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dlrg

# Damping of metallic wool with embedded rigid body motion amplifiers

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# What is metallic wool

- Metal filaments
- Porous material
- Homogenous
- Temperature insensitive

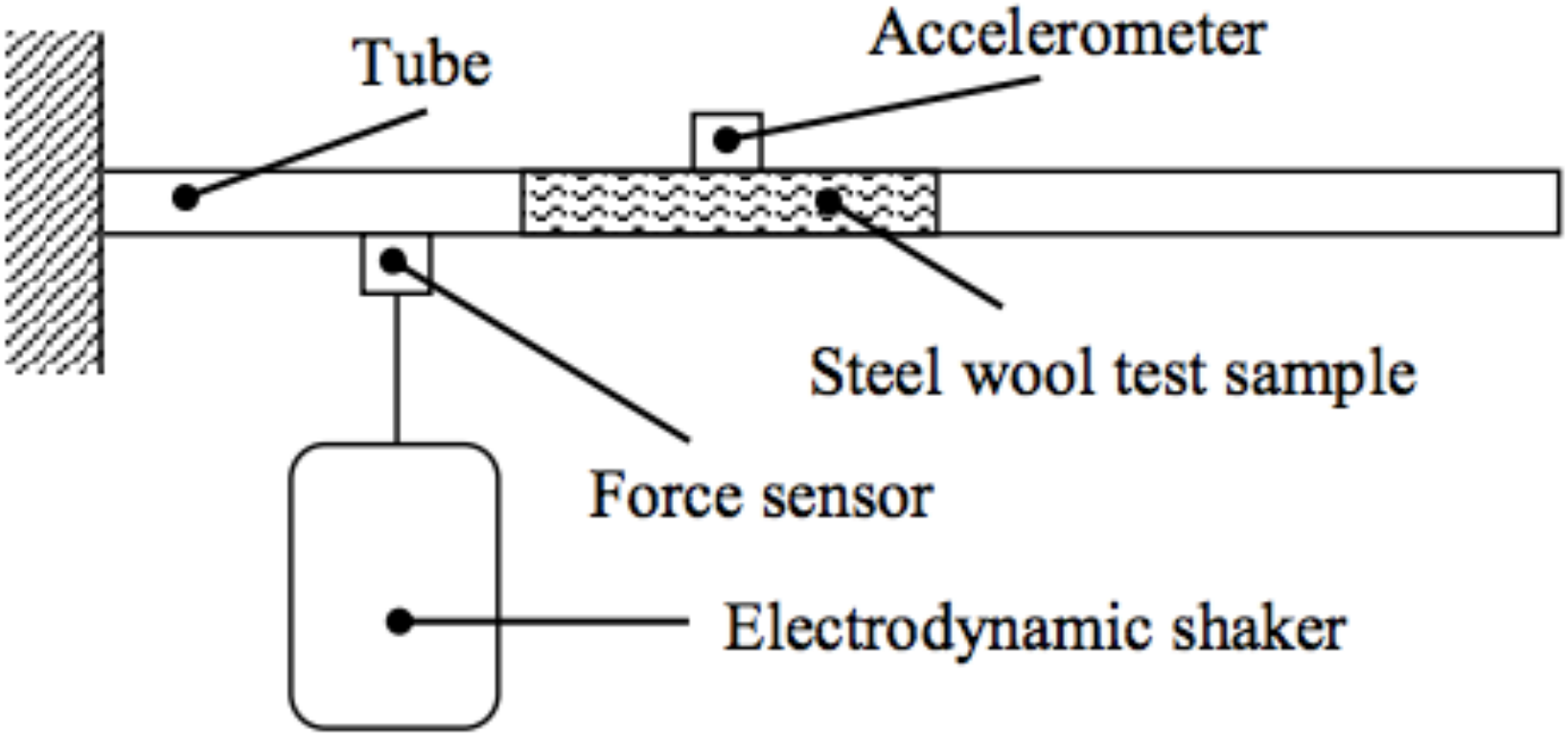
# Why to use steel wool as a vibration damper

- viscoelastic material
  - ✓ Damping varies with temperature
- porous metallic material
  - ✓ Tangled metal wire material
    - – Difficult to fabricate
  - ✓ Metal swarf
    - – Heavy weight and high additional volume
    - – Inconsistent stiffness and damping

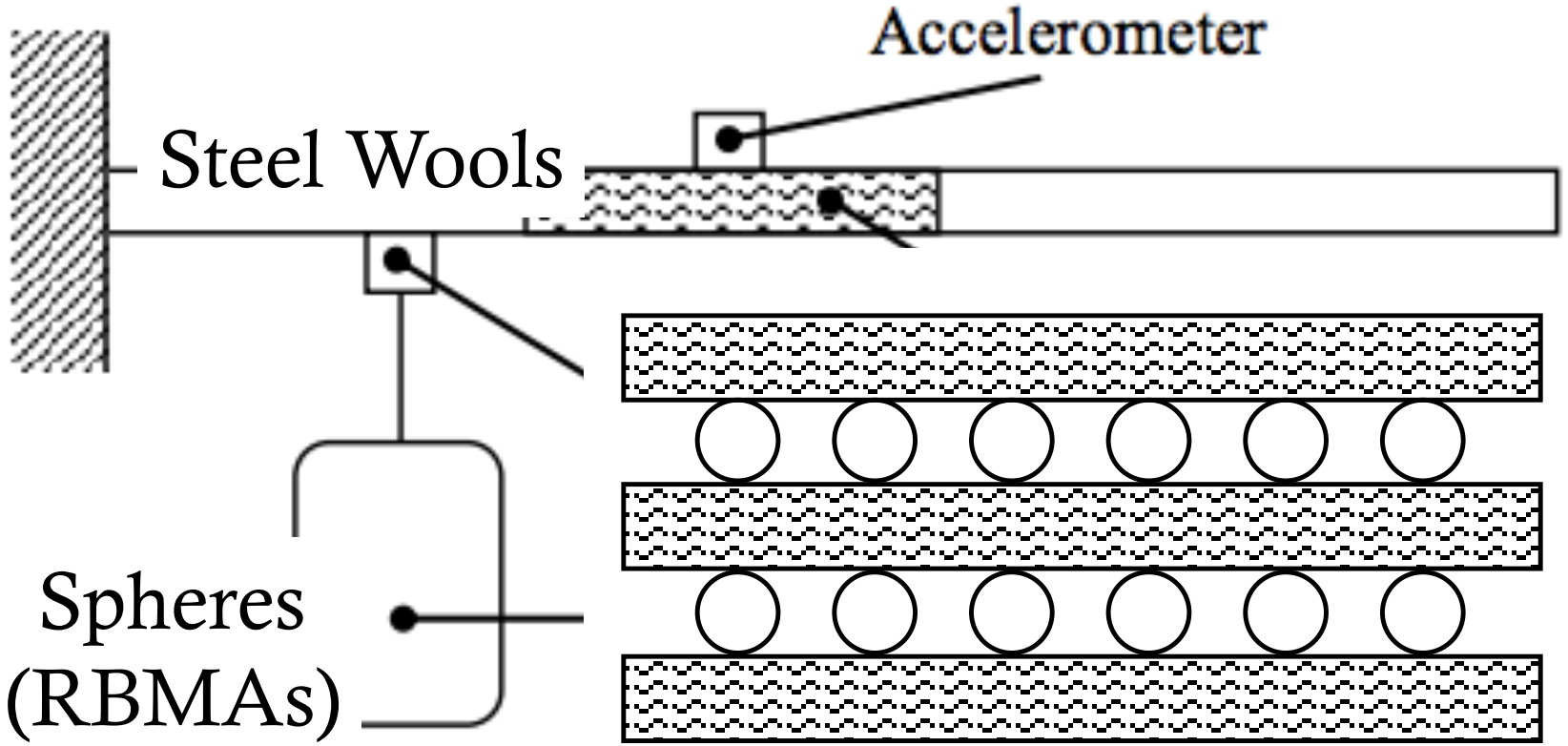
# Use steel wool as a vibrational damper

