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A field testing study on negative skin friction along piles induced by seismic subsidence of loess

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ABSTRACT

At present piles foundation is widely used in the earthquake-prone loess area of China. Unfortunately, negative skin friction (NSF) along piles induced by an abrupt settlement of loess under strong earthquakes, so called seismic subsidence, has not been taken into account in design of piles foundation due to the lack of NSF data from field test. In order to investigate NSF along piles caused by seismic subsidence of loess and develop a method to estimate this earthquake-induced NSF, the authors perform a field test at a loess site by means of a series of explosions, i.e. a short delay blasting, in which two reinforced concrete piles was grouted. The expected ground motion generated by the short delay blasting is strong enough to induce an obvious seismic subsidence in the loess site. There are 40 stress gages to be averagely disposed into the two piles with a certain interval to collect the data of NSF during this field test. Meanwhile, ground motion and seismic subsidence of loess were, respectively, observed by accelerographes and a level gauge. The obtained data particularly disclose the developing characteristics and magnitude of loess seismic subsidence and NSF at the condition of strong ground motion. The loess seismic subsidence and NSF both have a rapid development in the explosion process and then keep a slower increase for some days after the blasting. At the end of observation, the maximum seismic subsidence of loess in the field reaches 33 mm; the average NSF along piles attains to 54 kPa, which is much greater than previous cases of NSF caused by collapse of loess. This field test shows the NSF along piles induced by seismic subsidence of loess is significant and should not be ignored in design of piles foundation in seismic loess regions.

1. Introduction

Loess is a particular kind of soil with porous microstructure and weak cohesion, depositing in the Quaternary. It is well known that the compressibility of loess is low at natural moisture content as a result of a special microstructure [1]. While water immerges, however, strength of loess mass will be reduced dramatically, which could make the soil collapse [2–5]. In China, the area of loess reaches 640,000 km^2, in which collapsible loess area is about 500,000 km^2 [6]. Furthermore, most loess area in China is also seismic region, where many strong earthquakes occurred. Previous research and investigation reveal that under the effect of moderate or strong earthquakes, liquefaction or seismic subsidence of loess, a abrupt settlement of loess caused by strong ground motion, is easily induced [7]. These three kinds of subsidence due to collapse, liquefaction and seismic subsidence of loess, which associated with immerging water, additional load or ground shock, respectively, could come into being negative skin friction (NSF) along piles, which badly endangers piles foundation.

In the geotechnical engineering field, NSF is a complicated problem and it connects with some other theoretical problems in soil mechanics area. Because in situ test costs a lot and also needs a long-time period to prepare and accomplish, existing test data is limited for meeting the needs of NSF study. Especially, research results related to NSF on pile in loess ground caused by seismic subsidence, which is an abrupt settlement of soil mass induced by an enough dynamic stress, such as an earthquake, are very rare. As a result, NSF along piles generated by the seismic subsidence in loess ground under strong earthquakes cannot been taken account into the design of piles foundation, whereas piles foundation is widely used in the earthquake-prone loess area of China at present.

In order to investigate the characteristics of NSF along piles in loess ground caused by seismic subsidence and develop a method to estimate the seismic NSF, the authors performed a field test at a loess site (Q_3) by means of a series of explosions, i.e. a short delay

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