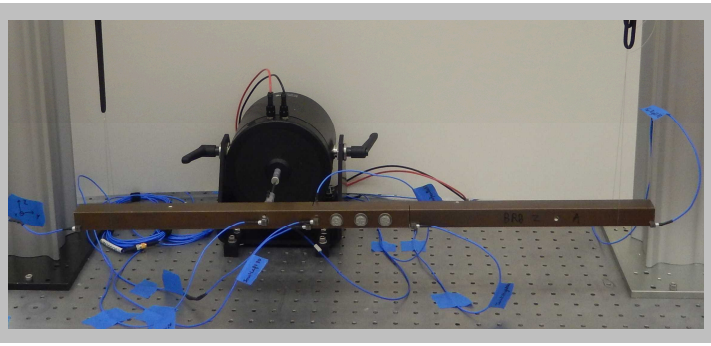
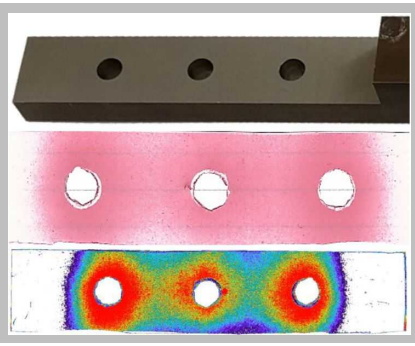
SAND2017-0930C





Experimental Assessment of the Influence of Interface Geometries on Structural Dynamic Response

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Outline

- Introduction
- Interface Design
- Experiment
- Discussion and Conclusions

Introduction

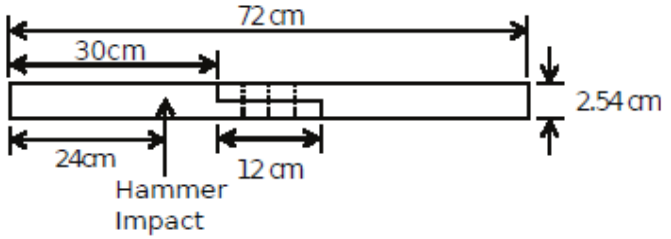
- Ability to model and predict behavior of bolted joints is of great interest
- Challenging engineering problem:
  - The frictional interactions within the interface of a jointed structure are not well understood, and existing models poorly capture both macro-slip and micro-slip effects, unless herculean efforts are made
  - The frictional characteristics of a jointed structure change over time as wear is accumulated
  - The extent and evolution of the contact patch during dynamic excitation is unknown

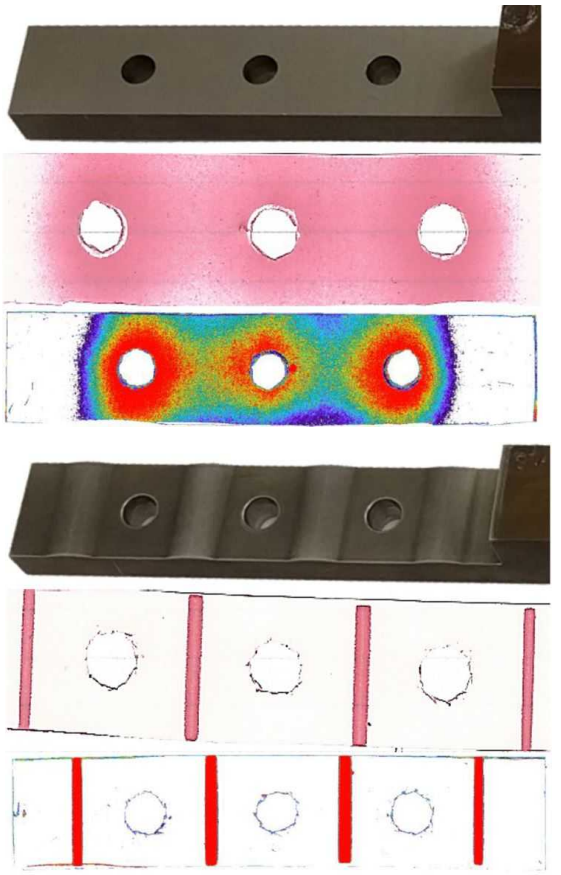
Introduction cont.

