Strain-Based Dynamic Identification and Numerical Model Comparison of the Steinavötn Bridge

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Research Question

Can dynamic strain measurements identify the modal properties of the Steinavötn Bridge, and how do the identified natural frequencies compare with numerical models?

Background

The Steinavötn Bridge was a 102 m-long, single-lane, six-span reinforced-concrete bridge as shown in Figure 1. Following flood damage in 2017, full-scale testing was conducted on the bridge prior to its demolition.



Figure 1: Steinavötn Bridge before demolition.

Study Data

Sixteen long-gauge strain sensors recorded dynamic strain data on 4 July 2019, as shown in Figure 2. The bridge was excited through five different vehicle-excitation events.

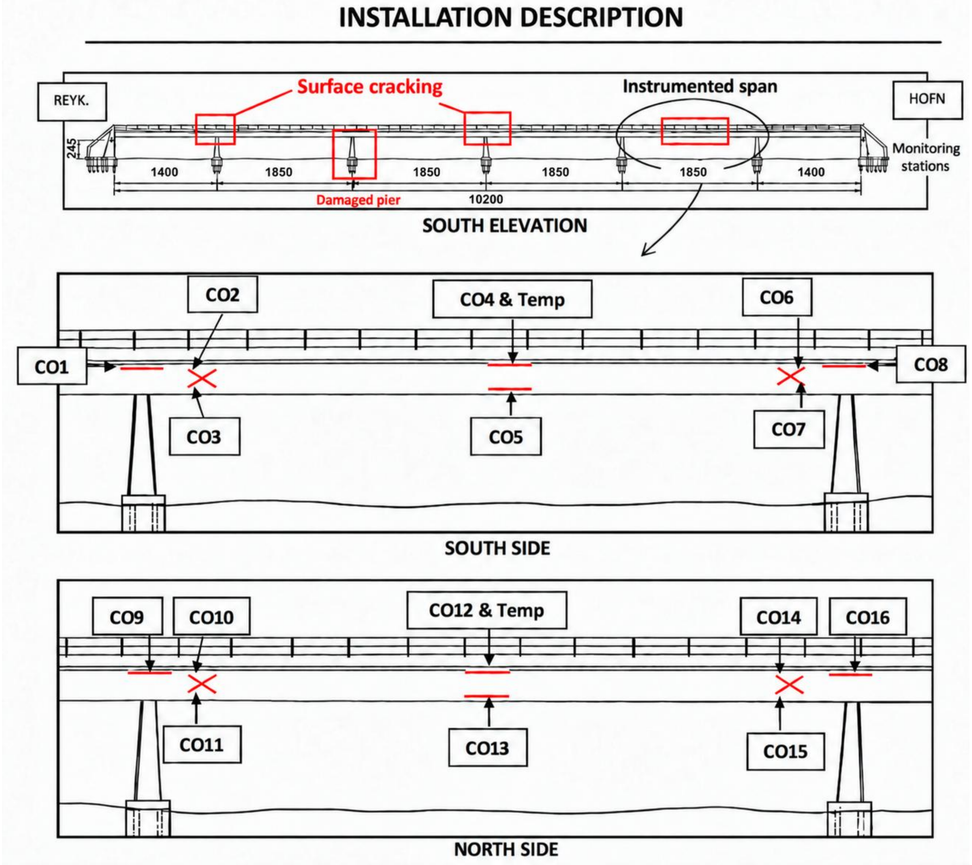


Figure 2: Optical strain sensors on the monitored span.

Numerical Models

Numerical models of the Steinavötn Bridge were developed in SAP2000 using beam elements and in OpenSees using fibre-section beam-column elements as shown in Figure 3 and Figure 4 respectively.

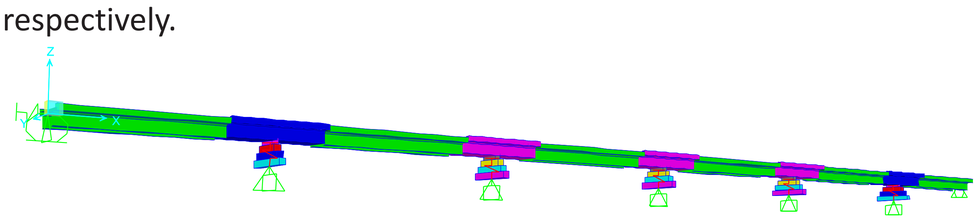


Figure 3: Extruded view of the Steinavötn bridge using SAP2000.

