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Muography as a novel complementary technique for geotechnical surveys

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Muography is an imaging technique that can utilize cosmic-ray muons for remote and non destructive exploration of large-sized natural and human-made structures [1]. We applied mobile gaseous-detector-based muography instruments [2] for surveying different human-made structures in Japan:

(1) A buried reinforced concrete pillar (that is a standard pillar along Japanese railways) was installed inside a mound, and muography was blind tested from a three meter deep shaft located three meters away from the pillar [3]. Our muographic surveys revealed the bottom of the pillar at the depth of 80 cm with a spatial resolution of 15 cm within a few days.

(2) Debris dams are applied to prevent the catastrophic impacts of fast debris flows on the landscapes in mountain areas. We muographically measured the density-lengths through different debris dams (e.g., see in Ref. [4]) with a spatial resolution of below 50 cm within 2-4 weeks. The muographic surveys detected a weak zone inside a debris dam of Karasugawa river in consistency with elastic wave tomography survey.

(3) Muographic inspection of the Imashirozuka burial mound was conducted for detecting physical evidences related to a past earthquake [5]. This mound collapsed after a landslide generated by the 1596 Fushimi earthquake. Bidirectional muographic surveys detected a 4-8 m width low-density region at the top of the mound. These were interpreted as large-scale vertical cracks that caused the translational collapse process behind the rotational landslide that was already found in prior trench-survey-based works. The observations revealed that the mound already had intrinsic problem with the stability of the basic foundation before the earthquake.

These proof of concepts demonstrate the applicability of muography for geotechnical surveys and encourage the further studies for improving the protection of landscapes, economies and

societies.

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