

Effects of Bearing Surfaces on Lap Joint Energy Dissipation

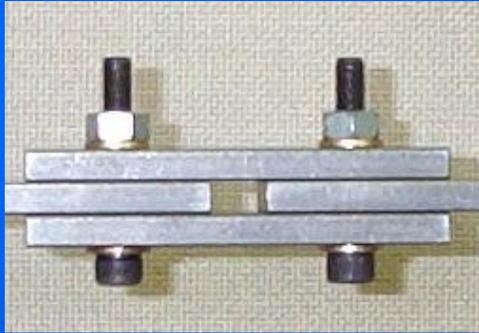
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Special thanks to the DOE and Los Alamos Laboratories



Motivation



Friction occurs in mechanical systems during relative motion at physical interfaces between contact surfaces.

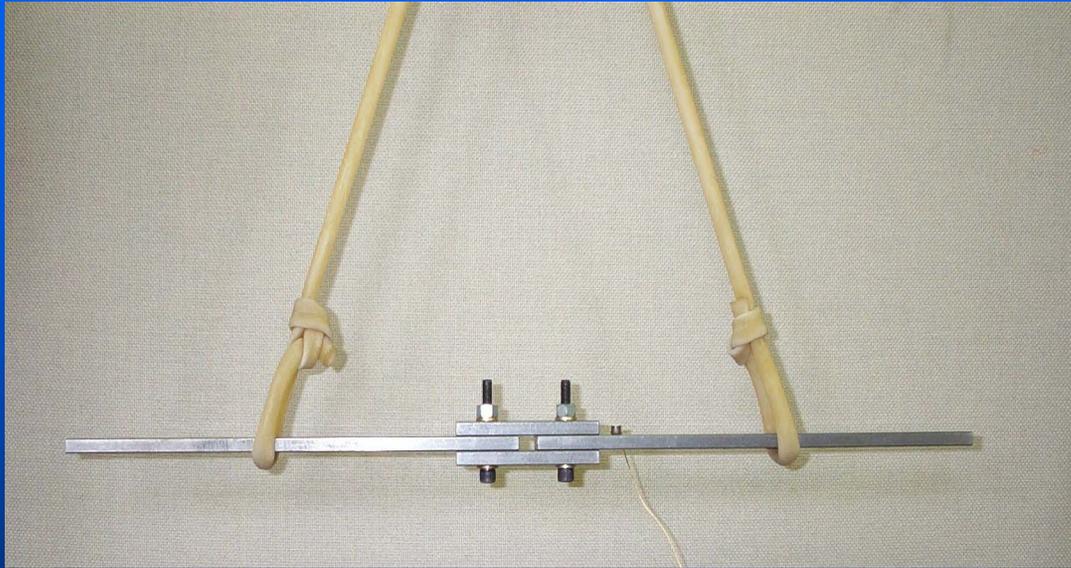
Friction causes energy dissipation.



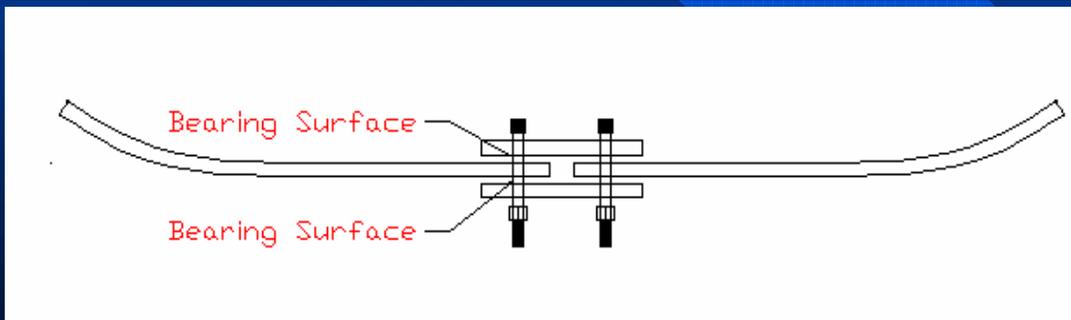
Introduction

- Hypothesis 1: Equivalent linear damping is a function of the amplitude at low levels of motion.
- Hypothesis 2: Equivalent linear damping is a function of bearing area. Damping increases with an area increase.

