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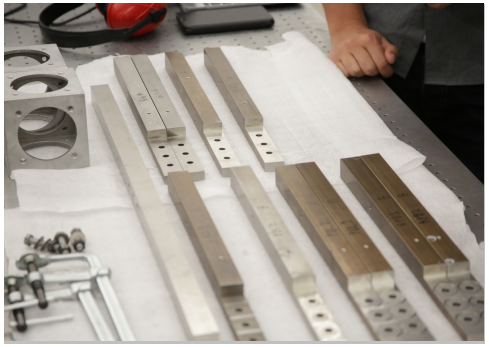

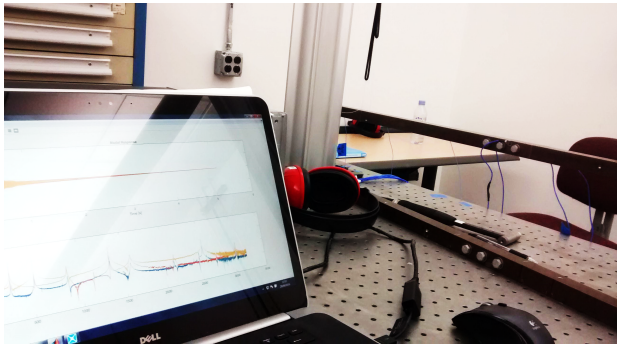

Effect of far-field structure on joint properties

S.B. Cooper, M. Rosatello, A.T. Mathis, K. Johnson, M.R.W Brake,
M.S. Allen, A.A. Ferri, D.R. Roettgen, B.R. Pacini, R.L. Mayes

U.S. DEPARTMENT OF ENERGY

NNSA National Nuclear Security Administration

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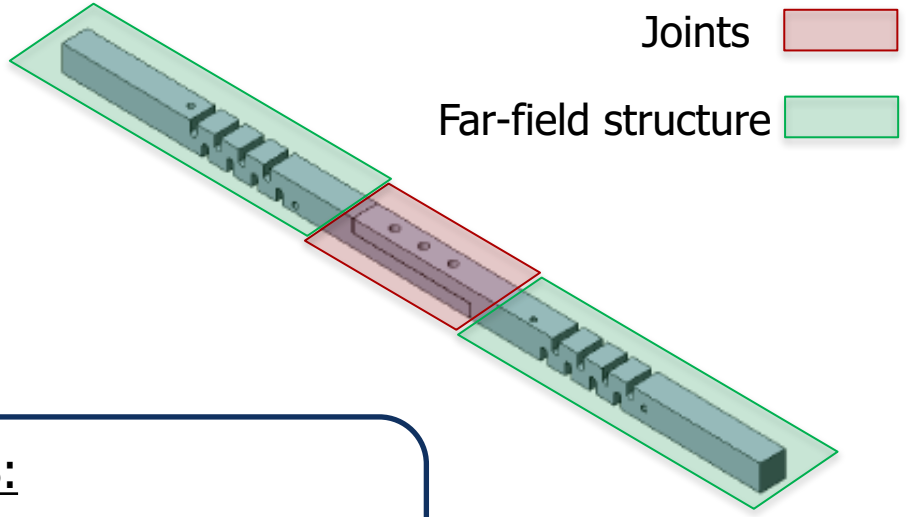
Outline

- Introduction
- Methods
- Experimental Study
- Numerical Investigation
- Conclusions

Introduction

- **Goal of the project:**
  - Assess the role of the far-field structure on measurements of joints properties

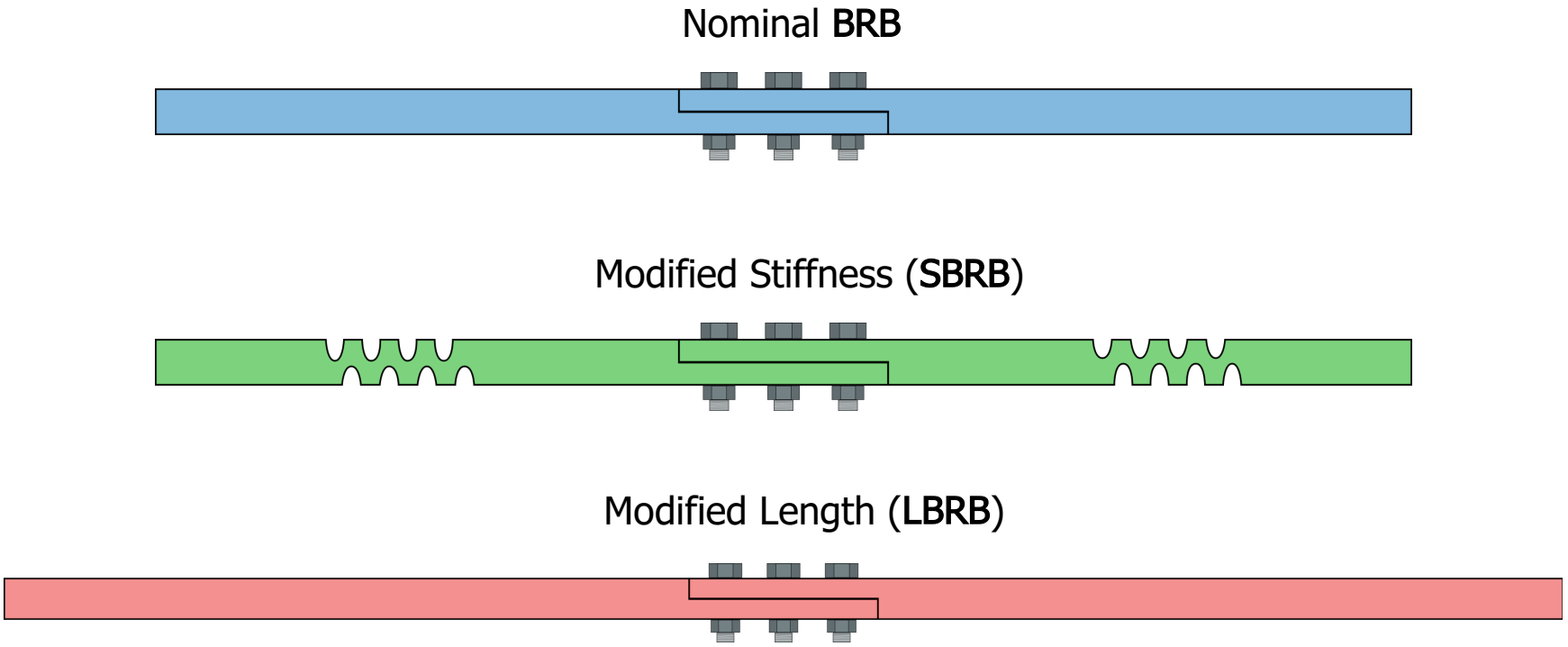


HYPOTHESIS:

A change in the far-field structure modifies the way in which the interface is loaded.

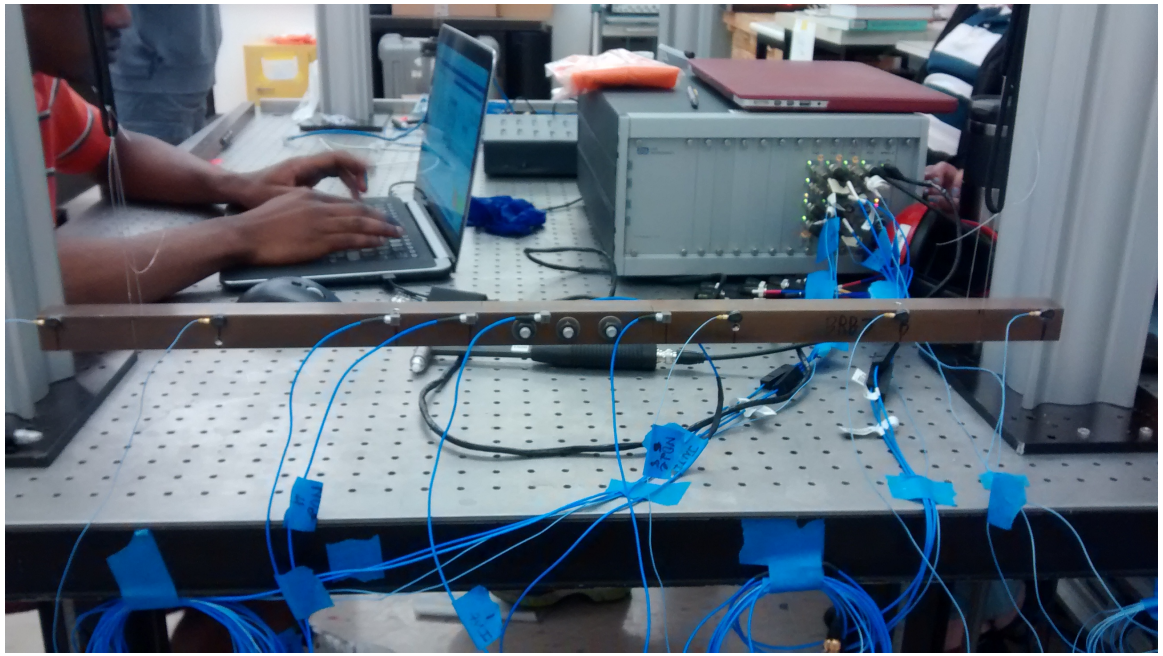
Introduction

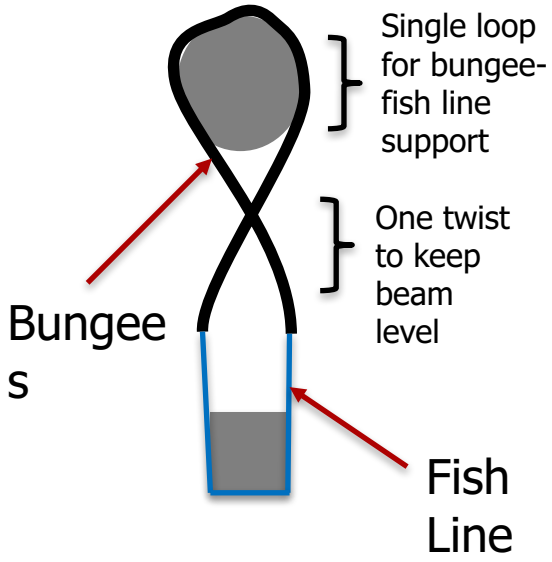
- Introduce structural modifications to the far-field structure of a nominal Brake-Reuss Beam (BRB)