- Investigation of damping from steel wool
  - ✓ Effect of mode shape/strain wave
  - ✓ Effect of amplitude dependent nonlinearity
- Investigation of effectiveness of RBMAs
  - ✓ Different quantities and distributions
  - ✓ Different compaction / pre-stress levels
- Semi-analytical model
  - ✓ Modal Strain Energy method
  - ✓ Multiple Tuned Mass damper model

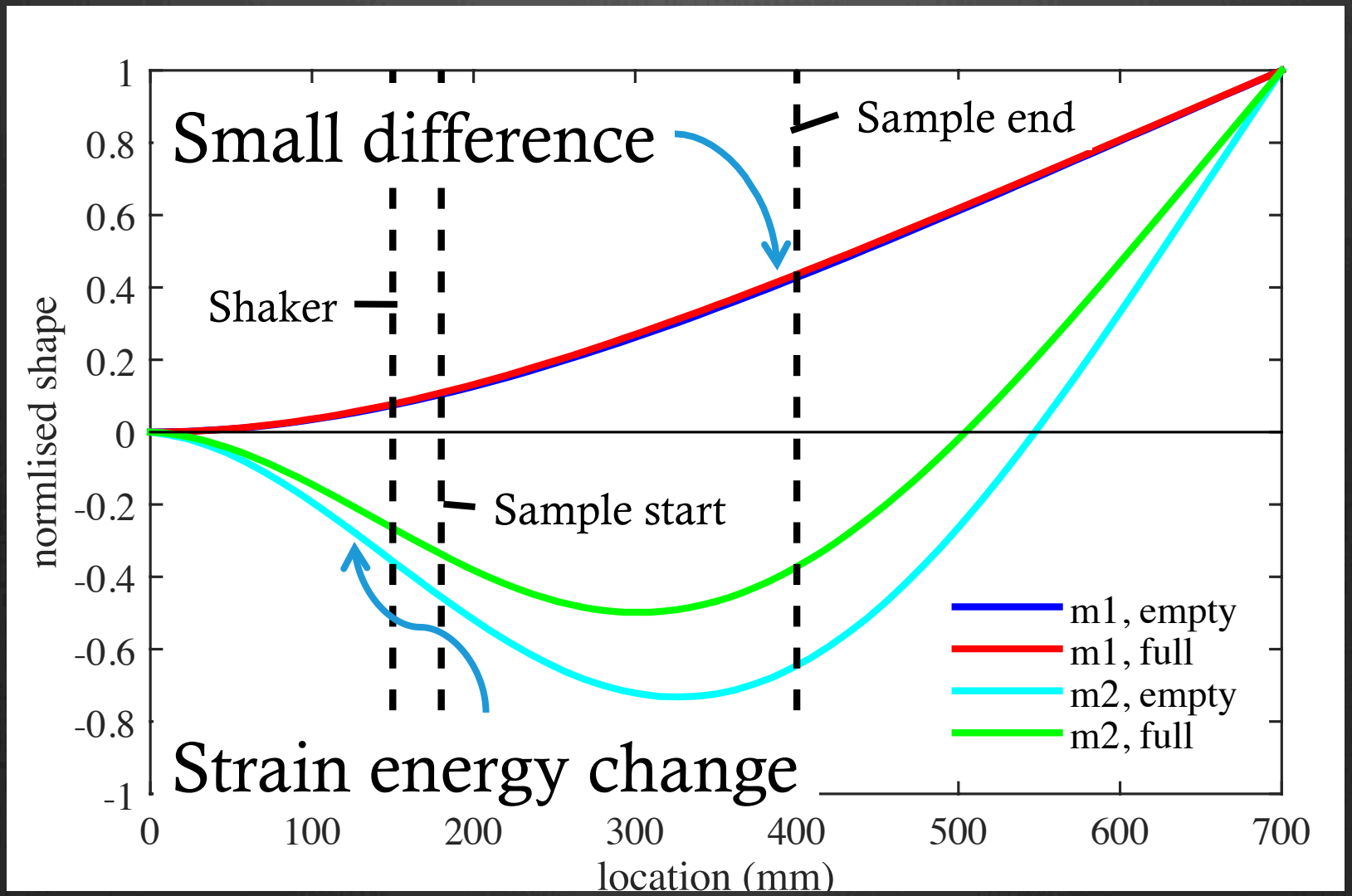
# How to use steel wool as a vibration damper



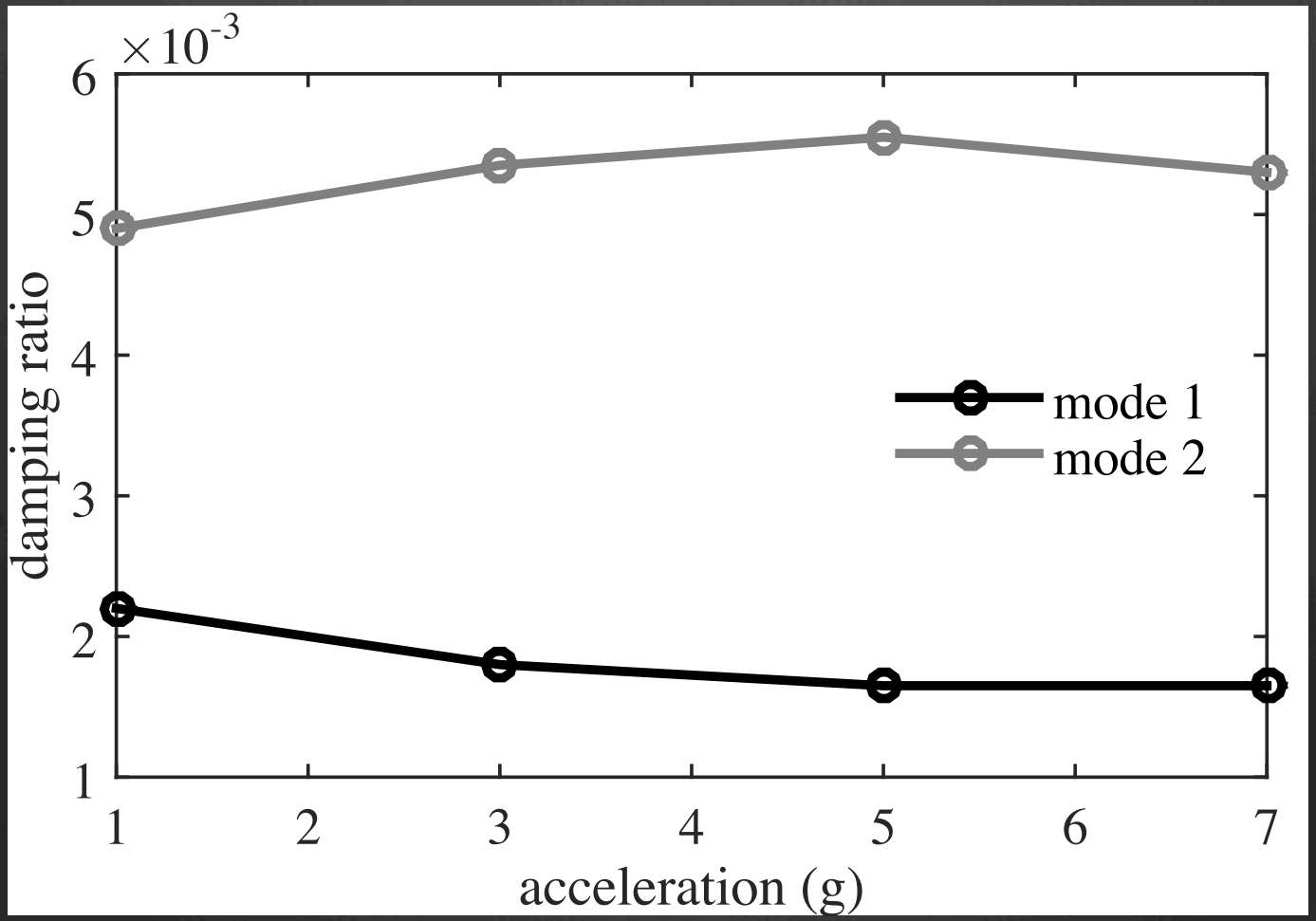
# How to use steel wool as a vibration damper



