QUAKELOGIC
Earthquake Risk Management Solutions

With over 16 years of experience in the field we have become an expert in signal processing, instrumentation and station installations. QuakeLogic engineers will define with you the best solution and provide a quality service to ensure optimum performance of your monitoring systems.

REALTIME AND AUTONOMOUS FATIGUE ASSESSMENT IN STRUCTURAL HEALTH MONITORING

One of the innovations of QuakeLogic's SHM platform is **a real-time and autonomous fatigue assessment** and remaining fatigue life prediction for structures prone to fatigue damage and deterioration.

Certain type structures such as flagpoles, bridges, and towers are subjected to high-cycle fatigue loading daily. The inevitable increasing loading demand on these structures both in terms of magnitude and number of cycles makes them more vulnerable to fatigue cracking and failure. Fatigue-prone or fatigue-critical members, if not detected and properly treated in time, can lead to catastrophic failure, and result in loss of lives.

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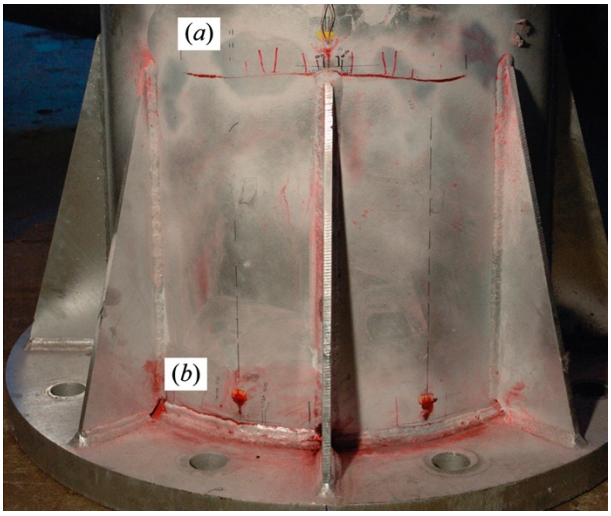

Figure on the right displays (a) fatigue damage concentration on top of the (b) stiffeners in a high-mast structure (adapted from Roy et al. 2012)

Visual inspection cannot detect hidden or microscopic fatigue damages, which grow over time with progressive consequences. If such damages are not identified at an early stage, as visual inspection may fail to do, protracted damage may lead to expensive repairs or collapse, resulting in a threat to public health and safety. Because of these reasons, fatigue assessment of structures in service is of utmost importance to assess the fatigue damage and determine the remaining service life, and subsequently, to guide the authorities to make informed and timely decisions for their maintenance and operations.

Field measurements by using sensors are essential to accurately determine the real stress range in the members and connections in question. The field measurements by QuakeLogic's on-site monitoring will provide "**peace of mind**" to owners.

QuakeLogic's advanced monitoring system **continuously evaluates** the structures for fatigue performance. The foundation of this method is based on the fact that the change of vibrating signals and their patterns reflects the status of structural properties, such as structural stiffness and strength. The application of AI algorithms on these patterns allows an accurate understanding of the status of an actual system without conducting a rigorous analytical understanding of the structure. Data analysis for early fatigue damage detection and the trained AI decide the damage locations and their severity.

QuakeLogic is the only company with a cloud-based, AI-powered technology performing autonomous structural assessments using sensor data. This platform is unmatched in long-term reliability, efficiency, and guaranteed performance.

Methodology

The SHM processing utilizes a well-known **rainflow-counting algorithm** in the analysis of fatigue data to reduce a spectrum of varying stress into an equivalent set of simple stress reversals. This process, performed in real-time and autonomously, successively extracts the smaller interruption cycles from a sequence, which models the material memory effect seen with stress-strain hysteresis cycles. This simplification allows the fatigue life of a component to be determined for each rainflow cycle using **Miner's rule to calculate the fatigue damage.**

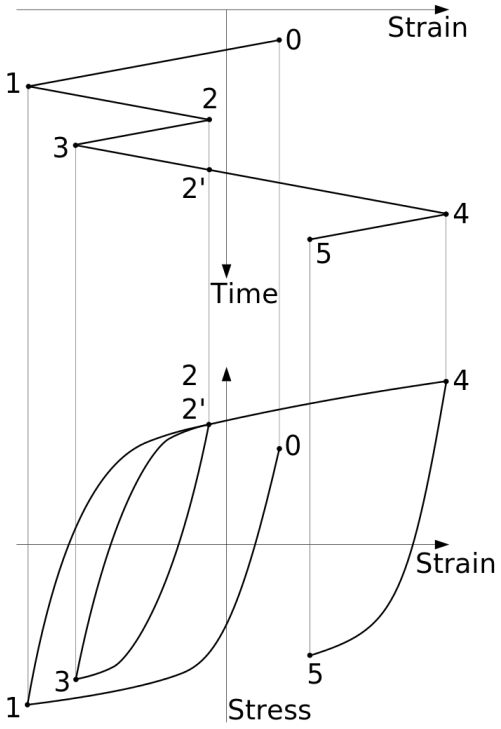

Figure on the right displays rainflow counting, which identifies the closed cycles in a stress-strain curve (adapted from Wikipedia).

The rainflow method is compatible with the cycles obtained from examination of the stress-strain hysteresis cycles. When a material is under cyclic deformation, a plot of stress against strain shows loops forming from the smaller

cycles. At the end of the smaller cycle, the material resumes the stress-strain path of the original cycle, as if the interruption had not occurred. The closed loops represent the energy dissipated by the material.

The QuakeLogic's fatigue assessment tool also provides rainflow matrix, cumulative distribution and endurance curve.