Vibration Experiments on a Damaged Beam

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NSF BRIGE 0824227

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Motivation

As part of an initial investigation of structural health evaluation, laboratory experiments are used to determine potential parameters for damage detection. A structural change due to damage may be identifiable by examining vibratory characteristics including natural frequency and damping shifts.

Objectives

- Relate motions of undamaged and damaged structures.
- Experimentally obtain time histories and frequency responses for a beam
  - undamaged state
  - two incrementally damaged states
- Examine natural frequencies and damping shifts

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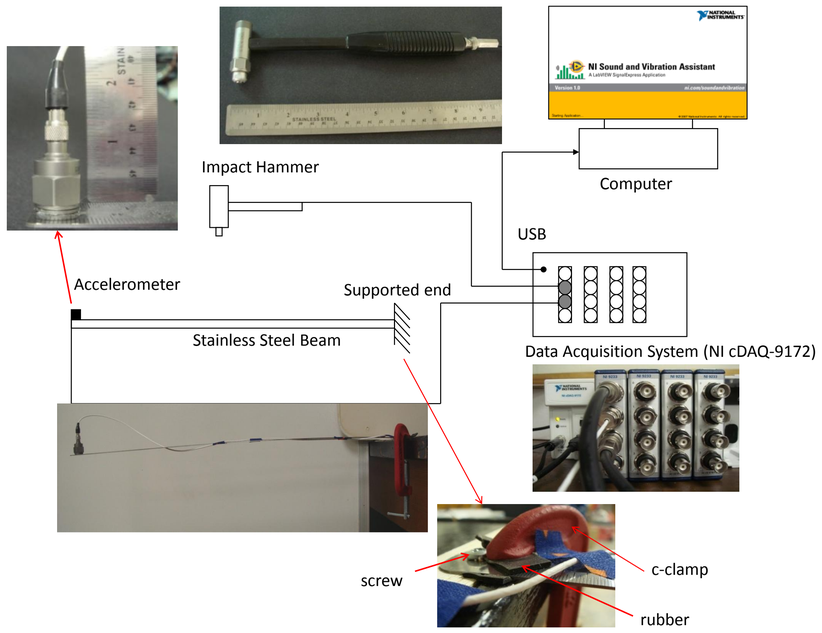
Experimental Setup



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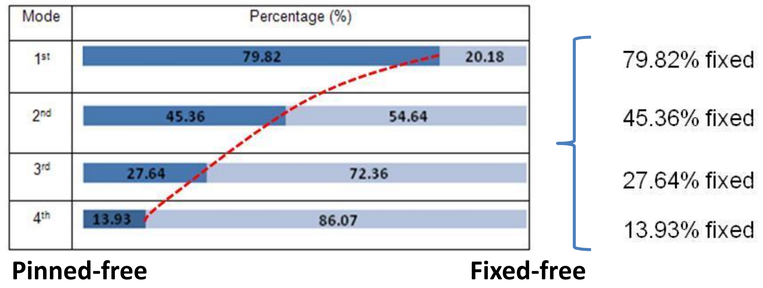
Support Condition

	Natural Frequencies (Hz)		
Mode	Pinned-free	Experimental	Fixed-free
1st	0	3.11	3.89
2nd	17.07	20.38	24.39
3rd	55.30	58.89	68.29



➡ Implies non-linearity

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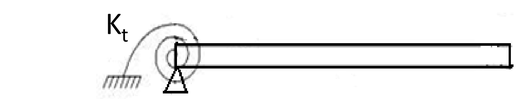
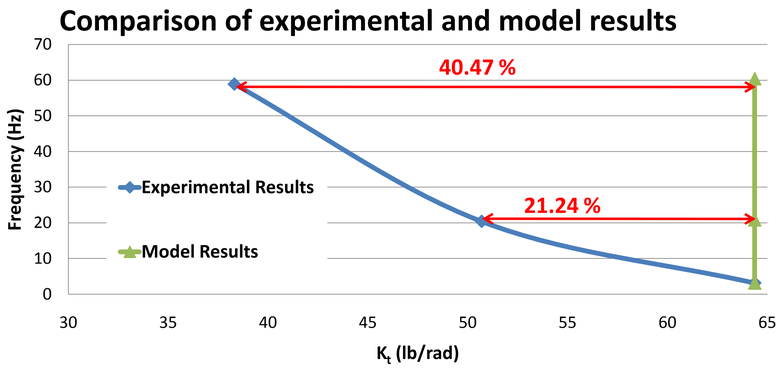
Analytical Model Comparison

Tuned torsional stiffness (K_t) for 1st mode.