Introduction: 3 Experiments



- No washers
- Large washers
- Small washers



Equipment

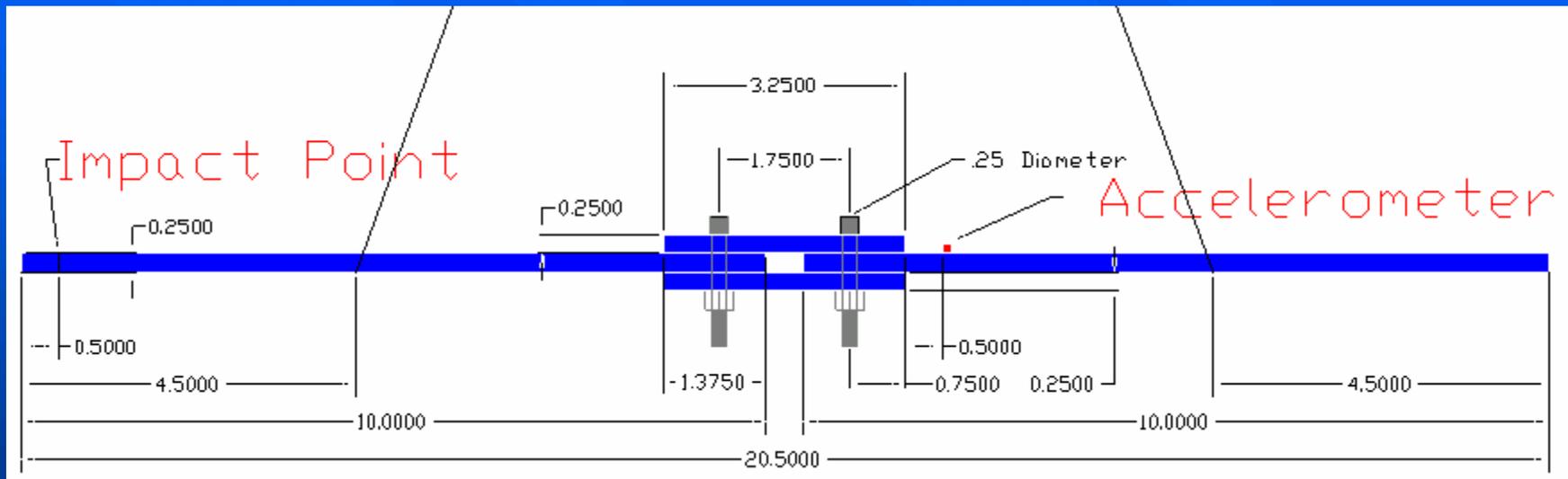
- Accelerometer: Endevco Isotron



- Hammer



Physical Configuration



- Steel
- Bolts $\frac{1}{4}$ "-28 1-1/2"
- Elastic Restraints
- Torqued to 85in-lbs

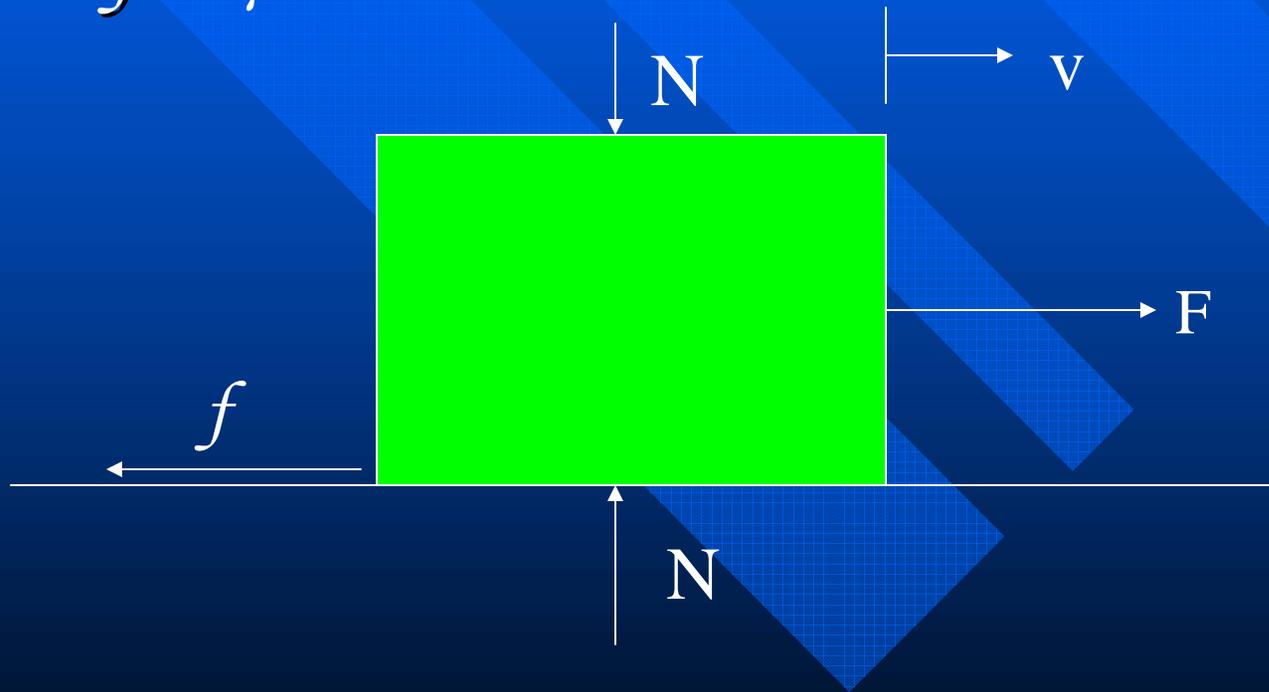
Introduction

- Analytical models: Dahl and LuGre
- Investigate plausibility to simulate experimental system

