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, $F_f$
- Rubber thickness, $t_p$
- Interspace between cladding and structure, $d_a$
- Interspace between cladding and rubber bumper, $d$
- The maximum deflection cladding will be, $u_{\text{max}}$

2DOF Structure

Methodology
The equation of motion for SDOF model:

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

where $F_f$ is the friction, $F_{\text{rubber}}$ is the force caused by rubber bumper, $F_{\text{blast}}$ is the external lateral blast.

Analytical Solutions:

$$ u_3(t) = e^{-F_f/K_c} \left[ -F_c/K_c \cos \omega_d t + \frac{\dot{u}(0) + \frac{F_c}{K_c} \omega_d}{\omega_d} \sin \omega_d t \right] + \frac{F_c}{K_c} t \gg T $$

where $T$ is the Moment when cladding touches the rubber bumper

Validating on Simulation
- State Space method
- Comparing Analytical and Numerical method (SDOF)
- Validating on 2DOF

PBD Procedure

1. $F_{\text{blast}}, F_f$ (given)
2. Select $m_c, k_c, c_c$
3. (if friction only)
   - Select $F_c$
   - find $u_{\text{max}}$, estimate $d$
   - $d > u_{\text{max}}$ DOBE!
   - $d < u_{\text{max}}$
4. (with rubber)
   - Select $d$ and rubber thickness $t_p$, find $u_{\text{max}}$

$$ H_1 = \frac{u_{\text{max}}}{u_{\text{stat}}} \quad H_2 = \frac{u_{\text{max}}}{u_{\text{stat}}} $$

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