Investigation of Corrosion Degradation Characteristics and Aluminum Cladding Thickness Variations in Optical Ground Wire (OPGW)

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1. Research Background and Objectives

Optical Ground Wire (OPGW) serves both as an overhead ground wire for lightning protection and as a medium for optical-fiber communication, making it an important component of transmission systems. Because OPGW is continuously exposed to outdoor environments, its metallic strands may be affected by environmental factors such as moisture, salinity, and atmospheric pollutants, which can lead to corrosion. In particular, at locations covered by clamps or protective rods, where moisture or corrosive substances may not be readily removed, the risk of localized corrosion may increase.

In recent years, some in-service OPGW lines have exhibited corrosion of aluminum wires, breakage of individual wires, and even exposure of the steel cores in aluminum-clad steel wires. In addition, OPGW installed in different periods has shown different degrees of corrosion under similar environmental conditions, suggesting that, in addition to service environment, material characteristics may also affect corrosion resistance.

To better understand the corrosion degradation of existing OPGW, this study collected samples with different service durations and conducted visual corrosion inspections, mechanical property tests, and cross-sectional analyses of aluminum-clad steel wires. The corrosion conditions and aluminum cladding thicknesses of OPGW from different installation periods were compared, and their possible relationships with OPGW degradation were investigated. The results are intended to provide a technical reference for future material selection, equipment maintenance, and corrosion management.

2. Research Methods and Major Findings

A total of eight OPGW samples with service durations ranging from 6 to 25 years were collected and categorized into earlier-period and recent-period samples according to their in-service conditions. Visual corrosion inspections, tensile tests on the complete OPGW strands and individual aluminum-clad steel wires, and cross-sectional analyses were performed. The thickness of the outer aluminum cladding on the aluminum-clad steel wires was also measured to compare the mechanical properties and corrosion degradation characteristics of OPGW from different periods.

The mechanical test results showed that most of the complete OPGW samples retained some load-bearing capacity at the time of sampling. The tensile test results did not clearly indicate poorer performance in recent-period samples than in earlier-period samples, either for complete OPGW specimens or for individual wires. These results suggest that insufficient overall mechanical strength alone does not adequately explain the corrosion and individual breakage of individual wires observed in the field (Figure 1). However, decreases in elongation were observed in some individual wires, and severe corrosion areas exhibited aluminum loss

and exposure of the steel core, indicating that localized material degradation may still affect the long-term service performance of OPGW.

Further comparison of the visual and cross-sectional observations showed that some recent-period samples exhibited exposed steel cores after approximately 12 years of service, whereas an earlier-period sample that had been in service for approximately 17 years remained relatively intact (Figure 2). Measurements of aluminum cladding thickness also revealed a clear difference. The average aluminum cladding thickness of the recent-period in-service samples was approximately 285 μm, compared with approximately 763 μm for the earlier-period samples (Figure 3). In addition, measurements of a new OPGW sample showed an average aluminum cladding thickness of approximately 265 μm (Figure 4). These results suggest that the thinner aluminum cladding observed in the recent-period samples may be associated with differences in material design or manufacturing, rather than resulting solely from corrosion loss during service. Although the measured aluminum cladding thicknesses still complied with the relevant specification requirements, the aluminum cladding serves as a protective layer between the internal steel core and the corrosive environment. Therefore, a thinner cladding layer provides a smaller corrosion allowance for long-term service and may lead to earlier exposure of the steel core under similar corrosive conditions.