# Test Structure – background



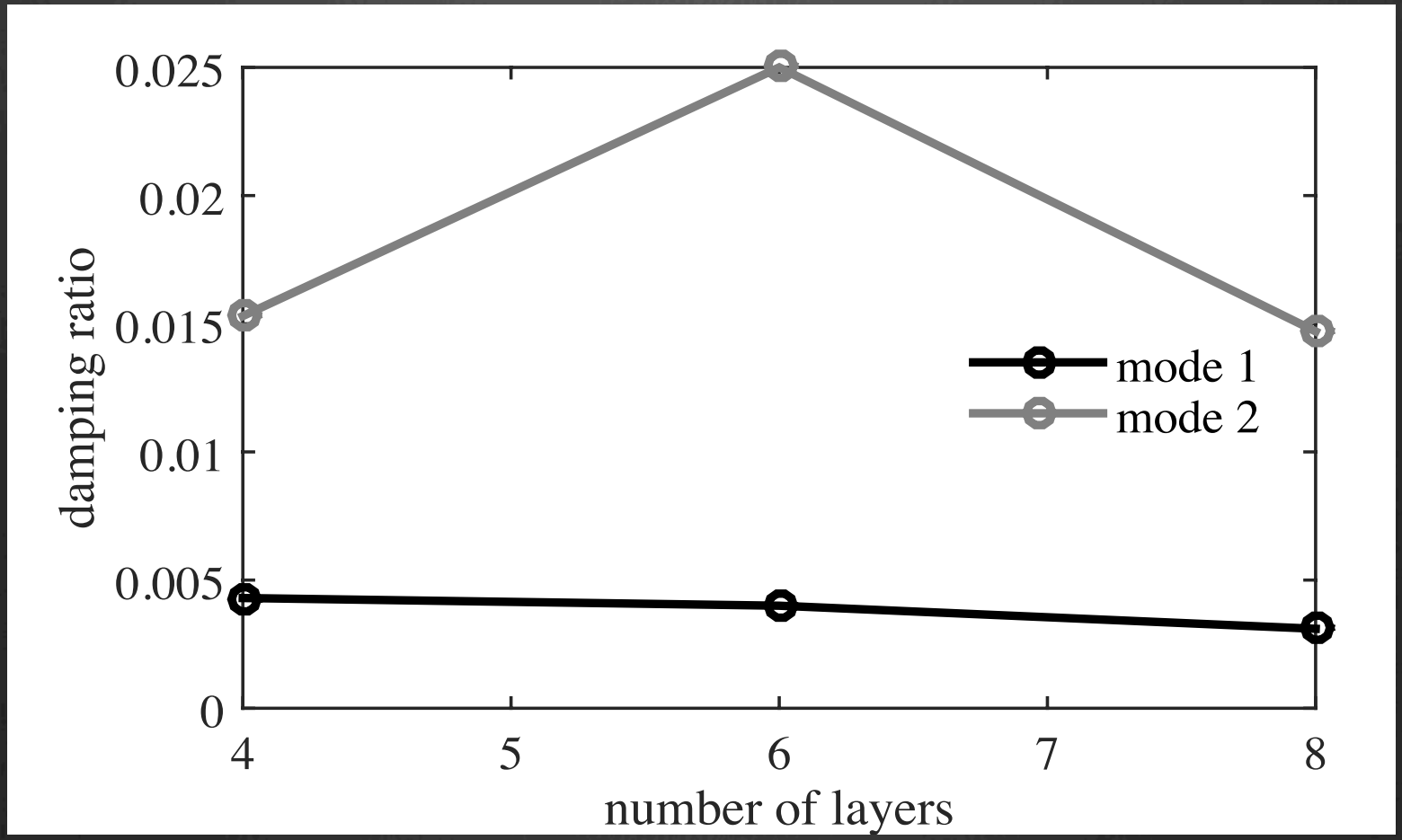
# Test Structure – background




- Natural frequencies does not vary with excitation amplitudes
- Damping fluctuation due to imperfect constraint.

# Damping from steel wool

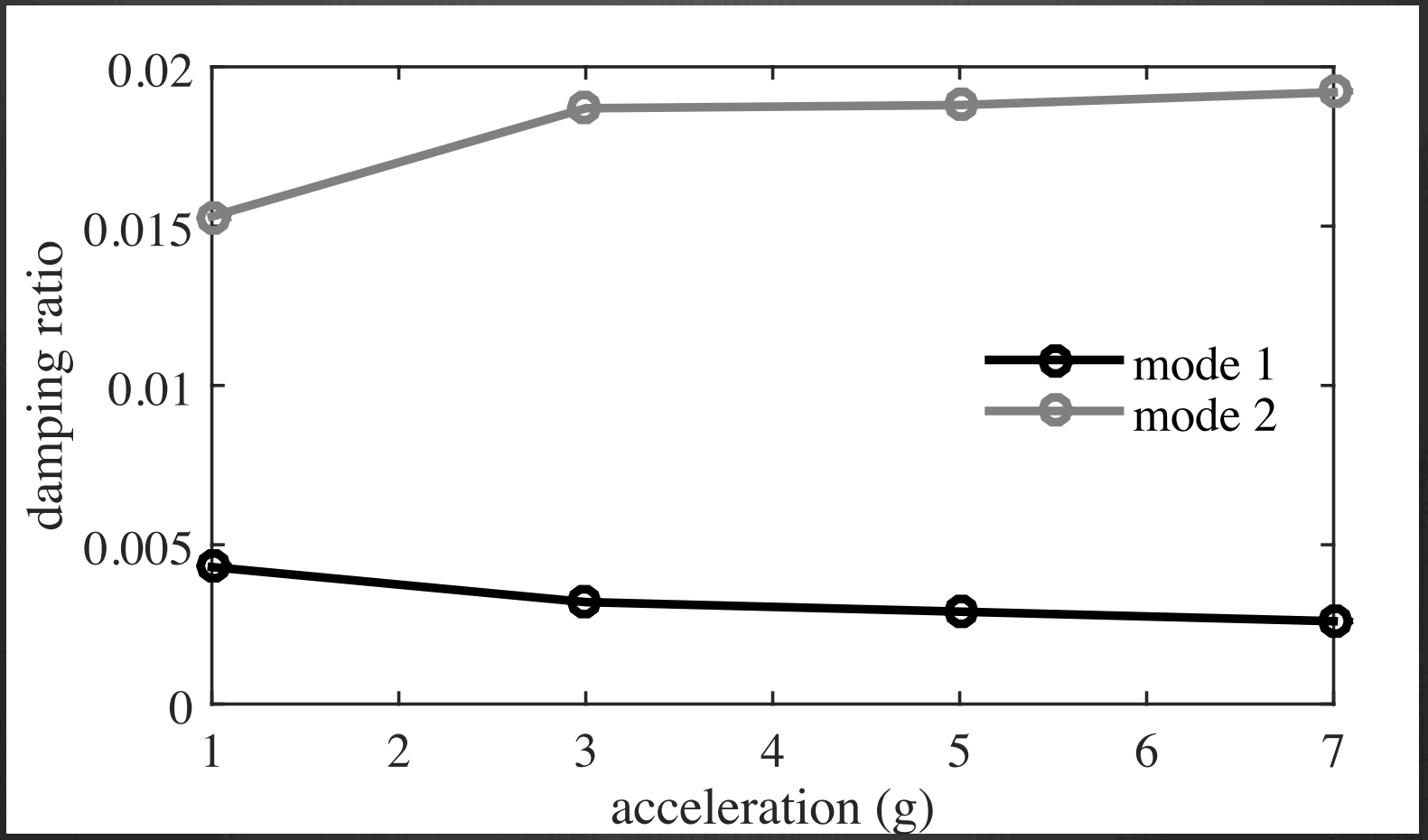
## Effect of pre-stress/compaction levels (1g)




- Natural frequencies does not vary with different compaction
- Damping for 1st mode ↓; for 2nd mode, 6-layer configuration ?