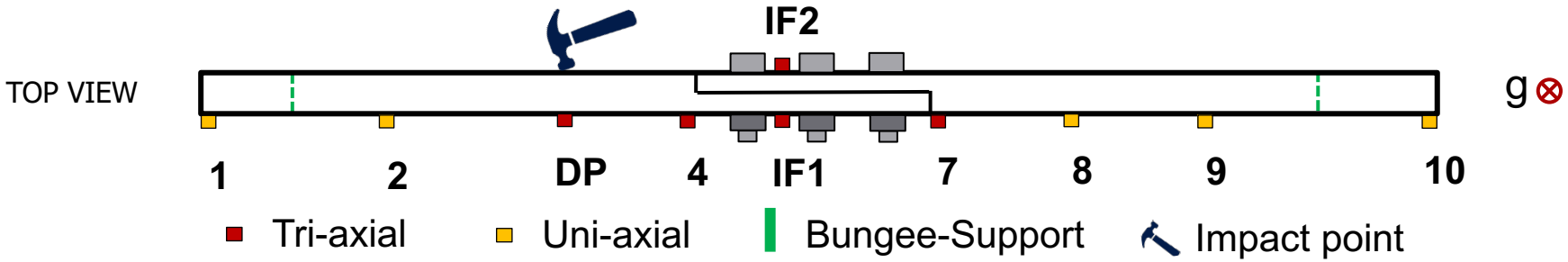


Experimental Study

- Free-Free Conditions
- Bolts tightening torque fixed at 20Nm







Experimental Study

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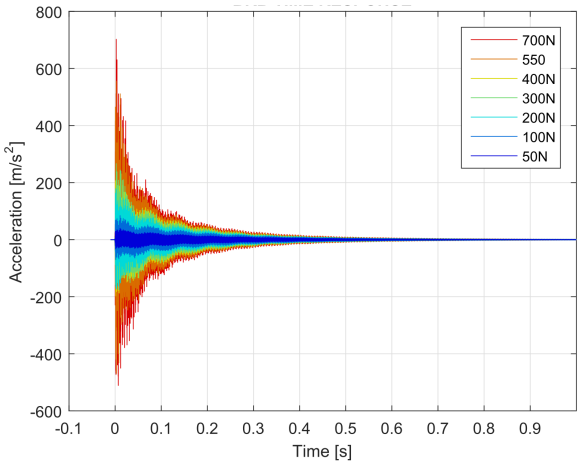
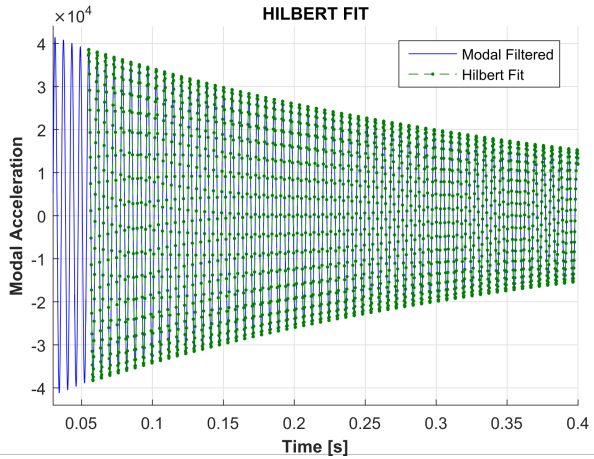
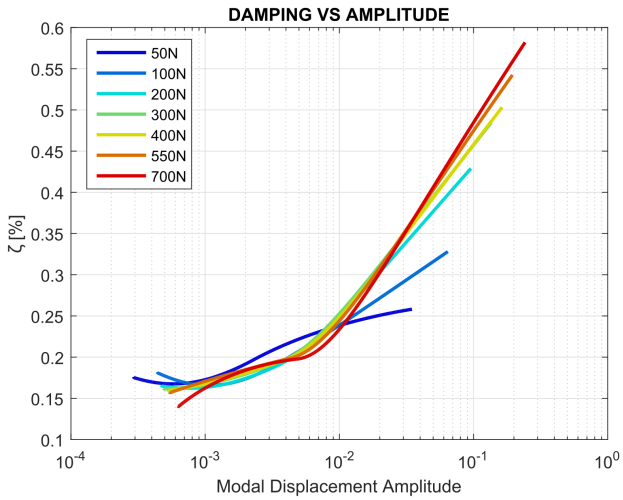
Impact Testing