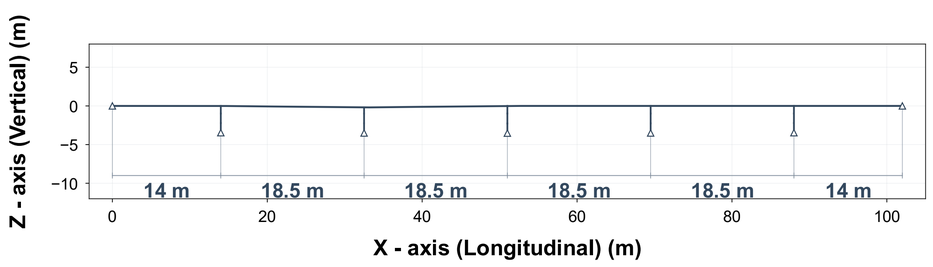


Figure 4: 2D view of Steinavötn bridge using OpenSees.

Analysis Workflow

Pre-processing

Signals were baseline-corrected and filtered for quality review. Responsive sensors and suitable analysis windows were selected.

Modal Identification

Operational Modal Analysis (OMA) was used to identify natural frequencies, damping ratios, and strain mode shapes from dynamic strain data.

Validation and Comparison

Results were checked for consistency across sensors and analysis methods. The identified natural frequencies were then compared with predictions from numerical models.

Results and Discussion

Natural Frequency

AFDD and SSI-COV methods each identified natural frequencies of seven vibration modes. The identified natural frequencies showed generally good agreement with numerical predictions, although agreement varied across modes as shown in Figure 5.

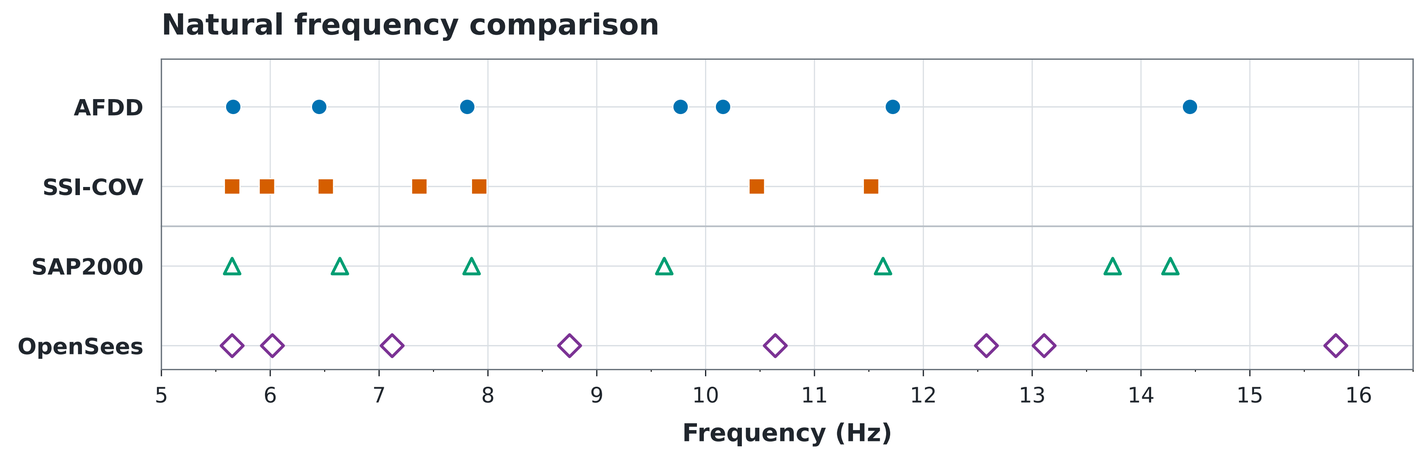


Figure 5: Comparison of natural frequencies from AFDD/SSI-COV with numerical models.

Damping

Damping ratios were estimated using EFDD, time-decay slope, and SSI-COV methods. A comparison of the results is presented in Figure 6.