Macrofriction

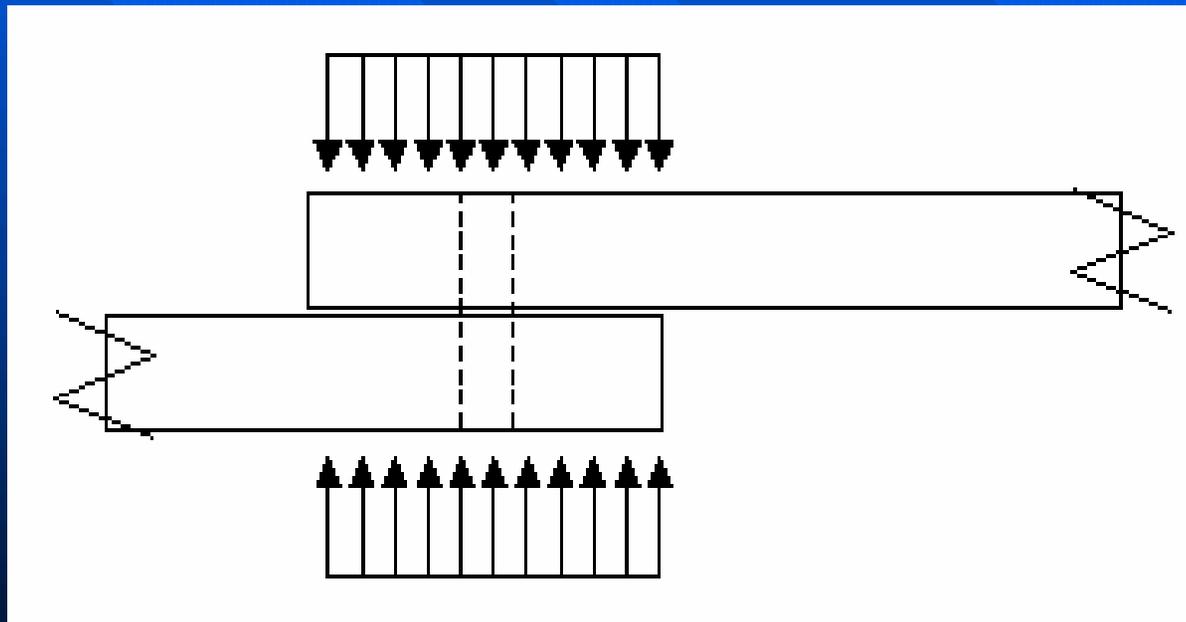
- Rigid Body Friction

$$f = \mu N$$



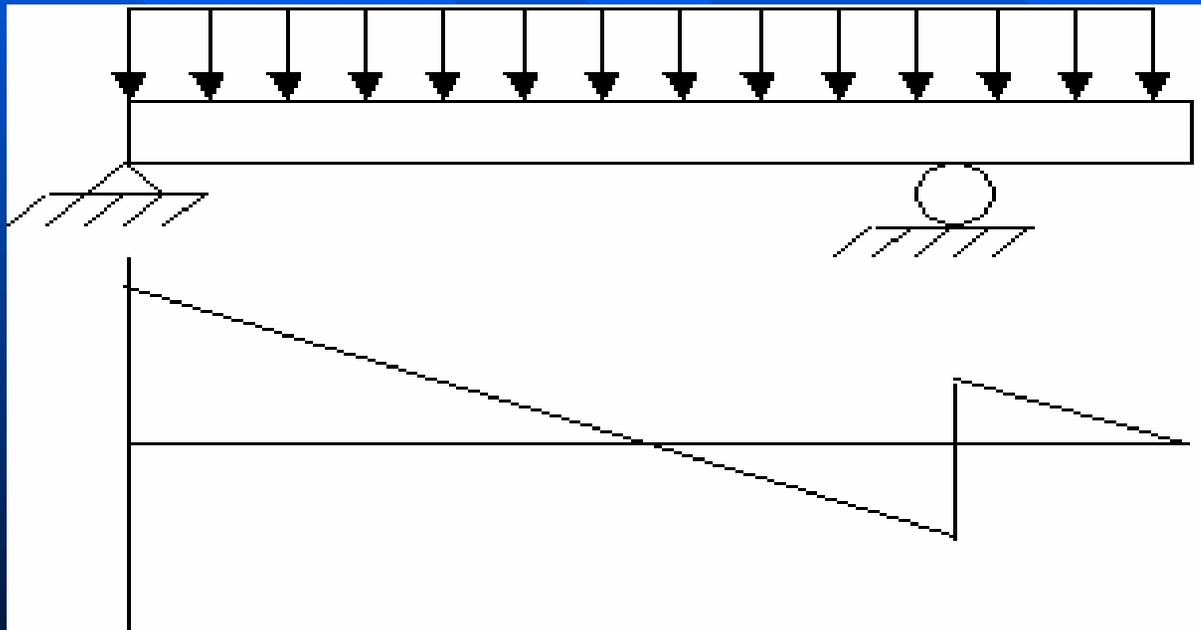
Statics Review: Distributed Load

- Pressure = Force / Area
- Distributed evenly



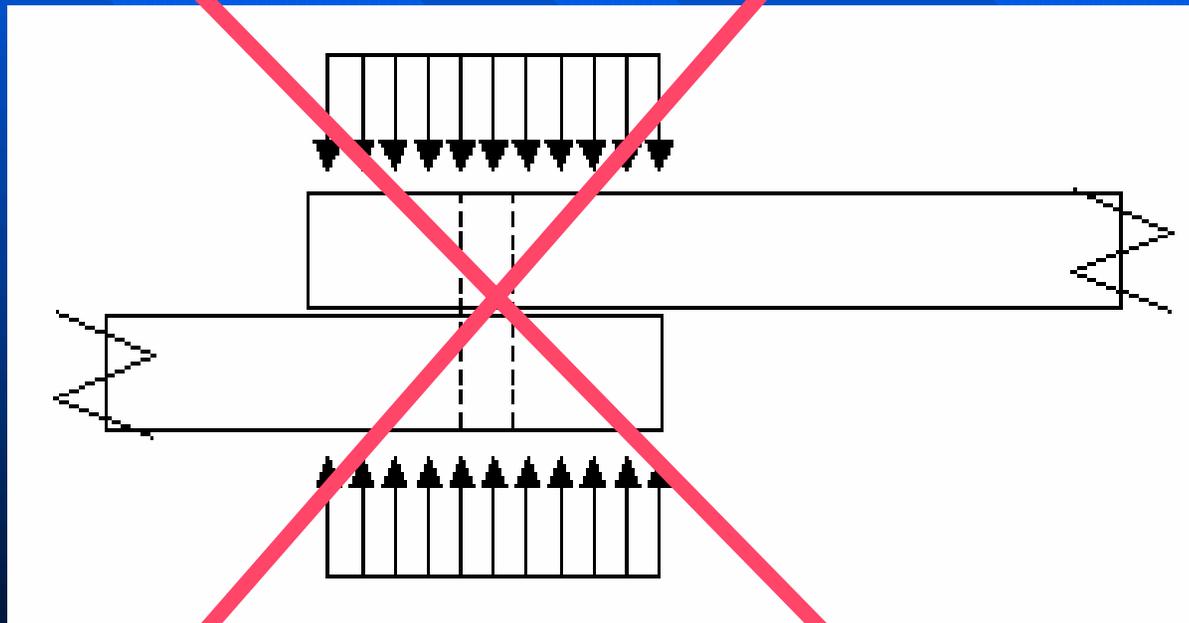
Shear Diagram

- Stress = 0 at the right end



