Geophysical Research Abstracts
Vol. 13, EGU2011-1074, 2011
EGU General Assembly 2011

Development of a cone penetrometer using fiber Bragg grating sensors

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Because of its simplicity, efficiency, and capability of logging continuous records, the cone penetration test (CPT) has become a popular in-situ testing method. Readings from a typical electric CPTU (CPT with pore pressure measurement, piezocone test) usually contain cone tip resistance (qc), sleeve friction (fs), and pore water pressure (u). These readings have mostly been monitored using electrical strain gauge based transducers. The electrical sensors are subject to electro-magnetic interference (EMI) and short circuit when used under water. The optic fiber sensors typically transmit signals via light and thus are not affected by EMI. Unless electric circuits are involved, the optic fiber sensors can be submerged under water without the concern of short circuit. The optic Fiber Bragg Grating (FBG) can be used as a partially distributive strain sensor. The signals from multiple FBG sensors can be transmitted reliably over 10 km via a single optic fiber. When installed properly, the FBG has high sensitivity, durability and is immune to EMI and short circuit. Taking advantage of these characteristics, the authors developed a fiber optic sensored cone penetrometer. Readings of qc and fs are measured by two independent FBG load cells. The arrangement of FBG is similar to an electrical strain gauge load cell. Two pairs of FBGs adhered to opposite side of the rod to monitor resistant and friction stresses during cone penetrating. One pair of FBG sensors near the cone is served as qc measurement, the other two sensors at the rear of penetrometer are used for measuring fs. The pore water pressure (u2) located right behind the cone is derived from an FBG pressure transducer which is fitted inside the base of cone. The FBG attached to the center of a circular diaphragm to measure its deformation induced by pore water pressure. The deflection of central part is linearly related to the pressure. This paper introduces the basic principles of FBG sensors and demonstrates calibration results of new developed fiber optic sensored cone. A series of CPTU were performed in a calibration chamber and test results were discussed to evaluate the performance of the optic FBG cone penetrometer.