# Damping from steel wool

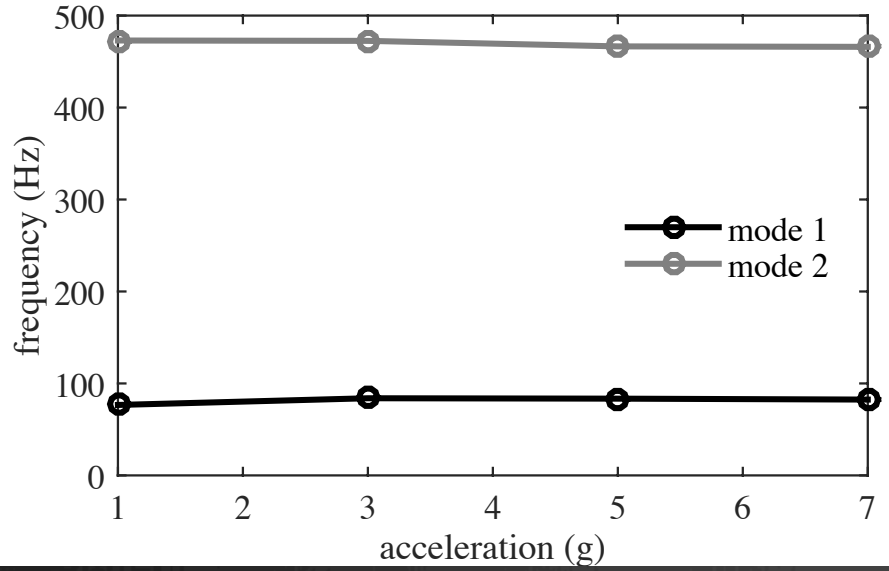
## Effect of excitation amplitudes (4 layer)

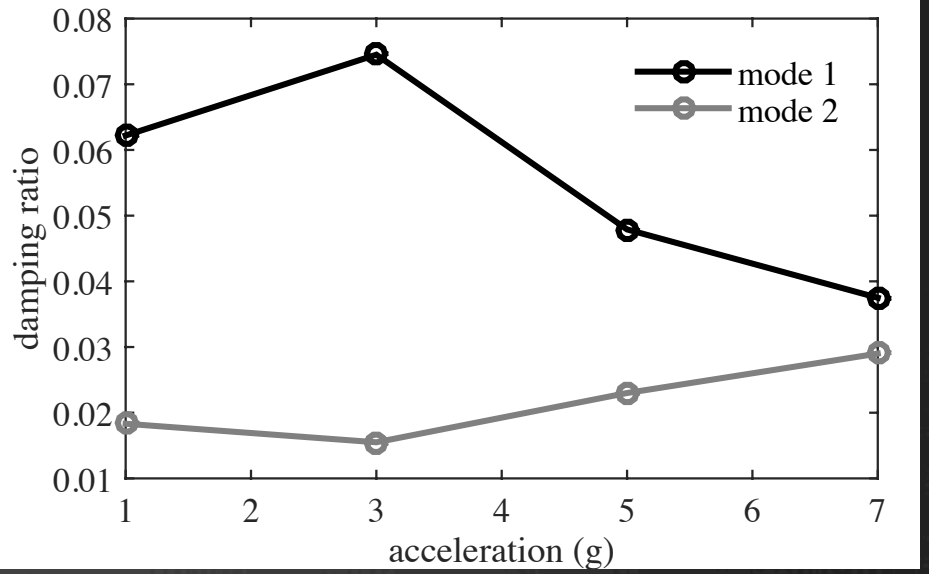



- Insignificant effect on natural frequencies for both modes
- Damping for 1st mode ↓; for 2nd mode ↑ ***SLIDING***

# Damping from steel wool with RBMAs

## Effect of excitation level

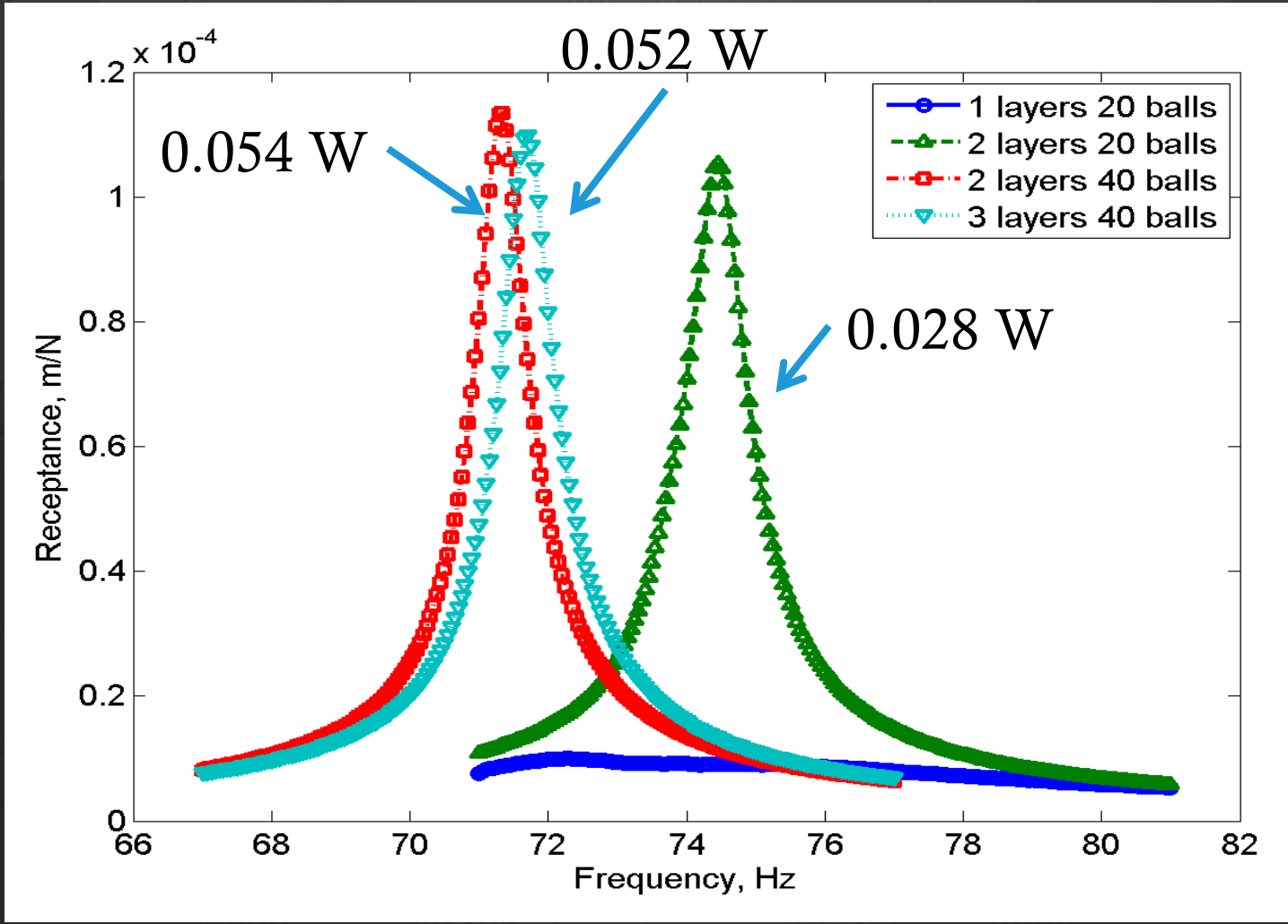



- ✧ Natural frequencies
  - ✓ ↑ for 1st mode, ↓ for 2nd mode
- ✧ Damping
  - ✓ 1st mode : ↑ up to 3g and then ↓ until 7g
  - ✓ 2nd mode : ↓ up to 3g and then ↑ until 7g
- ✧ Sloshing mode for rigid spheres

