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Editorial

Forensic Engineering

Editorial: Performance of highway structures in recent earthquakes

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Highways, bridges, and tunnels provide key transportation support for communities to be resilient against natural extreme events such as earthquakes. Post-earthquake safety and functionality of these facilities are also critical to the response and recovery activities by providing connectivity to hospitals, rescue operation centres, repair/reconstruction resources, and other basic needs such as food, fuel, and water. While effective design criteria have been developed and implemented in the past several decades, each earthquake continued to reveal certain aspects of damages that were previously not encountered or not emphasised.

This themed issue offers a stage for sharing and discussing the performance of highway structures in recent large earthquakes. Documentation of the findings and lessons learned from these experiences bear high value to understanding the hazard, structural behaviour, and emergency operation demands. The post-event investigation can also benefit the damage prediction tools such as fragility models that are used in emergency management or long-term planning. Effective techniques and procedures used in post-event inspection and investigation are discussed from experience or collective knowledge in practice.

The first paper "Bridge inspection using UAVs and selfie sticks after the 2024 Noto Peninsula earthquake" introduces use of UAV and photography techniques to obtain information of damage right after natural disasters to assess emergency of the situation (Kobayashi *et al*., 2026). In such cases, generally, scaffolding and inspection vehicles are not available. Unmanned aerial vehicle (UAV) and selfie sticks equipped with cameras are used as practical alternatives for close-up inspections of road bridge components, such as bearings and piers. The conditions – especially camera-to-target distance and lighting – under which deformations can be reliably detected in photographs are clarified. The research highlighted both the potential and limitations of these methods, and the study proposes a framework for combining UAVs and selfie sticks with conventional hands-on methods, ensuring reliable and efficient inspections without overlooking critical damage during post-earthquake recovery.

The second paper "Bridge assessment after 2024 Noto Peninsula earthquake and rainfall using point cloud" addresses the challenge of assessing bridge damage progression under compound disasters, specifically focusing on a bridge affected by the 2024 Noto Peninsula Earthquake and subsequent heavy rainfall (Katayama *et al*., 2026). Quantitative evaluation of potential changes in pier inclination is attempted using multi-temporal point cloud data (PCD) acquired by way of terrestrial LiDAR immediately after the earthquake and following the rainfall. Accurate pier detection from complex PCD, complicated by environmental changes such as sediment deposition, was achieved using a deep learning semantic segmentation model enhanced with low-rank adaptation fine-tuning. Their findings indicate no measurable progression of pier inclination during the observation period, demonstrating the effectiveness of the proposed workflow combining advanced scanning, segmentation, and robust multiple geometric analysis methods for monitoring structural stability and resilience in multi-hazard scenarios.

In the third paper "Damage assessment of bridges using segmentation and shape analysis from aerial imagery", segmentation model by deep learning is applied to aerial imagery for detecting and classifying bridges with the presence or absence of damage and to estimate bridge length and width from the detected regions for evaluation of changes in shape (Kubo *et al*., 2026). For damaged bridges, debris accumulation and inundation often resulted in only partial detection of the bridge, leading to a tendency for dimensional underestimation, particularly in the bridge length direction. Furthermore, damage caused changes in the relative scaling relationship between bridge length and width, disrupting the original balance between these dimensions. This suggests that analysing changes in shape dimensions is a potentially effective method for detecting the presence of bridge damage.

The last paper "Hierarchical deterioration prediction for risk-based expressway maintenance" describes research on deterioration prediction using machine learning and using big data accumulated from repeated inspections (Higashiwada and Chun, 2026). Risk-based maintenance and management that considers the uncertainty observed in actual deterioration phenomena are studied and a hierarchical deterioration prediction framework is demonstrated.

These four articles show how the contemporary sensing technologies such as UAV, point clouds or aerial photos are applied to evaluate structural failures, with assistance of artificial intelligence. By integrating advanced sensing technologies with artificial intelligence, forensic engineering is expected to evolve towards more accurate, efficient and reliable practices.

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