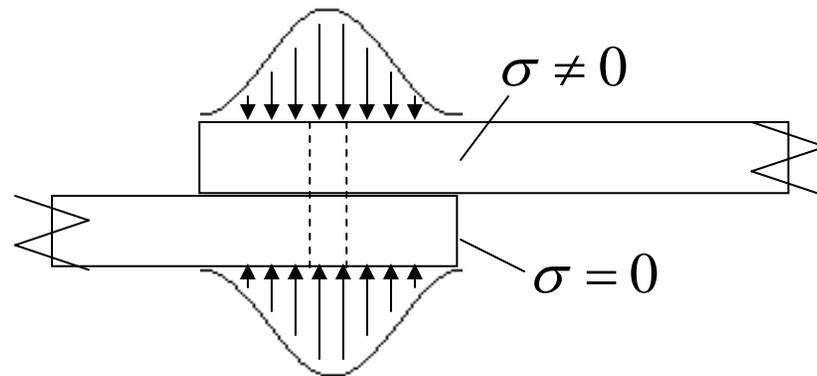
Statics Review: Distributed Load

- Pressure = Force / Area
- Not Evenly Distributed

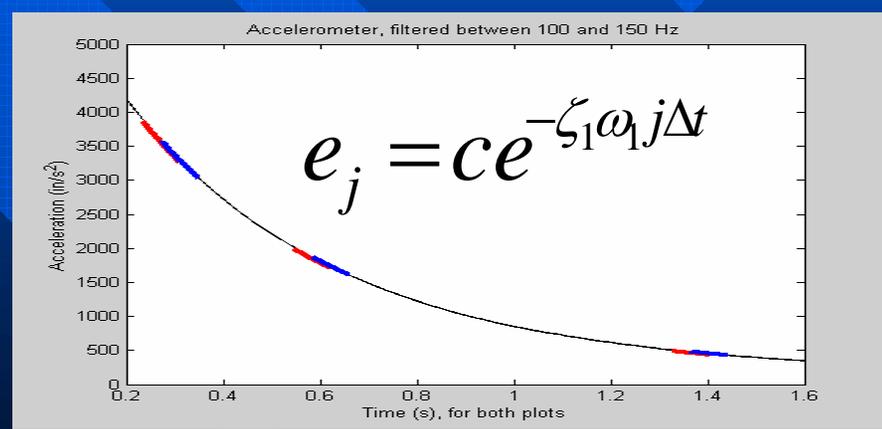
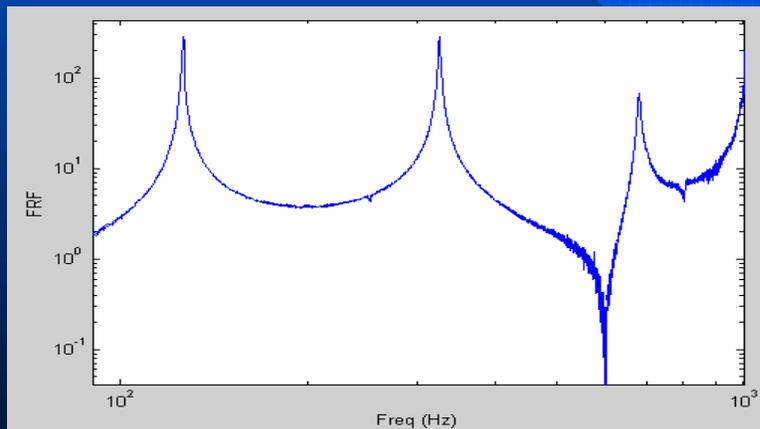
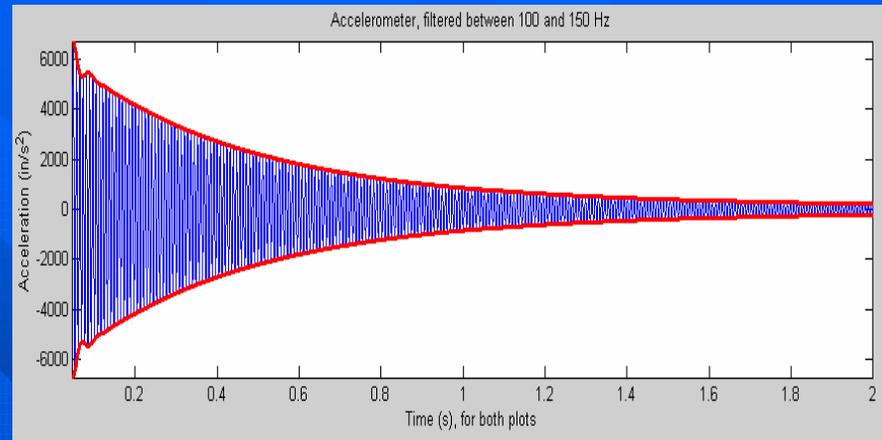
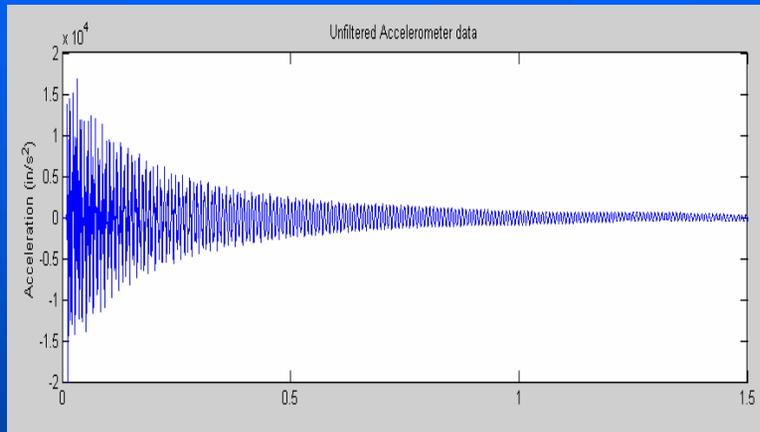