# Damping from Steel wool with RBMAs

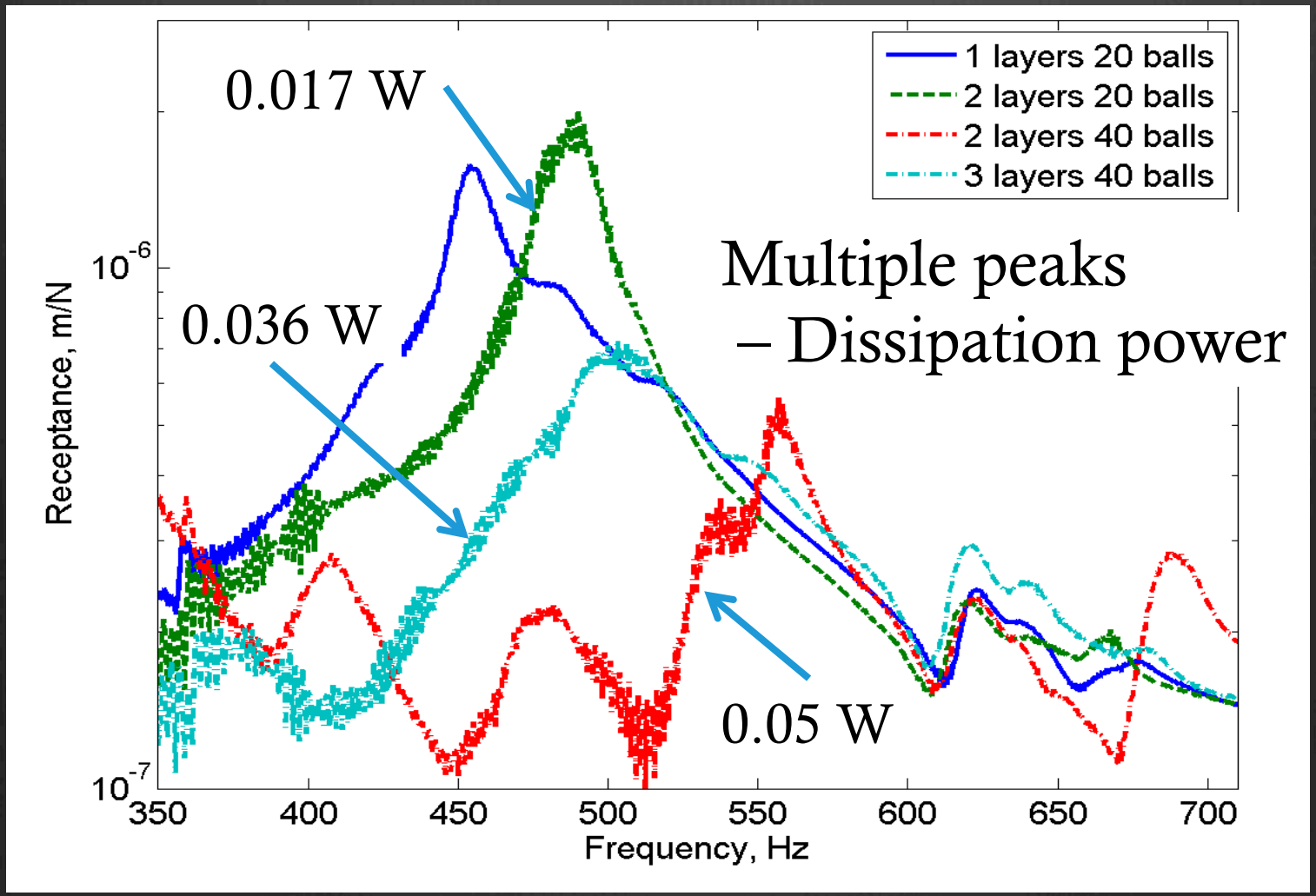
## Effect of RBMA quantities/distribution (1g excitation)




Mode 1

# Damping from Steel wool with RBMAs

## Effect of RBMA quantities/distribution (1g excitation)

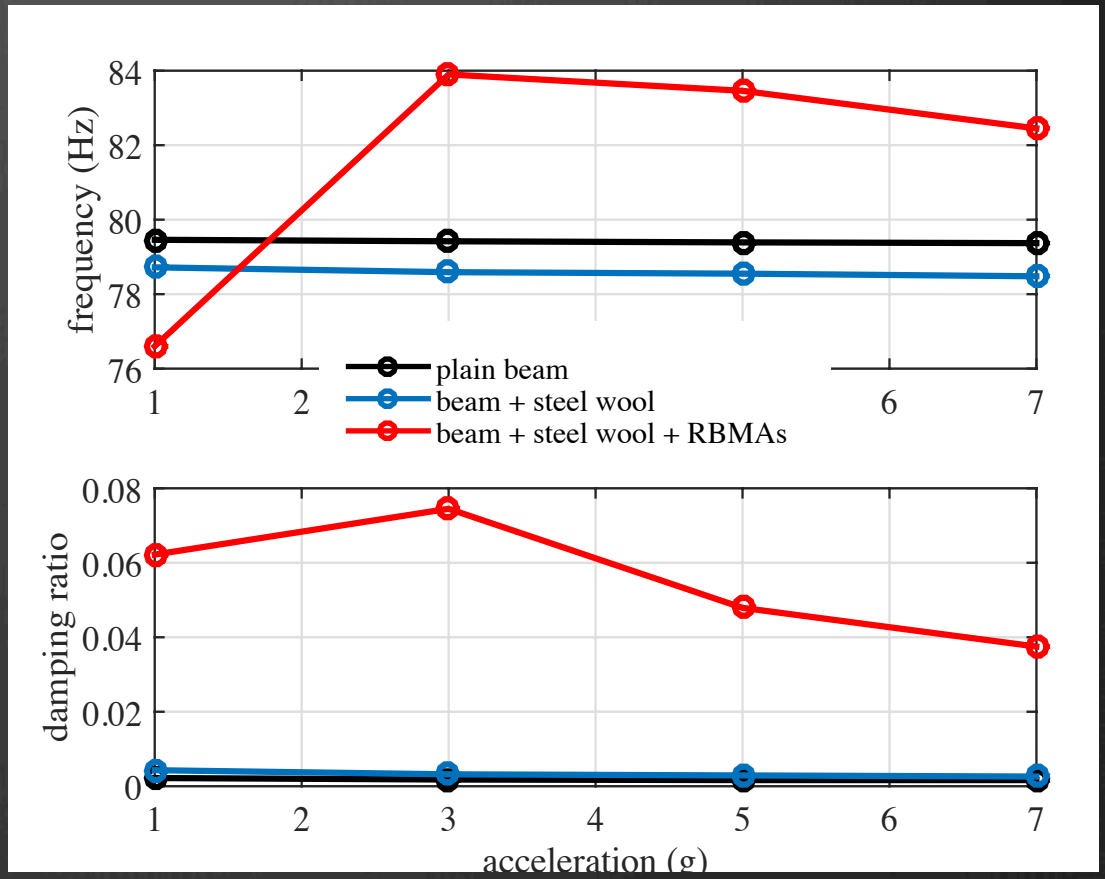



Mode 2

# Damping from steel wool with RBMAs

## Overall performance of RBMAs

- Natural frequency
  - ✓ steel wool → additional mass
  - ✓ locations of RBMAs
- Damping
  - ✓ steel wool → constant damping
  - ✓ internal resonance of RBMAs