3. Applications and Future Work

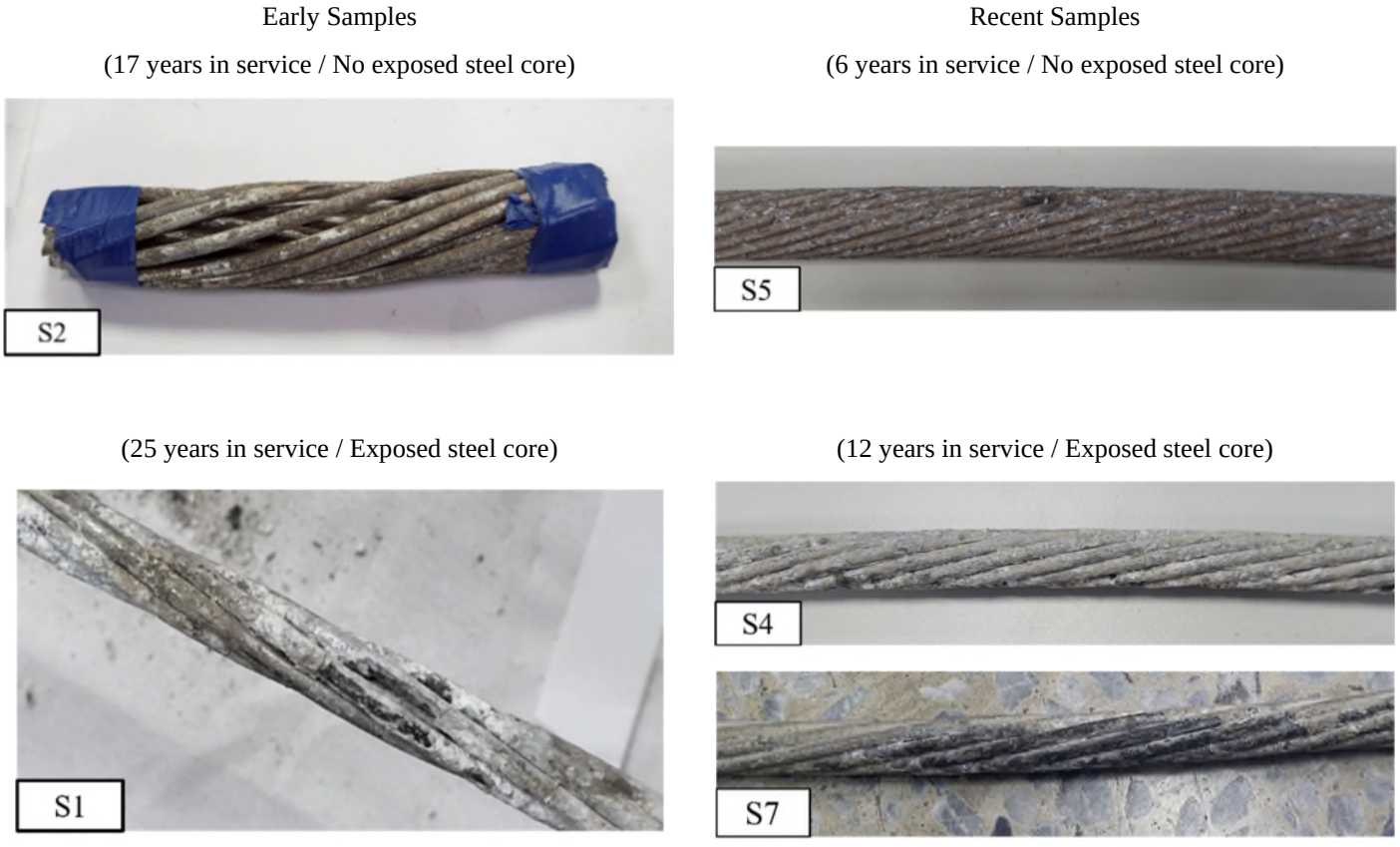
The overall results indicate that the long-term corrosion degradation of OPGW may be influenced not only by the service environment but also by material configuration, aluminum cladding thickness, and structures covering sections of the OPGW. Although the recent aluminum-clad steel wires complied with current specification requirements, their aluminum cladding thickness was substantially lower than that of the earlier-period samples. This suggests that, in addition to compliance with basic material performance requirements, the corrosion allowance provided by the aluminum cladding should also be considered when evaluating long-term service performance. These findings may serve as a technical reference for future OPGW material selection, procurement specification review, and corrosion management of transmission lines.

Future work may include the continued collection of OPGW samples from different regions and with different service durations and corrosion severities. By comparing aluminum cladding loss, steel core exposure, and changes in mechanical properties, a more systematic basis for assessing material degradation and service condition may gradually be established. In addition, locally covered areas such as protective rods and clamps may be considered priority locations for field inspection. Continued accumulation of actual corrosion cases and environmental data may further support improvements in equipment maintenance and corrosion prevention strategies.



