Cities on Volcanoes 9
November 20-25, 2016
Puerto Varas, Chile
'Understanding volcanoes and society: the key for risk mitigation'

Cannon Experiments Quantify Building Vulnerability to Ballistic Impacts

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Key words: Ballistics, Vulnerability, Fragility Functions, Life Safety

Ballistic block and bomb impacts from a number of recent eruptions, in some cases with very short or no useful warning, have led to a number of casualties and building damage. This has heightened the need for effective assessment and management of ballistic risk. Attempts to produce quantitative ballistic risk assessments have been limited by insufficient vulnerability data to adequately inform likely impact. An improved, quantitative understanding of how different building materials and construction types perform under ballistic impacts is critical for informing risk models and appropriate life safety actions. To address these limitations we conducted a field campaign measuring ballistic impacts to buildings from eruptions at Mt Usu and Mt Ontake in Japan. We additionally performed a series of experiments using a pneumatic cannon to simulate ballistic impacts to a range of building materials to develop a quantitative measure of building vulnerability and inform development of fragility functions. Fragility functions can be incorporated into risk assessments to relate hazard intensity (i.e. energy of ballistic projectile) with what assets are exposed (i.e. building type) to calculate impact. Here we develop fragility functions for residential and commercial buildings by analysing ballistic impacts to roof and wall cladding materials commonly used in New Zealand. Damage patterns from experiments were consistent with those from the post-eruption impact assessments and perforation thresholds were similar to those given in previously unvalidated studies. Our study has built on previous research by investigating the hazard associated with shrapnel formed when ballistics impact brittle claddings and the effects of impact obliquity and ballistic block strength on damage. Ballistic impacts to buildings in previous eruptions and our experiments imply that although unreinforced buildings appear to be highly vulnerable to large ballistics (>20 cm diameter), if appropriate protective actions are taken, they can still provide shelter, preventing death during eruptions.