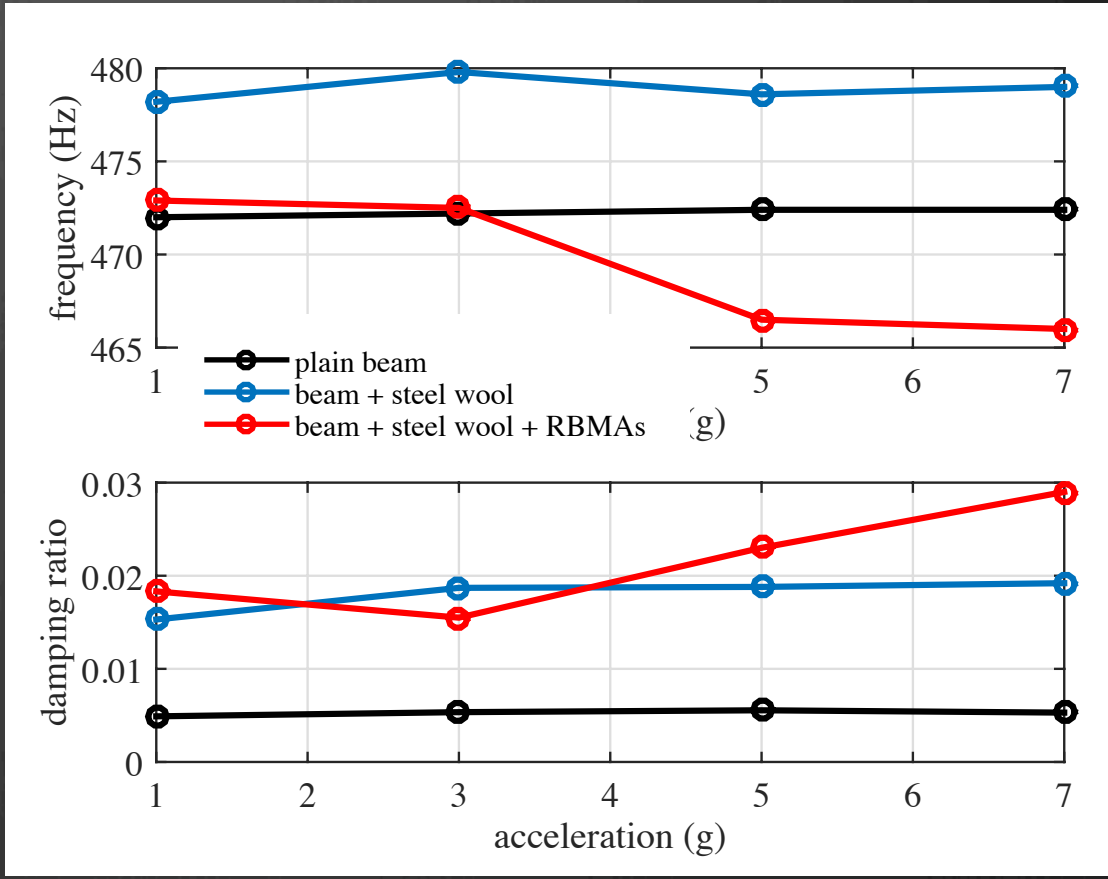



Mode 1

# Damping from steel wool with RBMAs

## Overall performance of RBMAs

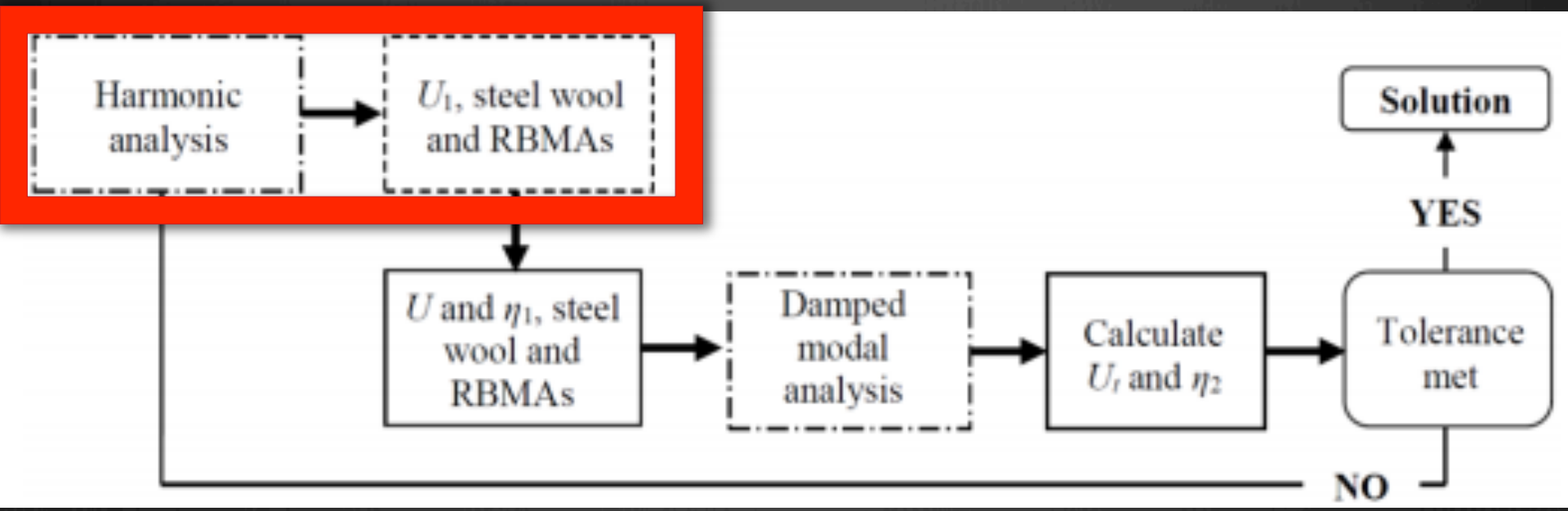
- Natural frequency
  - ✓ steel wool → structure stiffener
  - ✓ locations of RBMAs
- Damping
  - ✓ steel wool → constant damping
  - ✓ internal resonance of RBMAs