- Another set of problems originates from structures of the same geometric dimensions, material, and assembly process are:
  - Highly variable
  - Low repeatability
- If these could be minimized or understood, then models and designers would have some increased measure of predictability
- To investigate ways to decrease the variability and increase repeatability the geometry of the interface in investigated

Interface Designs

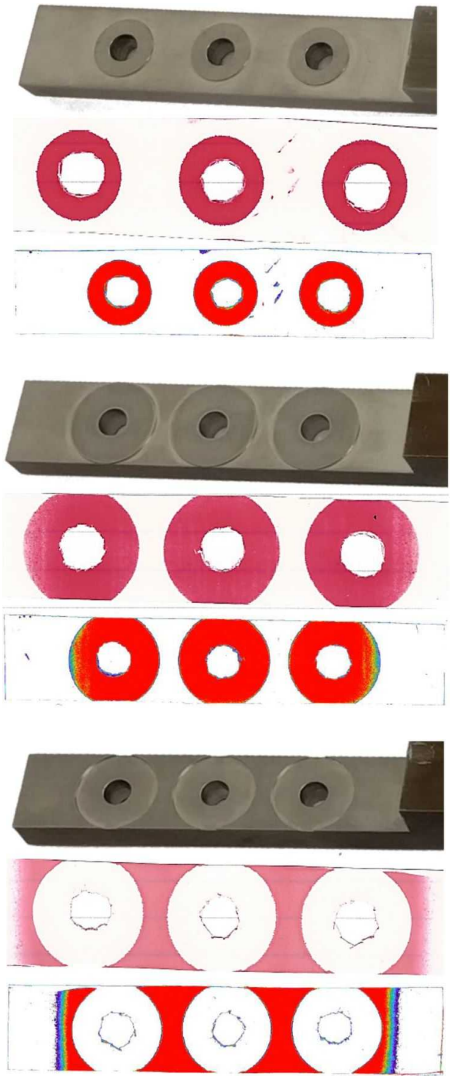
- To assess the effects of interface geometry, four perturbations of the Brake-Reuß beam (BRB) were designed
- All of the interfaces tested were looked at with pressure film which was then digitized
  - All of the interfaces are tested against the same half of the nominal interface
- The BRB has a three-bolt lap joint with a flat interface
  - System shows high variability and low repeatability
- Hertzian (HRZ) contact has a contact area that is a function of the load and area trends to zero is the first perturbation investigated





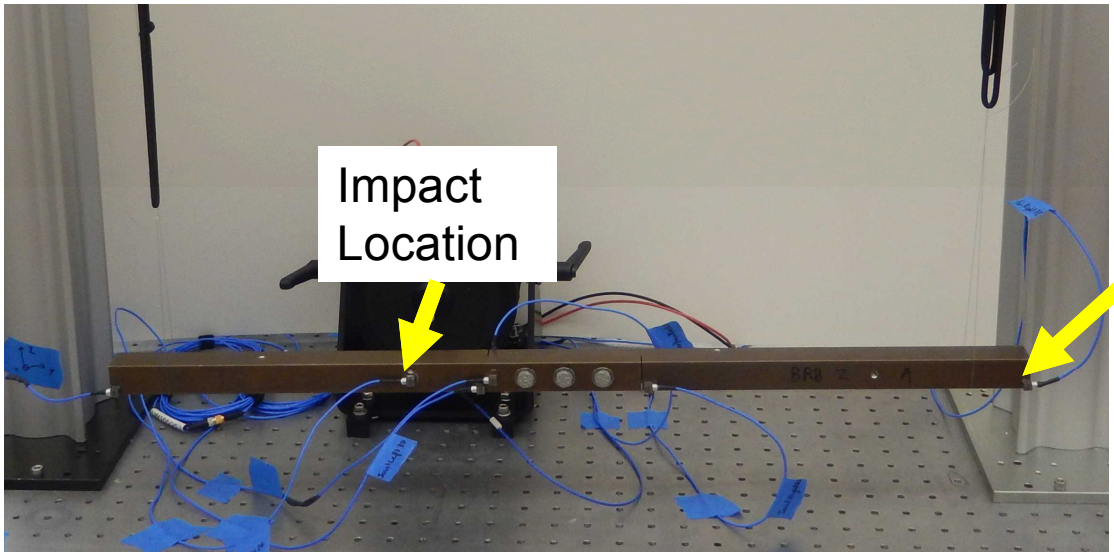
Interface Designs cont.

