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Performance-Based Design Procedures for Novel Semi-Active Cladding Connection Applied to Blast Mitigation

Objective

- Design a damping system to against and dissipate a blast load.
- Create a design procedure to determine dynamic parameters of a cladding connected a damping system.

Problem Statement

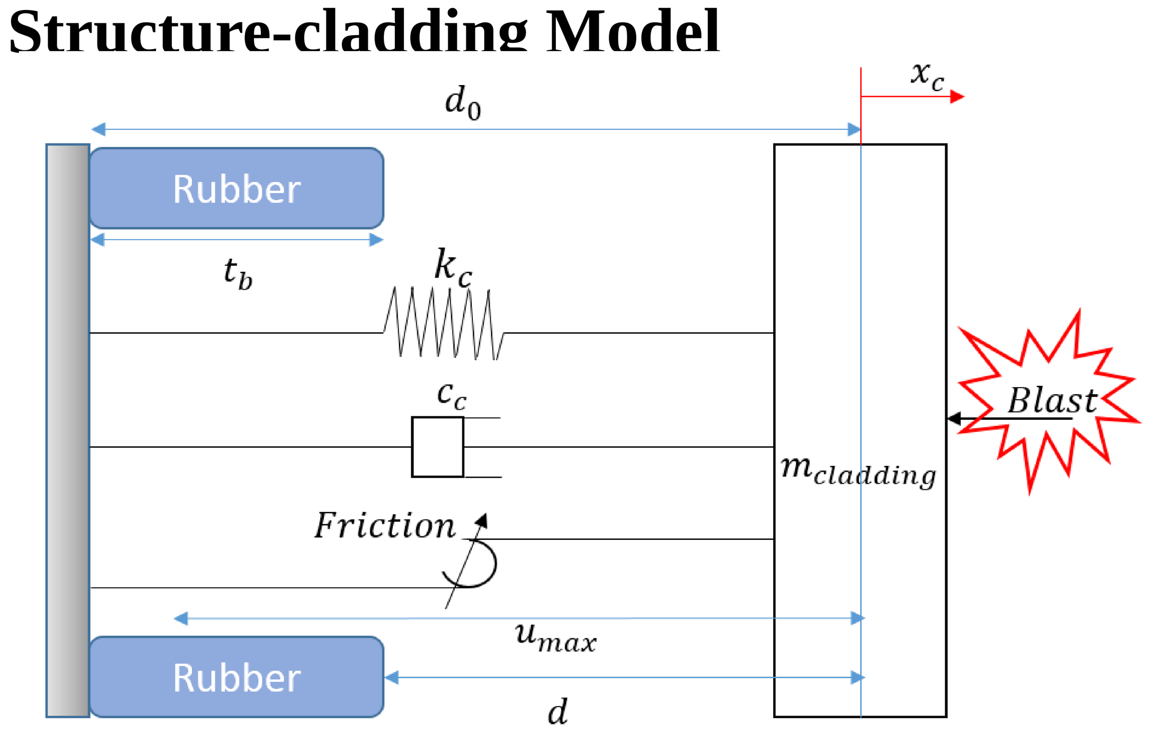
- Multi-functional cladding is considered to replace conventional cladding
- Semi-active device will provide variable force on resistance
- A maximum energy dissipation can be generated in a passive mode

Approach

- Design the performance-based design (PBD) mode.
- Derive governing design equations of cladding and control system.
- Validation of PBD procedure.

Structure-cladding Model

SDOF Structure



- Mass of cladding, m_c
- Stiffness of cladding, k_c
- Damping coefficient, c_c
- Friction, F_c
- Rubber thickness, t_b
- Interspace between cladding and structure, d_0
- Interspace between cladding and rubber bumper, d
- The maximum deflection cladding will be, u_{max}

