloys.

Key words: aluminum alloy; bridge deck; wearability; corrosion resistance; test method; life assessment

Introduction

In recent years the production of aluminum alloy has leaped to second place in overall metal material production, surpassed only by steel. In addition to use in the aviation industry, aluminum alloy has begun to be applied in the machinery manufacturing industry and in the field of civil engineering[1]. 27% of aluminum alloy material produced in the world is used in the construction industry[2], not only for non-structural elements such as doors, windows, and curtain accessories[3], but also for load-bearing structures like bridges, large span roofs, grids, and reticulated shell structures[4,5]. In addition, aluminum alloy formworks have been applied in cast-in-situ concrete construction[6]. In order to overcome the low elastic modulus of aluminum alloy materials, FRP-aluminum alloy[7] and CFRP-aluminum alloy[8] composite structures also have been used in engineering construction.

Aluminum alloy was applied in the construction of the sidewalk deck of the Bengbu Bridge in Tianjin, China. In consideration of the bridge's overall aesthetic effect, the aluminum alloy deck was to remain exposed. Therefore, a high degree of wearability and corrosion resistance was required. For previous experiments on the wearability and corrosion resistance of aluminum alloys, there have been few adequate approaches in the civil engineering field; relevant research conducted in China and elsewhere has been quite limited overall. In

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this study, feasible test methods for the experimental research on the wearability and corrosion resistance of an aluminum alloy bridge deck based on existing knowledge of material science and the details of the bridge's construction were proposed. Hopefully, the results will provide a reference for future engineering studies.

1 Engineering Background

The Bengbu Bridge is located on the Hai River in Tianjin Municipality. It has sidewalks on both sides for pedestrians. The main bridge has a width of 23.5 m and the sidewalk has a width of 3 m. The entire bridge is 192 m long. The Bengbu Bridge is shown in Fig. 1.

(a) Overall appearance

(b) Aluminum alloy bridge deck

Fig. 1 Bengbu Bridge in Tianjin

An aluminum alloy deck, which is part of the pedestrian sidewalk, was conducted of 6005 T5 aluminum alloy[9] extrusions with anti-slip strips located on the longitudinal beam. The aluminum alloy deck is shown in Fig. 2; each anti-slip strip has a height of 1 mm to improve the non-skid properties of the deck.

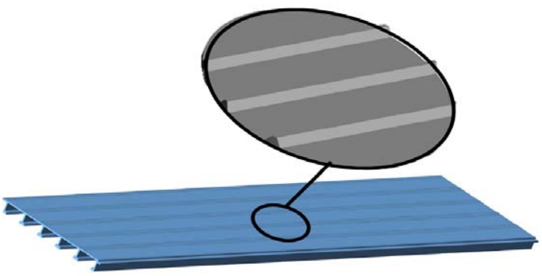

Fig. 2 Schematic diagram of the aluminum alloy bridge deck

2 Wearability Test

2.1 Test program

Under the influence of the constant friction from the soles of the pedestrians' shoes, especially the particulate matter attached to the soles, the anti-slip strips on the surface of the deck will gradually suffer wear and tear. Consequently, an examination of the wearability and life assessment of the anti-slip strips of the deck under certain pedestrian traffic situations would be useful. A feasible and reasonable test program is needed first; however, no research methods for the study of the wearability of metal materials currently exist in the field of engineering.

Currently, the most commonly-used experimental method concerning the wearability of roads is mainly applicable to concrete pavement, but the test equipment is too large for the small dimensions of this particular construction project. Another method that is suitable for ground tile involves sanding the tile with sandpaper of different strengths and evaluating the wearability based on various friction frequencies. In the field of material science, most wearability experiments concerning metals and alloy materials concentrate on comparisons between the wearability of different materials. Some experimental studies on aluminum alloy composite coating and high-silicon aluminum alloy cylinder sleeves have been conducted, in which steel materials were used as the upper specimen of the friction pair[10,11].

Considering both the feasibility of the operation and the experimental scale, the previously mentioned test method commonly used in the field of material science was used to simulate the actual work conditions of the deck in this study. The standard dimension cylindrical upper specimen was made of steel, whose hardness was used to simulate the particulate matter, such as gravel, that often becomes attached to the soles of pedestrians' shoes. During testing, the upper specimen was located on the anti-slip strip specimen (the lower specimen), and friction was produced to study the wearability. The lubricating conditions of the friction pair surface include pure friction, dry friction, fluid friction, boundary friction, and mixed friction[12], but only the dry friction condition was adopted in this test. In general, the upper specimen of the friction pair (steel) and the friction condition (dry friction) used in this study were both unfavorable to the wearability of the anti-slip strips of the deck (which nonetheless proved to be quite safe). The schematic diagram of the upper and lower specimens is shown in Fig. 3. The steel disc