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**Development of a monitoring system based on acoustic emissions
for micro-crack prediction in steel structures subjected to
fatigue loads (AKUSTAHL)
IGF-Nr.: 23120 N**

Summary of the research project AiF No.: 23120 N

Many bridges in Germany's long-distance highway network show signs of damage and need rehabilitation or must be replaced. However, there is a lack of simple, innovative, and cost-effective monitoring systems that can be used to collect the necessary data on existing structures that need repair for assessing damage that has occurred and losses in load-bearing capacity or fatigue resistance. The goal of the AKUSTAHL project was to develop such a monitoring system based on acoustic emission (AE) analysis. When cracks form in a structural component due to external loads, energy is released in the form of high-frequency transient waves. These can be detected using piezoelectric sensors. This enables the detection of crack formation and progression within bridge structures. However, acoustic emissions are also generated by a wide variety of other sources. To specifically detect crack growth, the signals from cracks must therefore be clearly distinguished from those of other sources of interference. To achieve this, various experiments were conducted over the course of the project. In quasi-static calibration tests, cracks were in-

duced in flat-tensile and CT specimens. The crack growth was recorded using a microscope. All measurements were accompanied by AE measurements. The results showed that, especially at the beginning of the tests, many AE signals had already appeared in the specimen before the first cracks formed. Later in the tests, however, when crack growth was clearly visible, hardly any measurable signals occurred. From this, it can be inferred that the technology appears to be more suitable for detecting damage processes in the material that can be viewed as precursors to crack initiation. In the second test phase, high-cycle fatigue tests were conducted on flat-tensile specimens. Despite comparable test conditions, the tests showed very different results. While in some tests the AE signals correlated with the specific formation of the crack in the specimen, in other tests many signals appeared right from the start that could not be attributed to crack formation. At the time of crack formation determined by strain gauges, hardly any signals were detected here. As a result, no clear conclusions could be drawn from the fatigue tests. In addition to the intended tests, tests were

conducted on pre-cracked specimens under various load levels. Although crack propagation in the centimetre range occurred during these tests, virtually no AE signals were detected. It therefore appears that even under laboratory conditions, it is not possible to reliably detect crack propagation using AE signals. This demonstrates that applying the technology to bridges in service poses significant challenges. Consequently, a monitoring system could not be developed as part of this project. However, the calibration tests show that the technology does indeed have the potential to detect damage mechanisms in steel

that occur prior to actual crack formation. These include the formation of dislocations and slip bands, as well as the development of intrusions and extrusions. Thus, the technology provides the basis for very early detection of potential damage in the material. However, this requires methods to distinguish between different damage mechanisms in the AE signal and ultimately to assess at what point the material is no longer structurally sound and action is required. Since the project focused on the detection of microcracks, this aspect was not addressed in the project.



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