Research on Improving the Anti-skid Performance of Manhole Covers

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1. Introduction

Recently, extreme weather and frequent heavy rains have led to the long-term use and exposure of manhole covers to rain and sun. It has caused wear and erosion on the covers' surfaces, increasing the risk to road safety. In response, the Legislative Yuan amended Article 72 of the Highway Act, stipulating that the anti-skid value of manhole covers in wet environments shall not be less than 50 BPN, as measured by the British Pendulum Tester, to reduce motorcycle accidents caused by skidding.

The anti-skid capability of a manhole cover is primarily determined by the friction between its surface and a vehicle's tires. This friction is closely related to the macro- and micro-textures of the cover's surface. Macro-textures facilitate drainage, which reduces the risk of skidding, while micro-textures provide direct friction. Other factors, such as the composition of the pavement material, particle shape and size, and construction techniques, also affect anti-skid performance. Research on the anti-skid properties of manhole covers involves multiple areas, including pavement materials, surface textures, and environmental factors. Various testing techniques can be used to evaluate the anti-skid performance of manhole covers, providing a scientific basis for road design, construction, and maintenance, and thereby enhancing driving safety.

2. Experimental Methods

This research conducted material tests on the TPC's power distribution manhole covers, including metallographic analysis, material composition analysis, hardness analysis, tensile testing, impact testing, U-bend testing, and coating thickness observation. These analyses were performed to evaluate the material properties, strength, and surface roughness of the manhole covers and the anti-skid coatings.

TPRI developed a composite material coating technique using arc spraying. This process uses aluminum-aluminum oxide (Al_2O_3) as the spray wire. When the ends of two wires are brought into contact, a short-circuit arc is created, generating high heat that melts the material. A high-pressure air stream then propels the molten material onto the manhole cover. Figure 1 shows a manhole cover with the anti-skid coating developed by our institute. For comparison, we also selected three commercially available anti-skid coating products: a pre-formed thermoplastic composite, a ceramic anti-skid material, and an anti-skid, wear-resistant, thermally insulating, and eco-friendly material.

According to current regulations, the standard measurement method for a manhole cover's anti-skid value is to take four measurements at four different points on the surface. The average of these 16 measurements (4 points × 4 measurements per point) is the final anti-skid value. TPRI conducted on-site measurements of new manhole covers at eight locations near the Shulin District office. These locations were divided into two main categories, each with two subcategories: two spots on expressways, two on slow lanes, two at intersections, and two on turning roads. We periodically measured the anti-skid values of these covers. Additionally, we selected five locations on a road near the Shulin District office to

measure the anti-skid values of different coatings. Four of these manhole covers were coated with TPRI's anti-skid coating, and the three other commercial coatings, respectively. The fifth manhole cover, a standard power distribution cover without any coating, served as the control group.

Source: This research

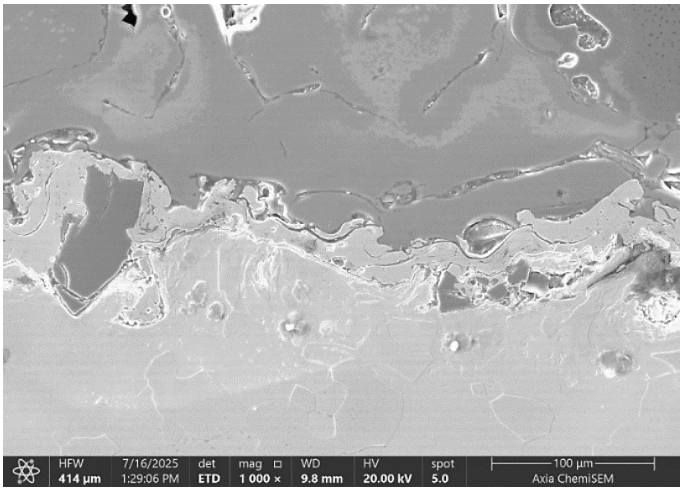
Figure 1. The photo shows a manhole cover with the anti-skid coating developed by TPRI.

3. Results and Discussion

Before applying our developed anti-skid coating, we performed sandblasting on the test pieces to increase surface roughness. This improved the bonding between the anti-skid coating and the manhole cover material, resulting in a more uniform coating with excellent adhesion. The aluminum oxide (Al_2O_3) material is hard and brittle, but when dispersed within the aluminum matrix, it provides good wear resistance and durability. Figure 2 shows a micrograph of the anti-skid coating developed by TPRI. The coating also contains dispersed pores, which create a porous structure that prevents water from accumulating on the surface, thereby suppressing skidding caused by water buildup. Figure 3 shows the microstructure of our anti-skid coating.

The on-site road measurement results for the TPC's power distribution manhole covers are shown in Figure 4. The results indicate a significant decrease in the anti-skid values at all measurement points after 24 days of road use. We speculate that the initial high anti-skid values of the new manhole covers were due to a layer of rust oxide on the surface, which increased surface roughness. As the covers were used, this rust layer was worn away, leading to a substantial decrease in anti-skid performance. Furthermore, in areas with frequent braking (intersections, turns, etc.), the manhole cover surfaces experienced greater erosion, resulting in lower anti-skid values.