- Recent research indicate dissipation within joints occur away from the pressure cone
- Second perturbation has pads which the contact area is only under the pressure cone, named Small Pad (PDS)
- The third design explores the transition between second perturbation and the BRB's flat interface, named large pad (PDL)
- The final perturbation is the inverse of the third, to explore if the design significantly exacerbates the dynamics of the system in terms of more variability and less repeatability, named reverse pad (RPD)



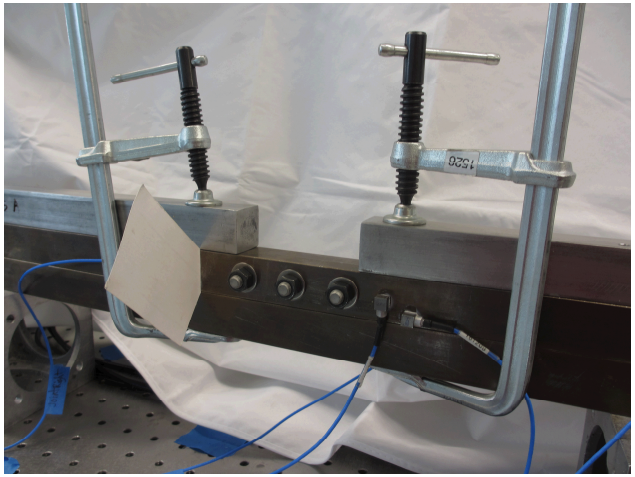
Experiment

- The beams are suspended using a combination of bungees and fishing line to simulate the free-free boundary
- The bolts were torqued to 20 Nm using the standard tightening technique, 70% torque to full torque
- The level used is lower than the standard 36.6 Nm for the bolts used
- The beam is impacted at 3 different levels (60 N, 210 N, 340 N) 5 times



Experiment cont.

- To assess repeatability, the beam is disassembled and reassembled 3 times
- To increase the likelihood that only the microscale disparity contact changes
  - The beam is clamped between a uniform beam and 2 parts of another beam with the interface perpendicular to the ground
  - Business cards are used to hold the gaps from manufacturing constant



Experiment cont.

- The results of the ring down tests are analyzed about the first bending mode using three different extraction methods
- To isolate a specific mode a band pass filter is applied
- Hilbert Transform (Used by T. Dossogne at University of Liege)
  - Can be used to rewrite experimental data into exponential form that can be used to fit a amplitude dependent single degree of freedom system
  - A polynomial regression is then used for the fit
- Direct Fitting (Used by D.P.T. Lancereau at Cranfield University)
  - Fits a standard oscillating exponential decay to a short time interval
- Short-time Fourier Transform (Used by myself at Sandia)
  - Takes discrete Fourier Transform of a small window of the response with rest of response set to zero
  - Natural frequency is extracted using a peak picking method and damping is extracted using the complex amplitude of the Fourier coefficients

Experiment cont.

