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Reply to discussion on “Test on application of distributed fiber optic sensing technique into soil slope monitoring” by L. Picarelli and L. Zeni

We thank Picarelli and Zeni for their discussion on our paper. We are also very glad to find so many researchers who are interested in this field. As the writers listed in their discussion paper, the optical fiber is born for monitoring of structures and had been successfully applied in structure monitoring. Before the lab test described in our paper, there have been many researches and engineering practices of optical fiber applied in civil engineering in China, including tunnel monitoring (Shi et al. 2003), anchor bolts strain monitoring (Sui et al. 2008), structural damage identification (Zhang et al. 2007a), and temperature monitoring of frozen soil (Zhang et al. 2007b). Recently, an optical fiber technique based on BOTDR was successfully applied in monitoring piles by embedding optical fiber sensors in reinforced concrete beams of piles (Piao et al. 2008; Wei et al. 2008).

However, when the optical fiber was applied in soil mass, such as soil landslides, there were new problems that should be faced:

- ◆ Compatible deformation between soil mass and optical fiber
- ◆ Protection of optical fiber sensors
- ◆ Pre-warning before fatal failure of soil mass
- ◆ Identification and localization of abnormal strain

For most of the structures, such as bridges, piles, tunnels, and so on, the optical fiber can be embedded directly in the rigid materials of the structures, and deformation of optical fiber approximately agrees with that of the structure. But for soil mass, it is difficult to keep compatible deformation between soil mass and optical fiber. Relative displacement between soil mass and optical fiber may happen and the strain of optical fiber cannot really reflect the movement of soil mass. This may be very serious for loose or soft soil. Embedding optical fiber into reinforcing material is a feasible and effective method, such as geosynthetics, anchor bolts, or others, depending on the reinforcing technique of the soil slope. The main aim of our test described in the paper is to test and prove the feasibility of embedding optical fiber into geosynthetics. The soil used in this test is silty clay, called Xiashu soil, which is widely distributed in Nanjing City, Jiangsu Province, China. The soil was lightly compacted after the geosynthetics with optical fiber were planted into filled soil.

In structure monitoring, the deformation of the structure before fatal failure is always small. But for soil mass, this may be relatively large and the optical fiber may be broken, as happened in our test as described in our paper. In the lab test, the optical fiber of type A (no jacket), including those emplaced in geo-textile and geo-grid, were all broken before loading; thus, there were no valid data obtained. This often happened in field tests carried out in a highway slope (Shi et al. 2007).

Early warning before fatal failure of soil mass is an ultimate and important target for slope monitoring. Unfortunately, it is difficult to draw conclusions for early warning before fatal failure of soil mass only through the lab test described in our paper. In fact, it needs further lab tests, field tests, and engineering practices.

As the writers state, compared to stimulated Brillouin scattering technique, the spatial resolution of BOTDR may truly be a shortage in our test, which was carried out in a 1.5-m×1.5-m-size model. This will affect the localization precision of abnormal strain. However, for a civil engineering practice instead of small-size lab test, protection of optical fiber and layout of fiber sensors may be more important than precision of localization. Of course, new techniques that can improve the precision of strain and spatial resolution of localization are sure to improve the level of safety monitoring for soil landslides.

Doubtlessly, optical fiber technique presents a new and feasible method for monitoring soil slope. With more and more researches and achievements in this field, this technique will become an effective tool for slope monitoring.

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