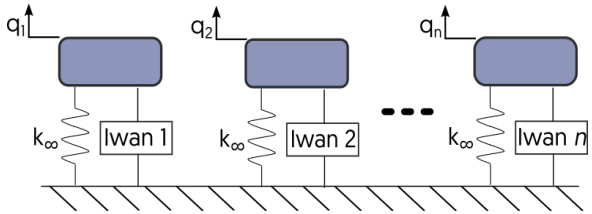
Modal Filtering and Hilbert Transform



Damping & Frequency VS Amplitude

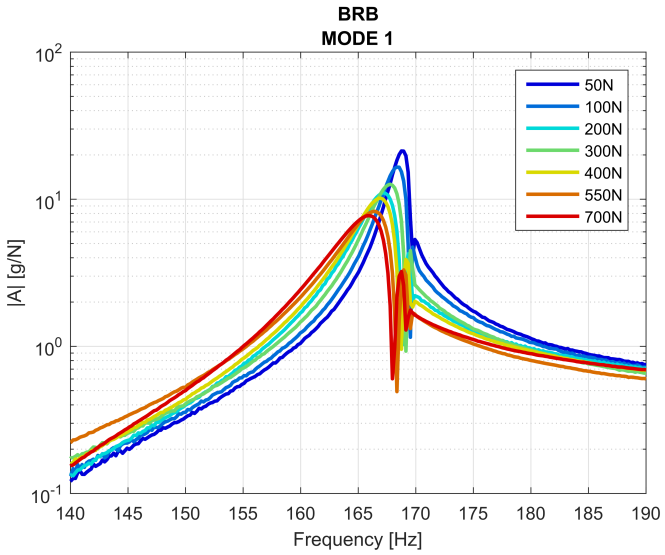


Modal Iwan Model

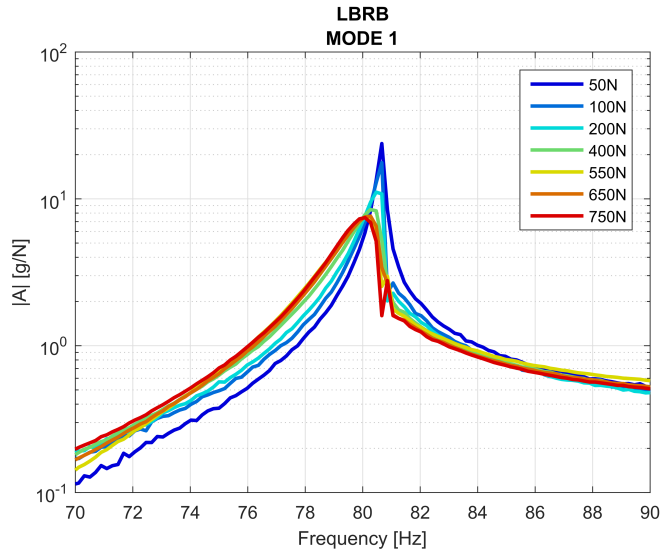


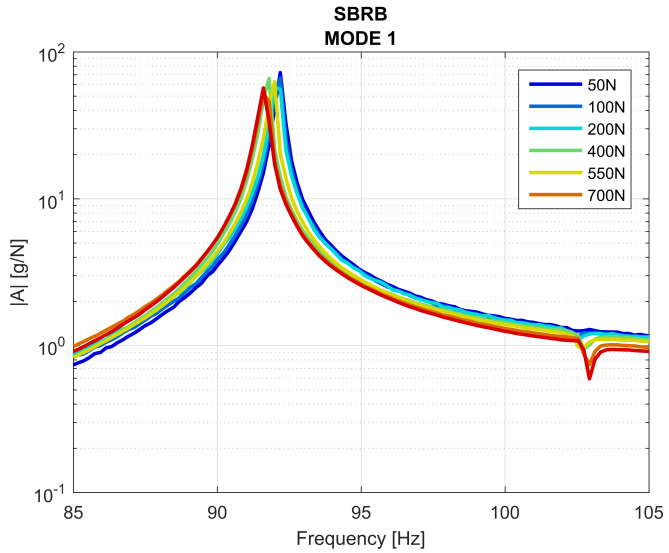
Experimental Study

- FRFs at different impact forcing levels for Mode 1



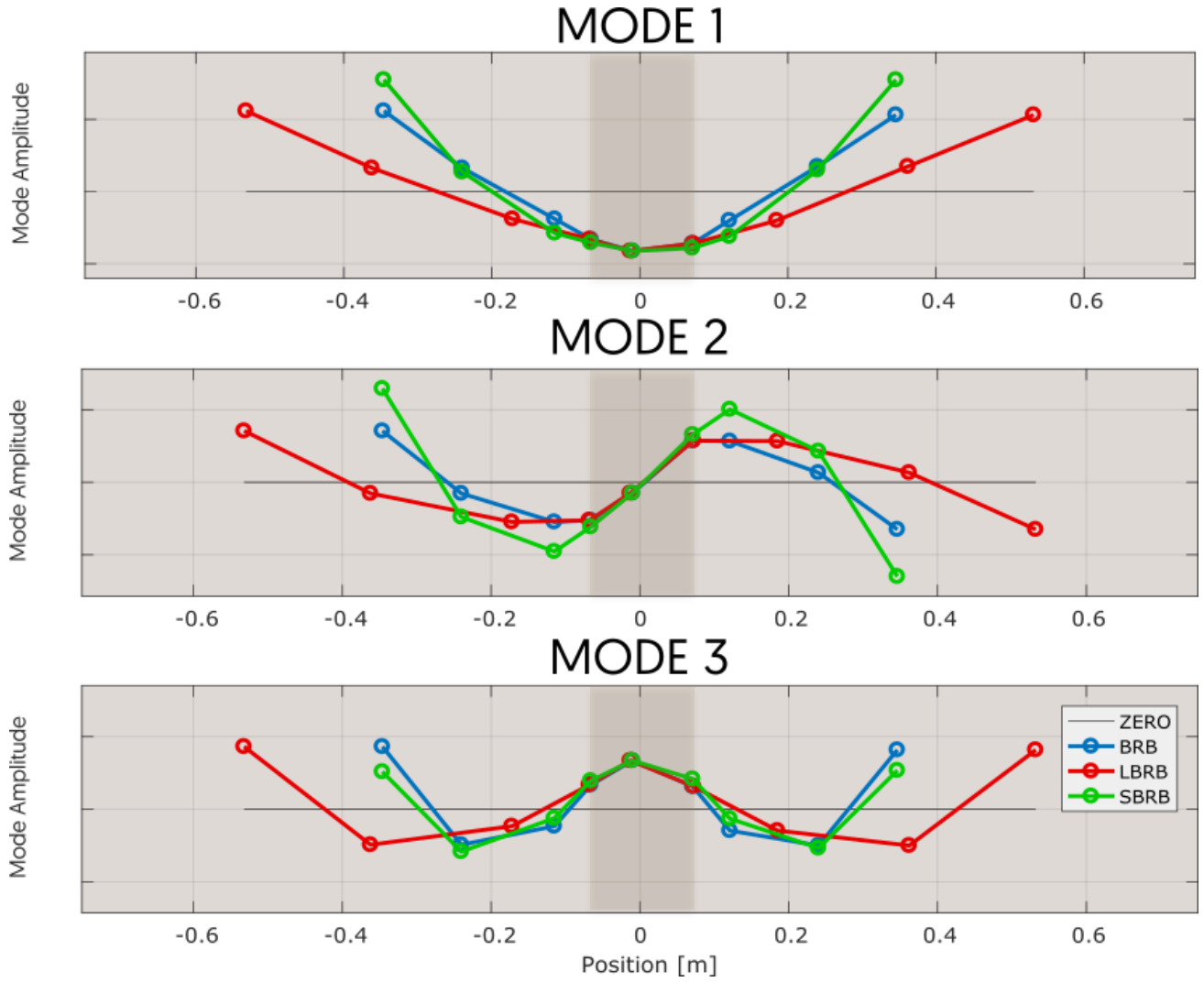
	Mode 1	Mode 2	Mode 3
BRB	169,4 Hz	585,7 Hz	1186,1 Hz
LBRB	80,7 Hz	291,7Hz	521,5 Hz
SBRB	91,5 Hz	194,3 Hz	496,1 Hz





