

## Study on stress corrosion behavior and failure mechanism of galvanized bolts in complex coal mine environments

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**Abstract** The premature failure of bolts caused by stress corrosion cracking (SCC) is a common issue in the global mining industry. Studies have shown that hot-dip galvanizing is an effective solution, but the first widespread application of galvanized bolts in Xin'Shang'Hai No. 1 coal mine, China, experienced extensive failures. To thoroughly investigate the fracture failure mechanism, this paper employed a comprehensive approach that included macro mechanical property testing, corrosion experiments, and micro-scale characterization. The findings indicate that significant stress concentration occurred on the surface threads of the bolts under high mine pressure, serving as the primary inducer of SCC in the bolts. Under long-term stress corrosion, the peak strength of ordinary bolts decreased by only 11.60%, while that of galvanized bolts decreased by 20.54%. This shows that the mechanical performance of galvanized bolts deteriorated more than ordinary ones, indicating that galvanized bolts cannot suppress SCC in bolts and may even aggravate it once the galvanized layer cracks. Analysis of hydrogen content revealed that after service underground, the hydrogen content in the body of galvanized bolts increased by 304.48%, significantly raising the risk of hydrogen-induced cracking (HIC). Therefore, the instantaneous fracture of galvanized bolts is primarily caused by stress concentration cracking due to the geometry of the bolts and stress corrosion failure promoted by HIC. Thus, in deep underground engineering, it is not recommended to promote the use of galvanized anti-corrosion processes and Class A shaped bolts, especially in environments with high stress and high mineralization. Instead, high-strength coated bolts are advised to replace galvanized ones to enhance the reliability and safety of bolt support.

**Keywords** SCC, HIC, Micro-scale Characterization, Failure Mechanism, Galvanized Bolts, High Mineralization Mine Water

### Reference

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