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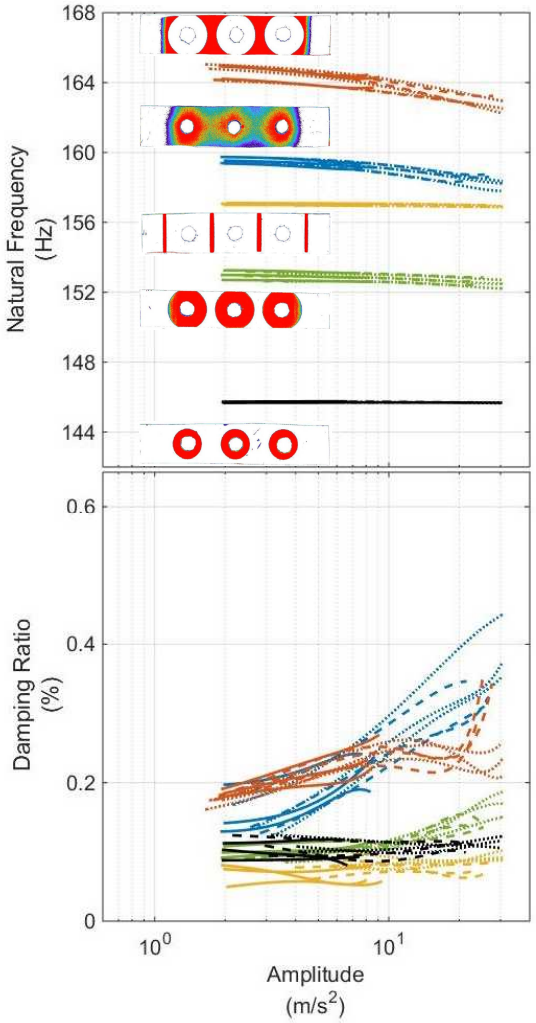