The on-site anti-skid measurement results for the manhole cover coatings are shown in Figure 5. The results, taken nearly one year after application, demonstrate that the anti-skid value of our developed coating is superior to that of the three commercial coatings. After 873 days of on-road use, the manhole cover coated with TPRI's coating material had an anti-skid value of 55.4 BPN, which meets the requirements of Article 72 of the Highway Act for wet conditions (an anti-skid value of 50 BPN or higher).



Source: This research

Figure 2. The photo shows a micrograph of the anti-skid coating developed by TPRI.

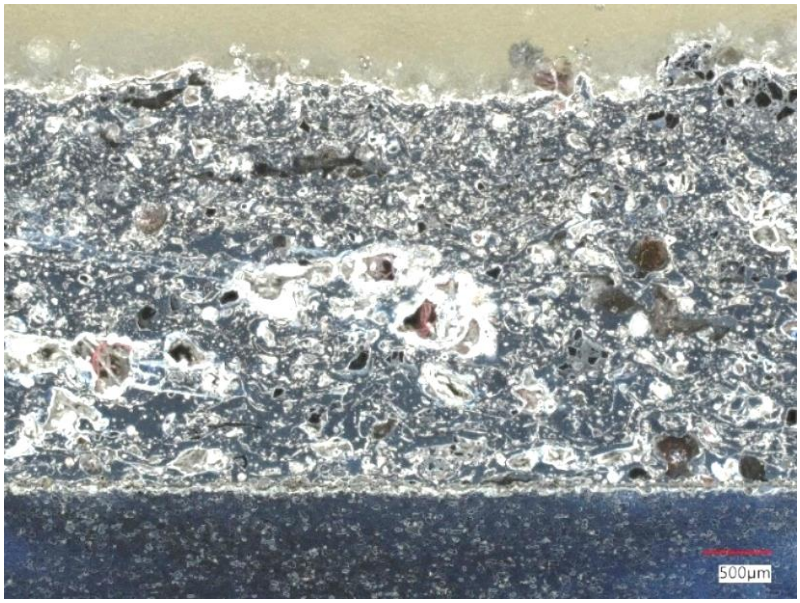


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Figure 3. The photo shows the microstructure of our anti-skid coating, the anti-skid coating developed by TPRI.

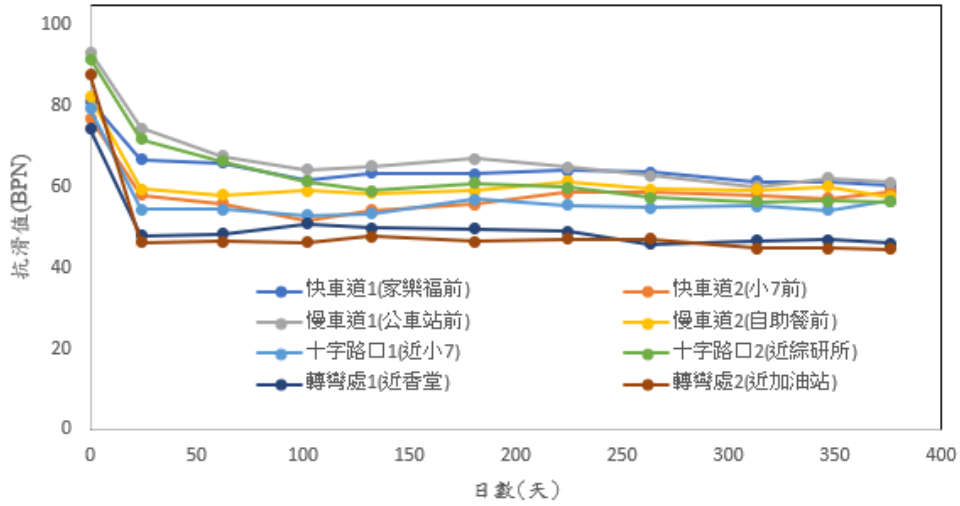

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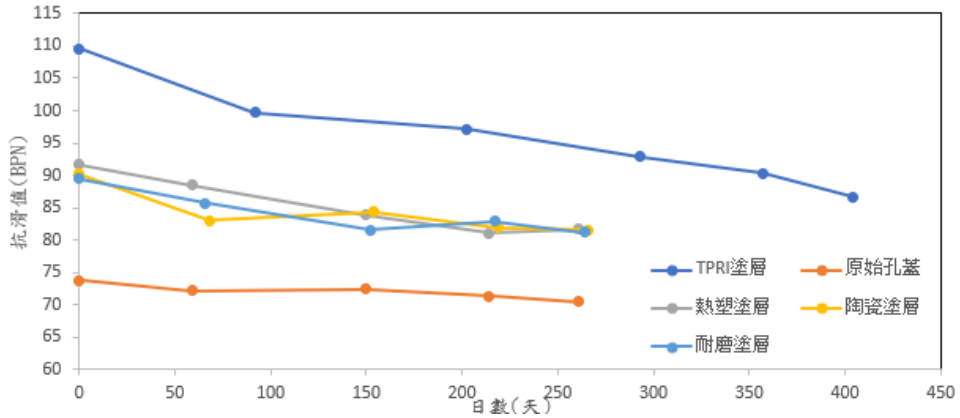
Figure 4. The diagram shows the on-site road measurement results for the TPC's power distribution manhole covers.



Source: This research

Figure 5. The diagram shows the on-site anti-skid measurement results for the manhole cover coatings.