Safety of wooden buildings roof subjected to ballistic block collision

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Damages and destruction of as-built wooden buildings caused by volcanic activities are due to various factors. Especially, at the phreatic eruption of Mt. Ontake in September 27, 2014, most of the damages were caused by collision of ballistic block.
In order to prevent these damages, it is suggested that evacuation to a mountain hut is effective. Thus, evaluation of safety for wooden buildings (e.g. mountain hut) against ballistic block collision is necessary. Previously, we reported the protective abilities of as-built wooden buildings, which were reinforced with high performance fabric using aramid fiber. However, the safety of unreinforced as-built wooden buildings has not been clarified.
In this study, safety of wooden buildings roof subjected to ballistic block collision was experimentally investigated.
A collision test was carried out at the velocity of 10 to 90 m/s using a large scale launching system. In this system, a projectile was accelerated by compressed air and then collided with the target. The projectile velocity was measured using two lasers and light receiving parts.
At the volcanic eruption, the diameter of ballistic block was approximately φ100 mm under normal circumstances of phreatic eruption. Therefore, abrasive materials similar to the common ballistic block (density: 2400kg/m3, diameter: 90mm, mass: 2.66kg) was used as the projectile.
For the target, typical wooden roof structure (e.g. cedar boards, waterproof sheet, galvalume steel plate and cedar rafter) was used. The thickness of the cedar board, waterproof sheet and galvalume steel plate were 18 mm, 1 mm and 0.4 mm, respectively. The components were fixed with nails and its spacing was approximately 150 mm. The dimensions of the specimen were 600 mm ×600 mm.
From results of collision tests, it was revealed that the penetration boundary energy of the specimen was approximately 1200J. When the collision energy was smaller (440, 818 J) then the penetration boundary, several deformation due to bending at rafters was dominant. On the other hand, when the collision energy was larger (10512 J), local shear failure was observed at the vicinity of the contact surface. It was clarified that fracture mode changed when the collision energy was increased.
In previous study, it was shown the maximum collision energy of volcanic lapillus (φ2-64 mm) was 1700 J (in the case of φ64mm, 100 m/s), and average collision energy was less than aproximately1200 J in many case. Therefore, it was revealed that the roof of cedar board having a thickness of 18 mm could prevent penetration of volcanic lapillus.

Keywords: Ballistic block, Wooden buildings roof, Collision