EVIDENCE-BASED DETERIORATION–DIAGNOSIS–DECISION FRAMEWORK FOR RESILIENT BRIDGE ASSET MANAGEMENT

ABSTRACT Resilient transport systems rely on the dependable performance of critical nodes such as bridges, where local deterioration can trigger cascading disruption across networks. Ageing concrete bridges thus pose both engineering and systemic risks. Yet current inspection and decision-making practices remain fragmented, with deterioration mechanisms, diagnostic methods, and management strategies often treated in isolation; limiting their effectiveness for resilience planning.

This study proposes an evidence-based deterioration–diagnosis framework that systematically links component-level degradation to bridge performance and network-wide resilience outcomes. Unlike conventional models, it integrates uncertainty, captures cross-scale interactions, and connects deterioration diagnostic data to network-level decision-making, enabling prioritisation of critical assets, reduced downtime, and faster recovery following disruptions.

The framework maps deterioration mechanism (e.g., corrosion, delamination, cracking) to stage-sensitive diagnostic methods (e.g., guided waves, acoustic emission, ground-penetrating radar). By integrating inspection data into system-level modelling and optimisation and using value-of-information principles to guide efficient data acquisition, the framework enhances inspection reliability, reduces life cycle costs and quantifies resilience benefit across the transport network.

Figure 1 shows the cross-scale workflow linking deterioration diagnostics to asset performance and network prioritisation, with feedback driving maintenance and inspection updates. Overall, the proposed framework integrates bridge deterioration diagnostics with transport system resilience, offering a practical tool for transport operators and policymakers to enhance reliability, safeguard accessibility, and accelerate recovery.