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On the behavior of the overcut and stuck effects during pipejacking

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Abstract

No-Dig constructions in the city might encounter of various difficulties. And the difficulties or obstacles, which might cause schedule delays and damage to the pipes. Among the others, the conditions of overcut and stuck could be the most common and critical to a pipejacking project. This study considered various difficult conditions, including different overcut range and sticking position, together with different resistance, jacking force, etc. The ABAQUS finite element software was applied for three-dimensional numerical simulations for pipe-jacking with different difficult situations. The analyses focused on the pipejacking in gravel formations, and the suggestions were concluded based on the results. The results suggest that the location of sticking and its severity (different frictional coefficient was set) affect the stress field in the pipe. And the worst condition, i.e., the totally stuck, the adjacent soil and pipe will experience excessive deformation, which must be avoided. Therefore, lubrication to avoid this extreme scenario is essential in the pipejacking operation. For the case with large diameter, unavoidable overcut and highly variable geology, the above suggestions are more crucial.

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Keywords: pipejacking, overcut, soil-pipe interaction, numerical analysis

1. Introduction

Due to the rapid urban development, which makes the space of construction more and more limited, trenchless technologies including shield excavation and pipejacking are more and more popular for the installation of utility pipelines in Taiwan area. In the operation of pipejacking, the copy cutters are commonly applied to make the gap

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between the shield machine and the soil mass, i.e., the overcut, such that the resistance of friction can be properly reduced. However, if the overcut was improper due to the variation of soil or other factors, the overcut could collapse and cause high resistance or the condition of sticking to the extreme. In the conditions of high resistance or sticking, the operation could be hindered by the shortage of jacking force, and the pipes could be over-stressed or damaged.

For the analysis of soil-pipe interaction during a pipejacking, there are three majors approaches, i.e., analytical method, physical modeling, and numerical modeling. However, to have an analysis more close to the reality, the numerical modeling is more feasible. For the numerical modeling of pipejacking, the soil mass is commonly considered as an elastoplastic material. The shield machine and the pipes are considered as more rigid elastic bodies. Nevertheless, the study on the effect of overcut and sticking is scarce. In this study, numerical method was applied to analyze the impact of overcutting and sticking on the soil-pipe interaction, with different overcutting and stuck considerations in a pipejacking. The pipejacking cases in Taichung area of Taiwan are adopted as examples, and suggestions are given based on the analysis results.

2. Methodologies

2.1. Meshes and boundary conditions

The boundary conditions and element type are considered are as below: (A) the bottom face is confined by hinges and the surrounding vertical faces are framed by rollers, (B) three-dimensional solid elements (C3D8I) are used to simulate the soil and the pipe, and (C) interface elements are applied to simulate the soil-pipe frictional behavior. Numerically, we simulate the pipejacking process by repeating three numerical steps: remove the soil element in the pipe and at the pipe location, equilibrate the domain to obtain and accumulate the influences, and drive the pipe elements forward. The three-dimensional functions of the finite element software ABAQUS (Abaqus, Inc.,2005) were applied in this study.

To simulate the pipejacking cases, the pipe is assumed 10m below surface, and the 40m * 40m * 25m block of soil was considered. The jacking pipes are 2.5m long, 2m in diameter and 0.2m in thickness. The pipejacking machine is also considered as 2.5m long and 2m in diameter. The overburden is set to be 11.5m below surface. However, for the case of the curved pipejacking, 20 m in the radius of curvature was considered. The special jacking pipes are 0.8m long, 2m in diameter and 0.2m in thickness (Liu, 2010). After all, 17800 elements were used for the straight line pipejacking case (see Figure 1) and 27432 elements were used for the curved pipejacking case (see Figure 2).

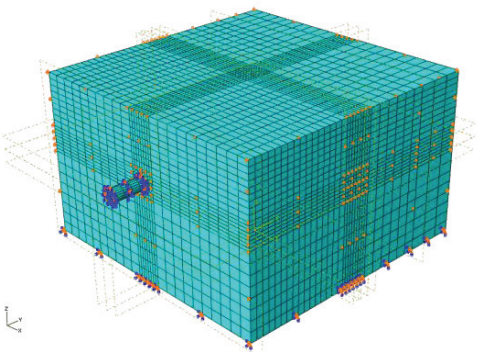

Fig. 1. The Mesh for Straight Line Pipejacking.