Mode 2

# Semi-analytical model

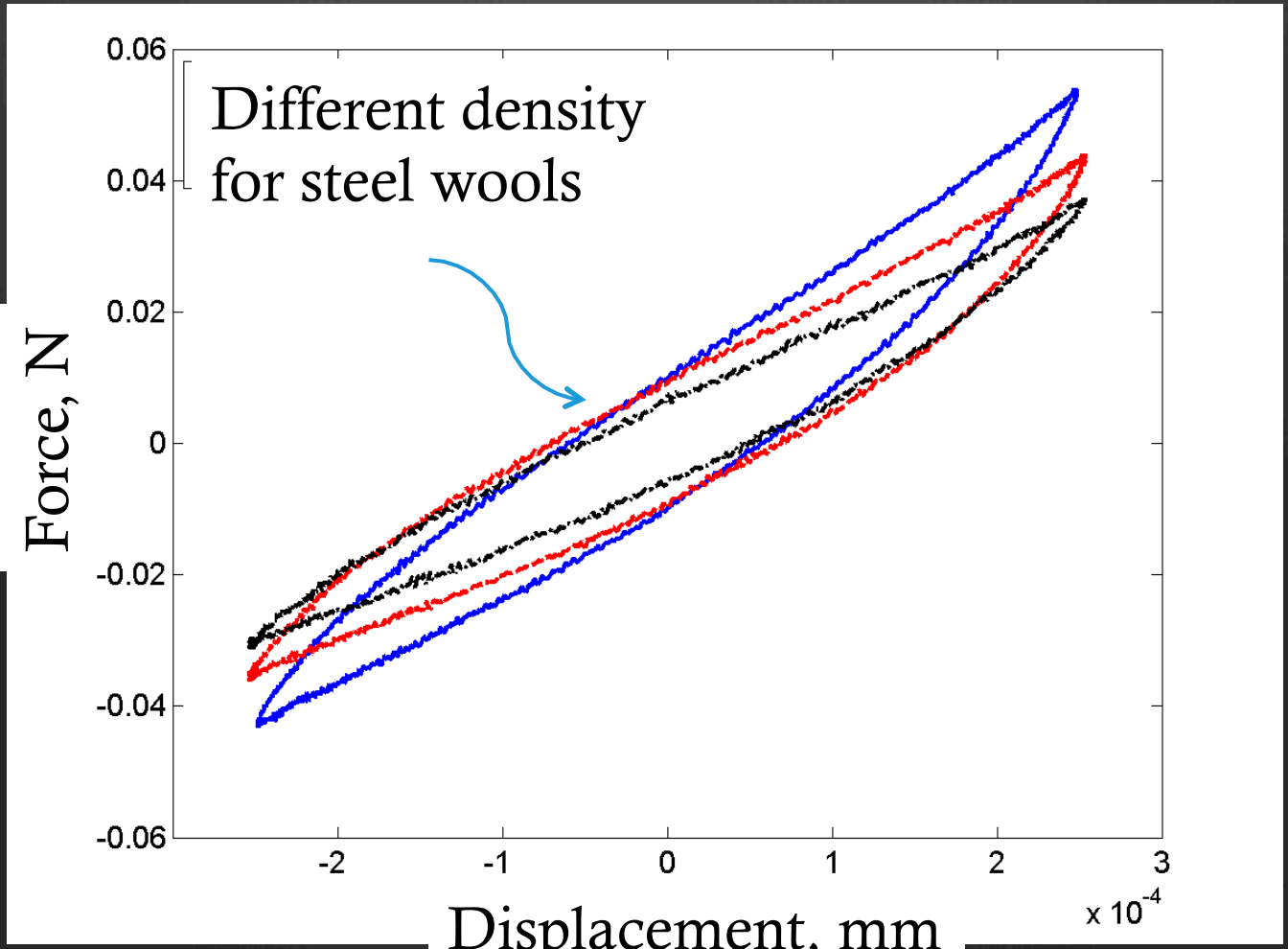
## Strategy




- ✧ Identify strain wave ➔ Total strain energy for steel wool.
- ✧ Using multiple TMD model to identify energy dissipation from Steel wool and RBMAs. (modal strain energy method)
- ✧ Insert updated strain energy of steel wool back to harmonic analysis

# Semi-analytical model

## Analytical model — elastic properties



# Semi-analytical model

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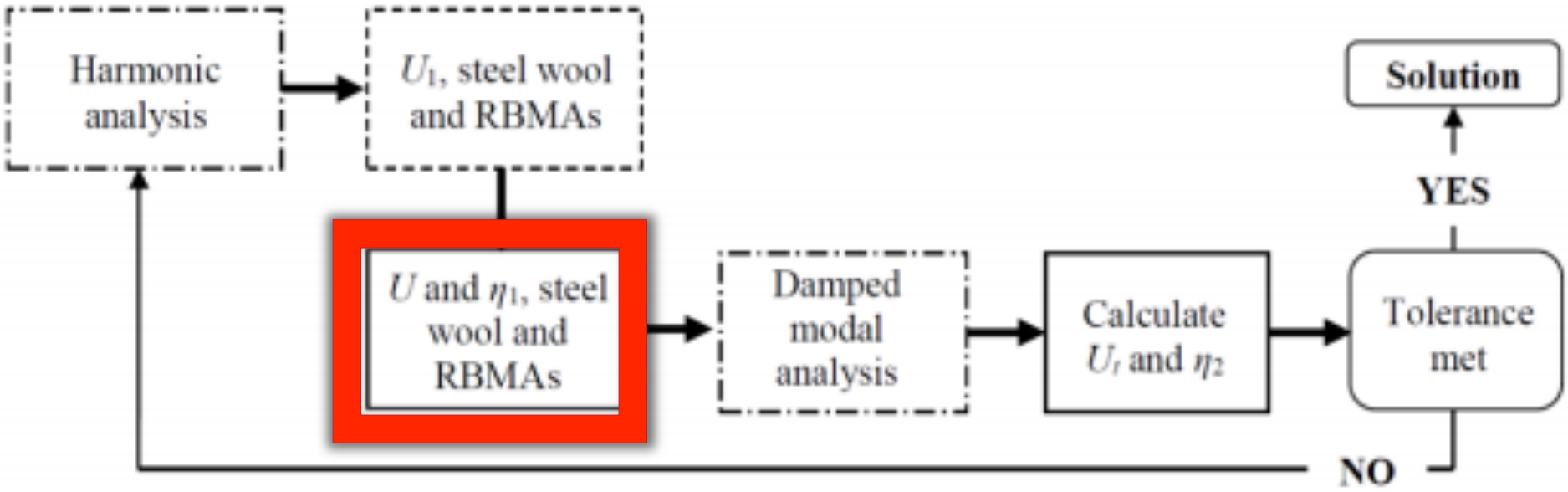


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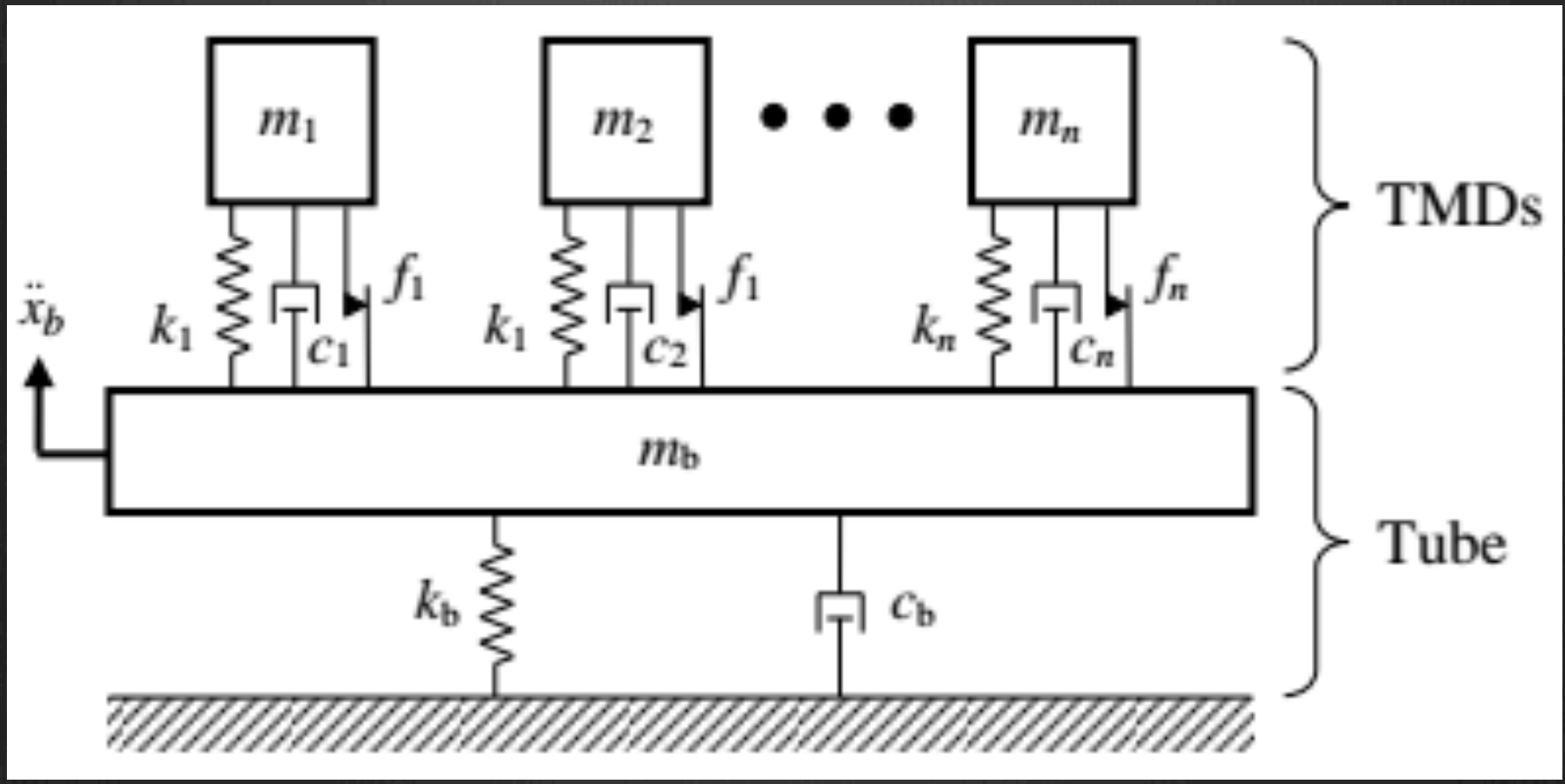
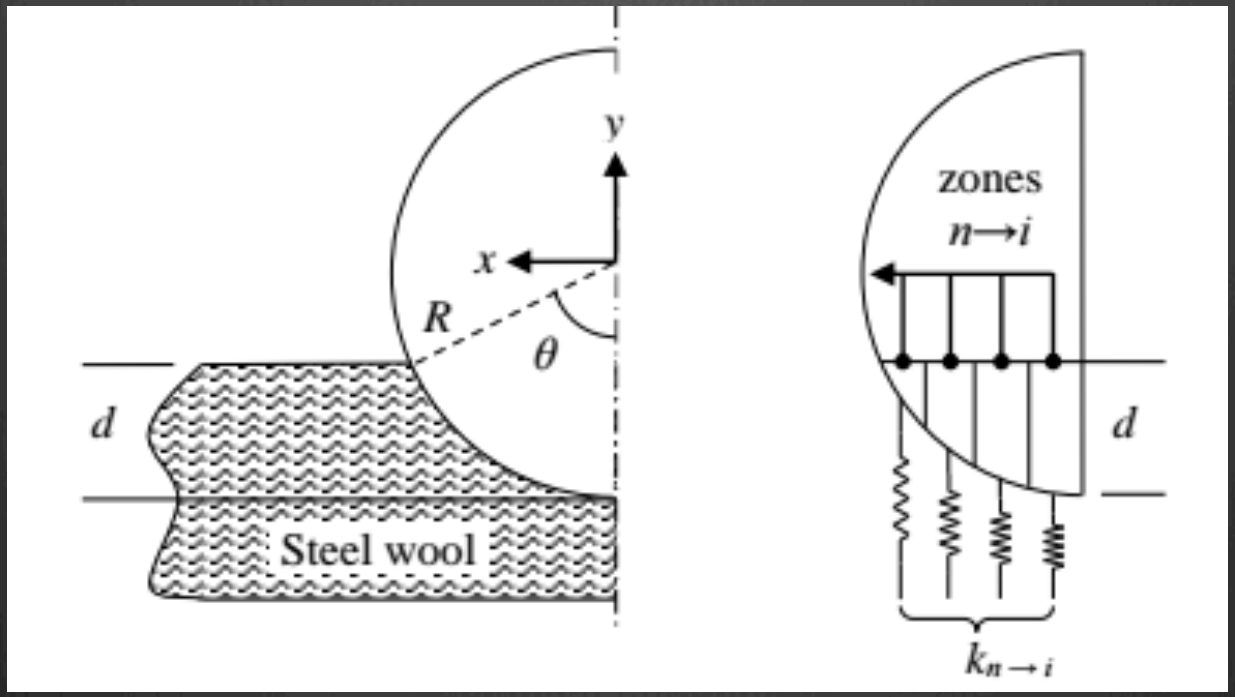
# Semi-analytical model