Microfriction

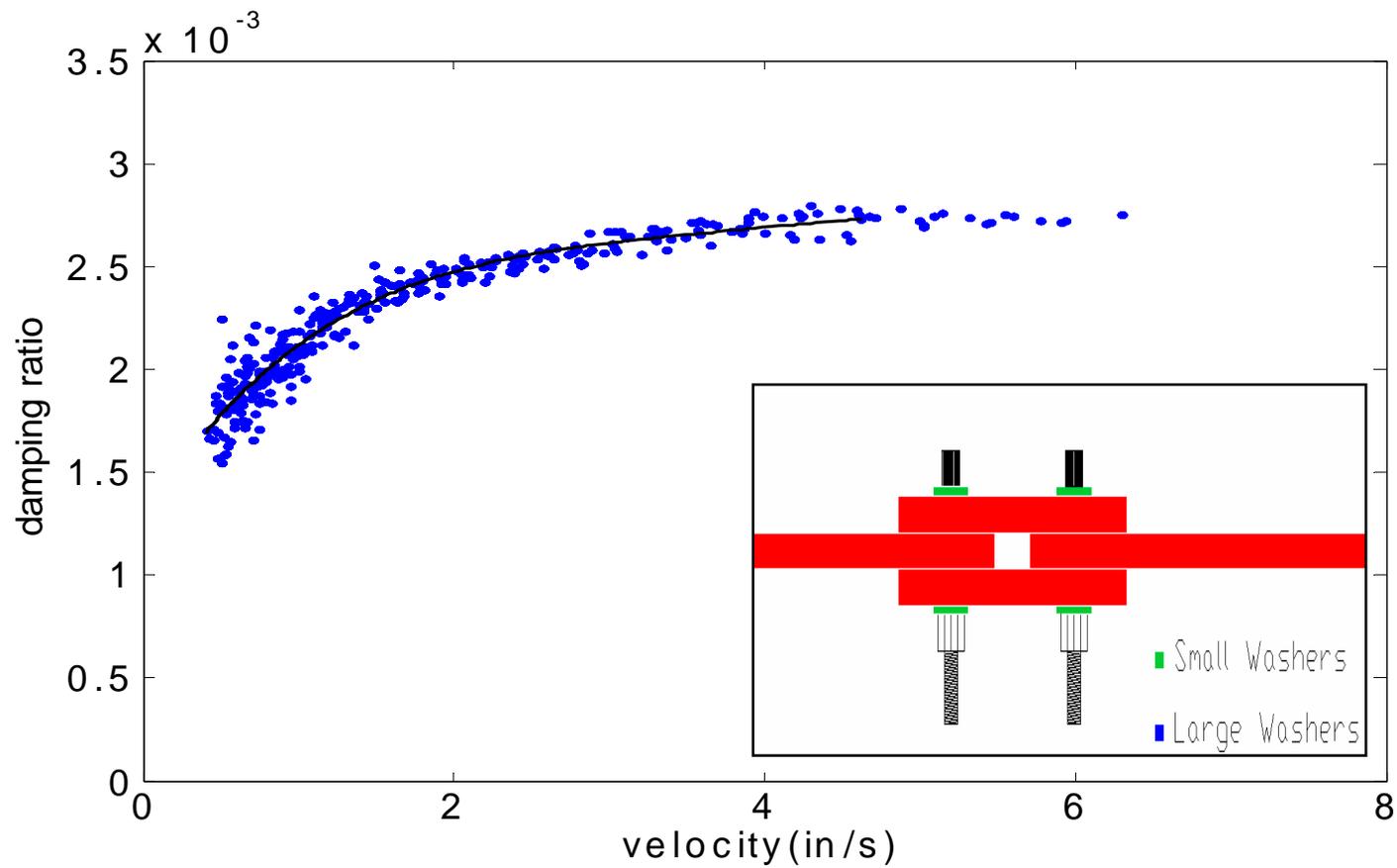
- Result of stress mismatch
- Low stress areas are more likely to slip