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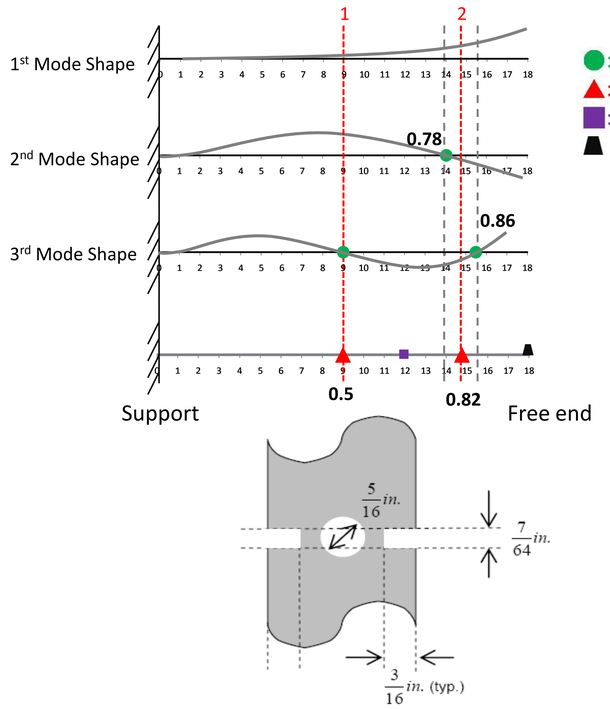
Damage Description



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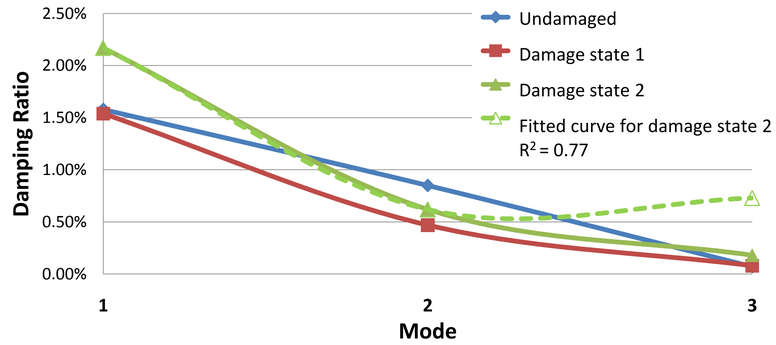
Damping Effects

	Damping Ratio		
Mode	Undamaged	Damage state 1	Damage state 2
1st	1.58%	1.54%	2.17%
2nd	0.85%	0.47%	0.62%
3rd	0.07%	0.08%	0.18%