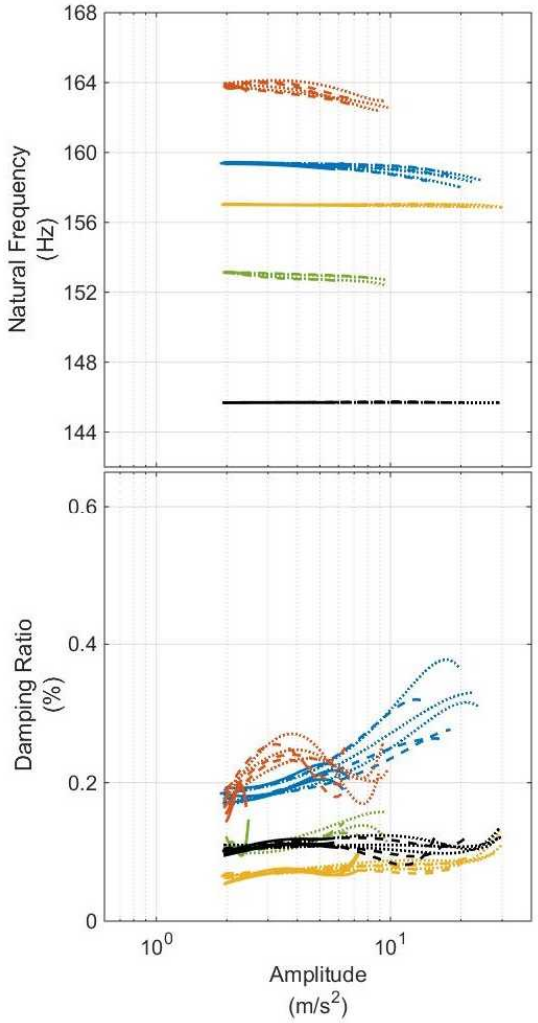
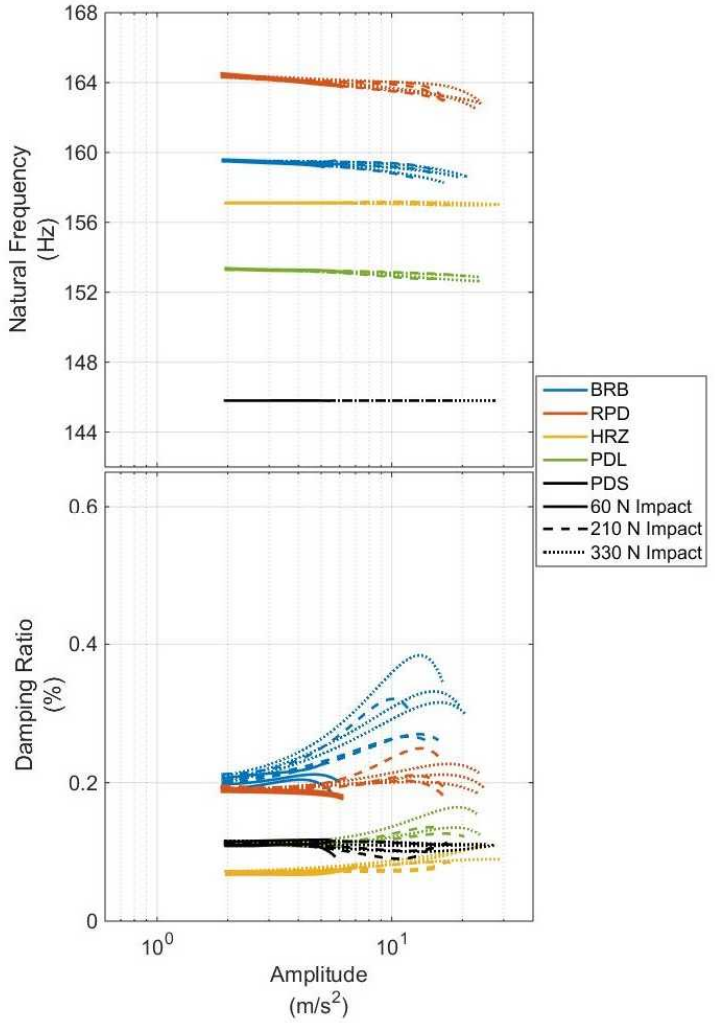
Hilbert Transform