Figure 1: *Structure-Cladding System of SDOF*

2DOF Structure

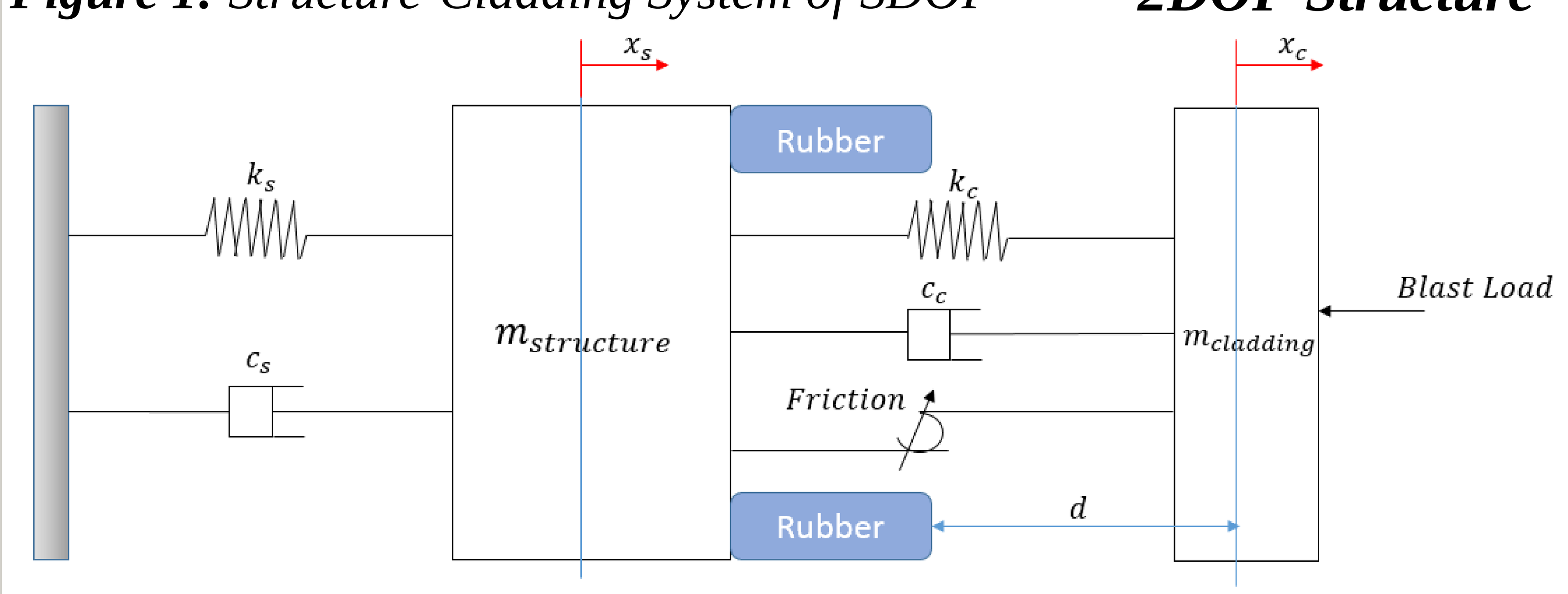


Figure 2: *Structure-Cladding System of 2DOF*

Methodology

The equation of motion for SDOF model:

$$m_{cladding}\ddot{u}(t)+c_c\dot{u}(t)+k_c u(t)+F_c+F_{rubber}=F_{blast}$$

where F_c is the friction, F_{rubber} is the force caused by rubber bumper, F_{blast} is the external lateral blast.

Analytical Solutions:

$$u_3(t) = e^{-\xi_r\omega_n t}\left[\left(u(T)-\frac{-F_c}{K_c}\right)\cos\omega_{dr}t+\frac{\dot{u}(T)+(u_0-\frac{-F_c}{K_c})\xi_r\,\omega_n}{\omega_{dr}}\sin\omega_d t\right]+\frac{-F_c}{K_c}\quad t\gg T$$

