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HTT33-P04 Room:Poster Time:May 2 16:15-17:30

Multicopter Aerial Photo Survey of Building Damages by 2013 Bohol Eearthquake in the Philippines

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We demonstrate the effectiveness of multicopter aerial photographing for recording earthquake damages of low to medium-rise buildings. M7.2 shallow inland earthquake occured on Bohol Island in the Philippines on October 15, 2013, which caused thousands of building damages and more than 200 casualties in the western part of the island. Post- earthquake surveys by PHIVOLCS showed the maximum earthquake intensity in Tagbilaran city near the epicentral area was VII in Philippines Eearthquake Intensity Scale, which is equivalent to VI in JMA intensity scale. We visited the island three weeks after the earthquake, to make the damage survey focusing on church buildings using a multicopter. We also carried out aerial photogrammetric survey of the surface rupture of the earthquake fault and the coastal uplift(Nakata et al., JpGU 2014) and the landslide damage of chocolate hill, a distinguishing morphology on the island.

A number of stone masonry churches founded in the 16th century in the Spanish colony times were damaged by the earthquake. The existing building of Baclayon Church, which was constructed in 1727 and known as the oldest church in the Philippines, lost the upper half of the bell tower and the whole front wall of the cathedral. Loboc Church and the adjoined museum in the Loboc city lost most of the side walls except their lower part. Maribojoc Church in the west and Clarin Church in the north of the island collapsed completely. Notable damages are also on non-structural masonry walls confined by RC columns and beams of public buildings, such as Sagbayan city hall and Tubigon city hall.

We used a small and easy-to-fly multicopter named DJI Phantom and a high-resolution and compact digital camera GoPro Hero3 Black Edition for the aerial photographing. We attached the camera facing obliquely down and manually controlled the copter in GPS stabilized mode. We used a FPV (First Person's View) system FatShark Telepoter V3 for watching the camera view. Photos were taken continuously in 2 seconds interval, while the copter was flying around the subjects. We limited the duration of each flight to five minutes and attached propeller guards to the rotors in order to reduce the possible dangers by crash as much as possible because people's activities in the areas around the churches were normal. We had no accident during the survey. We found that FPV is very useful in building damage survey because it can reduce the risk to crash to the building when taking photos, while it is difficult to know the distance from the copter to the subject in manual control from the ground.

The left figure shows the multicopter aerial photos of the damaged Baclayon Church. We can observe the fracture surfaces of the upper structure and its inside which are invisible from the ground. Aerial photographing using multicopter right after an earthquake is an efficient tool to easily get full picture of the damage even when approaching from the ground around a building is difficult. We then processed about 50 aerial photos using an SfM (Structure from Motion) software PhotoScan to reconstruct the 3-D model of the bell tower as shown in the right figure. The techniques enable modeling fractures of buildings and their analyses. The 3-D models are also valuable as digital architectural remains of disasters. Aerial photogrammetry using multicopter and SfM is easier than 3-D measurement using laser scanner. Creating a miniature of damaged building from the digital model using 3-D printer will also be useful for planning repairs and earthquake resistant design of buildings.

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