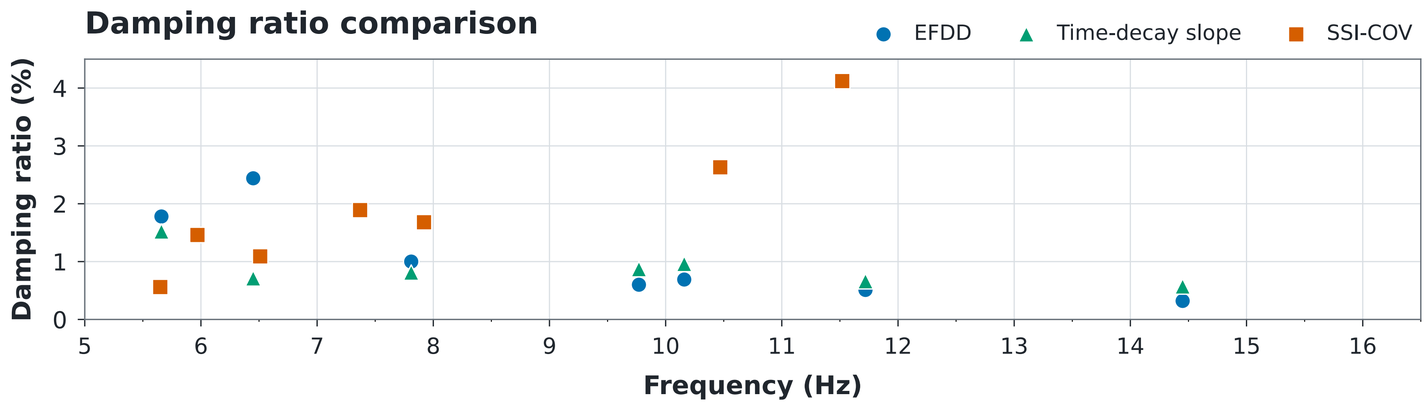


Figure 6: Comparison of damping from EFDD/Time-decay slope and SSI-COV.

Strain Mode Shape

The strain mode patterns identified from the dynamic strain data were predominantly interpreted as vertical bending, with a possible torsional mode, as shown in Figure 7.

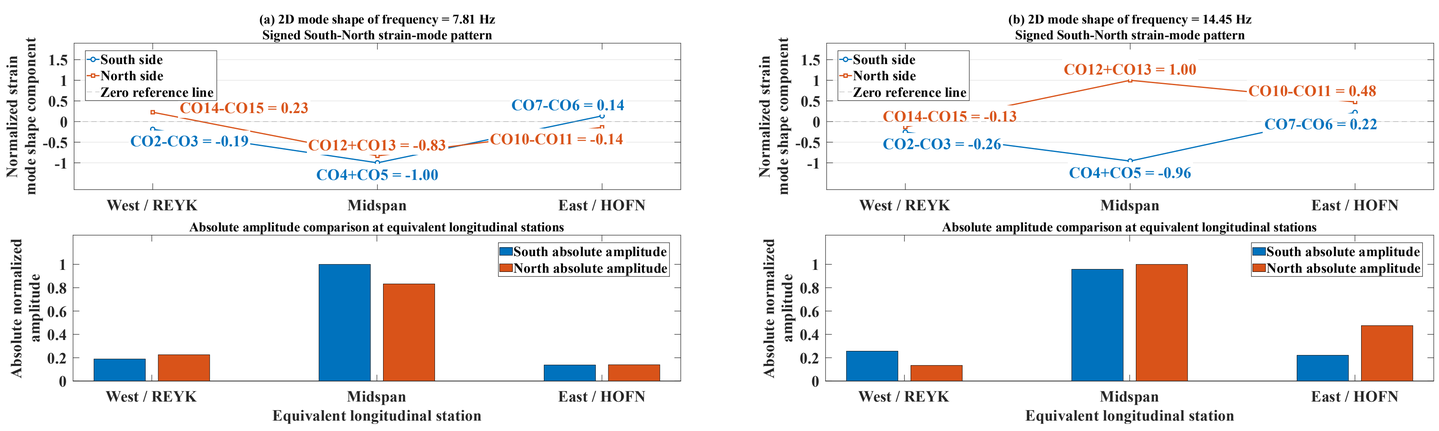


Figure 7: Identified strain mode shapes at (a) 7.81 Hz and (b) 14.45 Hz.

Conclusion

Dynamic strain data identified modal properties in the monitored span. Comparison with numerical models showed encouraging agreement, although differences remained. Further study is needed to improve damping estimates and clarify mode interpretation.

Acknowledgement

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