Source: This study

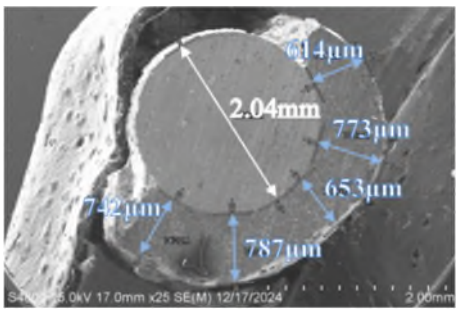
Figure 1. Corrosion observed in an OPGW line after 6 years of service

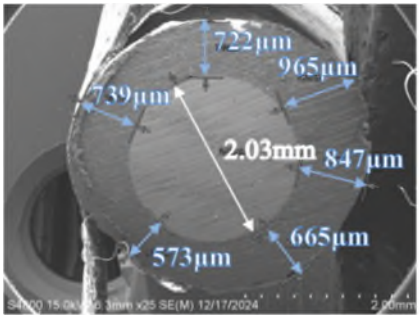


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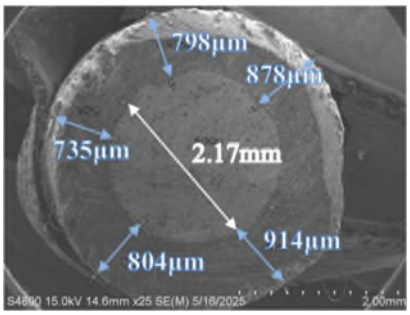
Figure 2. Corrosion appearance in OPGW samples after different service periods

Early Samples S1

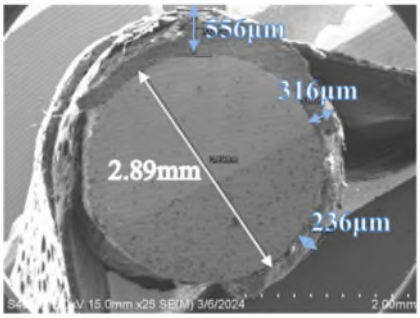




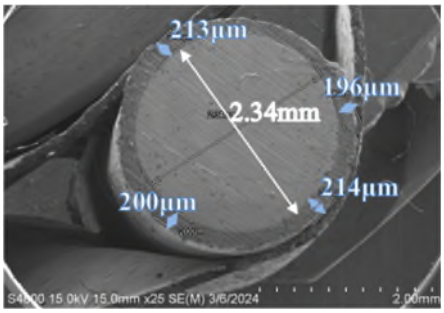
Early Samples S2



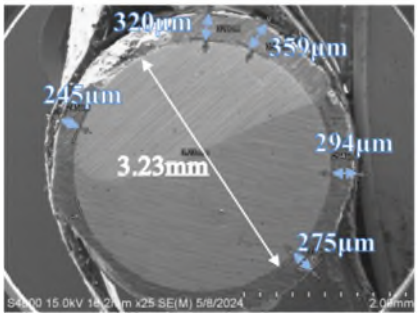
Recent Samples S4



Recent Samples S5



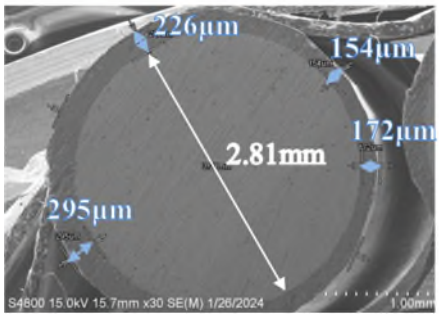
Recent Samples S7



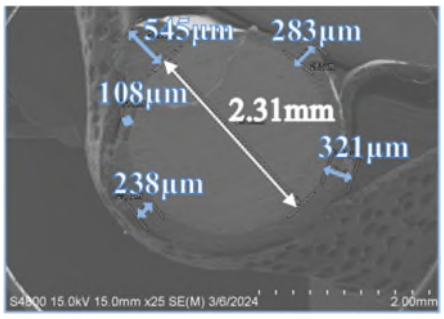
Source: This study

Figure 3. Cross-sections of aluminum-clad steel wires and comparison of aluminum cladding thickness in in-service OPGW samples

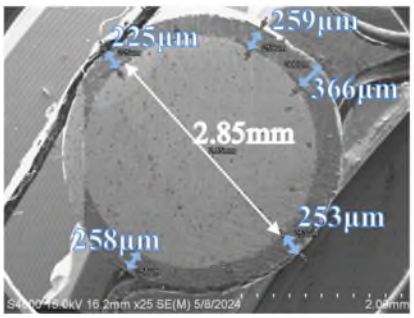
New Sample N1



New Sample N2



New Sample N3



Source: This study

Figure 4. Aluminum cladding thickness of aluminum-clad steel wires from new OPGW samples