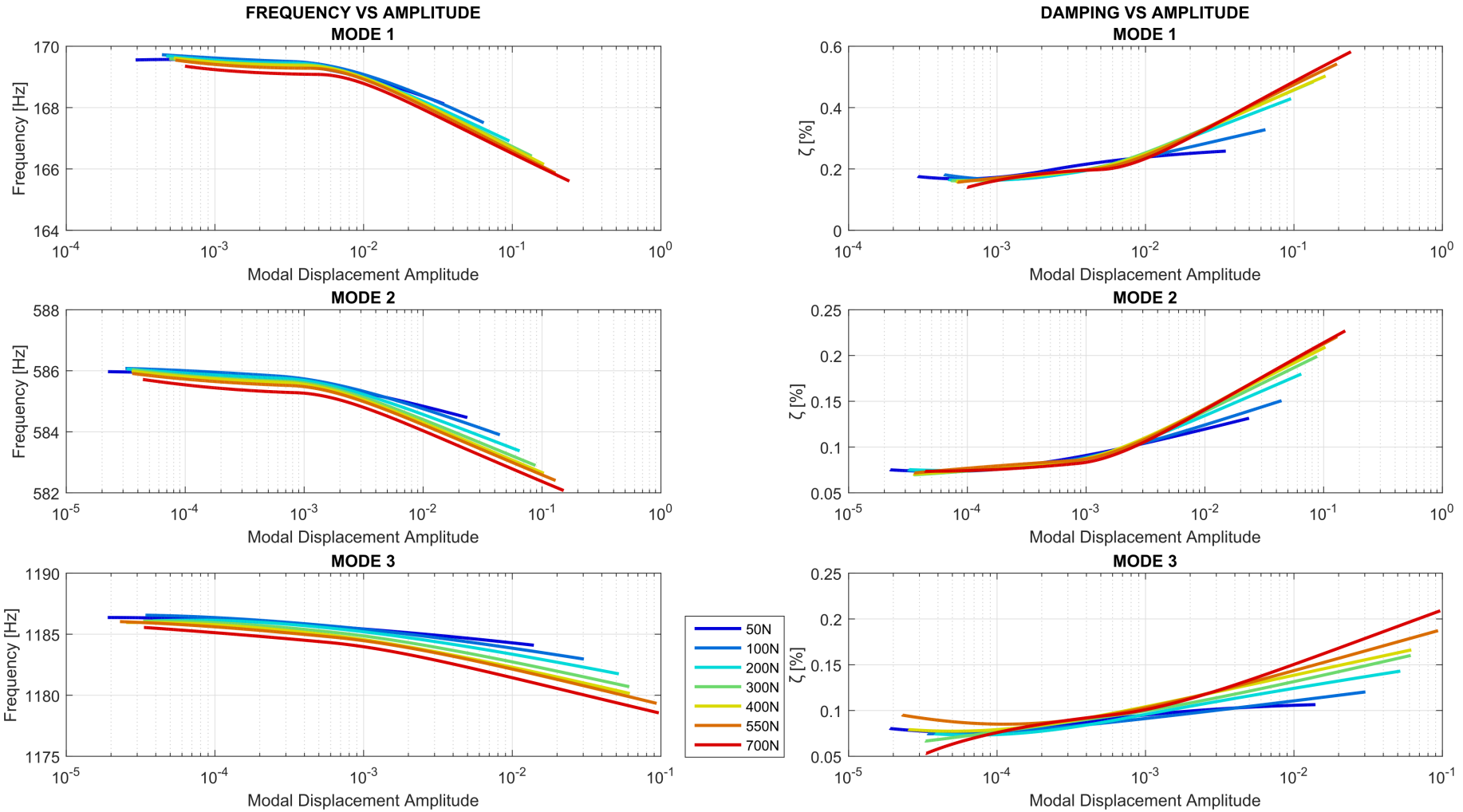
Experimental Study

- Mode shapes



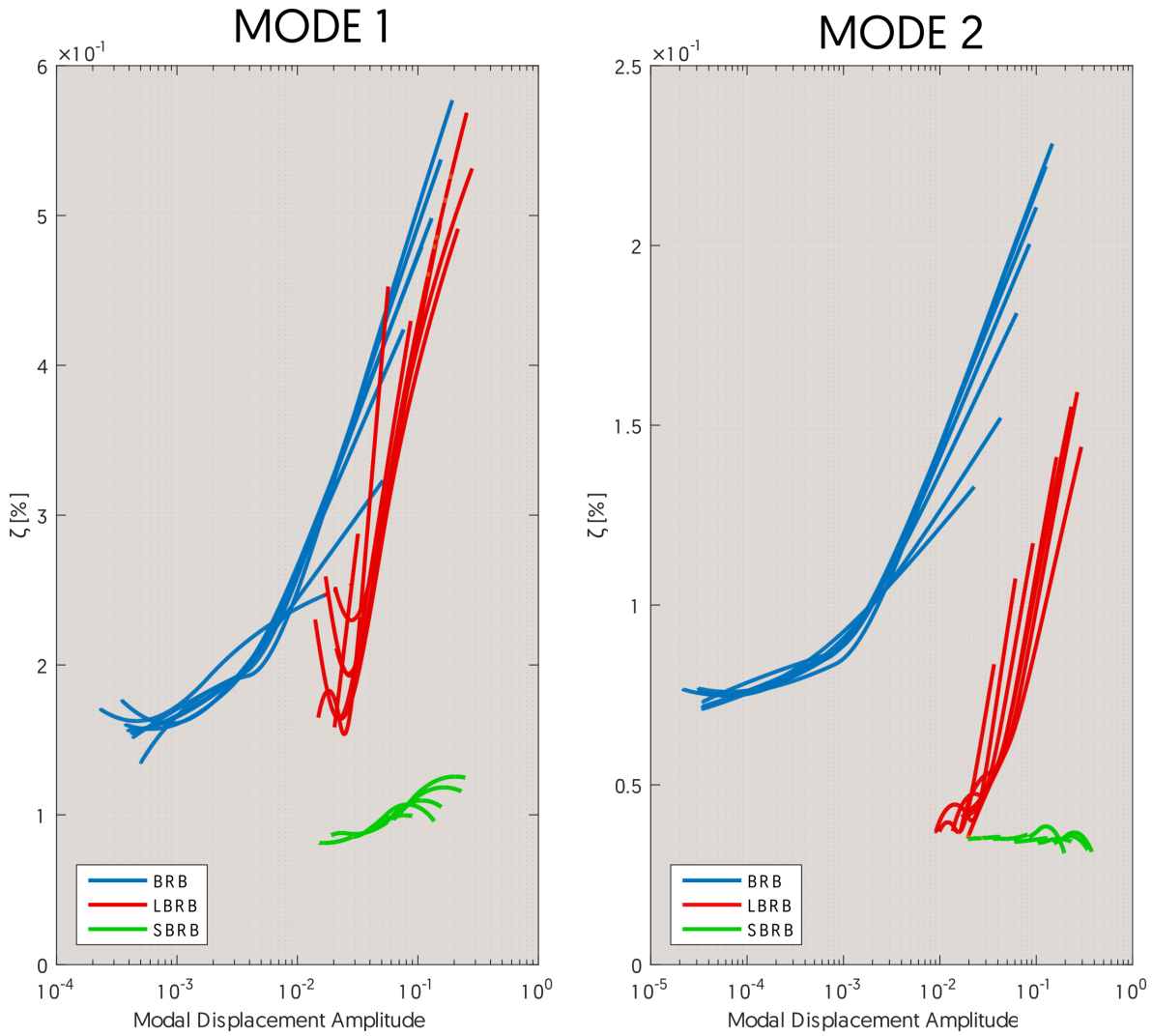
Experimental Study

- BRB Frequency and Damping VS Amplitude



Experimental Study

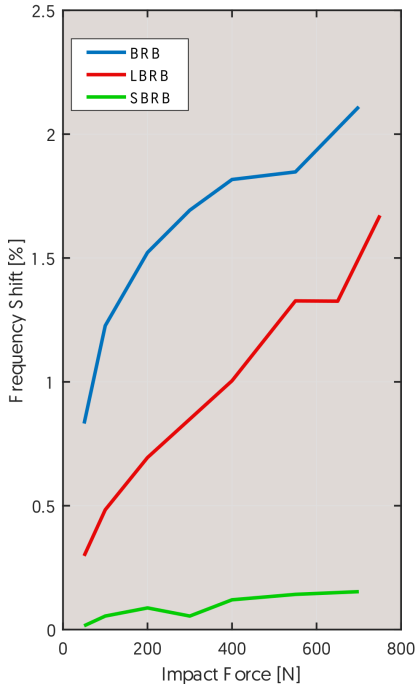
- BRB+LBRB+SBRB - Damping VS Amplitude

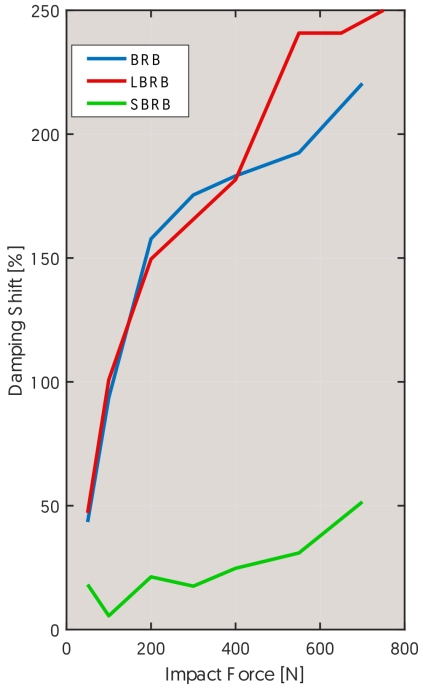


Experimental Study

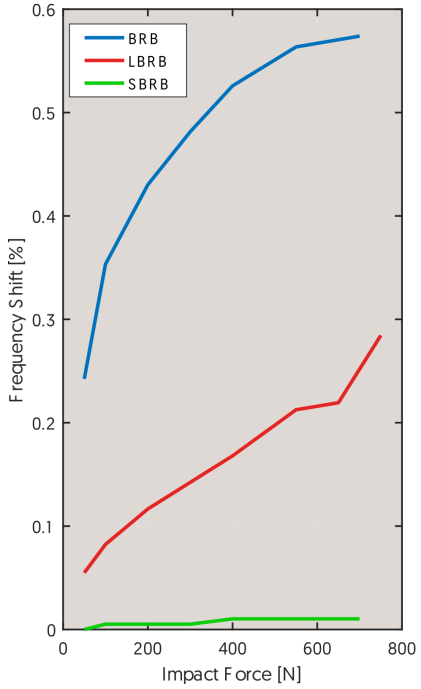
- Frequency and Damping shifts compared between beams

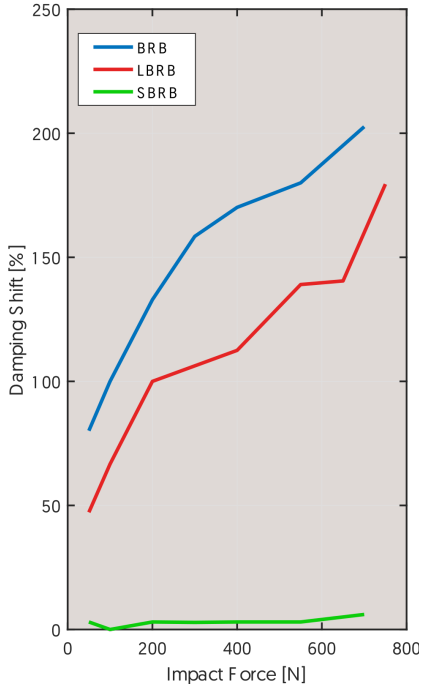
MODE 1





MODE 2



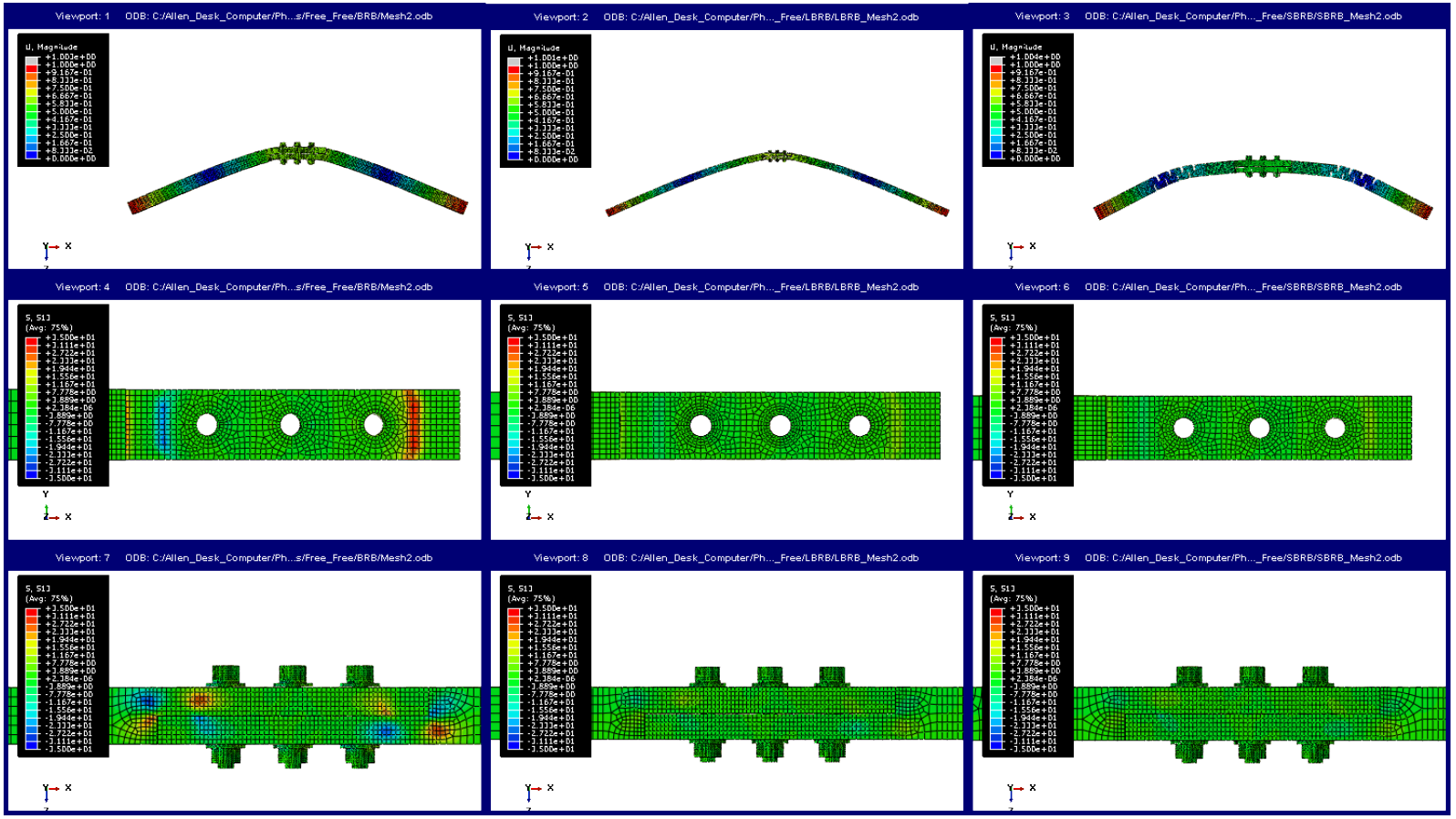


- The shift in damping between BRB and LBRB is comparable
- SBRB doesn't show a nonlinear behavior.

