Assessment of the effect of stone columns group on the liquefaction of different soil points

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Abstract

Liquefaction is one of the most critical phenomena in geotechnical earthquake engineering. One of the suitable methods for dissipating pore water pressure and thus reducing the soil liquefaction potential is the use of the stone column technique. The purpose of this study is to evaluate the effect of stone columns on the liquefaction potential of different soil points. To perform the nonlinear dynamic analysis, the FLAC^{3D} software has been used. Consequently, the effective radius of stone columns in different depths is evaluated and indicated that the effective area around the column is 2 to 3 times the diameter of the column.

Keywords: Soil improvement, Liquefaction, Stone column, Earthquake, Nonlinear dynamic analysis.

1. INTRODUCTION

Construction of structures in loose, low bearing capacity and high liquefaction potential soils has many risks. During the earthquake phenomenon, a factor such as liquefaction may contribute to undesirable soil behavior, which causes failure and loss of ground resistance. The purpose of soil improvement is to minimize the potential of liquefaction and minimize the destructive settlement of the soil. One of the most suitable land improvement techniques for soft clay and sandy soils is the use of stone column in the ground that can be used for fine-grained and coarse-grained soils. The stone column is a soil reinforcement method in which the soft soil is replaced at specific points by gravel or crushed rock in pre-drilled vertical holes to form columns in the soil. After performing the stone columns, the entire soil below a foundation acts as a reinforced soil with a higher bearing capacity than the virgin ground. The dissipation of pore-pressure by radial flow stimulates the consolidation of the subsoil.

Regarding the application of this method to reduce the potential of liquefaction, several studies have been carried out by various researchers. In general, these researches can be divided into numerical investigations and small-scale seismic experiments. Gravel drains (stone columns) as a method for liquefaction mitigation were first studied by Seed and Booker [1]. Then this technique attracted the attention of outstanding researchers.

Millea studied the seismic behavior of a liquefiable soil with stone columns using a finite element program [2]. He showed that stone columns dissipated the pore pressure. Millea also used the finite element method to show that changes in pore water pressure are high in contrast to Seed and Booker's theory within the stone column. Mitchell and Wentz evaluated the performance of 12 improved ground subjected to the Loma Prieta earthquake [3]. They found, without exception, that damages of ground motion on a soil reinforced by stone columns are slight. Nakata et al. using shaking table tests, obtained pore water pressure and settlement during vibration, both of which were reduced by the presence of stone columns [4]. Hyden and Baez surveyed two sandy soil sites with stone columns after the Northridge earthquake in 1994 [5]. The structures were not damaged at both sites, and there was no sign of ground distress or liquefaction around the structures. Priebe proposed an improvement factor to evaluate the performance of stone columns [6]. In this