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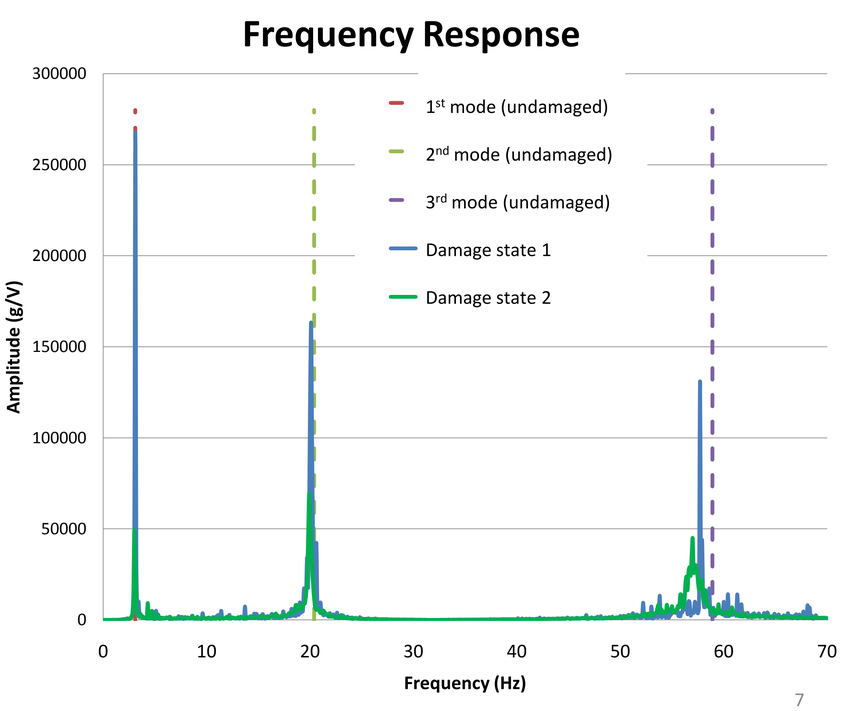
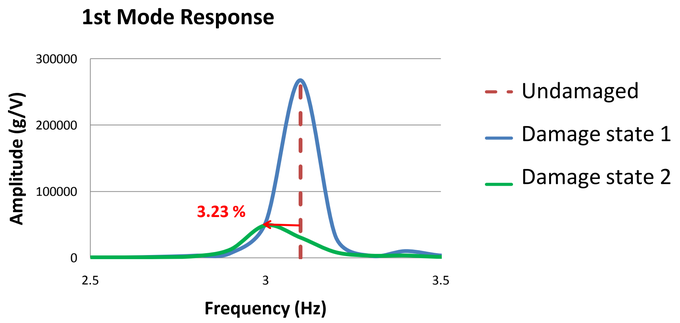
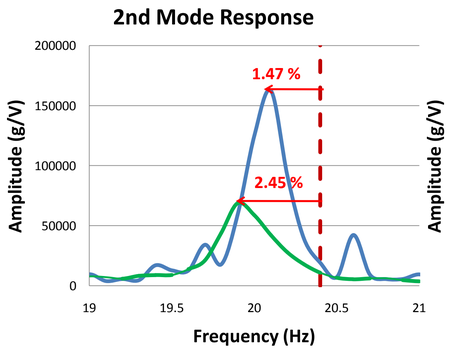
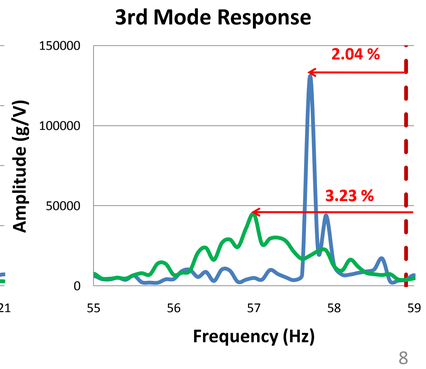
Comparison of Undamaged and Cumulatively Damaged Conditions









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Preliminary Conclusions

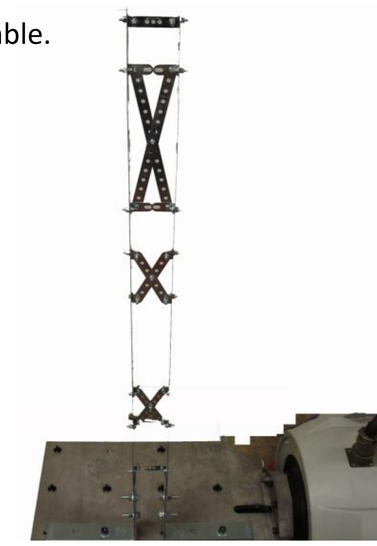
- Change of natural frequency in measured frequency response may be an indicator of cumulative damage.
- Damping might also be an indicator.
- Trend behavior is not yet predictable.

Sources of Error

- Coupled motion
- Hand machining
- Clamped condition disturbance
- Non-linearity

Future Work

Extend this process to the damage behavior of a laboratory-constructed tower.



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