Numerical Modeling

- FEM - Modal Analysis in ABAQUS

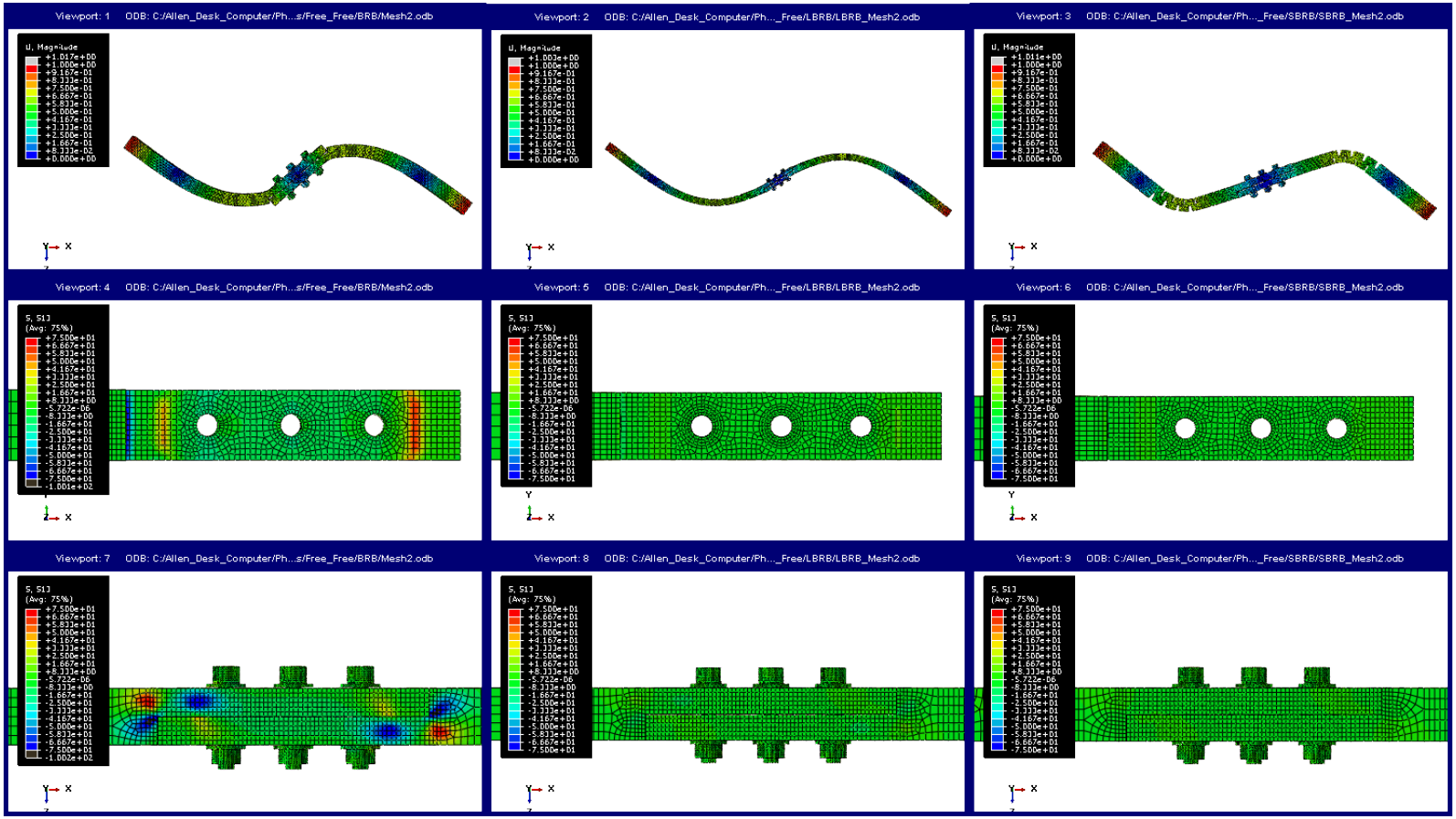
1st MODE



Numerical Modeling

- FEM - Modal Analysis in ABAQUS

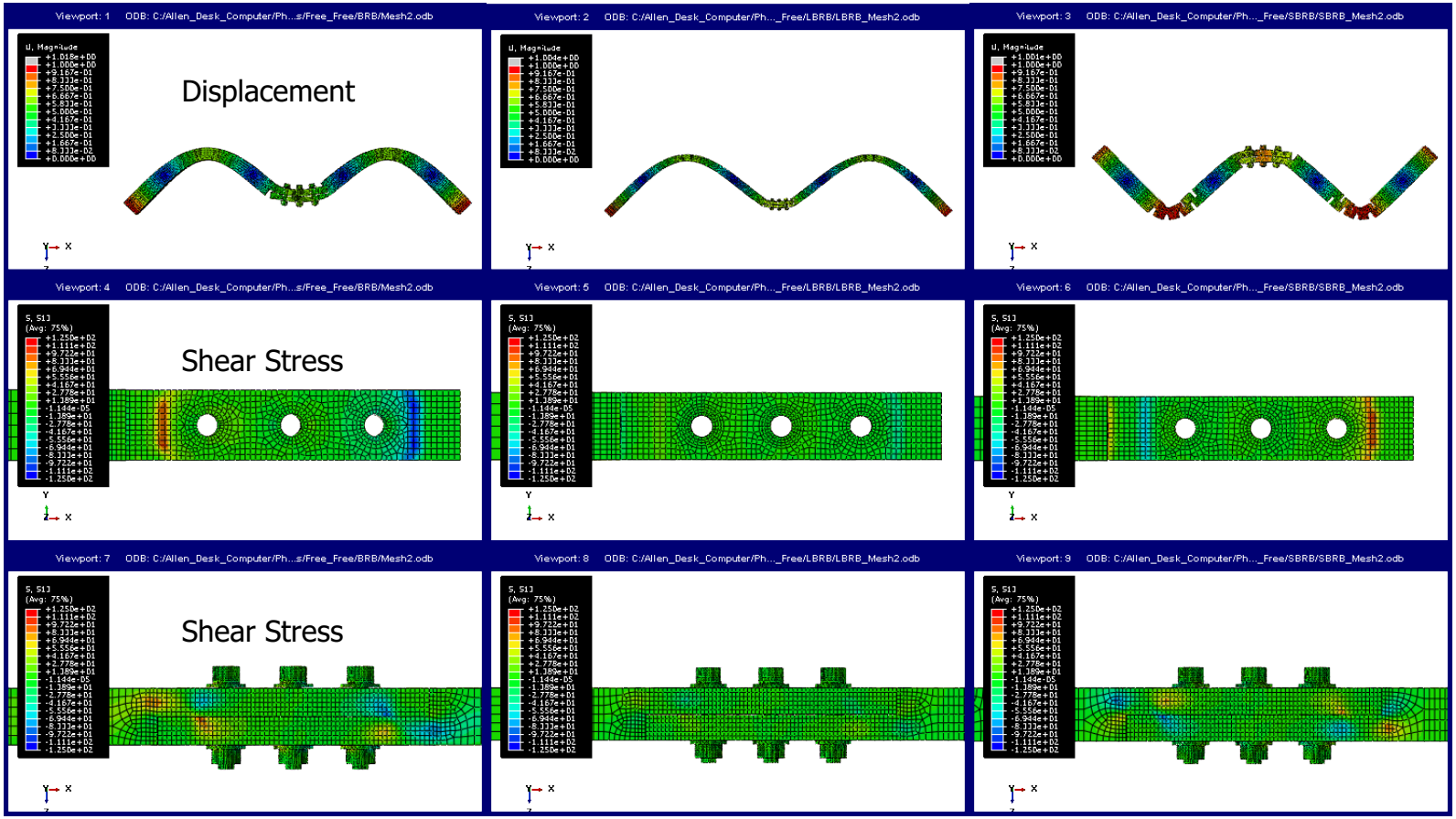
2nd MODE



Numerical Modeling

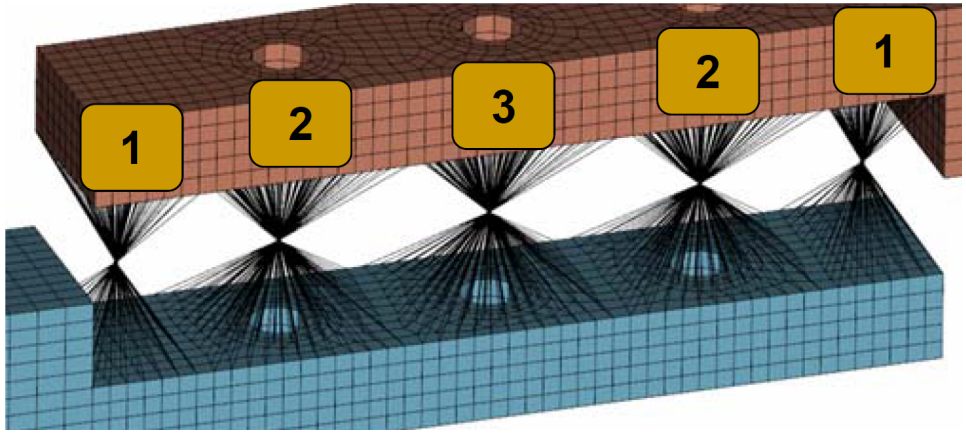
- FEM - Modal Analysis in ABAQUS

3rd MODE



Numerical Modeling

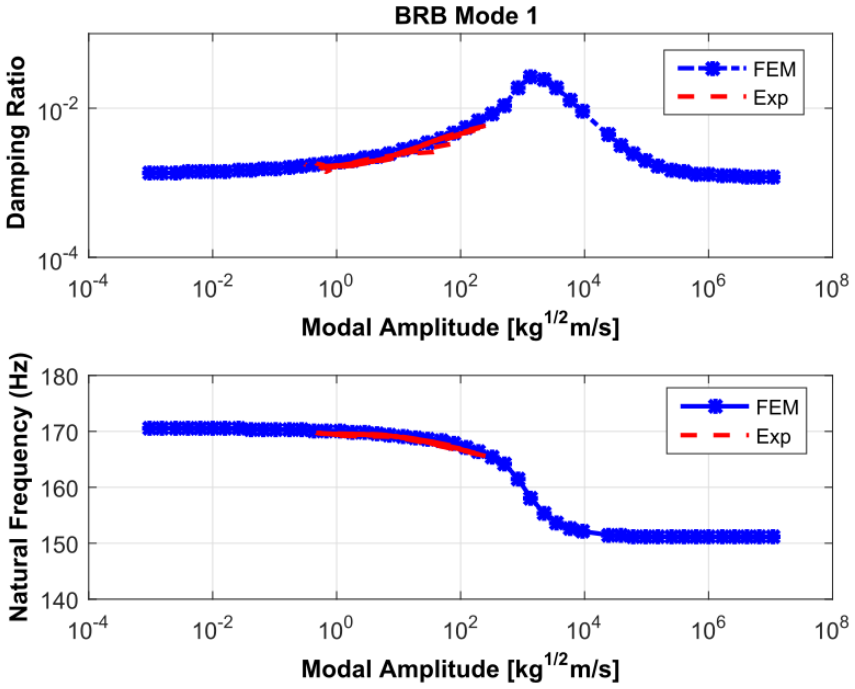
- FEM – Quasi-static Iwan Element Analysis
  - 5 spider elements connecting the joint interface containing an Iwan element
  - Tune the discrete Iwan parameters to reproduce BRB experimental data
  - Use the same set of parameters for the LBRB