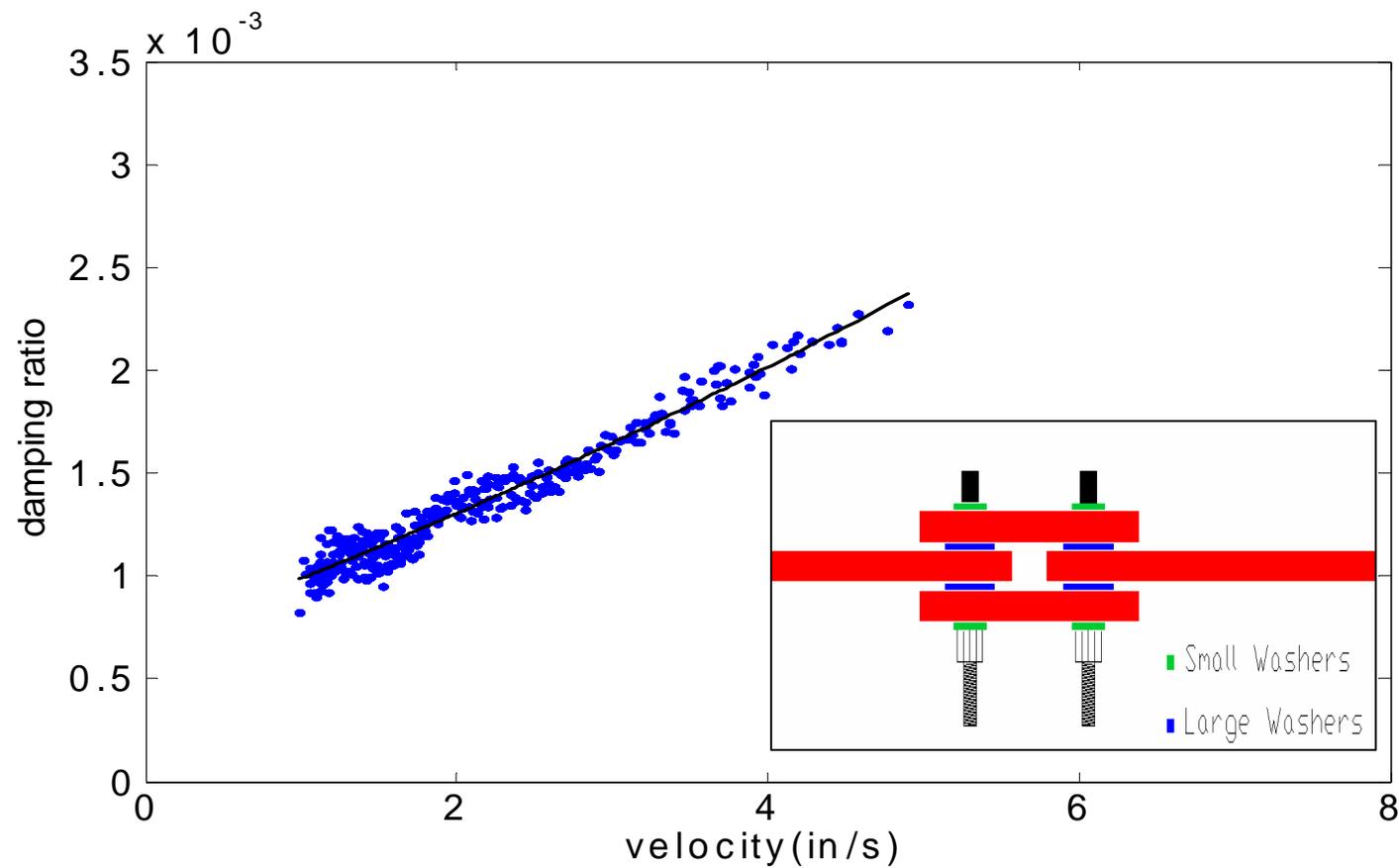
Data Analysis



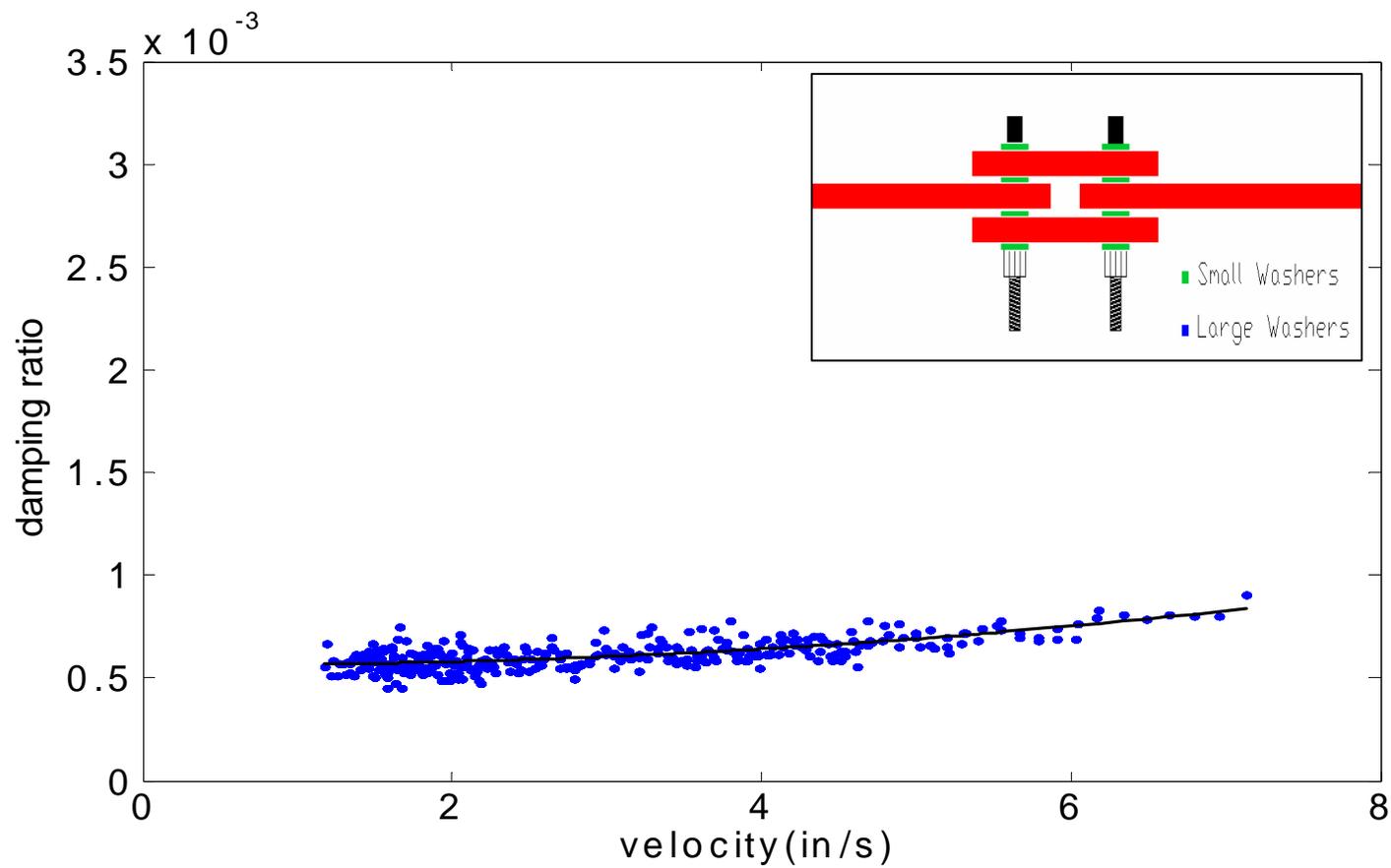
Test 1 – No Washers



Test 2 – Large Washers

