Wednesday, 3/15/2017

8–9:30 a.m.

Energy Geostructures 2

Chairs: Guney Olgun, Virginia Tech; John McCartney, University of California, San Diego

A Geothermal Perspective on Abandoned Oil and Gas Wells in Sedimentary Georeservoirs Located in California, USA

Robert Caulk and Ingrid Tomac, University of California, San Diego

An investigation was performed on the suitability of abandoned wells in California for Enhanced Geothermal Systems (EGS). The study identified three counties characterized by high numbers of abandoned wells, medium to high crustal heat flows (75-100 mW/m2), and suitable sedimentary geology: Santa Clara, Monterey, and Santa Barbara. Temperature gradients ranging between 4 and 7.3 oC/100 m access bottom hole temperatures between 40-73 oC for an average 1,000 m deep well. These rock temperatures are sufficient for the extraction of low-temperature geothermal energy for direct use such as district heating, greenhouse heating, and aquaculture. The mitigation of drilling costs and the documented lithology both reduce the risk associated with EGS. However, hydraulic fracturing of loosely to moderately consolidated sedimentary rock in transitional stress regimes remains one limitation to the EGS conversion of these abandoned wells.

Long-term Performance of Heat Exchanger Boreholes at Different Climatic Conditions

Guney Olgun and Mertcan Geyin, Virginia Tech; Tolga Y. Ozudogru, Istanbul Technical University

Ground-source heat pump systems consist of heat exchanger boreholes, embedded with circulation pipes, buried in the ground and connected to a heat pump for heating and cooling of buildings. Due to the changes in seasonal energy demands of the building, sustainability of borehole heat exchangers depends on the seasonal load balance. As the soil can be gradually heated up or cooled down considering the unbalanced thermal loads, long-term performance of heat exchanger boreholes is closely related to maintaining a constant ground temperature as progressively changing temperatures indicate loss of heat exchange efficiency in the long term. In order to address the long-term thermal performance for different unbalanced climatic conditions, ground thermal loads were estimated and representative equivalent half-sine waves of thermal loads from a hypothetical four floor medium size office building are created for 100+ different locations. Total required heat exchanger lengths for each location are then estimated for the proposed building. Findings suggest that for different seasonal energy demands, amplitudes and durations of the sine waves change significantly, consequently suggesting different loop lengths. For unbalanced climates, loop lengths found are considerably higher than balanced cases. Ultimately, numerical analyses were simulated for 30 years of heat exchanger operation to investigate the thermal performance under different climatic conditions.

Effect of End-restraint Conditions on Energy Pile Behavior

Melis Sutman and Guney Olgun, Virginia Tech; Lyesse Laloui, Swiss Federal Institute of Technology, EPFL; Tracy Brettmann, A.H. Beck Foundation Co. Inc.

Energy piles are deep foundation elements designed to utilize the relatively constant temperature of the ground for efficient heating and cooling of the buildings while at the same time serve as foundations. The temperature changes during the operation of energy piles result in axial displacements, a part of which is restrained by the surrounding soil or the building on top. The restrained part of the axial displacements induces compressive stresses during temperature increase and tensile stresses during temperature decrease along energy piles. Moreover, the unrestrained part of the displacement results in changes in the mobilized shaft resistance, which need to be taken into consideration during design of energy piles. With the aim of quantifying these effects, a series of full-scale field tests on three energy piles with different end-restraint conditions was carried out in Richmond, TX. The field test program included conventional pile load tests and application of temperature. Temperature changes were applied to the test piles with and without maintained mechanical loads to investigate the effects of structural loads on energy piles. Moreover, the lengths of the test piles were determined to represent different end-restraint conditions at the toe. In this paper, a comparison of the thermally induced axial stresses and mobilized shaft resistance of two identical, end-bearing test piles with and without maintained mechanical loads are presented along with the details from the full-scale field test.

Soil-concrete Interface Properties Subjected to Temperature Change and Cycles Using Direct Shear Test

Suguang Xiao, Muhannad Suleiman, Rehab Elzeiny, and Huan Xie, Lehigh University; Mohammed Al-Khawaja, Qatar University

Geothermal foundations (energy piles) combine the structural function of deep foundations with the ground source heat exchangers to transfer geothermal energy to superstructures. The intermittent operation of the geothermal energy pile system results in cyclic thermal loading on the soil-pile interface. To investigate the effects of cyclic thermal loading on soil-concrete interface properties, a conventional direct shear device was modified by replacing the bottom shear box with a concrete plate that has embedded aluminum tubes to heat and cool the interface. A series of tests were conducted with interface temperatures of 4.5, 22.5, and 42.5 °C, respectively. The normal stresses of the direct shear tests were 27.6, 41.4, and 100 kPa. The tests were performed both under cooling and heating with thermal cycle numbers of 0.5 and 10.5. The aforementioned tests were conducted at a shearing rate of 3 mm/min, and the water contents of all the samples were approximately 18.5%. The responses of soil-concrete interface at different temperatures and temperature cycles are presented in this paper.