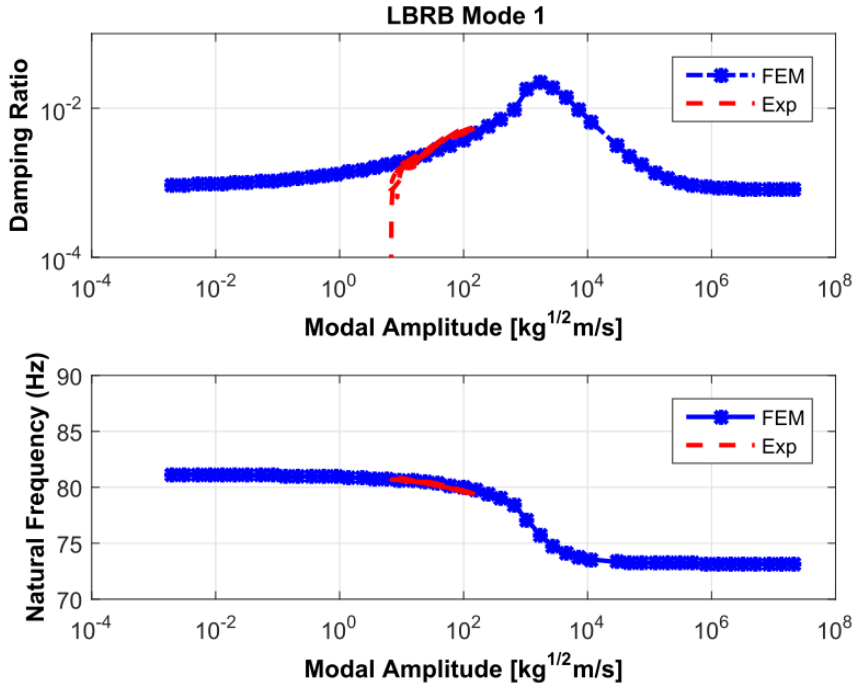


El. ID	Fs	Kt	χ	β
1	35000	1,5e5	-0,6	0,25
2	35000	2,2e5	-0,9	0,35
3	1750	2,2e5	-0,15	0,05

Numerical Modeling

- FEM – Quasi-static Iwan Element Analysis

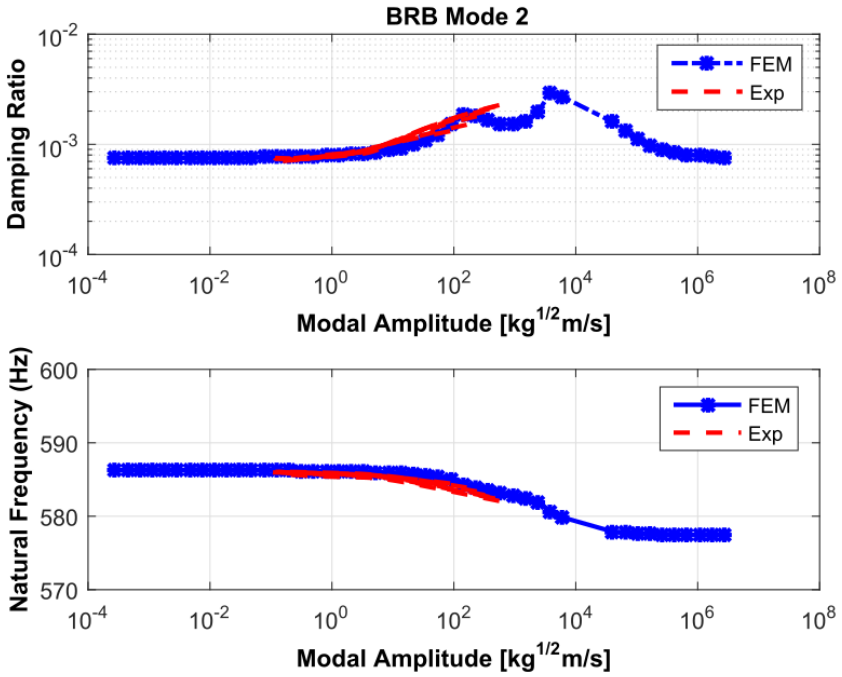


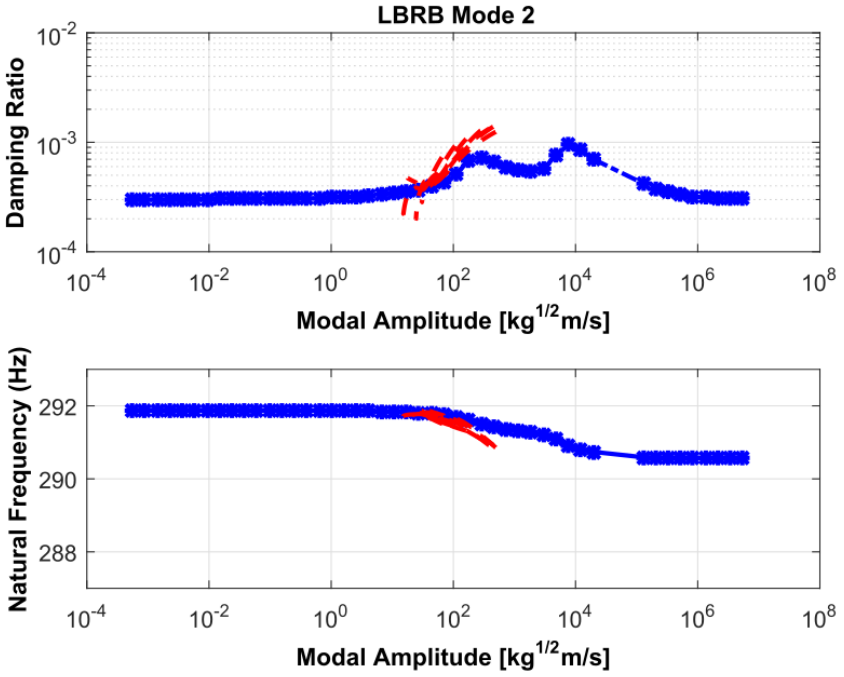


- Good correspondence between BRB and LBRB for MODE 1
- The same physical Iwan joints models are good for both beams
- Missing information about macro-slip

Numerical Modeling

- FEM – Quasi-static Iwan Element Analysis





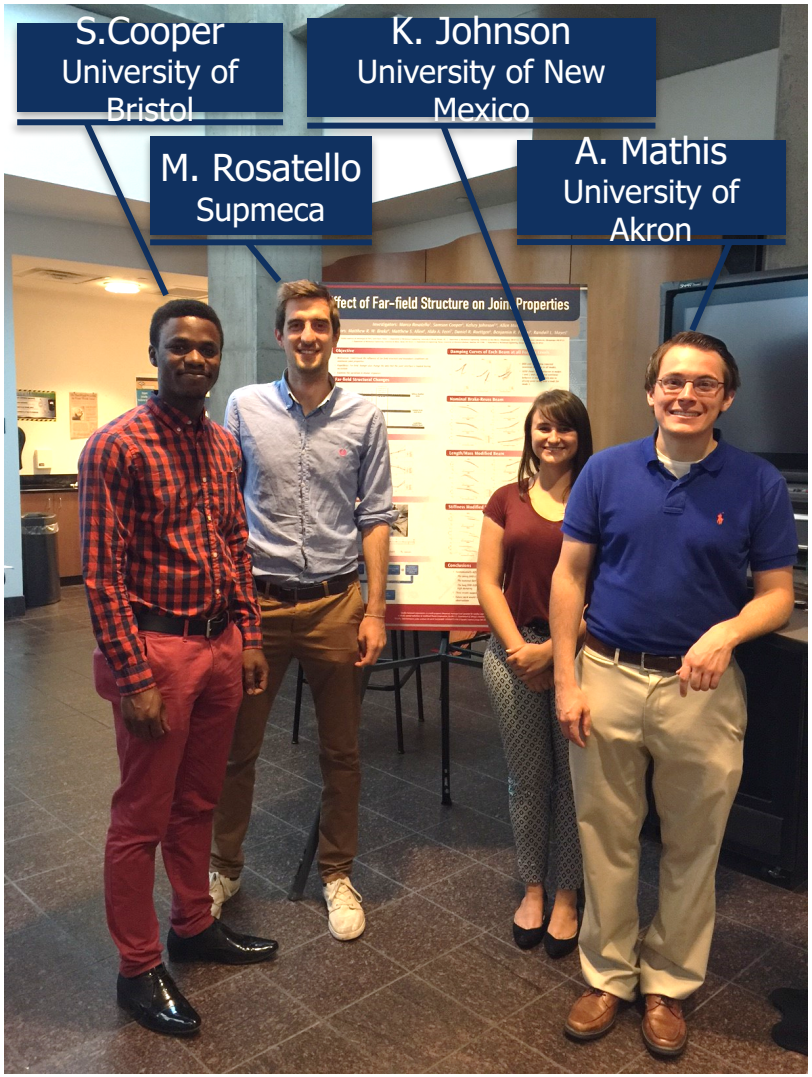
- Results for mode 2 are less good than for mode 1

Conclusions

- Experimental:
  - The far-field structure modifications have significant effects on the beams modal nonlinear properties.
  - It was impossible to fit the data of the three beams with a unique modal Iwan model.
- FEM:
  - It was possible to find a set of **physical** Iwan models capable of reproducing the nonlinear behavior of the BRB and LBRB
- Overall:
  - The far-field structure changes the way in which the interface is loaded and affects the nonlinear behavior of the structure itself.