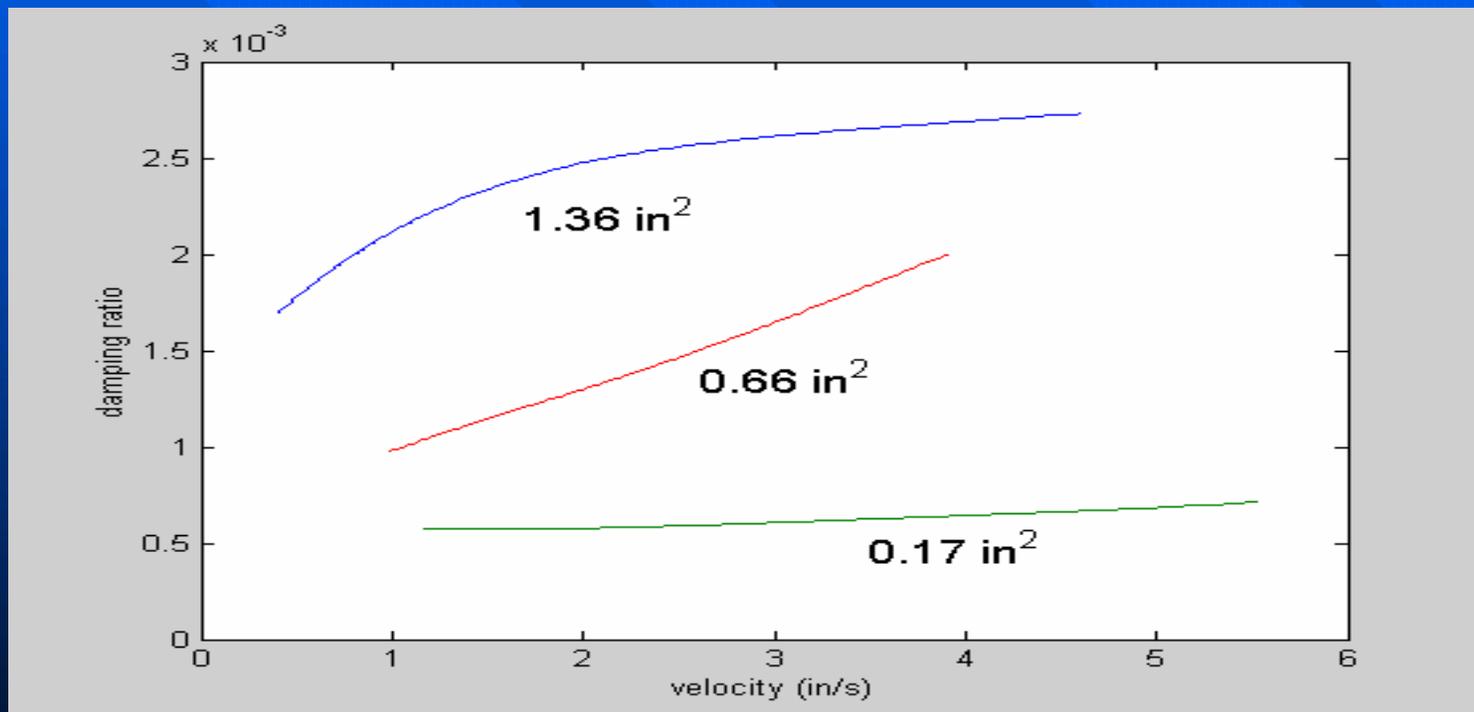


Test 3 – Small Washers



Experimental Conclusions

- Damping curve is related to contact area.

