Simulation Analysis on Impacts on Existing Pipeline Displacement from High-fill Slope Construction Based on ANSYS

Yi-shu WANG¹, Yun-feng MAO¹, Jian-min LI¹ and Si-chang WANG²,³,*

¹Yunnan Highway Engineering Supervision and Consultancy Co., Ltd., Kunming, Yunnan, 650021, China
²School of Civil Engineering and Architecture, Chongqing University of Science and Technology, 401331, China
³Chongqing Key Laboratory of Energy Engineering Mechanics & Disaster Prevention and Mitigation, Chongqing, 401331, China
*Corresponding author

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Abstract. During construction process of high-fill slope, additional load of foundation gradually increases with the increasing of filling height, whose influences on existing underground pipeline displacement has to be pay attention. This thesis takes existing oil pipeline as research object, in which upper filling brings about surrounding soil displacement, thus posing great threat to normal use of pipelines. Through analyzing on surroundings of pipelines and filling construction of slope, this thesis utilizes ANSYS Finite Element Simulation Software to construct model and realizes burial depth simulation through equivalent gravity field. Results show that vertical displacement of left pipeline mainly focuses on both sides, which explains that influences of filling on left oil pipeline mostly exist on both sides. The maximum vertical displacement is 19.0mm. Horizontal displacement mainly concentrates on top and bottom with the maximum value 5.7mm. Vertical displacement of right pipeline also centers on both sides, which explains that influences of filling on right oil pipeline mostly exist on both sides. Its maximum vertical displacement is 18.6mm. Horizontal displacement mainly concentrates on top and bottom with the maximum value 3.1mm.

Introduction

During construction process of high-fill slope, additional stress of foundation constantly increases with the gradual rising of filling soil. Therefore it is obvious that this construction process keeps great influences on surrounding environment, buildings and existing underground pipelines, thus enlarging construction security risk [1-3]. Zhiqiang Wang [4] does numerical simulation analysis on highway slope stability under continuous rainfall and describes changes of physical and mechanical parameters of soil with rainfall duration, which results in changing of slope stability. Honggang Wu [5]researches on high-fill slope reinforcement of airport and does simulation analysis on cooperative working effect of different reinforcement methods combining with BIM. This thesis utilizes ANSYS Software to do simulation on high-fill slope and does analysis on influences of foundation deformation from filling on existing pipelines, thus providing references for filling construction.

Overview of Engineering Project

Do artificial filling on the top of existing oil pipeline with filling height 20m. Original landform of the field is alluvial terrace and denudation residual hill. In the early stage, do flattening, construction filling and partial excavation on the field thus leading most part to be flat and local region to be undulated slightly. According to drilling and geological survey, underground water of the field mainly exists in overlying loose soil and bedrock fissure, which belongs to hole phreatic water and fissure water. It keeps middle water capacity.

After filling piles into slope, slope landscape comes into being. High-fill soil may result in lateral sway or sedimentation of existing oil pipeline, thus influencing its normal operation.
Establishment of ANSYS Analytical Model

According to data analysis, 3-3 Cross Section of oil pipeline is greatest impacted by filling slope. Therefore this numerical simulation firstly does simulation analysis on 3-3 Cross Section.

The model utilizes Mol-coulomb Rule to do analog computation. For the purpose of eliminating boundary effect, distance between left and right boundaries of pipeline model and pipeline boundary should be three times longer than inner diameter. The length from upper and lower boundaries to pipeline boundary should be three times bigger than headroom. Utilization of equivalent gravity field realizes burial depth simulation. Fig.1 shows finite element model.

Fig.2 shows plane relationship between oil pipeline and earthing. Fig.3 shows their spatial relationship.

Do elaborate mesh generation on finite element model. Fig.4 shows the mesh generation diagram.
Model Parameters

Relevant parameters of oil pipeline should be determined according to “Engineering Design Specification for Oil Pipeline (GB50253-2014)”. Rock and soil physical and mechanical parameters are confirmed through drilling and in-situ tests. Data information acquired through ego-technical testing is determined by “Code for Foundation Design of Buildings (DBJ15-31-2016)”. Tab.1 provides references for determining relevant mechanical parameters of each rock and soil layer in the field.

Table 1. Relevant mechanical parameters table of each rock and soil layer.

| sequence | cause code | rock and soil name | bearing capacity value $f_{ak}$ | compression modulus $E_s$ | internal friction angle $\phi$ | Cohesion $c$ | deformation modulus $E_0$ | standard value of uniaxial compressive strength of natural rock $f_m$ |
|----------|------------|--------------------|---------------------------------|--------------------------|-------------------------------|------------|--------------------------|----------------------------------|
| ① Q$^ml$| plain fill | 90 MPa 3.5 | 8 10 |
| ②-1 Q$^al$ | sludge | 50 1.7 2 6 |
| ②-2 Q$^al$ | silty clay | 150 4.8 25 15 |
| ②-3 Q$^al$ | coarse sand | 160 5.0 25 |
| ②-4 Q$^al$ | pebble | 280 6.0 30 |
| ③ Q$^el$ | silty clay | 180 5.5 20 17 30 |
| ④-1 K | completely weathered sandy conglomerate | 350 10 28 40 60 |
| ④-2 K | strong weathered sandy conglomerate | 600 30 30 50 120 |
| ④-3 K | moderately weathered sandy conglomerate | 3000 - 35 70 - 12.41 |

Simulation Analyses

Simulation Analyses on Left Pipeline

Fig.5 shows calculation result of left pipeline displacement. It is seen from the figure that vertical displacement of pipeline mainly focuses on both sides, which explains that influences of high-fill slope on left oil pipeline mostly exist on both sides. The maximum vertical displacement is 19.0mm. Horizontal displacement mainly concentrates on top and bottom with the maximum value 5.7mm.

Figure 5. Calculation result of left pipeline displacement.
Simulation Analyses on Right Pipeline

Fig. 6 shows calculation result of right pipeline displacement. It is seen from the figure that vertical displacement of right pipeline also focuses on both sides, which explains that influences of high-fill slope on right oil pipeline mostly exist on both sides. The maximum vertical displacement is 18.6mm. Horizontal displacement of right pipeline mainly concentrates on top and bottom with the maximum value 3.1mm.

Conclusions

On the basis of practical engineering data and in full consideration of filling soil’s influences on existing pipelines, this thesis establishes ANSYS analytical model, determines model parameters and does simulation analysis on existing oil pipelines thus confirming horizontal displacement and vertical displacement of both oil pipelines. Simulation analysis results show that influences of high-fill slope on oil pipeline displacement complies with related regulations of engineering safety, which provides theoretical guidance for engineering construction.

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