Acknowledgements

- NOMAD Institute 2016:
  - Beautiful working and human experience
  - Great knowledge sharing between participants and advisors



Thank you!

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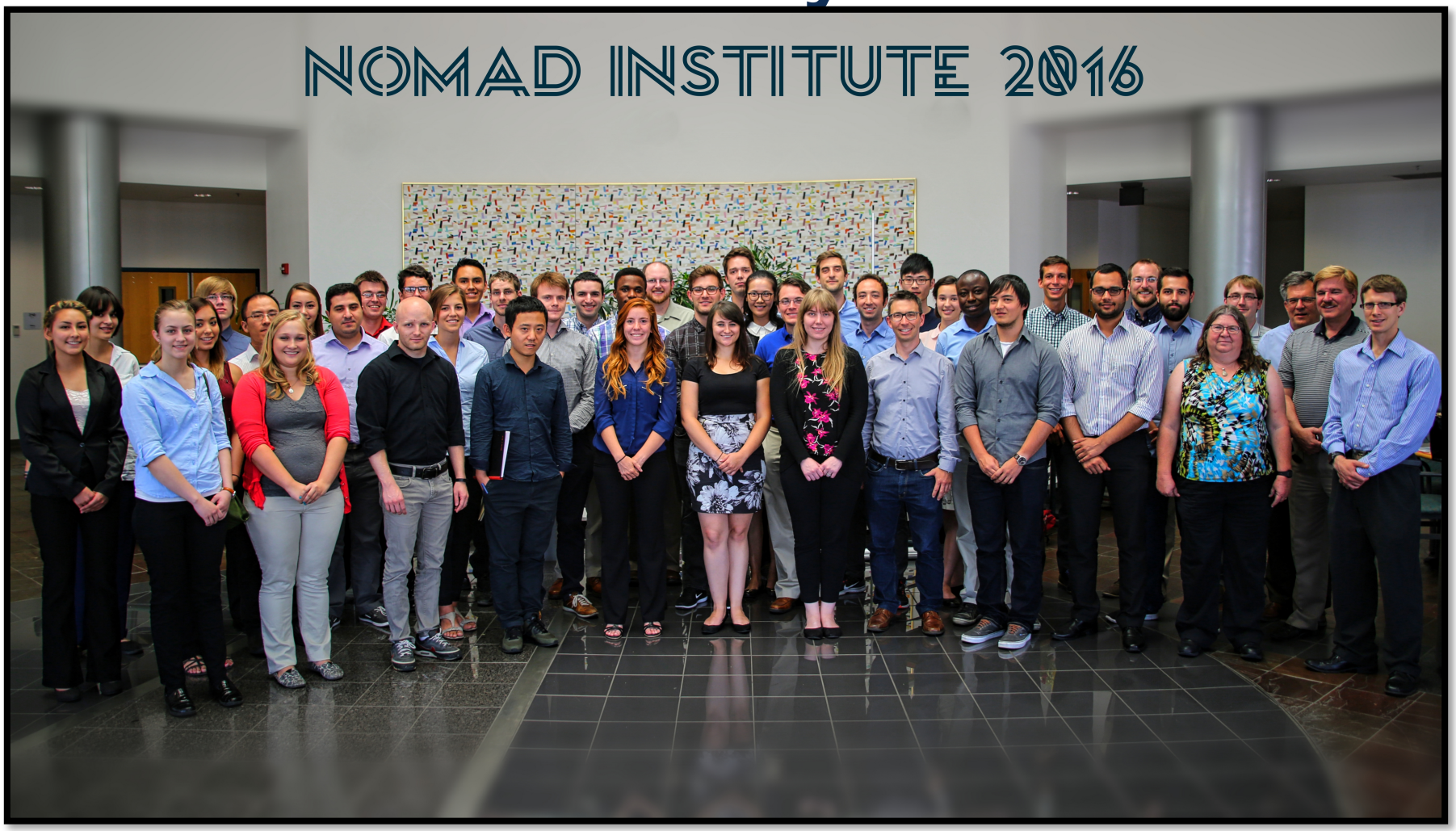
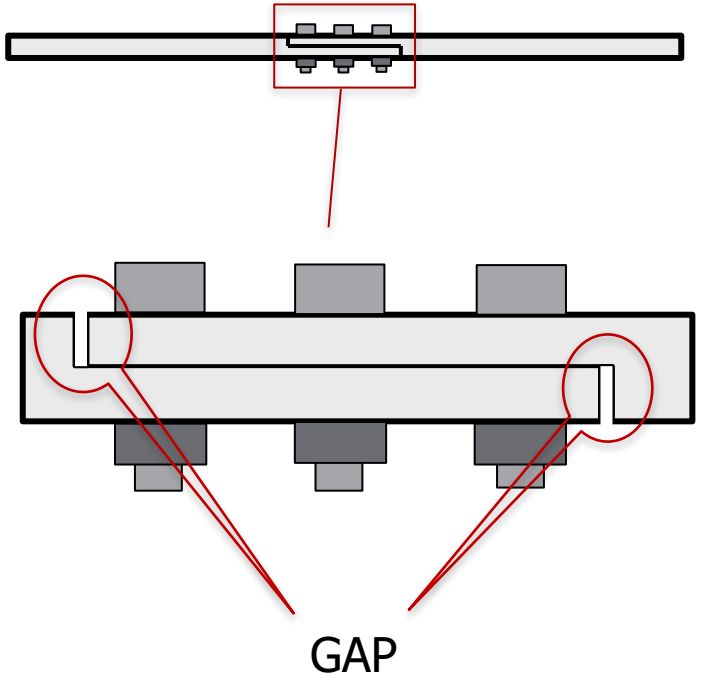
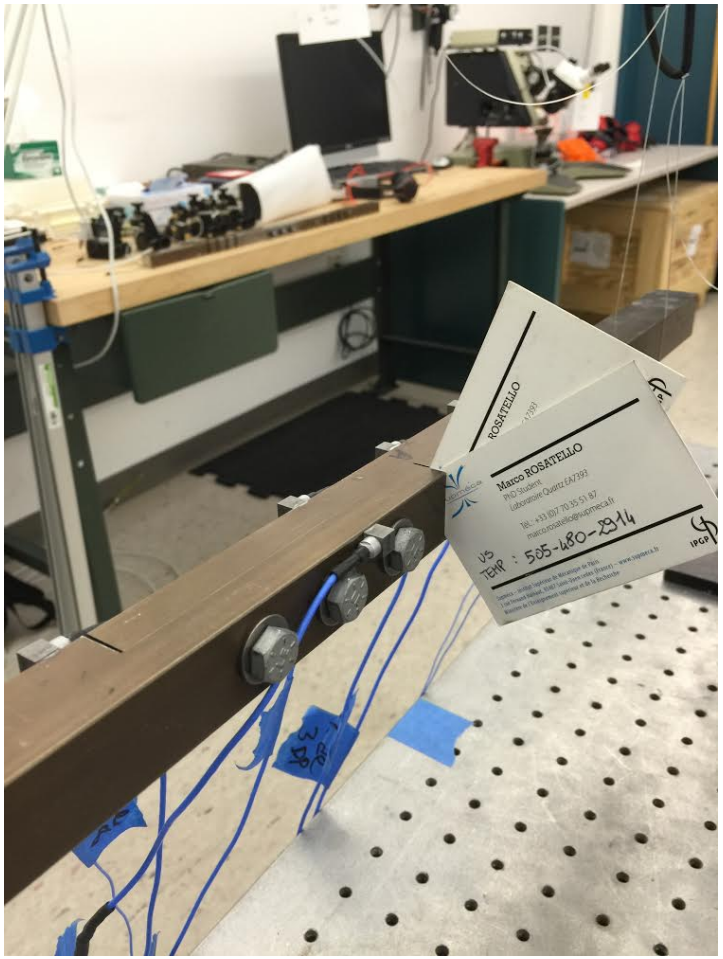


Questions?