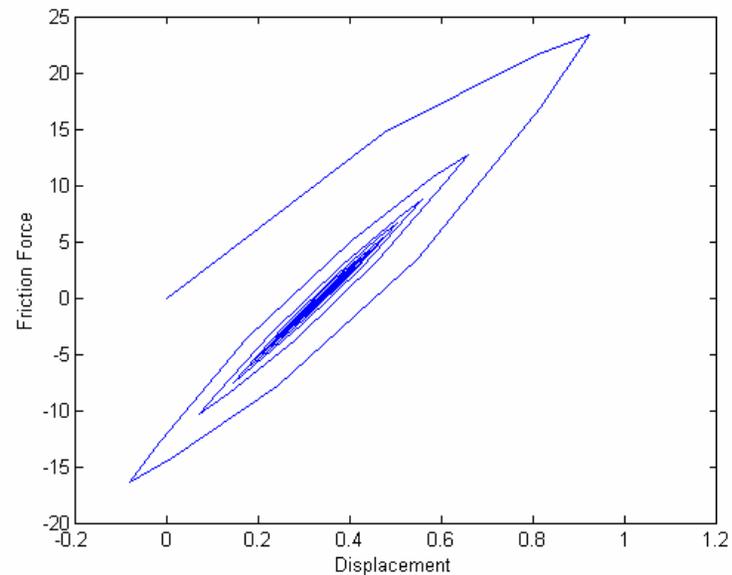


Dahl Model: Energy Dissipation

- Friction force is a function of displacement and sign of the velocity
- Therefore, rate independent
- 2 parameters

$$\frac{dz}{dt} = v - \frac{\sigma |v|}{F_c} z$$

$$F = \sigma z$$



LuGre: Energy Dissipation

- Combination of Dahl and Bristle models
- Stiction, Stribeck, and rate dependent
- 7 parameters

$$\frac{dz}{dt} = v - \frac{\sigma_0 |v|}{g(v)} z$$

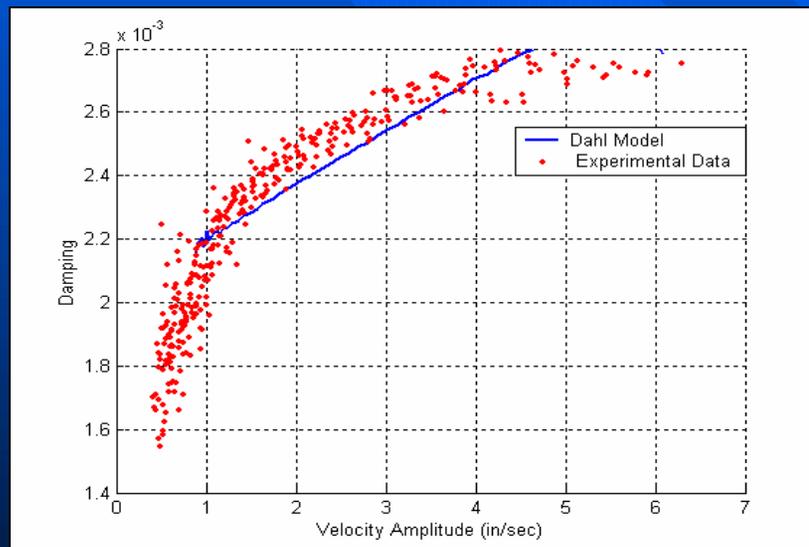
$$F = \sigma_0 z + \sigma_1 \dot{z} + \alpha_2 v$$

$$g(v) = \alpha_0 + \alpha_1 e^{-(v/v_0)^2}$$

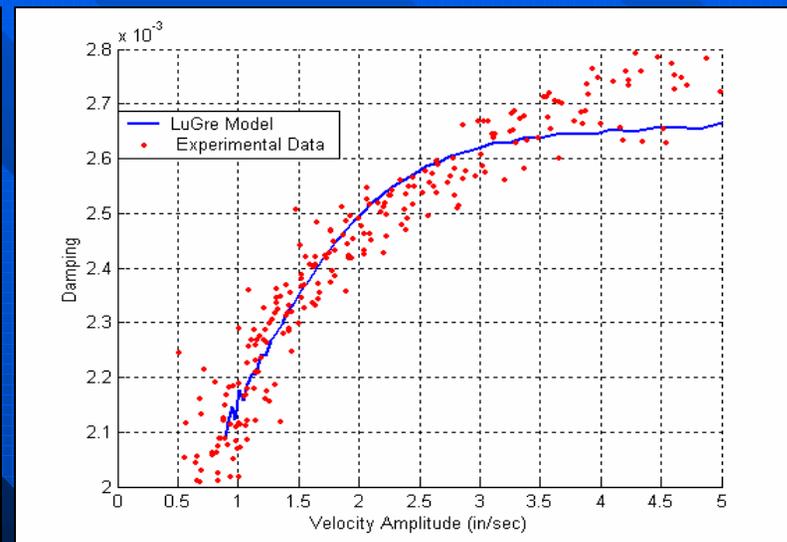
$$\sigma_1(v) = \sigma_1 e^{-(v/v_d)^2}$$

Analytical Model Results

- Adjust model parameters to fit the No Washer Experimental data



Dahl Model



LuGre Model

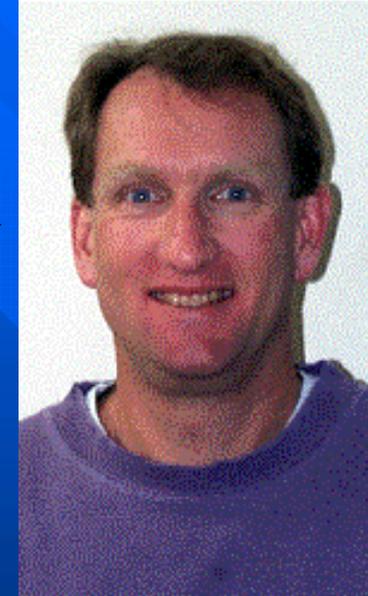
Conclusion

- Bolt damping is non-linear
- At low velocities, the damping factor increases with velocities
- Damping increases as a function of interface area

Acknowledgements

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Dr. Thomas Paez