CASE STUDY

Maintaining a safe connection – Nordland project drives progress in structural assessment

Nordland FYLKESKOMMUNE

Nordland County Municipality (Nordland fylkeskommune) serves as the governing body for Nordland county in Norway and oversees various regional affairs. Within Nordland county, a road bridge known as the Herøysund Bridge, constructed in 1966, connects the primary islands of Sør and Nord Herøy. In January, 2023, the construction of a replacement bridge commenced, and it is due to be completed and open for public use in the autumn of 2025.

CHALLENGE

With cracks appearing in the concrete of the ageing Herøysund bridge, Nordland County Municipality faced the task of keeping the bridge safe while the new bridge is being built.

SOLUTION

An HBK strain strain gauge solution for continuous monitoring of strain and crack extension in the structure and the long-term behaviour of the bridge.

RESULT

By monitoring the structure, one can make informed decisions about necessary repairs or replacements to maintain the bridge's structural integrity while also reassuring the public that the bridge is safe for use. The knowledge and lessons learnt from this project will play a pivotal role in enhancing bridge safety standards and ensuring the longevity and reliability of future bridge constructions.

A BRIDGE IN TROUBLE

The Herøysund bridge, opened in 1966, is an essential part of Nordland's county road 828, connecting the islands of Sør-Herøy and Nord-Herøy. However, the presence of cracks in the concrete gives warning signs, indicating that that the bridge is facing substantial challenges. While plans are well underway to construct a new bridge, this process will take several years. In the meantime, the local population heavily depends on the bridge as it serves as a vital transportation link. With boat travel being the only alternative, any decision to close the bridge would undoubtedly face significant opposition and disapproval from the local community. Therefore, given the circumstances, immediate measures were necessary to guarantee the safety and functionality of the bridge.

Strain gauge with temperature compensation (the Seven Sisters mountain range can be seen in the background)

Nordland County Municipality, in collaboration with partners Norwegian Public Roads Administration (Statens Vegvesen), the Norwegian University of Science and Technology (NTNU), SINTEF Narvik and The Arctic University of Norway (UiT) initiated a project aimed at strengthening and extending the operational life of the bridge. Per Ove Ravatsås, Master of Science and advisor at Nordland County Municipality, was given the crucial role of overseeing the entire project including arranging and supervising the monitoring of the cracks that had appeared in the concrete structure of the bridge.

TEST PILOT TO PREVENT BRIDGE DISASTERS

The project had two main objectives: firstly, to gather as much information as possible and assess the current condition of the bridge, and secondly, to conduct structural health monitoring to ensure ongoing safety and stability.

However, during discussions, it soon became evident that the Herøysund Bridge presented an ideal opportunity for research purposes. In light of recent bridge collapses both in Norway and worldwide, it is essential that methods of predicting and preventing such disasters are explored. "Herøysund Bridge was selected partly because, like many other bridges, it is constructed of concrete and we had already identified some issues that were worth following," says Per Ove Ravatsås. "Additionally, the bridge carries substantial heavy traffic, and monitoring systems are already in place, providing us with valuable initial data to get our research up and running quickly."

The research is spearheaded by Daniel Cantero, an Associate Professor at NTNU, along with a dedicated team of his students.The main focus areas of their research include:

1. The exploration of strain signals to evaluate the condition of the bridge. By analyzing changes in these signals, the researchers aim to assess and quantify potential structural damage. The signals are directly processed to identify any indications of change that align with possible structural damage.
2. Conducting capacity evaluations of the bridge. This entails assessing the structure in its current state as well as its anticipated future condition. The signals used for calibration of the model are employed to perform these evaluations.

In the search for an optimal strain sensor solution that would effectively monitor crack extension and provide valuable insights into the bridge's long-term performance, Daniel Cantero reached out to HBK for guidance on instrumentation and assistance with the installation process.

HBK's Director of Engineering Services SHM (Structural Health Monitoring), Arnt-Henning Andersson explains, "We were contacted due to our expertise in strain measurement, particularly on carbon fiber and composites. Given the substantial damages observed in the concrete of the Herøysund bridge and ongoing discussions about reinforcing it with carbon fibers, HBK was approached for their input. The main challenge was to propose a precise and stable long-term monitoring system to assess the structural integrity of the bridge. Our proposed solution involved electrical strain gauges mounted onto the carbon fiber, customised crack monitoring sensors developed in-house, and a data acquisition system that could be operated remotely. The installation process required experienced engineers who 'live and breathe' strain gauges every day. Our team was ideal for the task."

PREP WORK

With the system chosen, the project team embarked on their work. To enhance the structural integrity of the bridge, sheets of carbon fiber were securely adhered beneath it. Along the main span of the bridge, thirteen HBK strain gauges and a PT100 temperature measurement sensor were installed. In addition to the strain gauges and temperature sensor, two custom-designed Ohm-shaped 'Omega' sensors were also installed. Manufactured by HBK in France and calibrated at its facility in Paris, these

sensors were specifically designed to monitor changes in crack width, a crucial parameter for assessing structural health. To facilitate data acquisition and storage, a custom-made cabinet was positioned at the base of the bridge, housing a QuantumX amplifier, an industrial PC, catman software, and other measurement equipment. This setup ensured accurate measurement and reliable storage of the collected data.

With these installations in place, the Engineering Services team from HBK was ready to commence their monitoring and data analysis efforts, enabling them to assess the bridge's performance and detect any signs of structural deterioration or crack propagation.

Custom-designed 'Omega' sensor

The signals generated by vehicles crossing the bridge were analyzed to detect potential bridge damage. Additionally, a calibration process using a truck with known axle weights was employed to weigh other vehicles, leading to the implementation of a Bridge Weigh-in-Motion (B-WIM) system. This calibrated system will enable the development of traffic load models specific to the site.

Once installed, the project was able to gather substantial data on the bridge's condition and effectively monitor its structural health. The collaboration between Nordland County Municipality, NTNU, and HBK ensured a robust approach, combining expertise in monitoring technologies and academic research. This collaborative effort has the potential to prevent future accidents and significantly extend the lifespan of existing bridges by up to 40 years.

GLOBAL IMPACT

Per Ove Ravatsås explains, "This project is an excellent opportunity to try and improve current engineering practices in the assessment of existing structures, in this case the old Herøysund bridge, by implementing the latest scientific advancements. The evaluation of this bridge has the potential to yield valuable insights and a deeper understanding of the structure's condition, deterioration mechanisms, and overall safety. As a result, this knowledge will not only contribute to the refinement and improvement of structural assessment procedures, but also lead to more effective and accurate evaluations of similar structures in the future."

Per Ove Ravatsås, Master of Science and advisor at Nordland County Municipality

Monika Sande, representing the County Council for Transport and Infrastructure in Nordland County, shares the belief that by measuring bridge movements and monitoring deformations and shifts, early warning signals can be generated before a bridge is at risk of collapsing. Sande emphasizes the significant impact of this project, stating, "Every aspect of this project can have far-reaching effects. We have the potential to protect the environment, save costs, and prevent risks to life and health. If the research collaboration progresses as we envision, we can address virtually imperceptible defects in our bridges long before they escalate to a point where complete reconstruction is required."

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HBK – Hottinger Brüel & Kjær
www.hbkworld.com
info@hbkworld.com