Direct Fitting

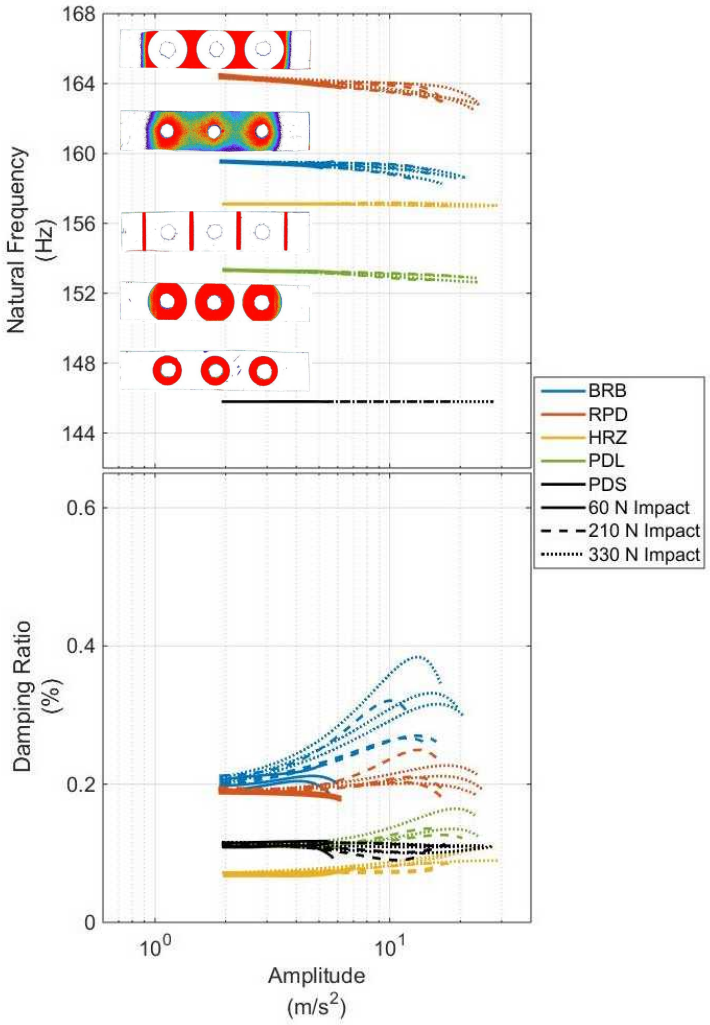


Short-time Fourier Transform



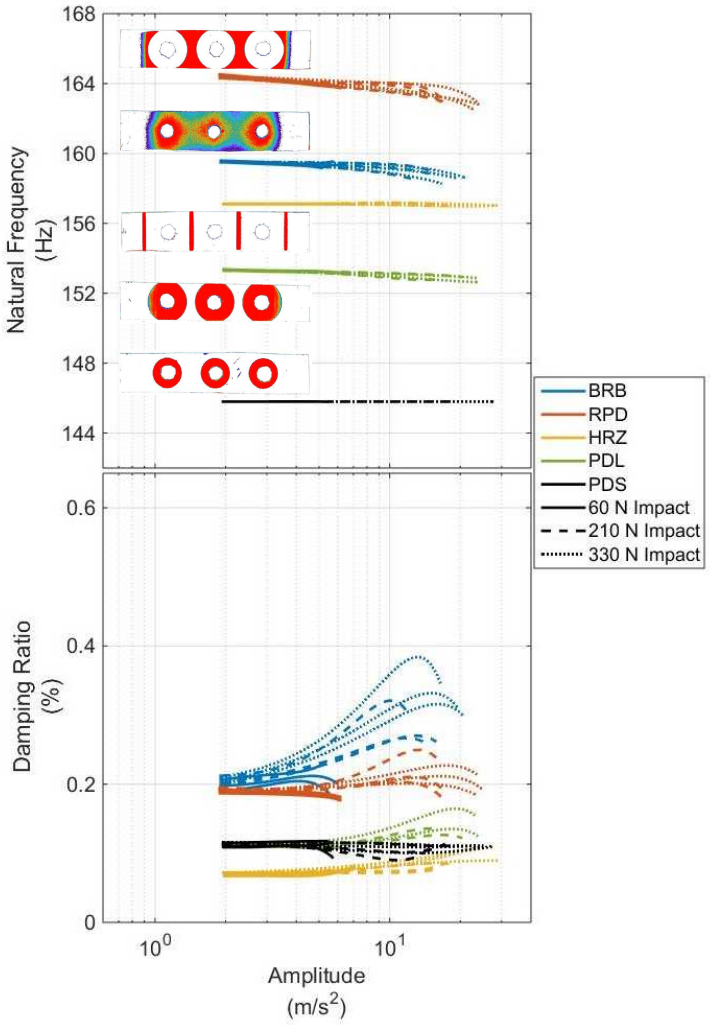
Discussion

- Perturbations with large contact area from bolts were less repeatable and had larger variability
- Interfaces with high pressure concentrations (PDS & HRZ) behaved linearly due to slip not occurring at the excitation levels achieved
- Interfaces that had more gradual pressure gradients (BRB, RPD, & PDL) behaved more nonlinearly due to micro-slip occurring in the transition zones
- Damping exhibited a higher amount of variability than frequency due to the damping being more susceptible to changes in disparity contact.
- The large pad has characteristics of the BRB and PDS
  - Pressure film has saturate areas and transition areas
  - Response is some where in between the 2



Conclusion

- Gradual pressure gradients and free edges are large source of nonlinear effects
- Interfaces with complete contact behave linearly
- Provided insight into possibility of designing interfaces that behave as expected
- Pressure film is proven to be a useful tool to help provide insight into dynamics of joint
- Results corroborate hypothesis that micro-slip at edge is origin of nonlinear damping



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Questions?