Related studies

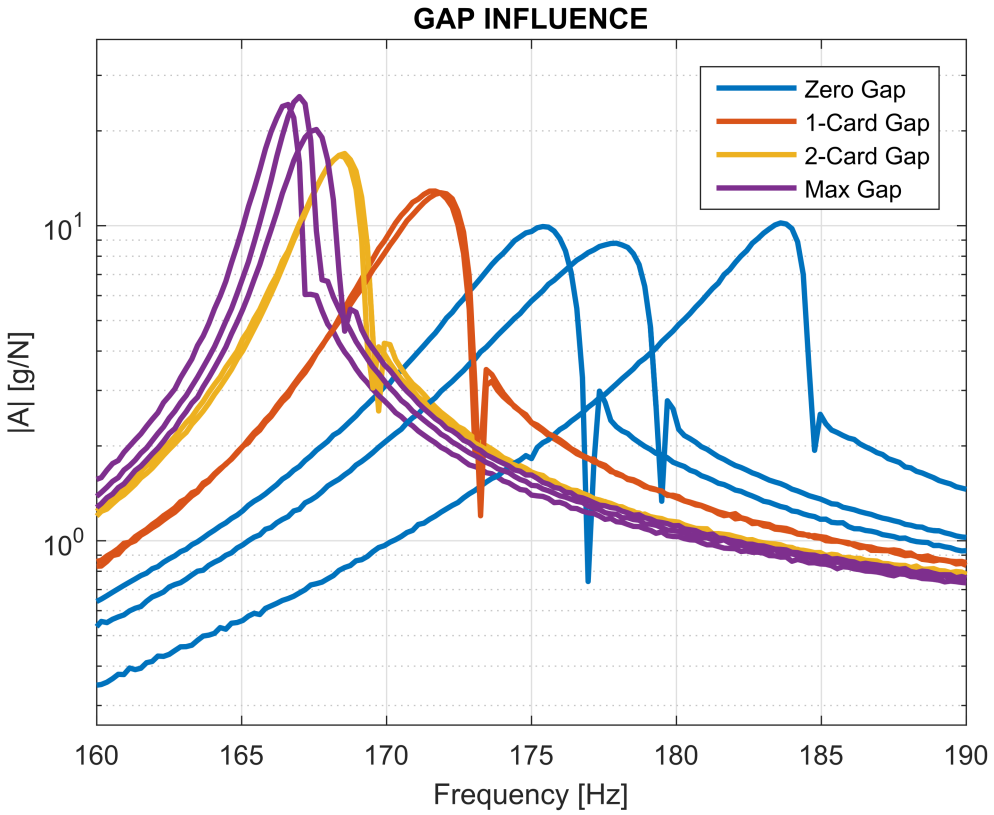
- Gap Influence





Related studies

- Gap Influence

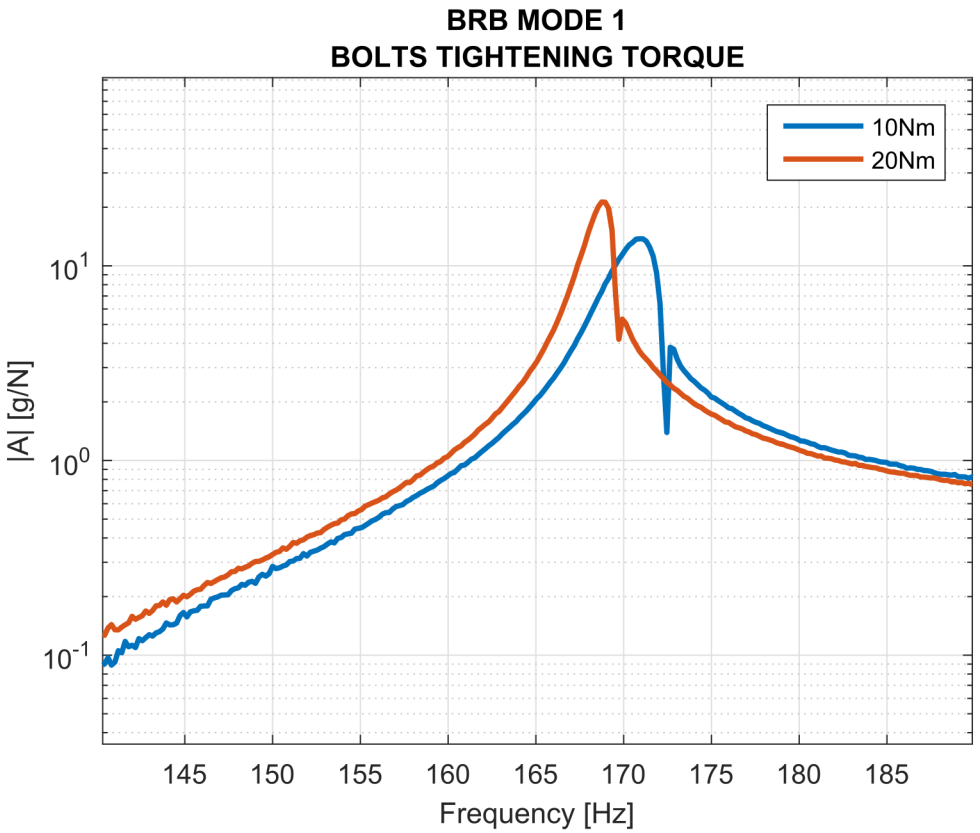


- Zero Gap tests are non-repeatable → Probably due to the additional contact
- 1-Card and 2-Cards gap tests are repeatable but there is still a difference of 5 Hz between them
- Max Gap tests shows less repeatability than teh medium gap test → probably due to contact between bolts and walls.

The gap size has a **strong** influence on the measured damping and natural frequencies!

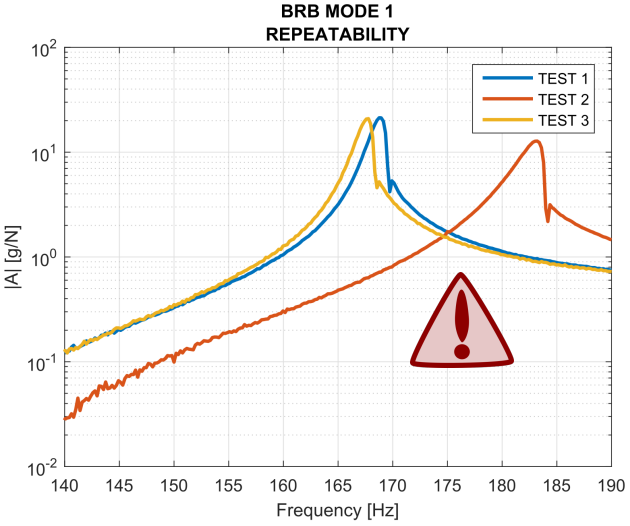
Related studies

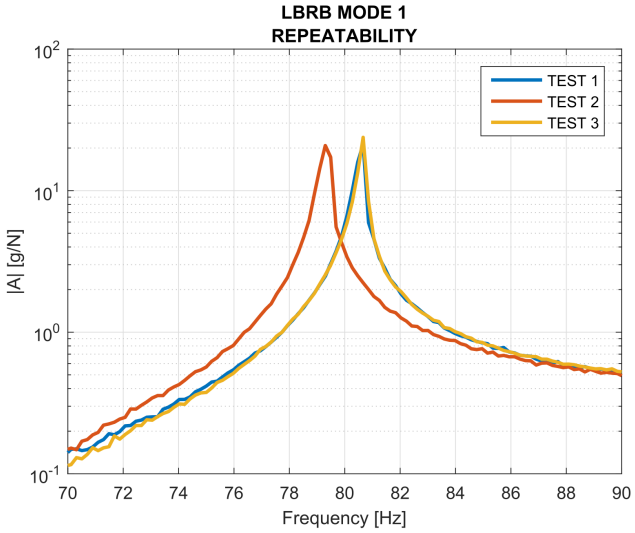
- Tightening torque
  - The stiffness and the damping decreases by increasing the tightening torque
  - The data were not thoroughly analyzed because the effect of the tightening torque was not a priority



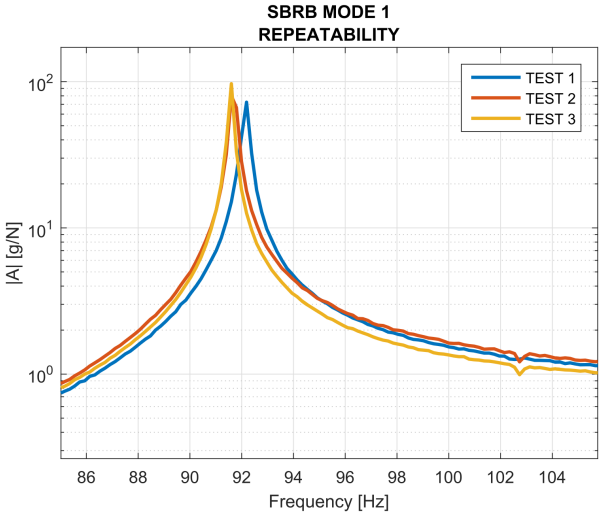
Related studies

- Repeatability





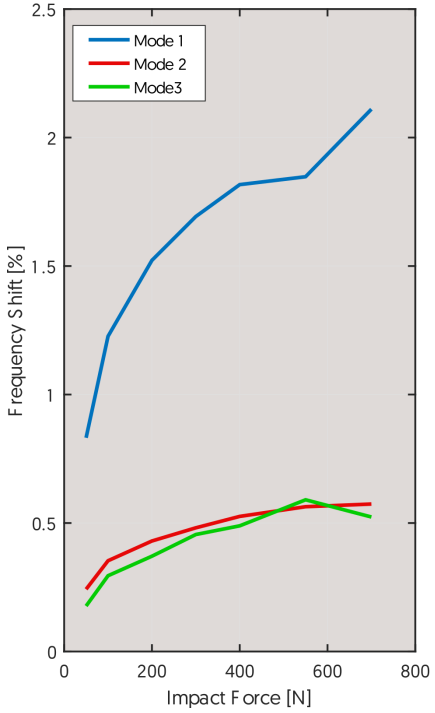
- Every beam was disassembled and riassembled 3 times
- Variability between the test is due to the gap influence
- Sadly the gap influence was studied only after 3 weeks…
- It can be really important!

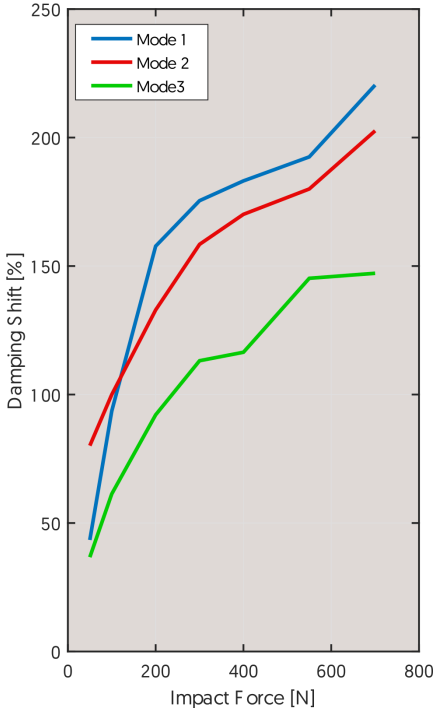


Results

- Frequency and Damping shifts for each beam

BRB





LBRB