## Analytical model



# Semi-analytical model

## Analytical model

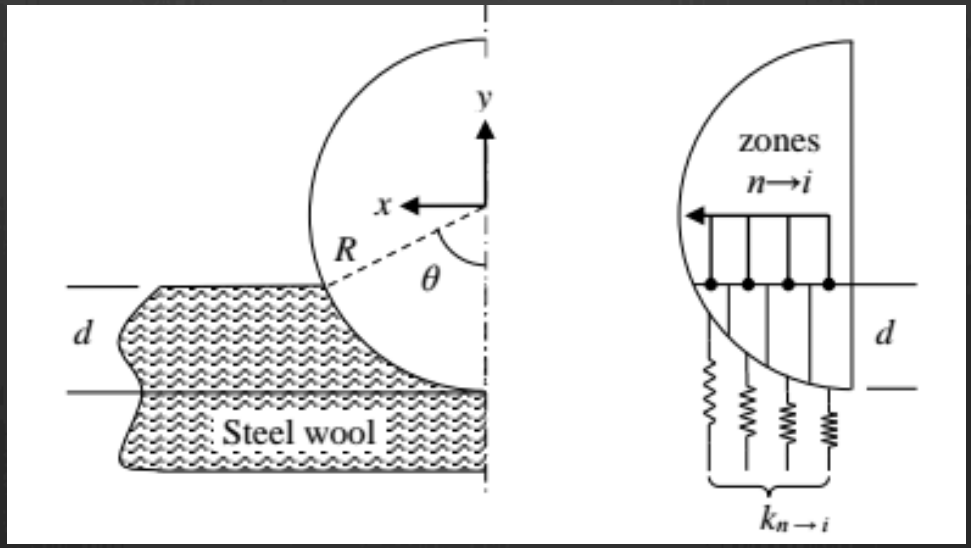



- Assumptions
  - ✓ RBMAs : Spherical and rigid ; Move normal to steel wool
  - ✓ Steel wool : isotropic and homogenous
  - ✓ No interaction between neighboring RBMAs

# Semi-analytical model

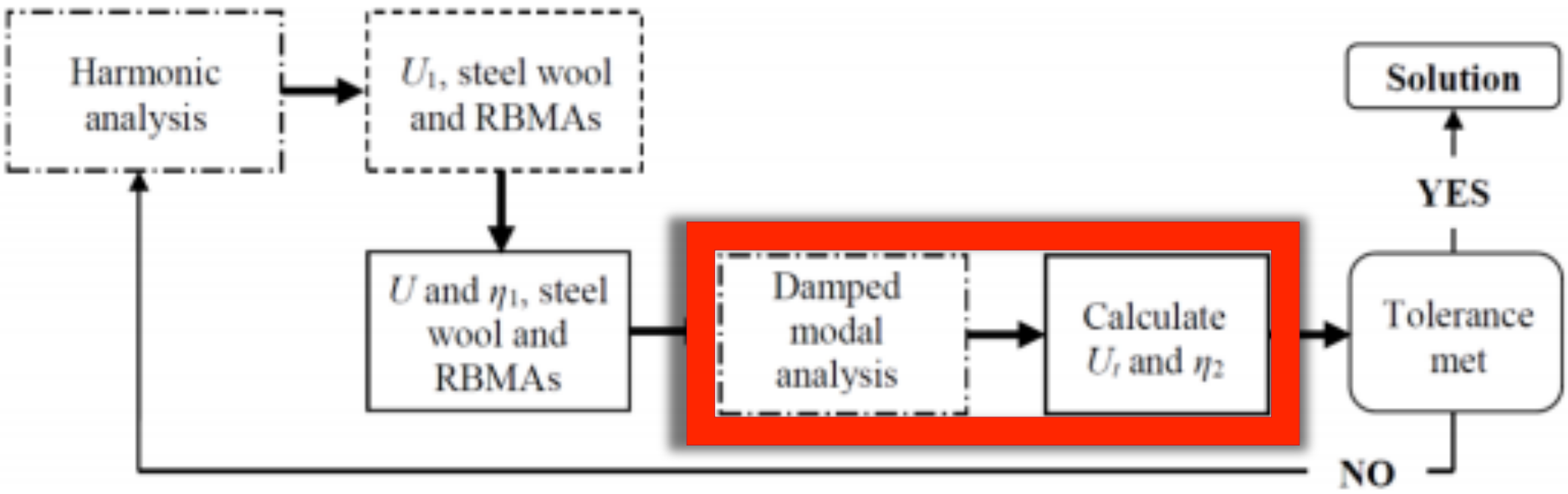
## Analytical model

- Procedures
  - ✓ Initial displacement was estimated using harmonic analysis
  - ✓ Force acting on steel wool by RBMAs was then calculated and compared with inertia force.
  - ✓ Iterations were carried out to achieve convergence between inertia force and displacement and then calculate strain energy



# Semi-analytical model

## Strategy




- ✧ Identify strain wave ➔ Total strain energy for whole system
- ✧ Using multiple TMD model to identify energy dissipation from Steel wool and RBMAs. (modal strain energy method)
- ✧ Insert updated strain energy of steel wool back to harmonic analysis

# Conclusion

- Steel wool was shown to be a good metallic damping medium
- RBMA showed a significant improvement on the energy dissipation of steel wool
- Semi-analytical numerical model was established to predict the performance of steel wool with RMBAs.

Thanks for your attention.
Any questions?