where T is the Moment when cladding touches the rubber bumper

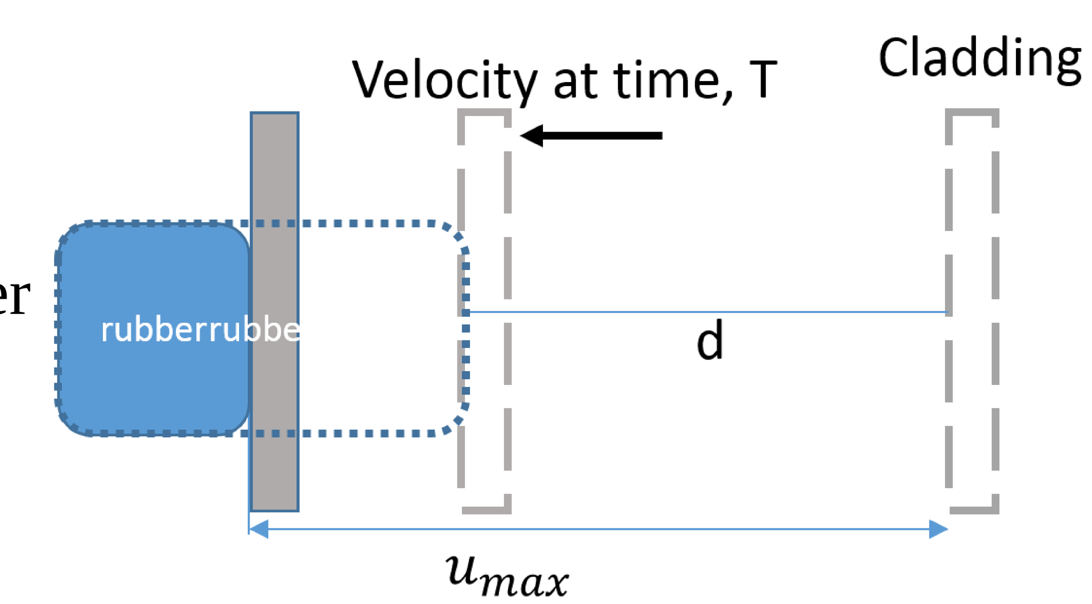


Figure 3: *Vibrating of rubber bumper*

Validating on Simulation

- State Space method
- Comparing Analytical and Numerical method (SDOF)

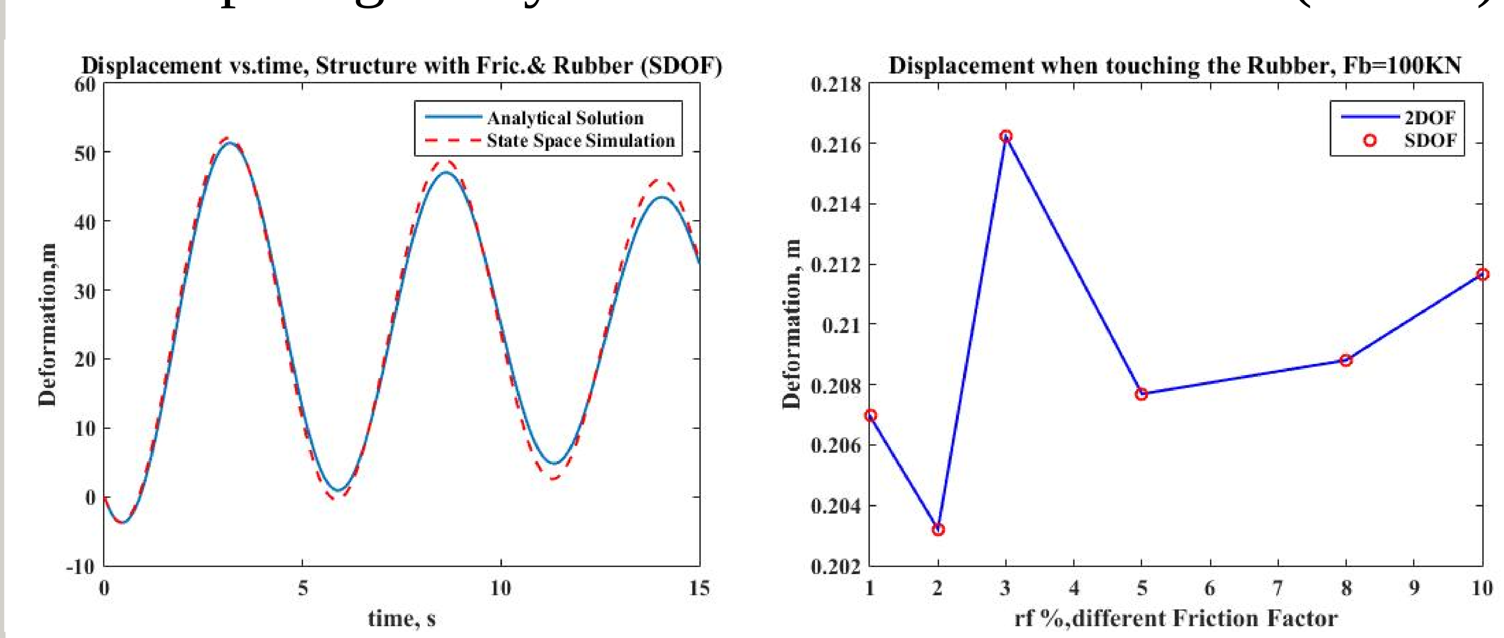


Figure 4: *(a) Comparison results by analytical and numerical method (b) Comparing maximum displacement by SDOF and 2DOF*

