Failure Detection of Laminated Rubber Bearing Under Thermal Degradation Using Deep Learning Approach

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Abstract. Laminated rubber bearings (LRB) are vital components of most building and bridge structures that support against dynamic loads from various sources. However, the dynamic and non-linear behaviour of rubber deteriorated over time due to environmental heat exposure that induced oxidation inevitably. Plus, failure detection is still a challenge via manual on-site inspection. Recent advancements in technology have facilitated structural health monitoring (SHM) using sensors and deep learning (DL) techniques. Hence, this paper explores the practical application of DL in distinguishing the aged (Faulty) over unaged (Healthy) LRBs. The Faulty LRB samples were obtained through thermal aging up to 3 weeks at 100˚C, along with dumbbell specimens made of rubber part only for mechanical and thermal characterizations. A vibration platform was developed to simulate a bridge structure supported by two miniature LRB samples at its base. Four neural network models involving the standard and hybrid architectures were employed in this work. During the data collection, the vibration platform was excited by 5Hz, 10Hz and 15Hz constant sine waves to acquire different levels of loads. Results from tensile test, dynamic mechanical analysis (DMA) and thermogravimetric analysis (TGA) shown that throughout the aging, the rubber compound has significantly lost its damping capability with enhanced thermal stability. Meanwhile, neural networks analysis found the highest performance recorded by U-Net with attention gate architecture in terms of accuracy (above 80%) and training period. In conclusion, DL is a viable alternative that offers a passive sensing technique by utilizing vibration to detect thermal degradation effect on LRBs.