PREDICTION METHODOLOGY FOR POST-EARTHQUAKE TRAFFIC CAPACITY OF SIMPLY-SUPPORTED GIRDER BRIDGE GROUPS IN REGIONAL HIGH-SPEED RAILWAYS

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Extended Abstract

Timely clarification of the post-earthquake operational performance of bridge groups in regional high-speed railway networks is fundamental for assessing regional traffic capacity after seismic events and for planning safe and reliable train operation schemes. This paper proposes a generation method for high-speed railway bridge groups based on Gibbs sampling, which integrates prior distributions of regional geographic information (e.g., terrain-induced pier height constraints) and structural parameters (e.g., material properties, dimensions). Unlike conventional Latin Hypercube Sampling that fails to capture topographic variations, the proposed hybrid sampling method uses at least five Markov chains, each containing 8,000 samples, with the first 1,000 samples discarded to ensure convergence.

A multimodal neural network-based surrogate model, termed RHN, is developed that incorporates seismic ground motions and structural information as inputs. The RHN architecture consists of a structural encoder based on temporal convolutional networks (TCN) and two seismic motion encoders based on a Transformer with multi-head self-attention and positional encoding. Two feature fusion strategies—recurrent fusion and decision-level fusion—are employed to enhance generalization capability. Furthermore, a seismic response prediction approach for simply-supported girder bridge systems in high-speed railways is established, accounting

for epistemic uncertainty. Using a Bootstrap-based interval prediction method, the model provides prediction intervals that successfully envelope the true responses.

Taking a southwestern region of China as a case study, the post-earthquake operational performance of regional bridge groups and railway lines under ground motions of different magnitudes (from 6.0 to 7.5) is analyzed. The results indicate that the proposed structural sample generation method can reflect terrain variations across different regions, as evidenced by Pearson correlation coefficients between pier heights in flat, hilly, and mountainous terrains. Compared with conventional methods, the proposed prediction framework improves accuracy by approximately 10%–20%, with mean absolute errors ranging from 0.16 to 0.36 mm and correlation coefficients reaching 82%–88%.

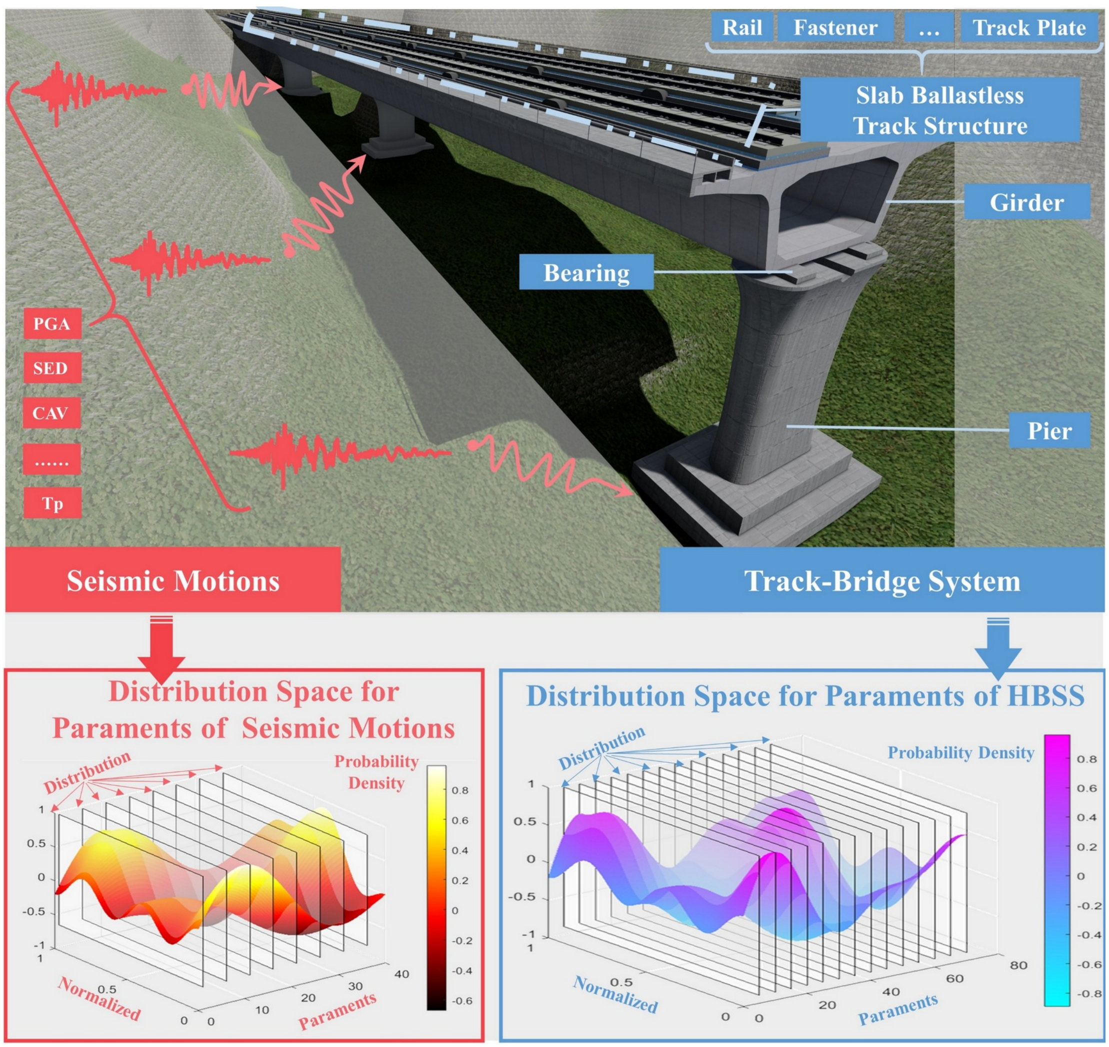

Figure 1- Regional railway lines and their parameter space schematic

What is particularly noteworthy is that seismic magnitude and epicentral distance are identified as the dominant factors influencing the post-earthquake traffic capacity of regional bridges. However, when the earthquake magnitude reaches 7 or above, topographic amplification effects become significant—bridges located in mountainous areas exhibit notably higher probabilities of performance degradation than those on flat ground at similar epicentral distances. Moreover, the choice of decision criteria (e.g., global minimax criterion versus hybrid criterion) exerts a greater influence on post-earthquake route optimization than the choice of decision objectives (e.g., minimizing travel time versus maximizing safety). The fastest path identified under the global minimax criterion arrives 30 minutes earlier than the slowest path, whereas different decision objectives yield a difference of only 10 minutes. These findings provide practical guidance for post-earthquake emergency response and traffic dispatching in regional high-speed rail networks.

Keywords: *High-speed railways simply-supported girder bridge groups; seismic response prediction; multimodal neural network; post-earthquake traffic capacity; regional geographic information.*