Infravation SEACON and SHAPE project collaboration

The ERA-NET Plus Infravation (Framework 7) programme is jointly funded by EU and US road authorities. It aims to address challenges in road infrastructure construction and maintenance and deliver Technology Readiness Level (TRL) 5-7 solutions, systems deployed in operational environments. Two of the nine Infravation projects are SEACON (University of Miami, US) and SHAPE (University of Bologna, Italy and University of the West of England, UK).

The SEACON project has developed sustainable solutions for concrete construction using seawater and Fiber Reinforced Polymers (FRP) instead of steel reinforcement. Through the SEACON project a pedestrian bridge (Innovation Bridge) was built at the University of Miami campus, Florida in 2016 and a highway bridge is currently under construction (Halls River Bridge) in Homosassa, Florida.

The SHAPE project has developed an NDT monitoring system for identifying the condition of bridges through dynamic characterization. With the use of highly sensitive accelerometer technology the frequency characteristics of bridges or structures is measure based on pure background vibration. Changes frequency modes over time can be identified automatically (e.g. in the due to deterioration, bridge strike, earthquake, hurricane, etc.) and alarm sent to the bridge owner/manager.

Collaboration has been initiated between the SEACON and SHAPE projects to

- identify the frequency response of bridges
- identify the effect of live loading and temperature changes
- provide reference data for future monitoring
- deploy the SHAPE system to new environments/structures
- test the SHAPE system by independent users.

Monitoring by the SHAPE system is planned to be carried out for both the Innovation and Halls River bridges. The Innovation bridge at the University of Miami was instrumented using vibrating wire gauges on the CFRP (Carbon Fiber Reinforced Polymer) tendons and BFRP (Basalt Fiber Reinforced Polymer) rein-forcement and deflection is monitored periodically using theodolites. In March 2018, ca. 2 years after it's opening, the bridge was monitored using the SHAPE accelerometer system. A commercially available SENSR CX1 accelerometer, an Intel NUC mini-computer (Figure 1) and custom-made data processing software were used. Acceleration was recorded in the X (transverse), Y (longitudinal) and Z (vertical) directions (2000 times a second) together with tilt and temperature. Mains power (110V) was made available from the adjoining building site. The CX1 accelerometer was placed ca. 1m from mid-span next to the south parapet (Figure 2).

Figure 1 CX1 accelerometer, NUC computer

Figure 2 SHAPE monitoring setup

Data collection was first carried out for a period of eight minutes to identify differences in the frequency response with and without pedestrian traffic. Figure 3 shows examples of the frequency patterns in the X, Y and Z directions up to 1000Hz with and without traffic. Frequencies were the same for both cases but amplitudes were significantly different in the vertical (Z) direction.

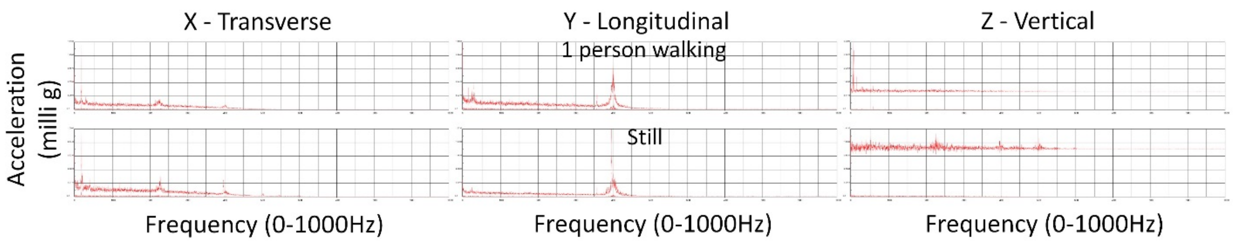

Figure 3 Frequency pattern 0-1000Hz with and without pedestrian traffic

Subsequently monitoring was carried out for a 24 hour period to characterize the frequency response of the bridge during the day and night with and without live loading and the impact of the adjoining building site and serve as reference data. Monitoring is planned to be repeated periodically in future and compared with the reference readings. If no change in the frequency characteristics is observed no change in the structural behavior would have taken place.

Once the Halls River Bridge is completed (Figure 4) a similar reference monitoring session will be carried out to with and without traffic loading and for a 24 hour period. The bridge is planned to be instrumented by a permanent SHAPE system to allow continuous monitoring. Data will be processed on the Intel NUC computer and output data uploaded to the cloud every 8 seconds. An alarm function can be set up to identify changes in frequency and warn of changes in the structure. Within 8 seconds the system will be able to

- alert of changes to the structure exceeding tolerance levels (e.g. due to deterioration, scour)
- alert of bridge strikes, hurricanes, natural disasters, etc.
- identify changes in the structural behavior of the bridge following bridge strikes, hurricanes, natural disasters, etc.

It is anticipated that once construction has been completed and the bridge has settled, no change will be observed in the frequency regime due to deterioration in the medium/long-term.

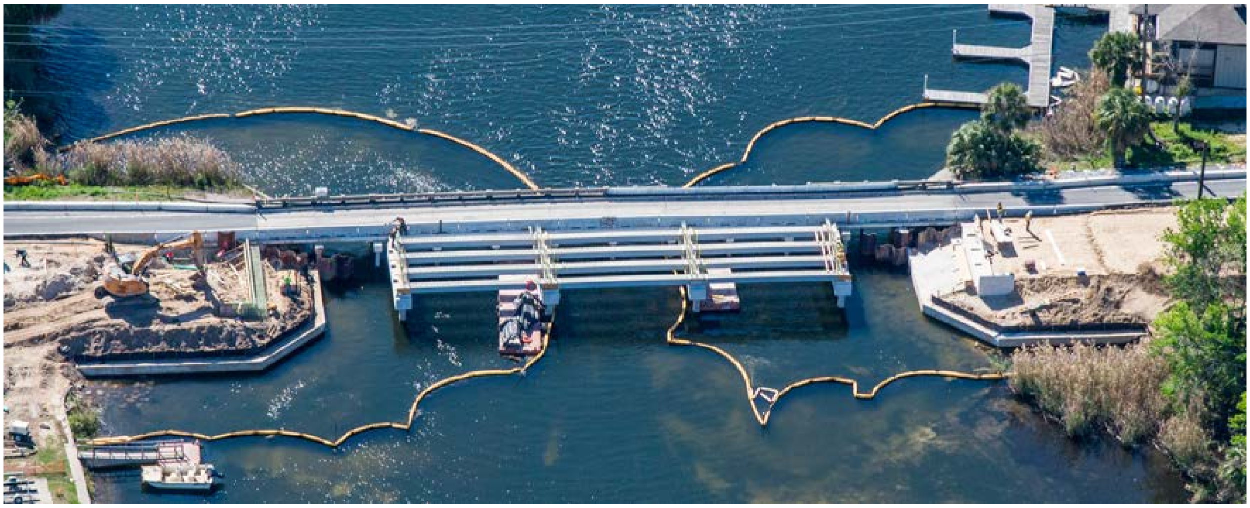

Figure 4 Halls River Bridge

Collaboration between the SEACON and SHAPE projects has been very positive and highly beneficial for both projects to date. Ongoing collaboration is planned for the long-term with the aim to deploy and test project outcomes in operational environments (at TRL 8).

Project partners wish to acknowledge the exceptionally positive support of all highway authorities sponsoring the Infravation scheme and the project management team, without whom the project developments could not have taken place.