PBD Procedure

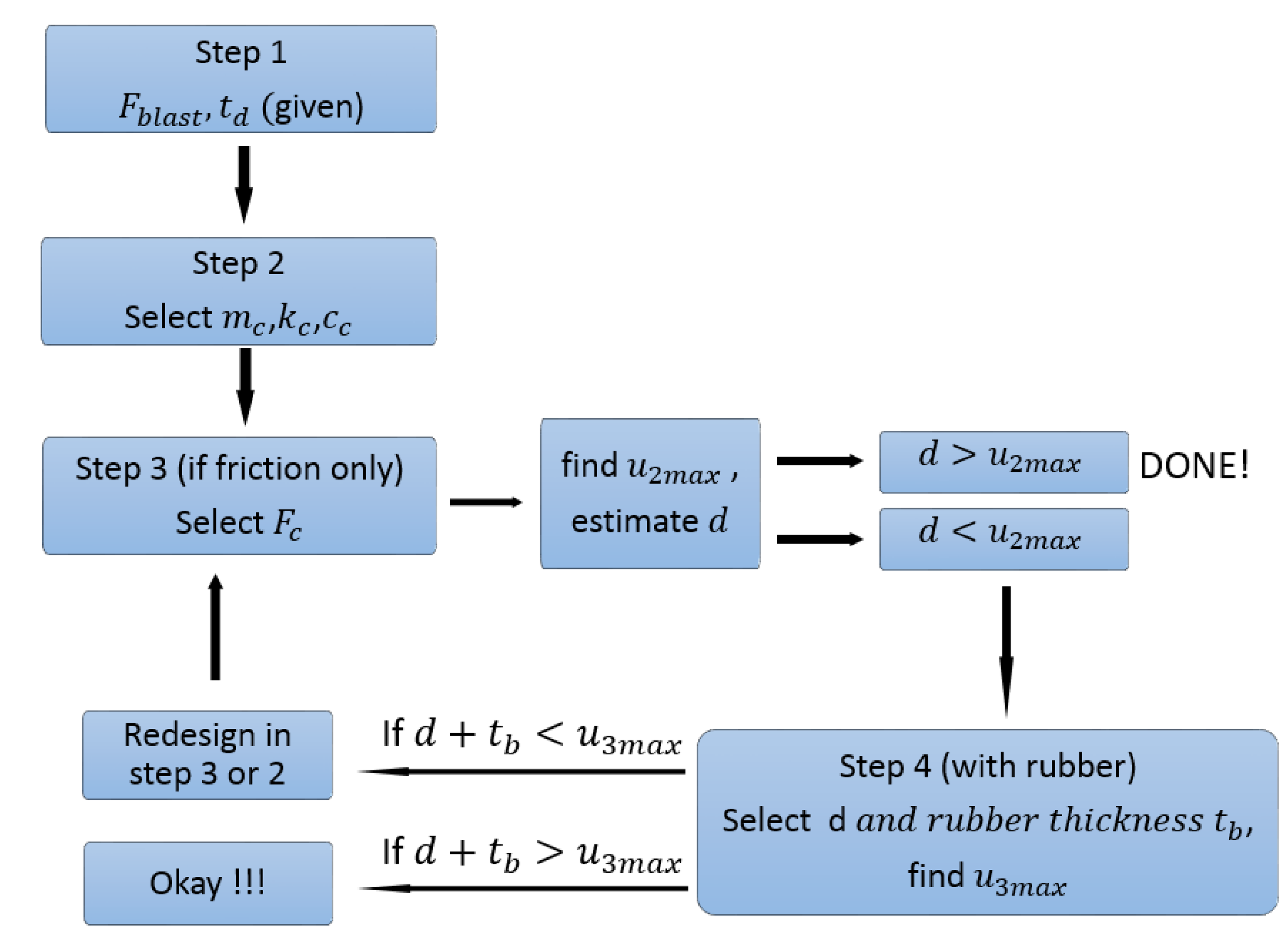
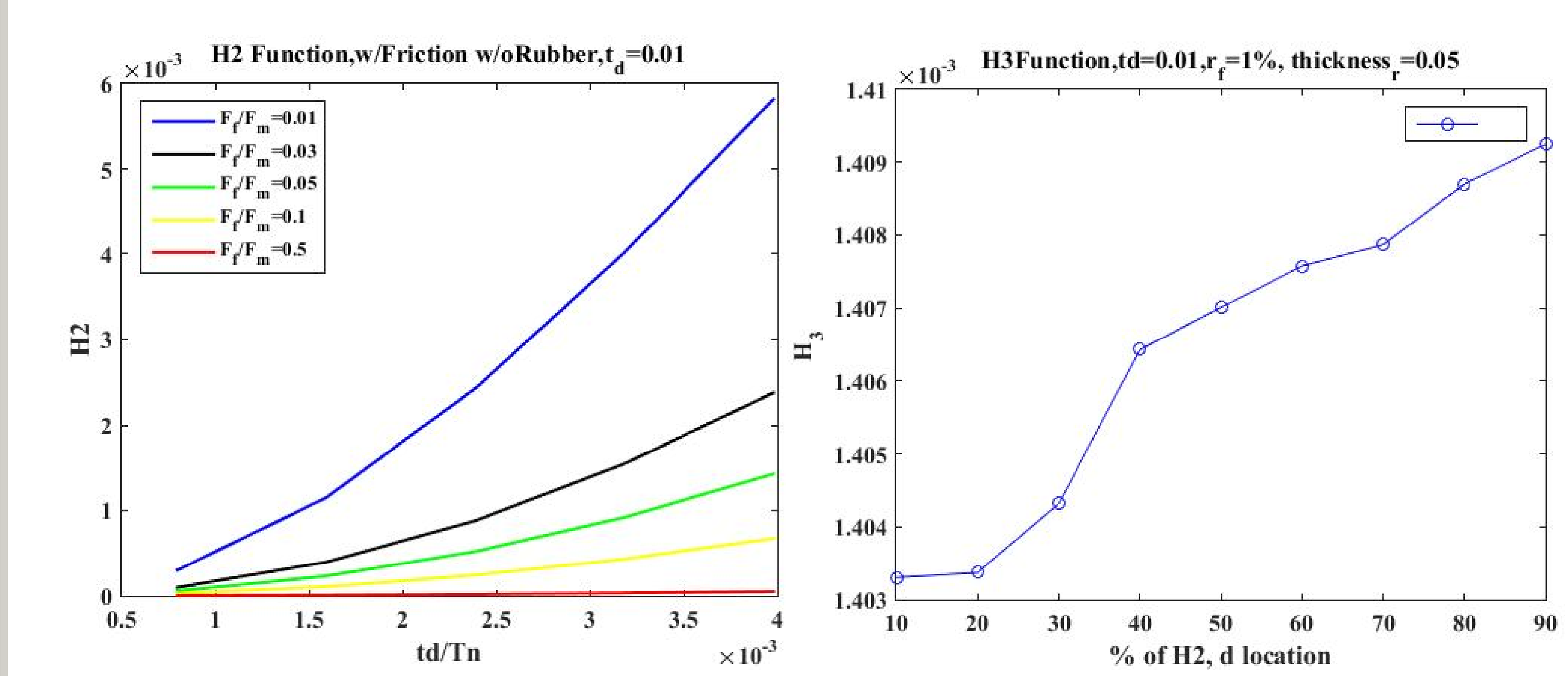


Figure 5: *Design flowchart*

- $H_2=\frac{u_{2max}}{u_{st}}$, $H_3=\frac{u_{3max}}{u_{st}}$, where u_{st} is $\frac{F_m}{K_C}$, static deformation



Conclusion

- Results obtained from analytical solutions are similar to results from numerical simulations.
- PBD procedure is validated, and it can also applied for 2DOF structure.
- Future work is to extend to semi-active functions