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Title of the Thesis: Walls, their Performance under Different Blast Scenario

FINDINGS

This research work ameliorates the understanding of the blast load-carrying mechanism of the URM wall and investigates certain techniques to protect the wall from severe damage. For this purpose, out-of-box techniques using (1) steel angle-strip system, (2) laminate of C-FRP, (3) coating of ultra-high-strength concrete, and (4) foams of polymer and metals, have been considered on the wall surface. ABAQUS software with various inbuilt material constitutive models has been employed for the numerical analyses.

The findings of this work will pave the way for new considerations to be considered by engineers to retrofit the URM walls against high-intensity blast waves.

➢ ***General conclusions***

- Maximum reflected pressures at the mid-height level of the un-strengthened monolithic braced URM wall at two considered scaled distances of explosion (i.e., 2.19 m/kg$^{1/3}$ and 1.83 m/kg$^{1/3}$) computed using the ABAQUS inbuilt ConWep blast program are within 1% of the measured values reported in the reference experimental study (Badshah et al., 2021). Also, the computed pressures are in good agreement with the predictions of Wu and Hao (2005) empirical blast model.
- Fine-scale numerical model of the braced monolithic URM wall developed using continuum and cohesive elements accurately predicts the out-of-plane response of the wall under the considered close-in blast loading. Computational results are within 2% of the observed ones reported by Badshah et al. (2021).
- Monolithic junctions of main and bracing walls are subjected to a complex state of stress and are instrumental to control the overall damage under the blast. Damages to the unprotected URM braced monolithic wall are observed in the form of (i) vertical cracks in the main and bracing walls adjacent to their joints, (ii) failure of bed joints of the lower courses of the main wall, (iii) interface bond rupture of the bricks and mortar at the topmost course of the main wall, and (iv) diagonal cracking in the lower part of the transverse bracing walls, under the maximum reflected pressure of 0.38 MPa at a scaled distance of 2.19 m/kg$^{1/3}$. Main as well as transverse walls collapse catastrophically under the reflected pressure of 1.01 MPa at scaled distance 1.83 m/kg$^{1/3}$. Bond rupture at the level of the top courses of the bricks owing to the free-boundary conditions produces large displacement (>> 230 mm = wall thickness).

➢ ***Specific conclusions***

- A slight decrease in the scaled distance of explosion from 2.19 m/kg$^{1/3}$ to 1.83 m/kg$^{1/3}$ alters the mode of failure of the un-strengthened wall from flexure-shear to out-of-plane catastrophic collapse shows that the wall response is highly influenced by the scaled distance.
- The non-monolithic joints between the main wall (i.e., exposed wall) and transverse bracing walls reflect a higher degree of damage to the bracing walls, which is governed by the response of the main wall, revealing that bracing walls with non-monolithic joints do not effectively contribute to minimizing the blast load effects.
- Wall having monolithic connectivity with bracing walls against the scaled distance without collapse, the monolithic connections majorly contribute to curbing the damage and displacement of the wall.
- Severity order of the damage to the strengthened monolithic URM braced walls under the maximum considered explosive load of 7.49 kg-TNT at scaled distance 1.83 m/kg$^{1/3}$ described in Appendix C (Figure C9) shows that the wall strengthened with 18 mm thick titanium foam on both faces displays the most outstanding performance with regards to displacement (3.09 mm), damage (11.42 J), and cracking (no cracks). Higher Young's modulus and inelastic stiffness characteristics of the crashworthy foam contribute to dissipating more explosion energy and improve the wall resistance against blast load.